ORTEC®

Model 974A
Quad Counter/Timer

Operating Manual

Printed in U.S.A. ORTEC® Part No. 932501 0210
Manual Revision A

Advanced Measurement Technology, Inc.

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

WARRANTY

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

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

Quality Control

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

Repair Service

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

Damage in Transit

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

TABLE OF CONTENTS

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.

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

DANGER–High Voltage!

ATTENTION–Refer to Manual

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 before opening it.

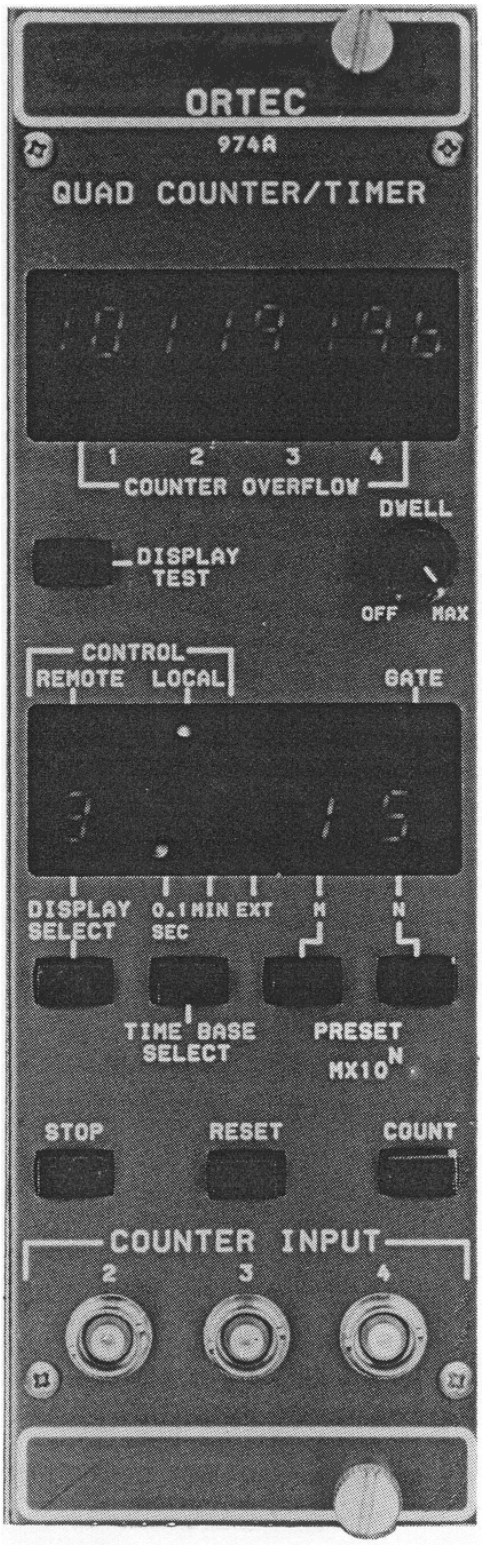
WARNING	Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

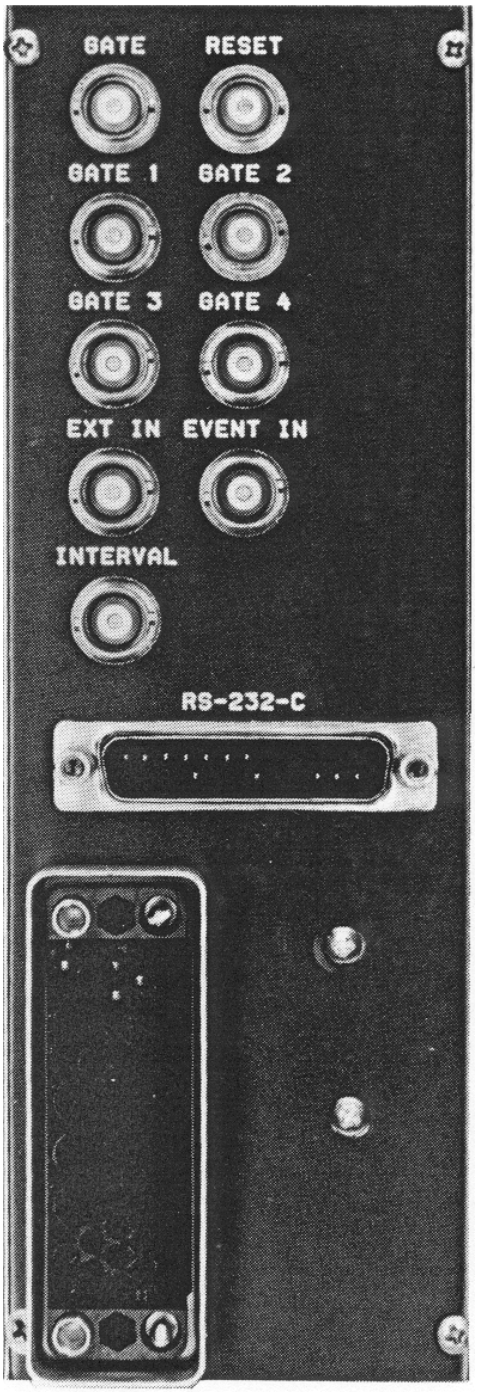
Cleaning Instructions

To clean the instrument exterior:

- 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.


ORTEC
974A
QUAD COUNTER/TIMER
1 2 3 4
COUNTER OVERFLOW
DWELL
DISPLAY TEST
OFF MAX
CONTROL
REMOTE LOCAL
GATE
DISPLAY SELECT
0.1 MIN EXT
SEC
M
N
TIME BASE SELECT
PRESET
MX10^N
STOP
RESET
COUNT
COUNTER INPUT
2 3 4


GATE
RESET
GATE 1
GATE 2
GATE 3
GATE 4
EXT IN
EVENT IN
INTERVAL
RS-232-C

1. INTRODUCTION

The ORTEC Model 974A is a four-channel, 100-MHz counter/timer that can be computer controlled or manually operated. The 974A can be used as a three-channel counter with one presettable timer, a four-channel counter (one counter channel presettable), or as a three-channel counter (one counter channel presettable) with one timer. Any one of the four 100-MHz timer/counter channels can be monitored on the large 8-decade LED display. In addition to the four 100-MHz channels, the 974A incorporates an 8-decade, presettable event counter which can only be controlled or read through one of the computer interfaces.

Standard computer interfaces built-in to the 974A are RS-232-C and 20-mA current loop. The command format (Appendix B) provides an easy to use language for programming the 974A. All front panel functions (with the exception of DISPLAY TEST) can be remotely controlled via a PC. In addition, several functions not accessible via the front panel are accessible with the computer interfaces. The front panel controls can be locked-out by the ENABLE-REMOTE command from a PC.

The input polarity to each of the four counting channels can be independently set using internal connectors. The maximum counting rate for negative input signals is 100 MHz; for positive input signals, 25 MHz. Each of the counting channels can be individually, externally gated through gate 1, 2, 3, and 4 inputs. All four counting channels can be simultaneously, externally gated through the master Gate input.

The architecture of the Model 974A Quad Counter/Timer is designed for maximum flexibility. Counter channel 1 acts as the gate controller for counter channels 1, 2, 3, and 4. When counting is started, the input gates to counting channels 1, 2, 3, and 4 are opened. When the accumulated counts in counting channel 1 equal the selected preset value (selected and displayed on the front panel), the counting interval is terminated, and the input gates to counting channels 1, 2, 3, and 4 are closed. If the DWELL control is turned fully counterclockwise to the Off position, no new counting cycle will be initiated. lf however, the DWELL control is set for a chosen dwell time, a new counting cycle will be initiated automatically after the end of the chosen dwell time and automatic reset. Since the input to counting channel 1 can be selected as the internal 0.1 -SEC time base, the internal 1-MIN time base, or an external source (EXT), counting channel 1 can act as a presettable timer or a presettable counter.

The event counter, which is accessible only through one of the computer interfaces, is primarily intended as a means of labeling printouts or listings of counting cycles. After the 974A receives an ENABLE_EVENT_AUTO command, the event counter increments one count at the end of each preset counting interval. The contents of the event counter, along with the contents of each of the four 100-MHz counting channels, are output during the implementation of a SHOW_ COUNTS command. This results in an integer labeling of the counting cycle printout. The event counter can be used alternately as a counter of external pulses by the ENABLE_EVENT_ EXTERNAL command. The maximum count rate input to the event counter must be <4 kHz; its

capacity is 8 decades. The ENABLE_EVENT_PRESET command allows the event counter to control the total number of counting cycles in a given counting run. After an event preset value is set (via a computer interface), the event counter will allow continuous counter interval recycling until the accumulated value equals the preset value. The complete list of commands is included in Appendix B.

1.1. Using this Manual

This manual is organized as follows to help you set up and operate the 974A:

Chapter 2 — All functions of the front and rear panels.

Chapter 3 — Hardware characteristics of the three interfaces, instructions for connecting the interfaces to the host PC, and hardware switch settings to control the interface parameters.

Chapter 4 — Using the module with a PC communicating over the serial interface.

