

**Model 994
Dual Counter/Timer
Operating and Service Manual**

Advanced Measurement Technology, Inc.

a/k/a/ ORTEC[®], a subsidiary of AMETEK[®], Inc.

WARRANTY

ORTEC* warrants that the items will be delivered free from defects in material or workmanship. ORTEC makes no other warranties, express or implied, and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

ORTEC's exclusive liability is limited to repairing or replacing at ORTEC's option, items found by ORTEC to be defective in workmanship or materials within one year from the date of delivery. ORTEC's liability on any claim of any kind, including negligence, loss, or damages arising out of, connected with, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair, or use of any item or services covered by this agreement or purchase order, shall in no case exceed the price allocable to the item or service furnished or any part thereof that gives rise to the claim. In the event ORTEC fails to manufacture or deliver items called for in this agreement or purchase order, ORTEC's exclusive liability and buyer's exclusive remedy shall be release of the buyer from the obligation to pay the purchase price. In no event shall ORTEC be liable for special or consequential damages.

Quality Control

Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

Repair Service

If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, ORTEC must be informed, either in writing, by telephone [(865) 482-4411] or by facsimile transmission [(865) 483-2133], of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. The ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped PREPAID via Air Parcel Post or United Parcel Service to the designated ORTEC repair center. The address label and the package should include the Return Authorization Number assigned. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty should follow the same procedure and ORTEC will provide a quotation.

Damage in Transit

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment, if necessary.

Copyright © 2002, Advanced Measurement Technology, Inc. All rights reserved.

*ORTEC[®] is a registered trademark of Advanced Measurement Technology, Inc. All other trademarks used herein are the property of their respective owners.

CONTENTS

WARRANTY	ii
SAFETY INSTRUCTIONS AND SYMBOLS	v
SAFETY WARNINGS AND CLEANING INSTRUCTIONS	vi
1. DESCRIPTION	1
2. SPECIFICATIONS	2
2.1. PERFORMANCE	2
2.2. INDICATORS	3
2.3. CONTROLS	3
2.4. INPUTS	4
2.5. OUTPUTS	4
2.6. INTERFACES	5
2.7. ELECTRICAL AND MECHANICAL	5
2.8. ORDERING INFORMATION	6
3. INSTALLATION	6
3.1. INPUT POLARITY SELECTION	6
3.2. COUNTER INPUT SELECT JUMPERS	6
3.3. GENERAL	7
3.4. CONNECTION TO POWER	7
3.5. SIGNAL CONNECTIONS	7
3.6. OUTPUT CONNECTIONS	8
3.7. PRESET TIME OPERATION	8
3.8. PRESET COUNT OPERATION	9
3.9. LIVE-TIME MEASUREMENTS	9
4. OPERATING INSTRUCTIONS	10
4.1. RS-232-C INTERFACE (MODEL 99X-1)	10
4.1.1. 20-mA CURRENT LOOP OUTPUT	11
4.1.2. USING THE 99X-1 WITH A PRINTER	11
4.1.3. INSTALLATION INSTRUCTIONS	12
4.2. IEEE-488 (GPIB) INTERFACE (MODEL 99X-2)	12
4.2.1. USING THE 99X-2 WITH A PRINTER	14
4.2.2. INSTALLATION INSTRUCTIONS	14
4.3. PRINT LOOP INTERFACE (MODEL 99X-3)	15
4.3.1. INSTALLATION INSTRUCTIONS	16
4.4. INTERNAL +6 V SUPPLY OPTION (MODEL 99X-4)	17
4.4.1. INSTALLATION INSTRUCTIONS	17
5. PROGRAMMING THE 994	18
5.1. RS-232-C INTERFACE	18
5.1.1. TERMINAL OPERATION	18
5.1.2. BASIC PROGRAMMING	19
5.2. INTERFACING TO THE IEEE-488 BUS	21
5.2.1. HEWLETT-PACKARD COMPUTER EXAMPLES	21
5.2.2. IBM-PC PROGRAMMING EXAMPLES	24
APPENDIX A. ASCII COMMANDS TO THE MODULE	29

A.1. COMMAND WORDS	29
A.2. DATA VALUES	29
A.3. CHECKSUMS	29
A.4. RESPONSE FROM THE MODULE	29
A.5. TIME UNITS USED IN COMMANDS	29
A.6. CATALOG OF COMMANDS FOR THE 994	29
APPENDIX B. RESPONSE RECORDS FROM THE 994 MODULE	33
B.1. DELIMITING CHARACTERS	33
B.2. PERCENT RESPONSE RECORDS	33
B.3. DOLLAR RESPONSE RECORDS	34
APPENDIX C. OPTIONAL PARTS LIST	35
C.1. CABLES AND CONNECTORS	35
C.2. ORDERING INFORMATION	35

SAFETY INSTRUCTIONS AND SYMBOLS

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

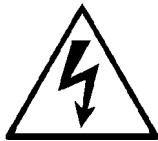
- DANGER** Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.
- WARNING** Indicates a hazard that could result in bodily harm if the safety instruction is not observed.
- CAUTION** Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

In addition, the following symbol may appear on the product:



ATTENTION—Refer to Manual



DANGER—High Voltage

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

SAFETY WARNINGS AND CLEANING INSTRUCTIONS

DANGER Opening the cover of this instrument is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.

WARNING Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

Cleaning Instructions

To clean the instrument exterior:

- Unplug the instrument from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

CAUTION To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

- Allow the instrument to dry completely before reconnecting it to the power source.



ORTEC MODEL 994 DUAL TIMER AND COUNTER

1. DESCRIPTION

The ORTEC Model 994 Dual Counter/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.¹ The CCNIM options can directly drive printers having RS-232-C or IEEE-488 ports.

For automated counting applications not requiring computer interfacing, the standard ORTEC print loop function is available as a field-installable, plug-in board. In conjunction with an 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 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

¹"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.

