

**Model 996
Timer and Counter
Operating and Service Manual**

Advanced Measurement Technology, Inc.

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

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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:

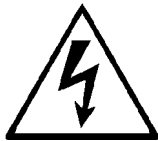
- DANGER** Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.
- WARNING** Indicates a hazard that could result in bodily harm if the safety instruction is not observed.
- CAUTION** Indicates a hazard that could result in property damage if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



This instrument may have been manufactured with round LED indicators instead of triangular shaped ones as shown.

ORTEC MODEL 996 TIMER AND COUNTER

1. DESCRIPTION

1.1. GENERAL

The ORTEC Model 996 Timer and Counter incorporates a 100-MHz, 8-decade counter and a blind preset timer. The basic model offers visual readout via an 8-decade LED display. By plugging in field-installable options, considerably enhanced readout and control capability can be added at any time.

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 8 digits of the counter's contents, along with that of other counters in the print loop. In place of the 777A, the ORTEC Model 879 Buffered Interface can be utilized with the print loop. This solution provides 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 the counter in the Model 996 along with other counters in the print loop.

The full power of CCNIM™ (Computer Controlled NIM) is obtainable 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, displaying the preset value, displaying the counter contents, 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 the contents of the counter, the preset value, and the current display mode. The IEEE-488 option also reads the overflow status for the counter. Implementation of the IEEE-488 interface in the Model 996 is compatible with

the NIM/GPIB standard.¹ The CCNIM options can directly drive printers having RS-232-C or IEEE-488 ports.

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. In the external (EXT) time base mode, the 996 becomes a displayed, preset counter. The 996 can function as a displayed, preset timer by changing the position of a circuit board jumper and using the 0.01-SEC or 0.01-MIN time base.

Both positive and negative sensing inputs to the counter are available on the front panel. The negative input 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 input can handle counting rates up to 100 MHz. The positive input can accept counting rates up to 25 MHz on a 1000- Ω input impedance. To enhance the flexibility of the positive input, a precision discriminator is included. The discriminator threshold is variable over the range of +100 mV to +9.5 V using a front-panel, 25-turn trimpot. The threshold can be adjusted to suit the amplitude of a specific source of logic pulses or used as a precision integral discriminator on analog pulses. For the latter application the TTL logic output of the discriminator is provided as a test point on the front panel. This output 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 996, thus permitting a very selective adjustment of the threshold.

¹See: "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.

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 996 is enabled to count. Selection of the 0.01-s, 0.01-min, or external time base is made by the TIME BASE push button. In the external mode the preset counter counts the events from the front-panel positive or negative inputs. The DISPLAY push button switches the display to show the contents of the counter or the preset stop value. 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 an overflow has occurred in the counter, and to advise when the front-panel controls are disabled by the computer in the remote mode.

When the Model 996 is used without a plug-in option, jumpers on the circuit board can select automatic recycling of the counting interval with a display dwell time of either 1 or 10 s at the end of

each counting interval. The plug-in options disable the dwell/automatic recycle function, when enabled by an external controller.

The counting function of the entire module can be disabled by holding the GATE input below +1.5 V using an external signal source. This condition also turns off the GATE LED. Open circuit or greater than +3 V at the GATE 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 996 counting with the other timer. The INTERVAL outputs on all ORTEC timers provide nominally +5 V when counting and less than +0.5 V when counting is inhibited. Interface connectors for the plug-in IEEE-488, RS-232-C, and print loop options are located on the rear panel. The overflow output for the counter is also located on the rear panel. Counting these overflows on another counter effectively extends the counting capacity of the Model 996.

The Model 996 derives its power from the ± 12 V, and +6 V supplies in a standard NIM bin with power supply.

2. SPECIFICATIONS

2.1. PERFORMANCE

COUNT CAPACITY 8 decades for counts ranging from 0 to 99,999,999.

MAXIMUM COUNTING RATE 100 MHz for negative input; 25 MHz for positive input.

TIMEBASE 10-MHz clock with minimum preset or displayed intervals of 0.01 s or 0.01 min. Synchronizing error is nominally 100 ns. Also accepts an external input from the counter input when the EXT (external) mode is selected.

TIME BASE ACCURACY Within $\pm 0.0025\%$ 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 OVF illuminates when the counter exceeds its capacity of 8 decades. The indicator remains on until a reset is generated.

M, N, AND P INDICATORS Three LED indicators aid in the selection of the preset value. When the PRESET display function is activated, the SEL (select) push button will select which of the three LEDs is illuminated. When one of these LEDs is on, that digit of the preset value can be incremented using the ADV (advance) push button.

DISPLAY Two LEDs labeled COUNTS and PRESET indicate the information being displayed in the counter display. The counter or the PRESET value may be displayed by repeatedly pressing the DISPLAY push button until the desired LED is illuminated.