Appendixes A, B, C, and D — provide the 974A specifications, command syntax, response records and formats, and a glossary of terms.

1.2. Getting Started

To avoid the possibility of communications problems due to unfamiliarity with the communications interface, review the following checklist and refer to Fig. 1.

1. Determine which communication interface will be used:

    a. If using the RS-232-C communications interface, the PC must have a serial interface. You will also need an RS-232-C connector cable; a null modem cable/adapter (if a modem is not used); and, depending on the PC, a gender-changer for the RS-232-C cable.

    b. To use the 20-mA current loop interface, a current loop cable is needed to connect the PC to the 974A.

2. Determine the characteristics of the computer interface:

    a. If using the RS-232-C interface, determine the PC baud rate, byte configuration, and parity mode. The 974A settings must match the settings of the PC.

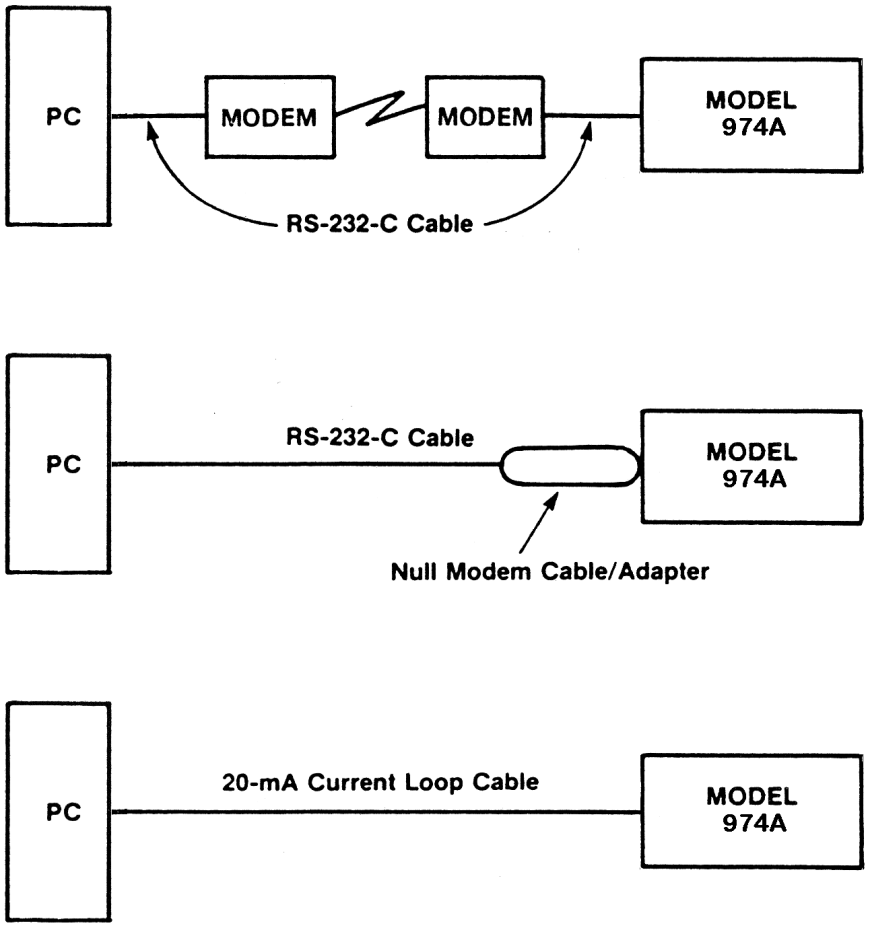


Fig. 1. Connecting the Model 974A to a PC.

b. If using the 20-mA current loop, determine whether the PC is configured for active or passive operation. If the PC is active (provides current for the loop), the 974A must be configured for passive, and vice versa. Jumpers are provided to select the active or passive mode (see Section 3.4).

3. Become familiar with the communication protocol:

a. Appendix B gives detailed descriptions of the commands recognized by the 974A. First-time users should read this section to better understand the command format.

b. Appendix C gives a detailed description of the responses the Model 974A will send to the PC. This information is critical in determining the results of a particular command sent to the 974A.

2. COUNTER FUNCTIONS AND CONNECTIONS

This chapter discusses the Model 974A's controllable front- and rear-panel functions in detail, and the input and output connections are described and defined.

2.1. Counter Display

The counter display is an 8-decade display that shows the contents of the counter selected by the DISPLAY SELECT control. It is made up of high-efficiency, 7-segment LED displays. The counter display has leading zero suppression until a COUNTER OVERFLOW occurs. At this time the leading zero suppression is disabled. When the counting channel and the internal 0.1-second time base are selected, a decimal point is inserted between the first and second decade to make it easier to read the actual value being displayed.

2.2. Counter Overflow Indicators

The Counter Overflow indicators are four single LEDs which blink at a rate of onetime per second when the corresponding counting channel has exceeded the capacity of its 8-decade counter. The OVERFLOW indicators continue to blink until the counting channel is reset.

2.3. Display Test

The DISPLAY TEST push button allows you to test all segments of the front-panel LED displays. When this push button is pressed, all segments of each 7-segment LED display on the front panel are illuminated. If any segment is not functioning properly, it will be apparent immediately.

2.4. Dwell Control

The DWELL control is used when the Model 974A is in the stand-alone mode. It allows you to select a variable time for the contents of the selected counting channel to be displayed before being automatically reset and a new counting cycle initiated. This control can be disabled by turning the front-panel control to the extreme counter- clockwise position (Off). The interval of the dwell period can be varied from ~0.5 seconds at the counterclockwise position to ~12 seconds at the maximum clockwise position.

2.5. Control Remote/Local

The REMOTE/LOCAL controls are two LED indicators that show whether the Model 974A is under LOCAL control (front-panel control) or REMOTE control (PC control). The Model 974A powers up in LOCAL mode and can only be placed in REMOTE mode from a PC. In REMOTE

mode, all front-panel functions, with the exception of DISPLAY TEST and DISPLAY SELECT are disabled.

2.6. Gate Indicator

The gate LED is an indicator that shows when the 974A is in a counting condition. This LED is illuminated when all conditions are correct to allow counting. The indicator lights when the COUNT push button is pressed and the master gate is not connected or when the dc level at the master gate input exceeds +1.5 V. The indicator will not light when the Stop push button is pressed, when the master gate input level is brought to a dc level of <0.5 V, when the RESET push button is pressed, or when the contents of counting channel 1 reaches a value equal to the selected preset value.

2.7. Display Select

The DISPLAY SELECT push button allows you to select the counting channel whose contents are to appear in the counter display. The number of the counting channel selected appears in the 7-segment LED display directly above the push button. When the DISPLAY SELECT push button is pressed, the display sequentially advances from 1 to 4, and then repeats the cycle starting at 1.

2.8. Time Base Select

The TIME BASE SELECT push button allows you to select the source of the input to counting channel 1, the presettable counter. At power up, the internal 0.1-SEC time base is selected. By pressing the push button, the internal 1-MIN time base or the EXT (external) input can be selected. An LED indicator shows which of the options is selected. When EXT input is selected, an input must be provided at the EXT IN (external input) BNC on the rear panel.

2.9. Preset M × 10^N

The PRESET control consists of one push button labeled **M** and one labeled **N** and 2 LED digits to display the selected value for each. The M value represents the multiplier or significant digit of the preset value. The N value is the exponent or power of 10 to which the multiplier is raised. To select a preset value, press the push buttons repeatedly until the proper preset value is displayed. The M value can be selected for any value from 1 to 9. An M value of 0 disables the preset function. The N value can be selected from 0 to 7. For example, to select a preset value of 600, press the M push button until the value of 6 appears in the M display. Next press the N push button until a value of 2 appears in the N display ($600 = 6 \times 10^2$). If the 0.1-SEC time base is selected this represents 60.0 seconds; if the 1-MIN time base is selected it represents 600 minutes.

2.10. Stop Control

The STOP push button allows a counting cycle to be stopped manually at any time the Model 974A is enabled to count. This control is disabled if the REMOTE LED is lit, indicating that a PC has control of the 974A.

2.11. Reset Control

The RESET push button allows you to set the contents of all 4 counting channels to a value of zero. This control is disabled in REMOTE mode.

2.12. Count Control

The COUNT push button allows the 4 counting channels to be placed manually in a counting condition if the master gate and gates 1, 2, 3, and 4 are at the correct level for counting. This control is disabled when the 974A is in REMOTE mode.

2.13. Signal Connections to the Model 974A

COUNTER INPUTS The 974A accepts either positive or negative logic pulses as inputs to the counting channels. The polarity of the input pulses must match the polarity setting of the 974A (Fig. 2).

The input circuit to the 974A is dc-coupled to eliminate baseline shifts associated with varying count rates. External capacitive coupling must be provided by you for signals superimposed on a dc level which might exceed +1.5 V. This is because the counter is designed to respond to signal transitions through the fixed threshold of +1.5 V (positive) or -250 mV (negative).

There are two important points to consider when supplying signals to the 974A: (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 and return, causing an extra count to be added.