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 ORTEC timer can perform this function to synchronize the Model 994 counting with the other timer. The Interval outputs on all 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 input; 25 MHz for positive input.

TIME BASE 10-MHZ clock with minimum preset or displayed intervals of 0.01 s 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 ACCURACY $\leq \pm 0.0025\%$ over the 0 - 50° C operating temperature range.

PRESET TIME/COUNTS The module stops counting when the preset value $MN \times 10^P$ 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-SEC time base, preset times from 0.01 to 990,000 s can be used. Preset times from 0.01 to 990,000 min are available using the 0.01-MIN 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 input; <40 ns for positive input.

2.2. INDICATORS

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

OVERFLOW INDICATOR An LED indicator 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 will select 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 Three LEDs labeled A, B, and PRESET indicate the information being displayed in the counter display. The 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 the counter to zero counts and turns off the overflow indicator. It also clears any counts accumulated in the blind preset register, but does not change the selected preset value. When power to the module is turned on, 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 trim pots to adjust the positive input threshold for the Counters A and B. The range is from +100 mV to +9.5 V. Adjacent test point provides the TTL logic signal output from the discriminator 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 counterclockwise 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 $\sim 50 \mu\text{s}$. 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. $Z_{in} = 1000 \Omega$ 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. $Z_{in} = 50 \Omega$; 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 $>+3 \text{ V}$ or open circuit allows counting provided the instrument is in the Count mode and has not reached the preset value; $<+1.5 \text{ V}$ 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 $>+3 \text{ V}$ or an open circuit allows counting of the clock. A level $<+1.5 \text{ V}$ 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 $>+3 \text{ V}$ or open circuit allows counting; $<+1.5 \text{ V}$ 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 $<+0.5 \text{ V}$ when counting is disabled. $Z_o \sim 30 \Omega$.

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 ps.

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 display mode, 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.

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 ORTEC daisy chain print loop operations. This option is field installable. When connected in a print loop with an ORTEC Model 777A Printer, this option offers automatic recycling of the counting and printing of all eight digits of the A and B Counters along with any other counters in the print loop. If the Model 777A is replaced with an ORTEC Model 879 Suffered 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 DOE/ER-0457T.

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 117V ac lines in the bin. With the Internal +6V 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 +6V	Internal +6-V Supply 117 V ac
Basic Model 994	55 mA	120 mA	1300 mA	110 mA
994 plus IEEE-488 option	65 mA	125 mA	1800 mA	145 mA
994 plus RS-232-C option	74 mA	135 mA	1800 mA	145 mA
994 plus Print Loop option	55 mA	120 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.

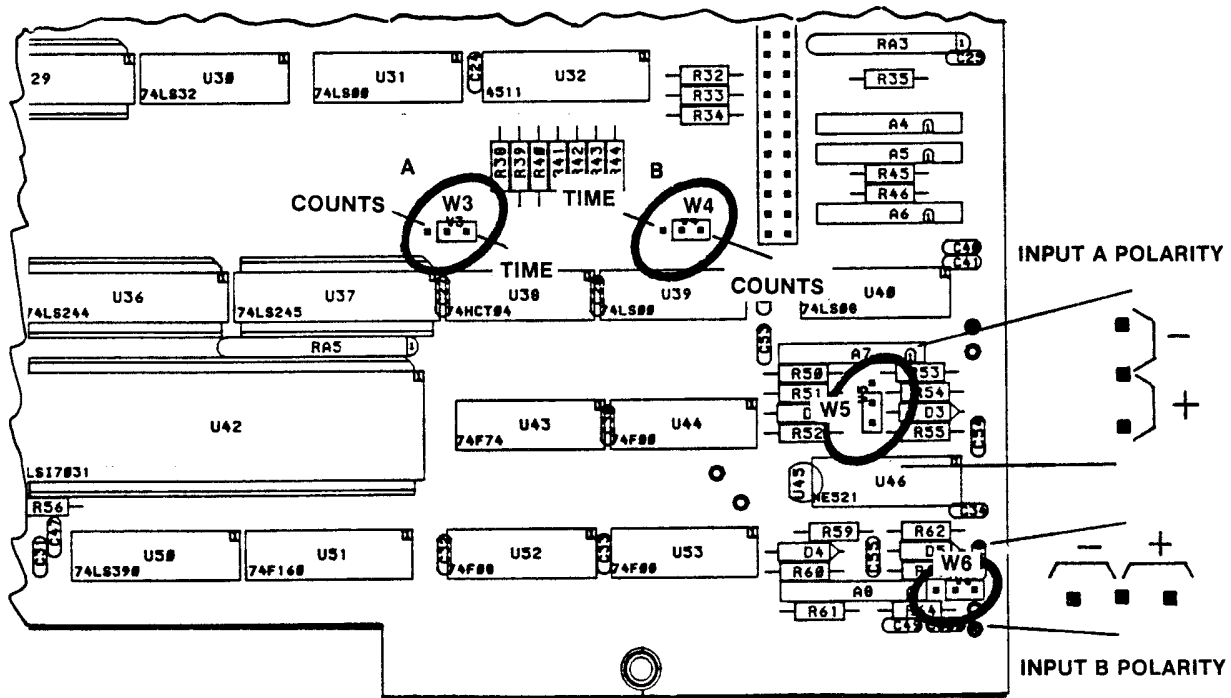


Fig. 1. Selecting Counter Source (W3 and W4) and Setting Input Polarity (W5 and W6).

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 ORTEC 4001/4002D 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 4001/4002D 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 +1.5V. 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 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 μ s) 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 $MN \times 10^P$, 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 15×10^2 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 Bass 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.