TIME BASE Three 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 GATE input must be above +3 V or open circuit, and the preset stop condition must not have been reached.

REMOTE A single LED labeled REM indicates that the 996 is under computer control and that 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 the counter or the PRESET value for presentation in the 8-decade display. Repeatedly pushing the button alternates the selection between the two choices as indicated by the COUNTS and PRESET LEDs.

SEL (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 SEL push button operates only if the PRESET mode has been selected by the DISPLAY push button.

ADV (Advance) Push button increments the preset digit selected by the SEL push button once each time the ADV button is depressed. The M and N digit ranges are both 0 to 9. The P digit range is from 0 to 6. The ADV 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 (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 GATE input is not held below +1.5 V and the preset value has not been reached.

THRESH ADJ Front-panel mounted, 25-turn trimpot to adjust the positive input threshold for the counter. 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.

AUTOMATIC RECYCLE WITH DISPLAY DWELL Normally the Model 996 stops counting at the end of a counting interval and displays the contents of the counter until the RESET button is pushed. Alternatively, an automatic recycle counting mode can be enabled using jumper W1 on the printed circuit board. When the automatic recycle mode is selected, the display dwells for 1 or 10 seconds at the end of the counting interval. At the end of the display dwell period, the 996 is reset and the next counting/display dwell cycle begins. Using jumper W2 on the printed circuit board, either a 1 - or 10-s display dwell can be chosen. The display dwell/automatic recycle mode is disabled automatically when the 996 is under print loop control or computer control.

COUNTER/TIMER JUMPER A two-position jumper (W3) located on the printed circuit board determines the information accumulated and displayed by the counter. With W3 in the COUNTER position, the counter always counts and displays the events connected to the front-panel

input (POS IN, NEG IN). With W3 set to the TIMER position, the counter 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, the counter will count and display the events from the front-panel inputs (POS IN or NEG IN).

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 996 reaches the preset value. Upon reaching preset the 996 latches its data into a buffer, resets the counters, and starts the next counting interval. This process takes approximately 50 μ s. The computer reads the data in the buffer before the next counting interval ends. In the 1 CYCLE mode the 996 simply stops counting and waits for further commands when the preset value is reached.

2.4. INPUTS

POS IN (Positive Input) Front-panel BNC connector for the counter input accepts positive unipolar signals with a minimum width above threshold of 20 ns at a 50% duty cycle. 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.

NEG IN (Negative Input) Front-panel BNC connector for the counter input accepts -600 to -1800 mV fast logic pulses with a fixed discriminator threshold of -250 mV. $Z_{in} = 50 \Omega$; dc coupled. Minimum pulse width above threshold is 4 ns.

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

2.5. OUTPUTS

INTERVAL Front-panel output BNC connector furnishes a positive level during the counting interval. The level is nominally +5 V when counting

is enabled and $<+0.5$ V when counting is disabled. $Z_o \sim 30 \Omega$.

OVFL Rear-panel output BNC connector provides a NIM standard slow-positive logic signal each time the counter overflows its 8-decade capacity. The signal has a nominal amplitude of +5 V; width $\sim 20 \mu$ s.

2.6. INTERFACES

PRINT LOOP When the print loop option board is installed, it furnishes a rear-panel, 14-pin, AMPTM CHAMPTM, 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 8 digits of the counter 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 counter.

IEEE-488 When the IEEE-488 option board is plugged in, it furnishes a rear-panel, standard, IEEE-488 bus connector. This 24-pin, AMPTM CHAMPTM, female connector allows the Model 996 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: counts, the preset value, the display mode, 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 display mode, and selecting the desired time base. In the remote mode the computer can disable all front-panel controls. Computer readout includes: counts, the preset value, and the display mode.

2.7. ELECTRICAL AND MECHANICAL

DIMENSIONS NIM-standard single-width module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per TID-20893 (Rev).

WEIGHT

Net 0.908 kg (2.0 lb)

Shipping 1.4 kg (3.1 lb)

POWER REQUIRED The Model 996 and the plug-in options derive power from a NIM bin furnishing ± 12 V and +6 V. The power required depends on the installed option as shown in the Power Requirements Table.

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.

| | |
|-------------------|---|
| 996 | 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-CI Print Loop Cable (61 cm long) with a double-ended connector. |
| 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-CI-X-S | Print Loop Cable with double-ended connector. Specify the length "X" in feet. |

POWER REQUIREMENTS TABLE

| | +12 V | -12 V | +6 V |
|----------------------------|-------|-------|---------|
| Basic Model 996 | 25 mA | 50 mA | 475 mA |
| 996 plus IEEE-488 option | 35 mA | 55 mA | 1000 mA |
| 996 plus RS-232-C option | 45 mA | 70 mA | 1000 mA |
| 996 plus Print Loop option | 25 mA | 50 mA | 600 mA |

3. INSTALLATION

Before inserting the Model 996 into the bin, set the switches and jumpers for the desired operating conditions. There are several jumpers inside the 996 that allow the operator to select the mode of operation 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 996 accepts and counts either fast, negative-logic pulses or slow, positive-logic pulses. Determine the type of input pulses that will be furnished and select the correct input BNC to accommodate the type of pulses.