EXTERNAL INPUT The timer portion of the 974A is a presettable counter. The source of the pulses counted is controlled by you by pressing the TIME BASE SELECT control on the front panel or remotely from a PC. When the EXT input is selected, a signal must be provided to the presettable counter through the EXT IN input on the rear panel

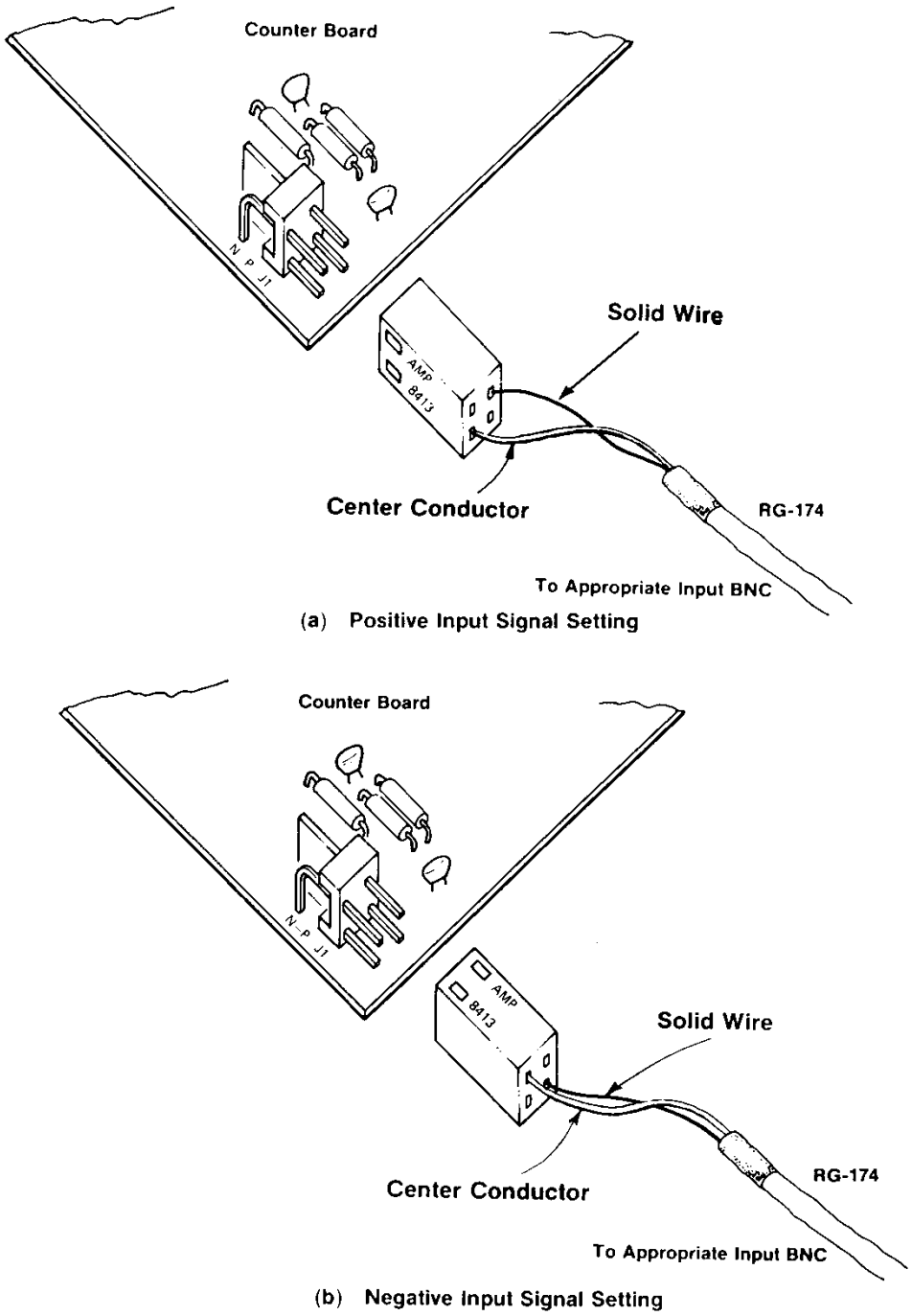


Fig. 2. Input Connector Orientation for Input Signals.

BNC. The input conditions are identical to the counter inputs and can be either positive or negative. The restrictions on the input signal are the same as for the counter inputs.

MASTER GATE INPUT A gate input signal or dc level can be connected to the 974A through the rear panel BNC master GATE connector to allow the counting channels to accept and count input signals. The gate will be enabled as long as the input level is ≥+3 V and will be disabled

when the level is <+1.5 V. The driver must be capable of sinking at least 1-mA of current from the gate input circuit. If this signal is left open or unconnected, the gate is enabled to the counting channels.

GATES 1, 2, 3, AND 4 An individual gate is provided to allow each counting channel to be selectively gated by providing a level of ≥+3 V to allow counting or to prevent counting by forcing the input level to <+1.5 V. The signal source must be capable of sinking 1 mA of current from the input connector. If no input is connected counting is enabled.

RESET INPUT A reset input signal can be connected to the 974A rear panel BNC RESET connector. To reset the counting channels to zero, a positive input signal of ≥+3 V with a minimum pulse width must be applied. Z_{in} ~ 6 kΩ. Negative signals will not activate the reset circuitry.

EVENT INPUT This rear panel BNC is connected to an event counter which can be controlled only from the computer interfaces. Its contents cannot be displayed on the 974A counter display. This counter can be controlled from, and its contents read from, a PC. To be counted, the input signal must exceed a level of +3 V and have a pulse width of >100 ns. The maximum count rate of this counter cannot exceed 4 kHz.

2.14. Output Connections

INTERVAL OUTPUT A dc level which follows the counting condition of the 974A is available at this BNC connector. When the counting gate is enabled, the dc level is at +5 V nominally. When counting is inhibited (by the master gate, by having reached preset, or by being stopped manually), the dc level is at 0 V nominally. The output through this connector can be used to gate a counting condition in another instrument.

2.15. Interface Connections

RS-232-C The 974A is equipped with a male, 25-pin "D" connector with DTE (Data Terminal Equipment) wiring as defined by the EIA RS-232-C standard. This should allow you to easily connect the 974A to a PC with standard cables. lf the PC is also equipped with a male connector, a standard null-modem cable must be used to provide the proper connections to send and receive signals. The 20-mA current loop connections are also present in this connector (Chapter 3).

2.16. Simple Setup Procedure for Standalone Operation

2.16.1. General

The Model 974A Quad Counter/Timer operates on +6-V power furnished from a NIM bin and power supply such as the ORTEC 4001/4002D Series. +6-V power can be added to a NIM bin power supply by using the ORTEC Model 495 Modular 6-V Power Supply.

If the 974A is operated in a rack with other equipment, there must be sufficient air flow to prevent localized heating of the integrated circuitry used throughout the instrument. The temperature of equipment in the racks can easily exceed the maximum limits of 120° F (50° C) unless precautions are taken.

2.16.2. Connection to Power

Turn off the bin power supply when inserting or removing any modules. Before inserting the Model 974A into the bin, set switches S-1 and S-2 for proper operating conditions according to instructions given in Section 3.3.

Power is automatically applied to the 974A when the power is switched on to the bin and power supply in which it is installed. At power-up, an automatic reset is generated in the 974A, resetting all counting channels to 0 and providing a standard set of start up conditions as follows: (1) DISPLAY SELECT is set to counter 1. (2) PRESETs M and N are set to 0. (3) The 0.1-SEC TIME BASE is selected. (4) The counting condition is set to STOP. (5) LOCAL control is enabled.

When the 974A is used outside the bin and power supply, be sure that the power extender cable used contains the power conductors to extend all the power supply voltages and the grounds needed to operate the 974A. Be careful to provide adequate grounding when operating the 974A outside a NIM bin.

The Model 974A can be used as a counter that operates during a preset interval of time and then stops when the preset time expires. The counter will hold the data acquired until it is reset manually or by an external signal, or it can dwell at the preset stop for an adjustable time period while the data are examined. The counter then resets automatically and a new counting cycle is started.

Forth is type of operation, turn the instrument on and connect the sources of the pulses to be counted to the desired counting section inputs. (NOTE: the polarity of the input pulses must agree with the polarity selected by the connector orientation at the counter board input.) The use of the gate inputs is optional, depending on the application requirements.

If preset operation is not desired, the preset function can be disabled by repeatedly pressing the M push button until a 0 appears in the display above the switch. The counting interval must then be controlled by manually pressing the COUNT and STOP push buttons on the front panel.

Determine the time during which the counters will accept data. To preset the timer count interval, press M to select the multiplier or significant digit of the time value. Next press the N push button to select the power of ten as an exponent. For example, to preset 600, set M to 6 and N to 2 ($600 = 6 \times 10^2$). Use the TIME BASE SELECT push button to select either 0.1 SEC or 1 MIN for the unit of time. When 0.1 SEC is selected, a decimal point appears in the display of counter 1 to aid in the interpretation. In the above example the preset value of 600 could be either 60.0 seconds or 600 minutes, depending on whether 0.1 SEC or 1 MIN was selected for the time base.

