HEWLETT PACKARD

MODEL 3497A
DATA ACQUISITION/CONTROL UNIT

OPERATING, PROGRAMMING AND CONFIGURATION MANUAL

Manual Part No. 03497-90019

Microfiche Part No. 03497-90069

Printed: December 1982

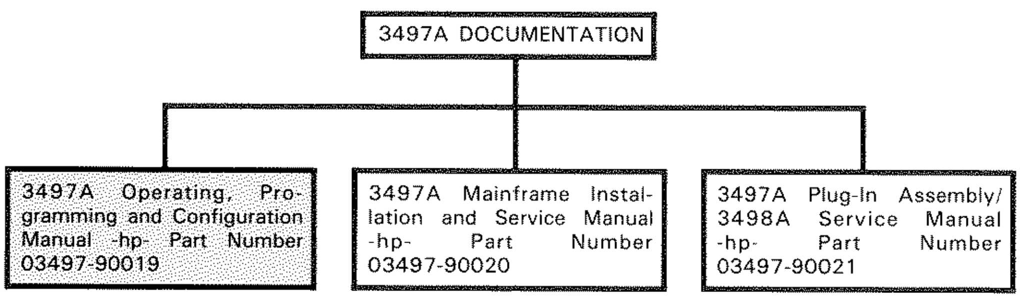
3497A DOCUMENTATION

This chart shows the manuals that are included in 3497A documentation. There are three types of 3497A manuals, as shown below. Each manual is enclosed in a separate three-ring binder.

The Operating, Programming and Configuration (OPC) Manual contains operating, programming and configuration information for the 3497A, for its plug-in assemblies (Options 010 through 140) and for the 3498A Extender.

The 3497A Mainframe Installation and Service (I&S) Manual contains installation and service information for the 3497A mainframe and the optional DVM.

The Plug-In Assembly Service Manual contains service information for all plug-in assemblies (except Option 140 which has no user service) and for the 3498A Extender.



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Preface
GETTING STARTED

When you receive your new 3497A, the first question, of course, is ''How do I get started''?. Hopefully this GETTING STARTED introduction will enable you to quickly and efficiently set up and operate your 3497A in your data acquisition/control system.

Although you are probably eager to turn the instrument on and operate it, please take a few minutes to examine this manual before you do so. The manual has been designed to enable you to use the 3497A Data Acquisition/Control Unit in the most effective manner for your data acquisition measurements and control applications. Before we discuss how to get started, let's see how to use this manual.

HOW TO USE THIS MANUAL

When you ordered your new 3497A, you specified certain options and plug-in assemblies. In addition, you may have ordered the 3497A as part of the 3054A/C or 3054DL system. In this manual, information is presented in two main categories, depending on the interface connection (HP-IB or Serial Data [RS-232 or RS449/423]) you specified for your 3497A. This manual is divided into two parts:

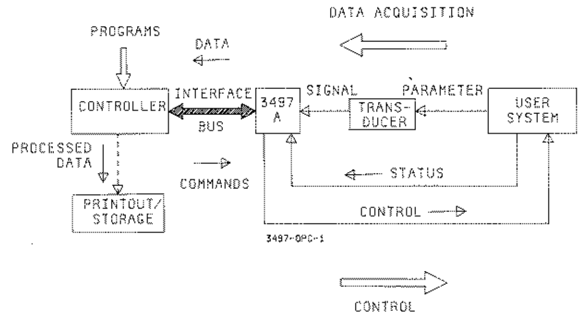
PART I - OPERATING AND PROGRAMMING THE 3497A shows how to send commands to the 3497A by using the front panel or from a controller via either HP-IB or Serial Data interface and shows how to use these commands to program 3497A operation.

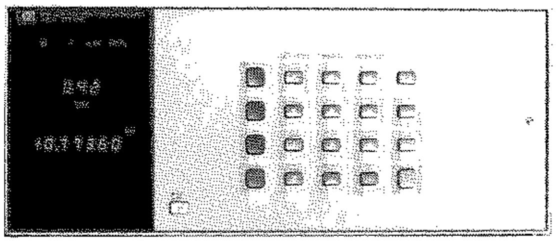
Part II - CONFIGURING THE 3497A shows how to hardware configure the 3497A, all plug-in assemblies (Options 010 through 140) and the 3498A Extender and shows sample ways to connect the 3497A to your system for data acquisition measurements or control applications.

In addition, APPENDIX A - INTERFACE CONCEPTS introduces HP-IB and Serial Data concepts and APPENDIX B - SPECIFICATIONS AND GENERAL INFORMATION shows 3497A specifications and provides general information such as warranties and shipping guidelines. Now, let's take a closer look at the manual organization.

CHAPTER 1
MEET THE 3497A

This chapter describes the 3497A and shows its capabilities in typical data acquisition and control systems. Read this chapter for an overall description of the 3497A and how it can be used to solve data acquisition measurement and control tasks.



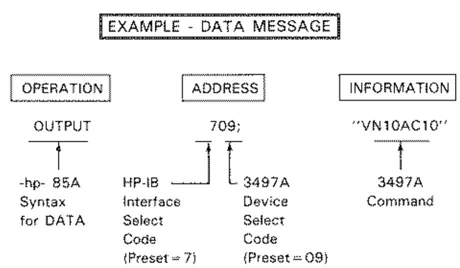


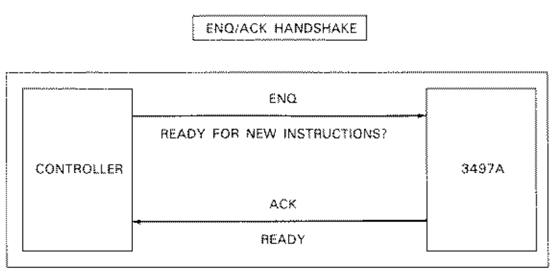
CHAPTER 2
FRONT PANEL OPERATION

This chapter describes the command structure for the 3497A and shows how to enter commands from the front panel. If you are going to use the 3497A without a controller, you should study this chapter carefully. Even if you are going to use a controller with the 3497A, this is the easiest way to learn the command structure and addressing schemes used for the 3497A.

CHAPTER 3
HP-IB PROGRAMMING

This chapter shows how to send commands from a controller to the 3497A over an HP-IB interface. If you ordered a 3497A with Serial Data (Option 232), skip this chapter and see Chapter 4 for programming information.





CHAPTER 4
SERIAL DATA PROGRAMMING

Shows how to send commands from a controller to the 3497A over a Serial Data (RS232C or RS449/423) interface. If you ordered a 3497A with Option 232, see this chapter for programming information.

CHAPTER 5
CONTROLLING THE 3497A

This chapter shows how to set up (control) the 3497A for specified actions, such as setting an audible alarm, time of day, voltmeter settings, etc. See this chapter to set up the 3497A mainframe, timer/real-time clock, voltmeter, rear panel control ports and plug-in assemblies for your specific application.

ANALOG CLOSE

AC chan#,chan#,... chan# = 0 to 999

Description

CHAPTER 7
INSTALLATION AND MAINFRAME CONFIGURATION

This chapter shows how to initially inspect and install your new 3497A and how to configure the 3497A mainframe for different operating conditions.

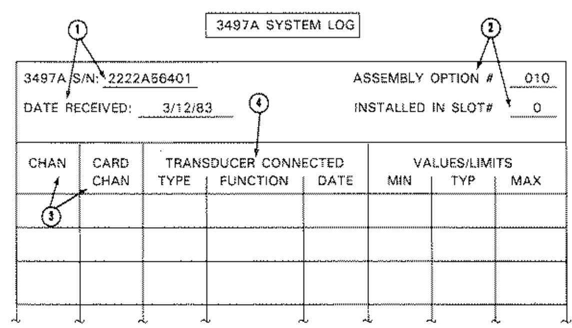
After initial installation, you will probably need to refer to this chapter only when your application requires a hardware configuration which is different from the 3497A factory settings.

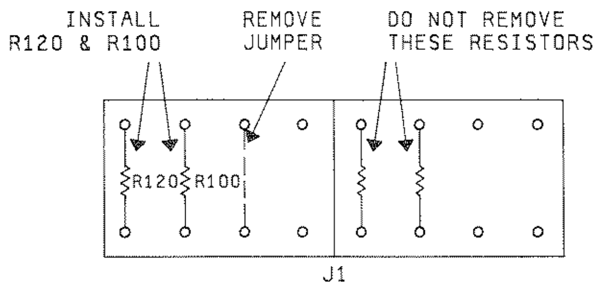
DATA FOLLOWING A SELF-TEST COMMAND

Data	Definition
8E8	Self Test Passes
1E1	Cross Guard Fails
2E2	Voltmeter Fails
3E3	Timer Fails

CHAPTER 6
COMMAND DIRECTORY

This chapter contains an alphabetical description of the six command groups (ANALOG, COUNTER, DIGITAL, SYSTEM, TIMER and VOLTMETER) used to control the 3497A. The directory also includes a list of the command states at power on. To avoid undesired actions by the 3497A, you should ALWAYS consult this directory before entering a command into the 3497A.



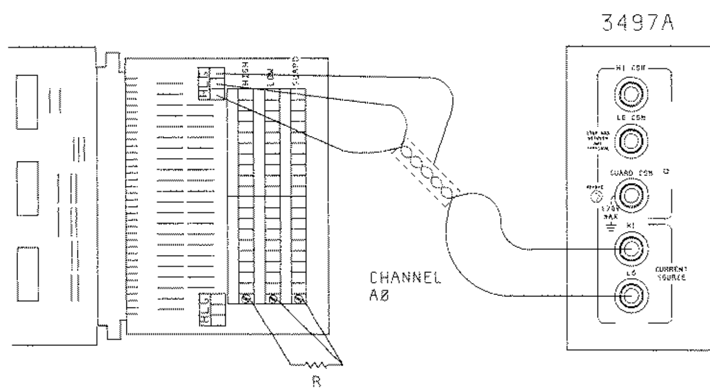


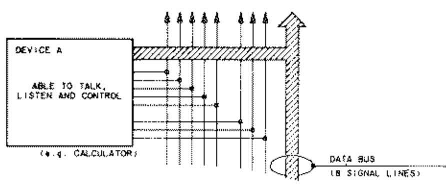
CHAPTER 8
PLUG-IN ASSEMBLY CONFIGURATION

This chapter shows how to initially inspect and install and how to configure plug-in assemblies (Options 010 to 140) and the 3498A Extender (Option 298), including switch/jumper settings and typical connections to your system.

CHAPTER 9
EXAMPLE 3497A CONFIGURATIONS

This chapter shows some example configurations for typical user applications, divided by functional categories into data acquisition measurements and control applications. For example, to make a guarded (3-wire) DC voltage measurement, see the GUARDED VOLTAGE MEASUREMENTS example, etc.



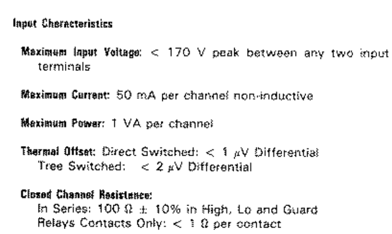


APPENDIX A
INTERFACE CONCEPTS

Refer to this appendix for introductory information on HP-IB, RS-232C and RS-449 interface concepts.

APPENDIX B
SPECIFICATIONS AND GENERAL INFORMATION

See this appendix for 3497A specifications, warranty information, shipping guidelines and manual information.


Input Characteristics

Maximum Input Voltage: < 170 V peak between any two input terminals

Maximum Current: 50 mA per channel non-inductive

Maximum Power: 1 VA per channel

Thermal Offset: Direct Switched: < 1 μV Differential
Tree Switched: < 2 μV Differential

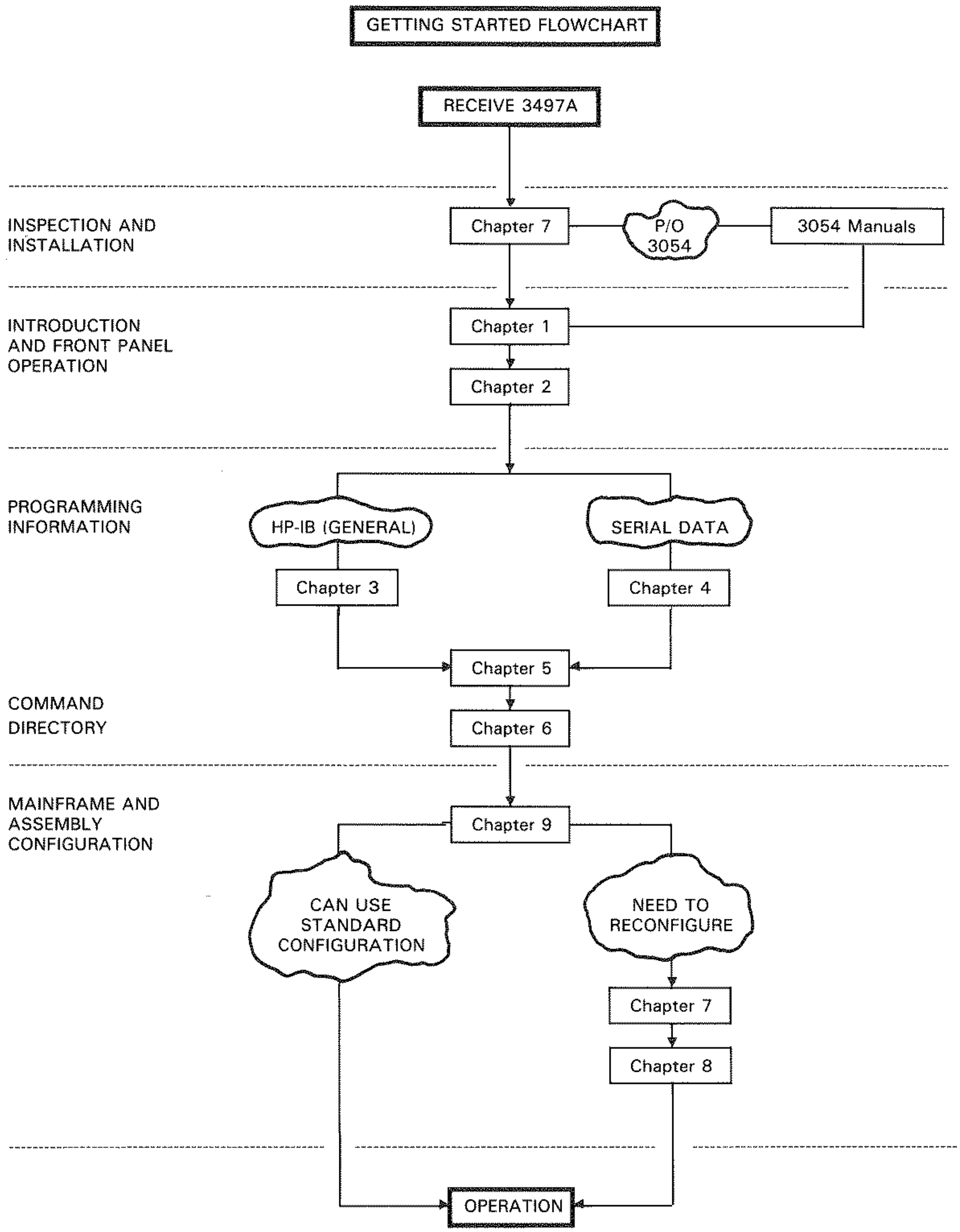
Closed Channel Resistance:
In Series: 100 Ω ± 10% in High, Lo and Guard
Relays Contacts Only: < 1 Ω per contact

GETTING STARTED

If you have just received your new 3497A, refer to the GETTING STARTED flowchart below for a suggested way to get started. The steps you should follow depend on the way that you are going to use the 3497A. If you are going to use the 3497A with a controller, see USING THE 3497A WITH A CONTROLLER which follows. If you are going to use the 3497A in stand-alone mode (without a controller), skip to USING THE 3497A IN STAND-ALONE.

WARNING

In this manual, examples and illustrations show connections between the 3497A and external circuits. Because of the potentially high voltages which may be present when an external circuit is connected, only qualified, service-trained personnel should install or configure the 3497A, 3498A or any plug-in assemblies.


GETTING STARTED FLOWCHART
RECEIVE 3497A
INSPECTION AND INSTALLATION
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INTRODUCTION AND FRONT PANEL OPERATION
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COMMAND DIRECTORY
Chapter 6
MAINFRAME AND ASSEMBLY CONFIGURATION
Chapter 9
CAN USE STANDARD CONFIGURATION
NEED TO RECONFIGURE
Chapter 7
Chapter 8
OPERATION

USING THE 3497A WITH A CONTROLLER

NOTE

If your 3497A is used as part of a 3054A/C/DL System, follow the suggested sequence for USING THE 3497A WITH A CONTROLLER shown below. In addition, consult the appropriate 3054 Systems Manuals for interconnection of the 3497A to other systems components, such as the 3456A, 3437A, etc.

If you are using the 3497A with an HP-IB or Serial Data interface, the first step is to inspect the 3497A and then connect the instrument to your controller as shown in Chapter 7, BUT DON'T CONNECT THE 3497A TO YOUR SYSTEM YET.

To become familiar with the 3497A, first see Chapter 1 for an overall description of the instrument. Then study Chapter 2 for the 3497A command structure and front panel features. Next, see Chapter 3 for HP-IB programming guidelines or Chapter 4 for Serial Data programming guidelines. The best way to become familiar with the 3497A is to enter the command sequences shown in the examples in Chapters 2 through 4 and observe the display and/or printout.

After you have become familiar with the command structure, see Chapter 5, Controlling the 3497A, to see how to set up the 3497A mainframe, timer, DVM and the plug-in assemblies.

The final step is to connect the 3497A to your system. To do this, first determine what function you want the 3497A to perform (DC voltage measurements, resistance measurements, etc.). See Chapter 9, Example 3497A Configurations, for some ways that the 3497A can be used for measurements or control applications.

If you don't find an example in Chapter 9 which can be used (or modified) for your application, see Chapter 7 or 8 for details on how to configure the 3497A and its plug-in assemblies. After the 3497A is properly configured and connected to your system, it is ready for operation.

CAUTION

To avoid undesired actions by the 3497A, be sure to see Chapter 6, Command Directory, before entering commands into a 3497A which is connected to your system.

USING THE 3497A IN STAND-ALONE

If you are using the 3497A without a controller, first inspect and check out the instrument as shown in Chapter 7, BUT DON'T CONNECT IT TO YOUR SYSTEM YET. Then, see Chapter 1 for an introduction to the features of the 3497A before you turn the instrument on.

Next, see Chapter 2 to see how to control the 3497A using the front panel keys. The best way to do this is to actually enter the commands shown in the examples in the text and observe the display. And, don't worry, you can't hurt the 3497A by entering commands, since the instrument isn't connected to your system.

After you have become familiar with how to enter commands, you can go directly to Chapter 5, Controlling the 3497A, to see how to set up the 3497A mainframe, timer, DVM (if your 3497A has Option 001), and the plug-in assemblies (Options 010 to 140) you ordered.

The next step is to connect the 3497A to your system. To do this, first determine what function you want the 3497A to perform (DC voltage measurements, resistance measurements, etc.). Then, see Chapter 9, Example Configurations, for some ways that the 3497A can be used for measurement or control applications.

If you don't find an example in Chapter 9 which can be used (or modified) for your application, see Chapter 7 and/or Chapter 8 for details on configuring the 3497A or its plug-in assemblies. When the 3497A is properly configured and connected to your system, it is ready for operation.

CAUTION

To avoid undesired 3497A actions, be sure to check Chapter 6, Command Directory, before you enter commands into a 3497A which is connected to your system.

Chapter 1
MEET THE 3497A

DATA ACQUISITION/CONTROL OVERVIEW

Congratulations on your selection of the Hewlett-Packard Model 3497A Data Acquisition/Control Unit! Since this is quite a long title, we'll refer to the instrument as the 3497A. Your new 3497A is a precise, flexible and easy to use instrument which can make a wide variety of data acquisition measurements and provide precise controls for literally thousands of applications.

In this chapter, we'll introduce the 3497A and show how it can be used in data acquisition/control system applications. To better understand the capabilities of the 3497A, we'll first present a brief overview of data acquisition and control systems as used in this manual.

A data acquisition and control system which uses the 3497A for measurement and control is shown in Figure 1. There are two main tasks for this system: data acquisition and control.

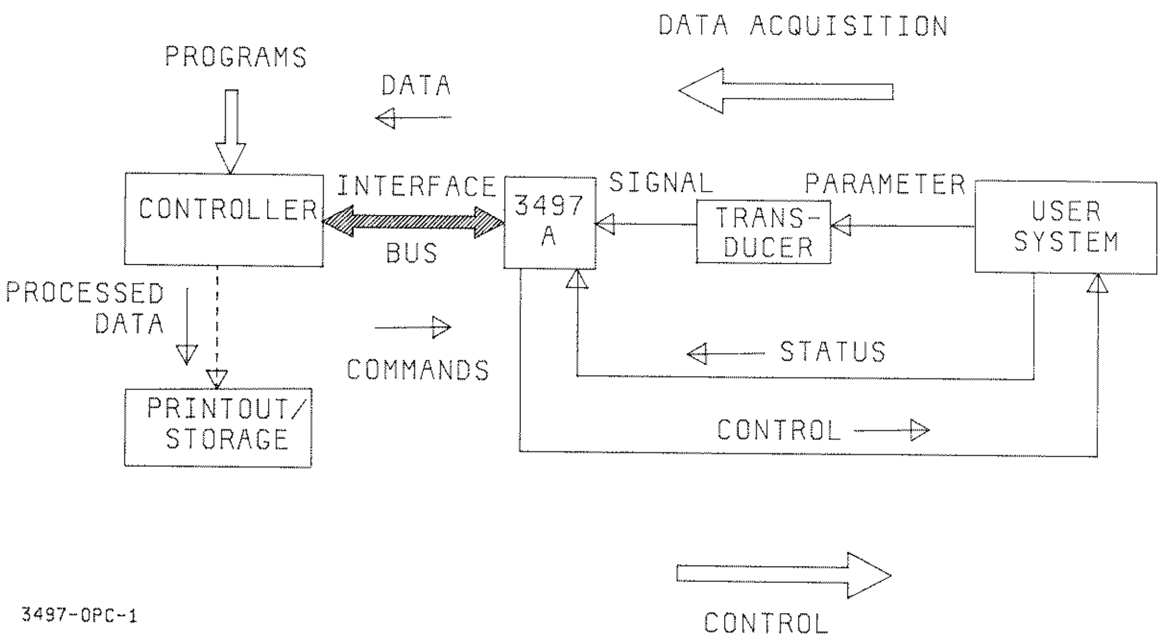


Figure 1. A Data Acquisition/Control System

Data Acquisition

The function of the data acquisition task is to measure data inputs from a user system. For the 3497A, data acquisition measurements are divided into five categories, depending on the user system parameter to be measured: voltage, temperature, resistance, frequency or pressure measurements.

In the data acquisition/control system shown, a transducer such as a strain gauge or thermocouple is connected to an external system and samples a system parameter such as temperature, pressure, flow rates, etc.

The transducer converts user system physical parameter inputs into an electrical signal (voltage) which can be measured by the 3497A. The controller sends commands to the 3497A (via the interface bus) to initiate measurements and transfer measurement data for processing. Processed data can then be displayed, printed out or stored.

Control

The function of the control task is to provide control signals from the 3497A to the user system, either in response to status inputs from the system or in response to commands issued from the controller.

For the 3497A, the control task is divided into three categories: interrupts, switching and control sources. When the 3497A is set for interrupt, the controller can do other functions and be interrupted by predetermined system status conditions.

Switching (multiplexing) refers to the capability of the 3497A to switch inputs/outputs from one channel to another. Control sources refer to voltage or current outputs for controlling user system functions.

For applications such as process control, external system status reports (open/closed, on/off, present/absent, etc) are input to the 3497A. If a system condition occurs which requires action, the 3497A outputs a signal (called an interrupt) to the controller. The controller, in turn, sends a command to the 3497A to send a control signal to the user system for required action.

In other applications, the 3497A can send a control signal to the external system in response to commands from the controller, regardless of user system status. For example, the controller can be programmed to initiate a control signal from the 3497A at time t, regardless of system status input conditions.

THE 3497A IN DATA ACQUISITION/CONTROL SYSTEMS

Now, let's see how the 3497A can be used in a typical data acquisition/control system environment. Figure 2 shows a system in which a 3497A is interfaced to an -hp- 85A Desktop Computer which acts as system controller. There are four main functions in this system: data acquisition, control, communication and data processing.

Data Acquisition

For data acquisition, on command from the controller, the 3497A receives inputs from user system sensors, measures the input data and outputs the measurement over a communications interface to the controller (an -hp- 85A Desktop Computer in this system). The controller then processes the data for display or storage.

Data acquisition measurements are divided into five categories, depending on the user system parameter to be determined: voltage, temperature, resistance, frequency or pressure. With the 3497A, you can measure (or determine) DC voltage, temperature, resistance, frequency or pressure or totalize events from a wide variety of user systems.

Control

Control functions for the 3497A are divided into three categories: interrupts, switching and control sources. For interrupts, the 3497A receives status inputs from user systems, from the 3497A timer or from the 100 kHz Counter Assembly (Option 060) and outputs interrupt signals to the controller for action.

For switching, the 3497A controls actuator relays to sound alarms, switch voltages, etc. For control sources, the 3497A provides programmable voltage and current sources for applications such as 4-20 mA loops and VCOs.

Communication

The 3497A can be used in stand-alone mode (without a controller) or can communicate over compatible interfaces with controllers. With the 3497A, you have communications capability for direct connection or long distance communication over telephone lines. The 3497A is compatible with HP-IB or Serial Data (RS 232C or RS449/423) interfaces.

With an HP-IB interface bus and compatible controller, you can simultaneously control up to fourteen 3497As. For long-distance communication between your controller and the 3497A, you can use the 3497A with RS 232 interface and compatible MODEMS for communication over telephone lines.

Data Processing

When an -hp- 85A or equivalent controller is used with the 3497A, you can provide CRT display, data storage or make plots, graphs or strip charts of data measured by the 3497A. Since the 3497A is fully programmable, data acquisition and control is easily accomplished by entering simple command sequences into the controller. See Figure 2 for some of the features of the 3497A in data acquisition/control applications.

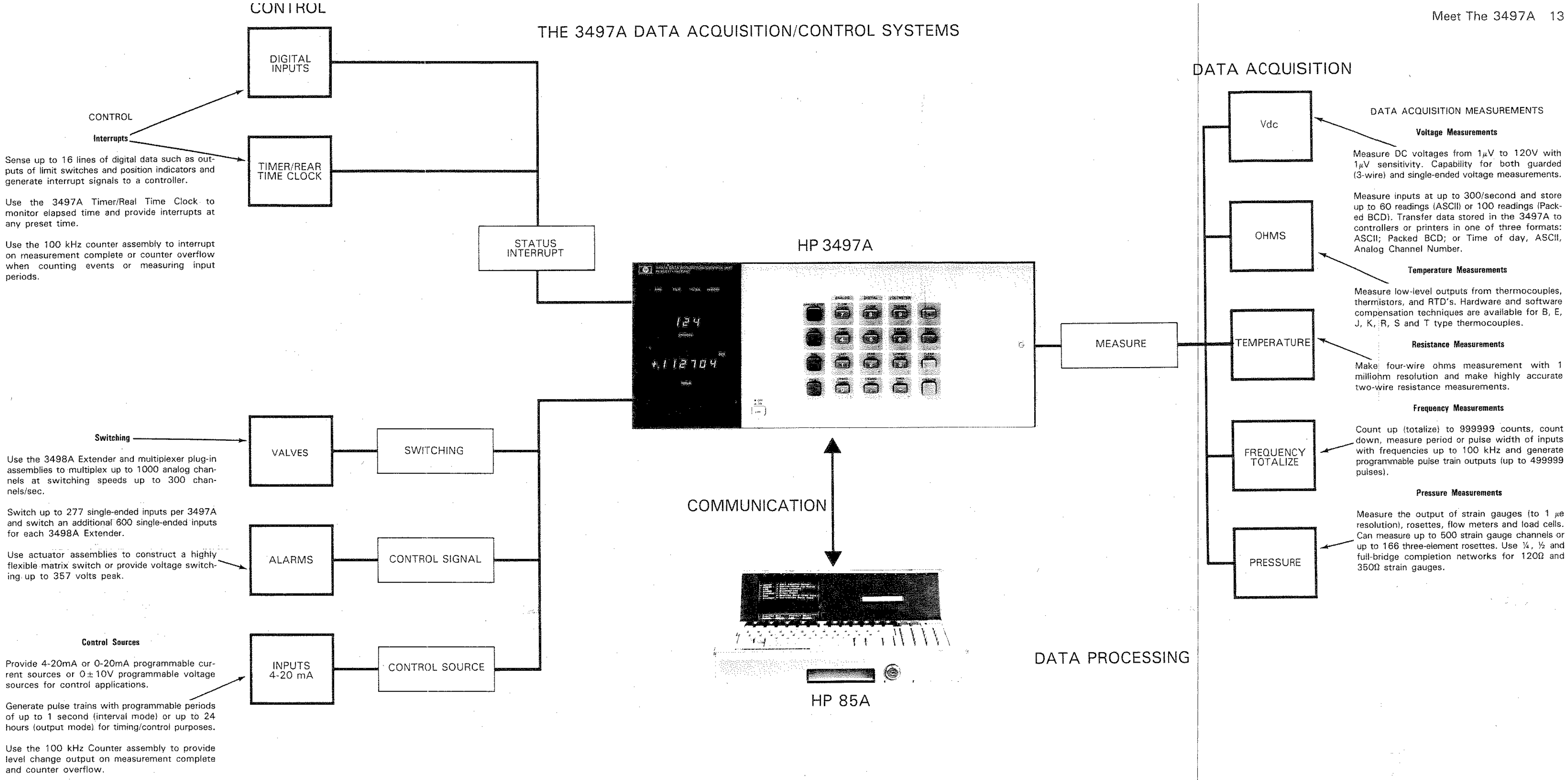


Figure 2. The 3497A in Data Acquisition/Control Systems

3497A MAINFRAME DESCRIPTION

Now that we've seen how the 3497A can be used in data acquisition and control systems and some of its features, let's take a look at the hardware description of the instrument. In later chapters, we'll examine each of the items described in more detail.

We'll divide the description of the 3497A into mainframe and options. The mainframe includes the front panel, clock/timer, alarm and rear panel. Options include the 11 plug-in assemblies, the DVM, RS-232 interface and the 3498A Extender.

A standard 3497A consists of a mainframe with a real-time clock and timer, an audible alarm (BEEP) and connectors for interface with controllers and external instrumentation. Options which can be added to the 3497A are:

3497A OPTIONS

Option 001	DVM with built-in current source
Options 010 - 140	Eleven plug-in assemblies
Option 232	Replace HP-IB with RS232C interface
Option 298	3498A Extender

Figure 3 summarizes the 3497A front panel features and Figure 4 shows the rear panel features. Although the DVM, clock, timer and alarm are shown as front panel features in Figure 3, they are physically located inside the 3497A mainframe.

Keyboard

A standard 3497A front panel consists of an alphanumeric keyboard and a display. The keyboard is used to enter command sequences into the 3497A to control its operation. An optional blank front panel (Option 260) has only a power ON/OFF switch and a power ON indicator light. The optional front panel has no display and must be remotely programmed by a controller.

In the standard keyboard, there are 12 alphanumeric keys and eight special purpose keys. Each of the special purpose keys has a single function, such as SELF-TEST, CLEAR ENTRY, etc. Each of the twelve alphanumeric keys, in contrast, has a dual function.

By using the alphanumeric keys, you can enter some commands with a single keystroke or, if you prefer, enter the commands with a series of keystrokes. For example, the command to close channel 10 in an analog assembly is ''AC10''. This command can be entered by doing the following keystrokes.

ENTERING A COMMAND - PRIMARY MODE

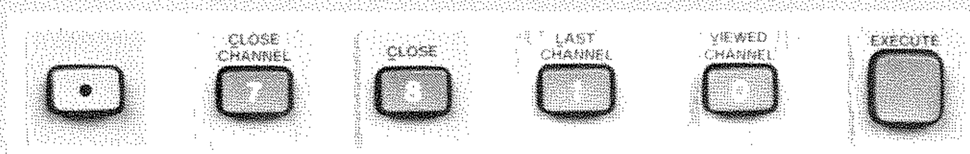
Press:

Data Entered:	AC	1	0	Enter AC10 into 3497A

You can also enter the same AC10 command by first pressing the SHIFT (blue) key and then entering the alpha and data characters individually, as shown below. Notice in this sequence that when the ANALOG CLOSE CHANNEL key (numeric 7) is pressed, alpha A (rather than AC) is entered into the 3497A, since pressing the blue SHIFT key shifts the alphanumeric keys to the shifted (Alpha) mode. See Chapter 2, Front Panel Operation, for details.

ENTERING A COMMAND - SHIFTED MODE

Press:



Data Entered:	Shift to Alpha Mode	A	C	1	0	Enter AC10 into 3497A

Display

The front panel display can be divided into three functional groups: Interface Bus Status Displays; Slot/Channel Displays; and Function Displays. The four Interface Bus Status displays (SRQ, TALK, LISTEN and REMOTE) indicate activity on the interface bus.

The Slot/Channel Display Indicators have dual functions. When analog assemblies are addressed, this display shows the analog channel addressed. When digital assemblies are addressed, this display shows the digital slot and channel(s) within the slot which are addressed. The VIEWED indicator is ON when a specific analog channel or digital slot is selected for monitoring.

The Function Display shows measurement data results from read statements. Measurement results are shown on the six-digit display (+.8.8.8.8.8.8 in Figure 3) and the type of measurement is shown by the LEDs to the right of the display (DCV, SEC, etc.).

Displays include voltmeter readings (DCV); digital data (OCT); time (SEC); totalized counts (TOT); or data entered from the front panel or from a controller (ENT). When the DVM current source is on, one of the three LEDs at the bottom of the display (10 μA, 100 μA or 1mA) is ON to show the value of the current output.

Timer/Real Time Clock

The 3497A includes a real time clock to provide a time base for measurement systems (such as data logging, for example). The timer/clock has 5 different modes of operation and has 24 hour battery back-up for all modes except Timer Output.

You can use the clock to provide real time printout of time of measurements. In addition, you can use the timer like a stop watch to monitor elapsed time or like an alarm clock to interrupt a process at any preset time.

Alarm

The 3497A has a built-in audible alarm (BEEP) which can be programmed to sound when system conditions (alarm conditions) require. The alarm also sounds when illegal commands are entered into the 3497A.

Rear Panel

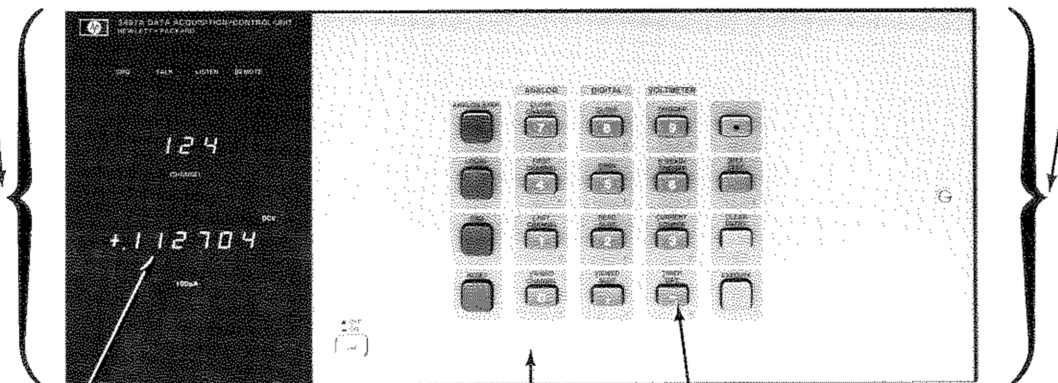
Figure 4 shows rear panel features of a 3497A with HP-IB interface and summarizes their functions. If you have the Serial Data (Option 232) version of the 3497A, the rear panel is identical to the one shown except that a Serial Data connector is used as the communication interface.

Display

Three types of displays: Interface Bus Status; Slot/Channel display and Function display. Function display includes voltmeter readings, digital data, time, totalized counts, or data entered from front panel or from a controller.

Keyboard

Use the keyboard to enter command sequences into the 3497A or to debug your system and check out your software. The keyboard consists of 12 alphanumeric keys (numerics 0 through 9 plus , and −); eight additional keys and a power ON/OFF switch.



DVM

Optional DVM has 5½ digit resolution and 1 μV sensitivity. The DVM includes a programmable three-level (10 μA, 100 μA or 1 mA) current source.

Alarm

If programmed, an audible alarm can be sounded for system alarm conditions. Alarm (BEEP) also sounds for illegal command entries.

Clock

A standard real-time clock provides a time base for your measurements. Month:Day:Hour: Minutes:Seconds or Day:Month:Hours:Minutes: Seconds formats are available.

Timer

Use the timer like a stop watch to monitor elapsed time or like an alarm clock to interrupt at any preset time. Timer can generate pulse trains with programmable periods up to 1 sec (interval mode) or up to 24 hours (output mode).

Figure 3. 3497A Front Panel Features

Plug-In Assemblies

Connect your system outputs to plug-in assemblies. Eleven different assemblies are available. The 3497A has slots for up to five cards and each 3498A Extender can hold up to 10 cards.

Card Cage

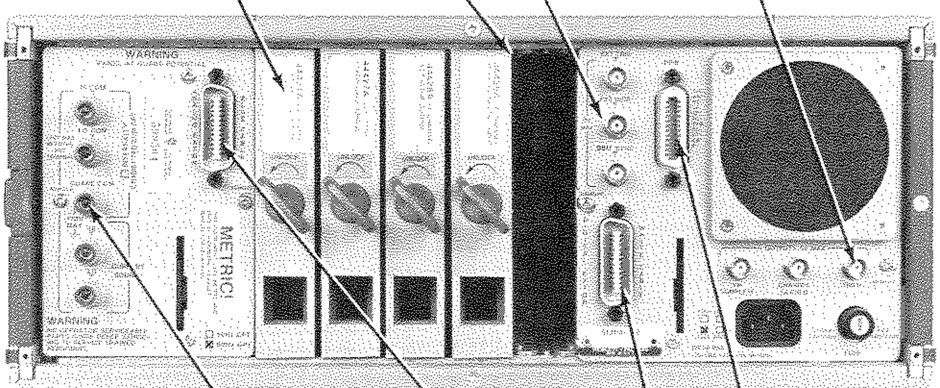
Each 3497A has slots for 5 plug-in assemblies. Slots are numbered from 0 to 4 (left to right).

BNC Input Ports

Use the EXT TRIG port to externally trigger the DVM. Use the EXT INCR port to increment analog channels with an external pulse. Use the BBM SYNC (Break-Before-Make) port to insure that only one 3497A has channel closure at any one time.

BNC Output Ports

The VM COMPLETE port outputs a TTL pulse when the DVM completes a measurement. The CHANNEL CLOSED port outputs a TTL pulse when an analog channel is closed. The TIMER port outputs pulse trains with programmable periods.



Voltmeter Connections

Use the HI COM, LO COM and GUARD COM terminals to input voltages to the DVM. Use the HI and LO CURRENT SOURCE terminals to output a programmable current (10 μA, 100 μA or 1mA) to an external circuit.

3498A Extenders

Connect up to 13 3498A Extenders to expand maximum system capability to 1000 analog channels or 1360 digital channels.

Communications Interface

HP-IB is the standard interface. RS-232 (which meets RS232C/RS423) is optional interface.

Figure 4. 3497A Rear Panel Features

3497A OPTIONS DESCRIPTIONS

As mentioned, options for the 3497A include the DVM (Option 001), plug-in assemblies (Options 010 through 140), an RS-232 interface (Option 232) and a 3498A Extender (Option 298). There are 11 plug-in assemblies which can be used with the 3497A to increase its capability for your data acquisition measurement or control application. Plug-in assemblies provide a connection interface between your system transducer outputs and the 3497A.

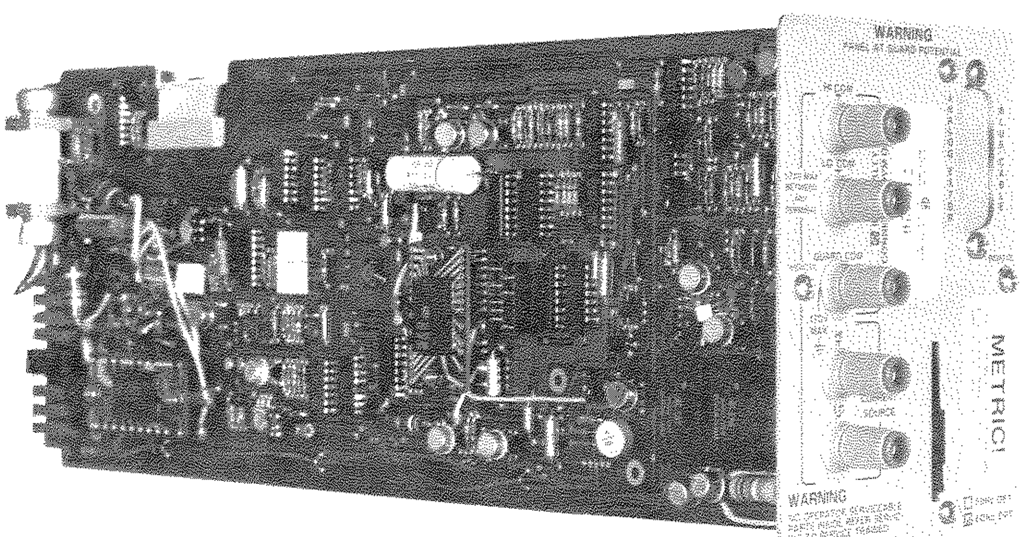
Plug-in assemblies are defined as analog or digital assemblies. Each plug-in assembly is identified by an assembly title and option number (010, 020, etc) or model number (44421A, 44422A, etc.). Descriptions of the plug-in assemblies plus the DVM (Option 001), the RS-232 interface (Option 232) and the 3498A Extender (Option 298) follow. See Appendix B, Specifications and General Information, for detailed specifications on these options.

OPTION 001

5½ Digit DVM and Current Source

Description

The 3497A DVM assembly is a systems quality, 5½ digit, 1 microvolt sensitive DC voltmeter which can measure voltages up to 119.9999 volts. The DVM assembly is fully guarded and uses an integrating A/D conversion technique which provides excellent common and normal mode noise reduction. The DVM includes a programmable three-level current source.



Features

The DVM is a very versatile instrument which has a wide range of features to measure DC voltages and (with its built-in current source) to make resistance measurements in the milliohm range. DVM operating features are shown below.

Display	Select 3½, 4½, or 5½ digit display.
Ranges	4 DC voltage ranges (.10V, 1.0V, 10.0V and 100.0V) plus autorange and 20% overrange.
Autozero	Select autozero for more accurate readings or turn autozero off for faster reading rates.
Trigger Modes	Select internal, external, software or hold trigger modes.
Trigger Rates	Program the DVM to take 1-999 readings/trigger and/or to pause between readings or after a reading. Pause intervals range from 0-99.9999 sec in 100 μsec intervals.
Reading Rates	Read a maximum of 50 readings/sec in 5½ digit mode or a maximum of 300 readings/sec in 3½ digit mode.
Reading Storage	Store up to 100 readings in the 3497A internal buffer and transfer the stored readings to a controller in one of three formats.
Current Source	The DVM contains a built-in current source which can be programmed to output a 10μA, 100 μA or 1mA constant current.

Applications

Measure low level outputs of thermocouples, strain gauges and other transducers. For high level signals, the DVM can measure a maximum of 119.999 volts. Use the DVM simultaneously with its internal current source to make high accuracy four-terminal resistance measurements with 1 milliohm resolution.

The DVM can be programmed to delay before taking a reading, to take a number of readings per trigger and to store up to a hundred (5½ digit) readings.

OPTION 010

20 Channel Relay Multiplexer Assembly

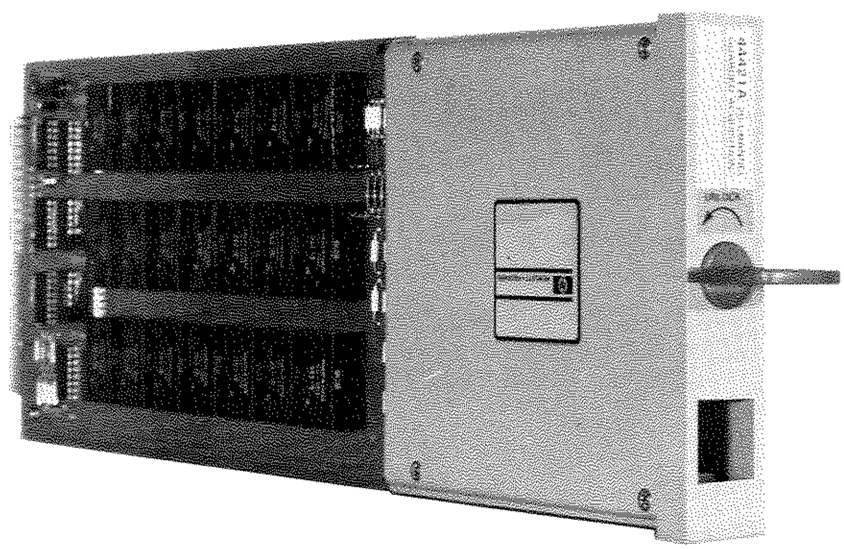
Description

Option 010 is a 20 channel analog signal multiplexer assembly which is used to switch (multiplex) signals from up to 20 channels to the 3497A DVM or to other assemblies or instruments.

Each of the 20 channels consists of three relays, one each for High, Low and Guard lines. The channels are organized into two groups of 10 channels and one channel can be closed in each decade. In addition, relays can be closed in a random fashion or can be incremented between programmable limits.

Applications

Because the 20 Channel Relay Multiplexer has low thermal offset characteristics, this option is ideal for precise low-level measurements of transducers and temperature measuring devices. Since two channels (one per decade) can be closed at a time, one Option 010 assembly can be used to make four-terminal resistance measurements.



OPTION 020

Relay Multiplexer Assembly with Thermocouple Compensation

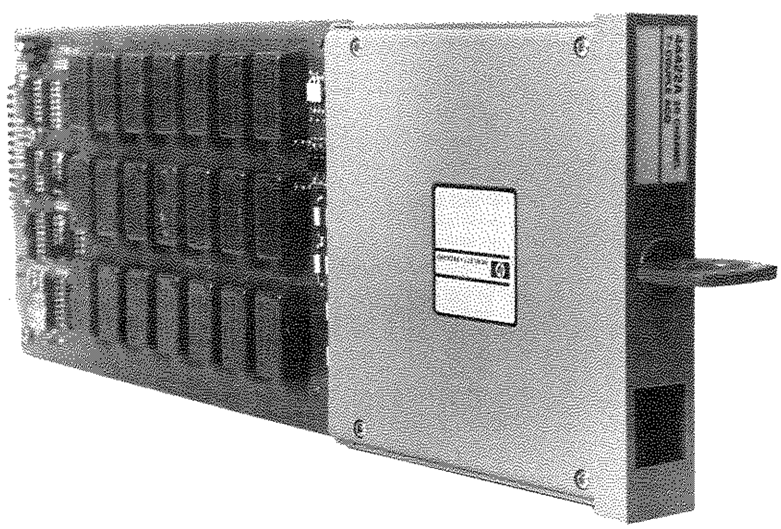
Description

The Option 020 Assembly uses the same relay multiplexer assembly as the Option 010, but adds a special isothermal connector block for thermocouple compensation to eliminate unwanted measurement errors when measuring thermocouple voltages.