There are two important points to consider when supplying signals to the 996: (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 pot should be set at ≥ 1 V. This prevents any accidental triggering due to high ground currents present at counting rates of 100 MHz.

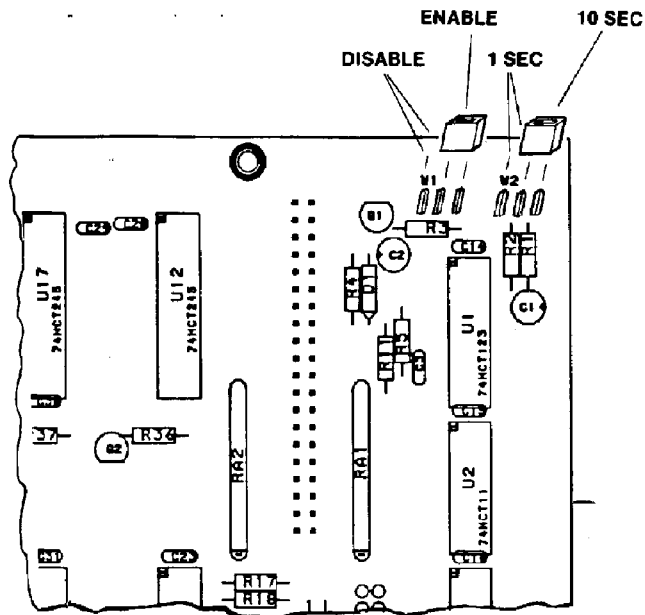


Fig. 1. Selecting the Dwell Period.

3.2. COUNTER INPUT SELECT JUMPER

Jumper W3, located on the Counter Board (mother board), allows flexibility in selecting the input to the counter with respect to the Time Base Selection (Fig. 1). The two positions are labeled TIME and COUNTS. In the Time position, the counter always counts the time base signals unless the External time base is selected, in which case the signals at the front-panel input are counted (POS IN, NEG IN). With W3 in the TIME position, the counter always displays the events driving the preset register. In the COUNTS position, the signals at the front-panel input are always counted by the counter, regardless of the time base selection. The preset register becomes a blind timer in this position unless the External time base is selected.

The 996 is shipped from the factory with W3 set to the COUNT position.

3.3. GENERAL

The Model 996 Timer and Counter operates on ± 12 V and +6 V power furnished from a NIM-standard bin and power supply such as the ORTEC 4001/4002D Series.

3.4. CONNECTION TO POWER

Always turn off the bin power supply before inserting or removing any modules. The power supply voltage 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 996, an automatic reset function clears the counters to zero and provides a standard set of start-up conditions: (1) display select set to COUNTS; (2) preset values of M, N, and P set to zero; and (3) time base select set to 0.01 SEC.

3.5. SIGNAL CONNECTIONS

COUNTER INPUT The 996 accepts and counts, either fast-negative logic pulses or positive pulses with an amplitude from 0.1 to 10 V. The negative input threshold is fixed at -250 mV. The positive input has a front-panel threshold adjustment that is variable from +100 mV to +9.5 V. A test point is included on the front panel to facilitate 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 threshold should be set just above the noise level.

GATE INPUT A gate input signal or dc level can be connected to the 996 through the GATE input on the front panel. With no input to this BNC, or with a voltage level $>+3$ V, the 996 is enabled to accept counts through the inputs on the front panel. To disable the timer and the counter, the input at this connector must be pulled below $+1.5$ V. To do this, the driving source must be capable of sinking 5 mA of current from the GATE input circuitry.

3.6. OUTPUT CONNECTIONS

INTERVAL OUTPUT A dc level that 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 OUTPUT The counter overflow output signals are available through the BNC connector located on the rear panel. A slow-positive logic signal (nominally $+5$ V, 20 μ s) appears at the connector each time the contents of the 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 996 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 a selected amount of time in which the data can be read. It then resets automatically and repeats the timing cycle. The use of the GATE input is 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 by which MN is multiplied. 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 two jumpers, W1 and W2 (Fig. 1). With W1 in the Off position, the dwell function is disabled and the data collected will be displayed until a manual reset is initiated. With W1 in the On position, the data will be displayed for either 1 second or 10 seconds, depending on the setting of W2. At the end of the dwell time, an automatic reset is generated, and the counting cycle will be repeated. The dwell function is automatically disabled when an output option board is enabled to control the 996.