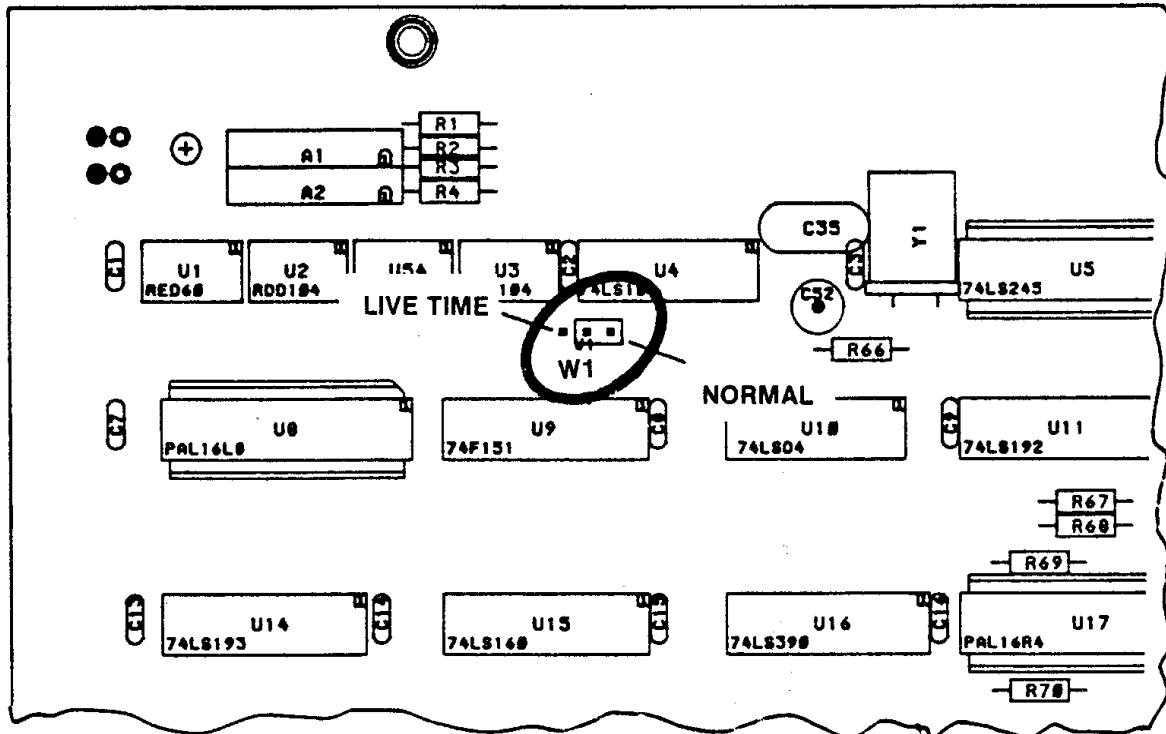


Fig. 2. Selecting Live-Time or Normal Mode of Operation.

4. OPERATING INSTRUCTIONS

There are three interfaces available for the module 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 ORTEC standard print loop interface. Each of these interfaces is a separate plug-in card that is easily installed in the field.

For bin and power supplies that do not provide the +6V needed for the logic circuitry used in the 994, an internal +6V supply is available. This option is field installable, and delivers regulated +5V 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 module. 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 ORTEC. (See Appendix C, 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 DIP switch located on the PWB (Fig. 3). The baud rate selected must match

exactly the baud rate of the device to which the module is connected. The switch settings are given in Table 3.

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	S4	S3	S2	S1
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

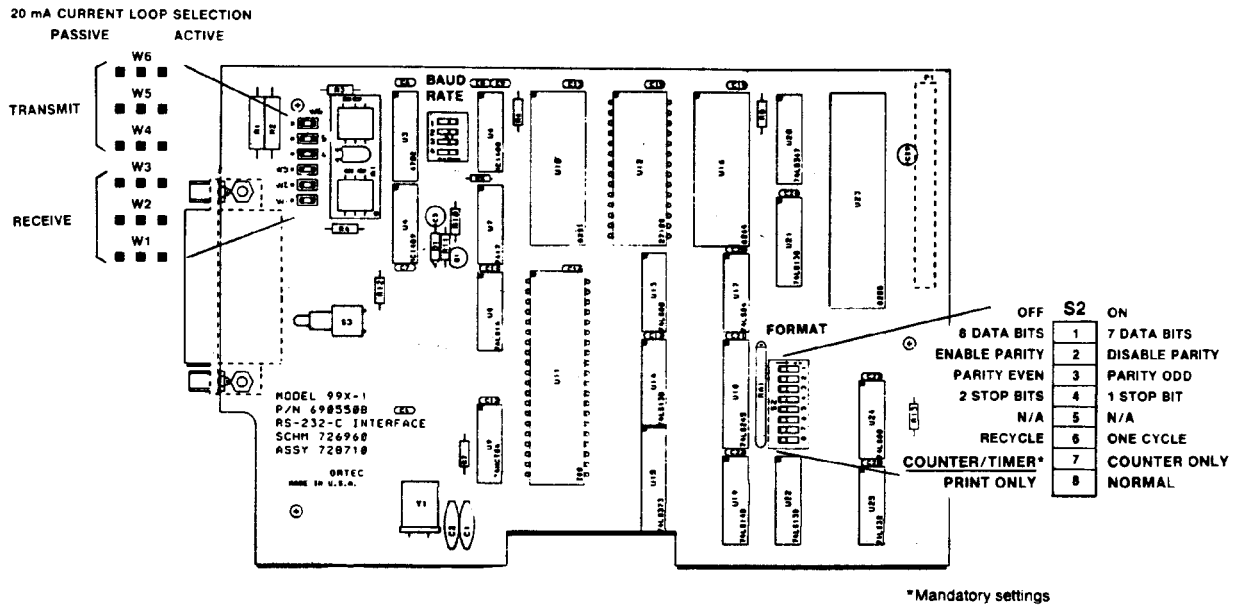


Fig. 3. Changing Jumpers on the 99X-1 RS-232-C Interface Board.