The Option 020 assembly uses both hardware or software compensation techniques. Hardware compensation is limited to one thermocouple type per assembly. Software compensation can be used with any mixture of thermocouples, but requires a computer program to convert voltages measured to the associated temperatures.

Applications

Use the Option 020 assembly with hardware compensation to measure the output of up to 20 B,E,J,K,R,S or T type thermocouples (one type per assembly). Use the Option 020 assembly with software compensation to measure the output of up to 19 thermocouples (any mixture of these types).



OPTION 050

16 Channel Isolated Digital Input/Interrupt Assembly

Description

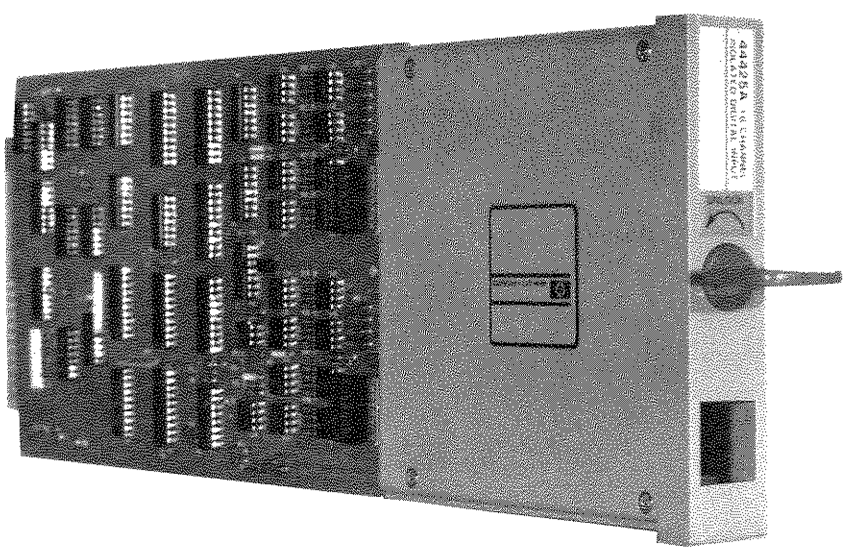
The Option 050 assembly has two functional modes: digital input mode and interrupt mode. In digital input mode, up to 16 digital inputs (ON, OFF; OPEN, CLOSE; etc.) can be input to the assembly. The assembly can also listen to digital data buses.

In interrupt mode, up to eight inputs (bits 0 - 7 in the assembly) can be monitored and, when specified system conditions occur, the assembly can send a signal (via the 3497A) to the controller to ''interrupt'' its program and take pre-programmed action.

Applications

Use the digital input mode to sense up to 16 lines of digital data such as the outputs of limit switches and position indicators. Use the interrupt mode to interrupt and take corrective action when immediate reaction to a level change is required or when the signal is transient (as in a momentary switch closure).

In addition, you can use the Option 050 assembly with the Actuator/Digital Output Assembly (Option 110) to form an independent digital input/output port.



OPTION 060

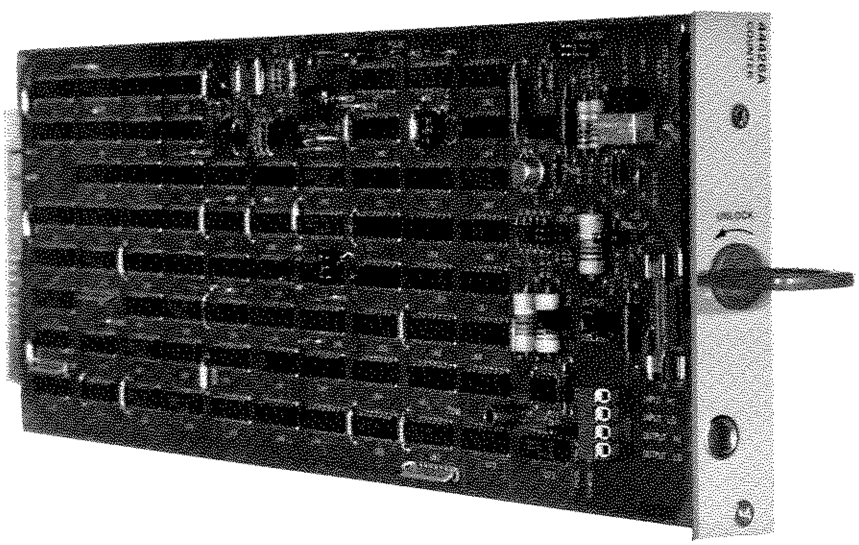
100 kHz Reciprocal Counter Assembly

Description

Option 060 is a 100 kHz reciprocal counter which can measure the period of input signals up to 100 kHz and the pulse width of signals down to 18 μsec. In addition, the counter can count up or down from a programmable start point and can output a programmable number of square wave pulses for control applications.

Applications

Use the Option 060 assembly to measure mechanical and low frequency electronic signals. Use the programmable square wave output pulse feature to control external circuits.



OPTIONS 070/071

120/350 Strain Gauge/Bridge Completion Assemblies

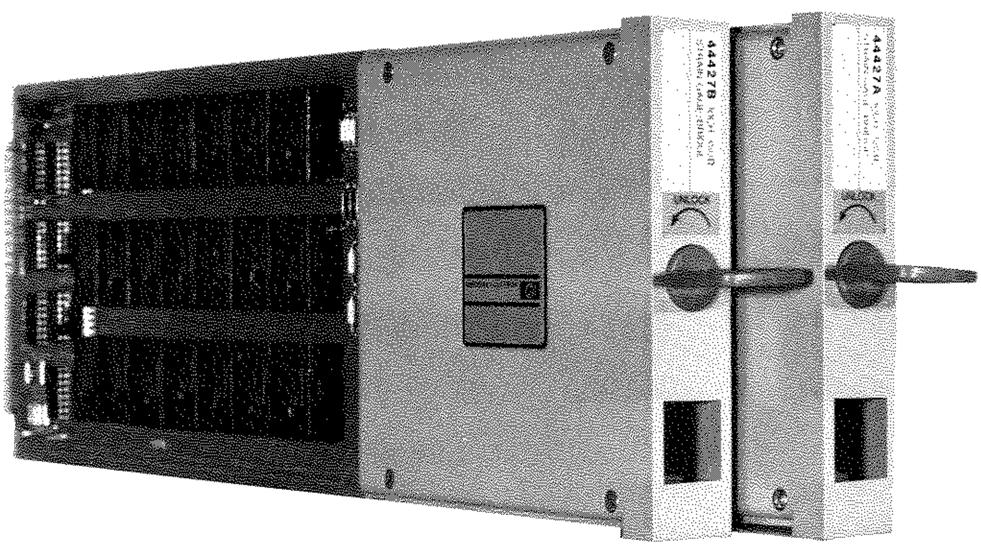
Description

The Strain Gauge/Bridge Completion assemblies provide bridge completion for strain gauges and other transducers, such as RTDs, pressure sensors and load cells. Each assembly can measure up to 10 bridges. You can measure up to 500 strain gauge channels or up to 166 three-element rosettes.

You can terminate any mixture of ¼, ½ or full-bridge circuits on the assembly. However, to compute strain, this assembly must be used with a controller.

Applications

Use the Option 070/071 assemblies to measure the outputs of strain gauges and three-element rosettes. Since these assemblies can be used in the same mainframe as other plug-in assemblies, you can mix strain measurements with other 3497A functions. For example, you can generate apparent strain curves by measuring temperature with one assembly and strain with another.



OPTION 110

Actuator/Digital Output Assembly

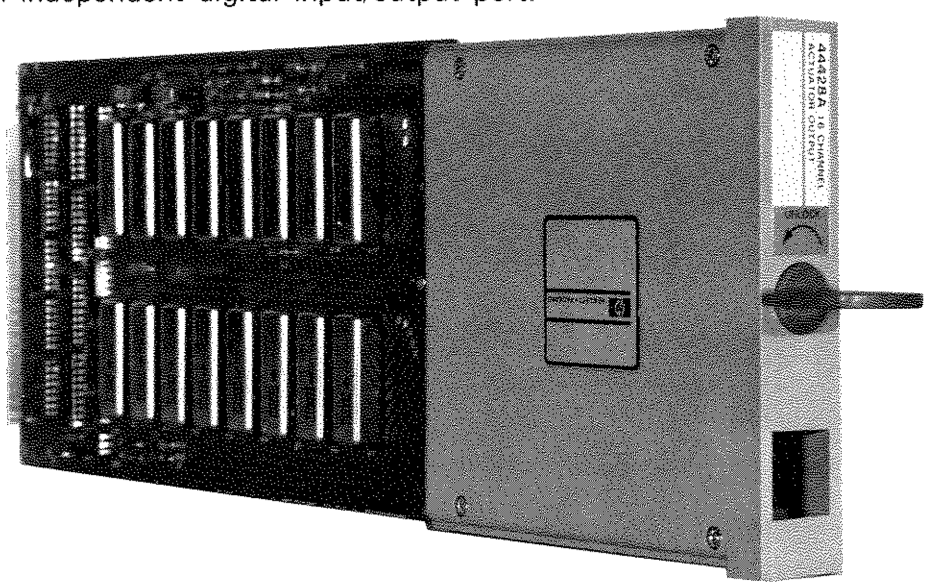
Description

The Option 110 assembly consists of 16 channels of single-pole, double-throw relays. The assembly has two different modes: actuator mode and digital output mode. In the actuator mode, each channel relay can be closed to switch power to (actuate) an external device. The relays can switch up to 1 Amp at 100 volts (peak).

In the digital output mode, each relay can be set open (logical 0) or closed (logical 1) to provide a 16-bit wide digital output.

Applications

Since the Option 110 assembly can switch one amp at 100 volts, it can be used to switch test fixture power or to actuate alarm bells. The assembly can be used with the 16 Channel Isolated Digital Input/Interrupt assembly (Option 050) to provide an independent digital input/output port.



OPTION 115

8 Channel High Voltage Actuator Assembly

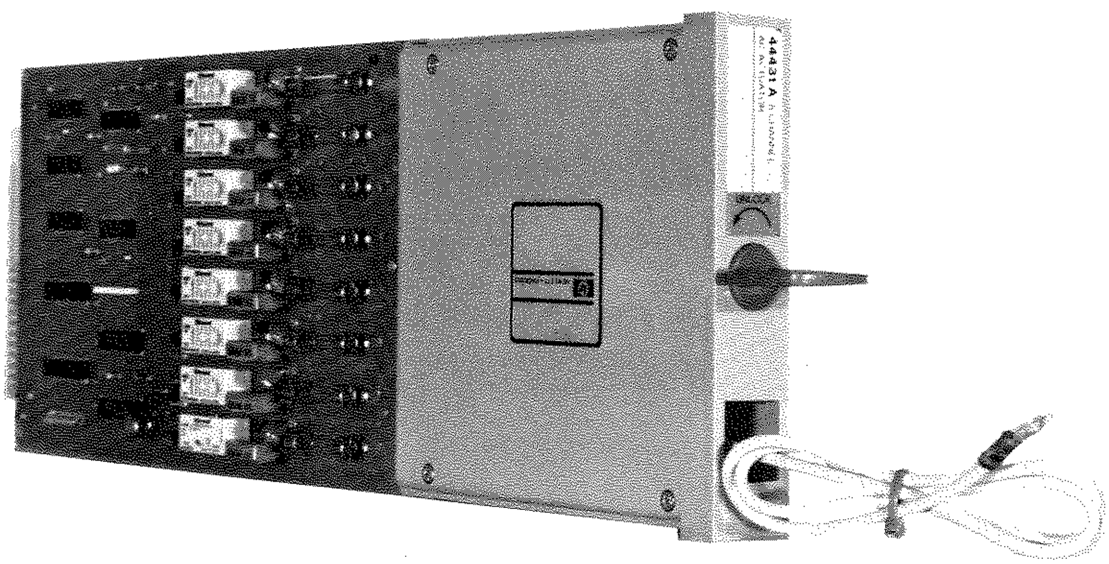
Description

Option 115 is an eight channel high voltage actuator which can be used to switch voltages up to 357 volts peak and currents up to 2 amps peak. Each channel consists of a normally open dry relay.

Each channel can be closed individually or any combination of channels can be closed simultaneously. The assembly contains a readback circuit so that the status of each channel can be determined.

Applications

Use the Option 115 Assembly to switch power line voltages to small motors, alarm bells and lights, motor starters and solenoids.



OPTION 120

Dual Output, 0 to ± 10 V Voltage D/A Converter

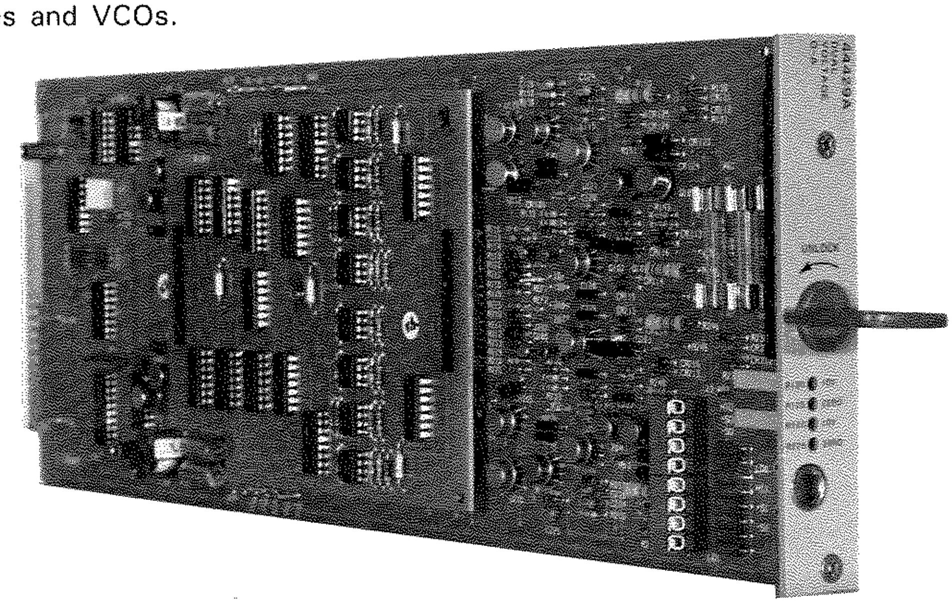
Description

The Option 120 assembly consists of two 0 to ± 10V programmable voltage sources (two channels). Each channel outputs a DC voltage with programmable range from -10.2375 volts to +10.2375 volts in increments of 2.5 millivolts.

Each voltage source is isolated from the other and from ground which breaks possible ground loops and permits control of devices floated up to 170 volts above ground.

Applications

Use the Option 120 assembly to control voltage programmed devices such as power supplies and VCOs.



OPTION 130

Dual Output, 0-20mA/ 4-20 mA Current D/A Converter

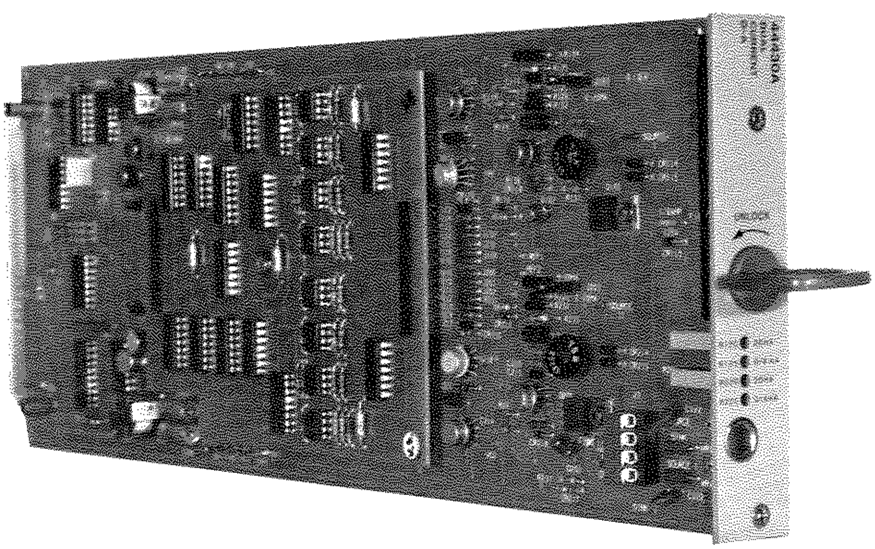
Description

The Option 130 assembly provides two 0- 20 mA or 4 - 20 mA programmable current sources. Each source can be configured to operate in a 0-20 mA range or a 4-20 mA range.

Each current source is isolated from the other and from ground which breaks possible ground loops and permits control of devices floated up to 170 volts above ground.

Applications

The Option 130 assembly, especially when the 4 - 20 mA range is used, can be used as a transmitter in an industrial current loop. Each output will drive an industrial current loop with up to 600 ohms of total loop resistance.



OPTION 140

Breadboard Card Assembly

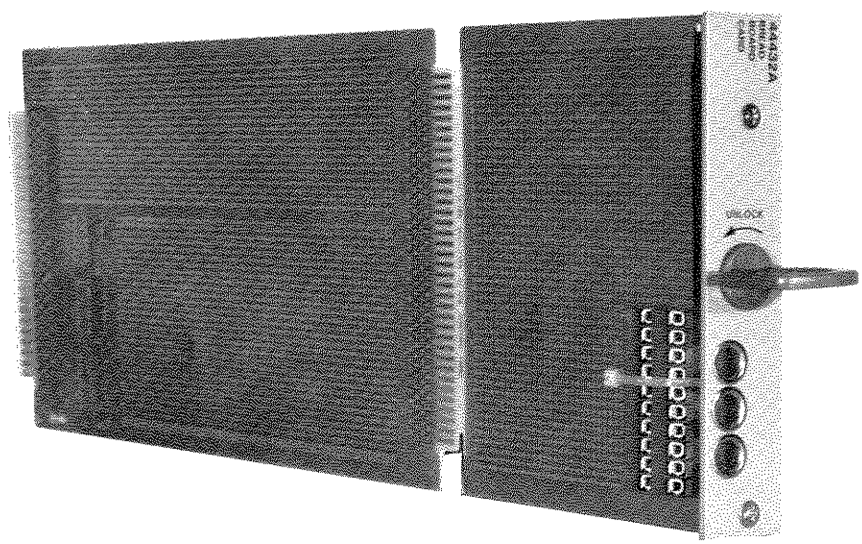
Description

In contrast to the other plug-in assemblies, Option 140 provides a ''breadboard'' for the design engineer or technician to custom design circuits for use with the 3497A or 3498A.

The board has three grid networks to mount components and power supply and ground buses. Two of the grids are labeled ANALOG SECTION and DIGITAL SECTION. The ANALOG SECTION grid contains two power supply buses and two ground buses. The DIGITAL SECTION grid contains a power supply bus and a ground bus.

Applications

Use Option 140 when you have a specialized measurement or control application which can't be satisfied by using manufactured plug-in assemblies.



OPTION 232

RS232/423 (CCITT V.24/V.10) Interface

Description

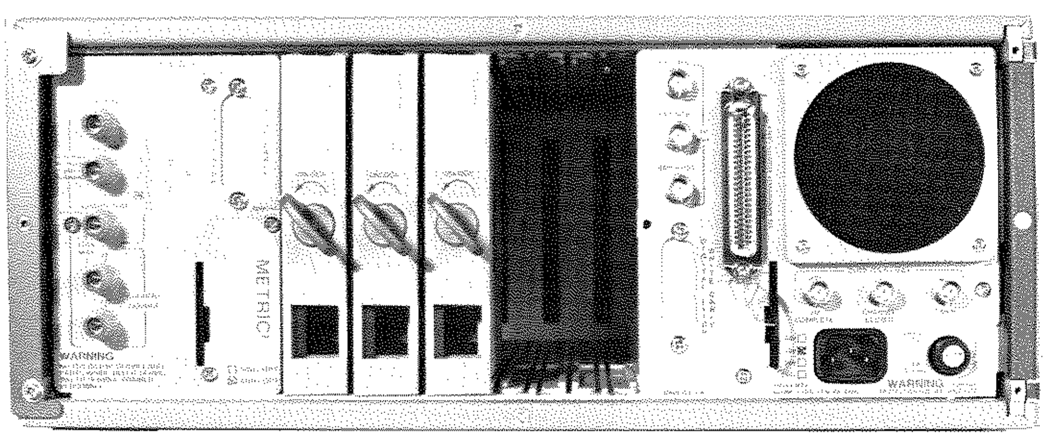
Option 232 to the 3497A deletes the standard HP-IB interface and adds an EIA RS232C (CCITT V.24) compatible serial interface. Option 232 is also compatible with the EIA version of the RS449 serial data interface standard.

Option 232 offers transmission rates of 110, 330, 600, 1200, 4800, 9600 and 19200 bits per second. You can choose even or odd parity, 7 or 8 bit character length and two handshake protocols (ENQuire/ACKnowledge or DC1).

Option 232 is compatible with computers that support RS232C or RS423 full duplex asynchronous operation and allow echo suppression.

Applications

Option 232 is especially valuable when operating the 3497A in remote locations. Use the RS232C version with MODEMS and telephone lines to control a 3497A from a computer hundreds of miles away. Use the RS423 version for point to point direct communication from the computer to a 3497A located up to 1200 meters (4000 feet) from the computer.



OPTION 298

3498A Extender

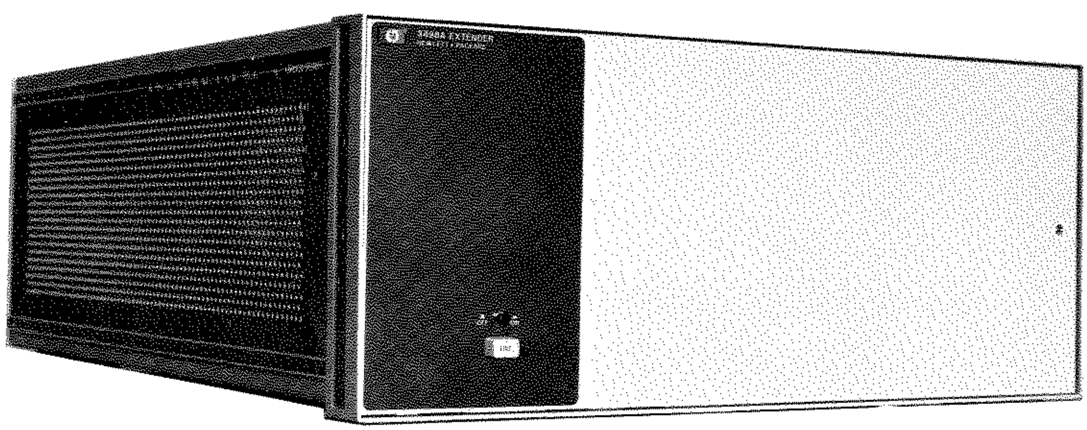
Description

The 3498A Extender allows you to add additional plug-in assemblies for expansion of system capability. Each 3498A can hold up to 10 plug-in assemblies, and you can add a maximum of thirteen 3498As to each 3497A for a total capability of 135 cards (5 in the 3497A and 10 in each 3498A).

The maximum number of analog assemblies (Options 010, 020, 070, 071) is 50 while the maximum number of digital assemblies (Options 050, 060, 110, 115, 120, 130 and 140) is 85. Maximum capability is 1000 analog channels(with 20 analog channels/assembly) and 1360 digital channels (with 16 digital channels/assembly).

Applications

Use the 3498A Extender to provide low cost expansion of 3497A based systems.



Chapter 2
FRONT PANEL OPERATION

Chapter 1 shows some ways that the 3497A can be used in data acquisition and control system applications and briefly describes the features of the instrument. In this chapter, we'll show how to control the 3497A operation by entering commands from the front panel keyboard. This chapter is divided into five parts: TURNING THE 3497A ON, COMMANDS, ADDRESSING, DISPLAY and KEYBOARD.

- TURNING THE 3497A ON shows you how to turn the instrument on and how to do the self-test to check the instrument for proper operation.
- COMMANDS describes the instruction set used to control the operation of the 3497A and shows command format and a command summary.
- ADDRESSING shows the 3497A/3498A slot and channel numbering system and shows how to address analog and digital assemblies.
- DISPLAY describes the functions of the front panel display and shows some sample analog and digital displays.
- KEYBOARD describes the keys on the front panel keyboard and shows sample keystroke sequences to enter commands.

TURNING THE 3497A ON

Before we begin the discussion on commands and front panel operation, let's turn the 3497A on to make sure that it is operating properly. For this chapter, we'll assume that the 3497A has been initially inspected and that the instrument is NOT connected to your system.

If the 3497A is connected to your system, you may want to have a service-trained person temporarily disconnect the instrument so that you can enter command sequences without possible damage to your equipment.

WARNING

If you have just received your new 3497A, don't turn the instrument on until a qualified, service-trained person has performed an initial inspection of the 3497A.

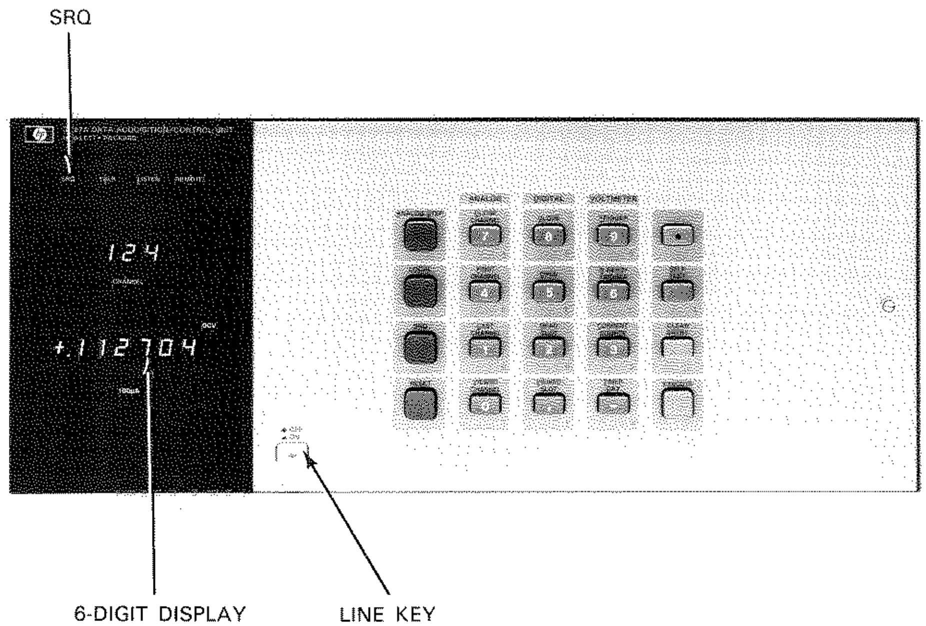
As shipped from the factory, a protective cover is installed over the card cage and DVM terminals. Because of potentially high voltages at the back of the instrument, this cover must be installed whenever the 3497A is connected to an external input. The cover should be removed only by service-trained personnel.

Power On Sequence

To start the discussion on front panel operation, let's cycle the 3497A through its power-on sequence and then do the self-test. The 3497A is very easy to operate by using front panel control (or by using a controller). And don't worry, you can't hurt the 3497A by pressing any of the front panel keys as long as the instrument is not connected to your system.

To turn the 3497A on, press the LINE key ON (see Figure 5 for location) and carefully observe the 6-digit display on the front panel as it cycles through sequences (a) through (e) as shown in Figure 5. Since the display cycles very quickly, you may want to press the LINE key ON and OFF a few times to better observe the sequence.

You should also hear an audible BEEP when you first press the LINE switch ON. If POWER-ON SRQ has been set, the SRQ indicator will also turn ON. (POWER-ON SRQ is set to OFF at the factory). If the display does not match that shown, an error message is displayed.



	6-Digit Display	Meaning
(a)	+.8.8.8.8.8.8	The 3497A goes through a complete self-test at power-on.
(b)	HP 3497	Identifies the instrument as the -hp- 3497A.
(c)	-Add 009	Shows that the 3497A is set to address of 09 (HP-IB version).
(d)	------	This is the final step of the power-on sequence for a 3497A without the optional DVM (Option 001).
(e)	DCV . +.112702 Blinking Light	This is the final step of the sequence for a 3497A with a DVM. The blinking light shows internal triggering of the DVM and the + shows completed measurement.
		The six-digit display shows the background DC voltage measured by the DVM and changes continuously as the DVM is triggered. The DCV light shows a DC Voltage measurement.

Figure 5. Power On Sequence

Self-Test

Next, let's do the self-test of the 3497A by pressing the SELF-TEST key (see Figure 6 for location). At the completion of the self-test, the display should be as shown in Figure 6. If the self-test fails, the 3497A will display an error message.

After you press the SELF-TEST key, note that the light in the center of the SHIFT (blue) key is on. If your 3497A has a DVM, the light at the upper left-hand corner of the six-digit display is blinking, indicating internal triggering of the DVM. This completes the self-test procedure. Now turn the 3497A off by pressing the LINE switch OFF while we discuss the commands for the 3497A.

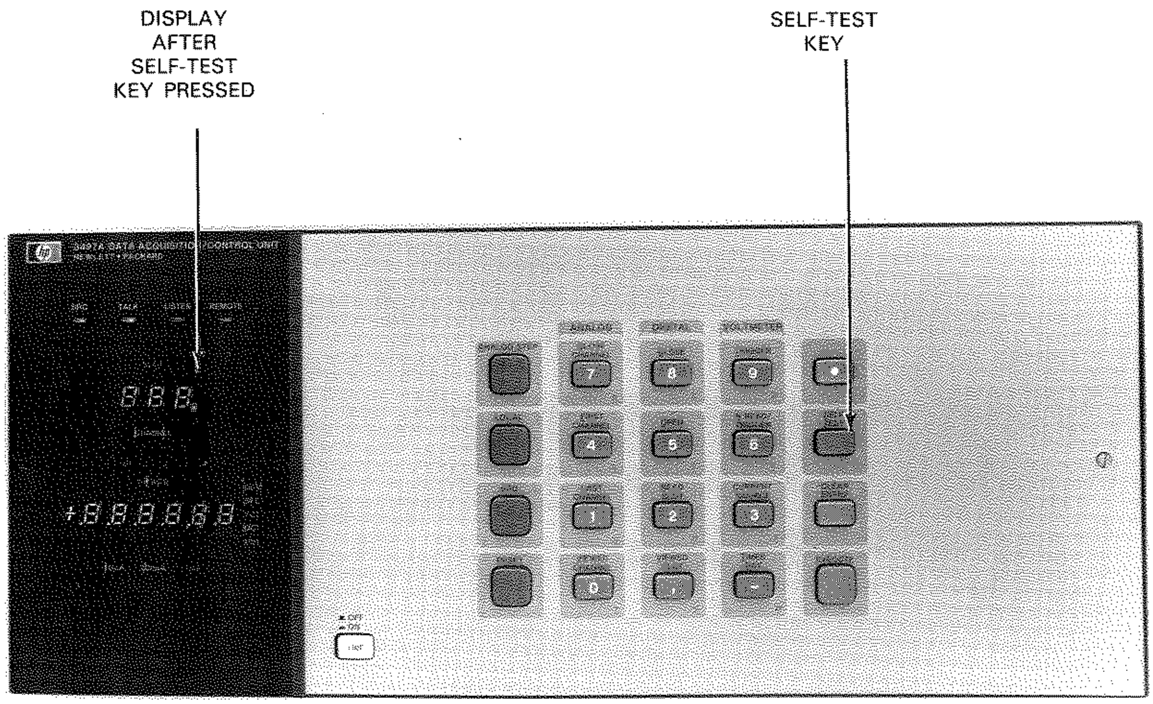


Figure 6. Self-Test Display

COMMANDS

Recall from Chapter 1 that the 3497A can be controlled by entering commands from the front panel keyboard or by sending commands from a controller via a communications (HP-IB or Serial Data) interface. In this part of the chapter, we'll show how to enter commands from the front panel. Before we see how to enter commands, we'll describe the command set for the 3497A.

Command Format

The 3497A is controlled by a command set which consists of six command groups: ANALOG, COUNTER, DIGITAL, SYSTEM, TIMER and VOLTMETER. The first letter of each command identifies the command group (i. e. A = ANALOG, C = COUNTER, D = DIGITAL, S = SYSTEM, T = TIMER and V = VOLTMETER). The 3497A recognizes binary code command sequences based on ASCII (American Standard Code for Information Interchange) standards.

In general, commands for the 3497A consist of two alpha characters (letters) followed by one or more data characters (numbers). However, some commands consist of only the two alpha characters. The first letter of a command identifies the command group, the second letter identifies the subgroup in the group and the data characters are parameters which act as qualifiers.

COMMAND FORMAT

XY n1,n2,.....

Command Group (X)
Command Subgroup (Y)
Data Characters (Parameters) (n1,n2,.....)

The data characters (n1,n2, etc.) can refer to addresses, values or conditions. They specify addresses for slot and channel numbers in plug-in assemblies; values for voltage or current level output; or conditions such as on or off.

EXAMPLE - ADDRESS PARAMETER

For example, AC10 is the command to close analog channel 10. In this command, A shows that the command belongs to the ANALOG command group, AC tells the 3497A to close an analog channel and data characters 10 define an address (analog channel 10) for the action to take place.

AC 10

AC = Close Analog Channel (AC)
Analog Channel 10 (10)

EXAMPLE - VALUE PARAMETER

As a second example, VC2 is the command to set the current source in the DVM to 100μA output. VC specifies that the current source is to be turned on and 2 specifies the value of the current as 100 μA.

VC 2

VC = Turn Current Source on (VC) — (2) 100μA output

Command Directory

For convenience, a Command Directory is located in Chapter 6 which summarizes the command format, shows typical programming examples and gives special operating notes for each command. Commands are listed alphabetically by command group and commands within each group.

The table which follows summarizes the commands shown in the Command Directory so that you can become familiar with the command format and functions. You may want to take a few minutes to examine the table before proceeding to the next section on addressing.

The format of each command remains the same whether you are entering the command from the front panel or from a controller. For example, we saw that AC10 was the command to close analog channel 10 from the front panel. To enter this same command from an -hp- 85 Desktop Computer via an HP-IB interface, the command is OUTPUT 709; ''AC10''. Thus, the AC10 command remains the same and only the controller mnemonics change.

Chapter 3 shows how to enter commands from a controller if your 3497A has HP-IB interface, while Chapter 4 shows how to enter commands for a 3497A with Serial Data (RS-232 or RS-449/423) interface.

3497A COMMANDS

ANALOG

AC chan#,chan#,... chan# = 0 to 999	ANALOG CLOSE. Closes 1 to 4 channels (one per decade) of analog assemblies.
AEn, n = 0 to 2 AE0 = EXT INCR OFF AE1 = EXT INCR ON AE2 = FAST SCAN	ANALOG EXTERNAL INCREMENT. Enables or disables the EXT INCR port. In FAST SCAN (AE2), multiframe BBM Sync is ignored. In AE1, external pulse into EXT INCR port increments channel closed to next channel.
AF chan# chan# = 0 to 999	ANALOG FIRST CHANNEL. Selects first channel to be closed in an analog sequence but does not close channel.
AI chan# chan# = 0 to 999	ANALOG INPUT. Closes channel and triggers DVM to take a measurement.
AL chan# chan# = 0 to 999	ANALOG LAST CHANNEL. Selects last channel to be closed in an analog sequence but does not close channel.
AO slot#,chan#,value slot# = 0 to 89 chan# = 0 or 1 value = 0 to ±10238 (VDAC) 0 to 10238 (IDAC)	ANALOG OUTPUT. Sets the output voltage level for the VDAC and output current level for the IDAC. VDAC output is −10.2375V to +10.2375V in 2.5 mV increments. IDAC output is 0−20 mA (5μA increments) or 4−20 mA (4 μA increments).
AR	ANALOG RESET. Opens analog assembly channels in 3497A and 3498A and sets VF1, VT1, VR5, VW0, VS0, AE0, AF0 and AL999.
AS	ANALOG STEP. Performs software channel advance from the presently closed channel to next channel. Repeating the command sequences channels from AF to AL and back to AF. If AF<AL, channels increment. If AF>AL, channels decrement.
AV chan# chan# = 0 to 999	ANALOG VIEWED CHANNEL. Dedicates display to channel selected but does not close channel and does not affect other 3497A operations. Display is updated when channel closed and measurement taken.

COUNTER

CE slot#,n
slot# = 0 to 4; n = 0 to 2 0 = No interrupts enabled 1 = Interrupt on measurement complete 2 = Interrupt on overflow

COUNTER ENABLE INTERRUPTS.

Enables counter to send an interrupt to 3497A when specified interrupt condition occurs. If 3497A is set for Digital Interrupt, interrupt is sent to controller.

CF slot#,n
slot# = 0 to 89; n = 0 to 6 0 = Counter Stop 1 = Count Up 2 = Count Down 3 = Avg 1000 Periods 4 = Avg 100 Periods 5 = Measure 1 Period 6 = Measure 1 Period

COUNTER FUNCTION.

Sets mode of operation for the counter and starts the function. CT command MUST be set before CF command is executed. For n = 3 to 6, CT slot#, 1 and 2 set period measurements and CT slot#, 3 and 4 set pulse width measurements.

CR slot#,n
slot# = 0 to 89; n = 1 to 3 1 = Read without wait 2 = Read with wait 3 = Read continuously

COUNTER READ.

Allows the results of counter measurements to be read in one of three ways.

CS slot#,value
slot# = 0 to 89 value = 0 to 999999

COUNTER SET.

Sets the start point (0 to 999999) for the Count Up or Count Down functions. Also sets number of pulses in Pulse Output mode (start point value = twice the number of pulses output).

CT slot#,n
slot# = 0 to 89; n = 1 to 4 1 = Rising/Rising Edges 2 = Falling/Falling Edges 3 = Rising/Falling Edges 4 = Falling/Rising Edges

COUNTER TRIGGER.

Selects edge of input signal on which to trigger counter. For Count Up or Count Down, CT slot#, 1 and 3 perform same function as do CT slot#, 2 and 4.

DIGITAL

DC slot#,chan#,chan#,... slot# = 0 to 89 chan# = 0 to 15	DIGITAL CLOSE. For Option 110 assembly, command connects NO contact to common. For Option 115 assembly, command closes channel relays. Channels not specified remain in previous state.
DE slot#,value slot# = 0 to 4 value = 0 to 377 (Octal)	DIGITAL INTERRUPT ENABLE. Enables the Option 050 assembly to send an interrupt to the 3497A when channel bits selected by the command are set true (by external input to the assembly).
DI slot# slot# = 0 to 4	DIGITAL INTERRUPT STATUS. Used to determine interrupt status of bits 0 – 7 in the Option 050 assembly. Also used to determine cause of interrupt from the Option 060 assembly.
DL slot# slot# = 0 to 89	DIGITAL LOAD. For Option 050 assembly, returns octal value (0 – 177777) of contents of 16 input channels. For Option 110 assembly, returns octal value (0 – 177777) of condition of 16 output channels. For Option 115 assembly, returns octal value (0 – 377) of condition of 8 channel relays.
DO slot#,chan#,chan#.... slot# = 0 to 89 chan# = 0 to 15	DIGITAL OPEN. For Option 110 assembly, connects NC contact to common for channels specified. For Option 115 assembly, opens relays in channels specified. Relays in channels not specified remain in previous state.
DR slot# slot# = 0 to 89	DIGITAL READ. For HP-IB, DR returns same information as DL command, except that readings are continuously updated. For Serial Data, with SO1 in effect returns continuously updated readings. With SO0 in effect, returns one reading per command.
DS slot# slot# = 0 to 4 value = 0 to 377 (Octal)	DIGITAL INTERRUPT SENSE. Sets edge transition sense which will cause channel 0 – 7 bits to be set in an Option 050 assembly. Polarity sense set by octal value. Polarity sense 1 = chan bit set by low-to-high transition.
DV slot# slot# = 0 to 89	DIGITAL VIEWED SLOT. Dedicates the front panel display to slot specified. To exit this mode, use DV without slot specifier.
DW slot#,value slot# = 0 to 89 value = 0 to 177777 (octal)	DIGITAL WRITE. For Option 110 assembly, connects NO or NC contact to common as specified by octal value. For Option 115 assembly, opens or closes relays as specified by octal value. All chans of assy in slot addressed are affected by DW command.

SYSTEM

Command	Description
SA	SYSTEM ALARM. Initiates an audible alarm (BEEP).
SC [Serial Data]	SYSTEM CLEAR. For Serial Data operation, the SC command is similar to BREAK message, except that SC does not clear the command buffer or return the 3497A to local mode. SC clears system errors but does not reset VF2, VF3 or clear voltmeter storage.
SDn SD0 = Display OFF SD1 = Display ON	SYSTEM DISPLAY. SD0 turns off the 6-digit display and CHANNEL lights for faster reading rates. With SD0, only data entered with SVn command affects display.
SEn [HP-IB] n = 0 to 377 (octal)	SERVICE REQUEST ENABLE. SE sets the SRQ mask bits which enables 3497A to send an interrupt to the controller when specified system conditions occur.
SEn [Serial Data] n = 0 to 377 (octal)	SERVICE REQUEST ENABLE. SE sets the interrupt mask bits which enables 3497A to send an interrupt to the controller when specified system conditions occur.
SI	SYSTEM INITIALIZE. Sets the digital assemblies and the DVM to initial conditions but does not affect the analog assemblies.
SLn [Serial Data] SL0 = Keyboard Enabled SL1 = Keyboard Disabled	SYSTEM LOCK. Used to disable the front panel keys so that commands can't be entered from the front panel. With SL1, 3497A can't be returned to local mode unless SL0 is sent or power is turned off.
SOn [HP-IB] SO0 = Output immed. SO1 = Output reading on controller request	SYSTEM OUTPUT WAIT. When SO1 in effect, two modes to return data to controller. With VS0, 3497A takes measurement and waits for controller request to transfer data. With VS1 or VS2, 3497A takes n readings (as set by VNn) and waits for controller request to transfer.
SOn [Serial Data] SO0 = Cont output SO1 = One output/comd	SYSTEM SINGLE/CONTINUOUS OUTPUT. SO1 enables 3497A to send a single reading/command for commands which normally return continuous data, such as ST, VT1, DR slot#, TD and CR slot#,3.
SR slot#,n slot# = 0 to 89; n = 0 to 7 SR slot#,0 = Read sig SR slot#,0 – 7 = Read register [Option 140]	SYSTEM READ. Use SR slot#,0 to determine type of assembly in slot (except analog assemblies). Use SR slot#, 0 through 7 to read register n in slot addressed (Option 140 only).
SR [Serial Data]	STATUS REGISTER READ. The SR command returns a six-bit octal value of the status register true bits.

STn
ST0 = Self Test OFF ST1 = Self Test ON

SELF-TEST

ST1 causes 3497A to perform internal self-test. 8E8 returned if self-test passes.

SVn
n = ±999999

SYSTEM VIEW.

When the display is turned off by an SD0 command, the SV command writes data specified by n to the display.

SW slot#,register#,data
slot# = 0 to 89 register# = 0 to 7 data = 0 to 377

SYSTEM WRITE.

Use SW to write data to any assembly directly controlled by the main processor (i.e. digital assemblies).

TIMER

TA HH MM SS
Hours = 0 to 24 Minutes = 0 to 59 Seconds = 0 to 59

TIME ALARM (SET).

Sets 3497A timer. If SRQ mask (HP-IB) or interrupt mask (Serial Data) has been set for time alarm, interrupt sent to controller when time on real-time clock matches time set by TA.

TD MMDDHHMMSS or TD DDMMHHMMSS

TIME OF DAY (SET).

Sets 3497A real-time clock to programmed time.

TD

TIME OF DAY (READ).

Reads time of day from real-time clock. Data returned has format MM:DD:HH:MM:SS or (European) DD:MM:HH:MM:SS.

TEn
TE0 = RESET TE1 = HALT TE2 = START

ELAPSED TIME (CONTROL).

Use TEn to monitor elapsed time from start of an operation. Use the TE command (without a number) to read time elapsed since TE2 command received.

TE

ELAPSED TIME (READ).

Use TE to read elapsed time (1 sec increments) since elapsed timer control started by TE2 command. Data returned has format DDDDDD sec.

TI HH MM SS

TIME INTERVAL.

Use TIn to generate pulses from TIMER port with periods from 1 sec to 24 hr. If SRQ or interrupt mask set, 3497A sends interrupt for every pulse output.

TOn
n = 0 to 9999

TIME OUTPUT.

Use TOn to generate pulses from TIMER port with periods from 100 μsec to 0.9999 sec (in 100 μsec increments). Period output is n x 100 μsec. Interrupt not available with TOn command.

VOLTMETER

VAn	
VA0 = Autozero OFF VA1 = Autozero ON	**VOLTMETER AUTOZERO.** With autozero on, DVM takes measurement between each reading. With autozero off, DVM makes autozero measurement before first reading and when DVM switched to new range.

VCn n = 0 to 3	
0 = OFF 1 = 10 μA 2 = 100 μA 3 = 10 mA	**VOLTMETER CURRENT SOURCE RANGE.** Programs output of DVM current source to 1 of 3 values: 10 μA, 100 μA or 10 mA.

VDn n = 3 to 5	
3 = 3 1/2 digits 4 = 4 1/2 digits 5 = 5 1/2 digits	**VOLTMETER DISPLAY.** Selects number of digits to be displayed on front panel and sets voltmeter integration time. Max reading rate for 60 Hz operation is 300 readings/sec (Autozero OFF). Max rate for 50 Hz is 250 readings/sec.

VFn n = 1 to 3	
1 = ASCII 2 = Packed BCD 3 = Time, ASCII, Chan#	**VOLTMETER FORMAT.** Selects the output format for transmission of data over the bus, when voltmeter storage is off (VSO).

VNn n = 1 to 999	
	VOLTMETER NUMBER READINGS/TRIGGER. Sets number of readings taken per trigger pulse input. Readings are taken sequentially and output over the bus in format set by VFn.

VRn n = 1 to 5	
1 = 0.1V 2 = 1.0V 3 = 10 V 4 = 100V 5 = Autorange	**VOLTMETER RANGE.** Sets range of DVM. Maximum overrange capability for each range is 120% of full-scale. In autorange, DVM upranges at 120% of full-scale and downranges at 11% of full-scale.