To monitor the data collected during a counting period, press the Display Select until the LED indicating COUNTS is lighted.

To start a counting cycle, press the STOP push button, then press the RESET push button, and then press the COUNT push button. The counting can be halted at any time by pressing the STOP push button.

If desired the cycle can be resumed from the point of interruption by pressing the COUNT push button without pressing RESET.

3.8. PRESET COUNT OPERATION

To select the preset count mode of operation, press the Time Base Select push button until the LED representing the External mode is lighted. Now the input to the preset register is taken from the front-panel counter inputs (POS IN, NEG IN). 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.

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.

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.

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 | | | |

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.

Table 2. Null Modem Cable Connections.

| Computer | Pin No. | Pin No. | 996 |
|---------------------|-----------|---------|---------------------|
| 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 |

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. 2). 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 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 |

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 module is connected. To accomplish this, an 8-position DIP switch (Fig. 2)

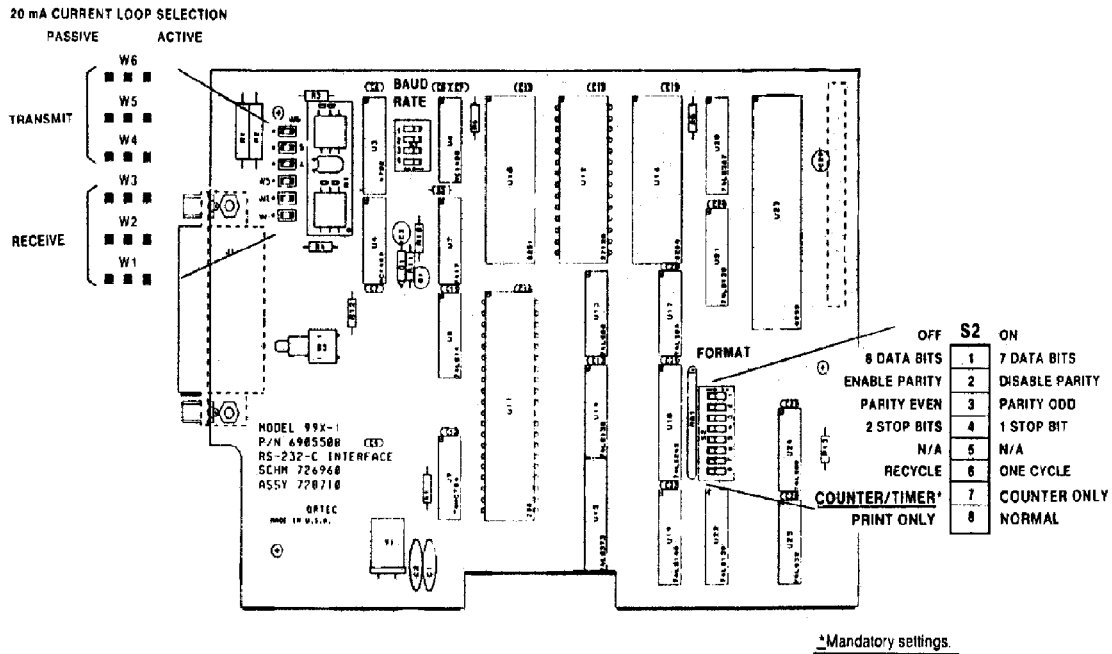


Fig. 2. Changing Jumpers on the 99X-1 RS-232-C Interface Board.

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. 2). 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 and right side plates from the module.
2. Replace the two 5/8" metal stand-offs on the printed circuit board in the module with the two 1/2" stand-offs included in the mounting kit for the 99X-1 Interface Board.
3. 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.
4. 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.

5. Install the two mounting screws into the standoffs provided on the counter board.
6. 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).

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

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.

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.

SRO (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.