A DWELL control is provided on the front panel of the 974A to reset the counters automatically and start a new counting cycle. The counterclockwise position of the control is an OFF switch that disables the dwell control. As the control is rotated clockwise, the dwell time (time the counter information is displayed before being reset and a new counting cycle initiated), is increased from ~0.5 seconds to ~12 seconds at the full clockwise position.

To view the contents of the four counting channels, press the DISPLAY SELECT push button until the number of the desired counter appears. The contents of the selected counter are displayed in the 8-digit display at the top of the front panel.

To start a counting cycle, press the COUNT push button. To stop a counting interval, press the STOP push button. The counting interval can be resumed from the point of interruption by pressing the COUNT push button without pressing the RESET push button. Note that all these functions and more can be implemented by commands through either of the communications interfaces.

3. COMMUNICATIONS INTERFACES AND CONFIGURATION SWITCHES

3.1. Serial Interfaces RS-232-C and 20-mA Current Loop

The serial communications connector on the rear panel of the 974A is a 25-pin, male “D” connector with DTE wiring (see glossary). The wiring is as shown:

	14	1	protective ground
	15	2	transmit data
	16	3	receive data
POSITIVE TRANSMIT	17	4	request to send
	18	5	clear to send
	19	6	data set ready
data terminal ready	20	7	signal ground
	21	8	
	22	9	
POSITIVE RECEIVE	23	10	
NEGATIVE TRANSMIT	24	11	
NEGATIVE RECEIVE	25	12	
		13	

The leads shown in uppercase are used for the 20-mA current loop connections to PCs with a 20-mA current loop interface. The leads shown in lower case are used for connection to a standard RS-232-C modem.

If modems are not to be used in connecting the 974A to a PC, a null-modem cable will be necessary to enable the 974A to communicate with a PC. The null-modem cable makes up for the fact that both the Model 974A and the PC are wired as DTE devices. The null-modem cable is wired to make the following connections between the 974A and the PC:

COMPUTER				**MODEL 974A**
PROTECTIVE GROUND	1	↔	1	PROTECTIVE 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

If only a short null-modem cable is available, it may be necessary to use a standard RS-232-C male-female connector cable as an extender. If the PC has a female connector rather than a male, a male-female gender changer will also be needed. These parts are available from ORTEC or from other PC parts suppliers.

Asynchronous, full duplex character transmission across the serial interface is factory set with the following settings:

- 8 data bits per character rather than 7 bits
- Parity checking and generation disabled
- Parity selection set as even
- Baud rate set for 9600
- 1 stop bit generated

The factory settings can be changed with the hardware switches (Section 3.3).

Command records sent to the 974A by the PC must be delimited by a particular ASCII control character. The choice of a delimiting character is fully explained in the introduction to Appendix C. The delimiter is either a carriage return, a line feed, or both.

Two separate buffers are maintained in the module for communication with the PC. One is a circular, type-ahead buffer containing room for 64 characters. The second is a 64-byte area which is the buffer for an entire command record before it is executed.

An integrated circuit which services the module's serial interface (UART) interrupts the microprocessor when a character arrives and must be deposited into the type-ahead buffer. When time permits, the microprocessor moves the contents of the type-ahead buffer over to the record buffer.

If 56 characters accumulate in the type-ahead buffer before the processor has time to transfer them to the record buffer, an X-OFF (Control S) character is sent to the sender to prevent further characters from being transmitted. An X-ON (Control Q) character is then sent out only after the microprocessor has had time to reduce the contents of the type-ahead buffer to 16 characters.

20-mA CURRENT LOOP The 20-mA current operates in exactly the same way as the RS-232-C interface. In fact, the microprocessor does not know which interface is being used. The main difference in the two modes is the electrical characteristics of the signals. RS-232-C uses a change in voltage to transmit data, and the current loop uses a change in current to send and receive data. The current loop is optically coupled to the 974A and can be made to be either active (current for the loop supplied by the 974A) or passive (current for the loop supplied by the connected device) by changing a set of jumpers on the microprocessor board. The transmit

and receive loops can be individually selected to be active or passive. The Model 974A is factory-set at shipment with both the transmit and receive set in active mode. 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 interface to connect the 974A to a PC. This cable is available from ORTEC.

3.2. Hardware Switch Settings

The Model 974A has three multi-section programming dip switches that are accessible through cutouts on the left side as viewed from the front of the module. S-2 is mainly associated with the serial interface and is used to format the character which is transmitted over the serial communications link, either RS-232-C or 20-mA current loop. It is also used to select which of the four counting channel's contents will be transmitted and which will be omitted. S-3 is a four-position switch used to select the baud rate at which the characters are transmitted and received over the serial interface.

The factory settings of S-1, S-2, and S-3 are as follows:

1. Serial interface selected
2. Eight data bits selected
4. Parity disabled
5. Switch set to even parity
6. One stop bit selected
7. Baud rate set for 9600

3.2.1. S-1

	OFF (Open)	**ON (Closed)**
1	Not Used	Not Used
2	Not Used	Not Used
3	Not Used	Not Used
4	Not Used	Not Used
5	Not Used	Not Used
6	Recycle	One-Cycle
7	Not Used	Not Used
8	Not Used	Not Used

Only position 6 is used. It selects the action that occurs at the end of a counting cycle. When this switch is set to one-cycle or On, the data collected during the counting cycle are held in the counters after being transferred to the buffer. The data are then transmitted to the PC, and the counting cycle is not repeated. When set to recycle or Off, the counters are reset as soon as the

data is latched in the buffers, and a new counting cycle is started immediately. The dead time between counting cycles is ~50 µs.

3.2.2. S-2

OFF (Open)	ON (Closed)
1 Print 1	Skip 1
2 Print 2	Skip 2
3 Print 3	Skip 3
4 Print 4	Skip 4
5 Data Bits (8)	Data Bits (7)
6 Parity Enable	Parity Disable
7 Parity Even	Parity Odd
8 Stop Bits (2)	Stop Bits (1)

Positions 1 through 4 allow you to select which counting channels will transfer information to the PC. This prevents redundant information from being transmitted when transfer speed is important. In cases where the timer information is always the same, it may not be necessary to transfer this information at the end of every counting cycle.

Positions 5 through 8 are used to format the data byte that is transmitted to the PC. They select the data length, parity, and the number of stop bits for each character transmitted over the serial interface. They also select the conditions which are checked on each character received to indicate an error in transmission. The conditions set with these switches must match the conditions selected on the PC connected to the 974A.

Position 5 selects the number of data bits: On selects 7 data bits and Off selects 8 data bits.

Position 6 disables or enables parity generation or checking. On disables parity and Off enables parity.

Position 7 selects the parity which is generated and checked on the characters moved through the serial interface. When set to On odd parity is selected; Off selects even parity. This function is disabled when the switch position is set to parity disable (On).

Position 8 selects the number of stop bits attached to the character transmitted via the serial interface. When set to On 1 stop bit is generated, and when set to Off 2 stop bits are generated.

3.2.3. S-3

Switch 3 selects the baud rate at which information is transmitted and received over the serial interface. A table of the switch settings and the baud rates follows:

BAUD RATE	S3-1	S3-2	S3-3	S3-4
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
19200	On	On	On	On
19200	On	On	On	Off

3.3. Input Polarity Selection for Counters

The input polarity to each counting channel is selected as positive or negative by changing the direction in which the cable from the counter input BNCs are connected to the counter boards. Each of the counting channels are physically located on a separate printed wiring board (PWB) which plugs into a larger mother board. Counter number 1 is located nearest the center of the module and counter number 4 is nearest the bottom module bar. The signal input to the counters enter through a coax cable terminated into a four-position connector. To select positive input signals, connect the coax to the connector on the card so that the center conductor of the coax is toward the top of the card and in contact with the pin on the card connector that is nearest the surface of the PWB (Fig. 3).

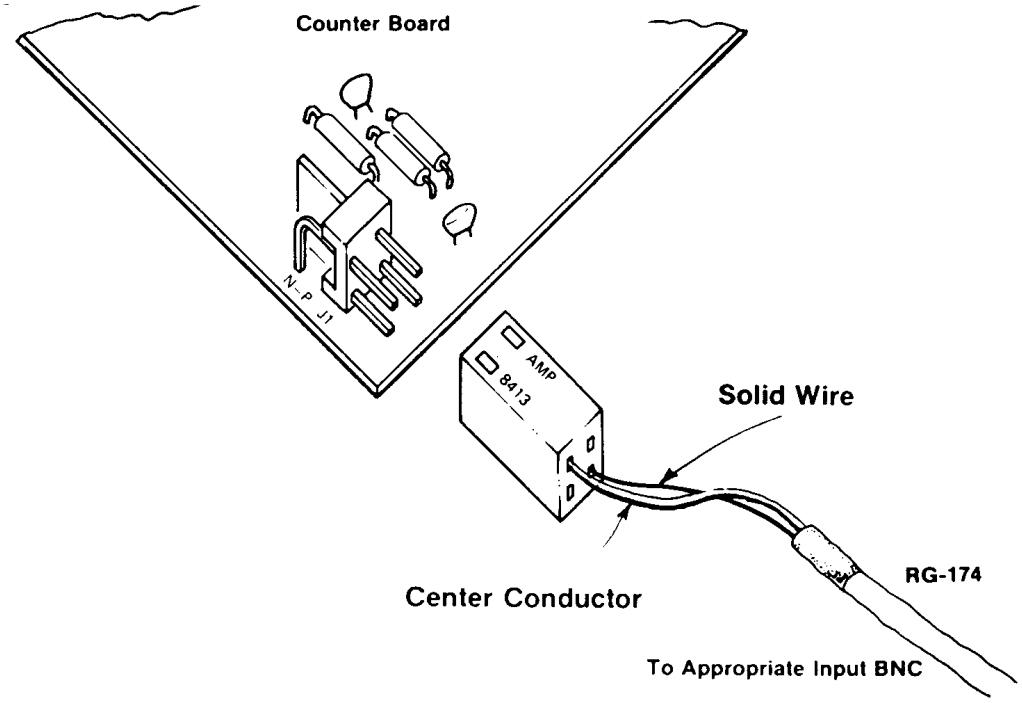


Fig. 3. Input Connector Orientation for Negative Input Signals.