VSn n = 0 to 2	
0 = Storage OFF 1 = Store in ASCII 2 = Packed BCD	**VOLTMETER STORAGE.** Store up to 60 readings in ASCII (50 for Serial Data) or up to 100 readings in Packed BCD (85 in Serial Data). Use VS without number to transfer readings to controller.

VTn n = 1 to 4	
1 = Internal 2 = External 3 = Software 4 = Hold	**VOLTMETER TRIGGER.** Set one of four trigger modes. In internal, DVM automatically takes another reading when present one completed. In external, trigger signal input to EXT TRIG port causes DVM to take n readings/trigger (as set by VNn). In software, command causes DVM to trigger and take n readings as set by VNn. In hold, DVM pauses and does not take measurements.

VWn n = 0 to 999999	
	VOLTMETER WAIT. Causes the DVM to wait n x 100 μsec between each reading. Maximum wait time is 99.9999 sec.

ADDRESSING

Previously, we said that the data characters in a command can specify addresses, values or conditions. When the data characters specify addresses, the addressing scheme used depends on whether analog or digital assemblies are to be addressed. As shown in Chapter 1, plug-in assemblies are defined as analog or digital assemblies, depending on the type of command(s) which the assembly recognizes.

For the 3497A, plug-in assemblies Options 010, 020, 070 and 071 are defined as analog assemblies. The remaining plug-in assemblies (Options 050, 060, 110, 115, 120, 130 and 140) are defined as digital assemblies. The formats for addressing plug-in assemblies are shown below. In this part of the chapter, we'll show how to address analog and then digital assemblies.

PLUG-IN ASSEMBLY ADDRESSING

Type	Option(s)	Command Format
Analog Assemblies		
Multiplexers	010, 020	AX chan#, chan#, ...
Strain Gauge	070, 071	AX chan#, chan#, ...
Digital Assemblies		
Digital Input	050	DX slot#, chan#, chan#,...
Actuators	110,115	DX slot#, chan#, chan#,...
Counter	060	CX slot#, function
D/A Converters	120, 130	AO slot#, chan#, value
Breadboard	140	SX slot#, register, value

Analog Assembly Addressing

Analog assemblies are addressed by channel number, with channel numbers from 0-999. Recall that the 3497A has five slot numbers (0-4) and each 3498A Extender has 10 slots. Each slot in a 3497A and 3498A is assigned 20 analog channel numbers, starting with channels 0-19 in slot 0. Slot 1 has channel addresses 20-39, slot 2 has addresses 40-59, etc.

This table shows the addresses for analog assemblies, by slot number, in the 3497A and 3498A. Since slot numbers 5 through 9 do not exist, slot number 10 (the left slot in the first 3498A) has channel addresses 100-119. Although you can add up to thirteen 3498As to a 3497A, the 3497A can only address a maximum of 1000 analog channels (channels 0-999).

3497A/3498A ANALOG ASSEMBLY ADDRESSES

3497A		3498A*	
Slot	Channel Numbers	Slot	Channel Numbers
0	0 - 19	10	100 - 119
1	20 - 39	11	120 - 139
2	40 - 59	12	140 - 159
3	60 - 79	13	160 - 179
4	80 - 99	14	180 - 199
		15	200 - 219
		16	220 - 239
		17	240 - 259
		18	260 - 279
		19	280 - 299

* For first 3498A only. The second 3498A has slot numbers 20 - 29 and channel numbers 300 - 499, etc. up to channel 999. Slots 5 - 9 do not exist.

EXAMPLE - CLOSE ANALOG CHANNELS

To close a channel of an analog assembly in slot 2, the command is AC40 through AC59, depending on the channel to be closed in the assembly. To close a channel of the same assembly placed in slot 4, the command is AC80 through AC99. Note that the slot number is not a part of the analog assembly addressing scheme.

AC45 — Closes channel of an analog assembly in slot 2.

AC85 — Closes same channel of an analog assembly in slot 4.

Digital Assembly Addressing

In contrast to analog assembly addressing, the slot number in which a digital assembly is placed is a part of the addressing scheme. Commands for digital assemblies have the form XY slot#, chan#,chan#,... with slot numbers from 0-4 and 10-89 and channel numbers 0-15 for each slot. That is, slot 1 has channel numbers 0-15, slot 2 has channel numbers 0-15, etc. Since slots 5-9 do not exist, the first 3498A has slots 10-19, as shown in the table.

Although you can add a maximum of thirteen 3498As to a 3497A, the 3497A can only address a maximum of 90 slots (slots 0-89). Since each slot has 16 channels (channel 0-15), a maximum of 1360 digital channels can be addressed.

The command group does not necessarily specify whether analog or digital assemblies are to be addressed. For example, the 100 kHz counter (Option 060) responds to the COUNTER command group, but is a digital assembly since the COUNTER command group has the form CX slot#, function. Also, the two D/A converter assemblies (Options 120 and 130) respond to a single ANALOG command (AO slot#,chan#,value) but they too are digital assemblies since the command has the form XY slot#, ...

3497A/3498A DIGITAL ASSEMBLY ADDRESSING

3497A

SLOT #	0	1	2	3	4
CHANNELS	0-15	0-15	0-15	0-15	0-15

3498A *

SLOT #	10	11	12	. . .	19
CHANNELS	0-15	0-15	0-15		0-15

* First 3498A only. The second 3498A has slot numbers 20-29, up to a maximum of 89 slots.

EXAMPLE - CLOSE DIGITAL CHANNELS

To close a channel of a digital assembly in slot 1, the command is DC1,0 through DC1,15. To close a channel of the same digital assembly in slot 4, the command is DC4,0 through DC4,15.

DC1,5	DC3,5
Closes channel 5 of a digital assembly in slot 1.	Closes same channel of a digital assembly in slot 3.

DISPLAY

Now that we have introduced the commands for the 3497A and discussed the addressing scheme, let's take a closer look at the front panel of the 3497A, beginning with the display.

For convenience, we'll divide the display into three functional groups: Interface Bus Status display; Slot/Channel display and Function display. Figure 7 shows the display after a self-test of the 3497A. As you read the description, you may want to do the self-test again so that the display on your 3497A matches that in Figure 7.

Interface Bus Status Display

The interface bus status indicators show the status of activity on the interface bus. Figure 7 summarizes the functions of each of the four LEDs. The SRQ and REMOTE indications are the same for HP-IB or Serial Data operation. For the conditions described in Figure 7, the TALK and LISTEN lights flash on and off for Serial Data operation but remain on for HP-IB operation. See Chapter 3 (HP-IB) or Chapter 4 (Serial Data) for further information on these indicators.

INTERFACE BUS STATUS DISPLAY

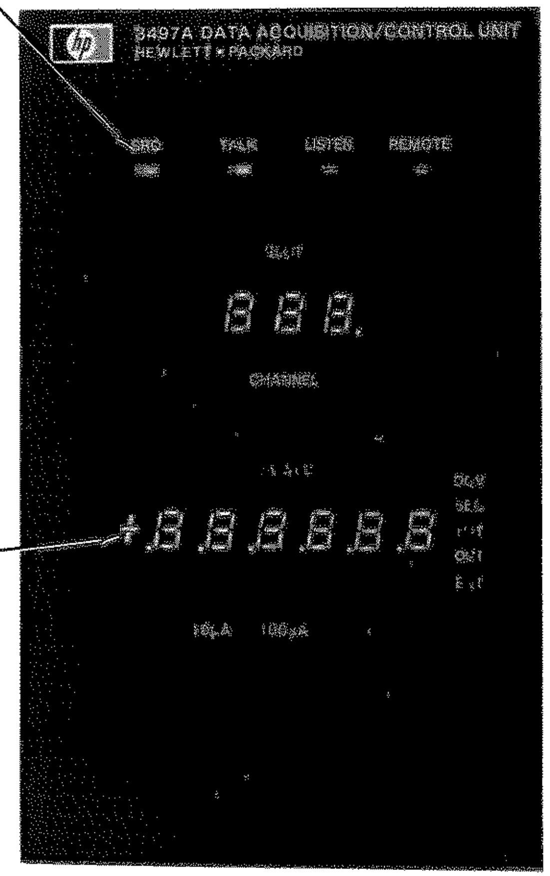
The interface bus status display shows the status of activity on the HP-IB or Serial Data interface bus. There are four LED annunciator lights. For HP-IB operation, each LED is on for the condition shown. For Serial Data (RS232C or RS449/423) operation, the TALK and LISTEN LEDs flash on and off for the conditions shown.

LED	ON (OR FLASHING) WHEN THE 3497A:
SRQ	Makes a Service Request (SRQ) to the controller. If the controller is programmed to respond to the SRQ, a Service Request interrupts current controller activity to take action as previously specified.
TALK	Sends information to the controller (i.e. the 3497A is an active TALKER over the HP-IB). This information can be data or control information, such as SRQ.
LISTEN	Receives information from the controller (i.e. the 3497A is an active LISTENER on the bus). When the 3497A is in the LISTEN mode, the REMOTE indicator is also on.
REMOTE	Is externally controlled by a controller over the interface bus. In REMOTE mode, the front panel keyboard, except for the ANALOG AND DIGITAL VIEWED keys, the SRQ key and the LOCAL key, is disabled.

FUNCTION DISPLAY

The function display shows the decimal value of an analog measurement or the octal value of digital data returned from a channel. The value of the data is shown on the six-digit display and the type of data is shown on the 5 LED indicators to the right of the display.

LED ON	TYPE OF DISPLAY
DCV	DC voltage measured by the DVM.
SEC	Period or pulse width (in seconds) of an input signal.
TOT	Totalized number of counts of input. (999999 counts maximum).
OCT	Display is octal value of digital data entered.
ENT	Value of data entered (up to six digits) from front panel or from controller.
CURRENT SOURCE (10 μA, 100μA, 1mA LEDs)	These LEDs are ON when the DVM current source outputs a current from the 3497A. LED which is ON shows the value of the current output (10μA, 100μA or 1 mA).



SLOT/CHANNEL DISPLAY

The slot/channel display shows information on slot or channel addressed. This display has two different forms: analog display when analog assemblies are addressed or digital display when digital assemblies are addressed.

LED	MEANING
SLOT	ON when a digital assembly is addressed.
3-DIGIT DISPLAY	When the SLOT indicator is ON, displays the number of the digital slot addressed. When the CHANNEL indicator is on, displays the number of the analog channel addressed.
CHANNEL	Indicates analog channel when analog assemblies are addressed. Indicates channel within a digital slot when digital assemblies are addressed.
CHANNEL LEDs	The LEDs ON show the channel(s) bits true (set to 1) within a digital slot.
VIEWED	ON when ANALOG VIEWED or DIGITAL VIEWED command is used.

Figure 7. Front Panel Display

Slot/Channel Display

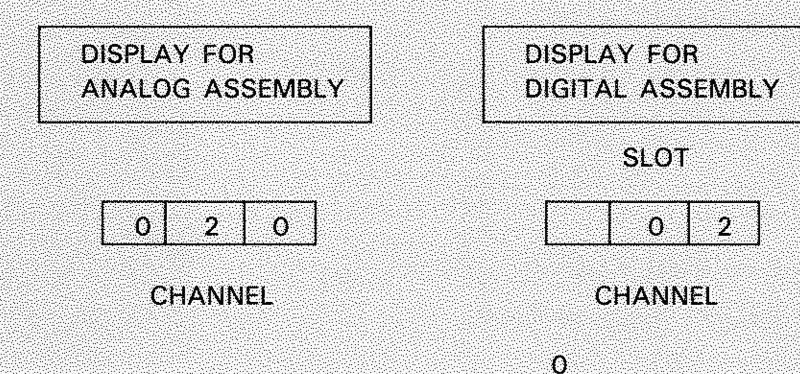
The slot/channel display consists of 5 indicators: SLOT, 3-DIGIT DISPLAY, CHANNEL, CHANNEL LEDs and VIEWED. The slot/channel display has a dual purpose, depending on whether analog or digital assemblies are addressed.

The SLOT indicator is ON only when digital assemblies are addressed. The 3-digit display (shown as 888 in Figure 7) shows the digital assembly slot addressed or the analog assembly channel addressed.

The CHANNEL indicator also has two functions. For analog assemblies, the CHANNEL (0,1,..., 15) LEDs are OFF and the 3-DIGIT DISPLAY shows the analog channel addressed. For digital assemblies, the CHANNEL LEDs ON show the channel bits which are true (set to digital 1).

EXAMPLE - SLOT/CHANNEL INDICATORS

Let's compare the SLOT and CHANNEL indicator displays for an analog assembly vs a digital assembly in slot 2, where channel 0 (address 20) is closed for the analog assembly and channel 0 (address 2,0) is closed for a digital assembly.



Function Display

The function display displays the decimal value of an analog measurement or the octal value of digital data returned from a channel. The function display has three parts: the six-digit LED display (+8.8.8.8.8.8 in Figure 7), five display indicators (DCV, SEC, TOT, OCT and ENT) and three current source indicators (10μA, 100 μA and 10 mA).

The six-digit display shows the results of frequency, voltage or period (time) measurements, indicates time of day, shows totalized events or displays the octal value of digital data inputs. The type of display is shown by the display indicators to the right of the six-digit display.

When DCV is ON, the value of the DVM measurement is displayed on the six-digit display. SEC and TOT are used with the 100 kHz Reciprocal Counter (Option 060). SEC means that the input signal period or pulse width (in seconds) is displayed. TOT means that the display is the totalized number of events.

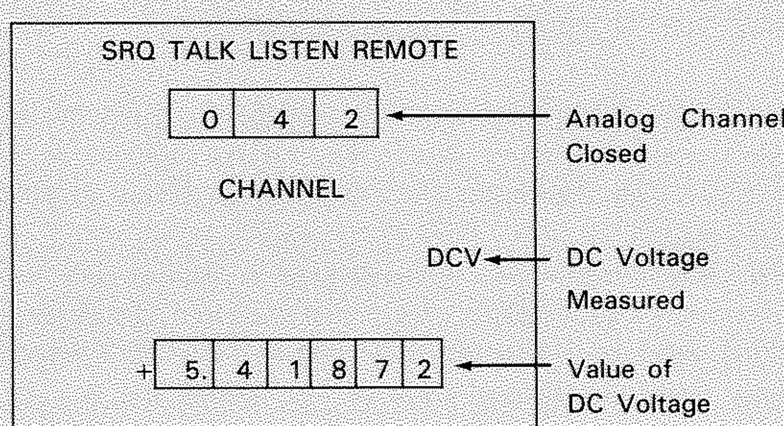
OCT means that the 6-digit display shows the octal value of the true bits in digital channels. ENT shows that the 3497A is ready to accept new inputs or that data is being input from the front panel or from a controller.

Now, let's look at a couple of examples to show typical analog and digital displays. Later on, we'll show some sample command sequences to produce the displays shown.

EXAMPLE - ANALOG DISPLAY

Assume that an analog assembly such as the 20-Channel Relay Multiplexer assembly (Option 010) is placed in slot 2 of a 3497A and the DVM measures a voltage from channel 42 of the assembly. (Recall that an analog assembly in slot 2 has channel addresses 40-59).

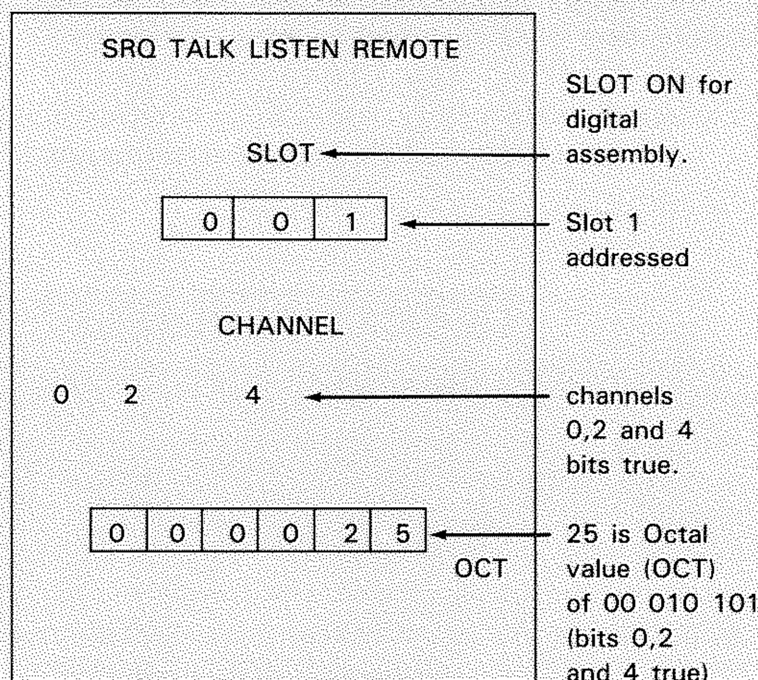
Since the multiplexer is an analog assembly, the SLOT light is OFF, the 3-DIGIT DISPLAY shows the number of the channel measured by the DVM (042 in this case) and the 6-digit display shows the decimal value of the DC voltage measured. The DCV indicator shows that a DC voltage is measured.



EXAMPLE - DIGITAL DISPLAY

For this example, a digital assembly such as the 16 Channel Isolated Digital Input/Interrupt assembly (Option 050) is placed in slot 1 and the channel 0, 2 and 4 bits are true (a "1" condition).

The SLOT indicator ON shows that a digital assembly is addressed. The 3-DIGIT DISPLAY shows that slot 1 was addressed and CHANNEL indicators 0, 2 and 4 ON show that channel bits 0,2 and 4 are true. The six-digit display shows 25 OCT, where 25 is the octal value of bits 0,2 and 4 true (see Binary-to-Octal Conversion).



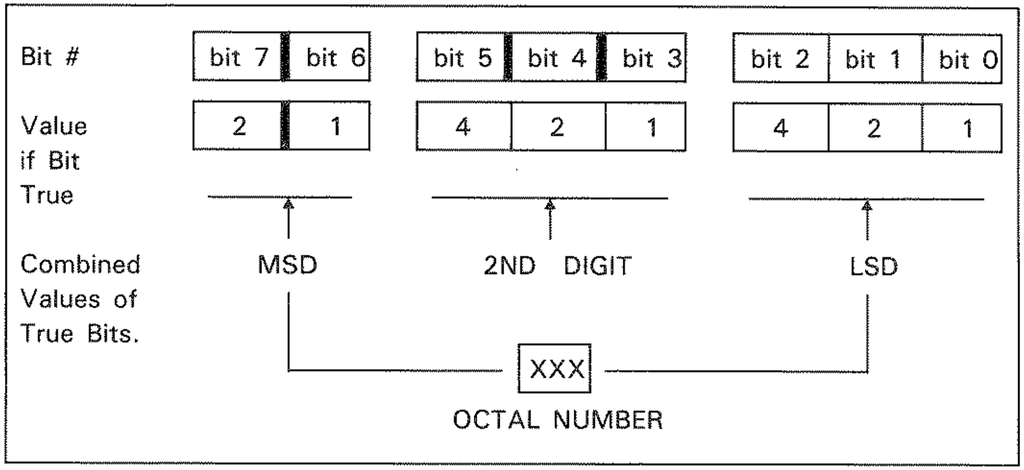
Binary-to-Octal Conversion

As shown, for digital displays the 6-digit display gives the octal value of the digital data. In the example above, bits 0, 2 and 4 are high or true, and the equivalent octal value is 000025. To clarify this, let's look at binary-to-octal conversion.

For the 3497A, digital data is transmitted in digital bytes, with 8 bits per byte. The least significant digit (LSD) is bit 0 and the most significant digit (MSD) is bit 7. A weighted value of 1 is assigned to bits 0,3 and 6; a weighted value of 2 to bits 1,4 and 7 and a weighted value of 4 to bits 2 and 5.

The combined value of bits 6 and 7 which are true forms the MSD of the octal number. The combined value of true bits 3, 4 and 5 forms the second octal digit and the combined value of true bits 0, 1 and 2 forms the LSD of the octal number, as shown.

BINARY TO OCTAL CONVERSION



EXAMPLE - BINARY-TO-OCTAL CONVERSION

For example, for an 8-bit byte with bits 1, 3, 5 and 7 true (digital 1), the digital representation is 10 101 010. Since bit 7 is 1, its value is 2. However, since bit 6 is 0, its value is 0. The combined value of bits 6 and 7 is thus 2 + 0 = 2 and the MSD of the octal number is 2. Similarly, the second digit of the octal number is 5, the LSD is 2 and the octal representation of digital 10 101 010 is 252.

Bit #	7	6	5	4	3	2	1	0
Digital Value	1	0	1	0	1	0	1	0

KEYBOARD

Now, let's examine the 3497A front panel keyboard and see how to enter commands. Figure 8 shows the features of the keyboard and summarizes the functions of each key. For convenience, the keyboard is divided into five groups of keys: SPECIAL PURPOSE, CONTROL, ANALOG, DIGITAL and VOLTMETER. This section shows how to enter commands from the keyboard, describes the function of each key and shows some typical command entries.

How to Enter Commands From the Keyboard

Recall that commands consist of two alpha characters (letters) generally followed by one or more data characters (numbers). Although commands are entered into the 3497A one character at a time, the 3497A recognizes the first two entries as alpha characters and the remaining entries as data characters or delimiters (comma or -).

Also recall that you can enter some commands from the keyboard in two ways. The first way is to enter the two alpha characters with a single keystroke and then enter the data characters. The second way is to first press the (blue) SHIFT key and then enter the alpha characters and data characters one at a time. Let's see how this is done.

On the keyboard, there are 12 keys called alpha-numeric keys (numerics 0-9 plus the , and -) (see Figure 8). Each of these keys has a function description (CLOSE CHANNEL, TRIGGER, etc.) above it; a number or punctuation mark (0 through 9 plus , and -) in the center and an alpha character (A, C, D, etc) at the lower right-hand corner. (In addition, alpha L is at the lower right-hand corner of the self-test key).

Alpha-numeric keys have three modes for entering data: a primary mode for command function; a numeric mode for data characters; and a shifted mode (A,C,D, etc.) which is entered when the blue SHIFT key is pressed to start a keystroke sequence.

Thus, with the alpha-numeric keys and SHIFT key, you can enter some commands in two different ways: (1) use the primary function of the alpha-numeric key or (2) press the SHIFT key first and then enter the command by using the shifted mode. The 3497A automatically interprets whether alpha or data characters are to be entered

ANALOG

These 5 keys control analog assembly operation. Each key specifies the action to be taken by the 3497A (open or close channels, increment or decrement channels or view a specified channel).

- CLOSE CHANNEL (7) — Close selected analog channel(s). From one to four channels can be closed at a time.
- FIRST CHANNEL (4) — Sets first channel to be closed in an analog sequence.
- LAST CHANNEL (1) — Sets last channel to be closed in an analog sequence.
- VIEWED CHANNEL (0) — Dedicates display to designated analog channel.
- ANALOG STEP — Steps (increments or decrements) the 3497A to the next analog channel.

DIGITAL

These 4 keys control digital assembly operation. Each key specifies the action to be taken by the 3497A (open or close digital channels within slot(s) addressed, read a designated slot or view a designated slot).

- CLOSE (8) — Close selected channel(s) in slot addressed.
- OPEN (5) — Open selected channel(s) in slot addressed.
- READ SLOT (2) — Read selected slot. Following the command, display shows octal value of true channel bits.
- VIEWED SLOT (.) — Dedicates display to selected slot.

VOLTMETER

Use these keys to set some functions of the DVM and its current source.

- TRIGGER (9) — Set DVM to internal trigger, trigger on external input, software trigger or hold.
- N READ/TRIGGER (6) — Set number of readings/trigger input.
- CURRENT SOURCE (3) — Set the DVM current source to one of three outputs.

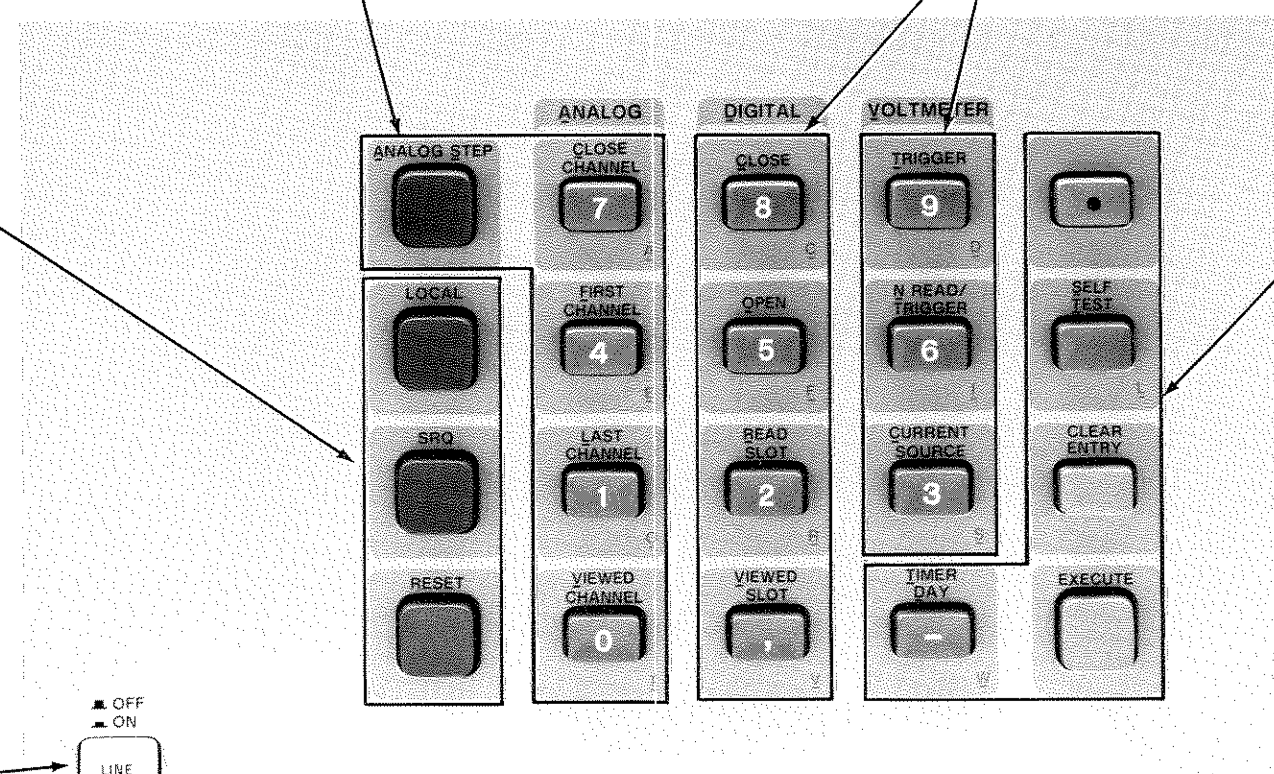
CONTROL

These keys control the mode of operation of the 3497A and allow manual SRQ to be sent to the controller.

- LOCAL — Returns control of the 3497A to the front panel unless LOCAL LOCKOUT was previously sent from controller.
- SRQ — Use this key to send a manual Service Request (SRQ) to the controller.
- RESET — Cycles the 3497A through a power-on sequence except for return to LOCAL control and Power-On SRQ.

POWER ON/OFF SWITCH

Press on/press off switch to apply AC power to the 3497A.



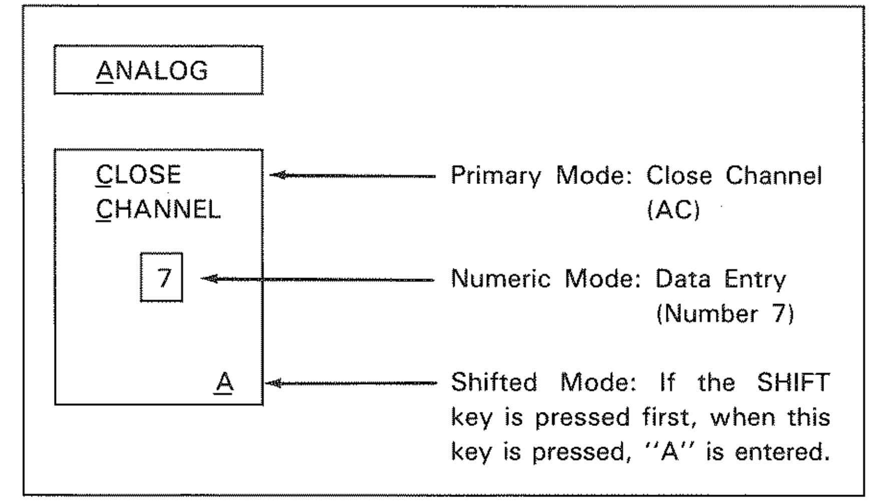
SPECIAL PURPOSE

Use these 5 keys to shift the keyboard to Alpha mode, self-test the 3497A, clear entries, execute commands entered and set the 3497A clock to a specified time.

- (•) — Shifts Alpha-Numeric portion of keyboard to Alpha (A, C, D, etc.) mode.
- SELF TEST — Tests the 3497A internal functions.
- CLEAR ENTRY — Clears entries if pressed before the EXECUTE key.
- EXECUTE — Implements commands entered and prepares 3497A for next command.
- TIMER DAY (–) — Set Real Time clock to specified time.

Figure 8. Front Panel Keyboard

ALPHA-NUMERIC KEY MODES



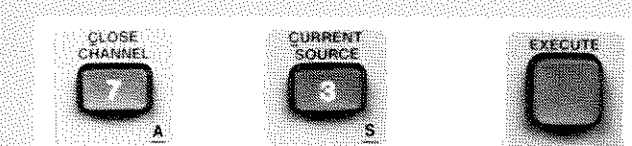
EXAMPLE - CLOSE ANALOG CHANNEL

The command to close channel 3 in an analog assembly is AC3. Let's enter this command in two ways by using different keystroke sequences. You may want to practice entering commands by pressing the LINE key ON and following the sequences shown.

Sequence 1: Use the ANALOG CLOSE CHANNEL key

To Enter AC3, Press:

Keystroke Sequence:



Data Entered: AC 3 AC3 Command Into 3497A

Pressing the ANALOG CLOSE CHANNEL key enters AC. Since the two alpha characters in the command (AC) were entered with the ANALOG CLOSE CHANNEL key, the 3497A interprets the next entry as a data character (number). Pressing the CURRENT SOURCE key enters the number 3.

As with all commands entered from the keyboard, you must press the EXECUTE key to actually enter commands. If you press a key in error, you can delete the entire command sequence and start over by pressing the CLEAR ENTRY key BEFORE you press the EXECUTE key.

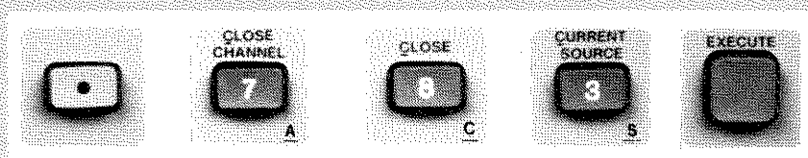
Note that the EXECUTE key also acts as a delimiter. That is, it tells the 3497A that this is the end of this command and sets the 3497A for the next command. If you enter an illegal command, the audible BEEP sounds and the entire (correct) command must be re-entered.

Sequence (2): Use the SHIFT key

When the SHIFT key is pressed first, the keyboard is shifted to alpha mode. Now, when the ANALOG CLOSE CHANNEL key is pressed, the data entered is alpha A, rather than AC entered in the previous sequence. Pressing the DIGITAL CLOSE key enters C (rather than 8) since the 3497A interprets the first two entries as alpha characters.

To Enter AC3, Press:

Keystroke Sequence:



Data Entered:	Shifts to Alpha Mode	A	C	3	AC3 Command into 3497A

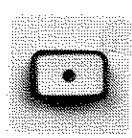
Special Purpose Keys

Now, let's examine each of the five keyboard groups and define the function of each of the keys, beginning with the special purpose key group. As mentioned, we've divided the keyboard into five functional groups.

Some typical keystroke sequences are shown to illustrate the function of the keys. In these examples, only the primary mode is shown. However, many of the commands can be entered in shifted mode as well. You may want to practice entering commands by using both methods.

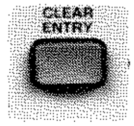
The special purpose keys are used to shift the keyboard to the Alpha mode, self-test the 3497A, clear an undesired entry, execute commands entered and set the real-time clock to a desired time. This key group includes the SHIFT (blue) key, the SELF-TEST key, the CLEAR ENTRY key, the EXECUTE key and the TIMER DAY key.

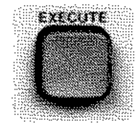
SHIFT



The SHIFT (blue) key shifts the keyboard from the primary mode to a shifted Alpha mode so that you can enter some commands in two different ways. When the SHIFT key is pressed, the light in the center of the key is ON, indicating that the keyboard is in the shifted (alpha) mode.

SELF TEST 

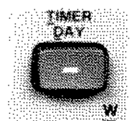
CLEAR ENTRY 

and EXECUTE 

Use the SELF TEST key to test internal 3497A operation. When the SELF TEST key is pressed the display is as shown in Figure 8 if the 3497A is operating properly.

Use the CLEAR ENTRY key to cancel undesired command sequences entered before the EXECUTE key is pressed. This cancels the entire sequence and you must reenter the entire command. For example, if you wanted to enter DC3, but entered DC2, pressing the CLEAR ENTRY key will require that you enter DC3, rather than 3 only.

Use the EXECUTE key to actually enter the command sequences into the 3497A. The EXECUTE key also acts as a delimiter for the keyboard to end the numeric portion of the previous command and prepare the keyboard for a new command.

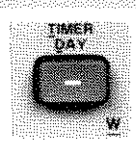
TIMER DAY 

Use the TIMER DAY key to enter a desired time of day into the real-time clock in one of two formats: Month:Day:Hours:Minutes:Seconds or Day:Month:Hours:Minutes:Seconds. The clock then provides a real time data base for your measurements.

EXAMPLE - SETTING THE CLOCK

We'll set the clock to Oct 15, 6:24:53 PM. The command to do this is TDn, where n = MM:DD:HH:MM:SS (US format). Press the LINE key on and enter the data as shown.

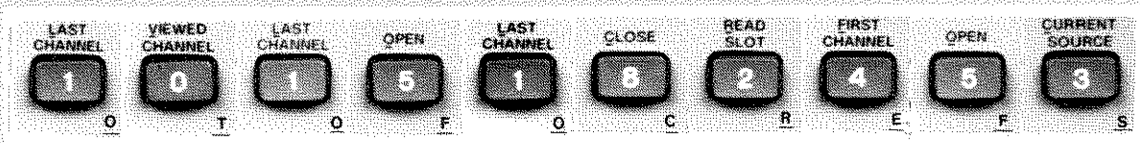
1. To enter TD, press:



Notice that the display is blank except for ENT to the right of the 6-digit display, showing that data is about to be entered.

2. To enter Oct 15, 6:24:53 PM, press:

Keystroke
Sequence

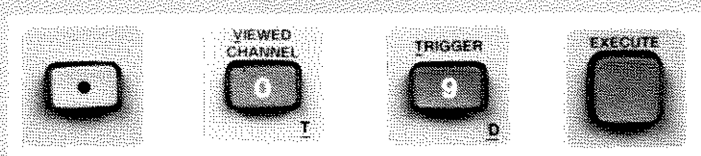


Data Entered	10	15	18	24	53
	10th Month (Oct)	15th day	6PM (24-hr clock)	24 min	53 sec

At the end of this sequence, the 6-digit display shows 18.24.53. Next, press the EXECUTE key to set the clock. Now that the time has been entered into the 3497A, to show the time of day on the display, enter the following sequence.

3. To read the time of day, press:

Keystrokes



Data Entered	Shifts to Alpha Entries	T	D	Executes TD command to display.

The display shows some time after 18.24.53 (depending on the time that you entered the last keystroke sequence). Notice that the display acts as a digital clock, updating each second.

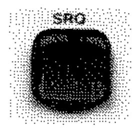
Control Keys

This group consists of the LOCAL, SRQ and RESET keys. You can use these keys to return control to the front panel, send an interrupt signal to your controller or reset the 3497A.

LOCAL 

The LOCAL key returns control to the front panel keyboard by taking the 3497A out of the remote operating mode. If the 3497A was previously placed in remote mode by a controller, the REMOTE light on the display is ON and most of the keyboard is disabled.

The only keys which are not disabled in remote mode are the ANALOG VIEWED CHANNEL, DIGITAL VIEWED SLOT, SRQ and LOCAL keys. When the LOCAL key is pressed, all front panel keys are enabled and, if the 3497A was previously in remote mode, the REMOTE display light goes OFF.

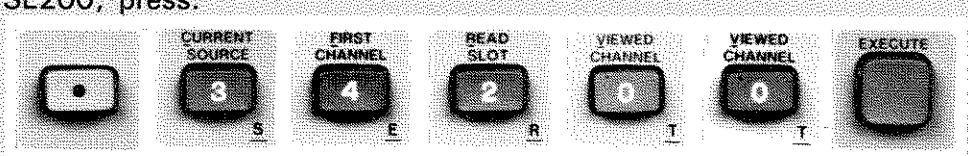
SRQ 

SRQ stands for Service Request. The purpose of the SRQ key is to send a service request to the controller from the front panel. Service requests are discussed in Chapters 3 and 4. However, to see how the front panel SRQ key works, let's perform the example keystroke sequence shown to enable and send the SRQ message.

EXAMPLE - SETTING FRONT PANEL SRQ

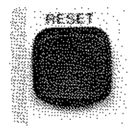
To send an SRQ mesage to a controller by using the front panel SRQ, the first step is to program the 3497A to acknowledge an input from the SRQ key. As described later in Chapter 5, you can do this by entering an SE200 command.

To enter SE200, press:

Keystroke Sequence: 

Data Entered	Shifts to Alpha Mode	S	E	2	0	0	Enters Command into 3497A

Now that the 3497A has been set to acknowledge Front Panel SRQ, simply press the SRQ key and note that the SRQ light goes on, showing that a Service Request has been sent to the controller. To clear SRQ, press the RESET key and note that the SRQ indicator on the display goes OFF.

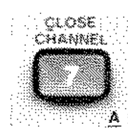
RESET 

Pressing the RESET key causes the 3497A to go through a complete power-on sequence, except for resetting the interface and POWER ON SRQ. If the 3497A was in REMOTE mode before pressing the RESET key, the RESET key is disabled and the 3497A remains in REMOTE.

The RESET key also returns the 3497A to its power on condition. Press the RESET key and observe that the display goes through the same sequence as when the LINE key is pressed ON, except that ''HP 3497'' is not displayed and the audible alarm (BEEP) is not sounded.

Analog Keys

This key group consists of the ANALOG STEP key and four alpha-numeric keys (CLOSE CHANNEL, FIRST CHANNEL, LAST CHANNEL and VIEWED CHANNEL). This group controls the operation of the analog plug-in assemblies (Options 010, 020, 070 and 071).

CLOSE CHANNEL 

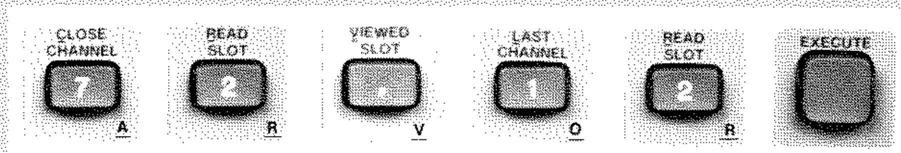
Use the CLOSE CHANNEL key to close from one to four analog assembly channels simultaneously. If more than one channel is to be closed at a time, only one channel/decade can be closed. For example, you can close only one channel at a time in channels 0-9, channels 10-19, etc. up to a maximum of four channels per 3497A.

EXAMPLE - CLOSE TWO ANALOG CHANNELS

A sample sequence to close channels 2 and 12 simultaneously is shown. The command sequence to do this is AC2,12. Note that the channels are in different decades and that a comma is required to separate the channel numbers in the command sequence.

To enter AC2,12, press:

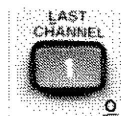
Keystroke Sequence:



Data Entered:	AC	2	1 2
	Analog Close	Closes Chan 2	Closes Chan 12

FIRST CHANNEL

LAST CHANNEL



ANALOG STEP

The FIRST CHANNEL key sets the first channel to be closed in an analog sequence and the LAST CHANNEL key sets the last channel to be closed in an analog sequence. These two keys do NOT close channels, but merely set the limits of the sequence. When the 3497A is reset or at power on the first analog channel is set to 000 and the last analog channel is set to 999.

The ANALOG STEP key closes channels in increasing or decreasing sequence, depending on the first and last channels set. If the first channel is less than the last channel (AF<AL), the sequence is increasing. If the first channel is greater than the last channel (AF>AL), the sequence is decreasing.

For example, if AF = 20 and AL = 30, repeatedly pressing the ANALOG STEP key causes the 3497A to sequence from channel 20 to 21, 22, ...,30, 20, 21, ... If AF = 20 and AL = 10, the sequence is 20, 19, 18, ..., 10, 20, 19, ... Since the 3497A uses BBM (Break-Before-Make) synchronization, the channel presently closed is opened before the next channel is closed, so only one channel is closed at a time.

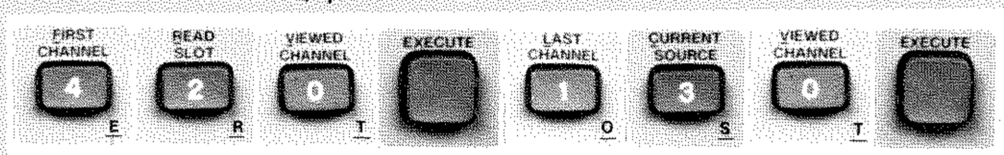
EXAMPLE - STEP ANALOG CHANNELS

For this example, we'll set the first and last analog channels to be closed in a sequence and then use the ANALOG STEP key to close channels in an increasing sequence for an analog assembly in slot 1 (channel addresses 20-39).

Set the first channel to be closed as 20 and the last channel to be closed as 30 by entering the keystrokes below. Note that the FIRST CHANNEL key and LAST CHANNEL key do NOT close the channels but merely define the limits on the sequence. The ANALOG STEP key first opens, then closes the channels.

To set AF = 20 and AL = 30, press:

Keystroke Sequence:

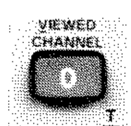


Data Entered:	AF 2 0	AL 3 0
	Sets First Channel to 20	Sets Last Channel to 30

Now, press the ANALOG STEP key to close channel 20 and note that 020 is displayed on the 3-digit display. Press the ANALOG STEP key again and note that the display is 021, showing that channel 20 has been opened and channel 21 closed.

Repeatedly press the ANALOG STEP key until the display reaches 030. Then, with the next press of the key, note that the display goes back to 020. Thus, the channel closure sequence is 20, 21, ..., 30, 20, ...

VIEWED CHANNEL



This key allows you to dedicate the display to a specified analog channel. Since the ANALOG VIEWED mode does not affect scan sequences, this mode is useful if you want to scan through a number of channels but only want to display the input on a certain channel.

EXAMPLE - VIEWED ANALOG CHANNEL

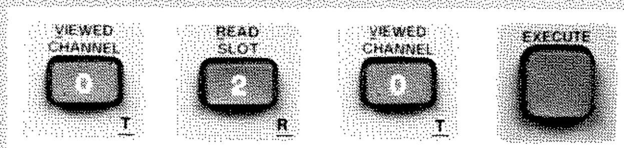
To set channel 20 as the dedicated channel, the command is AV20. To clear a channel from the viewed mode, the command is AV, without a data character.

After you press the EXECUTE key, the 3-digit display shows 020, the VIEWED indicator is ON and the 6-digit display shows six dashes (- - - - - -). As with the FIRST and LAST CHANNEL keys, the VIEWED CHANNEL key does not close the channel.

When channel 20 is closed with an appropriate command, the input to the channel will be updated on channel closure and displayed on the six-digit display. To clear the 3497A from this mode, press the ANALOG VIEWED key and then the EXECUTE key.

To set channel 20 as the dedicated channel, press:

Keystroke Sequence:



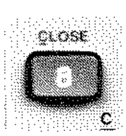
Data Entered: AV 2 0

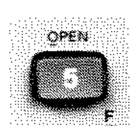
Dedicates channel 20 to Viewed mode.

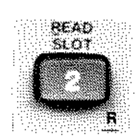
Digital Keys

This group of keys controls the operation of some of the digital assemblies (Options 050, 110 and 115). This group consists of the DIGITAL CLOSE, DIGITAL OPEN, READ SLOT and VIEWED SLOT keys.

Addresses for digital assemblies have the form (slot,channel) with slot numbers from 0-89 (except slots 5-9) and channels 0-15 in each slot. In contrast to ANALOG commands in which a maximum of four channels can be closed simultaneously, with DIGITAL commands, any combination of channels can be closed in a slot.

CLOSE 

OPEN 

READ SLOT 

The CLOSE and OPEN keys are used with the two actuator assemblies (Options 110 and 115). These keys are not used with the Option 050 (digital input/interrupt) assembly. Use the CLOSE key to simultaneously close from one to 16 channels of an actuator assembly. Use the OPEN key to open from desired channels of an actuator assembly.

In contrast to the CLOSE and OPEN keys, the READ SLOT key can be used with all three digital assemblies. When the READ SLOT key is used, the octal value of the digital data on each channel of the slot addressed is displayed.

For example, for an actuator assembly (Option 110 or 115) with channels 0, 2 and 4 closed, the front panel display shows CHANNEL 0,2 and 4 indicators ON (indicating that the relays in channels 0, 2 and 4 are closed) and the six-digit display shows 000025, which is the octal representation of bits 0, 2 and 4 true (logic 1).

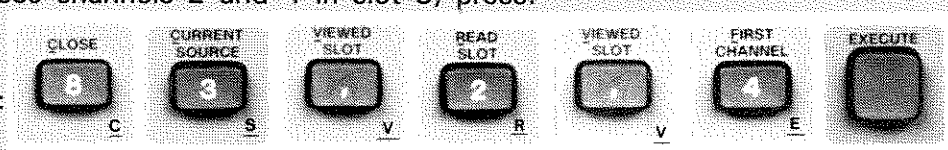
EXAMPLE - CLOSE AND READ DIGITAL CHANNELS

Let's take an example to see how digital channels of an actuator assembly in slot 3 can be closed and read. We'll reset the 3497A, close channels 2 and 4 and read the slot. This example is for an actuator assembly in slot 3. If an actuator assembly in not in slot 3, when keystrokes shown are entered the 3497A will BEEP to show invalid entries.

To close more than one channel in a slot, the command is DC slot#,chan#,... Note that commas must be inserted between the slot number and the first channel number and between each channel number. Thus, to close channels 2 and 4 in slot 3, the command is DC3,2,4 (or DC3,4,2).

1. To close channels 2 and 4 in slot 3, press:

Keystroke Sequence:

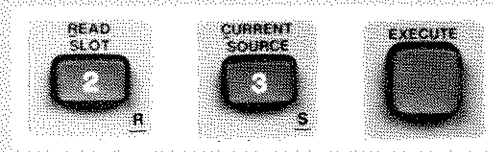


Data Entered:	DC	3	,	2	,	4
	Digital Close	Slot 3 Addressed		Close Chan 2		Close Chan 4

The command to read a slot of the 3497A is DR slot#. So, to read the status of slot 3, the command is DR3. Now that channels 2 and 4 have been closed, to display this information enter the keystroke sequence shown. Following this, the the six-digit display shows 000024 OCT and CHANNEL indicators 2 and 4 are ON.