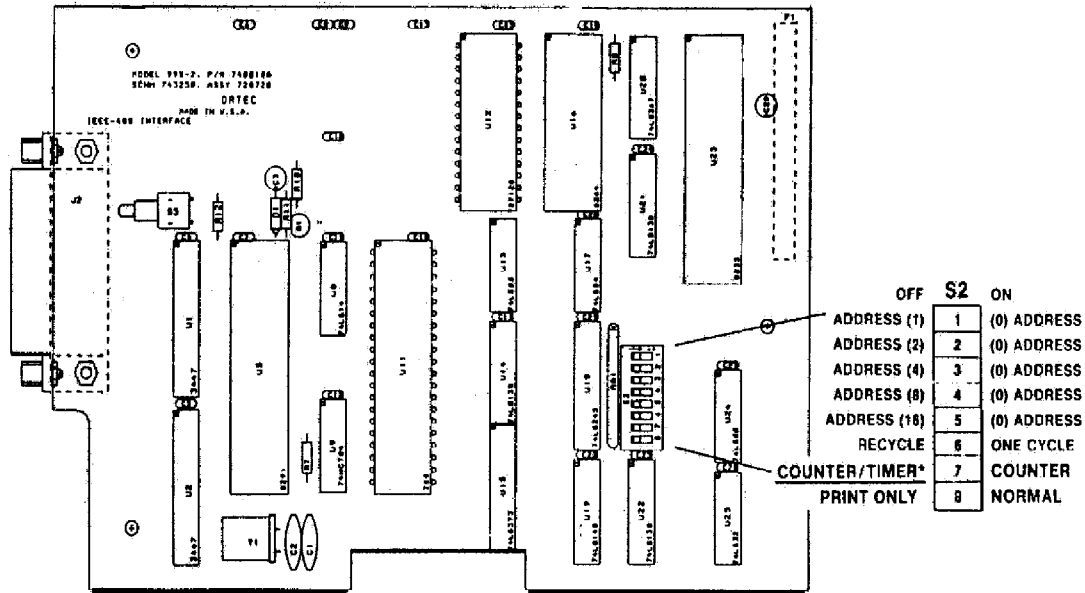
EOI (End Or Identify) The fifth bus management line used to indicate the end of a multiple-byte transfer sequence. This line is asserted with the last byte of a data record.

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. 3).

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.



*Mandatory settings.

Fig. 3. 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.
2. Remove the right side panel.
3. On the interface board, set the switches to the desired positions using Table 5. Set switch 7 to Counter/Timer.

4. 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.
5. Install the two mounting screws into the stand-offs provided on the counter board.
6. Replace side panels and installation is complete.

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.

A four-position DIP switch (Fig. 4) 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.

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.

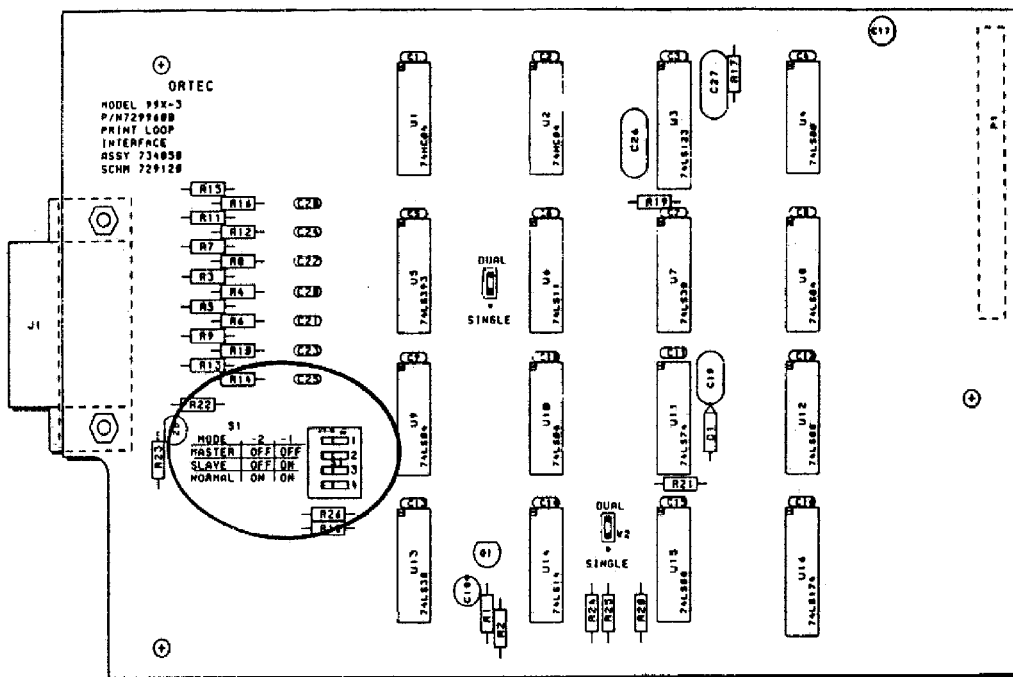


Fig. 4. Selecting Operating Modes on the 99X-3 Print Loop Interface PWB.

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 follow the steps listed below:

1. Remove the left side plate from the module.
2. Remove the right side panel.
3. On the interface board, set the switch to the desired position, Master, Slave, or Normal.
4. Set both W1 and W2 jumpers for Models 994 and 995 to the DUAL position and Models 996 and 997 to the SINGLE position.
5. 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.
6. Install the two mounting screws into the standoffs provided on the counter board.
7. Replace side panels and installation is complete.