To select negative input signals, connect the coax so that the center conductor of the coax is in contact with the pin of the connector on the card which is at the top of the board but farthest from the surface of the PWB (Fig. 4).

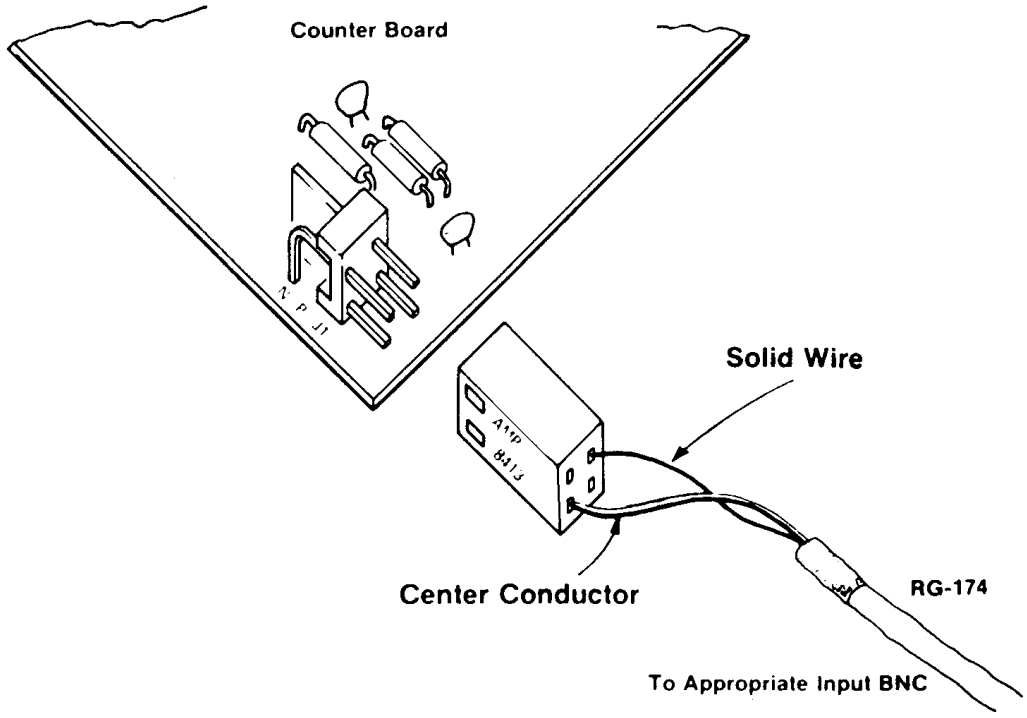


Fig. 4. Input Connector Orientation for Positive Input Signals.

3.4. 20-mA Current Loop Active or Passive Selection

To select whether the Model 974A supplies the 20 mA for the current loop (Active) or does not supply the current (Passive), a set of six jumpers is provided on the PWB mounted to the left-top module bar. These jumpers are labeled W-1 through W-6 and are located at the bottom rear of the board near the 12-pin hybrid optical couplers. Three jumpers (W-1 through W-3) are associated with the receive loop, and three are associated with the transmit loop (W-4 through W-6). The transmit and receive loops can be individually selected to be Active or Passive, but all three jumpers associated with the loop must be moved to the proper position. Placing the jumpers toward the center of the board selects Active mode; placing the jumpers toward the rear of the board selects Passive mode (Fig. 5).

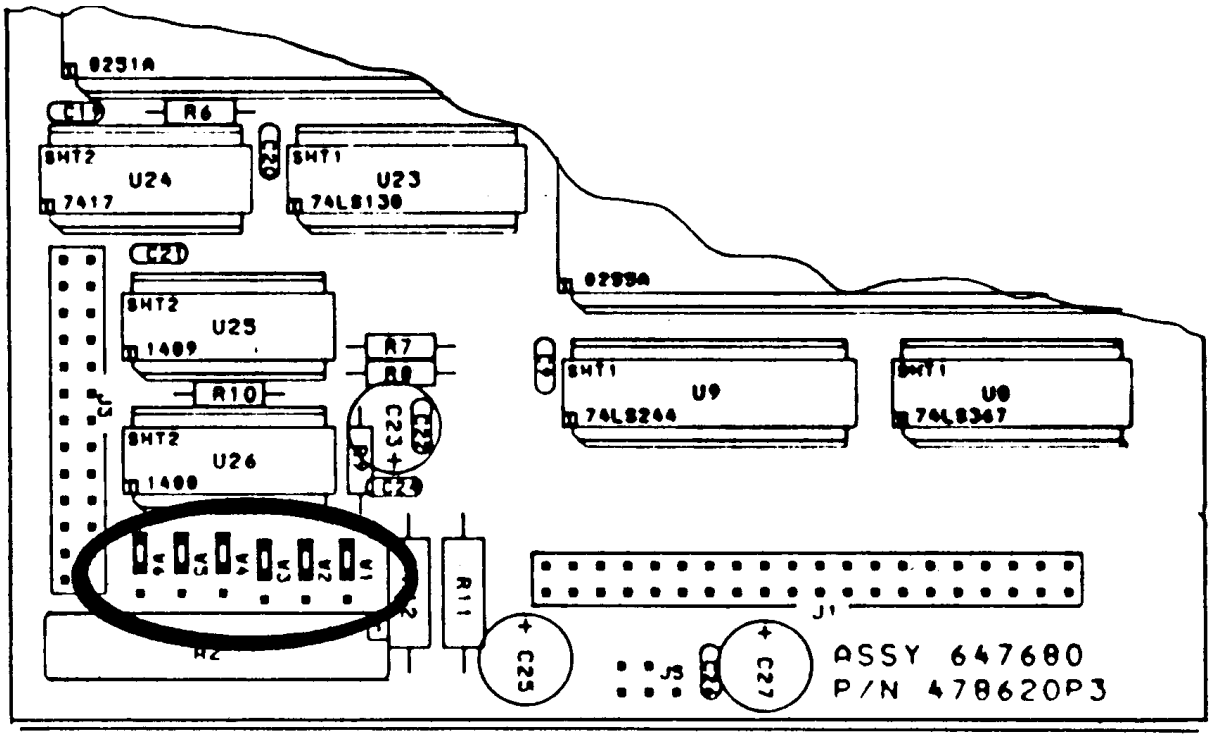


Fig. 5. Jumpers on the Controller Board Shown in the Active Position.

3.5. Using a Counting Channel to Show Time

On each of the three nonpresettable counting channels is a jumper which allows the counter to count the 0.1-second time base, rather than the input signal, when the external time base is selected. This jumper is normally tied to +5 V, but may be changed to allow any of the counters to show time. When either of the internal time bases is selected, the counter functions in the normal manner and responds to the input signals applied to its input. This jumper is located near the 3 hybrid circuits toward the front of the counter boards. When the jumper is placed toward the top of the board, counting time is inhibited; placing the jumper toward the bottom of the

board allows time to be counted when the external mode is selected. (See Fig. 6 for positioning this jumper.)