2. To read slot 3, press:

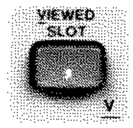
Keystroke Sequence



Data Entered: DR 3

Reads Slot 3 Status

VIEWED SLOT

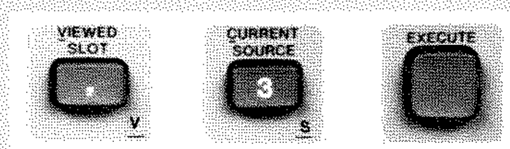


Use the DIGITAL VIEWED SLOT to dedicate the front panel display to a specified slot. The display is updated after a channel is changed (open to closed or closed to open) or when a Digital Read or Digital Load command is sent to that slot. As with VIEWED CHANNEL for analog assemblies, DIGITAL VIEWED SLOT causes the VIEWED light on the display to turn on. The command is DV slot#. To clear the 3497A from this mode, use DV without a slot #.

EXAMPLE - DEDICATE DISPLAY TO SLOT

To dedicate the display to slot 3, press:

Keystroke Sequence:



Data Entered: DV 3

Dedicates Front Panel Display to Slot 3.

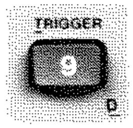
After the EXECUTE key is pressed, the display is as shown. Whenever channels are closed in slot 3, the display will show channels closed and the corresponding octal value.

SLOT
03
VIEWED

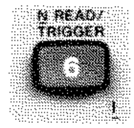
Voltmeter Keys

This group consists of three keys (TRIGGER, N READ/TRIGGER and CURRENT SOURCE) which can be used to set some of the functions of the optional voltmeter and current source. However, to set other functions of the voltmeter, such as Auto-Zero and Voltmeter Wait, you must use the Alpha-Numeric keys in shifted mode to enter commands. See Chapter 5 for details.

TRIGGER

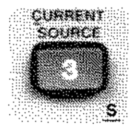


N READ/
TRIGGER



Use the TRIGGER key to set the method of triggering the voltmeter to one of four modes: internal, external, software or hold. Use the N READ/TRIGGER key to set the voltmeter to take from 1-999 readings/trigger.

CURRENT
SOURCE



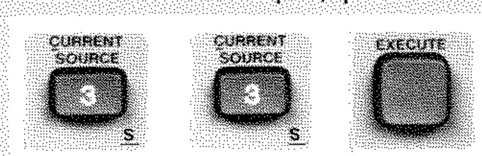
Use the CURRENT SOURCE key to set the current source in the voltmeter to one of three constant-current outputs: 10 μA, 100 μA or 1 mA. The command for this is VCn (n = 0 to 3). When this command is executed, one of the Current Source Display Indicators is turned ON.

EXAMPLE - SET CURRENT SOURCE TO 1 mA

The command to set the current source to 1 mA output is VC3. The keystroke sequence is shown below. After the EXECUTE key is pressed, the 1 mA display indicator is ON.

To set the current source to 1mA output, press:

Keystroke Sequence:



Data Entered: VC 3

Sets current source to 1 mA

Chapter 3
HP-IB PROGRAMMING

Chapter 2 showed how to enter commands using the 3497A front panel keyboard. In this chapter, we'll show how to enter the same commands from a controller using an HP-IB interface bus. Since this chapter concerns HP-IB programming, if you have a 3497A with Option 232 (Serial Data), refer to Chapter 4. If you are not familiar with HP-IB or some of the terms used in this chapter, see Appendix A for a summary description of HP-IB.

This chapter is primarily devoted to programming considerations for communication between the 3497A and an HP-IB compatible controller. For command sequences to program the 3497A and its plug-in assemblies, see Chapter 5, Controlling the 3497A.

HP-IB (Hewlett-Packard Interface Bus) is Hewlett-Packard's implementation of IEEE Standard 488-1978, ''Standard Digital Interface for Programmable Instrumentation''. Since HP-IB is a standard interface, the 3497A can be used with a wide variety of controllers/computers.

However, unless indicated, all sample programs used in this manual are written in an enhanced BASIC (Beginners All-Purpose Symbolic Instruction Code) language used by the -hp- 85 Desktop Computer and similar controllers.

Before beginning this chapter, you should be familiar with the material in Chapter 2 on 3497A commands. For further information on 3497A commands, see the Command Directory in Chapter 6.

CAUTION

If you have just received your new 3497A, don't turn the instrument on before a qualified, service-trained person has performed an initial inspection of the 3497A.

HP-IB BUS MESSAGES

The purpose of the HP-IB interface is to allow the 3497A and controller to communicate with each other. Although several types of information can be transmitted over the bus, information is usually transmitted in the form of Bus Messages.

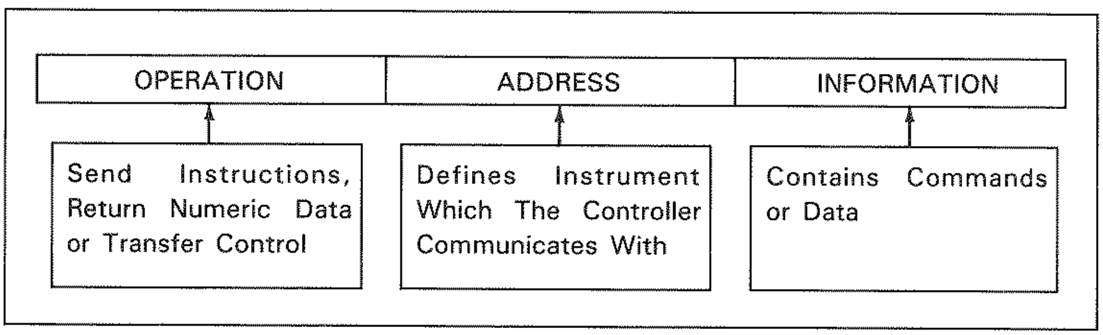
There are 12 HP-IB bus messages (see Appendix A). However, only nine of these are directly applicable to the 3497A. Later on, the 3497A response to these bus messages is summarized. First, let's take a look at the structure of bus messages.

Bus messages generally perform one of three functions: (1) send instructions to the 3497A (2) cause the 3497A to output data to the controller (or other device on the bus) or (3) transfer control from the controller to the 3497A or from the 3497A to the controller.

Format

Each bus mesage is divided into three parts: Operation, Address and Information. The format of bus messages is shown below.

HP-IB BUS MESSAGE FORMAT

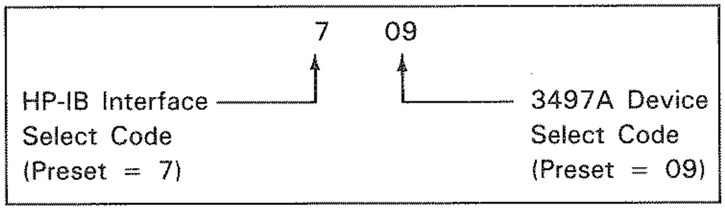


The operation portion of a bus message specifies the type of bus message (CLEAR, DATA, etc., see Appendix A for definitions). Each HP-IB compatible controller has an equivalent syntax which is controller dependent for the operation portion of bus messages. For example, the syntax for the -hp- 85A is OUTPUT for sending instructions and ENTER for returning data.

Each instrument connected to the HP-IB bus has a unique ''address'' which provides a way for the controller to communicate with only one instrument at a time even though all instruments are connected together. The address portion of a bus message consists of the interface select code (ISC) and the device select code.

As factory preset, the 3497A is addressed at 709, where 7 is the interface select code and 09 is the 3497A device select code (address). All examples in this manual use address 709 for the 3497A.

3497A ADDRESS



The information portion of the message consists of 3497A commands and/or data to be returned from the 3497A. For bus messages which send instructions to the 3497A, the information portion consists of 3497A commands (see the Command Directory in Chapter 6 for a list of 3497A commands).

For bus messages which require that data be returned from the 3497A, the information portion consists of measurement or status data. For bus messages which transfer control between the 3497A and the controller, the information portion is not used. Some typical HP-IB messages for the 3497A using typical -hp- controllers are shown below.

TYPICAL HP-IB BUS MESSAGES

MESSAGE TYPE	OPERATION	ADDRESS	INFORMATION
Send instructions to the 3497A.	OUTPUT	709;	"DC1"
	wrt	709,	"DC1"
Require numeric data return from the 3497A.	ENTER	709;	A
	red	709,	A
Transfer control from the 3497A to the controller.	REMOTE	709	
	rem	709	

Note: OUTPUT, ENTER and REMOTE syntax is for -hp- 85A, 9826A, 9836A, etc. controllers. wrt,red,rem syntax is for -hp-9825A.

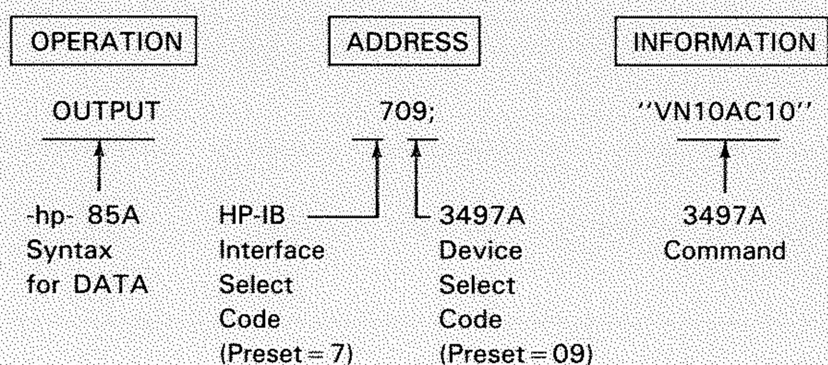
The bus messages must include any delimiters required by the computer language syntax. A delimiter is a character that is used to separate one expression from another or to terminate a list. Delimiters for the 3497A include semicolons, quotation marks, commas and minus (-) signs. The 3497A ignores LF as an input command.

When commands are included in bus messages, more than one command can be used per message. Delimiters should not be used between commands in a bus message (i.e. for commands AC10VN10, do not use delimiters between ''0'' and ''V'').

EXAMPLE - DATA MESSAGE

A common bus message is the DATA message (see Appendix A). When a controller such as the -hp- 85A sends a DATA message to the 3497A, the syntax for the operation portion of the message is OUTPUT, the address portion is 709 and the information portion contains instructions for the 3497A.

In the example bus message shown, the controller tells the 3497A to set the DVM for 10 readings/trigger (VN10) and then close channel 10 (AC10). Since the information portion contains instructions to change the state of the 3497A, it consists of 3497A commands.



Syntax and Programming Hints

As shown in the sample bus message above, you can send more than one command in a message. In general, you can send as many commands as required in a single message. Some other considerations in designing bus messages and programs are listed below.

1. The Bus Message must include delimiters, such as semicolons, quotation marks, commas and spaces which are required by the controller syntax. When linking commands (such as AC10VN10), it is not necessary to separate commands with delimiters. See the Command Directory for examples.

2. Characters in received commands must be upper case letters, since the 3497A ignores lower case letters. Numeric inputs must be between 0 and 9,999,999,999.

The 3497A ignores spaces, Line Feed (LF), colon and +. It recognizes the decimal point with the SV (System Viewed) command.

3. The 3497A recognizes the minus (-) sign only as the first character following an ''AO'' (Analog Output) or an ''SV'' (System Viewed) command. If a numeric is required but none is supplied in the command, the 3497A assumes that ''0'' is intended (i.e., if DC2,1 is intended but DC2 is sent, DC2,0 is the action initiated).

4. When illegal characters are received over the interface, the 3497A sounds an audible alarm (BEEP) and the command is not executed. In this case, the bus message must be re-transmitted.

5. When commands are ''strung together'' in a bus message, commands are acted upon sequentially as they are received. For example, in the bus message OUTPUT 709; ''VN10AC10'', the DVM is first set for 10 readings/trigger and then channel 10 is closed. For bus message OUTPUT 709;''AC10VN10'', the order of actions is reversed.

6. Certain commands such as AE2 or AR may take a relatively long time to execute. If you place this type of command at the beginning of a string of commands, the HP-IB interface is ''locked in'' to this message until the command string is completed. However, if you place long-time commands at the END of the command string, the HP-IB is cleared as soon as the last command is entered into the 3497A, even though the command is still being executed by the 3497A.

7. Since up to 14 devices can be controlled simultaneously on an HP-IB network, it is essential that each device have a unique address. If you have more than one 3497A on the HP-IB interface, only one of the instruments should have address 09 and each of the other 3497As should be set to a different address.

8. For applications such as data logging, it may be required to send data directly from the 3497A to an external printer and not use a controller for this operation. For these applications, the 3497A can function as an active talker or listener or it can be set to the TALK ONLY mode. In the TALK ONLY mode, the 3497A does not respond to bus messages from the controller and commands must be entered from the front panel.

COMMUNICATING WITH THE 3497A

As mentioned, bus messages have three primary functions: sending instructions to the 3497A, requiring data returns from the 3497A or transferring control from the controller to the 3497A or vice versa. In this part, we'll provide some guidelines for forming bus messages to send instructions to the 3497A, to receive data from the 3497A and to transfer control from the controller to the 3497A and back to the controller. We'll begin with sending instructions to the 3497A.

Sending Instructions to the 3497A

A bus message which sends instructions to the 3497A includes one or more commands. Recall from Chapter 2 that the 3497A recognizes two letter command mnemonics usually followed by one or more numeric characters (i. e. AC10, ST1, etc.). Thus, a bus message to send instructions to the 3497A has the form OUTPUT 709; ''AC10''.

To send instructions to the 3497A, first decide what you want the instrument to do and determine the appropriate command(s) from the Command Directory in Chapter 6 (also see Chapter 2 for a command summary). Then, form a bus message, enter the message into your controller and press the RUN (or equivalent) key on the controller to initiate the desired action. Let's take a couple of examples to show how instructions can be sent to the 3497A with bus messages.

EXAMPLE - TURN FRONT PANEL DISPLAY OFF

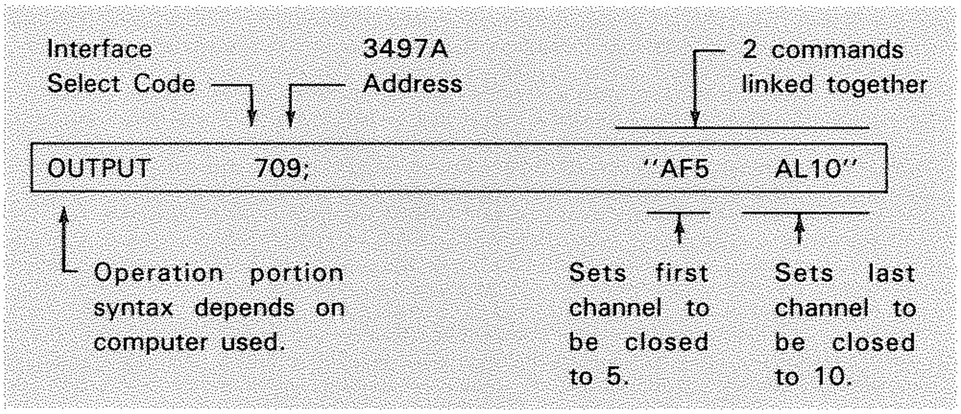
In certain applications, it's convenient to turn the front panel display off for faster reading rates. To do this, enter OUTPUT 709; ''SD0'' into the 85A and press the END LINE key. When this command is executed, the front panel 6-digit display is turned off.

The REMOTE indicator LED shows that the OUTPUT operation transferred control to the controller and the LISTEN indicator shows that the 3497A is ready to accept further inputs from the controller. Thus, the OUTPUT operation of the bus message transferred control to the controller, the 709 addressed the 3497A and the information portion was the SD0 command. To turn the front panel display back on, send OUTPUT 709; ''SD1''.

EXAMPLE - SET FIRST AND LAST ANALOG CHANNELS

As required, you can send any number of commands in a single bus message. For this example, we'll set the channel 5 as the first analog channel to be closed in a sequence and set channel 10 as the last channel to be closed in the sequence. The following bus message shows this.

Notice that there are no delimiters (punctuation marks such as commas) between the two commands. This is a general rule for the 3497A, as delimiters between commands may cause erronous action by the 3497A or cause commands not to be executed.



Receiving Data From the 3497A

The 3497A can talk to the controller (or to other instruments such as printers) to provide results of measurements or status information. Naturally, the controller must tell (address) the 3497A to talk for the instrument to send data. Let's take an example to show how data is sent from the 3497A to an -hp- 85A.

EXAMPLE - ENTERING VOLTAGE MEASUREMENT DATA

In this example, we'll use the AI10 (Analog Input) command to close analog channel 10 and trigger the DVM to take a measurement of the voltage on channel 10. Then, we'll transfer the voltage measurment to the controller (called a READ operation). A program to do this is shown. You may want to enter and run this program and observe the front panel display as the program is executed.

Program

```
10 CLEAR 709
20 OUTPUT 709; "AI10"
30 ENTER 709; A
40 PRINT A
50 END
```

Line	Description
10	Resets 3497A to Power-On State (See CLEAR command).
20	Closes Channel 10 and Triggers DVM to take a measurement.
30	Transfers voltage measurement to controller and stores value in A.
40	Prints voltage value on 85A printer.

In this program, the 3497A is set to its power-on state by the CLEAR 709 statement. Then channel 10 is closed and the DVM takes a voltage measurement and stores it in the 3497A. The ENTER 709; A statement transfers the result to the controller and stores it in a variable called A. The value is then printed on the -hp- 85A printer and the program ends.

At the end of the program, the 3497A Front Panel TALK LED is ON, indicating that the 3497A transferred data to the controller and the REMOTE LED is ON showing that the 3497A is in the remote mode of operation.

Transferring Control

The third function for bus messages is to transfer control from the 3497A to the controller or from the controller to the 3497A. These commands are LOCAL, LOCAL LOCKOUT, CLEAR LOCKOUT & SET LOCAL and REMOTE. The DATA (OUTPUT) command also transfers control from the 3497A to the controller. Note that these commands, except for OUTPUT, do not cause the 3497A to change state or to send data to the controller.

EXAMPLE - TRANSFER CONTROL USING LOCAL AND REMOTE MESSAGES

When the REMOTE 709 command is sent, all the front panel keys of the 3497A, except for the SRQ, LOCAL, ANALOG VIEWED CHANNEL and DIGITAL VIEWED SLOT are disabled and commands can't be entered from the front panel unless the LOCAL key is pressed.

To put the 3497A in the REMOTE mode, send REMOTE 709 (note that there is no information portion in the message). After message execution, the REMOTE LED is ON. If you press any of the front panel keys except the four mentioned above, the 3497A will BEEP and the entries cannot be made.

To put the 3497A back in LOCAL (front panel) operation, you can either press the front panel LOCAL key or send a LOCAL 709 command. In either case, the REMOTE LED goes OFF and the keyboard is once again enabled.

3497A DATA OUTPUT FORMATS

In response to ENTER messages, the 3497A can output data to a controller in one of three formats: (1) ASCII (2) Packed Binary Coded Decimal (BCD) or (3) Time of Day, ASCII, Analog Channel Number. The output formats for ASCII (American Standard Code for Information Interchange), Packed BCD (Binary Coded Decimal) and Voltmeter Format 3 are described below.

ASCII Format

The output format for ASCII data from the 3497A is as follows, where D = Decimal digit, O = Octal Digit, 0 = Zeros, E = Exponent, CR = Carriage Return and LF = Line Feed.

ASCII DATA OUTPUT FORMATS

Voltage Measurement:	± D.DDDDD E±D CRLF
Time of Day:	DD:DD:DD:DD:DD CRLF
Elapsed Time:	DDDDDDDDDD CRLF (First 4 Digits are Zeroes)
Digital Read or Digital Load:	OOOOOO CRLF (0-177777 Octal)
Digital Interrupt:	000OOO CRLF (Last 3 digits are 0-377 Octal)
Counter Totalize:	DDDDDD CRLF
Counter Period or Pulse Width:	D.DDDDDD E+D CRLF (Seconds)
Analog Channel:	±DDD CRLF (- = No Chan Closed)
System Read:	000OOO CRLF (last 3 digits are 0-377 Octal)

Packed BCD Format

Packed BCD Format is used for voltage measurements to increase transfer (reading) speed from the 3497A to the controller. In Packed BCD, data is transmitted in three 8-bit bytes, in contrast to normal ASCII format which requires eleven or more bytes to transmit each voltage measurement. When packed BCD data is received by the controller, it must be "unpacked" to arrive at the reading.

The format for Packed BCD is shown below. In this format, the Most Significant Digit (MSD), 2nd, 3rd, 4th and Least Significant Digit (LSD) are in Binary Coded Decimal (8,4,2,1) format.

PACKED BCD FORMAT

Bit #	7	6	5	4	3	2	1	0
	Range		Sign	Overrange	MSD			
1st Byte	RNG	RNG	SGN	OR	D	D	D	D
BCD value					8	4	2	1
	2nd Digit				3rd Digit			
2nd Byte	D	D	D	D	D	D	D	D
BCD value	8	4	2	1	8	4	2	1
	4th Digit				LSD			
3rd Byte	D	D	D	D	D	D	D	D
BCD value	8	4	2	1	8	4	2	1

In packed BCD, three bytes are always returned. Bits 6 and 7 of the first byte show the range selected and also select the multiplier for the digits. Data is returned in the form .DDDDD Ed, where d is determined by the decimal value of bits 6 and 7 (i. e. 00 = 0; 01 = 1; 10 = 2 and 11 = 3).

Bit 7	Bit 6	Range Selected	Multiplier
0	0	.1V	0
0	1	1V	1
1	0	10V	2
1	1	100V	3

For example, suppose the five digits to be transferred are all 1s (disregard the sign and overrange bits for this example) and the 10V range is specified. The data returned is .11111 Ed, where d = 2, since bit 7 = 1 and bit 6 = 0 for the 10V range. Thus, the reading is $.11111 \times 10^2 = 11.111$V.

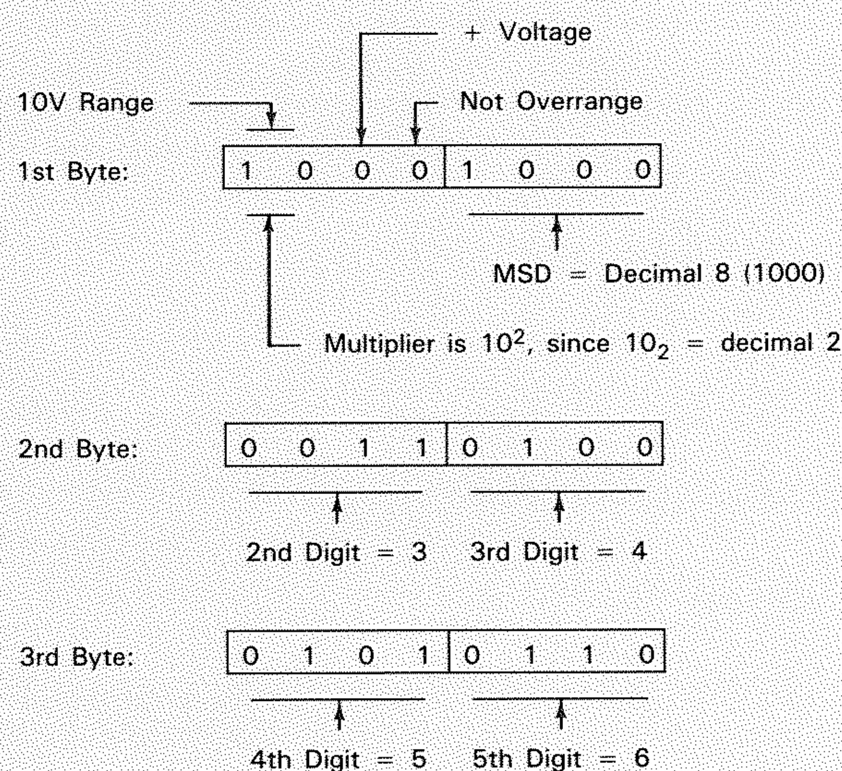
Bit 5 of the first byte is the sign of the measurement. It is 1 for negative voltages and 0 for positive voltages. Bit 4 of the first byte is the overrange indicator and is 1 when the voltage is greater than the range selected. An overload is a voltage which cannot be read and is indicated by 199999.

In packed BCD format, a reading always has five digits. If you are transferring a four digit reading, the MSD will be 0. For three-digit readings, the MSD and the 2nd digit are both 0s. Data input to the computer in packed BCD must be "unpacked" (returned to normal ASCII format) to be viewed or processed.

EXAMPLE - PACKED BCD FORMAT

Assume that the 3497A voltmeter is set to to the 10V range and a voltage of 8.3456V is measured. When the voltmeter is set for format VF2 (see the Command Directory) the three data bytes output from the 3497A are as shown.

The data returned for this measurement is $+.083456 \times 10^2 = 8.3456$V. The multiplier is derived from the range bits (bit 7 = 1 and bit 6 = 0) for a decimal value of 2.



Voltmeter Format 3

When the voltmeter format is set to VF3 (see the Command Directory), the output from the 3497A is Time of Day, ASCII, Analog Channel Number, as shown below where D = decimal digit. Let's take an example for a typical voltage measurement.

DD:DD:DD:DD:DD,	±D.DDDDD E±D,	±DDD CRLF
Time of Day	ASCII Format Measurement	Analog Channel Number

EXAMPLE - VF3 FORMAT

For this example, we'll set the 3497A to output a voltage measurement in Voltmeter Format 3 (with a VF3 command) and then take a voltage measurement on channel 10 (with an AI10 command). A sample program to do this is shown. Note that you must use I = 1 to 2 to get the time of day reading followed by the voltage reading and the channel number.

```
10  CLEAR 709
20  DIM A$[20]
30  OUTPUT 709 ;"VF3AI10"
40  FOR I=1 TO 2
50  ENTER 709 ; A$
60  PRINT A$
70  NEXT I
80  END
```

After the program is executed, a typical printout is:

```
01:12:23:40:25
+0.54751E-1, +010
```

The first line gives the month, day and time of day. The second line gives the voltage measured (+.054751 volts in this example) and the channel measured (channel 10). The + sign in front of the 010 shows that channel 10 actually closed and thus the measurement is not of background noise. If the channel does not close, a - sign appears in front of the channel number.

3497A BUS CAPABILITIES

So far, we've seen how to use bus messages to send instructions to the 3497A, receive data from the 3497A or transfer control from the controller to the 3497A or vice versa. Now, we'll discuss the response of the 3497A to the nine applicable bus commands. First, however, let's introduce the TALK ONLY mode and review the Interface Bus Display Indicators.

TALK ONLY Mode

Certain applications, such as data logging for example, may require that the 3497A take measurements (readings) and output them to a device such as a printer. In this case, the controller is not required and the 3497A can be placed in the TALK ONLY mode (by setting the TALK ONLY switch in the 1 position). In TALK ONLY mode, commands cannot be entered from the controller and must be entered from the front panel.

Interface Bus Status Displays

In Chapter 2 (see Figure 7), we outlined the functions of the four Interface Bus Status Displays (SRQ, TALK, LISTEN and REMOTE). Since the rest of this section describes the 3497A response to bus messages, you may want to enter the messages from your controller and observe the Interface Bus Status Displays as the messages are executed.

The following table shows the LEDs which are ON (starting from a 3497A power-on state) after the bus message listed is executed. Note that more than one LED can be ON. For example, when the DATA Message OUTPUT 709 is executed, the LISTEN and REMOTE LEDs turn ON.

	BUS STATUS DISPLAYS			
BUS MESSAGE	SRQ	TALK	LISTEN	REMOTE
CLEAR				ON
DATA (ENTER)		ON		
DATA (OUTPUT)			ON	ON
LOCAL				
LOCAL LOCKOUT				
CLEAR LOCKOUT & SET LOCAL				
REMOTE				ON
REQUIRE SERVICE	ON*		ON	ON
STATUS BYTE				
TRIGGER				ON

*SRQ is ON when OUTPUT 709; ''SE200'' is sent and front panel SRQ key is then pressed.

3497A Response to Bus Messages

Earlier, we noted that nine of the 12 HP-IB bus messages apply to the 3497A. This table summarizes these messages and shows the -hp-85A syntax for the bus message. The examples shown in the descriptions following the table apply to the -hp- 85, 9836, 9845 and similar computers. For other controllers, refer to the I/O programming manual.

HP-IB BUS MESSAGES FOR THE 3497A

Bus Message	85A Syntax	3497A Response to Message
CLEAR	CLEAR	Reset to power-on state, with two exceptions: 1. If previously set for REMOTE, remains in REMOTE after CLEAR message. 2. If POWER ON SRQ bit (Bit 5 in Status Register) set, bit remains set after CLEAR message (See REQUIRE SERVICE).
DATA	OUTPUT ---------------- ENTER	An OUTPUT message causes the 3497A to take action specified by the command(s) in the message. ---------------- An ENTER message transfers data from the 3497A to the controller.
LOCAL	LOCAL	Removes the 3497A from REMOTE operation and restores control to the front panel keyboard.
LOCAL LOCKOUT	LOCAL LOCKOUT	When the 3497A is in REMOTE mode, sending the LOCAL LOCKOUT message disables all the front panel keyboard except for Power ON/OFF.
CLEAR LOCKOUT AND SET LOCAL	LOCAL	Clears the LOCAL LOCKOUT and REMOTE modes and returns the 3497A to front panel control.
REMOTE	REMOTE	Switches control of the 3497A from the front panel to the controller. All front panel keys, except LOCAL, SRQ, ANALOG VIEWED CHANNEL and DIGITAL VIEWED SLOT are disabled.
REQUIRE SERVICE	----	If programmed to do so, the 3497A sends a REQUIRE SERVICE (SRQ) message when it requires action by the controller. If the controller is programmed to respond to the SRQ, it generates a SERIAL POLL operation and the 3497A returns a STATUS BYTE message to the controller.
STATUS BYTE	----	When the controller sends a SERIAL POLL message, the 3497A returns a STATUS BYTE message to the controller. Many controllers display the value of the STATUS BYTE as the decimal sum of the true bits in the byte.
TRIGGER	TRIGGER	Causes the 3497A to increment to the next analog channel and take a voltage measurement. If a reading is in progress, the TRIGGER message is delayed until the current reading is complete.

CLEAR

EXAMPLES

```
100 CLEAR 7      (Clears all devices on the interface)
250 CLEAR 709    (Clears 3497A set to address 09)
```

COMMENTS

When the CLEAR message is received, the 3497A is reset to its power-on condition, with two exceptions:

1. If the 3497A was previously set for remote operation (see REMOTE message), it remains in REMOTE after the CLEAR message.

2. If the POWER ON SRQ bit (Bit 5 in the Status Register) was previously set (see SERVICE REQUESTS), this bit remains set after a CLEAR message.

The CLEAR message initiates the same action pressing the front panel RESET key. The 3497A state after the CLEAR message is executed is:

3497A CONDITIONS AFTER CLEAR (OR RESET) ACTIONS

CLEAR (OR RESET) ACTIONS
1) Stops all task execution. 2) Clears all 3497A buffers and any other results. 3) Stops all data transmission from the 3497A.
4) Opens all analog and digital assembly channels. 5) Clears all interrupt capability. 6) Clears the STATUS BYTE.
7) Initializes analog and digital assemblies. 8) Initializes voltmeter to pre-defined state. 9) Sets first chan = 000 and last chan = 999.

DATA (ENTER & OUTPUT)

EXAMPLES

110 OUTPUT 709 (Send Data to 3497A)
220 ENTER 709 (Receive Data from 3497A)

COMMENTS

The DATA Messages (ENTER and OUTPUT) are used to transfer command information to the 3497A (OUTPUT) and to receive data from the 3497A (ENTER). Naturally, the syntax terms ENTER and OUTPUT are controller-dependent.

When the OUTPUT message is sent, commands are executed in the order received. For example, in the message OUTPUT 709;''AC40VN10'', the action is to first close analog channel 40 then set the voltmeter to take 10 readings/trigger. For the message OUTPUT 709; ''VN10AC40'', the action is reversed.

LOCAL

EXAMPLES

100 LOCAL 7
120 LOCAL 709

COMMENTS

The LOCAL 709 message clears the 3497A from the REMOTE operation mode (controller operation) and restores control to the front panel. Unless LOCAL LOCKOUT was previously established, this can also be accomplished by pressing the LOCAL key on the front panel. LOCAL 7 removes all instruments on the bus from the REMOTE mode.

LOCAL LOCKOUT

EXAMPLE

```
110 LOCAL LOCKOUT 7
```

COMMENTS

If the 3497A is in REMOTE mode and LOCAL LOCKOUT is set, all the front panel keys are disabled and the only way to return to front panel control is to either turn the power off and then on or to execute a CLEAR LOCKOUT/SET LOCAL message. For many controllers, this is the same as a LOCAL message (i.e. LOCAL 7).

If LOCAL LOCKOUT is set, the message LOCAL 709 returns front panel control to the 3497A, but the next REMOTE message (or OUTPUT 709) will return operation to the LOCAL LOCKOUT mode.

CLEAR LOCKOUT AND SET LOCAL

EXAMPLES

```
110 LOCAL 7
240 LOCAL 709
```

COMMENTS

The CLEAR LOCKOUT AND SET LOCAL message clears the 3497A from the REMOTE mode and clears the LOCAL LOCKOUT message.

REMOTE

EXAMPLES

```
110 REMOTE 7
240 REMOTE 709
```

COMMENTS

The REMOTE message switches control of the 3497A from the front panel to a controller. In REMOTE mode, all front panel keys on the 3497A are disabled, except for the ANALOG VIEWED CHANNEL, DIGITAL VIEWED SLOT, LOCAL and SRQ keys. The 3497A must be addressed (by sending a REMOTE 709 message) before it will go to REMOTE mode (a REMOTE 7 message will NOT put the 3497A in REMOTE mode).

When the 3497A is in REMOTE mode, the REMOTE indicator on the front panel display is ON. It is generally not necessary to use the REMOTE message, since the 3497A goes to REMOTE mode when it is first addressed (with an OUTPUT 709 message, for example).

REQUIRE SERVICE (SRQ)

COMMENTS

An important feature of the 3497A is that you can program it to interrupt the controller whenever a pre-determined condition occurs in your system. This means that the controller can do other tasks until these conditions occur and then take necessary action. Of course, the controller must also be programmed to respond to the interrupt.

For the 3497A, the interrupt message is a REQUIRE SERVICE (SRQ) message. Since SRQ is sent from the 3497A over the SRQ line of the HP-IB, SRQ activity is totally independent of other HP-IB activity.

An SRQ message is sent from the 3497A whenever certain system conditions occur, provided that the 3497A has previously been programmed to respond to these conditions. If the 3497A has not been programmed, when the conditions occur no SRQ (interrupt) is generated. To see why this happens, let's examine the Status Register and SRQ Mask in the 3497A.

Status Register

The 3497A contains an 8-bit Status Register which constantly monitors several possible interrupt (SRQ) conditions. Whenever an interrupt condition occurs, the appropriate bit in the Status Register is set true (a 1 condition). The following table defines the conditions which set the bits in the Status Register true.

For example, when the voltmeter completes a measurement, a DATA READY condition occurs and bit 0 of the Status Register is set to 1. When a message is not executed (for any of six reasons), a MESSAGE NOT EXECUTED condition occurs and bit 4 is set to 1.

It is important to note, however, that an SRQ message is NOT sent when these conditions occur, unless the 3497A is programmed to respond to the interrupt condition(s). This is done by setting the SRQ Mask.

STATUS REGISTER - DEFINITIONS

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Interv	Time Alarm	Dig Intr	Data Ready
2	1	4	2	1	4	2	1
Octal MSD		Octal 2ND DIGIT			Octal LSD		

Bit	Title	Condition Which Sets The Bit to 1 (true)
7	Manual SRQ	Pressing the front panel SRQ key.
6	SRQ	Bit 6 is 1 when SRQ Mask true bit(s) match Status Register true bit(s).
5	Power On SRQ	At 3497A Power On, IF the POWER ON SRQ ENABLE switch is set to 1 position.
4	Message Not Executed	Set by one of six conditions (see STATUS BYTE)
3	Time Interval	Set when a pre-established time interval has elapsed from a t=0 reference.
2	Time Alarm	Set when the time of day matches a pre-set time.
1	Digital Interrupt	Set when the digital input/interrupt counter assembly sends an interrupt to the status register.
0	Data Ready SRQ	Set when the voltmeter completes a measurement.

Setting the SRQ Mask

The SRQ Mask permits the 3497A to generate an SRQ message ONLY for the interrupt conditions specified. Whenever an interrupt condition occurs, the Status Register bit(s) are set as shown previously. However, to send an SRQ to the controller, the SRQ Mask bits must previously have been set.

The SRQ Mask bits and the ways in which the bits are set are shown below. Note that the SRQ Mask is identical to the Status Register, except that bit 6 is missing (we'll cover this later).

Bits 0 through 4 and bit 7 are set to 1 by SEn commands, where n = 0 to 377 is the octal value of the bit. Bit 5 is set to 1 ONLY when the POWER ON SRQ ENABLE switch is set to the 1 position and cannot be set with an SEn command.

The chart below also shows the SE command to set each of the bits true (i.e. send SE2 to set the SRQ Mask for Digital Interrupt - bit 1 true). Any combination of bits 0 through 4 and/or bit 7 can be set by an appropriate SEn command. For example, to set bits 4 and 0 true, the command is SE21 (SE20 + SE1).

SRQ MASK - BIT DEFINITIONS AND BIT SET COMMANDS

Bit 7	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Man SRQ	Pon SRQ	Msg Not Exec	Time Interv	Time Alarm	Dig Intr	Data Ready
SE200		SE20	SE10	SE4	SE2	SE1

POWER ON SRQ ENABLE SWITCH IN THE 1 POSITION SETS BIT 5 TRUE

Sending SRQ

To send SRQ to the controller, set the SRQ Mask for the interrupt conditions desired by sending an SEn command and/or setting the POWER ON SRQ ENABLE SWITCH to the 1 position. When the specified interrupt conditions occur, the Status Register bit(s) will be set. Since the SRQ Mask bits are also set, bit 6 of the Status Register is set and an SRQ occurs.

EXAMPLE - POWER ON SRQ

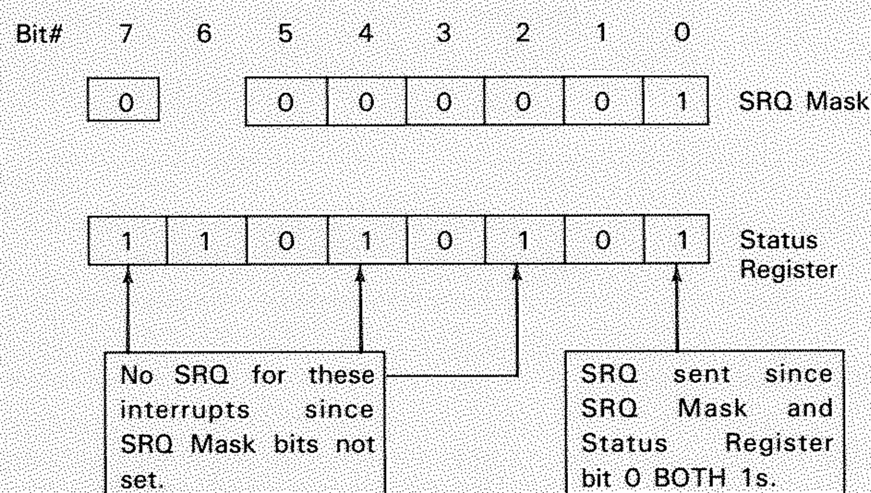
To send SRQ when the 3497A is turned on, set bit 5 of the SRQ Mask by placing the POWER ON SRQ ENABLE switch in the 3497A to the 1 position. Then, at power-on bit 5 of the Status Register is set and SRQ is generated. If the POWER ON SRQ ENABLE switch is in the 0 position, Status Register bit 5 is NOT set at power on and SRQ is not generated.

EXAMPLE - FRONT PANEL SRQ

To generate an SRQ from the front panel, first set the SRQ Mask bit 7 true by sending OUTPUT 709; "SE200". Then, when the front panel SRQ key is pressed, an SRQ is generated and the SRQ LED on the display turns ON, indicating that the SRQ has been sent.

EXAMPLE - DATA READY SRQ

To generate an SRQ for Data Ready conditions, set bit 0 of the SRQ Mask by sending OUTPUT 709; "SE1". When a DATA READY condition occurs (see STATUS BYTE), bit 0 of the Status Register is set and the combination of SRQ Mask bit 0 true and Status Register bit 0 true generates an SRQ.



STATUS BYTE

EXAMPLES

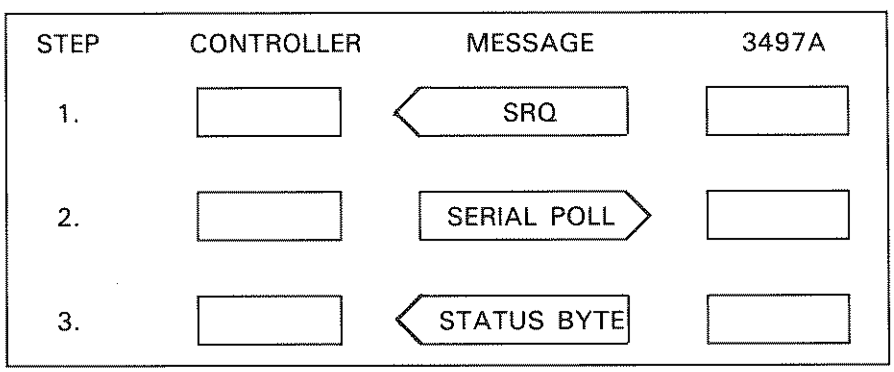
P = SPOLL 709 (-hp- 85A)
STATUS 709;P (-hp- 9845 A/B)

COMMENTS

When the 3497A sends an SRQ (see REQUIRE SERVICE), if the controller has been programmed to respond to the SRQ, the controller sends a SERIAL POLL message to determine the source of the SRQ.

After the 3497A receives the SERIAL POLL message, it outputs a STATUS BYTE message which contains information on the condition of the bits in the status register. The sequence of actions is shown below, assuming that the controller has been programmed to respond to SRQ.

SERIAL POLL SEQUENCE



Many controllers display the condition of the STATUS BYTE as the decimal sum of the individual true bits. For example, if bits 0 and 7 of the Status Register are true, the decimal value of the status byte is 129 (128 + 1). This chart shows the bits in the status register and their equivalent decimal value. See REQUIRE SERVICE (SRQ) for a description of the bits.

STATUS REGISTER - DECIMAL VALUES

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Man SRQ	SRQ	P On SRQ	Msg Not Exec	Time Inter-val	Time Alarm	Dig Intr	Data Ready
Decimal Value	128	64	32	16	8	4	2	1

In most cases, when the STATUS BYTE message is sent to the controller in response to a SERIAL POLL message, all bits in the Status Register are cleared to 0. However, there some exceptions for bit 4 (Message Not Executed) and bit 0 (Data Ready).

The following table shows conditions for which the bits in the Status Register are set and cleared, assuming that the SRQ Mask is set for these conditions (see REQUIRE SERVICE). The SRQ Mask is NOT reset by a SERIAL POLL. The SRQ Mask is changed only when power is turned off, by a RESET or when new mask conditions are entered.

TRIGGER

EXAMPLES

```
100 TRIGGER 7
290 TRIGGER 709
```

COMMENTS

If the 3497A has been addressed to listen, the TRIGGER message (also known as GET for Group Execute Trigger) causes the 3497A to increment to the next analog channel and take a single voltage measurement with the DVM (if installed). If a reading is in progress, execution of the TRIGGER message is delayed until the current measurement is complete.

For example, at power-on, sending TRIGGER 709 causes the 3497A to close analog channel 000 and take a voltage measurement of the channel 0 voltage. Sending TRIGGER 709 again causes the 3497A to close channel 001 and measure the voltage on channel 1.

STATUS REGISTER - BIT SET AND CLEAR CONDITIONS
(IN RESPONSE TO A SERIAL POLL)

BIT	DESCRIPTION	SET	CLEAR AFTER SERIAL POLL (YES/NO)
7	Manual SRQ	When Front Panel SRQ key is pressed.	YES
6	SRQ	When Status Register Bit 0,1,2,3,4,5 and/or 7 = 1.	YES*
5	Power-On SRQ	At power-on if POWER ON SRQ ENABLE switch set to 1 position.	YES
4	Message** Not Executed	When one of the six conditions shown occurs.	
		1) Voltmeter receives an external trigger but has not completed measurement.	YES
		2) New data is requested before the previous data completely transferred to the controller.	NO
		3) An illegal command is sent to the 3497A.	YES
		4) A parameter sent exceeds limits of of the 3497A.	NO
		5) The internal 3497A buffer storage is full.	NO
		6) A digital assembly is not present in the slot addressed.	NO
3	Time Interval	When time interval set by TIn command is reached.	YES
2	Time Alarm	When time of day set by TAn command is reached.	YES
1	Digital Interrupt	Set by signal from digital input/interrupt or counter assembly when pre-set conditions occur.	YES
0	Data Ready SRQ	1) When voltmeter storage is OFF, bit is set after each measurement is sent to the controller.	YES
		2) When voltmeter storage is ON, bit is set after n measurements (set by the VNn command) are stored.	NO

* Also cleared at Power On or RESET.

** Can't determine which condition caused SRQ, since bit 4 true is only information returned.

Chapter 4
SERIAL DATA PROGRAMMING

INTRODUCTION

In Chapter 2, we showed how to enter commands from the front panel. In this chapter, we'll show how to enter these same commands using a controller and an RS-232C or RS-449/423 interface and provide some programming hints to help your controller communicate more effectively with the 3497A.

If you are not familiar with RS-232C or RS-449/423, see Appendix A for a summary of these interfaces. Now, let's take a look at the capabilities of the 3497A for Serial Data communication.

With Option 232, the 3497A is compatible with Electronic Industries Association (EIA) standards RS-232C and RS-449 with the RS-423 electrical subset. It is also compatible with CCITT (Comite Consultatif International Telephonique et Telegraphique) standards CCITT V.24 (for RS-232C) and CCITT V.10 (for RS-449/423).

The 3497A can be operated from a controller in one of two ways: (1) directly connected to a controller via RS-232C or RS-449/423 or (2) connected to an asynchronous, full duplex MODEM via RS-232C or RS-449/423 for remote site operation using dedicated telephone lines.