5. PROGRAMMING THE 996

5.1. RS-232-C INTERFACE

To become familiar with the 996 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 996 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 996 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 996 to the Recycle mode. When these conditions have been satisfied, connect the terminal to the 996 and apply power to the terminal. Next, apply power to the 996. 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 996 powers up in the Computer mode, the first command to the 996 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 \$F0996-002 %000000069 > | This command shows the version of firmware installed in the 996. |
| SHOW_COUNTS 00000000 %000000069 > | This command shows the contents of the counter. |
| SET_COUNT_PRESET 35,4 %000000069 > | This command loads the M, N, and P registers with the data values included. The format is <MN.P> where MN is any number from 0 to 99 and P is any value from 0 to 6. |
| SHOW_COUNT_PRESET \$B035004CCC > | In this command, the \$B response record shows the value loaded in the preset registers. 035 is the MN value, 004 is the P value, and CCC is the checksum. |
| SET_DISPLAY 1 %000000069 > | This command selects the preset value to be displayed. The display should show 354 for M, N, and P, respectively. |
| SET_DISPLAY 0 %000000069 > | This command selects the counter for display. |

Set up the 996 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 counter will be displayed on the terminal screen:

```
00000100
00000100
00000100
```

This sequence will continue until a STOP command is sent to the 996. The actual contents of the counter will depend on the signal connected to its input.

```
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 996 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 996 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 996
60 OK$ = "%0000000069"
70 REM  INITIALIZE THE 996 TO A POWER-UP CONDITION
80 PRINT #1, "INIT"
90 REM  READ RESPONSE RECORD FROM THE 996 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 996
```

```

170 INPUT #1,RESP$
180 REM CHECK FOR CORRECT EXECUTION OF COMMAND
190 IF RESP$ <> OK$ THEN PRINT RESP$: STOP
200 REM READ VALUE BACK AND CHECK IT
210 PRINT #1, "SHOW_COUNT_PRESET"
220 INPUT #1, ANS$
230 INPUT #1, RESP$: REM TWO RESPONSE RECORDS FOR A SHOW COMMAND
240 A$ = MID$(ANS$,3,3)
250 A = VAL(A$) IF A <> MN THEN PRINT MN,A$: STOP
260 NEXT MN: REM LOOP UNTIL ALL VALUES HAVE BEEN TESTED
270 REM CHECK FOR CORRECT LOADING OF P VALUES
280 FOR P = 0 TO 6 STEP 1
290 REM LOAD P VALUES
300 PRINT #1, "SET_COUNT_PRESET 01,";P
310 REM READ RESPONSE RECORD
320 INPUT #1, RESP$
330 REM CHECK FOR CORRECT EXECUTION
340 IF RESP$ <> OK$ THEN PRINT RESP$: STOP
350 REM READ VALUE BACK FROM 996 AND CHECK FOR PROPER LOADING
360 PRINT #1, "SHOW_COUNT_PRESET"
370 INPUT #1, ANS$: REM READ VALUE
380 INPUT #1, RESP$: REM READ RESPONSE RECORD
390 P$ = MID$(ANS$ 6,3)
400 IF P <> VAL(P$) THEN PRINT ANS$: STOP
410 NEXT P
420 REM EXERCISE A FEW OF THE COMMANDS
430 PRINT #1, "CLEAR_COUNT_PRESET"
440 INPUT #1, RESP$
450 IF RESP$ <> 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, ANS$: REM READ VALUE BACK
560 INPUT #1, RESP$: REM READ RESPONSE RECORD
570 D$ = MID$(ANS$ 3,3)
580 IF VAL(D$) <> 1 THEN PRINT ANS$: STOP
590 END

```

5.2. INTERFACING TO THE IEEE-488 BUS

Of the three choices of interface, the IEEE-488 interface holds the greatest potential for misunderstandings. This section on programming the IEEE-488 will hopefully help smooth the interfacing. The two computer systems discussed in this section are the Hewlett-Packard and the IBM-PC compatibles. For other computers, there should be enough information included to allow interfacing to the Model 996. 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 996 are set correctly and that the correct address is used when accessing the 996 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 996 will not

respond. Also, when the 996 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 996.

Before attempting to connect the 996 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 996 is the fact that the 996 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 996. 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 996 and is defined in Fig. 5.

The 996 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 996 in the bin and connect the IEEE-488 bus cable to the connector on the rear panel of the 996. Turn On the power to the bin. The

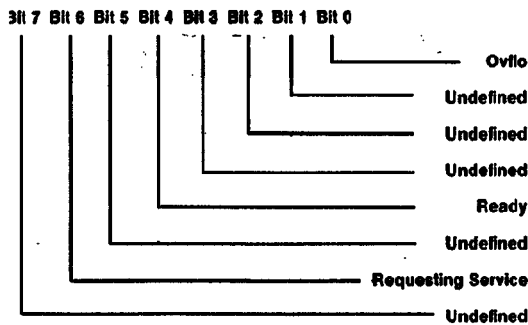


Fig. 5. Serial Poll Status Byte.

easiest way to become familiar with programming the 996 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 996 communications structure. The following examples for the Hewlett-Packard and the IBM-PC compatibles will show the command formats and responses from the 996.