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 DIP switch (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 module is connected. Table 4 defines these selections.

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	Counter/Timer*	Counter Only
8	Print Only	Normal

*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. Counter/Timer selected.
8. NORMAL.

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 module and can be made to be either active (current for the loop supplied by the module) 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 module 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 module to a computer or terminal. This cable is available from ORTEC (Appendix C, Optional Parts List).

4.1.2. USING THE 99X-1 WITH A PRINTER

By placing the PRINT ONLY-NORMAL (S2-8) to the PRINT ONLY position, the 99X-1 Interface will drive a printer with an RS-232-C interface directly. This allows the module to generate a hard-copy of the data collected without the need for commands from

a computer or keyboard. When the interface is installed in a Counter/Timer and the module is started with the Count control, each time the preset value is reached the data is automatically transferred to a printer. If the Recycle mode is selected (S2-6 Off), the Counter data is cleared and a new cycle is started immediately. If the One Cycle mode is selected (S2-6 On), the counter will halt until a reset is generated either by the front-panel Reset switch or by the Dwell time expiring, at which time a new counting cycle will begin.

When the interface is installed in a Counter Only module, a counting cycle is started by the front-panel Count control. When the counting cycle is stopped either by pressing the Stop control or by bringing the Master Enable (or Gate) input low, the data which has accumulated in the counter will be transferred to the printer. If the Recycle mode is selected, the counter will be cleared and a new data collection cycle started as soon as the counter is enabled either by the Count control if the counting was terminated by the Stop switch, or by the Master Enable (or Gate) going high if the counting was stopped by this signal. If the One Cycle mode is selected, the counter will continue counting from the point of interruption without being reset when reenabled to count.

When power is applied to the module, the Model Number of the Module and the firmware version will be printed. When any of the mode switches are changed, the module must be powered up again before the changes are recognized.

4.1.3. 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 ensure 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 <1 M-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 (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, SRQ, 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 DIP switch. Sections 1 thru 5 of switch 1 are used for the address selection (Table 5).

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	Counter/Timer*	Counter Only
8	Print Only	Normal

*Mandatory settings.

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

DIO 1 THROUGH DIO 8 (DATA INPUT/OUTPUT)

These bidirectional lines are used to transfer data between devices. Data is asynchronous and generally bidirectional. 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 Read 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 module 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 module. 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 module, a series of self-test routines is 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 module 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 module must be terminated with ASCII (carriage return and line feed) characters. For every command received by the module, 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 module, two response records must be read by the controller. All response records from the module 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 counters will be reset, and another counting interval will be started immediately.

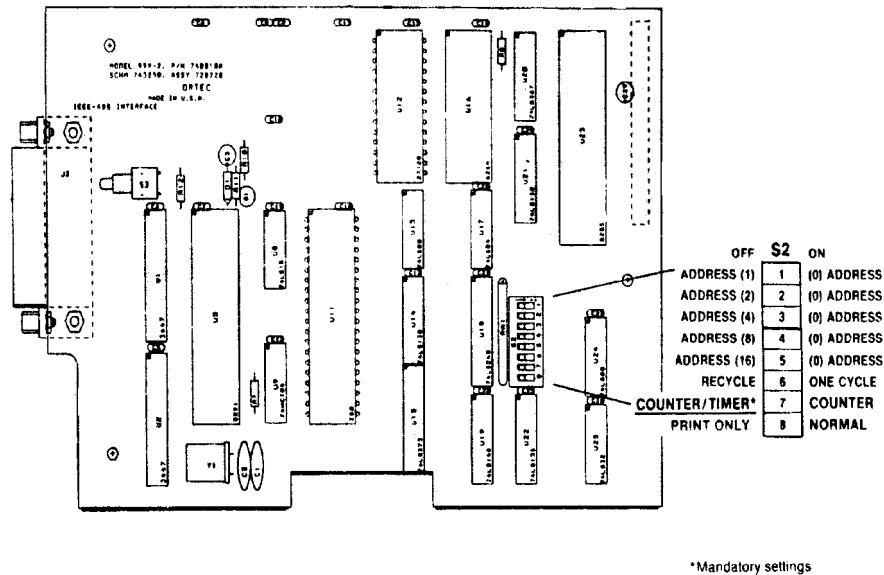


Fig. 4. Address Selection of Dip Switch on the 99X-2 IEEE-488 Interface Board.

4.2.1. USING THE 99X-2 WITH A PRINTER

By placing the PRINT ONLY-NORMAL (S2-8) to the PRINT ONLY position, the 99X-2 Interface will drive a printer with an IEEE-488 (GPIB) interface directly if the printer is addressable as a **Listen Only** device. A bus controller is not needed for this operation, but only one Counting module can be connected to the printer. This will allow the module to generate a hard-copy of the data collected by controlling the module with the front-panel controls. When the interface is installed in a Counter/Timer, and started by the Count control, each time the preset value is reached the data is automatically transferred to a printer. If the Recycle mode is selected (S2-6 Off), the Counter data is cleared and a new cycle is started immediately. If the One Cycle mode is selected (S2-6 On), the counter will halt until a reset is generated either by the front-panel Reset switch or by the Dwell time expiring, at which time a new counting cycle will begin.

When the interface is installed in a Counter Only module, a counting cycle is started by the front-panel Count control. When the counting cycle is stopped either by pressing the Stop control or by bringing the Master Enable (or Gate) input low, the data which has accumulated in the counter will be transferred to the printer. If the Recycle mode is selected, the counter will be cleared and a new data collection cycle started as soon as the counter is enabled either by the Count control if the counting was terminated by the Stop switch, or by the Master

Enable (or Gate) going high if the counting was stopped by this signal. If the One Cycle mode is selected, the counter will continue counting from the point of interruption without being reset when reenabled to count.