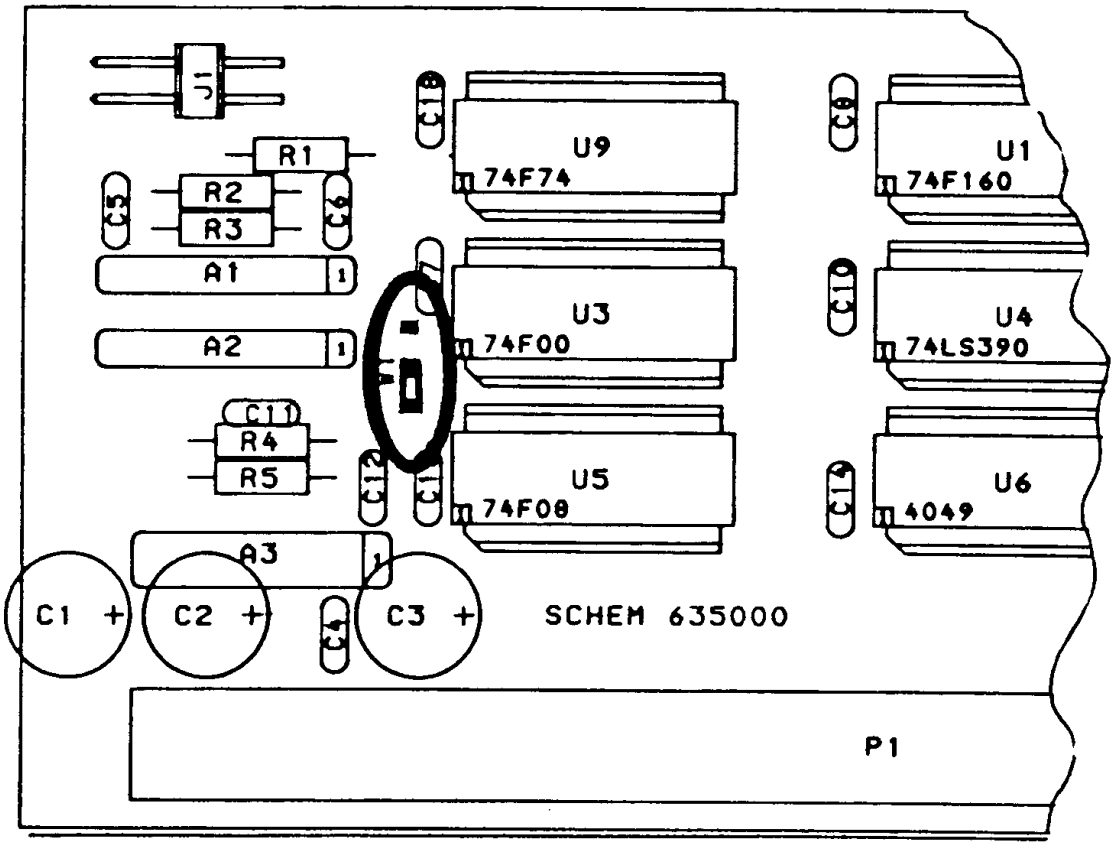


Fig. 6. Jumper on the Counting Board Positioned for Counting Time.

4. COMMUNICATING WITH A PC VIA RS-232-C

This section describes the initial testing of a new 974A. We recommend you familiarize yourself with its command language (Appendixes B and C) before proceeding.

4.1. RS-232-C Connection to a PC via Modems

The 974A is equipped with a male, DTE-wired RS-232-C connector (Glossary, DCE and DTE wiring). If the amplifier module is to be remote-controlled from a PC via modems over a transmission line, a standard male-female RS-232-C connector cable should connect the module to the modem (standard modems should have a female, DCE-wired connector).

4.2. RS-232-C Direct Connection to a PC

The 974A module has a male, DTE-wired connector and is ready for direct connection to a modem (female connector with DCE wiring). Most PCs also have male connectors with DTE wiring. All that is needed to connect the module with such PCs is a null modem adapter cable (standard null modem cables have female connectors at both ends). Null modem adapter cables are described along with the RS-232-C interface at the beginning of Chapter 3.

4.3. The PC's Baud Rate

You must know the rate at which the PC communicates. The 974A module is factory set for a default baud rate of 9600. If the PC does not operate at 9600 baud and cannot be changed to 9600 baud, you can change the 974A's baud rate with the dip switches discussed in Section 3.3. Once the baud rates have been determined to be equal, setup can continue.

4.4. Byte Format

The PC and the 974A must format each byte of data in exactly the same manner for successful use of the serial interface. The dip switches (Section 3.3) can be used to alter the byte characteristics of the module, or you may want to change the PC to match the module's defaults.

When shipped, the module is set to transmit and receive 8-bit bytes; this can be changed to 7 bits. The module is set to add a start bit and 1 stop bit to each byte; this can be changed to 2 stop bits (Section 3.3). When shipped, the module does not regard parity; this may be changed so that the module generates and checks for either even or odd parity (Section 3.3).

4.5. Initial Connection to the 974A

After the baud rate and byte format of the 974A and PC have been established to be compatible, it is time to plug the module into a NIM bin. (Be sure the bin power is Off before the module is plugged in.) Note that the bin must be able to provide +6 V power. If it cannot, a separate NIM module is available from ORTEC to supply +6 V power to the bin. Contact your ORTEC representative for more information.

Connect the 974A to the PC or modem with RS-232-C cables (Section 5.2). Turn the NIM bin and PC on. If modems are in use, establish a connection between the PC's modem and the module's modem.

A program on the PC should now be able to transmit commands to the module and receive and interpret response records sent back by the module.

4.6. A BASIC Program for Initial Testing of the Module

```
10 REM ......SIMPLE INTERFACE, IBM-PC TO ORTEC 974
15 REM ......I1$ IS THE FIRST RESPONSE FROM MODEL 974
16 REM ......I2$ IS THE SECOND RESPONSE FROM MODEL 974
17 REM ......I3$ and I4$ ARE THE THIRD AND FOURTH RESPONSE RESPECTIVELY
18 '
20 REM ......OPEN IBM PORT 1
30 OPEN "COM1:9600,N,8" AS #1
40 RS$="%000000069"
45 '
50 REM ......INITITALIZE THE MODEL 974
60 PRINT #1,"INIT"
64 '
65 REM ...READ RESPONSE FROM MODEL 974
70 INPUT #1, I1$
74 '
75 REM .....LIST INITIALIZATION RESPONSE ON TERMINAL
80 PRINT I1$
94 '
95 REM ....SEND COMMAND TO MODEL 974
100 PRINT #1,"SET_COUNT_PRESET 1,1"
104 '
105 REM ...READ RESPONSE FROM MODEL 974
110 INPUT #1,I2$
112 PRINT I2$
114 '
115 REM ....CHECK FOR PROPER RESPONSE FROM MODEL 974
120 IF I2$<>RS$ THEN PRINT I2$:STOP
125 '
130 REM ......START COUNTERS
140 PRINT #1,"START"
```

```
144 '
145 REM ...READ RESPONSE FROM MODEL 974
150 INPUT #1,I3$
152 PRINT I3$
160 IF I3$<>RS$ THEN PRINT I3$:STOP
163 '
164 '**************************
165 'INCLUDE A LOOP FOR CHECKING PRESET TIME-OUT HERE BEFORE SHOW_COUNTS
166 FOR I=1 TO 2000:NEXT I
168 '
170 REM .....READ DATA FROM COUNTERS
180 PRINT #1,"SHOW_COUNTS"
184 '
185 REM ...READ RESPONSE FROM MODEL 974
190 INPUT #1,C$,I4$
194 '
195 REM ....LIST DATA TO TERMINAL
200 PRINT C$,I4$
205 REM ......CHECK FOR PROPER RESPONSE FROM MODEL 974
210 IF I4$<>RS$ THEN PRINT I4$:STOP
214 '
215 REM .....CLOSE THE COM1 PORT AND END PROGRAM
220 CLOSE
230 END
```

APPENDIX A. SPECIFICATIONS

A.1. Performance

COUNT CAPACITY 8 decades, all sections.

COUNTING RATE 100 MHz for negative inputs, all sections; 25 MHz for positive inputs, all sections.

TIME BASE 0.1 second or 1 minute increments derived from an internal 1 MHz crystal-controlled oscillator. Also accepts external input through rear panel BNC labeled EXT IN. Selectable from front panel or through computer control.

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

A.2. Indicators

COUNTER DISPLAY 8 characters, 7 LED segments per character plus decimal point.

TIMER PRESET 2 characters, 7 LED segments per character. Presettable from front panel or through computer control. Displayed in an $M \times 10^N$ format.

DISPLAYED COUNTER Single-digit display indicates which counter channel is being displayed.

CONTROL 2 LEDs indicating either Remote mode operation (front panel controls locked out) or Local mode operation (front panel controls operative).

0.1 SEC Single LED illuminates when the 0.1 second time base is selected.

1 MIN Single LED illuminates when 1 minute time base is selected.

EXT Single LED illuminates when Ext time base is selected or when using counter channel 1 as a counter.

COUNTER OVERFLOW 1, 2, 3, AND 4 Four separate LEDs illuminate when the corresponding counting channel exceeds the capacity of the counting channel.

GATE Single LED illuminates during an active counting interval.

A.3. Controls

DISPLAY TEST Push-button switch illuminates all segments of every 7-segment display.

RESET Push-button switch resets the internal counting channels to zero and turns Off the overflow indicators.

STOP Push-button switch selects the non-counting condition for all counting channels.

COUNT Push-button switch enables the counting condition for all counting channels provided the Gate input is not held below +1.5 V dc and the time is not at the preset count condition.

DISPLAY SELECT Push-button switch selects the counting channel whose contents will be displayed.

DWELL TIME Single-turn control with a switch at the full counterclockwise setting for Off. Off inhibits recycle operation of a preset counting interval. When the control is turned clockwise away from Off, it permits recycling with a dwell time between counting intervals that can be adjusted from 0.3 s to ~15 s. This control is disabled when computer control is in effect.