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 996 has just been powered up there will be a response record waiting to be transferred to the computer. This response record must be read before the 996 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 996 on the bus. This automatically conducts a serial poll of the 996 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 996.

```
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 996, and the resulting responses from the 996 are read.

```
OUTPUT 704; "SHOW-VERSION"
ENTER 704; A$
DISP A$
$FO996-001
ENTER 704; A$
DISP A$
%0000000069
```

In the above commands, the firmware version installed in the 996 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 996 which includes parameters along with the command.

```
OUTPUT 704; "SET_COUNT_PRESET 25,6"
ENTER 704; A$
DISP A$
%0000000069
```

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$
%0000000069
```

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$
%0000000069
```

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

```
OUTPUT 704; "STOP"
ENTER 704; A$
DISP A$
%0000000069
```

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

```
OUTPUT 704; "SHOW_COUNTS"
ENTER 704; A$
DISP A$
XXXXXXXXX
ENTER 704; A$
%0000000069
```

The XXXXXXXX should match the value shown in the display of the 996. 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 996 FROM
11 REM  HP COMPUTER. IT IS ASSUMED THAT AN ADDRESS OF 4 IS
12 REM  SELECTED FOR THE 996 AND 7 IS THE NUMBER OF THE GPIB
13 REM  INTERFACE IN THE COMPUTER
14 CLEAR !REM CLEAR DISPLAY
15 DIM A$(25)
20 REM  USE A SERIAL POLL TO FIND OUT IF THE 996 IS STARTING FROM
21 REM  A POWER-UP CONDITION
22 = SPOLL(704)
23 REM  SKIP RESPONSE RECORD IF SERVICE REQUEST BIT NOT SET
24 IF A < 64 THEN GOTO 30
25 ENTER 704; A$ !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 996
31 OUTPUT 704; "INIT"
32 REM  WAIT FOR INIT COMMAND TO COMPLETE
33 FOR I = 1 TO 200 @ NEXT I ! REM WAIT LOOP
34 REM  READ RESPONSE RECORD FROM 996
35 ENTER 704; A$
36 REM
40 REM  TEST COMMUNICATIONS FOR LOAD AND READ OPERATIONS OF MN VAL
```

```

41 FOR I = 1 TO 99
42 A$ = "SET_COUNT_PRESET"& VAL$(I) & ",1"
43 OUTPUT 704;A$
43 ENTER 704; A$! REM READ RESPONSE RECORD
44 REM READ VALUE BACK TO INSURE PROPER LOADING
45 OUTPUT 704; "SHOW_COUNT_PRESET"
46 ENTER 704; A$! REM READ VALUE RECORD
47 A = VAL(A$[3,5])! REM EXTRACT MN VALUE FROM RECORD
48 IF A <> I THEN DISP "ERROR LOADING MN."@ STOP
50 REM READ SECOND RESPONSE RECORD FROM SHOW COMMAND
51 ENTER 704; A$
52 REM COMPLETE LOOP FOR REMAINING VALUES
53 NEXT I
54 DISP "MN VALUES LOAD OK"
55 REM
60 REM NOW TEST FOR PROPER LOADING OF P VALUES
61 FOR I = 1 TO 6
62 OUTPUT 704; "SET_COUNT_PRESET 10,";I! REM LOAD P VALUE
63 ENTER 704; A$! REM READ RESPONSE RECORD
64 REM READ P VALUE BACK AND CHECK FOR PROPER LOADING
65 OUTPUT 704; "SHOW_COUNT_PRESET"
66 ENTER 704; A$! REM READ VALUE FROM 996
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$ = "%0000000069": 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 996
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 996 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 996. 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 996 on the bus. These programs are described in detail in the Users Guide.

When these initial setup procedures have been completed, connect the 996 to the computer and apply power to the 996. 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 996. 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 996 are only sent when the prompt DEV4: is present. Because the 996 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 996 is asserting the service request (SRQ) line on the bus.

DEV4: lbrsp
[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 996 (40 hex is bit 6 of the serial poll status byte set to a 1).

Next, read the power-up response record from the 996. 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 996 will be 11 bytes long including the line feed terminator. 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 996 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 996 is ready to accept commands from the computer. The next example sends a SHOW-VERSION command to the 996 that will cause the 996 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 996 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          $FO996-0
30 32 0A                          0 2.
```

DEV4:

Now read the response record:

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

```
25 30 30 30 30 30 30 30      %0000000 3
36 39 0A                      6 9.
```

DEV4:

The next command will load a preset value to the 996. 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      %00000000
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 the counter 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      %00000000
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: 10
30 30 30 3X 3X 3X 3X 3X      000XXXXX
3B 0A
```