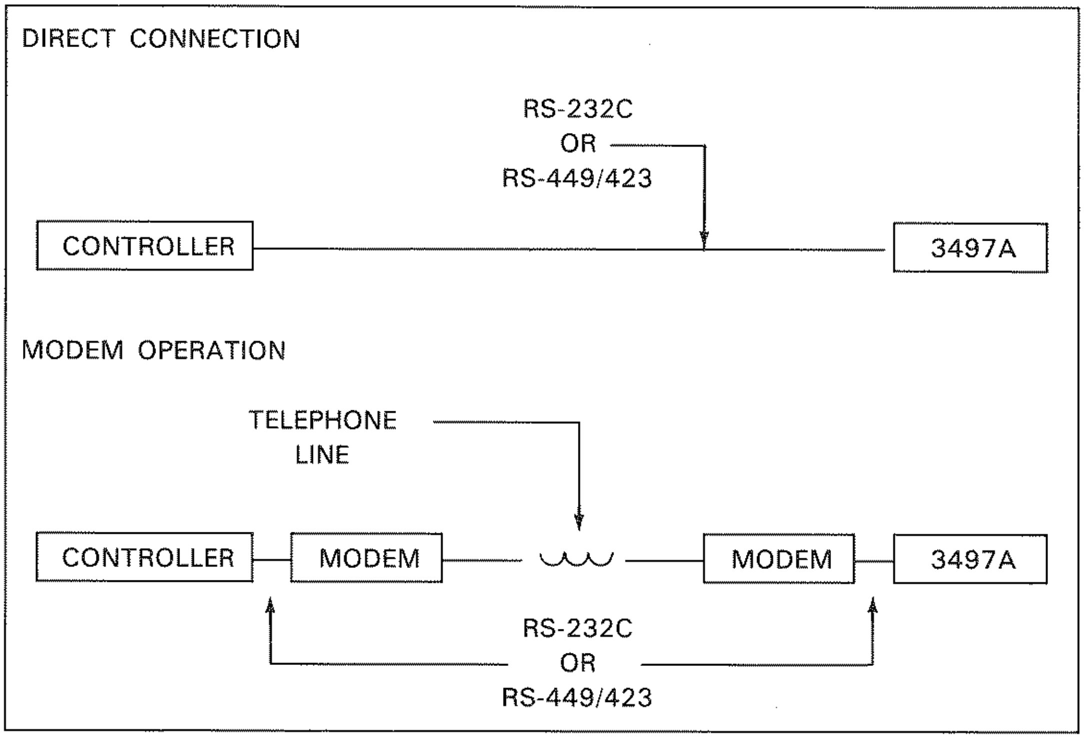
With RS-232 operation, the 3497A can be located a maximum of 50 feet (15.24 meters) from the controller. With RS-449/423 operation, the maximum separation depends on the speed of operation. For example, for data rates up to 1000 bits per second, maximum cable length between the controller and the 3497A is 4000 feet (1200 meters).

The 3497A can operate only with asynchronous, full duplex MODEMS (data sets) and has been functionally tested to operate with the following (or equivalent) MODEMS:

- Bell 103A, 212A, 103J
- Vadic 3400, 3451
- U.D.S. 103JLP
- -hp- Model 82950A MODEM Interface for the -hp- 85A

The 3497A can be configured for a wide variety of operating conditions, depending on controller and speed requirements. The following table shows the possible operating conditions for the 3497A with factory preset conditions outlined.

3497A SERIAL DATA CONFIGURATIONS



SERIAL DATA MESSAGES

Naturally, communication between your controller and the 3497A is a two-way street. However, for simplicity, we'll break the discussion into three parts: (1) sending commands to the 3497A (2) receiving data from the 3497A and (3) handshake techniques. To begin, however, let's take a look at the format and syntax rules of messages used to send information across the interface.

3497A OPERATING CONFIGURATIONS

Type of Operation	RS-449/423 Operation	
	RS-232C Operation	
Type of Connection	Direct Connection to Controller	
	Connect to MODEM	
Type of Handshake	ENQ/ACK	
	DC1 ON	
	DC1 OFF	
Speed of Operation/ # Stop Bits	Speed#	Stop Bits
	19,200	1
	9,600	1
	4,800	1
	2,400	1
	1,200	1
	600	1
	300	1
	110	2
Word Length & Parity	8-bit ASCII w/odd parity	
	7-bit ASCII w/odd parity	
	8-bit ASCII w/no parity	
	7-bit ASCII w/even parity	

(shaded) = Factory Setting

Message Format

Recall from Chapter 2 that commands for the 3497A consist of two alpha characters usually followed by one or more numerics (i. e., AC10, ST1, etc). To send these commands from your controller to the 3497A, it is necessary to add the controller transmit protocol and the interface select code (ISC). We'll call the combination a message. Thus, a message consists of three parts: protocol, ISC and command(s).

For BASIC language controllers such as the -hp- 85A, the protocol to send a command from the controller to the 3497A is OUTPUT. As factory preset, the ISC on the -hp- 85A Serial Data interface is 10, so a typical message would have the following form. For proper communication between your controller and the 3497A, you must use the protocol appropriate for your controller and the proper ISC for the interface used.

EXAMPLE - TYPICAL BASIC LANGUAGE MESSAGE

OUTPUT	10;	"AC10VD4"
↑	↑	↑
Protocol	ISC	Commands

Message Syntax

Before a command can be accepted by the 3497A, it must first get across the interface and then be accepted as valid by the 3497A. We'll talk later about getting the message across the interface. First, let's list some punctuation (syntax) rules for commands to be accepted as valid by the 3497A.

3497A COMMAND SYNTAX RULES

1. Each command must begin with two upper case letters and may be followed by one or more numerics. The 3497A ignores lower case letters, LF (Line Feed), colon (:), the plus (+) sign, spaces, nulls and ASCII characters between 18 and 31 (decimal).

2. The 3497A recognizes the minus (-) sign only as the first character following an AO (Analog Output) or System View (SV) command. The 3497A recognizes the decimal point as the first character following the SV command.

3. When numbers are used in a command, they must be free field integers from 0 to 9999999999. When numbers are required in a command but are not specified, a "0" is assumed, except for the AC, AV, DV, SR, TD and TE commands. For example, if the command DC2,3 (close digital channel 3 in slot 2) is intended, but DC2 is sent, the action is DC2,0 (close digital channel 0 in slot 2).

4. If more than one number is used in a command, comma(s) must be used between numbers (i.e. AC3,13). DON'T use commas anywhere else in the commands, such as between two commands in a message (AC10VD4 shown previously). In some commands, a comma as the last character is interpreted as a 0. In other commands, a comma as the last character causes any previous commands to be executed and generates an error message.

5. Several commands can be grouped together and sent in a single message. The 3497A executes the commands in the order received by use of the "CR" (Command Terminator) sent with each message. The command string should not exceed 42 characters (excluding the CR terminator). If a command string exceeds 42 characters, execution of commands begins with the 42nd character and all characters after the 42nd are ignored.

COMMUNICATING OVER THE BUS

As mentioned, communication between your controller and the 3497A takes place over the Serial Data interface bus. Also, as mentioned, we'll divide the discussion on transmitting messages over the bus into three parts: (1) sending commands to the 3497A (2) receiving data from the 3497A and (3) handshake techniques. We'll begin with sending commands to the 3497A.

Sending Commands to the 3497A

When the controller sends commands to the 3497A, the 3497A is in the receive mode of operation. In this mode, the front panel LISTEN light flashes to indicate information (commands) input to the 3497A. In receive mode, characters are input to a 42-character command buffer until either a CR (command terminator) is received or until the buffer is full (42 characters entered).

After it receives CR, the 3497A executes commands in the order that they are received. If the command string does not exceed 42 characters, the LISTEN light remains on but execution of commands does not start until the CR is received. However, if the command string exceeds 42 characters, execution starts after the buffer is full, even if CR is not sent.

This means that the 43rd and all following command characters will be ignored by the 3497A. Also, command strings exceeding 42 characters will cause the input buffer overflow bit to be set in the 3497A status register (see BREAKS, SERVICE REQUESTS and INTERRUPTS).

Also, if the 3497A is busy executing a command when another is received, the new command will be ignored and the system overrun bit will be set in the status register. Some programming notes for receive mode follow.

Receiving Data From the 3497A

Certain types of commands require that data be sent from the 3497A to the controller (or other requesting device). When the 3497A sends data to the controller, it is in the transmit mode. When the 3497A is in transmit mode, the front panel TALK light is flashing, indicating that data is being output.

For BASIC language controllers such as the -hp- 85A, the protocol for messages which require data returns is ENTER (i.e., ENTER 10; A) which tells the 3497A to send data to the controller and store in A. In response to ENTER messages, the 3497A outputs data in one of three formats (1) ASCII (2) Packed BCD or (3) Time of Day, ASCII, Analog Channel Number.

PROGRAMMING NOTES FOR RECEIVE MODE

1. The 3497A does NOT support ECHO. If your controller has this feature, turn the ECHO function OFF before communicating with the 3497A.

2. The 3497A is compatible with even, odd or no parity operation (7-bit ASCII w/odd parity is preset). If parity is not specified, a parity bit is NOT sent and character transmission time is reduced by one bit time.

3. If the front panel LISTEN light does not turn OFF after messages are sent to the 3497A, the controller is probably not sending the CR terminator and CR must be added to each message.

4. To avoid command (input) buffer overflow, do not send messages with command strings which exceed 42 characters.

5. To avoid a system overrun (commands being ignored):

   a. slow the speed of operation to give the 3497A time to execute commands before sending another command.

   b. Use WAIT statements in programs to give the 3497A time to execute commands before sending another.

   c. If the speed of operation can't be slowed down, use a handshake technique. The 3497A is compatible with either DC1 or ENQ/ACK handshakes (see HANDSHAKE TECHNIQUES).

NOTE

The 3497A sends a CR terminator at the end of the data message (LF is NOT sent). Some controllers, including the -hp- 85A, expect to see CR LF at the end of the message. Thus, if your controller normally requires CR LF, you must reconfigure it to eliminate this requirement for proper operation with the 3497A.

A sample way to eliminate the requirement for an LF character is ENTER 10 USING "#,K"; ... By using this type of ENTER statement, the -hp- 85A requires only the CR character sent by the 3497A.

3497A DATA OUTPUT FORMATS

As mentioned, the 3497A, outputs data in one of three formats. The formats for ASCII data and Time of Day, ASCII, Analog Channel Number are outlined as follows.

ASCII Format

The output format for ASCII data from the 3497A is as follows, where D = Decimal digit, O = Octal Digit, 0 = Zeros, E = Exponent and CR is the command terminator (LF is not sent).

ASCII DATA OUTPUT FORMATS

Voltage Measurement:	± D.DDDDD E±D CR
Time of Day:	DD:DD:DD:DD:DD CR
Elapsed Time:	DDDDDDDDDD CR (First 4 Digits are Zeroes)
Digital Read or Digital Load:	OOOOOO CR (0-177777 Octal)
Digital Interrupt:	000OOO CR (Last 3 digits are 0-377 Octal)
Counter Totalize:	DDDDDD CR
Counter Period or Pulse Width:	D.DDDDDD E+D CR (Seconds)
Analog Channel:	±DDD CR (- = No Chan Closed)
System Read:	000OOO CR (last 3 digits are 0-377 Octal)

Packed BCD Format

Packed BCD is used to increase transfer (reading) speed from the 3497A to the controller. In packed BCD, data is transmitted in three 8-bit bytes, in contrast to ASCII format which requires eleven or more bytes to transmit each measurement to the controller. Option 232 has a storage capacity of 85 readings using packed BCD format. See Chapter 3, HP-IB Programming, for Packed BCD format and example.

Voltmeter Format 3

When the voltmeter format is set to VF3 (see the Command Directory), the output from the 3497A is Time of Day, ASCII, Analog Channel Number, as shown where D = decimal digit. See Chapter 3 for an example.

DD:DD:DD:DD:DD,	±D.DDDDD E±D,	±DDD CR
Time of Day	Measurement ASCII Format	Analog Channel Number and Sign

HANDSHAKE TECHNIQUES

A handshake is a means to insure a complete and orderly transfer of information between the 3497A and the controller. As shown in the section on sending commands to the 3497A, difficulties can arise if the controller tries to send messages to the 3497A when the 3497A is not ready to accept them. The same problem occurs if the 3497A tries to return data to the controller when the controller is not ready to accept the data.

To prevent these occurrences, the 3497A is compatible with two types of handshakes: Enquire/Acknowledge (ENQ/ACK) and DC1. In addition, to avoid computer overflow, the 3497A can operate in single or continuous output mode. Finally, you can use Local/Remote operation to control the 3497A from the front panel or from your controller.

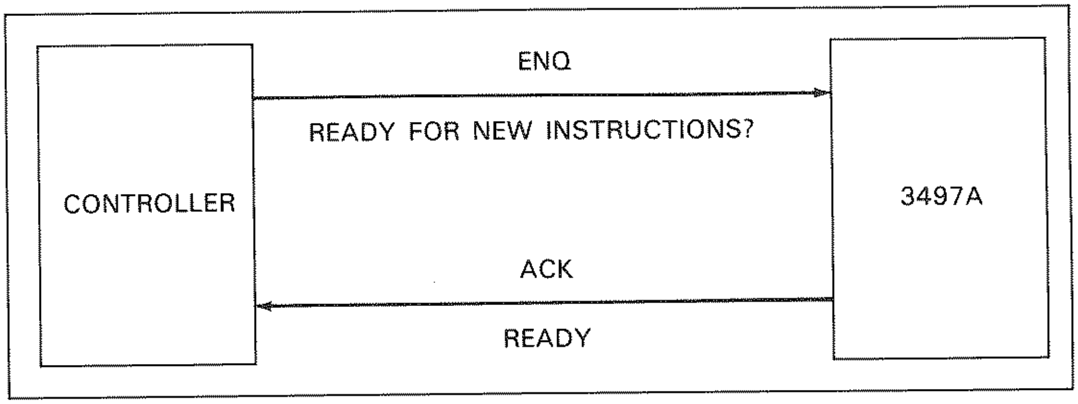
Enquire/Acknowledge (ENQ/ACK)

The purpose of the ENQuire/ACKnowledge handshake is to ensure that the controller does not send messages to the 3497A before the 3497A is ready to receive them. The controller sends an ENQ (ASCII character 5) message to the 3497A to see if the command (input) buffer is ready to accept new commands. When the 3497A receives the ENQ message, it does one of two things:

1. If the 3497A is busy executing a previous command, it completes execution of the command and then sends an ACK (ASCII character 6) message which tells the controller that the 3497A is ready.

2. If the 3497A is not busy, it returns the ACK message immediately.

ENQ/ACK HANDSHAKE



The ENQ message can be sent at any time. Usually, however, ENQ is sent as the last character of a message, following the CR terminator. Regardless of when the ENQ is received, the 3497A will not return ACK until all data requested is returned or, in general, until all command execution is complete.

Note that the ENQ/ACK handshake is executed entirely by software (in contrast to the DC1 handshake which is set by a switch inside the 3497A). A sample program to set the ENQ/ACK handshake using the -hp- 85A is shown which sets Control Registers 11, 15, 16 and 19 to implement the ENQ/ACK handshake. The -hp- 85A is defined as the host and an interface select code (ISC) of 10 is used.

EXAMPLE - ENQ/ACK HANDSHAKE TECHNIQUE

Program	Lines	Description
10 RESET 10	10	Sets Interface to Power On
20 CONTROL 10,11; 128	20	Allow XMIT FLAG Enable
30 CONTROL 10,15; 6	30	ACK enables XMIT FLAG
40 CONTROL 10,16; 66	40	2 char EOL & disable XMIT
50 CONTROL 10,18; 5	50	ENQ is 2nd EOL character
60 *	60	- Main Program
70 *		

DC1 Handshake

When the 3497A is set for DC1 mode (by setting the DC1 HANDSHAKE switch in the 3497A to the "1" position), the 3497A will not return any data to the controller until it receives a DC1 (ASCII 17) character from the controller. A sample program line to send DC1 is: OUTPUT 10 USING "#,K"; CHR$(17).

DC1 should only be used when your controller is not capable of receiving data from the 3497A at any time. Many computers send the DC1 character just prior to a read (ENTER) statement so that they will be ready to receive the data specified by the command. Some rules for DC1 operation follow.

DC1 OPERATION

1. DC1 must be sent for each reading requested unless it follows a read buffer command. For example, if the command VT3DL2 is sent, 2 "DC1s" must be sent to receive both pieces of data.

2. If a read buffer command is sent, DC1 following the command initiates transfer of all stored readings. A DC1 following a command for multiple readings/trigger initiates transfer of all readings.

3. If a command does not require data to be returned and a DC1 is sent with the command, the 3497A remembers the DC1 and uses it to transmit the next data requested.

4. If the 3497A is NOT set for DC1 mode, any DC1 characters will be ignored and data requested will be returned as soon as the 3497A has processed it.

5. Do NOT use external trigger (VT2) mode when in the DC1 mode. With external trigger, the 3497A will continuously take readings and try to output them to the controller. However, the DC1 mode requires that the 3497A wait for a DC1 command before outputting data. Thus, the 3497A is dependent on two conflicting mode requirements and data errors could result.

Single/Continuous Output Modes

When certain commands are sent to the 3497A, it will return data continuously. These commands include Internal Voltmeter Trigger (VT1); Counter Internal Trigger (CR slot#,3); Self-Test (ST1); Read Time of Day (TD); Read Elapsed Time (TE) and Digital Read (DR slot#) [see the Command Directory].

Because of this, the controller could overflow. To avoid controller overflow, the command SOn (n = 0 or 1) can be sent to establish the output mode of the 3497A. When SO0 is sent, the 3497A outputs data in the continuous mode. When SO1 is sent, the 3497A outputs a single reading for each command.

Local/Remote Operation

When the 3497A is in local mode, commands can be entered from the front panel.

Remote operation means that commands can only be entered from a controller via the serial interface. In remote operation, the front panel keyboard is disabled, except for the LOCAL, SRQ, ANALOG VIEWED CHANNEL and DIGITAL VIEWED SLOT keys. In local operation, the 3497A will not output data to the controller.

At power on, the 3497A is in local mode, but changes to remote mode after executing the first command sent to it (except for ENQ and DC1 messages). If the front panel LOCAL key is pressed, the 3497A goes from remote to local mode and data can't be output to the controller.

Also, at power on the 3497A is set to continuous output mode, but the mode is changed to single output whenever a local-to-remote mode transition occurs (i. e., whenever a command is sent to the 3497A). When the 3497A goes from remote to local mode, it will remain in the output mode programmed while in remote. If no output mode was programmed while in remote, the 3497A assumes the output mode it was in while in local.

For example, at power on the 3497A is in local operation with continuous output mode (SO0). When a command is sent, the 3497A goes to remote operation with single output mode (SO1). If the SOn command is NOT sent, when the 3497A goes to local operation it reverts back to continuous output mode (SO0). On the other hand, if the SO1 command IS sent while the 3497A is in remote mode, when the 3497A goes to local operation it stays in single output (SO0) mode.

BREAKS, SERVICE REQUESTS AND INTERRUPTS

In most cases, once communication is established between the 3497A and the controller, operation continues on a blissful course. However, there are times when the 3497A requires service from the controller or a glitch occurs when the message sent by the controller is not received or accepted by the 3497A (or vice versa). In these cases, special action is required. We'll next discuss the BREAK message and the SYSTEM CLEAR command and show how to program the controller and 3497A to respond to interrupt conditions.

BREAK Message

A BREAK message is sent by holding the transmitted data line in the space condition for about 250 msec. A BREAK message can be sent from the 3497A to the controller or from the controller to the 3497A. When the 3497A sends a BREAK message to the controller, it is requesting service from the controller.

When the controller sends a BREAK message to the 3497A, it causes the 3497A to revert to a power on condition (except for resetting the UART and reading the configuration switches). When the controller sends the BREAK message, the following actions occur.

3497A ACTIONS FOLLOWING A BREAK MESSAGE

1) All command execution is terminated.
2) All buffers are cleared.
3) All data transmission stops.

4) All analog and digital channels are opened.
5) The interrupt mask and status register are cleared.
6) Initializes all analog and digital assemblies and DVM.

7) Sets the DVM to internal trigger (VT1).
8) Sets analog first channel = 000 and analog last channel = 999.
9) Returns the 3497A to local mode.

PROGRAMMING NOTE

Many controllers recognize the BREAK message only AFTER commands already in the 3497A command buffer have been executed and all data requested returned to the controller. Other controllers recognize the BREAK message immediately. If your application requires immediate recognition of the BREAK message, consult the controller operating manual to insure that the controller has this capability.

System Clear

The SYSTEM CLEAR (SC) command is similar to the BREAK message, except that SC does not clear the command (input) buffer or return the 3497A to local mode. You can use the SC command if your controller cannot generate a BREAK message. Since SC clears the status register, data transmission errors, buffer overflow and system overrun information are lost when the SC command is executed.

Also, SC clears all system errors. Therefore, if an I/O error occurs prior to the execution of the SC, it may not be reported. You can avoid this by sending SC as a separate command and not in a string of commands. If SC is entered from the front panel, its effect is the same as pressing the front panel RESET key. The 3497A actions following an SC command are:

3497A ACTIONS FOLLOWING AN SC COMMAND

1) All command execution is terminated.
2) All data transmission stops.
3) All analog and digital channels are opened.

4) The interrupt mask and status registers are cleared.
5) Initializes all analog and digital assemblies.
6) Sets the DVM for internal trigger (VT1).
7) Sets first analog channel = 000 and last analog channel = 999.

PROGRAMMING NOTE

The SC command does not reset VF2 or VF3 (see Command Directory) or clear the voltmeter storage register. To completely reset the 3497A, the controller should send the BREAK message. If the controller can't send BREAK, send SC and reset the the voltmeter format to ASCII by sending VF1 and turn the voltmeter storage to OFF by sending VS0.

Require Service (SRQ)

When the 3497A requires service from the controller, it sends a BREAK message to the controller. When this BREAK message is sent to the controller, it is called a service request (SRQ). If the controller has been programmed to respond to the SRQ, it takes action as previously programmed. However, if the 3497A is executing a data request command, the BREAK message will not be sent until after the data has been sent.

An SRQ is generated in response to one or more system interrupt conditions. For example, it may be required to send an SRQ message when an I/O error occurs, for a time alarm, for message not executed, etc.

However, for the 3497A to send the BREAK (SRQ) message to the controller, the 3497A must first be programmed to respond when system interrupt conditions occur. To see how to do this, let's examine the status register and interrupt mask.

Status Register

The status register in the 3497A Option 232 is a 16-bit register which is constantly updated as events occur. The following table defines the conditions for which each bit is set to a 1 condition (i. e., bit 2 is set to 1 when a time alarm condition occurs). MSD, 5th digit, ... LSD under the bits represent the digits of the octal number returned to the controller in response to an SR (status register read) command.

STATUS REGISTER - SERIAL DATA

Bit 15	14	13	12	11	10	9
0	Data rcd/no MODEM	(CD) Recvr Ready	no/lost carrier disconn	(CTS) Clear To Send	(DSR) Data Set Ready	System Over-Run
MSD (Always Zero)	5th digit			4th digit		

8	7	6	5	4	3	2	1	0
Buffer Over-Flow	Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
3rd digit			2nd digit			LSD		

Bit	Condition(s) Which Set the Bit True
15	Always 0.
14	Data is received when MODEM not connected. This bit is set if either of two conditions occur: 1) False transitions occur on the Received Data line before a MODEM connect sequence is complete or after a disconnect sequence is complete. 2) If the 3497A is configured for MODEM operation, but is directly connected to the controller.
13	Data Carrier Detect (RS-232C); Receiver Ready (RS-449). When this MODEM line is ON, bit is set. When this MODEM line is OFF, bit is 0.
12	No or Lost Carrier. This bit is set if an attempt is made to connect the MODEM but no connect occurs within 20 seconds after the attempt. Bit is also set if connection is lost after connect sequence.
11	Clear to Send. Bit is set when the Clear to Send line (CTS) is ON. When this line is OFF, bit is 0.
10	Data Set Ready (RS-232C); Data Mode (RS-449). Bit is set when the MODEM turns this handshake line ON. Bit is 0 when this line is OFF.
9	System Overrun. Set if a command is received when the 3497A is executing a previous command. If a system overrun condition occurs, bit 4 (message not executed) is also set.
8	Buffer Overflow. Set if a command string exceeds 42 characters. If a buffer overflow occurs, bit 4 (message not executed) is also set.
7	Manual Service Request. Set when the front panel SRQ key is pressed.
6	Service Request. This bit is set when bit(s) 0-5 and/or bit 7 in the status register is set AND the corresponding bit(s) in the interrupt mask is set. For example, if bit 1 is set in the interrupt mask, when bit 1 in the status register is set, bit 6 of the status register is also set.
5	Power On SRQ. Bit is set at 3497A power-on and/or when the 3498A Extender experiences a power return.
4	Message Not Executed. This bit is set when any of the following 8 conditions exist: 1) Illegal commands received. 2) Trigger too fast when DVM in external trigger (VT2) mode. 3) Numeric parameter is out of limits. 4) Voltmeter storage buffer is full. 5) Digital assembly not present in slot addressed. 6) Packed BCD format (VF2) specified when the 3497A is configured for 7-bit ASCII. 7) Command (Input) buffer overflow. 8) System overrun.
3	Time Interval. Set when a time interval interrupt occurs.
2	Time Alarm. Set when a time alarm (match) condition occurs.
1	Digital Interrupt. Set when an interrupt is sent from a digital input or counter assembly.
0	I/O Error. Set when any of the following three conditions occur: 1) Parity error detected by UART. 2) Overrun detected by UART. 3) Framing error detected by UART.

To determine the condition of the bits in the status register, use the SR (Status Register Read) command followed by an ENTER command. The data returned is a 6-digit octal number which gives the values of the true bits. An example sequence for the -hp- 85A is:

```
10 OUTPUT 10; ''SR''
20 ENTER USING ''#,K''; A
```

Following the ENTER statement, a 6-digit octal number representing the true bits in the status register is input to the controller. Suppose that bits 1, 4, 10, and 14 are true (representing a theoretically disastrous situation). Then, the digital bit pattern is 0 100 010 000 010 010 and the octal number is 042022 (see Chapter 2, Binary-to-Octal Conversion).

Interrupt Mask

As shown, the status register bits are set to 1 by a variety of system conditions and the contents of the status register can be read at any time by using the SR command. It is convenient to have a means of interrupting the controller when certain system conditions occur. This is the purpose of the interrupt mask.

The status register is updated as events occur, and thus is constantly changing status. However, to allow ONLY those conditions desired to send a break message to the controller, it is necessary to program the interrupt mask.

To set the interrupt mask for the conditions you want to cause interrupt, send an SEn command, where n is an octal number corresponding to the bits to be set in the interrupt mask. The interrupt mask is a bit-by-bit replica of bits 0-7 of the status register.

Bit 6 (the SRQ bit) of the interrupt mask MUST be set to send the BREAK message to the controller. For example, suppose you want the 3497A to send a BREAK message if a parity, framing or overrun error occurs. Since these are I/O errors, bit 0 and bit 6 must BOTH be set to enable a BREAK message for I/O errors (and only I/O errors).

Note that even if any other system conditions, such as time alarm, message not executed, etc. occur, no BREAK message will be generated, since the interrupt mask is not set for these conditions.

INTERRUPT MASK

	7	6	5	4	3	2	1	0
Bit name	Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
Digit	Octal MSD		2nd Digit			LSD		

Bit	SEn*	Description
7	300	Manual Service Request. When bit 7 and bit 6 are set, pressing the front panel SRQ key sends the BREAK message.
6	100	Bit 6 MUST be set to enable the BREAK message when specified interrupt condition(s) occur.
5	140	Power On SRQ. When bit 5 and bit 6 are set, a BREAK is sent when the 3497A powers on or when the 3498A Extender recovers from a power loss.
4	120	Message Not Executed. If bit 4 and bit 6 are set, a BREAK is sent when any of the following 8 conditions occur: 1) Illegal command sent. 2) Trigger too fast when the DVM is set for external trigger (VT2) mode. 3) Numeric input is out of limits. 4) Voltmeter storage buffer is full. 5) Digital assembly not present in slot addressed. 6) Packed BCD format (VF2) programmed when the 3497A is configured for 7-bit ASCII. 7) Command (input) buffer overflow. 8) System overrun.
3	110	Time Interval. If bit 3 and bit 6 are set, a BREAK is sent when a specified time interval (set by the TIn command) has elapsed.
2	104	Time Alarm. If bit 2 and bit 6 are set, a BREAK is sent when a time alarm (time of day) match occurs.
1	102	Digital Interrupt. If bit 1 and bit 6 are set, a BREAK is sent when a digital input or counter assembly sends an interrupt signal to the 3497A.
0	101	I/O Error. If bit 0 and bit 6 are set, a BREAK is sent when any of the following 3 conditions occur: 1) parity error detected by UART. 2) overrun error detected by UART. 3) framing error detected by UART.

* The number shown sets this bit and bit 6 (i.e., SE102 sets bit 1 and bit 6). For other combinations, the SEn command must be set for interrupt mask bits to be set.

To set the interrupt mask for desired interrupt conditions, send an SEn command, where n = 0 to 377 is an octal number corresponding to the bits to be set. (Remember, bit 6 must be set in addition to any other bits set for BREAK to occur.) For example, to set bits 6 and 0 in the interrupt mask, send OUTPUT 10; "SE101". Then, whenever a parity, overrun or framing error occurs, a BREAK message occurs and the controller can take action (if it has been previously programmed to do so!).

Interrupts in MODEM Operation

All of the interrupt capabilities for direct connection are applicable to MODEM operation. In addition, MODEM operation adds some interrupt sequences during connect and disconnect sequences. As noted, the 3497A is compatible with asynchronous, full duplex MODEMS. In MODEM operation, there are two sequences in which a BREAK message will be generated to the controller (in addition to the conditions for direct connection).

At power on, when the 3497A is set for MODEM operation, the 3497A turns on Data Terminal Ready (Terminal Ready for RS-449) and Request to Send. The MODEM connected to the 3497A turns on Clear to Send and Data Set Ready (Data Mode) when a call is received from the distant MODEM. When the receiving MODEM detects the carrier from the remote MODEM, it turns on Data Carrier Detect (Receiver Ready).

The 3497A will wait for up to 20 seconds for its MODEM to assert Data Carrier Detect (Receiver Ready), Clear to Send and Data Set Ready (Data Mode) after which the 3497A starts a MODEM disconnect sequence. When the 3497A starts the disconnect sequence, it drops Data Terminal Ready (Terminal Ready) for 6 seconds to allow the MODEM to disconnect from its telephone line. During this 6 seconds, commands cannot be entered from the controller or the front panel.

The second condition for which MODEM interrupts can occur is after the 3497A has established a MODEM connection. After the 3497A has established a MODEM connection, loss of Data Carrier Detect (Receiver Ready), Data Set Ready (Data Mode) or Data Terminal Ready (Terminal Ready) for 300 msec or longer will cause the MODEM disconnect sequence previously described to occur.

PROGRAMMING NOTE

When the 3497A is in the MODEM mode, it always operates as a Data Terminal and will handle automatic call answering, if an appropriate MODEM is used. However, the 3497A will not initiate a call sequence (i.e., "Auto Dial") to a remote MODEM. Refer to your MODEM operating manual for procedures to call up the 3497A.

EXAMPLE PROGRAMMING SEQUENCES

Now, let's take a look at some example program sequences to see how to enter commands using a controller. All examples shown are written in enhanced BASIC language applicable to controllers such as the -hp- 85A. If necessary, change the protocol shown to fit your controller.

> **PROGRAMMING NOTE**
>
> *It is good programming practice to use the RESET ISC message as the first line of the program to ensure that the interface is reset to power-on conditions. For example, for an ISC of 10 the message is RESET 10.*

EXAMPLE - SETTING THE CLOCK

To set the real-time clock in the 3497A to a desired time of day, use the TDn command, where n = MM:DD:HH:MM:SS or (European) DD:MM:HH:MM:SS. To set the clock to October 15, 6:24:53 PM (US format) and then print the time of day, run the following program. The printout will be the time of day.

Program

```
10 RESET 10
20 OUTPUT 10; "TD1015182453"
30 OUTPUT 10; "TD"
40 ENTER USING "#,K"; A
50 PRINT A
60 END
```

Line	Description
10	Clears Serial Interface
20	Sets time to Oct 15, 6:24:53 PM.
30	Reads time of day.
40	Stores time of day in variable A.
50	Prints time of day.

EXAMPLE - SETTING AND DETERMINING INTERRUPTS

For this example, assume that the 3497A is directly connected to the controller and we want a BREAK Message (SRQ) to be generated for an I/O error or if a time alarm occurs. Then, when the BREAK occurs, we want to be able to determine which of these two conditions caused the interrupt.

Step 1. Set the Interrupt Mask.

To enable the 3497A to send a BREAK due to an I/O error, we must set bits 0 and 6 in the interrupt mask. For a BREAK due to time alarm, we must set bits 2 and 6. Thus, the interrupt mask bits to be set are 0, 2 and 6 and the command to set these bits is SE105.

Step 2. Read the Status Register.

The next step is to tell the controller what to do when the BREAK message arrives. In this case, we'll transfer the program to line 1000, read the status register and then return to the main program. An example program follows.

Program	Lines	Description
10 RESET 10	10	Clears Serial Interface.
20 OUTPUT 10;''SE105''	20	Sets the Interrupt Mask.
30 ENABLE INTR 10;128	30	Enables Serial Interface
40 ON INTR 10 GOSUB 1000	40	Transfers program to 1000 when break occurs.
50 ! Main Program		
980 GOTO 50		
990 END		
1000 OUTPUT 10; ''SR''	1000	Reads status register
1010 ENTER 10 USING ''#,K''; A	1010	Puts octal value of true bits in status register in variable A.
1020 PRINT A	1020	Prints octal value.
1030 STATUS 10,1;B	1030	Clears the 85A Status/Control register so it can accept next BREAK.
1040 RETURN	1040	Returns program control to where program was interrupted.

Step 3. Determining the Cause of the Interrupt

Let's assume that the octal value returned after reading the status register is 00104 (leading zero for Bit 15 is suppressed). The digits have the meanings shown in the status register chart.

From the LSD of the number returned, the interrupt (BREAK) resulted from a time alarm and not from an I/O error, since bit 2 = 1, bit 1 = 0 and bit 0 = 0 (i. e. LSD is octal 4 = 100 digital).

Note that even if bits 1, 3, 4, 5 or 7 in the status register are true, the BREAK message is not sent, since the interrupt mask ''allows'' the BREAK message to be generated ONLY for time alarm and I/O error conditions.

Octal Digit	Value	Status Bit#	Register Value	Meaning
MSD		14	0	All MODEM lines OFF.
	0	13	0	All MODEM lines OFF.
		12	0	All MODEM lines OFF.
4th		11	0	CTS MODEM line OFF.
Digit	0	10	0	DSR MODEM line OFF.
		9	0	No system overrun.
3rd		8	0	No buffer overflow.
Digit	1	7	0	No manual SRQ.
		6	1	BREAK due to interrupt.
2nd		5	0	No Power-On SRQ.
Digit	0	4	0	No msg not exec cond.
		3	0	No time interval intr.
(LSD)		2	1	Time alarm interrupt.
	4	1	0	No digital interrupt.
		0	0	No I/O errors.

EXAMPLE - READ ANALOG CHANNELS

For this example, we'll use an analog assembly in slot 1 (addresses 20-39) and close analog channels in sequence from channel 20 through channel 39. To sequentially close analog channels, enter and run the following program. As you run the program, watch the front panel and note that the 3-digit display goes from 20, 21, ..., 39 as the program closes channels 20 through 39 in sequence. A typical printout for this program follow the program listing.

Program	Line	Description
10 RESET 10	30	Closes channel I and
20 FOR I=1 TO 20		measures volts on channel
30 OUTPUT 10 ; ''AI'';I+19		
50 PRINT I+19,A	40-60	Enters and prints chan 1
60 NEXT I		voltage
70 END		

A typical printout for this program is:

```
20          2.6386
21          2.6006
 .             .
 .             .
39          2.9696
```

Chapter 5
CONTROLLING THE 3497A

INTRODUCTION

Chapter 2, Front Panel Operation, showed how to enter commands from the front panel of the 3497A and Chapters 3 and 4 showed how to program the 3497A using a controller with HP-IB or Serial Data interface. In this chapter, we'll show how to set up and control the 3497A for desired operation. The chapter is divided into five parts: MAINFRAME CONTROL, TIMER CONTROL, VOLTMETER CONTROL, REAR PANEL PORT CONTROL and PLUG-IN ASSEMBLY CONTROL.

- MAINFRAME CONTROL shows how to use the SYSTEM commands to control the 3497A mainframe.
- TIMER CONTROL shows how to use the TIMER commands to set the timer/real time clock.
- VOLTMETER CONTROL shows how to use the VOLTMETER commands to program the DVM for desired operation.
- REAR PANEL PORT CONTROL shows how to use the six ports on the rear panel of the 3497A.
- PLUG-IN ASSEMBLY CONTROL shows how to control operation of plug-in assemblies (Options 010 through 140).

In general, for any data acquisition/control system application, you will need to setup (program) the 3497A mainframe, timer and plug-in assemblies for the operation required. In addition, if you are using external instrumentation to interface with the 3497A, you should refer to the section on using the rear panel ports.

As with chapters 1 through 4, we suggest that you study this chapter carefully before connecting the 3497A to your system. Again, the best way to become familiar with the operation of the 3497A is to enter the example programs and observe the display and/or printout. Remember, you can't hurt your controller or 3497A by entering any of the commands shown as long as the 3497A is not connected to your system.

CAUTION

Chapter 6, Command Directory, summarizes all commands used with the 3497A and provides some operating considerations for each command. To avoid possible equipment damage or undesired actions by the 3497A, check the Command Directory before entering any commands into a 3497A which is connected to your system.

MAINFRAME CONTROL

The 3497A mainframe can be set for a wide variety of operating conditions by using the SYSTEM commands. In this chapter, the SYSTEM command descriptions are listed alphabetically. To see how to use a command for a specific function, refer to the SYSTEM COMMANDS table.

In this table, each command is associated with specific functions, such as turning the front panel off or setting the 3497A for digital interrupt SRQ. Thus, to use this chapter first decide what function you want the 3497A to perform and then refer to the command and page number listed in the table. For example, if you have an HP-IB interface and want to enable the 3497A for a Service Request, see the SE command, etc.

Since some commands have the same mnemonics but different interpretations for HP-IB and Serial Data, commands are shown for both interfaces. If an entry shows [HP-IB], the command applies ONLY to HP-IB while entries with [Serial Data] apply ONLY to Serial Data operation. Entries without qualifiers apply to both interfaces.

3497A SYSTEM COMMANDS

COMMAND	TITLE	FUNCTION	PAGE
SA	System Alarm	Set the 3497A to produce an audible alarm, for applications such as interrupts.	118
SC	System Clear [Serial Data]	Reset the 3497A from a controller (Serial Data ONLY).	118
SD	System Display	Turn the front panel display ON or OFF.	120
SE	Service Request Enable [HP-IB]	Enable the 3497A for Service Request to interrupt the controller (HP-IB ONLY).	121
SE	Service Request Enable [Serial Data]	Enable the 3497A for Service Request to interrupt the controller (Serial Data ONLY).	126
SI	System Initialize	Reset digital assemblies and the DVM to power-on condition.	130
SL	System Lock [Serial Data]	Disable the keyboard so that commands cannot be entered from the front panel (Serial Data ONLY).	131
SO	System Output Wait [HP-IB]	Set the 3497A so that measurements are not output to the controller until the controller requests them (HP-IB ONLY).	132
SO	System Single/ Continuous Output [Serial Data]	Set the 3497A to send one reading/command for commands which normally produce continuous output (Serial Data ONLY).	134
SR	System Read	Determine the type of assembly in a slot or (for Option 140) read the contents of a specified register.	135
SR	Status Register Read [Serial Data]	Read the contents of the 3497A status register (Serial Data ONLY).	137
ST	Self Test	Set the 3497A to perform an internal self-test.	139
SV	System View	Set the 3497A for front panel display of value sent from the controller.	140
SW	System Write	Write data to a digital input or digital output assembly or to the Option 140 assembly.	141

SYSTEM ALARM (SA)

Description

Certain applications, such as interrupts or completed measurements, may require that the operator be notified by an audible signal when the specified conditions occur. You can set the 3497A for this type of audible alarm by using the System Alarm (SA) command. When the SA command is executed, the 3497A sounds an alarm (BEEP).

EXAMPLES - SYSTEM ALARM

```
10 OUTPUT 709; "SA"    !Cause 3497A to BEEP (HP-IB)
20 OUTPUT 10; "SA"     !Cause 3497A to BEEP (Serial Data)
```

Operating Note

1. Power On State: "SA" - one BEEP.

SYSTEM CLEAR (SC)

Description

If you are using a controller which does not generate a BREAK message, you can use the System Clear (SC) command to reset the 3497A to specific conditions (NOT power on state).

The SC command is used with Serial Data (RS232C/RS423) operation to reset the 3497A to specified conditions. The command does not set the 3497A to a power-on condition. System Clear is similar to the BREAK message except that SC does not return the 3497A to local operation, clear the command (input) buffer or voltmeter storage buffer or reset VF2 or VF3 voltmeter settings.

You can use the SC command if your controller can't generate a BREAK message. Since the SC command does not reset the VF2 or VF3 voltmeter settings or clear the voltmeter storage buffer, to completely reset the 3497A to power-on conditions you must also send VF1 to set the voltmeter to ASCII format and send VS0 to turn the voltmeter storage OFF. (See Chapter 4, Serial Data Programming for details). Actions after the SC command follow.

SYSTEM CLEAR (SC) (Cont'd)

3497A ACTIONS FOLLOWING SC COMMAND

1) All command execution is terminated.
2) All data transmission stops.
3) All analog and digital channels are opened.
4) The interrupt mask and status registers are cleared.
5) Initializes all analog and digital assemblies.
6) Sets the DVM for internal trigger (VT1).
7) Sets first analog channel = 000 and last analog channel = 999.

Since SC clears the status register, data transmission errors, buffer overflow and system overrun information is lost when the SC command is executed. Also, SC clears all system errors. Therefore, if an I/O error occurs prior to execution of an SC command, it may not be reported. You can avoid this by sending the SC command separately (not in a command string). If SC is entered from the front panel the effect is the same as pressing the RESET key.

EXAMPLE - SYSTEM CLEAR

```
10 OUTPUT 10;''SC''     !Sends System Clear to the 3497A.
```

Operating Notes

1. SC command does not reset VF2 or VF3 or clear the voltmeter storage buffer.

2. SC command does not return the 3497A to local mode or clear the 3497A command (input) buffer.

3. Power On State: System Clear disabled.

SYSTEM DISPLAY (SD)

Description

For applications such as high-speed scanning, it may be desirable to turn the front panel display OFF for faster reading rates. The front panel display can be turned OFF with the System Display (SD0) command.

The SD0 command has two functions: (1) it turns the 6-digit display and the CHANNEL annunciator lights OFF for higher reading rates or (2) it allows only data entered with a SYSTEM VIEWED (SV) command to affect the data display. Note that the rest of the front panel display is not turned off by the SD0 command. To turn the display back on, send SD1. The format for the SD command is:

SD0 = OFF	SD1 = ON

EXAMPLE - TURN DISPLAY OFF FOR SV DATA

As shown in the SYSTEM VIEW command explanation, you can display data sent from the controller on the front panel of the 3497A by using an SV command. For example, if you are measuring voltage on a channel and want to continuously monitor the voltage, you can send the data input to the 3497A for front panel display by using an SV command.

However, to do this you must first turn off the front panel display with an SD0 command. For this example, we'll turn the display OFF so that +123456 can be displayed by using the SV command. Following line 10 execution, +123456 is shown on the 6-digit display for 5 seconds and then SD1 (line 30) restores the display to normal.

```
10 OUTPUT 709; "SD0SV123456"    !SD0 turns display OFF
20 WAIT 5000
30 OUTPUT 709; "SD1"            !SD1 turns display ON
40 END
```

Operating Note

1. Power On State: "SD1" - Display ON

SERVICE REQUEST ENABLE (SE) [HP-IB]

Description

An important feature of the 3497A is that you can program it to interrupt the controller whenever a pre-determined condition occurs in your system. This means that the controller can do other tasks until these conditions occur and then take necessary action. Of course, the controller must be programmed to respond to the interrupt.

A Service Request (SRQ) message is sent from the 3497A when specified interrupt conditions occur, if the 3497A has been programmed to respond to these conditions. If the 3497A has not been programmed, no SRQ (interrupt) is generated even when these conditions occur. In Chapter 3, we defined the status register and SRQ mask and showed how to set the SRQ Mask (see REQUIRE SERVICE (SRQ)), so we'll just review this material here. See Chapter 3 for further information.

What's the Status Register?

The 3497A has an 8-bit status register which constantly monitors several possible interrupt (SRQ) conditions. Whenever a defined interrupt condition occurs, a corresponding bit in the status register is set true (a 1 condition). The following chart defines conditions which set status register bits true.

For example, when the voltmeter completes a measurement, a ''data ready'' condition occurs and bit 0 of the status register is set to 1. When a message is not executed (for any of six reasons), a ''message not executed'' condition occurs and bit 4 is set to 1. However, unless the 3497A is programmed to respond to these interrupt condition(s), SRQ is NOT sent to the controller. The 3497A is programmed to respond by setting the SRQ mask.

SERVICE REQUEST ENABLE (SE) [HP-IB] (Cont'd)

STATUS REGISTER - HP-IB

Bit 7	Bit6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Interv	Time Alarm	Dig Intr	Data Ready

Bit	Title	Condition Which Sets The Bit to 1 (true).
7	Manual SRQ	Pressing the front panel SRQ key.
6	SRQ	Bit 6 is 1 when SRQ mask true bit(s) match status register true bit(s).
5	Power On SRQ	At 3497A power on, IF the POWER ON SRQ ENABLE switch is set to 1 position.
4	Message Not Executed	Set by one of six conditions (see STATUS BYTE in Chapter 3).
3	Time Interval	Set when a pre-established time interval has elapsed from a t=0 reference.
2	Time Alarm	Set when the time of day matches a pre-established time.
1	Digital Interrupt	Set when a digital input or counter assembly sends an interrupt signal to the 3497A status register.
0	Data Ready SRQ	Set when: (1) voltmeter reading complete (single trigger) (2) "n" voltmeter readings complete (when VNn and VS1 or VS2 commands used) or (3) DR, DL, DI, CR or TD commands have been executed.

How Do I Set the SRQ Mask?

The SRQ mask allows the 3497A to send SRQ ONLY for interrupt conditions specified. Whenever an interrupt condition occurs, the status register bit(s) are set as shown in the previous table. However, to send an SRQ to the controller, the SRQ mask bits must be set.

The SRQ mask bits are identical to the status register bits, except that bit 6 is missing. Bits 0 through 4 and bit 7 are set by the Service Request Enable (SEn) command where n = 0 to 377 is the octal value of the bit(s) to be set. Bit 5 can be set ONLY when the POWER ON SRQ ENABLE switch is set and can't be set with an SEn command. The format for the SEn command is:

SEn	n = 0 to 377 (octal)

The following chart shows the SEn command to set each of the SRQ mask bits true (i.e., send SE2 to set the SRQ mask for digital interrupt - bit 1 true). Any combination of bits 0 through 4 and/or bit 7 can be set by an appropriate SEn command. For example, to set bits 4 and 0 true, the command is SE21 (SE20 + SE1).