When power is applied to the module, the Model Number of the Module and the firmware version will be printed. When any of the mode switches are changed, the module must be powered up again before the changes are recognized.

4.2.2. 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 match the device to Counter/Timer.

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 ensure 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.

A four-position DIP 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 module 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 module does not drive the system gate or the system reset signals but does respond to both. In the Normal position, the module 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.

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

With this interface the module can be included in a print loop with the other counters and timers from 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.

There are two 2-position jumpers (W1 and W2) located on the PWB which are labeled DUAL and SINGLE. These jumpers must be set to match the number of counters on the mother board into which the interface boards are connected. If used with the Model 994 or 995, the jumpers must be set to the DUAL position. If used with the Model 996 or 997, the jumpers must be in the SINGLE position.

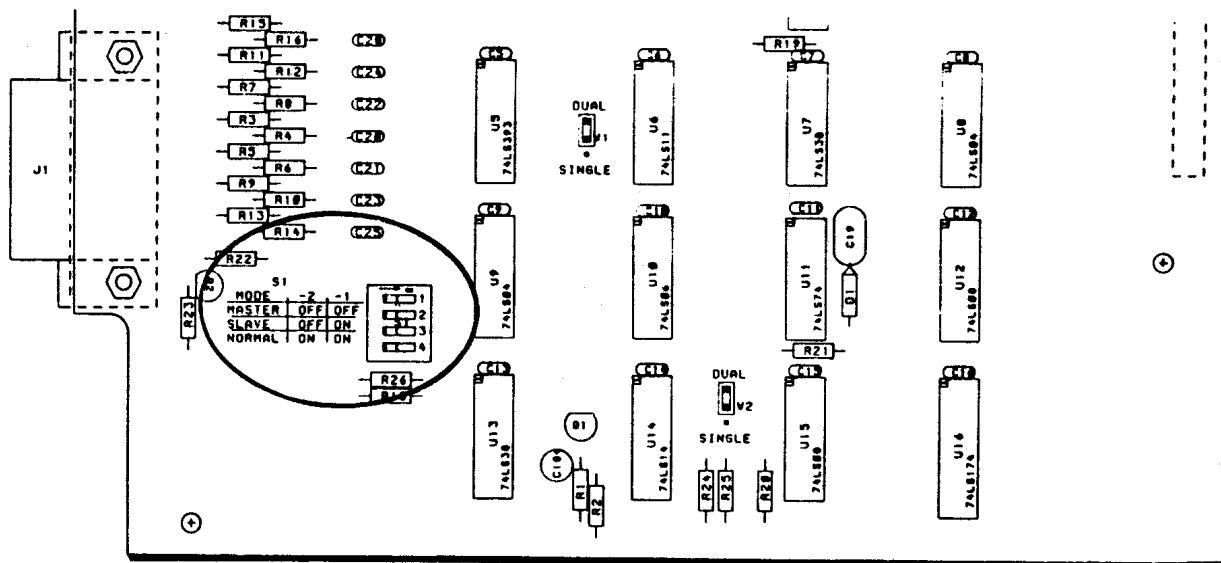


Fig. 5. Selecting Operating Modes on the 99X-3 Print Loop Interface Board.

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

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 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 in the ORTEC Models 994, 995, 996, or 997, follow the steps listed below:

1. Remove the left side plate from the module. If the optional +6 V power supply (Model 99X-4) 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. Set both W1 and W2 jumpers for Models 994 and 995 to the DUAL position and Model 996 and 997 to the SINGLE position.
7. 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 ensure proper match-up of connector and pins.
8. Install the two mounting screws into the standoffs provided on the counter board.
9. Reinstall the power supply chassis if one is present.
10. 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 module. 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.
 - 2.A. If the 99X-1 or 99X-2 Option is installed on the 994 module, perform the following: Remove the front bottom left screw next to the Enable BNC connector and remove the rear bottom right screw (see pictorial page iv), the module bar can be tilted out and 99X-4 option can be mounted to it.
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.
 - 8.A. Replace front and rear screws (Ref. Step 2.A.).

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          This command shows the version of firmware installed in the 994.
$F0994-001
%0000000069
>

SHOW_COUNTS          This command shows the contents of Counters A and B separated
00000000;00000000;  by a semicolon.
%0000000069
>

SET_COUNT_PRESET 35,4  This command loads the M, N, and P registers with the data values
%0000000069          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    In this command, the $B response record shows the value loaded in
$B035004CCC          the preset registers. 035 is the MN value, 004 is the P value, and CCC is
>                    the checksum.

SET_DISPLAY 2        This command selects the preset value to be displayed. The display
%0000000069          should show 354 for M, N, and P, respectively.
>

SET_DISPLAY 0        This command selects Counter A, and the display should read 0.00 if
%0000000069          the internal time base is selected.
>

Set up the 994 for automatic data collection:

ENABLE_ALARM         Enable data transfer at end of preset.
%0000000069
>

SET_COUNT_PRESET 10,1  Set preset time for 1 second.
%0000000069
>

START                Start data collection.
%0000000069
>

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
%0000000069
>

```

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$: STOP
200 REM READ VALUE BACK AND CHECK IT
210 PRINT #1, "SHOW_COUNT_PRESET"
220 INPUT #1, ANSS$
230 INPUT #1, RESP$: REM TWO RESPONSE RECORDS FOR A SHOW COMMAND
240 A$ = MID$(ANSS$,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$: STOP
350 REM READ VALUE BACK FROM 994 AND CHECK FOR PROPER LOADING
360 PRINT #1, "SHOW_COUNT_PRESET"
370 INPUT #1, ANSS$: REM READ VALUE
380 INPUT #1, RESP$: REM READ RESPONSE RECORD
390 P$ = MID$(ANSS$,6,3)
400 IF P <> VAL(P$) THEN PRINT ANSS$: 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$ <> 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$ <> 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, ANSS$: REM READ VALUE BACK
560 INPUT #1, RESP$: REM READ RESPONSE RECORD
570 D$ = MID$(ANSS$,3,3)
580 IF VAL(D$) <> 1 THEN PRINT ANSS$: 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 the 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 switch 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.

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 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 setup 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

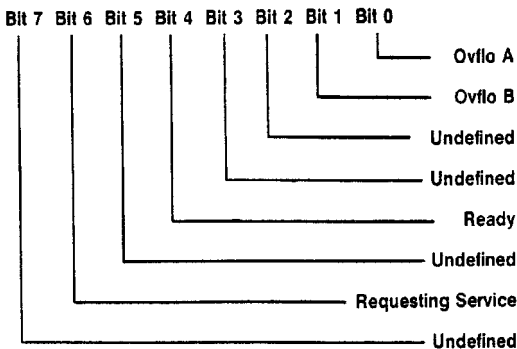


Fig. 6. Serial Poll Status Byte.

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$
$FO994-001
ENTER 704; A$
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 25×10^6 . Press the Display Select push button 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 the counter for display. The display should now read 0.

```
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 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 OUPUT 704;"INIT"
32 REM WAIT FOR INIT COMMAND TO COMPLETE
33 FOR I = 1 TO 200 @ NEXT ! 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,";! 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

```

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 FI FOR HELP

GPISO: 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      %0010000
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 36 2D 30      $FO994-0
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      %0000000
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      %0000000
36 39 0A                      69.

```

DEV4:

The above command should have loaded a preset value of 25×10^6 . 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.

```

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      %0000000
36 39 0A                      69.

```

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      000XXXXX
3B 30 30 30 30 30 30 30      ;0000000
30 3B 0A                      0;
```

```
DEV4: ibrd 12
[2100] ( END CMPL)
COUNT: 11
25 30 30 30 30 30 30 30      %0000000
36 39 0A                      69.
```

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$(&H0A): REM LINEFEED CHARACTER
105 COUNTER$ = "DEV4": REM REFER TO DEV 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
```

APPENDIX A. ASCII COMMANDS TO THE MODULE

This appendix describes the ASCII command format used by the 994 module.

NOTE: When controlling the module from a terminal, lower case letters typed at the terminal are converted to upper case by the module before echoing the characters to the terminal and evaluating the command.

A.1. COMMAND WORDS

A command consists of words separated by underscores. The first word of the command is a verb. The second and third words are not always used and are called nouns and modifiers, respectively. The following is a typical command:

```
SHOW_COUNT_PRESET
```

In the preceding command, SHOW is the verb, and COUNT is the noun, and PRESET is the modifier. Only enough letters of a word to make it unique (four letters are always sufficient) need be used in a command. The preceding command could thus be abbreviated to SH_COU_PRE.

A.2. DATA VALUES

Some commands need to include data values. Such values must be separated from the keywords by one or more spaces. The data is also sent as ASCII characters, and if more than one parameter is included in the value, the parameter values must be separated by commas. The following is a command with data values:

```
SET_COUNT_PRESET 75,3
```

In the preceding command, the module is told to set the preset value to 75×10^3 . This represents a preset value of 75,000.

In the command descriptions given in this appendix, the following notation is important:

< ... > encloses a required value
[...] encloses an optional value

A.3. CHECKSUMS

A checksum may optionally be included at the end of a command record. It is used by the module upon reception of the command to verify that the record was transmitted without error. The actual checksum is a byte obtained by adding all of the bytes of the record together, as if they were 8-bit, unsigned, binary integers. Unless otherwise stated, the checksum is to be transmitted as three ASCII characters representing the decimal equivalent of the binary integer (decimal values range from 000 to 255 for 8-bit integers) rather than a single binary byte. The three checksum characters, if present, must be the last characters of the command record before the delimiter and must be separated from any data values by a comma. If a data value is optional or not used, a comma must precede the checksum for clarity.

A.4. RESPONSE FROM THE MODULE

After a command has been transmitted from the computer or terminal to the module, no other command should be issued until a response record has been received from the module. The response record indicates how the module responded to the previous command and that the module is ready to receive another command. Appendix B explains how the computer or terminal operator should interpret the response records.

A.5. TIME UNITS USED IN COMMANDS

"Delay" is the time the module will wait before processing or responding to a command from the operator or computer. Delay values must be given in special time units of 0.25 ms. The computer operator must remember to enter the values for Delay properly.

A.6. CATALOG OF COMMANDS FOR THE 994

The commands on the following pages are arranged in alphabetical order. Be sure to read the introductory material in this appendix before proceeding to the command descriptions.