M Push-button switch used to set the timer preset value. The "M" preset value [preset = ($M \times 10^N$) time base] is incremented each time the button is pressed. Maximum value = 9.

N Push-button switch used to set the timer "N" preset value. The N preset value is incremented each time the button is pressed. Maximum value = 7.

TIME BASE SELECT Push button used to select the internal time base of 0.1 SEC or 1 MIN or the EXT IN rear panel input for external time base.

SERIAL INTERFACE CONTROL (S-2) An 8-position slide switch accessible through a cutout in the left-side panel. Sections 1 through 4 select the counting channels whose contents will be transmitted when data is transferred to the PC. If the corresponding switch is set for print, the data for that counting channel will be transmitted; if set to the skip position, the data will not be transmitted. Section 5 selects the length of the data byte which will be transmitted over the serial communications interface. On selects 7 data bits; Off selects 8 data bits. Section 6 is used to enable or disable the parity generation and checking when characters are sent or received over the serial interface. If parity is enabled, Section 7 selects either odd or even parity mode. Section 8 selects whether one or two stop bits are added to the character transmitted over the serial interface.

BAUD RATE SELECT (S-3) A 4-position slide switch accessible through a cutout in the left-side panel. This switch selects the baud rate at which characters are transmitted and received over the serial communications interface (Section 3.3).

A.4. Inputs

COUNTERS 2, 3, AND 4 Front-panel BNC connectors accept positive unipolar signals; minimum pulse width above threshold, 20 ns at 50% duty cycle. Z_{in} = 1 kΩ to ground. Threshold is fixed at +1.5 V dc. Input protected to +25 V, dc-coupled.

Changing the input connector to the counter board permits independent selection of fast negative logic pulses, 14 mA into 50 Ω. Minimum pulse width above threshold is 4 ns. Input is dc-coupled, 250 mV fixed threshold.

COUNTER 1 OR EXT Rear-panel BNC connector accepts positive unipolar signals; minimum pulse width above threshold, 20 ns at 50% duty cycle. Z_{in} = 1 kΩ to ground. Threshold is fixed at +1.5 V dc. Input protected to +25 V, dc-coupled.

Changing the input connector to the negative input permits selection of fast negative logic pulses, 14 mA into 50 Ω. Minimum pulse width above threshold is 4 ns; threshold fixed at −250 mV; input is dc-coupled.

MASTER GATE Rear-panel BNC connector accepts standard slow positive logic signal to control counter input gate for all counting sections and the front-panel count LED indicator. A signal >+3 V or open circuit allows counting; a level of <+1.5 V inhibits counting. Protected to +25 V. Driving source must be capable of sinking 0.5 mA positive current during inhibit.

GATES 1, 2, 3, AND 4 Rear-panel BNC connectors accept standard slow positive logic signal to control individual counting channel inputs. A signal >+3 V dc or open circuit allows counting; 25 V dc maximum. A level of <+1.5 V inhibits counting. Driving source must be capable of sinking 0.5 mA of positive current during inhibit.

EVENT Rear-panel BNC connector accepts standard positive logic pulse to increment the event counter. Signal must exceed a level of +2.5 V dc for a period of >100 ns to increment the event counter. Maximum frequency of input signal is 4 kHz.

RESET Rear-panel BNC connector accepts standard positive logic pulse to remotely reset all counting sections to zero. A signal of >+3 V dc is needed to reset; a signal of <+1.5 V dc or open circuit is required to not reset. Protected to +25 V dc; minimum pulse width is 100 ns; Z_{in} = 6 kΩ to ground, dc-coupled.

A.5. Output

INTERVAL Rear-panel BNC connector furnishes a positive level during the counting interval. Nominally +5 V dc; Z_o = 30 Ω.

A.6. Interface

SERIAL RS-232-C or 20-mA current loop signal on a single, 25-pin rear-panel-mounted connector.

A.7. Electrical and Mechanical

POWER REQUIRED +6 V, 1.6 A; +12 V, 70 mA; -12 V, 290 mA.

WEIGHT

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

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

APPENDIX B. ASCII COMMANDS

This appendix describes the ASCII command format used by the 974A.

B.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 needed and are called nouns and modifiers, respectively. The following is a typical command:

SHOW_COUNT_PRESET

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

B.2. Data Values

Some commands need to include data values. Such values must be separated from the command keywords by one or more spaces. The data is also sent as ASCII character sequences rather than integer words. 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 1,2

in the preceding command, the module is told to set the preset M value to 1 and the preset N value to 2. These settings result in a preset value of 100 (1×10^2).

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

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

B.3. Checksums

A checksum may optionally be present at the end of any 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 transmitted 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 binary integers) rather than a single binary byte.

The 3 checksum characters, if present, must be the last of the command record before the delimiter and must be separated from any data values by a comma. If a data value is optional and is omitted, a comma must precede the checksum for clarity.

B.4. Response from the Module

After a command has been transmitted from the PC to the module, no other command should be issued until a "percent response" record [a character string beginning with the ASCII percent (%) character] has been received from the module. The percent response indicates how the module responded to the previous command and that the module is ready to receive a subsequent command.

Appendix C explains how to interpret percent response records and also any other types of response records sent by the module. Because it will always be sent, the percent response record is not included in the description of commands in this appendix. However, any other response records to be expected after issuing a command are explicitly noted in this appendix.

B.5. Time Units in Commands

"Delay" is the time the module will wait before processing and responding to a command you have issued. Delay values must be given in special time units; for example, Delay is given in units of 0.25 ms. You must remember to enter the values for Delay appropriately.

B.6. Optional Mask Values

For some of the set, show, and clear commands an optional [MASK] value may be included in the command. The mask is a number from 0 through 15 that represents a 4-bit binary value. Each of the bits represents a counting channel, with the right-most bit (1) representing counter 1 and the left-most bit (8) representing counter 4. A value of 1 for the corresponding bit allows the action, and a value of 0 for the corresponding bit prevents the action. For example the command CLEAR_COUNT 7 (0111) clears counter channels 1, 2, and 3, but does not clear counter 4.

B.7. Catalog of Commands for the 974A

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

Command	Minimum Entry	Description
CLEAR_ALL	CL_ALL	Clears counters, count preset event counter, and event preset.
CLEAR_COUNTERS [MASK]	CL_COU	Clears the four counters. If a mask is included, only the counters selected by the mask are cleared.
CLEAR_COUNT_PRESET	CL_COU_PR	Clears the M and N values of the preset value to zero.
CLEAR_EVENT_PRESET	CL_EV_PR	Resets the event preset register to zero.
DISABLE_ALARM	DIS_ALA	Disables the alarm function. When the alarm is disabled, the 974A does not automatically send the contents of the counters to the host PC when the preset count value is reached. The front-panel dwell control is enabled, and the 974A operates in a stand-alone mode.
DISABLE_EVENT	DIS_EV	Disables the event counter in the 974A.
DISABLE_EVENT_PRESET	DIS_EV_PR	Disables the event preset function.
ENABLE_ALARM	EN_ALA	Causes the 974A to transfer the contents of the counters to the host at the end of each preset interval without a direct command from the host.
ENABLE_EVENT_AUTO	EN_EV_AU	Causes the event counter to be advanced, by one count, each time the preset count or preset time is reached in the 974A.

ENABLE_EVENT_EXTERNAL	EN_EV_EXT	Enables the external event input on the rear panel of the 974A.
ENABLE_EVENT_PRESET	EN_EV_PR	Enables the event counter to stop after a preset number of events has occurred.
ENABLE_LOCAL	EN_LOC	Places the 974A under local control (i.e., the front-panel controls). The 974A will still respond to the communications interfaces and to commands from a host.
ENABLE_REMOTE	EN_REM	Places the 974A totally under the control of the host PC. All front-panel controls except the Display Test and the Counter Select controls are disabled.
SET_COUNT_PRESET M,N	SET_COU_PR	Loads the M (multiplier) and the N (exponent) values to the preset count function of the 974A. The M value is a single digit between 0 and 9, and the N value is a single digit between 0 and 7.
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 the preset value.
SET_MODE_EXTERNAL	SET_MOD_EXT	Selects the external input to the preset counter in the 974A.
SET_MODE_MINUTES	SET_MOD_MIN	Selects the minutes time base as the input to the preset counter in the 974A.