SRQ MASK - BIT DEFINITIONS AND BIT SET COMMANDS

Bit 7	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Man SRQ	Pon SRQ	Msg Not Exec	Time Interv	Time Alarm	Dig Intr	Data Ready
SE200		SE20	SE10	SE4	SE2	SE1

BIT 5 CAN'T BE SET WITH SEn COMD. POWER ON SRQ ENABLE SWITCH IN THE 1 POSITION SETS BIT 5 TRUE

When is SRQ sent to the Controller?

To program the 3497A to send SRQ to the controller, set the SRQ mask for the interrupt conditions desired by using an SEn command and/or setting the POWER ON SRQ ENABLE switch. Then, since the SRQ mask bits are set, SRQ is sent when interrupt conditions set the corresponding status register bits true.

EXAMPLE - POWER ON SRQ

To send SRQ when the 3497A is turned on, set bit 5 of the SRQ mask by placing the POWER ON SRQ ENABLE switch in the 3497A to the 1 position. Then, at power on, bit 5 of the status register is set and SRQ is generated. If the POWER ON SRQ ENABLE switch is in the 0 position, status register bit 5 is not set at power on and SRQ is not generated. Again, note that bit 5 of the SRQ mask cannot be set with an SEn command.

EXAMPLE - FRONT PANEL SRQ

To generate a manual (front panel) SRQ, set SRQ mask bit 7 by sending SE200. Then, SRQ is generated when the front panel SRQ key is pressed and the SRQ LED on the display turns ON, indicating that the SRQ has been sent to the controller.

SERVICE REQUEST ENABLE (SE) [HP-IB] (Cont'd)

EXAMPLE - DATA READY SRQ

For this example, we'll set the 3497A to send SRQ whenever a "data ready" condition occurs. To enable the 3497A to send SRQ for data ready, bit 0 of the SRQ mask must be set by sending SE1.

Note that even if bit 7 or bits 1 through 4 in the status register go true, SRQ will not be sent since the SRQ mask is not set for these conditions. A sample program for data ready SRQ follows. The value returned by the program is the DECIMAL value of the status register true bits.

Program

```
  10 CLEAR 709
  20 OUTPUT 709; "SE1"
  30 ON INTR 7 GOSUB 1000
  40 ENABLE INTR 7;8
  50 !Main Program
      .
      .
 980 GOTO 50
 990 END
1000 P=SPOLL (709)
1010 STATUS 7,1;A
1020 ENTER 709;B
1030 DISP B
1040 RETURN
```

Lines	Description
20	Sets the SRQ mask for data ready (sets bit 0).
30	Instructs controller to go to line 1000 when SRQ occurs on interface 7.
40	ENABLE INTR 7;8 actually enables the -hp- 85 interface to respond to the SRQ (octal code "8" in 85 control register).
50-990	Main body of program.
1000	Start of interrupt subroutine. SPOLL returns the 3497A status byte to variable "P" and resets bit 6 of the status register (if it was set).
1010	Reads and clears the -hp- 85 Status/Control register so that it can respond to the next interrupt.
1020	Line 1020 reads the data and resets bit 0 of the status register. Line 1030 displays the decimal value (1 for data ready) of the true bits in the status register. Line 1040 returns program control to the line where program was interrupted.

Operating Notes

1. Once the status register is set (as a result of an interrupt), it must be read (polled) to reset the SRQ function and enable another interrupt. However, the SRQ mask is not reset by the polling function. It is reset only by RESET, power-on or another SEn command.

2. To read the contents of the status register, send a serial poll (SPOLL) command. The value returned is the DECIMAL equivalent of the true bits in the status register.

3. Setting the SRQ mask also sets registers in the interface which must be cleared after each SRQ in order to re-enable SRQ interrupt (as shown in line 1010 of the example program above).

4. Power On State: ''SE000'' - SRQ disabled.

SERVICE REQUEST ENABLE (SE) [SERIAL DATA]

Description

For Serial Data operation, when the 3497A requires service from the controller, it sends a BREAK message called a Service Request (SRQ) to the controller. If the controller has been programmed to respond to the SRQ, it takes action as previously programmed. However, if the 3497A is executing a data request command, the BREAK message will not be sent until after the data has been sent.

An SRQ is generated in response to one or more system interrupt conditions. For example, it may be required to send an SRQ message when an I/O error occurs, for a time alarm, for message not executed, etc. However, for the 3497A to send the BREAK (SRQ) message to the controller, the 3497A must first be programmed to respond when system interrupt conditions occur. In Chapter 4, we described the status register and interrupt mask, so we'll just review them here. See Chapter 4 for further information.

What's the Status Register?

The status register in the 3497A Option 232 is a 16-bit register which is constantly updated as events occur. The following table defines the conditions for which each bit is set to a true ("1") condition (i. e. bit 2 is set true when a time alarm condition occurs). MSD, 5th digit, ... LSD under the bits represent the digits of the octal number returned to the controller in response to an SR (Status Register Read) command. See Chapter 4 for the conditions which set the status register bits true.

STATUS REGISTER

Bit 15	14	13	12	11	10	9
0	Data rcd/no MODEM	(CD) Recvr Ready	no/lost carrier disconn	(CTS) Clear To Send	(DSR) Data Set Ready	System Over-Run
MSD (Always Zero)	5th digit			4th digit		

8	7	6	5	4	3	2	1	0
Buffer Over-Flow	Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
3rd digit			2nd digit			LSD		

How do I set the Interrupt Mask?

Since the status register bits are set true by a variety of system conditions, it is convenient to have a means of interrupting the controller only when specified system conditions occur. This is the purpose of the interrupt mask.

To set the interrupt mask for the conditions you want to cause interrupt, send a Service Request Enable (SEn) command where n is an octal number corresponding to the bits to be set in the interrupt mask. The interrupt mask bits are a bit-by-bit replica of bits 0-7 of the status register. The format for the SEn command is:

SEn	n = 0 to 377 (octal)

Bit 6 (SRQ bit) of the interrupt mask MUST be set to send the BREAK message to the controller. For example, suppose you want the 3497A to send a BREAK message if a parity, framing or overrun error occurs. Since these are I/O errors, bits 0 and bit 6 must BOTH be set (by sending an SE101 command) to enable a BREAK message for I/O errors.

Note that even if other system conditions, such as time alarm, message not executed, etc. occur, a BREAK message will not be generated, since the interrupt mask is not set for these conditions.

SERVICE REQUEST ENABLE (SE) [SERIAL DATA] (Cont'd)

INTERRUPT MASK

7	6	5	4	3	2	1	0
Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
SE200	SE100	SE40	SE20	SE10	SE4	SE2	SE1

Bit	SEn*	Description
7	300	Manual Service Request. When bit 7 and bit 6 are set, pressing the front panel SRQ key sends the BREAK message.
6	100	Bit 6 MUST be set to enable the BREAK message when specified interrupt condition(s) occur.
5	140	Power On SRQ. When bit 5 and bit 6 are set, a BREAK is sent when the 3497A powers on or when the 3498A Extender recovers from a power loss.
4	120	Message Not Executed. If bit 4 and bit 6 are set, a BREAK is sent when any of the following 8 conditions occur: 1) Illegal command sent. 2) Trigger too fast when the DVM is set for external trigger (VT2) mode. 3) Numeric input is out of limits. 4) Voltmeter storage buffer is full. 5) Digital assembly not present in slot addressed. 6) Packed BCD format (VF2) programmed when the 3497A is configured for 7-bit ASCII. 7) Command (input) buffer overflow. 8) System overrun.
3	110	Time Interval. If bit 3 and bit 6 are set, a BREAK is sent when a specified time interval (set by the TIn command) has elapsed.
2	104	Time Alarm. If bit 2 and bit 6 are set, a BREAK is sent when a time alarm (time of day) match occurs.
1	102	Digital Interrupt. If bit 1 and bit 6 are set, a BREAK is sent when a digital input or counter assembly sends an interrupt signal to the 3497A.
0	101	I/O Error. If bit 0 and bit 6 are set, a BREAK is sent when any of the following 3 conditions occur: 1) parity error detected by UART. 2) overrun error detected by UART. 3) framing error detected by UART.

* The number shown sets this bit and bit 6 (i.e., SE102 sets bit 1 and bit 6). For other combinations, the SEn command must be set for interrupt mask bits to be set.

EXAMPLE - SET MASK FOR SRQ ON I/O ERROR

For this example, we'll set the 3497A to send SRQ whenever an I/O error (parity, overrun or framing error) condition occurs. To enable SRQ on I/O Error, bit 6 and bit 0 of the interrupt mask must be set by sending "SE101". A sample program follows.

In this program, the 3497A is set for I/O error by the SE 101 command. When the controller receives an I/O interrupt (bit 0 of the status register true), the program goes to a subroutine which reads and displays the octal value of the true bits in the status register.

Program

```
  10 RESET 10
  20 OUTPUT 10;"SE101"
  30 ON INTR 10 GOSUB 1000
  40 !Main Program
     .
     .
 980 GOTO 40
 990 END
1000 OUTPUT 10;"SR"
1010 ENTER USING "#,K";A
1020 DISP A
1030 RETURN
```

Lines	Description
20	Sets the Interrupt Mask for I/O Error (only).
30	Instructs controller to go to line 1000 when SRQ occurs on interface 10.
40-990	Main body of the program
1000	Start of interrupt subroutine. The SR command reads the condition of the status register true bits.
1010	Enters octal value of the true bits in the status register ("1" for an I/O Error).
1020	Displays octal value entered at line 1010.
1030	Returns program control to the line where program was interrupted.

Operating Notes

1. Once the status register is set (as a result of an interrupt), it must be read (polled) to reset the SRQ function and enable another interrupt. The interrupt mask is not reset by the polling function. It is reset only by RESET, power on or another SEn command.

2. To read the status register, send an SR command (see STATUS REGISTER READ command). The value returned (0 to 377) is the octal value of the true bits in the status register.

3. Power On State: "SE000" - SRQ disabled.

SYSTEM INITIALIZE (SI)

Description

For some applications, it may be required to initialize digital assemblies in a 3497A without changing the state of analog assemblies in the same 3497A. You can initialize the digital assemblies and the DVM by using the System Initialize (SI) command.

The SI command sets the digital assemblies and the DVM to the state shown in the following table. The SI command does not affect the analog assemblies (Options 010, 020, 070 and 071). A 3 msec wait is included so that the relays in the Option 110 assembly can connect the Normal Closed position to common and the relay contacts in the Option 115 Assembly can open.

DIGITAL ASSEMBLY AND DVM STATES AFTER SI COMMAND

Option	Title	State
001	DVM	VA0,VC0,VF1,VN1,VR5,VSO,VT1,VW0
050	Digital Input	Handshake and Interrupts disabled.
060	Counter	All counter functions disabled.
110	Actuator	All relays NC connected to common.
115	HV Actuator	All relays opened.
120	D/A Converter	No voltage output.
130	D/A Converter	No current output.
140	Breadboard	Activates the digital reset line.

EXAMPLES - SYSTEM INITIALIZE

```
10 OUTPUT 709; ''SI''     !Initializes digital assemblies
                           and DVM (HP-IB)
20 OUTPUT 10; ''SI''      !See HP-IB example (Serial
                           Data)
```

Operating Notes

1. A 3 msec wait is included to allow actuator relays to connect Normal Closed position to common (Option 110) or to allow relays to open (Option 115).

2. Power On State: ''SI'' for one system initialization.

SYSTEM LOCK (SL) [SERIAL DATA]

Description

For Serial Data operation, the System Lock (SL1) command is used to disable the front panel keyboard of the 3497A (including LOCAL, RESET and SRQ keys) so that entries cannot be made by pressing the keys. Use SL0 or a power off, power on sequence to re-enable the keyboard. With SL1, all keys are disabled and the 3497A cannot be returned to local mode unless SL0 is sent or the power is turned off. The format for the SL command is:

SL0 = keyboard enabled	SL1 = keyboard disabled

EXAMPLE - SYSTEM LOCK

```
10 OUTPUT 10; "SL1"     !Disables front panel keyboard.
```

Operating Note

1. Power On State: "SL0" - Front Panel Keyboard enabled.

SYSTEM OUTPUT WAIT (SO) [HP-IB]

Description

When making a series of measurements, it is essential that the controller can accept and store data on each measurement before the 3497A sends another reading so that data is not lost.

For HP-IB operation, the System Output With Wait (SO1) command is used to ensure that readings made by the 3497A are not sent to the controller until the controller requests them. With SO1 in effect, a reading taken by the 3497A is not output over the HP-IB until the controller requests it (by using an ENTER 709 type command).

The SO1 command is primarily used with the VNn (number of readings/trigger) command to ensure that data is not output faster than the controller can accept it. The format for the SOn command is:

SO0 = Output reading to bus immediately after measurement.
SO1 = Output reading to bus when requested by controller.

With SO1 in effect, there are two modes of operation, depending on the VNn (Number Readings/Trigger) and VSn (Voltmeter Storage) commands.

Mode 1: With VS0 (Voltmeter Storage OFF), the 3497A takes the number of readings/trigger specified by the VNn command and outputs the readings (one at a time) as requested by the controller. The sequence is read-wait-output, read-wait-output, ... for n readings.

Mode 2: With VS1 or VS2, the 3497A takes the number of readings/trigger specified by the VNn command and stores all n readings in internal storage, without wait between readings (unless the VWn command is in effect). Then, all n readings are output on request by the controller.

EXAMPLE - SET SYSTEM TO WAIT FOR CONTROLLER

For example, set VN5 to take 5 readings/trigger, VT2 for external trigger and VS0 (Storage OFF) and SO1 with the following program line: 10 OUTPUT 709; ''VN5VT2VS0SO1''.

Then, when the 3497A receives an external trigger, it takes a measurement and waits until the controller requests an output. If the 3497A doesn't receive an ENTER request, it waits (and waits) and the 2nd (and 3rd, 4th and 5th) measurements are never taken and subsequent triggers are ignored.

Now, change the VS0 to a VS1 (store up to 60 ASCII readings) command. For the same external trigger, the 3497A takes all 5 readings (without wait between readings if VW0 is assumed) and waits for an ENTER statement from the controller to output the readings.

With VS1 in effect, each external trigger received before the ENTER statement causes n readings to be stored. So, if more than 60 readings/trigger are programmed to be stored, data will be lost (100 readings for Packed BCD format).

Operating Notes

1. Any device dependent (OUTPUT) command to the 3497A will abort the present wait (and existing measurement will be lost), but will NOT change the SO mode set.

2. Power On State: ''SO0'' - No system wait.

SYSTEM SINGLE/CONTINUOUS OUTPUT (SO) [SERIAL DATA]

Description

In Serial Data operation, certain commands sent to the 3497A, such as ST1, VT1, DR slot#, TD and CR slot#,3 normally require that data be returned continuously for the command. This is the mode of operation when the System Continuous Output (SO0) command is in effect.

However, by sending the Single Output Mode (SO1) command, the 3497A returns a single reading/command for these commands. For example, with SO1, the TD command returns a single time of day reading.

The 3497A powers on in continuous output (SO0) mode, but changes to single output (SO1) mode when the first command is received over the interface. To revert back to the continuous mode, send SO0. The command format is:

SO0	=	Continuous Output to Controller
SO1	=	Single Output/Command to Controller

EXAMPLE - SINGLE READING/COMMAND

```
10 OUTPUT 10; "SO1VT1"      !Normally, VT1 returns data to the
                             controller continuously. With SO1 in
                             effect, a single reading is returned
                             for the VT1 command.
```

Operating Notes

1. The 3497A powers on in continuous (SO0) mode, but goes to single output (SO1) mode when the first command is received over the interface. To return to continuous mode, transmit SO0 command.

2. Power On State: "SO0" - Continuous Output Mode.

SYSTEM READ (SR)

Description

With the System Read (SR) command, you can determine the type of assembly (except analog assemblies) in any slot of the 3497A or the 3498A. In addition, for the breadboard card (Option 140), you can use a modified version of the SR command to read the condition of registers in a slot addressed.

System Read (SR) has two different functions. For digital input, digital output, counter and D/A converter assemblies (Options 050, 060, 110, 115, 120 and 130), the SR slot#,0 command allows you to determine what type of assembly is in the slot addressed.

When the SR slot#,0 command is sent, a six-digit octal value is returned. The Least Significant Digit (LSD) of this number identifies the type of assembly in the slot, as shown.

For the breadboard card assembly (Option 140), use the SR slot#,n (n = 0 to 7) command to read the contents of register n in the slot addressed. The value returned after this command is a 3-digit octal number (0 to 377) which shows the condition of the bits in register n. The formats for the SR command are:

SR slot#,0 = Reads ''signature'' of assembly in slot (0-89)
SR slot#,0-7 = Reads register (0-7) in slot (0-89) [Option 140]

VALUE RETURNED AFTER SR slot#,0 COMMAND

C*	Assembly	Option(s)
0	Digital Input	050
1	Actuator or HV Actuator	110,115
2	D/A Converter	120,130
3	Counter	060
7	Empty or Analog Assembly	010,020, 070,071
Option 140 returns 0-377 (octal), depending on register true bits.		

* Value returned is XXXXXC, where C identifies assembly.

SYSTEM READ (SR) (Cont'd)

From the chart, note that analog assemblies (Options 010, 020, 070 and 071) and empty slots both return ''7'' as the LSD, the D/A Converters (Options 120 and 130) both return ''2'', and the actuators (Options 110 and 115) both return ''1'' as the LSD so other means must be used to determine the type of analog, actuator or converter assembly in the slot (such as looking at the slot).

EXAMPLES - SYSTEM READ COMMANDS

10 OUTPUT 709; ''SR3,0''	!Requests identity of assembly in slot 3. If, for example, 000363 (octal) was returned, the ''3'' in the LSD shows that a counter is in slot 3 (HP-IB).
20 OUTPUT 10; ''SR3,1''	!For an Option 140 card in slot 3, reads contents of register #1.

Operating Note

1. Power On State: ''SR'' disabled.

STATUS REGISTER READ (SR) [SERIAL DATA]

Description

For Serial Data operation, the Status Register Read (SR) command is used to read the contents of the status register in the 3497A. When the SR command is sent, a six-digit octal value (0 to 177777) is returned. The value of the number returned identifies the true bits in the status register.

You can use the SR command for two purposes: (1) check the condition of the status register at any time or (2) read the status register to determine the cause of a BREAK message. The status register in the 3497A Option 232 is a 16-bit register which is constantly updated as events occur. The following table shows the conditions for which each bit is set true (''1'').

For example, bit 2 is set to 1 when a time alarm condition occurs. MSD, 5th digit, ... LSD under the bits represent the digits of the octal number returned to the controller in response to the SR command. See Chapter 4 for details on the status register.

STATUS REGISTER - BIT DEFINITIONS

Bit 15	14	13	12	11	10	9
0	Data rcd/no MODEM	(CD) Recvr Ready	no/lost carrier disconn	(CTS) Clear To Send	(DSR) Data Set Ready	System Over-Run
MSD (Always Zero)	5th digit			4th digit		

8	7	6	5	4	3	2	1	0
Buffer Over-Flow	Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
3rd digit			2nd digit			LSD		

STATUS REGISTER READ (SR) [SERIAL DATA] (Cont'd)

EXAMPLE - READ STATUS REGISTER

To determine the condition of the bits in the status register, use the SR command followed by an ENTER command. The data returned is a 6-digit octal number which gives the value of the true bits. For example, to determine the condition of the status register use:

```
10 OUTPUT 10; "SR"
20 ENTER USING "#,K"; A
```

Following the ENTER statement, a 6-digit octal number representing the true ("1") bits in the status register is input to the controller. Suppose that bits 14, 10, 4 and 2 are true (representing a theoretically disastrous situation). Then, the digital bit pattern is 0 100 010 000 010 010 and octal number 042022 is returned to the controller.

Bit#	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0
Octal	0		4			2			0			2			2	

Operating Note

1. Power On State: "SR" disabled.

SELF-TEST (ST)

Description

The Self-Test (ST1) command causes the 3497A to perform an internal self-test (identical to the self-test performed at power on). Data returned after the self-test indicates the results of the test. If 8E8 is returned, the self-test passes.

Use ST1 to turn the self-test ON and ST0 to turn the self-test OFF. Following the ST0 command, the 3497A reverts to the state it was in before the self-test was initiated. Data returned following a self-test is:

DATA FOLLOWING A SELF-TEST COMMAND

Data	Definition
8E8	Self Test Passes
1E1	Cross Guard Fails
2E2	Voltmeter Fails
3E3	Timer Fails

EXAMPLES - SELF-TEST

```
10 OUTPUT 709; "ST1"      !Initiates 3497A Self Test. If 8E8
20 ENTER 709; A           is returned after ENTER command,
30 DISP A                 the self test passes. (HP-IB)
40 END

10 OUTPUT 10; "ST0"       !Turns Self Test off. (Serial Data)
```

Operating Notes

1. When ST0 is sent, the 3497A reverts to the state it was in before ST1 initiated.

2. Pressing any front panel key (other than SELF TEST) exits the self-test mode.

3. For Serial Data ONLY, continuous output mode for SO0 and ST1. Single output mode for SO1 and ST1.

4. Power On State: "ST1" - one test.

SYSTEM VIEW (SV)

Description

The System View (SVn) command allows you to display a value from -999999 to +999999 on the front panel display by sending data from the controller. However, to use SV, the front panel display MUST first be turned off by using the SD0 command (see the SYSTEM DISPLAY command). The format for the SV command is:

SVn	n = -999999 to +999999

For instance, you may want to monitor a measurement by displaying the value on the 3497A front panel display. You can do this with the System View (SV) command. Suppose you are measuring thermocouple voltages and converting them to temperatures with the controller. If a temperature is 23.67 deg C, then outputting "SV23.6700" displays this value on the 3497A front panel.

EXAMPLES - SYSTEM VIEW COMMAND

```
10 OUTPUT 709; "SD0SV23.6700"     !Turns front panel display
                                   off, then displays
                                   +23.6700. (HP-IB)
20 OUTPUT 10; "SD0SV-23.7502"     !Turns front panel display
                                   off, then displays -23.7502.
                                   (Serial Data)
```

Operating Notes

1. A decimal point may be placed after the V in the command or between any two digits. If no sign is used, + is displayed. The minus (-) sign can be used only after the V in the command.

2. SD0 must be sent before SV is valid.

3. Power On State: "SV" disabled.

SYSTEM WRITE (SW)

Description

When you are using the Breadboard Card assembly (Option 140), you can use the System Write (SW) command to write data to a specified register in the assembly. When the SW command is sent, the command activates the WRITE line in the 3497A mainframe. The specific assembly response depends on the configuration of the card.

System Write is used to write data to a specified register (0 to 7) in the slot addressed for the breadboard card assembly (Option 140). The format is:

SW slot#,register#,data	slot# = 0 to 89 register# = 0 to 7 data = 0 to 377 (octal)

EXAMPLES - SYSTEM WRITE COMMAND

```
10 OUTPUT 709; "SW3,1,120"      !Enters 1 010 000 into register
                                 1 of card in slot 3. (HP-IB)
20 OUTPUT 10; "SW3,1,120"       !See HP-IB example. (Serial Data)
```

Operating Note

1. Power On State: System Write disabled.

TIMER CONTROL

A standard feature on the 3497A is a real-time clock and timer. The clock and timer are both controlled with the TIMER command group. With the real-time clock, you can provide complete timing data ranging from months to seconds with 1 second resolution. In addition, you can use the timer like a stop watch to monitor elapsed time from a defined start point or like an alarm clock, interrupting at any preset time.

Pulse trains with programmable periods from 100 μsec to .9999 sec (using the Time Interval mode) or from 1 second to 24 hours (Time Output mode) can be output from the TIMER port on the rear panel. All functions (except for Time Interval and Time Output) can be used simultaneously.

This part of the chapter shows how to use the TIMER commands to set the real-time clock and timer for various operations. To use this section, first consult the following chart to determine the type of function you want the 3497A to perform and then see the appropriate command for details (i.e. to set the time of day, see the Time of Day (Set) [TD] command).

TIMER COMMANDS

COMMAND	TITLE	FUNCTION	PAGE
TA	Time Alarm (Set)	Set the timer for a specified time of day (24-hour format). If 3497A set for time alarm SRQ, interrupt sent to controller at time set.	143
TD	Time of Day (Set)	Set the real-time clock for a specified time (month, day, hour, minute, second).	144
TD	Time of Day (Read)	Read the time (month, day, hours, minutes, seconds) on the real-time clock.	145
TE	Time Elapsed (Control)	Set elapsed time control to start at beginning of an operation (in one second increments).	146
TE	Time Elapsed (Read)	Read the number of seconds accumulated on the elapsed time control (i.e. the number of seconds since the start of an operation).	147
TI	Time Interval	Set the period of pulses to be output from the TIMER port (period from 1 sec to 24 hours).	148
TO	Time Output	Set the period of pulses to be output from the TIMER port (period from 100 μsec to .9999 sec).	149

TIME ALARM (SET)

Description

Use the Time Alarm Set (TA) command to set the 3497A timer to a specified time of day (24-hour format). If the SRQ mask (interrupt mask for Serial Data) has been set for time alarm with an SEn command (SE4 for HP-IB, SE104 for Serial Data), an interrupt is generated when the time set matches the 3497A real-time clock reading. The format for the time alarm set command is:

TA HoursHours MinMin SecSec	Hours = 0 to 24 Min = 0 to 59 Sec = 0 to 59

EXAMPLES - SETTING TIME ALARM

```
10 OUTPUT 709; "SE4TA180000"       !SE4 enables SRQ mask (Time Alarm)
                                   so SRQ will be sent at 6:00:00 P.M.
                                   (24-hour clock). (HP-IB)

20 OUTPUT 10; "SE104TA180000"      !SE104 enables Interrupt Mask (Time
                                   Alarm), so BREAK will be sent to con-
                                   troller at 6:00:00 P.M. (24-hour clock).
                                   (Serial Data)
```

Operating Notes

1. Timer Alarm SRQ in effect until disabled with SEn command.
2. Timer Alarm has maximum repeatable period of 24 hours.
3. Power On State: Timer Alarm disabled.

TIME OF DAY (SET)

Description

Use the Time of Day (Set) command (TD) to set the real-time clock in the 3497A. Two formats are available: Month, Day, Hour, Minute, Second (Option 230) or Day, Month, Hour, Minute, Second (Option 231). You can read the time of day by sending a TD (Time of Day Read) command.

To execute the TDn command, a minimum of 6 numbers must be entered. If the full complement of numbers is not entered with the TD command, the 3497A interprets the first six digits as HH:MM:SS. Also, only hours, minutes and seconds are displayed following a TD command.

When the time of day is set, the Time Alarm Set (TA) and Service Request Enable (SE) commands can be used to cause an interrupt when the time set by the TA command matches the time of day on the real-time clock. The format for the time of day (set) command is:

```
TD MonthMonth DayDay HourHour MinMin SecSec [Option 230]

TD DayDay MonthMonth HourHour MinMin SecSec [Option 231]
```

EXAMPLES - SET TIME OF DAY

```
10 OUTPUT 709; "TD0524183230"   !Sets the clock for May 24
                                 @6:32:30 PM (Option 230 for-
                                 mat). (HP-IB).
20 OUTPUT 10; "TD2405183230"    !Sets the clock for May 24
                                 @6:32:30 PM (Option 231 for-
                                 mat). (Serial Data).
```

Operating Notes

1. After RESET or power loss, clock is set to 01:01:00:00:00 and does not start counting until a new TD command is sent.

2. Programming an invalid month (month >12) resets the clock to 01:01:00:00:00.

3. Dates up to 31 will be accepted regardless of the month. If programmed correctly, clock will turn over to the next month at the appropriate date (i.e., Feb 28

to Mar 1), except for leap year so clock must be adjusted on Feb 29.

4. Programming a date > 31 causes a BEEP and the clock setting to remain unchanged.

5. Power On State: ''TD0101000000'' - Set clock to Jan 1 @ 000000.

TIME OF DAY (READ) (TD)

Description

Use the Time of Day (Read) command (TD) to read the time on the real-time clock. Data received after the TD command has format MM:DD:HH:MM:SS or DD:MM:HH:MM:SS. The real-time clock records on a 24-hr convention, so the ''hours'' data is 00 to 24. For Serial Data operation, output is continuous for SO0 mode, single output/command for SO1 mode.

EXAMPLE - READING THE CLOCK

If the time on the real-time clock is May 24, 6:32:30 PM, the following program displays 05:24:18:32:30 (Option 230 format) where 18 = 6 PM on the 24-hour clock. After the OUTPUT 709; ''TD'' statement, the front-panel display shows the hours, minutes and seconds portion of the time of day. The front panel display acts as a digital clock, updating each second.

Program	Lines	Description
10 DIM A$[14] 20 OUTPUT 709; ''TD'' 30 ENTER 709; A$ 40 DISP A$ 50 END	10 20-40	Dimension A as a string variable, since data entered has : entries. Reads, enters and displays time set on real-time clock.

Operating Notes

1. For Serial Data ONLY, data returned is same as for HP-IB. Continuous output mode for SO0; single output mode for SO1.

2. Real-time clock records using 24-hour time convention.

3. Power On State: TD Read - disabled.

TIME ELAPSED (CONTROL) (TE)

Description

You can use the Time Elapsed (Control) commands to determine the time (to one second accuracy) since the start of an operation. The elapsed timer is reset to 0 with the TE0 command, started with the TE2 command and halted with the TE1 command. The format for the TEn command is:

TE0 = RESET	TE1 = HALT	TE2 = START

EXAMPLES - SET ELAPSED TIMER CONTROL

10 OUTPUT 709; ''TE2''	!Starts elapsed timer (at 0) when the TE2 command is received. (HP-IB)
10 OUTPUT 10; ''TE1'' 20 ENTER USING 10 ''#,K'';A 30 DISP A 40 END	!Halts the elapsed time count process and displays the time (in sec) since the TE2 command was received. (Serial Data)

Operating Note:

1. Power On State: ''TE1'' - Elapsed timer halted and set to zero.

TIME ELAPSED (READ) (TE)

Description

You can use the Time Elapsed (Read) command (TE without numbers) to read the number of seconds since the Elapsed Timer was started by the TE2 command. Following a TE command, the data returned has the form DDDDDD seconds and the number of seconds elapsed is displayed on the front panel display.

EXAMPLES - READ ELAPSED TIME

```
10 OUTPUT 709; "TE2"          !Starts elapsed timer (at 0).
20 !Main Program
       .
       .
70 OUTPUT 709; "TE"           !Reads and displays number of
80 ENTER 709; A               seconds on the timer since the TE2
90 DISP A                     command was received. (HP-IB).
       .
       .
10 OUTPUT 10; "TE2"           !See HP-IB for example. (Serial Data)
       .
       .
```

Operating Note

1. Power On State: Elapsed Time Read disabled.

TIME INTERVAL (TI)

Description

The Time Interval (TIn) command has two functions: (1) it sets the period of the pulse train output from the TIMER port and (2) if the SRQ mask (interrupt mask for Serial Data) has been set for time interval SRQ, the 3497A generates SRQ (BREAK) when each pulse is output.

With the TIn command, 50 μsec-wide TTL pulses are output from the TIMER port (also see discussion on TIMER port) with periods from 1 sec to 24 hours. The period is set by TIn, where n = HoursHours MinMin SecSec.

For example, to output pulses from the TIMER port every 2.5 hours, use TI23000. In addition, if the SRQ Mask is set for time interval interrupt by sending an SE10 command, SRQ will be generated every 2.5 hours. The format for the TIn command is:

TI HoursHours MinMin SecSec

EXAMPLES - SETTING TIME INTERVAL SRQ

10 OUTPUT 709; "SE10TI200"	!Every 2 minutes, a pulse is output at TIMER port and SRQ is generated (since SRQ Mask enabled by the SE10 command). (HP-IB)
20 OUTPUT 10; "SE110TI200"	!Every 2 minutes, a pulse is output at TIMER port and BREAK is generated (since interrupt mask enabled by SE110 command). (Serial Data).

Operating Notes

1. Leading zeros not required in TIn command (i.e., for 2 minutes only TI200 rather than TI000200 is required).

2. When TI command sent, pulses are available at TIMER port even if SRQ (BREAK) is not enabled.

3. Maximum period of TI command is 24 hours. To disable the TI function, send "TI0".

4. Power On State: Time Interval Disabled.

TIME OUTPUT (TO)

Description

For output pulses with periods less than one second, the Time Output (TOn) command sets the period of pulses output from the TIMER port. When the TOn command is used, 16 μsec-wide pulses are output from the TIMER port (also see discussion on TIMER port) with periods from 100 μsec to 0.9999 sec, in 100 μsec increments. The period is determined by n = (0 to 9999)*100 μsec. For example, to output pulses every 1 msec, use TO10, since 10*100 μsec = 1 msec.

With the Time Output command (in contrast to the Time Interval [TIn] command), SRQ (BREAK for Serial Data) is NOT available. The TOn command overrides the TIn command at the TIMER port. However, you can use the Time Interval command to generate SRQ (BREAK) even when the TOn command is used to output pulses from the TIMER port. The format for the TOn command is:

TOn	n = 0 to 9999

There are three main differences between the TOn and TIn commands: pulse width, period and SRQ capability, as summarized.

	TOn	TIn
Pulse Width	16 μsec	50 μsec
Period (range)	100 μsec - .9999 sec	1 sec - 24 hours
SRQ capability?	NO	YES

EXAMPLES - SETTING TIME OUTPUT PULSES

```
10 OUTPUT 709; "TO100"      !Generate pulses from the TIMER
                             port every 10 msec. (HP-IB)
20 OUTPUT 10; "TO100"       !See HP-IB example (Serial Data)
```

Operating Notes

1. Time Output (TOn) overrides Time Interval (TIn) command. However, Time Interval may be used to generate SRQ (BREAK) even when Time Output is active.

2. Use "TO0" to disable the Time Output function.

3. Power On State: Time Output Disabled.

VOLTMETER CONTROL

This part of the chapter shows how to use the optional Digital Voltmeter (DVM) (Option 001). It includes a description of the DVM, shows simplified DVM block diagram operation and shows how to use the VOLTMETER command group to control the operation of the DVM.

DVM Description

The 3497A DVM is a systems quality, 5½ digit, 1 microvolt sensitive DC voltmeter which can measure DC voltages up to 119.9999 volts. The DVM is fully guarded and uses an integrating A/D conversion technique which provides excellent common and normal mode noise reduction. The DVM includes a programmable three-level current source which can be used with the DVM to make accurate four-wire resistance measurements. Some of the operating features of the DVM are:

3497A DVM OPERATING FEATURES

DISPLAY	Select 3½, 4½, or 5½ digit display.
RANGES	4 DC voltage ranges (.10V, 1.0V, 10.0V and 100.0V) plus autorange and 20% overrange.
AUTOZERO	Select autozero ON for more accurate readings or turn autozero OFF for faster reading rates.
TRIGGER MODES	Select internal, external, software or hold trigger modes.
TRIGGER RATES	Program the DVM to take 1 to 999 readings/trigger. Can also program the DVM to pause between readings or after a reading. Pause intervals range from 0 to 99.9999 sec in 100 μsec intervals.
READING RATES	Read a maximum of 50 readings/sec in 5½ digit mode or a maximum of 300 readings/sec in 3½ digit mode.
STORE AND TRANSFER READINGS	Store up to 100 readings in the 3497A internal buffer and transfer the stored readings to a controller in one of three formats.
CURRENT SOURCE	The DVM contains a built-in current source which can be programmed to output a 10 μA, 100 μA or 1mA constant current.

DVM Block Diagram Operation

The 3497A DVM is a 5½ digit systems quality voltmeter which can measure DC Volts up to 120V and includes a built-in current source for high-accuracy resistance measurements. One of the features of the DVM is that DC voltages to be measured can be input either to the rear panel terminals of the 3497A or to analog assembly terminals. Figure 9 shows a simplified block diagram for the DVM.

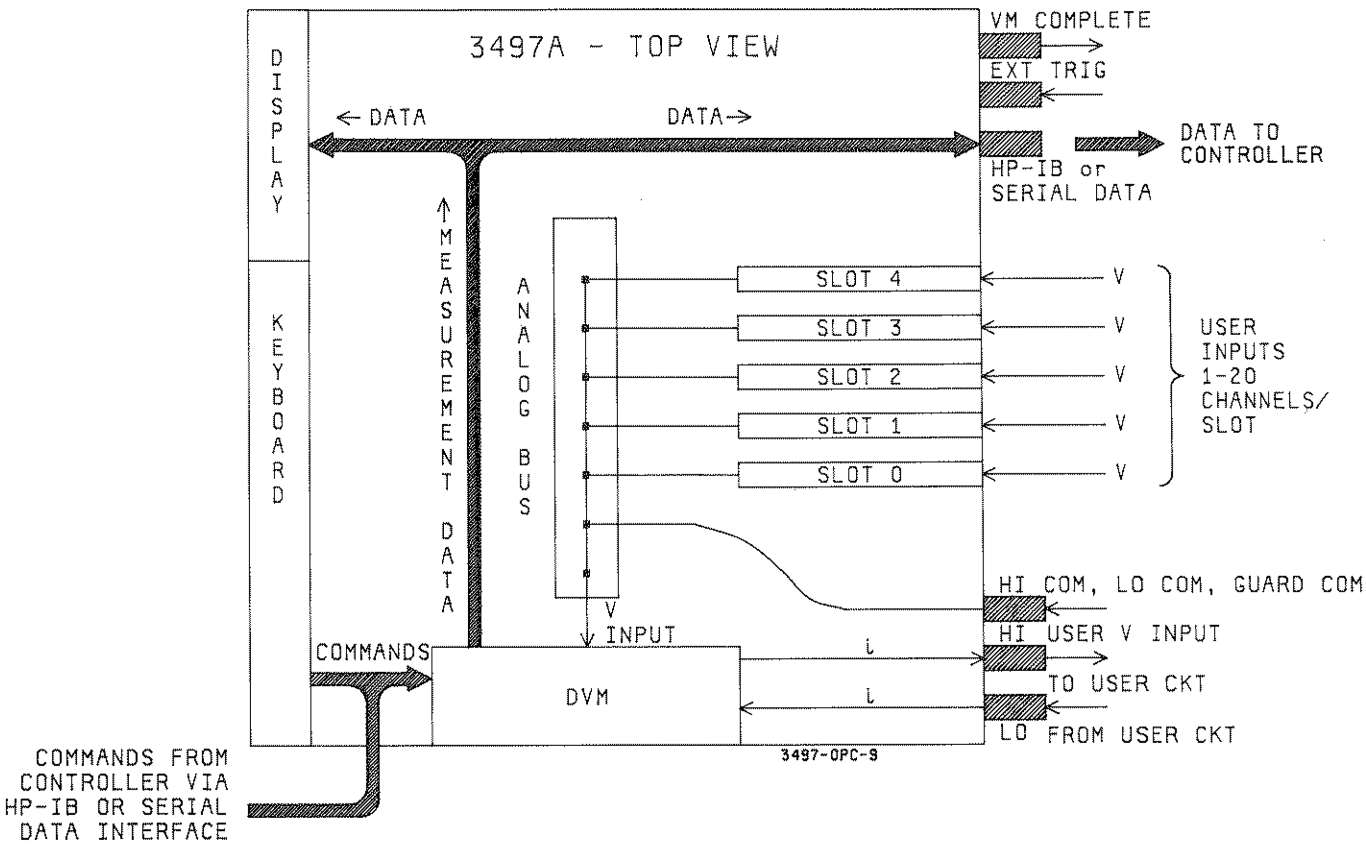


Figure 9. DVM Data Flow Block Diagram

As mentioned, DC voltages to be measured can be input either from analog assemblies or from the rear panel connectors. Let's look first at the operation when voltages are input by using the analog assemblies.

Since each analog assembly (Options 010, 020, 070 and 071) contains 20 channels, up to 100 voltages can be simultaneously input to the 3497A. The voltage to be measured is selected by ANALOG commands. For example, to measure a voltage on channel 4 of an analog assembly in slot 3, the channel relay is closed with an AC64 command (see Chapter 2 for a discussion of ANALOG commands).

When a channel is closed, the voltage is passed through the assembly to an analog common bus and then to the DVM for measurement. The DVM is set for a specific measurement mode by the VOLTMETER command group, as shown later.

When the DVM completes a measurement, the results are sent to the front panel display and - via the HP-IB or Serial Data bus - to the controller. In addition, when the DVM completes a measurement, a 0.5 μsec TTL pulse is output from the VM COMPLETE port.

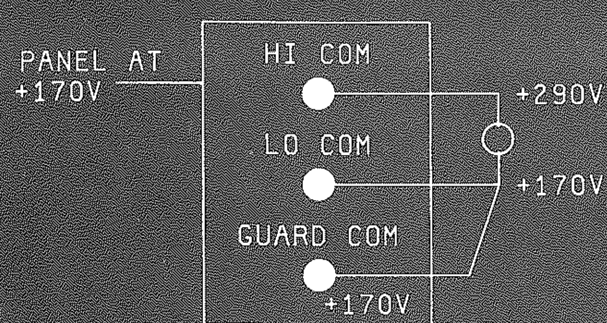
When voltages are input to analog assemblies, sequential channel-to-channel scanning (at speeds up to 300 channels/second) is available. If measurement of a single voltage is required, the voltage may be input from the rear panel connectors. As shown in Figure 9, the DVM uses a three-wire (HIGH, LOW and GUARD) arrangement.

Voltages input to the rear panel HI COM, LO COM and GUARD COM terminals are sent to the analog common bus and the sequence of actions described for analog assemblies occurs. However, when inputting voltages through the rear panel connectors, several precautions are necessary.

WARNING

When external voltages are input to the 3497A, either from the rear panel HI COM, LO COM and GUARD terminals or from a plug-in assembly in a 3497A or 3498A slot, the terminals AND the panel connected to the terminals are at Guard Potential. This means that the panel could be as much as 170 volts above ground.

For example, in the following diagram a floating voltage of 120V (290V max and 170 volts min) is input to the terminals. Since GUARD is tied to LOW, the panel is at +170V with respect to ground. For this reason, the rear panel safety cover MUST be installed whenever the 3497A is connected to an external voltage source.



CAUTION

To avoid possible damage to equipment, NEVER input voltages simultaneously from the rear panel terminals and an analog assembly. Any voltage appearing at the rear panel HI COM, LO COM and GUARD COM terminals will also appear at the analog assemblies. If a channel relay is closed, this voltage will appear at any external circuitry connected to the channel (such as a thermocouple) and may damage the circuitry.

Also, when inputting voltages to the rear panel connectors, do not exceed 170 volts between GUARD COM and earth ground or exceed 170 volts between any two connectors.

The DVM contains a built-in current source which is used with the DVM for accurate resistance measurements. The current source outputs one of three programmable constant currents: 10 μA, 100 μA or 1 mA, depending on the VCn command used. As shown in Figure 9, conventional current flow is out of the HI port and into the LO port.

The DVM can be triggered in four different ways, as discussed later. One of the ways is with an external trigger input to the EXT TRIG (EXTernal TRIGger) port. When the EXT TRIG port is used, the DVM can be triggered by appropriate TTL pulses input to the port. See EXT TRIG port discussion in this chapter for details.

You can also input external pulses into the EXT INCR (EXTernal INCRement) port to increment or decrement channels. If the DVM is set for external trigger (VT2 command), each input pulse into the EXT INCR port causes the 3497A to advance to the next channel and take a voltage measurement on that channel. See EXT INCR port discussion in this chapter for details.

Using VOLTMETER Commands

The 3497A DVM is controlled with the VOLTMETER command group and is fully programmable either from the front panel or from a controller. This part of the chapter shows how to use the VOLTMETER commands to set the DVM for desired operation. As with the SYSTEM and TIMER commands, a list of commands and functions is shown. Thus, for example, to turn Auto Zero ON, see the Voltmeter Auto Zero (VA) command, etc.

3497A VOLTMETER COMMANDS

COMMAND	TITLE	FUNCTION	PAGE
VA	**V**oltmeter **A**uto Zero	Turn autozero ON for more accurate measurements. Turn autozero OFF for faster reading speeds (about twice the rate as for autozero ON).	156
VC	**V**oltmeter **C**urrent Source Range	Set the current source for 10 μA, 100 μA or 1 mA output.	157
VD	**V**oltmeter **D**isplay	Set 3½, 4½ or 5½ digits on the front panel display.	158
VF	**V**oltmeter **F**ormat	Set one of three formats for data to be output on the interface bus.	161
VN	**V**oltmeter **N**umber Readings/Trigger	Set the number of readings/input (external) trigger from 1 to 999.	166
VR	**V**oltmeter **R**ange	Set the range of the voltmeter or set the DVM for autorange.	167
VS	**V**oltmeter **S**torage	Store readings in the 3497A for eventual output over the interface bus or for sequential display on the front panel.	169
VT	**V**oltmeter **T**rigger	Select one of four trigger modes for the voltmeter.	172
VW	**V**oltmeter **W**ait	Set the voltmeter to wait between readings.	173

Voltmeter Commands - Power On State

The power on state for the voltmeter is shown in the following chart. The power on state occurs after a power on or RESET from the front panel or after a CLEAR 709 type statement is sent over the HP-IB.

NOTE

For Serial Data operation, the power on command states shown are set after a BREAK message is sent from the controller. If the SC (SYSTEM CLEAR) command is sent, VS0 and VF1 must also be sent to set the voltmeter to power on conditions.

VOLTMETER COMMANDS - POWER ON STATE

Autozero	(VA)	VA1	Autozero ON
Current Source Out	(VC)	VC0	Current Source OFF
Display Digits	(VD)	VD5	5½ Digit Display
Format	(VF)	VF1	ASCII output format
No. Readings/Trig	(VN)	VN1	One Reading/Trigger
Range (Volts)	(VR)	VR5	Autorange
Storage	(VS)	VS0	Internal Storage OFF
Trigger	(VT)	VT1	Internal Trigger
Wait Between Trig	(VW)	VW0	No wait between trig

VOLTMETER AUTO ZERO (VA)

Description

The auto zero function of the DVM enables voltage offset errors internally generated in the DVM to be automatically compensated. When the auto zero function is set to ON with the VA1 command, the 3497A takes two measurements for each reading: a ''zero'' measurement and a measurement of the input voltage. The display is the algebraic difference between the two measurements.

When the auto zero function is turned OFF with the VA0 command, whenever a new function or range is selected, the 3497A takes a single ''zero'' measurement and stores it. Then, all subsequent measurements subtract this single ''zero'' measurement to correct the input voltage measurements. Since only one ''zero'' measurement is made, the reading rate with auto zero OFF is nearly twice the reading rate with auto zero ON.

The maximum reading speed for the 3497A is 300 channels/second, with auto zero OFF and 3 ½ digits displayed. As shown in the following chart, maximum reading speed depends on the line frequency, number of digits displayed (see the VDn command) and whether auto zero is ON or OFF.