```
DEV4: ibrd 12
[2100] ( END CMPL)
COUNT: 11
25 30 30 30 30 30 30 30      %00000000
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 996. 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 DECLBAS 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 DEV3 AS COUNTER IN PROGRAM
106 GPIB0$ = "GPIB0"; REM GPIB0 REMAINS GPIB0
107 CALL IBFIND (GPIB0$,GPIB0%)
108 CALL IBFIND (COUNTER$,COUNTER%)
109 OK$ = "%000000069"; REM RESPONSE GENERATED IF EVERYTHING OK
110 REM THIS PROGRAM TESTS THE COMMUNICATION BETWEEN THE 998
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 996
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$): REM READ POWER-UP RESPONSE
134 REM
135 REM SKIP INIT COMMAND IF STARTING FROM POWER-UP
136 GOTO 150
137 REM
140 REM SEND INIT COMMAND TO 996
141 WRT$ = "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 996 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 996 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 996

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 counter, count preset event counter, and event preset. |
| CLEAR_COUNTERS | CL_COU | Clears all counters in the 996 module. |
| CLEAR_COUNT_PRESET | CL_COU_PR | Clears the M, N, and P values in the 996. |
| CLEAR_EVENT_PRESET | CL_EV_PR | Resets the event preset register to zero. |
| COMPUTER | COMP | Sets the 996 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 996 does not automatically send the contents of the counters to the host computer when the preset count value is reached. The Dwell control is enabled, and the 996 operates in the stand-alone mode. |
| DISABLE_EVENT | DIS_EV | Disables the event counter in the 996. |
| DISABLE_EVENT_PRESET | DIS_EV_PR | Disables the event preset function. |
| DISABLE_TRIGGER_START | DIS_TRI_STA | (IEEE-488 operation only.) Disables the group execute trigger command from starting the counting cycle in the 996. |
| DISABLE_TRIGGER_STOP | DIS_TRI_STO | (IEEE-488 operation only.) Disables the group execute trigger command from stopping the counting cycle in the 996. |
| ENABLE_ALARM | EN_ALA | Causes the 996 to transfer the contents of the counters to the host at the end of a preset interval without a direct command. It also disables the Dwell control. |
| 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 996. |
| 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 996 under local control (i.e., the front-panel controls). The 996 will still respond to the communications interfaces and to commands from a host. |
| ENABLE_REMOTE | EN_REM | Places the 996 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 996 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. |

CATALOG OF COMMANDS (cont'd.)

| Command | Minimum Letters | Description |
|--------------------------|-----------------|--|
| ENABLE_TRIGGER_STOP | EN_TR1STO | Enables the 996 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 996 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 996 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. |
| 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 996. |
| 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 996 front-panel, 7-segment LEDs. The value will be either 0 or 1 for Count and Preset, 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 the counter. 00000000 %0000000069 |
| SHOW_COUNT_PRESET | SH_COU_PRE | Causes the 996 to transmit a \$D response record which includes the MN and P values presently selected. \$D015004146 %0000000069 |
| SHOW_DISPLAY | SH_DISP | Causes the 996 to send a response record showing the number of the counter whose contents are being displayed in the digits on the front panel. 0 = COUNTS; 1 = PRESET. \$A000144 %0000000069 |

CATALOG OF COMMANDS (cont'd.)

| Command | Minimum Letters | Description |
|-------------------|-----------------|--|
| SHOW_EVENT | SH_EV | Causes the 996 to send the contents of the event counter. This is an 8-digit number. \$G00000000235 %000000069 |
| SHOW_EVENT_PRESET | SH_EV_PRE | Causes the 996 to send the contents of the event preset register. This will be an 8-digit number. \$G00000000235 %000000069 |
| SHOW_MODE | SH_MOD | Causes the 996 to send a record showing which input is selected for the preset counter. 0 = seconds, 1 = minutes, 2 = external. \$A000245 %000000069 |
| SHOW_VERSION | SH_VER | Causes the 996 to send a record which shows the firmware version included in the 996. \$F0996-002 %000000069 |
| START | STA | Causes the 996 to start a counting cycle. |
| STOP | STO | Stops the 996 from counting. |
| TERMINAL | TER | Places the 996 in the terminal mode so that every character received is echoed to and displayed on the terminal. |
| TEST <NUMBER> | TEST | Causes the 996 to perform certain self-test routines. Only the ROM and RAM self-tests are implemented. 1 = ROM test; 4 = RAM test. |

APPENDIX B. RESPONSE RECORDS FROM THE 996 MODULE

The 996 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 996 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 yy 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 | | | parameter |
| % 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 | | | |

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 Instruments
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-CI print loop cable | 462360 |
| 918 20-mA cable (C19) | 609820 |

**Table 1. 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.