CATALOG OF COMMANDS

Command	Minimum Letters	Description
CLEAR_ALL	CL_ALL	Clears counters, count preset, event counter, and event preset.
CLEAR_COUNTERS	CL_COU	Clears all counters in the 994 module.
CLEAR_COUNT_PRESET	CL_COU_PR	Clears the M, N, and P values in the 994.
CLEAR_EVENT_PRESET	CL_EV_PR	Resets the event preset register to zero.
COMPUTER	COMP	Sets the 994 to the computer mode, where it does not echo any characters. This is the complement to the TERMINAL command.
DISABLE_ALARM	DIS_ALA	Disables the alarm function. When the alarm is disabled, the 994 does not automatically send the contents of the counters to the host computer when the preset count value is reached. The front-panel Dwell control is enabled, and the 994 operates in the stand-alone mode.
DISABLE_EVENT	DIS_EV	Disables the event counter in the 994.
DISABLE_EVENT_PRESET	DIS_EV_PR	Disables the event preset function.
DISABLE_TRIGGER_START	DIS_TRI_START	(IEEE-488 operation only.) Disables the group execute trigger command from starting the counting cycle in the 994.
DISABLE_TRIGGER_STOP	DIS_TRI_STOP	(IEEE-488 operation only.) Disables the group execute trigger command from stopping the counting cycle in the 994.
ENABLE_ALARM	EN_ALA	Causes the 994 to transfer the contents of the counters to the host at the end of a preset interval without a direct command.
ENABLE_EVENT_AUTO	EN_EV_AU	Causes the event counter to be advanced, by one count, each time the preset value is reached in the 994.
ENABLE_EVENT_PRESET	EN_EV_PR	Enables the event counter to stop after a preset number of counting cycles have occurred.
ENABLE_LOCAL	EN_LOC	Places the 994 under local control (i.e., the front-panel controls). The 994 will still respond to the communications interfaces and to commands from a host.
ENABLE_REMOTE	EN_REM	Places the 994 totally under the control of a host computer. All front-panel controls except the display select are disabled.
ENABLE_TRIGGER_START	EN_TRI_STA	Enables the 994 to start a counting cycle on a "group execute trigger" command from the IEEE-488 bus. This enables a number of counters to start simultaneously from a single trigger command.
ENABLE_TRIGGER_STOP	EN_TRI_STO	Enables the 994 to stop a counting cycle on receiving a "group execute trigger" command from the IEEE-488 bus. This is the complement to the ENABLE_TRIGGER_START command.
INIT	INIT	Causes the 994 to restart or initialize. Same as a reset or power up.
SET_COUNT_PRESET <MN,P>	SET_COU_PR	Sets the preset value in the 994 to the value of the MN,P parameter of the command. MN can be any value from 01 to 99, and N can be any value from 0 to 6.

CATALOG OF COMMANDS (cont'd)

Command	Minimum Letters	Description
SET_EVENT_PRESET <VALUE>	SET_EV_PR	Loads the value (a number between 1 and 99,999,999) to the event preset register. Counting will be stopped when the event counter reaches that value.
SET_MODE_EXTERNAL	SET_MOD_EXT	Selects the external input to the preset counter in the 994.
SET_MODE_MINUTES	SET_MOD_MIN	Selects the minutes time base as the input to the preset counter.
SET_MODE_SECONDS	SET_MOD_SEC	Selects the seconds time base as the input to the preset counter.
SET_DISPLAY_ <VALUE>	SET_DISP	Selects the counter whose contents will be displayed on the 994 front-panel, 7-segment LEDs. The value will be either 0 or 1 for Counters A and B respectively.
SHOW_ALARM	SH_ALA	Returns a \$I response record showing the status of the alarm. The answer is in the form of a "T" for true and "F" for false. Example: \$IF.
SHOW_COUNTS	SH_COU	Shows the contents of Counters A and B of the 994. 00000000;00000000; %0000000069
SHOW_COUNT_PRESET	SH_COU_PRE	Causes the 994 to transmit a \$D response record which includes the MN and P values presently selected. \$D015004146 %0000000069
SHOW_DISPLAY	SH_DISP	Causes the 994 to send a response record showing the number of the counter whose contents are being displayed in the digits on the front panel. 0 = Counter A, 1 = Counter B. \$A000245 %0000000069
SHOW_EVENT	SH_EV	Causes the 994 to send the contents of the event counter. This is an 8-digit number. \$G00000000235 %0000000069
SHOW_EVENT_PRESET	SH_EV_PRE	Causes the 994 to send the contents of the event preset register. This will be an 8-digit number. \$G00000000235 %0000000069
SHOW_MODE	SH_MOD	Causes the 994 to send a record showing which input is selected for the preset counter. 0 = seconds, 1 = minutes, 2 = external. \$A000245 %0000000069

CATALOG OF COMMANDS (cont'd)

Command	Minimum Letters	Description
SHOW_VERSION	SH_VER	Causes the 994 to send a record which shows the firmware version included in the 994. \$F0994-001 %000000069
START	STA	Causes the 994 to start a counting cycle.
STOP	STO	Stops the 994 from counting.
TERMINAL	TER	Places the 994 in the terminal mode so that every character received is echoed to and displayed on the terminal.
TEST <NUMBER>	TEST	Causes the 994 to perform certain self-test routines. Only the ROM and RAM self-tests are implemented.

APPENDIX B. RESPONSE RECORDS FROM THE 994 MODULE

The 994 Timer and Counter sends various types of information to the controlling terminal or computer. This appendix describes the types of responses the module makes to the various commands. The operator must be familiar with the concept of a record; that is, a continuous stream of characters with a special character such as the ASCII carriage return or line feed marking its end.

B.1. DELIMITING CHARACTERS

The end of a record transmitted between two devices must be marked by a special delimiting character. The record delimiter for communications with the 994 module is either a carriage return or a line feed character, or both, as follows:

INPUT from either RS-232-C or IEEE-488:

Either a carriage return or a line feed character will be accepted.

OUTPUT to IEEE-488:

A line feed character is always used.

OUTPUT to RS-232-C:

Either a carriage return or the two-character combination of a carriage return and a line feed may be appended to a record transmitted over the RS-232-C interface.

B.2. PERCENT RESPONSE RECORDS

This type of record is called a "percent" record because it always begins with the ASCII percent (%) character. A percent record is always transmitted after the execution of a command by the module; it tells whether the command execution was successful and, if not, what type of error may have occurred. Execution of a subsequent command cannot begin until the module has transmitted the percent response record, terminating the current command. Percent response records are fixed in length and have the following format (the spaces are for readability and are not part of the record):

% xxx yyy ccc <DL>

where % is the ASCII percent character, the next three bytes (xxx) are a code for the general type of error, the second three bytes (yyy) are the specific type of error, and the final three bytes (ccc) are the checksum bytes (Appendix A). <DL> is an appropriate delimiting character (Appendix B).