Note that reading speed with auto zero OFF is twice that for auto zero ON. However, with auto zero ON, measurement accuracy is slightly greater than with auto zero OFF. So, for high-accuracy measurements at lower speed, turn auto zero ON. For higher-speed applications with lower accuracy requirements, turn auto zero OFF.

MAXIMUM READING SPEED (Channels/sec)

	60 Hz Operation			50 Hz Operation		
# Digits	5½	4½	3½	5½	4½	3½
Auto Zero ON	25	100	150	20	83	125
Auto Zero OFF	50	200	300	40	166	250

EXAMPLES - VOLTMETER AUTOZERO

```
10 OUTPUT 709; "VA1"     !Turns auto zero ON. (HP-IB)
20 OUTPUT 10; "VA0"      !Turns auto zero OFF. (Serial
                          Data)
```

Operating Note

1. Power On State: ''VA1'' - auto zero ON

VOLTMETER CURRENT SOURCE RANGE (VC)

Description

With the current source in the DVM, you can make accurate resistance measurements by passing a known current through the unknown resistance, measuring the voltage drop across the resistance with the DVM and computing the resistance (in the controller) from R = E/I.

The current source can be set to OFF or to 10 μA, 100 μA or 1 mA current outputs by using the VC command. Current is output from the HI and LOW terminals on the rear panel. Conventional current flow is out of the HI terminal and into the LO terminal. The format for the VCn command is:

VC0 = OFF	VC1 = 10 μA	VC2 = 100 μA	VC3 = 1 mA

EXAMPLES - CURRENT SOURCE OUTPUTS

```
10 OUTPUT 709; ''VC2''     !Sets current source output to 100 μA. (HP-IB)
20 OUTPUT 10; ''VC0''      !Turns current source output OFF. (Serial Data)
```

Operating Note

1. Power On State: ''VC0'' - current source OFF.

VOLTMETER DISPLAY (VD)

Description

The Voltmeter Display (VD) command sets the number of digits displayed on the front panel to 3½, 4½ or 5½ digits. In the 3½ digit mode, 4 digits are shown on the display, but the first digit can only be a 0 or a 1. Similarly, for the 4½ digit mode, 5 digits are displayed and for the 5½ digit mode, 6 digits are displayed.

The VD command also sets the number of power line cycles (PLC) and the integration time of the DVM and thus affects the maximum reading rates for the 3497A. The format for the VDn command is:

VOLTMETER DISPLAY

VDn	Digits Displayed	Line Cycles Integration
VD3	3½	0.01
VD4	4½	0.10
VD5	5½	1.00

Integration and Measurement Time

An important concept for a DVM is integration. Integration is a process where the effects of power line related noise are averaged to zero over the period of an integral number of power line cycles (PLCs) during a measurement. Integration thus greatly improves the Normal Mode Rejection (NMR) for a DVM where NMR is defined as the ability of a voltmeter to measure DC voltages in the presence of AC voltages at power line frequency.

The 3497A has best NMR at 5½ digit setting (60 dB). NMR for both 4½ and 3½ digits is 0 dB. However, to achieve this high NMR, maximum speed is 50 channels/sec as opposed to 300 channels/sec with 3½ digit mode.

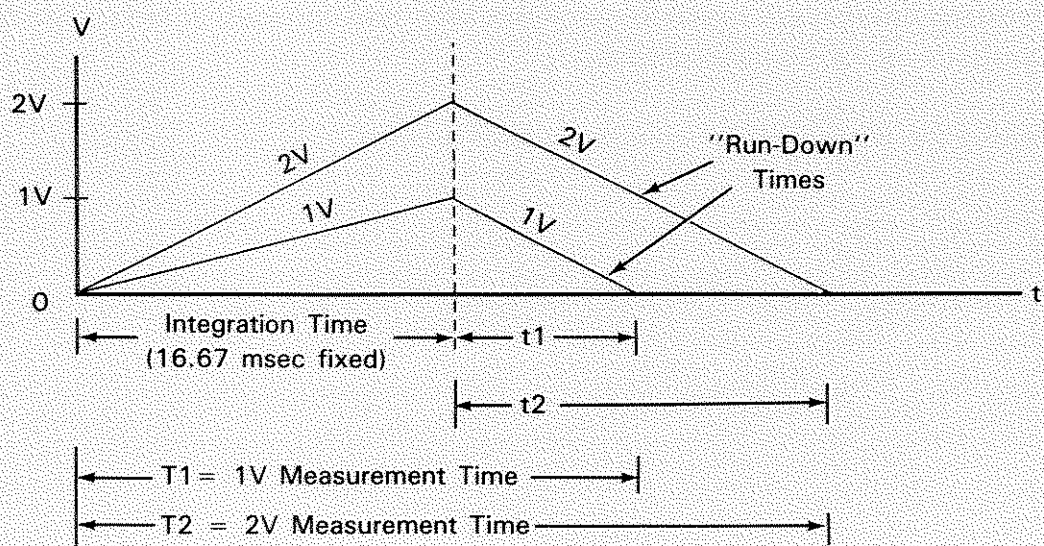
Another important concept for the DVM is integration time. Integration time is the time period, in PLCs, during which the input voltage is sampled by the voltmeter. Note that integration time is NOT the same as measurement time.

For example, with 5½ digit display, the DVM requires 1 PLC (16.67 msec at 60Hz operation, 20 msec at 50 Hz operation) to complete the sampling time. However, the measurement time is the sum of the sampling time and the "run down" time, as shown in the following example.

EXAMPLE - DVM INTEGRATION VS MEASUREMENT TIME

Although the 3497A uses a multi-slope integration technique, this example will illustrate basic concepts with a dual slope technique. In this figure, assume that the DVM is set for 5½ digit display. Then, input voltages (1 volt and 2 volts in this case) are sampled during a FIXED 16.67 msec time. This is the integration time and is the same for both measurements.

However, total measurement time varies depending on the value of the input voltage. As shown, total measurement time T1 for a 1 volt input is 16.67 ms + t1 where t1 is the "run-down" time while total measurement time T2 for a 2 volt input is 16.67 ms + t2.



Reading Rates for 3497A

Maximum reading rates for 60 Hz operation of the DVM follow. For 50 Hz operation, multiply readings shown by 5/6.

			Max Readings/Sec (60 Hz)	
VDn	Digits	Power Line Cycles	Autozero ON	Autozero OFF
VD3	3½	0.01	150	300
VD4	4½	0.10	100	200
VD5	5½	1.00	25	50

VOLTMETER DISPLAY (VD) (Cont'd)

EXAMPLES - SETTING DVM DISPLAY

10 OUTPUT 709; "VD3"	!Sets voltmeter for 3½ digit display and 0.01 power line cycle integration. Maximum reading speed = 300 readings/second with auto zero OFF. (HP-IB)
20 OUTPUT 10; "VD3"	!See HP-IB example. (Serial Data)

Operating Notes

1. Resolution and noise rejection are higher (but reading speed is lower) for 5½ digit display than for 3½ digit display.

2. Power On State: "VD5" - 5½ digit display.

VOLTMETER FORMAT (VF)

Description

By using the Voltmeter Format (VF) command, the 3497A can be programmed to output data to the controller in one of three formats: (1) ASCII (American Standard Code for Information Interchange); (2) Packed Binary Coded Decimal (BCD) or (3) Time of Day, measurement in ASCII format, Analog Channel Number.

Use VF1 for ASCII format, VF2 for Packed BCD format and VF3 for Time of Day, measurement, channel number format. When the voltmeter storage is OFF (VSO command), the VF command sets the output format for the data. The format for the VF command is:

VF1 = ASCII   VF2 = PACKED BCD   VF3 = VOLTMETER FORMAT 3

VF1	Each reading is output in standard ASCII format. Multiple readings (as set by the VNn command) are separated by commas and the last reading is followed by CR EOI LF.
VF2	Each reading is output in packed BCD format. Multiple readings (as set the VNn command) are output every 3 bytes with no delimiters between readings.
VF3	Each reading is output as: Time of Day (string), CR LF, Voltage (ASCII), Analog Channel Number (ASCII). For multiple readings (as set by VNn command), Time of Day ONLY is sent with each new trigger, rather than with each reading and CR LF is sent after the last channel number.

ASCII Format

The output format for ASCII data from the 3497A was defined in Chapter 3 (for HP-IB) or in Chapter 4 (for Serial Data). See the appropriate chapter for details on ASCII format.

Packed BCD Format

As discussed in Chapter 3, packed BCD is used to increase transfer (reading) speed from the 3497A to the controller. In Packed BCD, data is transmitted in three 8-bit bytes, in contrast to normal ASCII format which requires eleven or more bytes to transmit each voltage measurement.

VOLTMETER FORMAT (VF) (Cont'd)

Unlike ASCII, Packed BCD cannot be "read" directly by a controller and must be "unpacked" by a computer program before the data can be displayed or printed out. The following example shows one way to store up to 100 voltage readings in the 3497A (in Packed BCD), output these readings to an -hp- 85, unpack the readings and printout the results.

EXAMPLE - UNPACKING PACKED BCD READINGS

This program shows one way to unpack a number of Packed BCD voltage readings (100 readings maximum). To run the program, you must first connect a BNC connector between the VM COMPLETE and the EXT INCR ports on the rear of the 3497A. Then, when the prompt INPUT NUMBER OF READINGS (100 OR LESS) ? appears on the 85A screen, enter the number of channels you want to be measured and press END LINE to continue the program.

This program sequentially measures input voltages from channel 0 to channel n-1 where n is the number you input (i.e., if you specify 10 readings, channel 0 through 9 voltages are measured). For other channels, add appropriate AF and AL commands to line 90 to specify first and last channels to be measured.

Program	Lines	Description
SET INITIAL CONDITIONS		
10 CLEAR 709 20 PRINT "CHANNEL";TAB(16);"VOLTS" 30 PRINT 40 OPTION BASE 1 50 DIM P1$[308],P(100) 60 IOBUFFER P1$	60	Sets P1$ as storage variable for packed readings
STORE N READINGS IN 3497A	90	VT4 = Trigger Hold VF2 = Packed BCD VS2 = Store in Packed BCD VN = N Reading/Trigger AE1 = Enable EXT INCR port VT3 = Single Trigger
70 DISP "INPUT NUMBER OF READINGS (100 OR LESS)" 80 INPUT N 90 OUTPUT 709; "VT4VF2VS2VN";N;"AE1VT3" 100 WAIT 1000		
TRANSFER N READINGS TO 85A (IN PACKED BCD FORMAT)		

```
110 OUTPUT 709; "S01VS"
120 TRANSFER 709 TO P1$ FHS; EOI

UNPACK AND PRINT N READINGS

130 O7 = LEN (P1$)
140 P(1) = 0
150 IF O7>2 THEN P(O7 DIV 3) = 0
160 O6 = 0
170 FOR O5 = 1 TO O7 STEP 3
180 O6 = O6 + 1
190 O1 = NUM (P1$[O5])
200 O2 = NUM (P1$[O5+1])
210 O3 = NUM (P1$[O5+2])
220 P(O6) = .1*BINAND(O1,15)
230 P(O6) = P(O6) + .01*(O2 DIV 16)+.001*BINAND(O2,15)
    + .0001*(O3 DIV 16) + .00001*BINAND(O3,15)
240 P(O6) = (P(O6) +BIT(O1,4))*(1-2*BIT(O1,5))*
    10 ^ (O1 DIV 64-1)
250 PRINT (O5-1)/3;TAB(15);P(O6)
260 NEXT O5
270 END
```

110	SO1 = Output only when 85 is ready VS = Output all N stored readings (in packed BCD)
130-260	Unpack each reading and print out.

For N = 10 readings input, a typical printout is:

CHANNEL	VOLTS
0	2.5387
1	2.2809
.	.
.	.
9	2.1695

Voltmeter Format 3

As shown in Chapter 3, when the voltmeter format is set to VF3, the output from the 3497A is Time of Day, Voltage Measured (in ASCII format), Analog Channel Number, as illustrated where D = decimal digit.

DD:DD:DD:DD:DD,	±D.DDDDD E±D,	±DDD CRLF
Time of Day	ASCII Format Measurement	Analog Channel Number and Sign

With VF3, you can automatically record the time of day and the channel number of each measurement. This is particularly useful in data logging applications. Another very useful feature is that if the channel addressed does not close, a minus (-) sign appears before the number of the channel.

VOLTMETER FORMAT (VF) (Cont'd)

EXAMPLE - DATA LOGGING SEQUENCE

For example, consider the following sequence of readings returned from a data logger scanning operation. These readings show that on Jan 6 (1 June European) at 1:02 PM, channel 12 did not close and the .02789 volts printed is from background noise rather than the voltage on channel 12.

TIME OF DAY	CHAN	VOLTS
01:06:13:00:00	10	.12567
01:06:13:01:00	11	.15678
01:06:13:02:00	-12	.02789
01:06:13:03:00	13	.12345
.	.	.
.	.	.

EXAMPLE - VF3 OUTPUT FORMAT

A sample program is shown which prints VF3 data format. In this program, you can set the desired time of day in line 30, insert numbers of channels to be measured in line 50 and set the amount of time (if any) desired between measurements in line 90.

Program

```
 10 CLEAR 709
 20 DIM A$[16]
 30 OUTPUT 709;"TD0611130000VF3"
 40 PRINT "TIME OF DAY";TAB(17);
    "VOLTS"; TAB(26); "CHAN"
 50 FOR I = 1 TO 10
 60 OUTPUT 709; "AI";I
 70 ENTER 709; A$,V,C
 80 PRINT A$; TAB(17);V;TAB(26);C
 90 WAIT 1000
100 NEXT I
110 END
```

Lines	Description
20	A must be string variable since : is transferred
30	Sets time of day and single triggers DVM
40-80	Inputs 10 voltages and prints results

A typical printout is:

TIME OF DAY	VOLTS	CHAN
06:11:13:00:01	.18091	1
06:11:13:00:03	.17772	2
.	.	.
.	.	.
06:11:13:00:17	.17844	10

Operating Notes

1. When the 3497A Voltmeter Storage is OFF (VS0), the VFn command selects the format of data output to the controller. When voltmeter storage is ON (VS1 or VS2), the output format is determined by the VS1 or VS2 and the VF1 or VF2 command.

2. For Serial Data ONLY: Delete LF in format.

3. Power On State: ''VF1'' - ASCII Output.

VOLTMETER NUMBER READINGS/TRIGGER (VN)

Description

The VNn (n = 1 to 999) command allows you to set the number of readings (measurements) to be taken with a single input trigger pulse. This command is usually used with the external trigger (VT2) mode for the voltmeter (see VOLTMETER TRIGGER). For example, with VN5 and VT2 set, each trigger pulse input to the EXT TRIG port on the 3497A causes the voltmeter to take 5 readings.

There are two different ways to keep track of measurements, depending on the setting of the voltmeter storage (VS) command. The first way is to set the voltmeter to VS0 (Voltmeter Storage OFF) and output the readings (one at a time) to the controller.

The second way is to use the VS1 or VS2 command to store all n readings in the internal buffer in the 3497A for output to the controller or for later display on the front panel. When voltmeter storage is ON (VS1 or VS2 set), each trigger pulse causes all n readings to be stored in the buffer.

For example, with VT2, VN5 and VS1 set, each trigger pulse input to the EXT TRIG port causes the voltmeter to take and store 5 readings in ASCII format (up to a maximum of 60 readings for HP-IB, 50 readings for Serial Data). The format for the VT command is:

VN #readings/trigger	#readings/trigger = 1 to 999

To transfer the stored readings to the controller, send a ''VS'' command (without parameter). When the VS command is sent, all n readings are output to the controller in the format set by the VS command. See the VOLTMETER STORAGE (VS) command for details.

EXAMPLES - SETTING DVM FOR 10 READINGS/TRIGGER

```
10 OUTPUT 709; ''VT2VN10''    !Sets the voltmeter to external trigger and
                              take 10 readings for each trigger receiv-
                              ed at the EXT TRIG port. (HP-IB)
20 OUTPUT 10; ''VT2VN10''     !See HP-IB example. (Serial Data)
```

Operating Note

1. Power On State: ''VN1'' - One reading per trigger.

VOLTMETER RANGE (VR)

Description

The 3497A has four voltage ranges plus an autorange, as selected by the VRn command. Each of the four ranges has a 20% overrange capability. If a voltage input exceeds the overrange capability, indications are "+. OL" on the front panel and +9.00000E+9 sent over the interface to the controller. The format for the VRn command is:

VR1	= 0.1 V
VR2	= 1.0 V
VR3	= 10 V
VR4	= 100 V
VR5	= AUTORANGE

The 3497A voltage resolution (the minimum voltage difference which can be displayed) depends on the number of digits selected for display by the VDn command. The maximum display and resolution for 5½, 4½ and 3½ digit displays are shown. Note that maximum input voltage for the 3497A is 120V peak.

3497A DVM RANGES/RESOLUTION

VRn	Range	Maximum Display (±)	Resolution For:		
			5½ digits	4½ digits	3½ digits
VR1	.10V	.119999	1 μV	10 μV	100 μV
VR2	1.0V	1.19999	10 μV	100 μV	1 mV
VR3	10.0V	11.9999	100 μV	1 mV	10 mV
VR4	100.0V	119.999	1 mV	10 mV	100 mV

Autorange

Autorange is selected with the VR5 command. In autorange, the 3497A automatically selects the appropriate range to measure the input voltage by upranging or downranging to the first range which can accurately measure the input. For example, with an 8.0 volt input, the DVM upranges or downranges to the 10.0V range.

Each of the DVM ranges can display a range of voltages (i.e., the 1.0V range can display voltages from -1.19999V to +1.19999V, etc.). In autorange mode, the DVM upranges at 120% of full-scale and downranges at 11% of full-scale.

VOLTMETER RANGE (VR) (Cont'd)

For example, in the 1.0V range the DVM upranges at 1.2V and downranges at 0.11V. In the 10.0V range, the DVM upranges at 12.0V and downranges at 1.1V. The overlap between the uprange point of a range and the downrange point of the next higher range is called autorange hysteresis (1.2V - 1.1V = 0.1V in the example).

An autorange hysteresis chart for the 3497A is shown in Figure 10. When a voltage is input, the range selected depends on the previous range for the DVM. For example, a 1.15V input can be displayed on either the 1.0V or 10.0V range. If the DVM was previously on the 0.1V range, it will uprange to the 1.0V range. If the DVM was previously on the 100V range, it will downrange to the 10.0V range.

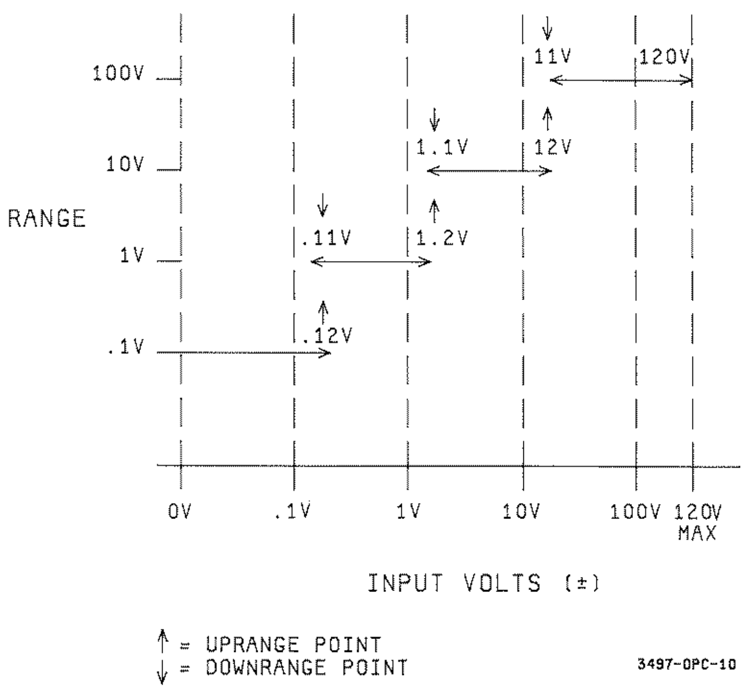


Figure 10. DVM Autorange Hysteresis

EXAMPLES - SETTING DVM RANGE

10 OUTPUT 709; "VR2"	!Sets voltmeter to 1V range. Maximum voltage which can be measured is ±1.19999V (for 5½ digit display). (HP-IB)
20 OUTPUT 10; "VR2"	!See HP-IB example. (Serial Data)

Operating Note

1. Power On State: "VR5" - Autorange

VOLTMETER STORAGE (VS)

Description

The 3497A has an internal voltmeter storage buffer which allows you to store readings in the 3497A rather than send them to the controller. There are two ways to store readings: ASCII or Packed BCD format. Voltmeter storage is turned on by the VS1 or VS2 command. Format for the VS command is:

VS0	=	Voltmeter storage OFF
VS1	=	Store 60 readings (50 in Serial Data) in ASCII
VS2	=	Store 100 readings (85 in Serial Data) in Packed BCD

Maximum Reading Storage

The following chart shows the maximum number of readings which can be stored for HP-IB and Serial Data versions of the 3497A. Note that the voltmeter storage must be turned ON with a VS1 or VS2 command for readings to be entered. The power on state for the 3497A is voltmeter storage OFF (VS0).

VOLTMETER STORAGE - MAXIMUM # READINGS

		Maximum Readings For:	
Command	Format	HP-IB	Serial Data
VS1	ASCII	60	50
VS2	Packed BCD	100	85

When the VS1 or VS2 command is selected and the DVM receives a trigger, it takes the number of measurements set by the VNn command and stores all n readings in the voltmeter storage buffer. There are two ways to get these readings out of the buffer: front panel display or transfer to the controller. Let's start with the front panel display.

Displaying Readings on the Front Panel

To display n readings stored in the buffer on the front panel display, enter the "VS" command (without a number). This will display the first number entered in the buffer. Then press the CLEAR ENTRY key to clear the first number and display the second entry. Continue to press the CLEAR ENTRY key for measurements 3, 4, ...,n.

VOLTMETER STORAGE (VS) (Cont'd)

EXAMPLE - DISPLAYING READINGS ON FRONT PANEL

For example, to enter 5 measurements in the storage buffer, enter the following commands from the keyboard:

VT4 VS1 VN5 VT3

- VT3 → Sends single trigger to the DVM.
- VN5 → Sets the DVM to take 5 readings/trigger.
- VS1 → Turns on Voltmeter Storage in ASCII mode.
- VT4 → Voltmeter Trigger to HOLD.

Now that the 5 readings are stored in the storage buffer, enter VS to display the first reading entered. Then, press the CLEAR ENTRY key to display the 2nd reading entered. Press the CLEAR ENTRY key again to display the 3rd reading, etc. When the 5th reading is displayed, pressing the CLEAR ENTRY key has no effect on the display.

Transferring Stored Readings to the Controller

There are two modes to return stored readings to the controller, depending on whether VS1 or VS2 is set. With VS1 (ASCII format), all n stored readings can be input to the controller using an ENTER command and placing readings in a string or array variable. Readings can then be directly printed or displayed. Readings are loaded into the variable in the order taken (first reading sent first, etc.).

With VS2 (Packed BCD), the procedure is the same as with ASCII format, but readings loaded into the controller variable must be "unpacked" before they can be displayed (see the VOLTMETER FORMAT (VF) command for a sample unpacking program).

NOTE

With VS0 (Voltmeter Storage OFF), the format of readings output to the controller is determined by the VFn (Voltmeter Format) command. With VS1 or VS2, the format of readings output is determined by the VS1 or VS2 and the VF1 or VF2 command. It is good programming practice to put both VF1 and VS1 or VF2 and VS2 in the same programming line.

EXAMPLE - TRANSFER STORED READINGS TO CONTROLLER

The following program sets the DVM to take 5 readings/trigger, store the readings in the 3497A internal storage buffer and then output all 5 readings to the controller and store in array A(I). The 5 readings are then printed out.

Program	Lines	Description
10 OPTION BASE 1	40	VT4 = Trigger hold
20 DIM A(5)		VS1 = Storage ON (ASCII)
30 CLEAR 709		VN5 = 5 readings/trig
40 OUTPUT 709;		VT3 = Single trigger
"VT4VF1VS1VN5VT3"		VF1 = ASCII Format
50 WAIT 1000		
60 OUTPUT 709; "VS"		
70 PRINT "READING VOLTS"		
80 FOR I = 1 TO 5		
90 ENTER 709; A(I)	60	Request transfer of stored
100 PRINT I; A(I)		readings.
110 NEXT I		
120 END	80-110	Enter and print readings.

Operating Notes

1. Stored readings can be read (sequentially) from the front panel by entering "VS" to get the first reading, followed by pressing the CLEAR ENTRY key for successive readings.

2. Sending the "VS" command stops loading of data into buffer, so buffer cannot be read into and out of at the same time.

3. Power On State: "VS0" - Voltmeter Storage OFF.

VOLTMETER TRIGGER (VT)

Description

Triggering is simply the process which causes the 3497A to take one or more readings. There are four trigger modes, as set by the VTn command: Internal (VT1); External (VT2); Software (VT3) and Hold (VT4). The power-on state for the 3497A is Internal Trigger (VT1). When the DVM is triggered (making a measurement), the LED indicator (.) on the 6-digit display is ON.

Internal Trigger (VT1)

In the INTERNAL TRIGGER (VT1) mode, the DVM is constantly triggered to make measurements of the voltage input. If no channel is closed, or if there are no inputs to the HI COM, LO COM and GUARD COM terminals on the rear panel, the front panel display shows random background voltage.

External Trigger (VT2)

In external trigger mode, the DVM is triggered by pulses input to the EXT TRIG port on the rear panel. When an external trigger (must be a TTL pulse of at least 50 ns) is received, the DVM takes one or more measurements, as set by the VNn command, and then sets idle waiting for the next trigger. If a trigger pulse is received when the 3497A is making a measurement, the pulse is ignored.

Software Trigger (VT3)

When a VT3 command is sent, the DVM is single-triggered and takes the number of readings set by the VNn command. Note that the VT3 command only triggers the DVM. In contrast, a TRIGGER command (see Chapter 3) sent over the HP-IB interface increments the analog channel and triggers the DVM.

Hold (VT4)

The VT4 command causes the DVM to go into a pause state where no measurements are taken. This command is used with the VT3 command to ensure that the DVM does not take measurements before the controller is ready to accept them.

EXAMPLES - SET DVM TRIGGER STATE

10 OUTPUT 709; "VN10VT3"	!Causes the voltmeter to single-trigger and take 10 readings. (HP-IB)
20 OUTPUT 10; "VN10VT2"	!Causes the voltmeter to take 10 readings whenever an external trigger is received at the EXT TRIG port. (Serial Data)

Operating Notes

1. For Serial Data ONLY: In VT1 mode, single output for each trigger when SO1 in effect. Continuous output for SO0.

2. Power On State: "VT1" - Internal Trigger.

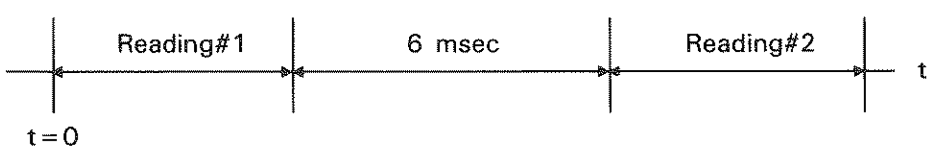
VOLTMETER WAIT (VW)

Description

Use the Voltmeter Wait (VWn) command to program a pause between readings or after a trigger. You can set the DVM to wait in intervals of 100 μsec increments, from 0 (no wait) to 99.9999 seconds. The format for the VWn command is:

VWn	n = 0 to 999999

For example, use VW 60 for a 6 msec pause between readings, since 60 x 100 μsec = 6 msec. Then, as shown, if reading #1 occurs at t = 0, a 6 msec wait occurs after reading #1 is completed before reading #2 is initiated.



EXAMPLES - SET VOLTMETER WAIT

10 OUTPUT 709; "VW60"	!Causes voltmeter to wait 6 msec between readings. (HP-IB)
20 OUTPUT 10; "VW500"	!Causes voltmeter to wait 50 msec between readings. (Serial Data)

Operating Note

1. Power On State: "VW0" - No wait between readings.

REAR PANEL PORT CONTROL

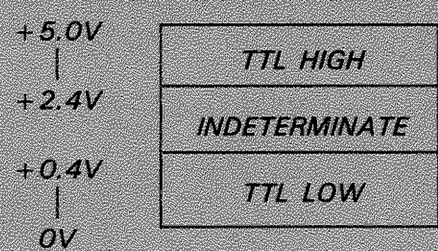
As shown in Figure 11, there are six BNC connectors located on the right rear panel of the 3497A. VM COMPLETE (Voltmeter Complete), CHANNEL CLOSED and TIMER are output ports, EXT TRIG (External Trigger) and EXT INCR (External Increment) are input ports and BBM SYNC (Break-Before-Make Synchronization) is both an input and an output port. This part of the chapter shows how these ports can be used.

CAUTION

All ports use TTL logic levels with active pullup (totem pole) used for output signals. Outputs must not be grounded by external devices. Do not exceed 5V MAX for inputs to the EXT TRIG, EXT INCR or BBM SYNC ports.

NOTE

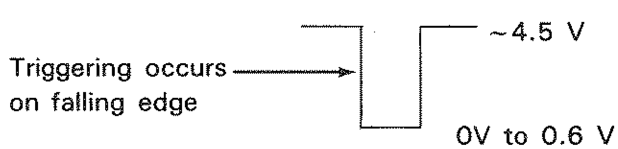
The 3497A requires the following TTL voltage levels for proper operation (+2.4V to +5V = TTL HIGH and 0V to +0.4V = TTL LOW).



EXT TRIG Port

The EXT TRIG (External Trigger) port allows you to trigger the DVM by using an external input pulse. A low-going TTL pulse input to the port triggers the DVM to take one or more readings and then wait for the next trigger input. Input trigger signal requirements are:

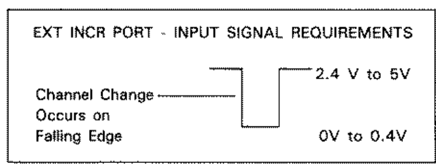
EXT TRIG PORT - INPUT SIGNAL REQUIREMENTS



EXT INCR

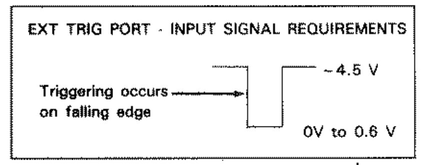
If the port is enabled by an AE1 or AE2 command, a TTL pulse input to the EXT INCR (External Increment) port steps the 3497A from the present analog channel to the next higher (or next lower) analog channel.

For example, if the present analog channel is 12, an input pulse will step the 3497A to channel 13 or 11, as previously programmed. The input pulse requirements for EXT INCR are:



EXT TRIG

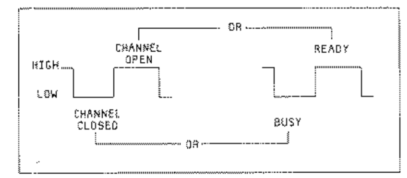
When the DVM is set for external trigger with a VT2 command, a low-going TTL pulse input to the EXT TRIG port causes the DVM to take one or more readings (as set by the VNn command), then set idle and wait for the next trigger input.

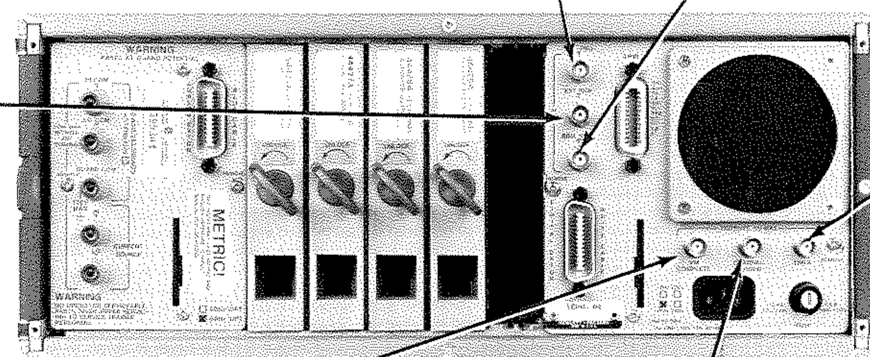


BBM SYNC

The BBM (Break Before Make) SYNC port outputs a TTL LOW when a channel is closed and a TTL HIGH when a channel is open. The BBM SYNC ports for two 3497As may be connected together to ensure that only one mainframe has channels closed at any one time.

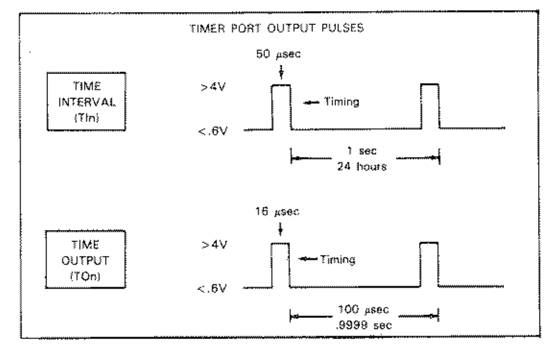
When two or more mainframes are connected together, the signal levels out of the BBM SYNC port are defined as BUSY for LOW (channel closed) or READY for HIGH (channel open) conditions.





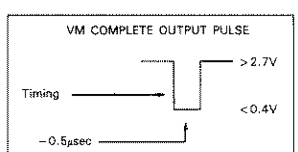
TIMER

Pulses can be output from the TIMER port using the Time Interval (TIn) or Time Output (TOn) command. With TOn, the TIMER port outputs positive going 16 μsec-wide TTL pulses with periods from 100μsec to .9999 sec. With TIn, the TIMER port outputs positive going 50 μsec-wide TTL pulses with periods from 1 sec to 24 hours.



VM COMPLETE

When the voltmeter completes a measurement, a low going TTL pulse appears at the VM COMPLETE (Voltmeter Complete) port. This pulse can be used for timing or control applications.



CHANNEL CLOSED

When an analog channel has been closed, a low-going TTL pulse is output at the CHANNEL CLOSED port. One application for this output is in high-speed scanning to trigger an external voltmeter to take a reading after a channel is closed. Pulse is identical to the VM COMPLETE output.

To use the EXT TRIG port, the voltmeter must be set to external trigger (VT2), the number of readings/trigger must be specified with the VNn command and the analog channel to be measured must be closed with an AC chan# command.

EXAMPLE - USING EXT TRIG PORT

Suppose we want to input a TTL pulse to trigger the DVM to take 10 readings of the voltage on channel 1. A sample program is shown which makes the 10 readings and transfers each reading (sequentially) to the controller.

In line 20 of the program, VN10 sets the DVM to take 10 readings for each external trigger input, VT2 sets the DVM for external trigger mode, AC1 closes analog channel 1 and SO1 insures that the controller can accept each reading as it is transferred.

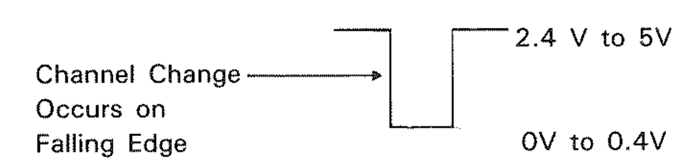
Line 30 halts the program so that an external trigger be input to the EXT TRIG port to start the DVM measurements. After the trigger has been input, you can continue the program by pressing the CONT key on the -hp-85A.

```
 10 CLEAR 709
 20 OUTPUT 709; "VN10VT2SO1AC1"
 30 PAUSE
 40 !Send external trigger to EXT TRIG PORT.
 50 !Press CONT key.
 60 FOR I = 1 TO 10
 70 ENTER 709;A(I)
 80 PRINT I; A(I)
 90 NEXT I
100 END
```

EXT INCR Port

Use the EXTernal INCRement port to increment or decrement analog channels with an external pulse. To use this port, the port must be enabled with an AE1 (port enable) or AE2 (FAST SCAN) command. Channels are either incremented or decremented depending on the AF and AL commands set. If AF<AL, channels are incremented. If AF>AL, channels are decremented. Input signal requirements are shown.

EXT INCR PORT - INPUT SIGNAL REQUIREMENTS



The AE2 (FAST SCAN) mode is particularly useful when you want to scan channels at high scan rates. When the 3497A is in FAST SCAN mode, the 3497A ignores BBM SYNC (Break Before Make Synchronization) inputs from other 3497As (see BBM SYNC Port description). However, BBM SYNC between the 3497A and any connected 3498As remains.

The AE2 command takes the 3497A out of any previous measurement mode, but any command sent after the AE2 command changes the port to the AE1 mode.

EXAMPLE - SCANNING USING THE EXT INCR PORT

For example, suppose we want to scan channels 20 through 29 by inputting pulses into the EXT INCR port. To do this, two actions are required:

1. Connect a BNC connector between the VM COMPLETE port and the EXT INCR port. Then, after the DVM takes a measurement on the channel closed, a pulse is output from the VM COMPLETE port into the EXT INCR port which causes the 3497A to increment to the next channel.

2. Set first channel to be closed with AF20 and the last channel to be closed with AL29 (the channel closure sequence will be 20,21, 22, ..., 29, 20, 21, ...) and enable the EXT INCR port with an AE1 command.

A sample program is shown to measure and record voltages on channels 20 through 29 when the EXT INCR port is used as described previously. With this program, the 3497A will cycle through channels 20 through 29, first taking a reading on channel 20, then incrementing to channel 21, taking a reading on channel 21, incrementing to channel 22, etc. Note that the channels are incremented each time the VT3 command is sent (line 70).

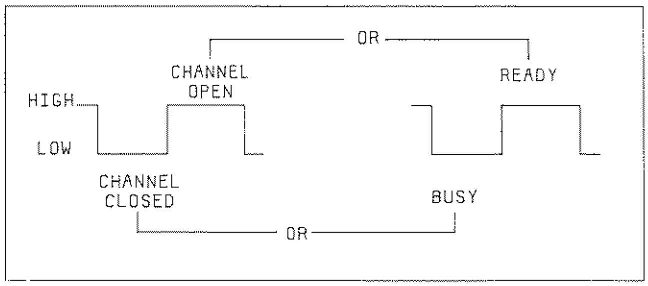
```
 10 PRINT "CHANNEL";TAB(15);"VOLTAGE"
 20 PRINT
 30 DIM A(30)
 40 CLEAR 709
 50 OUTPUT 709; "VT4AF20AL29AE1AC20"
 60 FOR I = 20 TO 29
 70 OUTPUT 709; "SO1VT3"
 80 ENTER 709; A(I)
 90 PRINT I;TAB(17);A(I)
100 WAIT 1000
110 NEXT I
120 END
```

BBM SYNC Port

The BBM SYNC (Break Before Make Synchronization) port is both an input and an output port. This port outputs a TTL LOW when a channel is closed and a TTL HIGH when a channel is open. BBM SYNC ports for two 3497As may be connected together to insure that only one mainframe has channels closed at any one time.

When two or more mainframes are connected together, the signal levels out of the BBM SYNC port are defined as BUSY for LOW (channel closed) or READY for HIGH (channel open) conditions, as shown.

BBM SYNC PULSE DEFINITIONS



3497-OPC-BBM

EXAMPLE - USING THE BBM SYNC PORT

As an example of how the BBM SYNC port can be used, consider the system shown in Figure 12 in which two 3497A mainframes are connected to a controller via the HP-IB bus. For this example, we'll use an Option 010 assembly in each of the 5 slots of the 3497As for a total channel capacity of 20 channels/assembly x 10 slots = 200 channels (the example shows only one assembly per 3497A for simplicity).

For this system, the top 3497A is set to address 709 and the bottom 3497A to address 710. Also, the 3497A at address 710 does not have a DVM so all 200 measurements will be taken by the DVM at address 709. Inputs from the 3497A at address 710 are via the HI COM, LO COM and GUARD COM terminals on the rear of the 3497A (see VOLTMETER CONTROL description for details).

A potential problem can arise from this setup if the BBM SYNC ports are not connected together. For example, to measure the voltage on channel 0 for the 3497A at address 709, the command is OUTPUT 709; ''AI0''. However, to measure the voltage on channel 0 of the 3497A at address 710 is OUTPUT 710; ''AI0''. So far, no problem as long as the BBM SYNC ports are connected. However, consider the following command sequence if the BBM SYNC ports are NOT connected.

```
        .
        .
40 OUTPUT 709; ''AI0''      !Closes Channel 0 at address 709
50 WAIT 1000                !Waits one second
60 OUTPUT 710; ''AI0''      !Closes Channel 0 at address 710
        .
        .
```

In this sequence, we now have channel 0 closed at address 709 AND channel 0 closed at address 710 (since channel 0 at address 709 was NOT opened by the command at line 60) and voltage sources A and B are simultaneously input to the DVM.

However, if the BBM SYNC ports are tied together as shown, line 60 in the program will not be executed. When channel 0 at address 709 is closed, the BBM SYNC port outputs a CHANNEL CLOSED (TTL LOW) pulse which does not allow channel 0 (or any other channel) at address 710 to close until channel 0 at address 709 is opened.

Thus, the BBM SYNC port offers protection from unwanted multi-channel closures when two or more 3497A mainframes are used on a single HP-IB Bus.

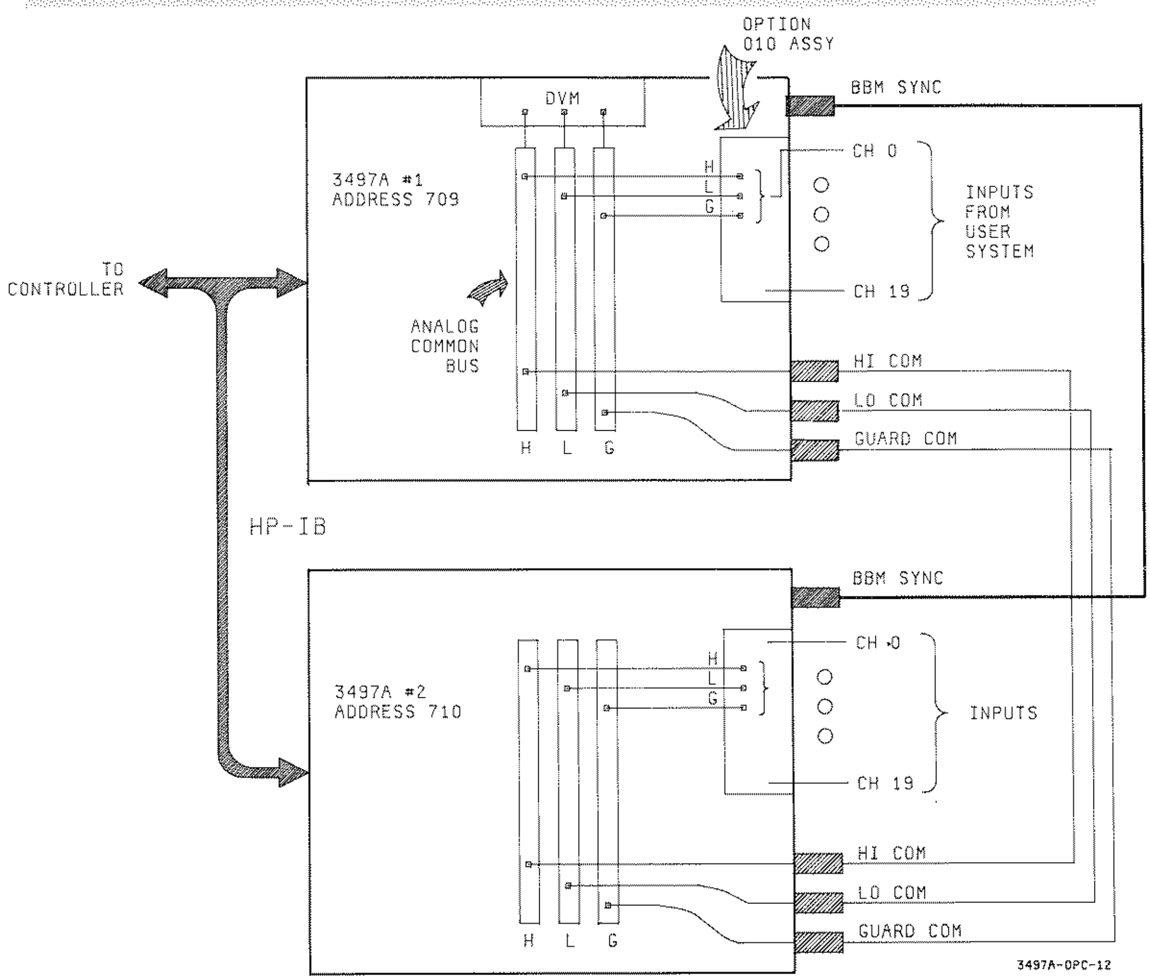
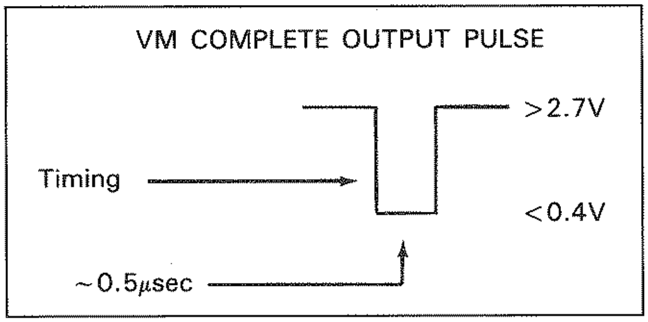


Figure 12. Using the BBM SYNC Port

VM COMPLETE Port

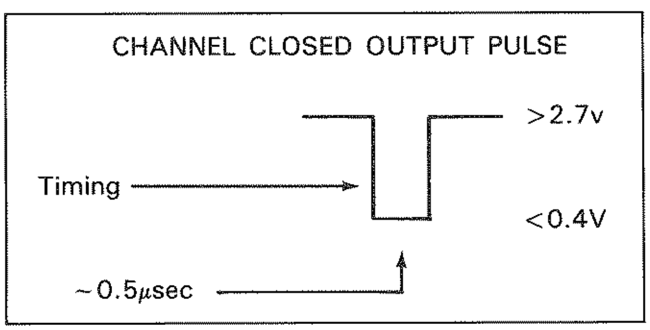
When the voltmeter completes a measurement, a TTL pulse of approximately 0.5 μsec is available at the VM COMPLETE port. The characteristics of the output pulse are shown. Note that the VM COMPLETE port does not have to be enabled by a command. For an example of how this port can be used, see the description of the EXT INCR port. Timing reference should be with respect to the HIGH to LOW edge of the pulse.



CHANNEL CLOSED Port

When an analog channel has been selected and the channel relay closed, a TTL pulse of about 0.5 μsec is available at the CHANNEL CLOSED port. The pulse characteristics are shown. This pulse is identical to that output from the VM COMPLETE port, so timing reference should be from the HIGH to LOW edge of the pulse.

The CHANNEL CLOSED port output is especially useful when making high speed scanning measurements, as the time to close relays becomes a significant factor in high-speed operations. One use of this output is to trigger an external voltmeter (such as the -hp- 3437A Systems Voltmeter) to take a reading after each channel is closed.