SET_MODE_SECONDS	SET_MOD_SEC	Selects the 0.1 seconds time base as the input to the preset counter in the 974A.
SET_DISPLAY<VALUE>	SET_DISP	Selects the counter whose contents will be displayed on the 974A front-panel LEDs. The value is a single digit between 1 and 4.
SHOW_ALARM	SH_ALA	Returns a "$I" response record showing the status of the alarm. The answer is in the form of "T" for true or "F" for false. $IF.
SHOW_COUNTS [MASK]	SH_COU	Shows the contents of the four counters if no mask is included. If a mask value is included, only the counters enabled by the mask value are included. The mask is a number between 1 and 15 whose binary value determines which counters will be sent. 00000000;00000000;00000000; 00000000 %000000069
SHOW_COUNT_PRESET	SH_COU_PR	Causes the 974A to transmit a response record which includes the M and N values presently selected. $D001002139
SHOW_DISPLAY	SH_DISP	Causes the 974A to send a record showing the number of the counter whose contents are being displayed on the 974A front panel. $A002247

SHOW_EVENT	SH_EV	Causes the 974A to send the contents of the event counter. This will be an eight-digit number. $G00000000235
SHOW_EVENT_PRESET	SH_EV_PR	Causes the 974A to send the contents of the event preset register. This will be an eight-digit number. $G00000000235
SHOW_MODE	SH_MOD	Causes the 974A to send a record showing which input is selected for the preset counter in the 974A. Zero = seconds, one minutes, and two = external. $A000245
SHOW_RADIX	SH_RAD	Causes the 974A to send a record showing which radix is selected. Bin = binary, dec = decimal. Complement is the SET_RADIX command. $FDEC
SHOW_VERSION	SH_VER	Causes the 974A to send a record which shows the firmware version included in the 974A. $F0974A-001
INIT	INIT	Causes the 974A to restart or initialize. Same as a reset or power-up condition.

SET_RADIX_BINARY	SET_RAD_BIN	When issued, the 974A will send all numerical information in binary format.
SET_RADIX_DECIMAL	SET_RAD_DEC	Causes the 974A to send all numeric data in the decimal format.
START	STA	Causes the 974A to start a counting cycle.
STOP	STO	Stops the 974A from counting.
TEST <NUMBER>	TEST	Causes the 974A to self-test.

APPENDIX C. RESPONSE RECORDS FROM THE 974A MODULE

This appendix describes the type of responses the module makes to the ASCII commands. You must be familiar with the concept of a *record*, that is, a continuous stream of bytes or characters with a special character such as the ASCII carriage return or line feed marking its end.

C.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 974A module is either a carriage return or a line feed character, or both, as, follows:

INPUT from RS-232-C:

Either a carriage return character (<CR>) or a line feed character (<LF>) can be accepted.

OUTPUT to RS-232-C:

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

C.2. Percent Response Records

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

% xxx yyy CCC <DL>

Where "%" is the ASCII percent character, the next three bytes (xxx) are a code for the general type of disposition, the second three bytes (yyy) are the specific form of disposition, and the final three bytes (CCC) are the checksum bytes (Appendix B). <DL> is an appropriate delimiting character (Section C.1).

Records beginning with 001, 002 and 004 can be OR-ed together to obtain composite error indications. That is, the indications of power-up, data back-up, and self-tests 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 part meaning that % 004 002 occurred (ROM-1 failed).

The following are percent response code assignments:

Command executed successfully:

```
% 0 0 0   0 0 0   C C C
```

Power-up just occurred:

```
% 0 0 1   0 0 0   C C C
```

Power-up self-test failure:

```
% 0 0 4   0 0 2   C C C      ROM test failed
% 0 0 4   0 0 8   C C C      Scratchpad RAM failed
```

Command syntax error:

```
% 1 2 9   0 0 1   C C C      invalid verb
% 1 2 9   0 0 2   C C C      invalid noun
% 1 2 9   0 0 4   C C C      invalid modifier
% 1 2 9   0 0 8   C C C      invalid command data
% 1 2 9   1 2 8   C C C      invalid lst data value
% 1 2 9   1 2 9   C C C      invalid 2nd data value
% 1 2 9   1 3 0   C C C      invalid 3rd data value
% 1 2 9   1 3 1   C C C      invalid 4th data value
% 1 2 9   1 3 2   C C C      invalid command
```

Communications error:

```
% 1 3 0   0 0 1   C C C      UART buffer overrun
% 1 3 0   0 0 2   C C C      UART parity error
% 1 3 0   0 0 4   C C C      UART framing error
% 1 3 0   1 2 8   C C C      input checksum error
% 1 3 0   1 2 9   C C C      input record too long
```

% 1 3 0 1 3 0 C C C	invalid input data record
% 1 3 0 1 3 3 C C C	aborted due to invalid handshake

Execution error:

% 1 3 1 1 2 8 C C C	invalid 1st command parameter
% 1 3 1 1 2 9 C C C	invalid 2nd command parameter
% 1 3 1 1 3 0 C C C	invalid 3rd command parameter
% 1 3 1 1 3 1 C C C	invalid 4th command parameter
% 1 3 1 1 3 2 C C C	invalid number of parameters
% 1 3 1 1 3 3 C C C	invalid data (other than command data)
% 1 3 1 1 3 4 C C C	could not load selected value
% 1 3 1 1 3 5 C C C	counters must be stopped but were not
% 1 3 1 1 3 6 C C C	start/stop trigger must be disabled

C.3. Dollar Response Records

All other response records begin with the ASCII dollar sign character ($) and another letter 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 eight-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 binary checksum value for the record as a three-digit decimal value. <DL> is an appropriate delimiter character (Section C.1). See SHOW_DISPLAY and SHOW_MODE commands in Appendix B.
$B xxx yyy CCC <DL>	A $B record is used to transmit two eight-bit binary integers. The integers are expressed as two, three-digit ASCII characters (xxx and yyy) which are the decimal equivalents of the binary integers. The values will fall between 0 and 255. The command which generates the $B response record is SHOW_COUNT_PRESET.

	The final three characters (CCC) are three-digit ASCII characters representing the binary checksum value for the record. <DL> is the appropriate delimiting character (Section C.1).
$F xx <DL>	The $F response record is used to transmit a variable-length string of printable ASCII characters. The character string, shown here as "xx," may consist of one or more characters. No checksum is used, and <DL> is an appropriate delimiting character (Section C.1). The commands generating a $F record are SHOW_VERSION and SHOW_RADIX.
$G xxxxxxxx CCC <DL>	A $G response record is used to transmit an eight-digit decimal value represented here as (xxxxxxxx). The decimal value will be between 00000000 and 99999999.
	The checksum represented as (CCC) will be a three-digit decimal representing the eight-bit binary integer whose value is the checksum for the record. <DL> is an appropriate delimiting character. The commands generating a $G record are SHOW_EVENT and SHOW_EVENT_ PRESET.
$I x <DL>	A $I 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. This record is transmitted in response to the SHOW_ALARM command.

APPENDIX D. GLOSSARY

ASCII (American Standard Code of Information Interchanges) Characters: The first seven binary bits of a byte have distinct meanings for unique and uniform representation of 96 printable characters and 32 control characters. The control characters (usually non-printable) are used to give commands to printers and other peripheral devices.

Baud Rate: The rate at which distinct units of information can be communicated over an interface. The baud rate is the number of binary hits transmitted per second over the serial interface for the 974A.

Byte: A fixed-length string of binary bits. Eight bits is the most common byte size. The 974A can use 7-bit or 8-bit bytes over the serial interface.

CPU (Central Processing Unit): One of the basic functional parts of a computer. Other parts are main memory, auxiliary memory, and input-output devices. The CPU for the 974A is a Z80 microprocessor.

Current-Loop Device: A device which communicates with another device (such as a computer or a 974A module) by the opening and closing of an electrical circuit (loop). Current loops are appropriate for long, direct-wired hookups or where a lot of electrical noise is present.

DCE (Data Communications Equipment) Wiring: One of two wiring plans for devices using the RS-232-C standard serial interface. According to the standard, modems have DCE wiring, whereas PCs have DTE (Data Terminal Equipment) wiring. Any two unlike-wired devices can connect directly to each other (e.g., a PC to a modem). A modifying cable (called a "null" modem) must be used to directly connect two devices having the same wiring. See the RS-232-C standard for more information.

DTE (Data Terminal Equipment) Wiring: One of two wiring plans for devices using the RS-232-C standard serial interface. According to the standard, modems have DCE (Data Communications Equipment) wiring. PCs have DTE wiring. Any two unlike-wired devices may connect directly to each other (e.g., a PC to a modem). A modifying cable (called a "null" modem) must be used to directly connect two devices having the same wiring. See the RS-232-C standard for more information.

Firmware: A program (or set of programs) for a computer or digital controller which is permanently stored and ready for access in the read-only portion of the primary memory.

Full Duplex: Full duplex (bidirectional) communication over an RS-232-C serial interface is communication occurring in both directions simultaneously. (Half-duplex is transmission in only one direction at a time; simplex is transmission occurring in a single direction only.)

Hardware: Physical equipment such as mechanical, electrical, magnetic, or electronic devices.

Interfaces: An interface is the transmission line(s) and a set of rules for using the line that links hardware devices to provide communication between the devices. An interface between two software programs is a logical boundary or set of rules on how the two shall communicate.

Serial Interface: An interface over which each binary bit of information in a byte is sent sequentially on a single transmission line rather than simultaneously on separate lines (parallel).

Software: A set of computer programs. (See also Hardware and Firmware.)

Stop Bit: During the asynchronous transmission of bytes, bit-by-bit, over a serial interface, a stop bit of fixed duration is sent at the end of each byte to mark the end of the byte. A start bit is sent before each byte. The start bit always has the duration of one binary bit, but the stop bit can vary in duration among 1, 1.5, and 2 bit lengths. The purpose of varying the length of the stop bit is to affect the overall rate at which characters can be sent across an interface in byte form for a given baud rate.