Records beginning with 001, 002, and 004 can be OR-ed together to obtain composite error indications. That is, the indication of power-up and self-test results must all be considered in order to determine what actually happened in the event of an error. For example (see code below), % 005 002 could be derived by OR-ing % 001 with % 004 (power-up just occurred and a self-test failed), with the 002 indicating that the ROM-1 test failed.

The following are percent response code assignments:

Command executed successfully:

% 000 000 CCC

Power-up just occurred:

%001 000 CCC

Power-up self-test failed:

% 004 002 CCC ROM test failed

% 004 008 CCC RAM test failed

Command syntax error:

% 129 001 CCC	invalid verb
% 129 002 CCC	invalid noun
% 129 004 CCC	invalid modifier
% 129 008 CCC	invalid command data
% 129 128 CCC	invalid first data value
% 129 129 CCC	invalid second data value
% 129 130 CCC	invalid third data value
% 129 131 CCC	invalid fourth data value
% 129 132 CCC	invalid command

Communications error:

% 130 001 CCC	UART buffer overrun
% 130 002 CCC	UART parity error
% 130 004 CCC	UART framing error

% 130 008 CCC	IEEE-488 communications error	% 131 130 CCC	invalid third command parameter
% 130 128 CCC	input checksum error	% 131 131 CCC	invalid fourth command parameter
% 130 129 CCC	input record too long	% 131 132 CCC	invalid number of parameters
% 130 130 CCC	invalid input data record	% 131 133 CCC	invalid data (other than command data)
% 130 133 CCC	aborted due to invalid handshake	% 131 134 CCC	could not load selected value
Execution error:		% 131 135 CCC	counters must be stopped but were not
% 131 128 CCC	invalid first command parameter		
% 131 129 CCC	invalid second command parameter		

B.3. DOLLAR RESPONSE RECORDS

All other response records begin with the ASCII dollar sign character (\$) and another character to indicate the particular type of dollar record. The following dollar response records are available:

\$A xxx CCC <DL>	A \$A record is used to transmit one 8-bit unsigned binary integer. The integer is transmitted as three ASCII character digits (xxx) which are the decimal equivalent of the binary integer. The decimal value will be between 0 and 255.
	The final three characters (CCC) are three ASCII character digits representing the checksum value for the record as a three-digit decimal value. <DL> is an appropriate delimiting character. (See SHOW_DISPLAY and SHOW_MODE commands in Appendix A.)
\$B xxx yyy CCC <DL>	A \$B record is used to transmit two 8-bit binary integers. The integers are expressed as two 3-digit decimal numbers (xxx and yyy). The values will fall between 0 and 255. The command that generates the \$B response is SHOW_COUNT_PRESET.
	The final three digits (CCC) represent the checksum value for the record. <DL> is the appropriate delimiting character.
\$F xx <DL>	The \$F response record is used to transmit a variable-length string of printable ASCII characters, shown here as "xx". It may consist of one or more characters. No checksum is used, and <DL> is an appropriate delimiter. The command generating a \$F record is SHOW_VERSION.
\$G xxxxxxxx CCC <DL>	A \$G response record is used to transmit an 8-digit decimal value represented here as "xxxxxxx". The decimal value will be between 0 and 99,999,999.
	The checksum represented as "CCC" will be a 3-digit number, and <DL> will be an appropriate delimiting character. The commands generating this record are SHOW_EVENT and SHOW_EVENT_PRESET.
\$1 x <DL>	A \$1 response record is used to transmit a single character record, either an ASCII "T" for true or an ASCII "F" for false, represented in the example by "x". <DL> is an appropriate delimiting character. The command generating this record is SHOW_ALARM.

APPENDIX C. OPTIONAL PARTS LIST

C.1. CABLES AND CONNECTORS

A maximum cable length of 50 feet should be used for the RS-232-C interface. The following cables should only be used for data rates of 9600 baud or less; higher rates require shielded cables to minimize RF interference with other devices located in the area.

C.2. ORDERING INFORMATION

Information about or orders for parts should be submitted to an ORTEC sales representative or to the following address:

ORTEC
ATTN: Nuclear Electronics
801 South Illinois Avenue
Oak Ridge, TN 37831-0895
U.S.A.

<i>Module Description</i>	ORTEC Part No.
459 Power Supply ($\pm 6V$)	638630
 <i>Cable Description</i>	
25-foot, male-female RS-232-C cable	641810
10-foot, female-female RS-232-C null modem cable	641830
C-75 (3-meter length), female-female RS-232-C null modem cable	641820
Male-male gender changer	641840
3.3-foot, IEEE-488 cable	603620
13.2-foot, IEEE-488 cable	641720
772-C1 print loop cable	462360
918 20-mA cable (C19)	609820

**Bin/Module Connector Pin Assignments For
Standard Nuclear Instrument Modules
per DOE/ER-0457T.**

Pin	Function	Pin	Function
1	+3 V	23	Reserved
2	- 3 V	24	Reserved
3	Spare bus	25	Reserved
4	Reserved bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 V
7	Coaxial	*29	- 24 V
8	200 V dc	30	Spare bus
9	Spare	31	Spare
*10	+6 V	32	Spare
*11	- 6 V	*33	117 V ac (hot)
12	Reserved bus	*34	Power return ground
13	Spare	35	Reset (Scaler)
14	Spare	36	Gate
15	Reserved	37	Reset (Auxiliary)
*16	+12 V	38	Coaxial
*17	- 12 V	39	Coaxial
18	Spare bus	40	Coaxial
19	Reserved bus	*41	117 V ac (neutral)
20	Spare	*42	High-quality ground
21	Spare	G	Ground guide pin
22	Reserved		

Pins marked (*) are installed and wired in ORTEC's 4001A and 4001C Modular System Bins.