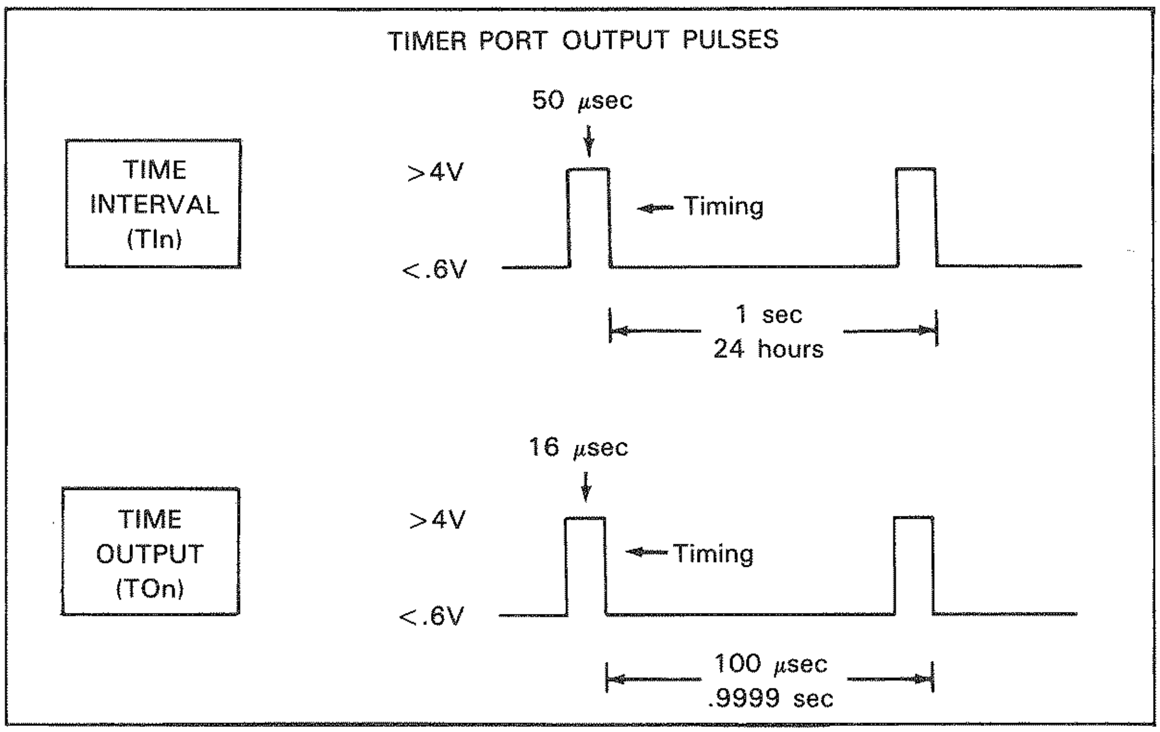
TIMER Port

When the TIMER port is enabled by a Timer Interval (TIn) command or Timer Output (TOn) command, the port outputs a pulse train consisting of TTL pulses. The period of the pulse train and the pulse width of individual pulses depends on the command used.

When the Timer Interval (TIn) command is used, the TIMER port outputs positive going 50 μsec-wide TTL pulses with periods from 1 second to 24 hours (maximum), with 1 second increments. In addition, if the SRQ mask (interrupt mask for Serial Data operation) has been set for Time Interval Interrupt, the 3497A generates an SRQ (BREAK message for Serial Data) when each pulse is output.

When the Timer Output (TOn) command is used, the TIMER port outputs positive going 16 μsec-wide TTL pulses with minimum period of 100 μsec and maximum period of .9999 sec, with 100 μsec increments. SRQ (BREAK) is not available with the TOn command. Although, TOn overrides TIn at the TIMER port, SRQ (BREAK) can still be used even when Time Output is active.

As with the VM COMPLETE AND CHANNEL CLOSED ports, timing reference should be from the HIGH to LOW edge of the pulse. The two TIMER port output pulse characteristics are shown.



EXAMPLES - USING THE TIMER PORT

For example, to output pulses from the TIMER port every 300 μsec, use the Time Output (TOn) command. The TOn command produces output pulses at the TIMER port with periods from 100 μsec to .9999 sec in 100 μsec increments. Thus, to produce 16 μsec-wide pulses every 300 μsec, send OUTPUT 709; ''TO3''.

As a second example, suppose we want to output pulses from the TIMER port every 37.5 minutes. Since the period of the pulse train exceeds 1 second, use the Timer Interval (TIn) command. The TI command has the form TI HoursHours MinMin SecSec, so to produce 50 μsec-wide pulses every 37.5 minutes, send OUTPUT 709;''TI3730''.

As a third example, consider the following HP-IB program line: 10 OUTPUT 709; ''SE10TI200''. Two minutes after the 3497A receives this input, a 50 μsec-wide pulse is output from the TIMER port and SRQ is sent to the controller, since the SRQ Mask is set for Time Interval Interrupt by the SE10 command.

If the controller clears the SRQ, another SRQ message is sent every two minutes. Even if the controller does not clear SRQ, pulses are output from the TIMER port every two minutes.

PLUG-IN ASSEMBLY CONTROL

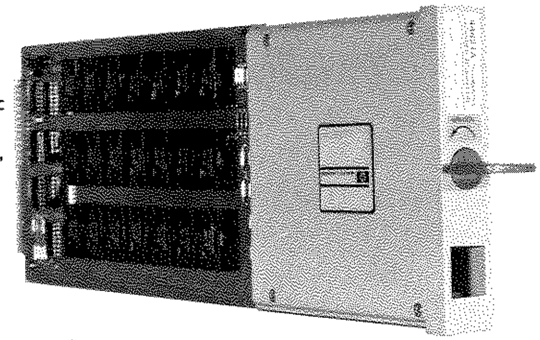
This part of the chapter shows how to use the 3497A commands to control the operation of the plug-in assemblies (Options 010 through 140). Assemblies are presented in order of increasing option number from 010 to 140. Thus, to set up and control the plug-in assemblies you are using in your 3497A or 3498A, refer to the option number(s) of the assemblies (see the following table for pages).

For each plug-in assembly, information contained includes a summary of the purpose of the assembly, a simplified operational description and modes of operation for the assembly, commands used to control the assembly and some example programming sequences for typical assembly applications.

3497A PLUG-IN ASSEMBLIES

OPTION	MODEL	ASSEMBLY TITLE	PAGE
010	44421A	20 Channel Relay Multiplexer	184
020	44422A	20 Channel Relay Multiplexer/ Thermocouple Compensation	191
050	44425A	16 Channel Isolated Digital Input/ Interrupt	200
060	44426A	100 kHz Reciprocal Counter	209
070	44427A	120 Ohm Strain Gauge/Bridge Completion	231
071	44427B	350 Ohm Strain Gauge/Bridge Completion	231
110	44428A	Actuator/Digital Output	245
115	44431A	8 Channel High Voltage Acutator	257
120	44429A	Dual Output, 0 to ± 10V Voltage D/A Converter	265
130	44430A	Dual Output, 0-20mA/4-20mA Current D/A Converter	270
140	44432A	Breadboard Card	275

OPTION 010



20 Channel Relay Multiplexer Assembly

Introduction

Option 010 is a 20 channel analog signal multiplexer assembly which is used to switch (multiplex) signals from up to 20 channels to the 3497A DVM or to other assemblies or instruments.

Each of the 20 channels consists of three reed-actuated relays, one each for HIGH, LOW and GUARD lines. The channels are organized into two decades of 10 channels and one channel can be closed in each decade. Relays can be closed in a random fashion or can be incremented between programmable limits.

Because the 20 channel relay multiplexer has low thermal offset characteristics, this assembly is ideal for precise low-level measurements of transducers and temperature measuring devices. Since two channels (one per decade) can be closed at a time, one Option 010 assembly can be used to make four-terminal resistance measurements.

Simplified Operation

As shown in Figure 13, the relay multiplexer assembly consists of a relay card and a terminal card. Inputs from system sensors, such as voltage sources, etc. are input to the terminal card on channels A0 through B9 and are sent to the relay card relays. Each channel consists of a HIGH, LOW and GUARD line. Relays are divided into two groups (decades): A decade and B decade.

In normal operation, a close channel (AC chan#,chan#,..) command from the 3497A closes the relay in the channel selected and simultaneously closes the tree switch relay. When this happens, the input signal is sent to four places: the A COMMON and B COMMON connectors on the terminal card and (through the tree switch relay) to the 3497A DVM and to the rear panel (HI COM, LO COM and GUARD COM) terminals.

For example, for an assembly in slot 0, channel A0 address is 0, channel A1 address is 1, ... and channel B9 address is 19. Thus, the command AC0 closes the relay in channel A0 and the tree switch. The voltage at channel A0 is sent to the

A COMMON and B COMMON terminals on the terminal card, to the rear panel connectors on the 3497A and to the DVM.

Four optional configurations are available by removing jumpers JM1 through JM6. For example, by removing JM1, JM2 and JM3, channel inputs are not sent to the 3497A. Or, by removing JM4, JM5 and JM6, you can separate the A decade outputs from the B decade outputs (for four-wire ohms measurements).

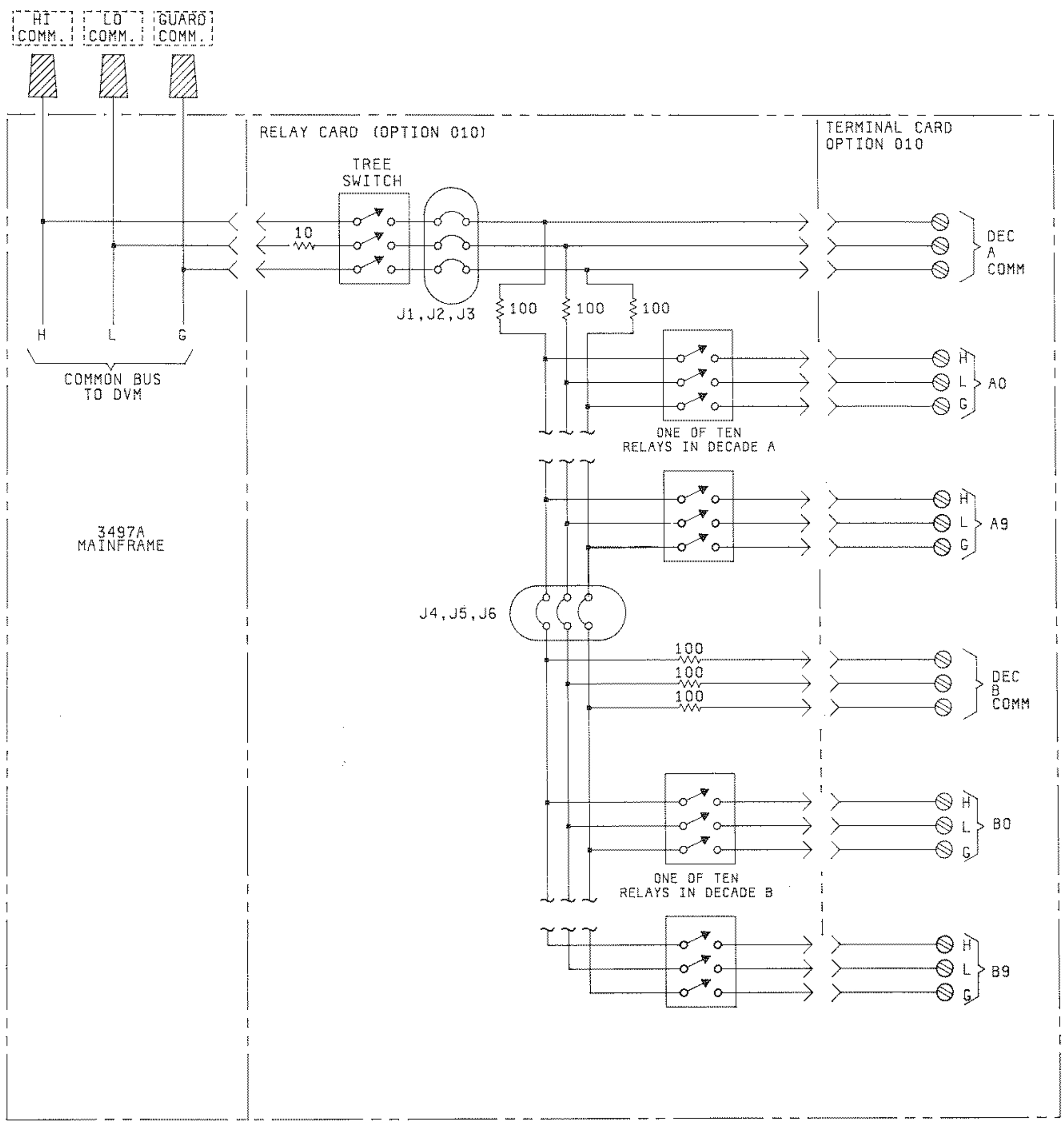


Figure 13. Option 010 - Simplified Operation

COMMANDS FOR THE RELAY MULTIPLEXER ASSEMBLY

Command	Description
AC chan#,chan#,. chan# = 0 to 999	CLOSE ANALOG CHANNELS Close up to four channels (1/decade). Channels not addressed are opened. To close channel 3, use "AC3". To close channels 3, 13, 23 and 33, use "AC3,13,23,33".
AEn n = 0 to 2	ENABLE EXTERNAL INCREMENT PORT Enable the EXT INCR port. AE0 disables the EXT INCR port and AE1 enables the port. AE2 (FAST SCAN) enables the port and external BBM sync pulse is ignored.
AF chan# chan# = 0 to 999	SET ANALOG FIRST CHANNEL Sets first channel to be closed in a sequence, but does not close the channel. To set channel 53 as first channel, use "AF53".
AI chan# chan# = 0 to 999	CLOSE A CHANNEL, TRIGGER DVM Closes channel addressed and triggers DVM to take a measurement. To make a reading of channel 23, use "AI23".
AL chan# chan# = 0 to 999	SET ANALOG LAST CHANNEL Sets last channel to be closed in a sequence, but does not close the channel. If AF < AL, sequence is increasing. If AF > AL, sequence is decreasing. To set 53 as last channel to be closed, use "AL53".
AR	ANALOG RESET Opens all channels on all multiplexer assemblies in a 3497A or 3498A. In addition, AR sets VF1, VT1, VR5, VW0, VS0, AE0, AF0 and AL999.
AS	ANALOG STEP Increments or decrements channel closure between AF and AL channels. If AF < AL, sequence is increasing. If AF > AL, sequence is decreasing. If AF and AL are not specified, sequence increments from presently closed channel (i.e., for channel 30 closed, sequence is 30, 31, ...,999, 0, 1 ... for each AS input).
AV chan# chan# = 0 to 999	DEDICATE DISPLAY TO CHANNEL Dedicates the front panel display to channel addressed. Command does not close channel or affect other 3497A operations. Display is updated when measurement is taken.

Controlling the Multiplexer Assembly

The 20 channel relay multiplexer assembly is controlled with the ANALOG command group as summarized in the following chart. For details and sample sequences, see the Command Directory in Chapter 6.

3497A Panel Features Used with the Assembly

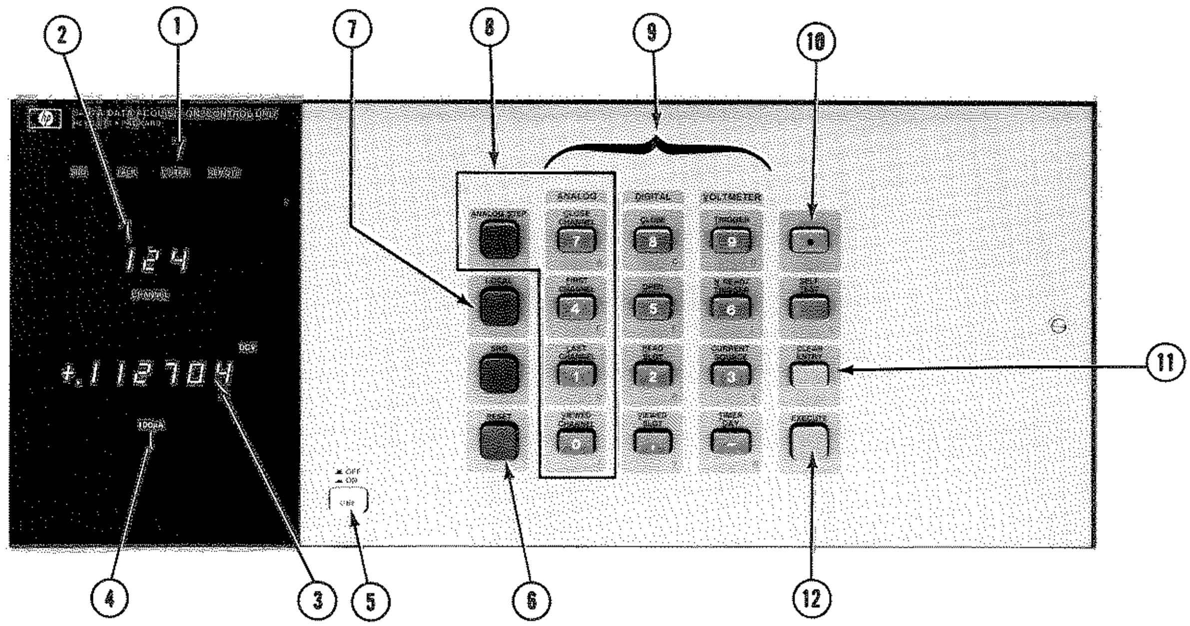
Figure 14 identifies front panel keys used with the relay multiplexer and shows their functions. Since the relay multiplexer is an analog assembly, only the analog display is used. When a channel is closed, the 3-digit display shows the number of the channel closed and the 6-digit display shows the value of the DC voltage measured (DCV on the display).

Relay Assembly Channel Addresses

The slot in which the assembly is placed determines its channel addresses. Since each assembly has decades A and B (with inputs A0 through B9), for an assembly in slot 0 the A decade addresses are 0 through 9 and the B decade addresses are 10 through 19. For an assembly in slot 1, the A decade addresses are 20 through 29 and the B decade addresses are 30 through 39, etc. See the following table for details.

RELAY MULTIPLEXER - CHANNEL ADDRESSES

Terminal Card Channel	Address for Assembly in Slot:				
	0	1	2	3	4
A0	0	20	40	60	80
A1	1	21	41	61	81
A2	2	22	42	62	82
.	.	.	.	.	.
.	.	.	.	.	.
A9	9	29	49	69	89
B0	10	30	50	70	90
B1	11	31	51	71	91
.	.	.	.	.	.
.	.	.	.	.	.
B9	19	39	59	79	99



DISPLAYS

(1) HP-IB STATUS: Indicates HP-IB status when the 3497A is connected to bus. TALK = ON when 3497A is active talker; LISTEN = ON when 3497A is active listener; REMOTE = ON when 3497A controlled externally.

(2) CHANNEL: 3-digit display of channel being measured through the multiplexer assembly.

(3) NUMERIC DISPLAY: 6-digit display of DC volts measured on channel. DCV indicates DC voltage measurement. Display shows value of voltage measured.

(4) CURRENT SOURCE: Displays range of internal 3497A current source (10μA, 100μA or 1mA). ON only when current source is used.

Keys

(5) LINE: AC power ON/OFF switch.

(6) RESET: Clears 3497A, sets assembly as follows:

AO, AI, AS, AV = Disabled
AE0 = EXT INCR Port OFF
AF000 = First Chan = 000
AL999 = Last Chan = 999

(7) LOCAL: Puts 3497A in local (front-panel) mode of operation.

(8) ANALOG KEY GROUP: Used to control relay multiplexer.

(9) ALPHA-NUMERIC KEYBOARD: Each key has three modes:

Primary (upper part)
Numeric (0-9 plus ,-)
Shifted (A,C,D, etc. on lower part).

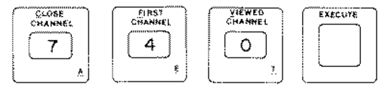
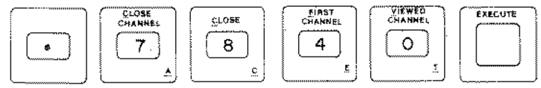
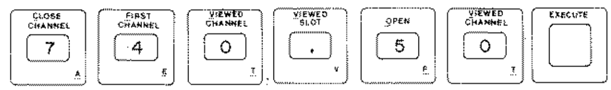
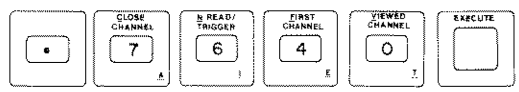
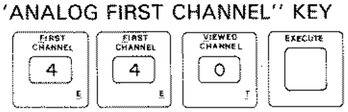
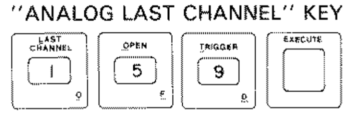
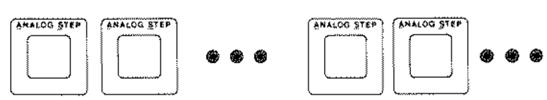
(10) SHIFT: Shifts keyboard (9) to shifted mode (A,C,D, etc). When pressed, light in center of key is ON.

(11) CLEAR ENTRY: Clears previous entry if EXECUTE key has not been pressed.

EXECUTE: Implements commands and prepares keyboard for new commands.

Figure 14. Option 010 - Front Panel Features Used With Assembly

Sample Command Sequences - Fron Panel Entry

Action	Command	Keystroke Sequences
CLOSE SINGLE CHANNEL (40)	"AC40"	"ANALOG CLOSE CHANNEL" KEY  "SHIFT" KEY 
CLOSE TWO CHANNELS* (40,50)	"AC40,50"	"ANALOG CLOSE CHANNEL" KEY  "SHIFT" KEY
CLOSE CHANNEL, TRIGGER DVM	"AI40"	"SHIFT" KEY 
SET FIRST CHANNEL (40)**	"AF40"	"ANALOG FIRST CHANNEL" KEY  "SHIFT" KEY
SET LAST CHANNEL (59)**	"AL59"	"ANALOG LAST CHANNEL" KEY  "SHIFT" KEY
SEQUENCE CHANNELS*** (40-59)	"AS"	"ANALOG STEP" KEY (ASSUMES AF40 AND AL59 PREV SET) 

* The multiplexer card DECADE TO DECADE jumpers must be out for proper 4-wire ohms measurements using this command.

** AF and AL commands do NOT close channels. Another command, such as AC or AI must be used to close channels. AF and AL determine the first and last channels to be closed in a sequence.

*** AS command sequences channel closures between AF and AL. The sequence is increasing if AL >AF and decreasing if AL <AF (i.e. if AF is 40 and AL is 59, AS increments channels from 40 to 41, etc. If AF is 50 and AL is 40, AS decrements channels from 50 to 49, etc.)

Figure 15. Option 010 - Keystroke Sequences

Front Panel Control

To show how the Option 010 assembly can be controlled from the 3497A front panel, sample keystroke sequences to enter commands are shown in Figure 15. For all commands except multi-channel closure (AC chan#,chan#, ..), jumpers JM1 through JM6 are IN and the T/C COMP jumper is in the NO T/C COMP position. For the AC chan#,chan# command, the T/C COMP jumper is in the NO T/C COMP position and jumpers J4, J5 and J6 are OUT.

The sample command sequences shown list action desired, commands required and keystroke sequences using primary key and shifted key sequences. See Chapter 2 for details on front panel control.

Remote (HP-IB and Serial Data) Control

Some sample program sequences using BASIC language are shown in Figure 16 which apply to HP-IB or Serial Data operation. Jumper settings are the same as for front panel control.

Sample Command Sequences - Remote (HP-IB) Operation

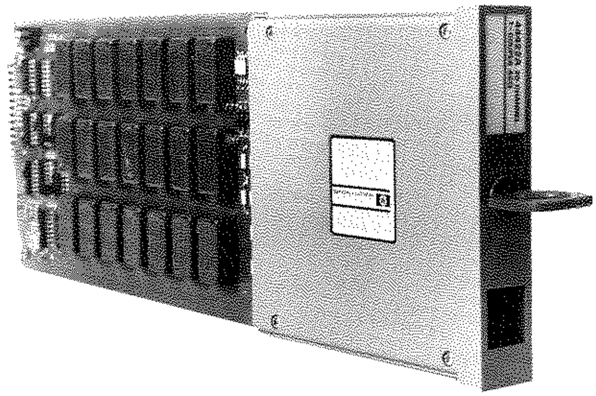
Action(s)	Command(s)	Example Programs
CLOSE CHANNEL 40, INPUT VALUE AT CHANNEL 40.	''AC40''	10 CLEAR 709 20 OUTPUT 709 ; ''AC40'' 30 ENTER 709 ; A 40 PRINT A 50 END
CLOSE CHANNELS 40,50;* INPUT VALUE AT CHANNEL 40, TRIGGER DVM TO TAKE MEASUREMENT.	''AC40,50'' AND ''AI40''	10 CLEAR 709 20 OUTPUT 709 ; ''AC40,50'' 30 OUTPUT 709 ; ''A140'' 40 ENTER 709 ; B 50 PRINT B 60 END
SET FIRST CHANNEL TO 40, SET LAST CHANNEL TO 59 AND SEQUENCE FROM 40 TO 59. DELAY .5 SEC BETWEEN CHANNEL CHANGES.	''AF40'',''AL59'' AND ''AS''	10 CLEAR 709 20 OUTPUT 709 ; ''AF40AL59'' 30 FOR I=40 TO 59 40 OUTPUT 709 ; ''AS'' 50 WAIT 500 60 NEXT I 70 END

* The multiplexer card DECADE TO DECADE jumpers must be out for proper measurements using this command.

Figure 16. Option 010 - Sample Programs

OPTION 020

Relay Multiplexer Assembly With Thermocouple Compensation



Introduction

The Model 44422A Relay Multiplexer Assembly with Thermocouple Compensation can be used for voltage, temperature and resistance measurements, but is primarily used with thermocouples for temperature measurements. The assembly consists of a relay card and a terminal card. The terminal card, which can be disconnected from the relay card, has temperature compensation circuits for thermocouple measurements.

The Option 020 assembly uses the same relay multiplexer card as the Option 010 assembly, but adds a special isothermal connector block on the terminal card to eliminate unwanted measurement errors when measuring thermocouple voltages.

Both hardware and software thermocouple compensation techniques are available. Hardware compensation can be used to measure the inputs of up to 20 thermocouples per assembly, but is limited to one thermocouple type per assembly. Software compensation can be used to measure the outputs of up to 19 thermocouples, with any mixture of thermocouples.

You can use the Option 020 assembly with hardware compensation to measure the outputs of up to 20 B, E, J, K, R, S or T type thermocouples (one type per assembly). You can use the assembly with software compensation to measure the outputs of up to 19 thermocouples (any mixture of these types).

In addition, with appropriate computer programs, you can use software compensation to determine the temperature measured by various types of thermocouples.

Simplified Operation

As shown in Figure 17, the assembly consists of a relay card and a terminal card. Inputs from system sensors, such as thermocouples, etc. are input to the terminals on channels A0 through B9 and sent to the relay card relays. Each channel consists of a HIGH, LOW and GUARD lines. Relays are divided into two groups (decades): A Decade and B Decade.

In normal operation, an AC chan# command from the 3497A closes the relay in one of the channels and simultaneously closes the tree switch relay. When this happens, the input signal is sent through the closed relay to four places: the A COMMON and B COMMON connectors on the terminal board and (through the tree switch) to the 3497A DVM and to the rear panel (HI COM, LO COM and GUARD COM) terminals.

For example, for an assembly in slot 0, the channel A0 address is 0, the channel A1 address is 1, ... and the channel B9 address is 19. Thus, the command AC0 closes the relay in channel A0 and the voltage input at channel A0 is sent to the A COMMON and B COMMON connectors on the terminal board, to the rear panel connectors on the 3497A and to the DVM.

Several optional configurations are available by removing jumpers JM1 through JM6. For example, by removing JM1, JM2 and JM3, channel inputs are not sent to the 3497A. Or, by removing JM4, JM5 and JM6 you can separate the A Decade outputs from the B Decade outputs (for 4-wire ohms measurements).

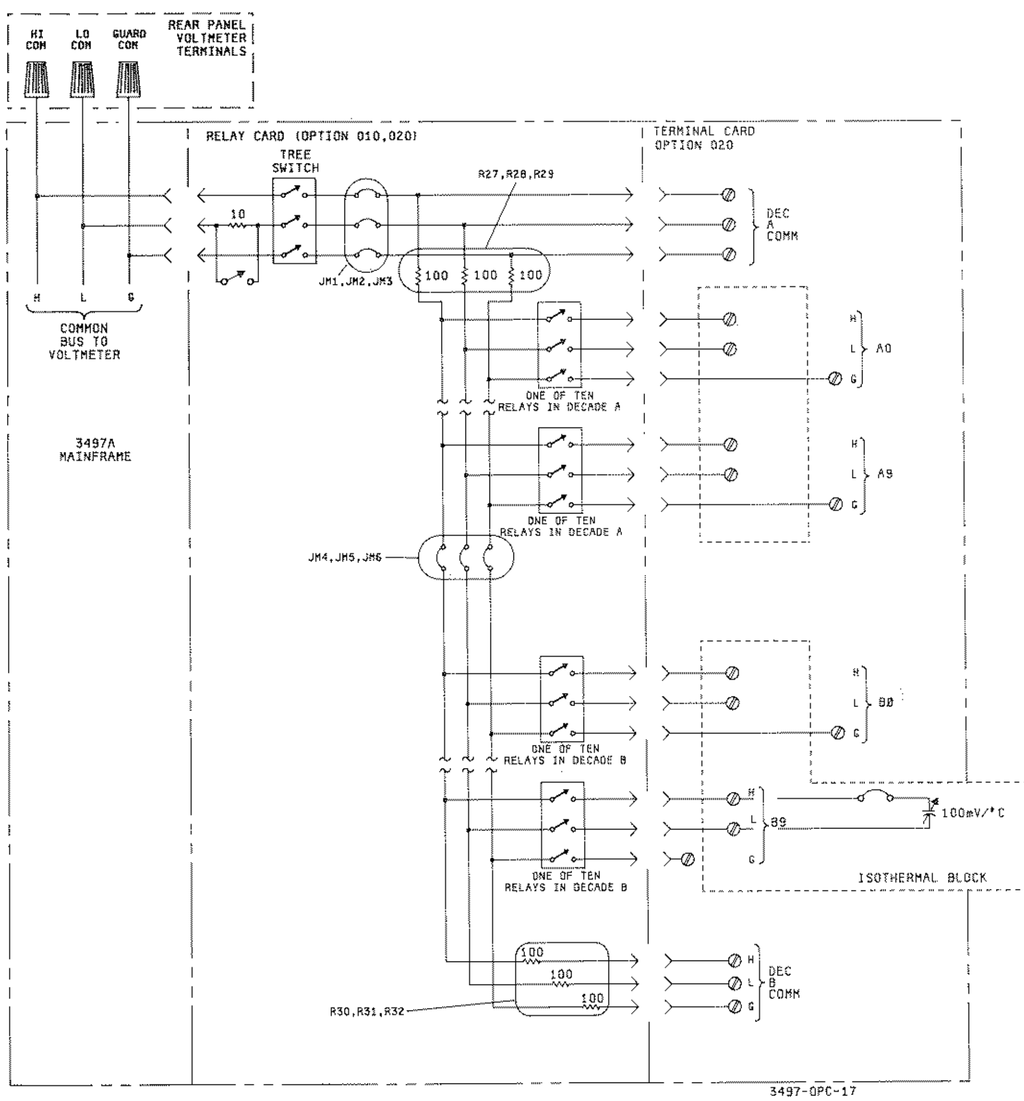


Figure 17. Option 020 - Simplified Schematic

Thermocouple Compensation

Since a primary purpose for the assembly is temperature measurements using thermocouples, the thermocouple compensation circuits require a word of explanation. The 3497A does not directly measure temperature, but rather measures voltage generated by thermocouples. This measured voltage (proportional to temperature) can then be converted to an equivalent temperature by reference to standard tables or through a computer program.

The problem with this approach is that the voltage measured by the 3497A is different than the actual thermocouple voltage (due to junction voltages) unless some compensating techniques are used. The Option 020 assembly has two types of thermocouple compensation techniques: software and hardware.

Software Compensation (Option A20)

As factory configured, the assembly is set for software compensation. Referring to Figure 17, with software compensation a reference junction transducer measures the voltage of an isothermal block. This voltage is a function of the temperature of the block and is input to channel B9 (100 mV/deg C).

Thus, with software compensation, only 19 channels are available for inputs, since the 20th channel (B9) is dedicated to the reference junction transducer circuits. However, you can use a mix of thermocouples on a single assembly.

To arrive at the true thermocouple voltage, a computer program which performs the following steps is necessary:

1. Measure the voltage from the reference junction transducer and convert this voltage to an equivalent ''reference'' temperature (i.e., 2.5V at 25 deg C with 100 mV/deg C).

2. Convert the reference temperature to a thermocouple voltage. Since the thermocouple voltage depends on the type of thermocouple being compensated, this allows different types of thermocouples to be used on an assembly.

3. Measure the voltage produced by the thermocouple and add the voltage computed in step 2 to this voltage for an icepoint reference voltage.

4. Convert the total voltage in step 3 to an equivalent temperature.

Hardware Compensation

Software compensation has the advantage of being able to mix various types of thermocouples on a single assembly. However, the measurement process is rather slow, since the reference voltage on channel 19 should be measured often to avoid isothermal block temperature drift errors.

If you have only one type of thermocouple to measure, the asembly can be configured for hardware compensation and thermocouple voltages can be measured directly. With hardware compensation, the reference junction transducer is removed from the circuit and 20 channels can be used for input (as opposed to 19 for software compensation).

For hardware compensation, the compensation voltage is determined by two resistors installed on the terminal card, whose value is dependent on the type of thermocouple being measured. Thus, with hardware compensation, the voltage displayed on the front panel or at the controller is the true (compensated) thermocouple voltage and can be directly used with a standard look up table to determine equivalent temperature.

Controlling the Multiplexer Assembly

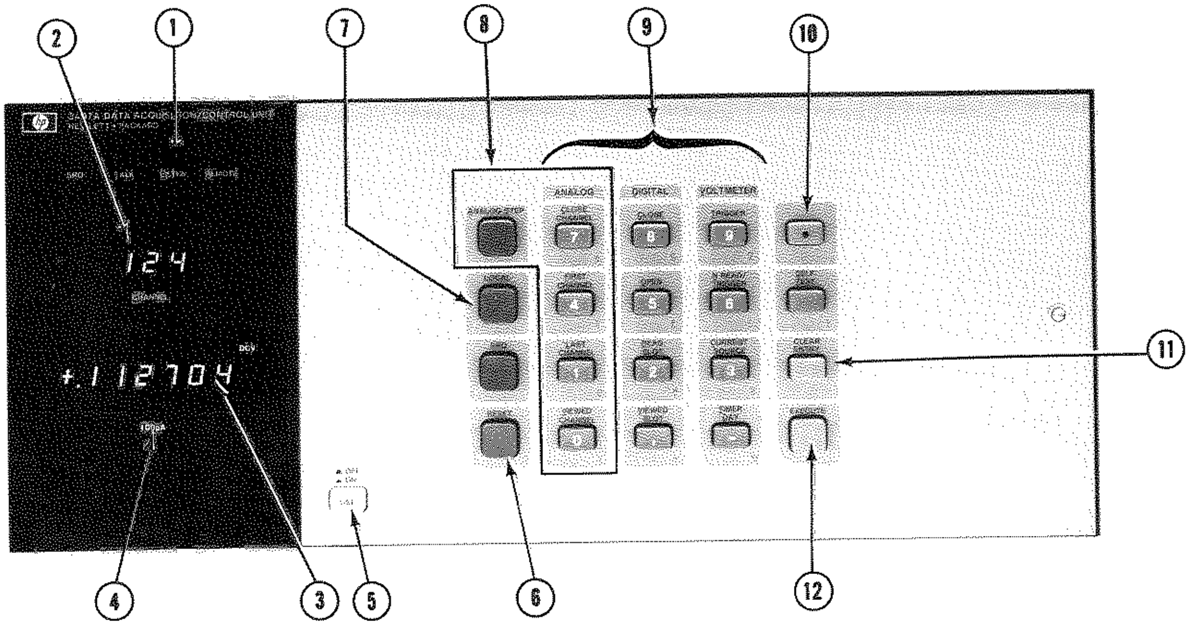
The 20 channel relay multiplexer with thermocouple compensation is controlled with the ANALOG command group. The following chart summarizes the ANALOG commands to control the assembly. For details and sample sequences, see the Command Directory in Chapter 6.

3497A Panel Features Used with the Assembly

Figure 18 identifies front panel keys used with the relay multiplexer and shows their functions. Since the relay multiplexer is an analog assembly, only the analog display is used. When a channel is closed, the 3-digit display shows the number of the channel closed and the 6-digit display shows the value of the DC voltage measured (DCV on the display).

COMMANDS FOR THE RELAY MULTIPLEXER ASSEMBLY

Command	Description
AC chan#,chan#,.. chan# = 0 to 999	CLOSE ANALOG CHANNELS Close up to four channels (1/decade). Channels not addressed are opened. To close channel 3, use "AC3". To close channels 3, 13, 23 and 33, use "AC3,13,23,33".
AEn n = 0 to 2	ENABLE EXTERNAL INCREMENT PORT Enable the EXT INCR port. AE0 disables the EXT INCR port and AE1 enables the port. AE2 (FAST SCAN) enables the port and external BBM sync pulse is ignored.
AF chan# chan# = 0 to 999	SET ANALOG FIRST CHANNEL Sets first channel to be closed in a sequence, but does not close the channel. To set channel 53 as first channel, use "AF53".
AI chan# chan# = 0 to 999	CLOSE A CHANNEL, TRIGGER DVM Closes channel addressed and triggers DVM to take a measurement. To make a reading of channel 23, use "AI23".
AL chan# chan# = 0 to 999	SET ANALOG LAST CHANNEL Sets last channel to be closed in a sequence, but does not close the channel. If AF < AL, sequence is increasing. If AF > AL, sequence is decreasing. To set 53 as last channel to be closed, use "AL53".
AR	ANALOG RESET Opens all channels on all multiplexer assemblies in a 3497A or 3498A. In addition, AR sets VF1, VT1, VR5, VW0, VS0, AE0, AF0 and AL999.
AS	ANALOG STEP Increments or decrements channel closure between AF and AL channels. If AF < AL, sequence is increasing. If AF > AL, sequence is decreasing. If AF and AL are not specified, sequence increments from presently closed channel (i.e., for channel 30 closed, sequence is 30, 31, ...,999, 0, 1 ... for each AS input).
AV chan# chan# = 0 to 999	DEDICATE DISPLAY TO CHANNEL Dedicates the front panel display to channel addressed. Command does not close channel or affect other 3497A operations. Display is updated when measurement is taken.



DISPLAYS

(1) HP-IB STATUS: Indicates HP-IB status when the 3497A is connected to bus. TALK = ON when 3497A is active talker; LISTEN = ON when 3497A is active listener; REMOTE = ON when 3497A controlled externally.

(2) CHANNEL: 3-digit display of channel being measured through the multiplexer assembly.

(3) NUMERIC DISPLAY: 6-digit display of DC volts measured on channel. DCV indicates DC voltage measurement. Display shows value of voltage measured.

(4) CURRENT SOURCE: Displays range of internal 3497A current source (10μA, 100μA or 1mA). ON only when current source is used.

Keys

(5) LINE: AC power ON/OFF switch.

(6) RESET: Clears 3497A, sets assembly as follows:

AO, AI, AS, AV = Disabled
AE0 = EXT INCR Port OFF
AF000 = First Chan = 000
AL999 = Last Chan = 999

(7) LOCAL: Puts 3497A in local (front-panel) mode of operation.

(8) ANALOG KEY GROUP: Used to control relay multiplexer.

(9) ALPHA-NUMERIC KEYBOARD: Each key has three modes:

Primary (upper part)
Numeric (0-9 plus ,-)
Shifted (A,C,D, etc. on lower part).

(10) SHIFT: Shifts keyboard (9) to shifted mode (A,C,D, etc). When pressed, light in center of key is ON.

(11) CLEAR ENTRY: Clears previous entry if EXECUTE key has not been pressed.

EXECUTE: Implements commands and prepares keyboard for new commands.

Figure 18. Option 020 - Front Panel Features Used With Assembly

Relay Assembly Channel Addresses

The slot in which the assembly is placed determines its channel addresses. Since the assembly has decades A and B (with inputs A0 through B9) for an assembly in slot 0 the A decade addresses are 0 through 9 and the B decade addresses are 10 through 19. For an assembly in slot 1, the A decade addresses are 20 through 29 and the B decade addresses are 30 through 39, etc.

RELAY MULTIPLEXER - CHANNEL ADDRESSES

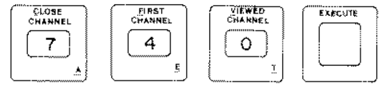
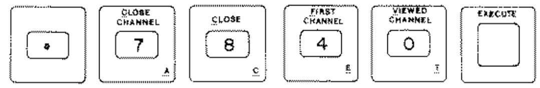
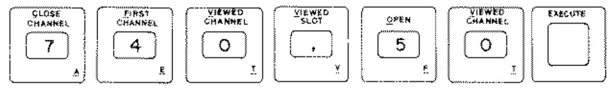
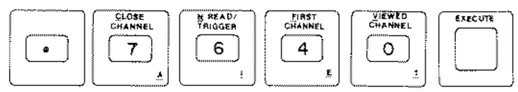
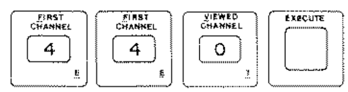
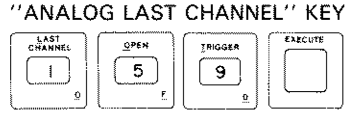
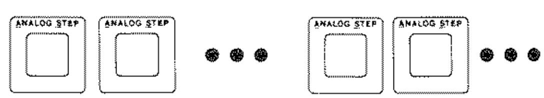
Terminal Card Channel	Address for Assembly in Slot:				
	0	1	2	3	4
A0	0	20	40	60	80
A1	1	21	41	61	81
A2	2	22	42	62	82
.	.	.	.	.	.
.	.	.	.	.	.
A9	9	29	49	69	89
B0	10	30	50	70	90
B1	11	31	51	71	91
.	.	.	.	.	.
.	.	.	.	.	.
B9	19	39	59	79	99

Front Panel Control

To show how the assembly can be controlled from the 3497A front panel, sample keystroke sequences to enter commands are shown in Figure 19. For all commands except multi-channel closure (AC chan#,chan#, ..), jumpers JM1 through JM6 are IN and the T/C COMP jumper is in the NO T/C COMP position. For the AC chan#,chan# command, the T/C COMP jumper is in the NO T/C COMP position and jumpers J4, J5 and J6 are OUT.

The sample command sequences shown list action desired, commands required and keystroke sequences using primary key and shifted key sequences. See Chapter 2 for details on front panel control.

Sample Command Sequences - Fron Panel Entry

Action	Command	Keystroke Sequences
CLOSE SINGLE CHANNEL (40)	"AC40"	"ANALOG CLOSE CHANNEL" KEY  "SHIFT" KEY 
CLOSE TWO CHANNELS* (40,50)	"AC40,50"	"ANALOG CLOSE CHANNEL" KEY  "SHIFT" KEY
CLOSE CHANNEL, TRIGGER DVM	"AI40"	"SHIFT" KEY 
SET FIRST CHANNEL (40)**	"AF40"	"ANALOG FIRST CHANNEL" KEY  "SHIFT" KEY
SET LAST CHANNEL (59)**	"AL59"	"ANALOG LAST CHANNEL" KEY  "SHIFT" KEY
SEQUENCE CHANNELS*** (40-59)	"AS"	"ANALOG STEP" KEY (ASSUMES AF40 AND AL59 PREV SET) 

* The multiplexer card DECADE TO DECADE jumpers must be out for proper 4-wire ohms measurements using this command.

** AF and AL commands do NOT close channels. Another command, such as AC or AI must be used to close channels. AF and AL determine the first and last channels to be closed in a sequence.

*** AS command sequences channel closures between AF and AL. The sequence is increasing if AL >AF and decreasing if AL <AF (i.e. if AF is 40 and AL is 59, AS increments channels from 40 to 41, etc. If AF is 50 and AL is 40, AS decrements channels from 50 to 49, etc.)

Figure 19. Option 020 - Keystroke Sequences

Remote (HP-IB and Serial Data) Control

Some sample program sequences using BASIC language are shown in Figure 20 for HP-IB operation. Jumper settings are the same as for front panel control.

Sample Command Sequences - Remote (HP-IB) Operation

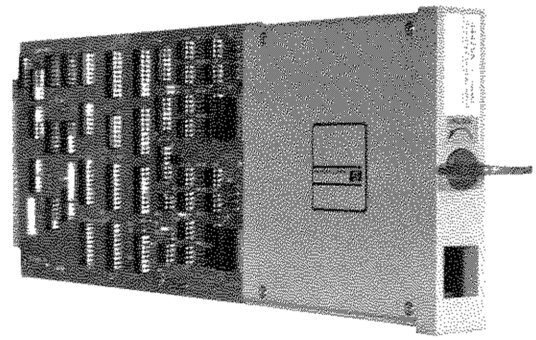
Action(s)	Command(s)	Example Programs
CLOSE CHANNEL 40, INPUT VALUE AT CHANNEL 40.	''AC40''	10 CLEAR 709 20 OUTPUT 709 ; ''AC40'' 30 ENTER 709 ; A 40 PRINT A 50 END
CLOSE CHANNELS 40,50;* INPUT VALUE AT CHANNEL 40, TRIGGER DVM TO TAKE MEASUREMENT.	''AC40,50'' AND ''AI40''	10 CLEAR 709 20 OUTPUT 709 ; ''AC40,50'' 30 OUTPUT 709 ; ''A140'' 40 ENTER 709 ; B 50 PRINT B 60 END
SET FIRST CHANNEL TO 40, SET LAST CHANNEL TO 59 AND SEQUENCE FROM 40 TO 59. DELAY .5 SEC BETWEEN CHANNEL CHANGES.	''AF40'',''AL59'' AND ''AS''	10 CLEAR 709 20 OUTPUT 709 ; ''AF40AL59'' 30 FOR I=40 TO 59 40 OUTPUT 709 ; ''AS'' 50 WAIT 500 60 NEXT I 70 END

* The multiplexer card DECADE TO DECADE jumpers must be out for proper measurements using this command.

Figure 20. Option 020 - Sample Programs

OPTION 050

16 Channel Isolated Digital Input/Interrupt Assembly



Introduction

The Option 050 assembly has two functional modes: Digital Input Mode and Interrupt Mode. In digital input mode, up to 16 digital inputs (ON, OFF; OPEN, CLOSE; etc.) can be input to the assembly. The assembly can also listen to digital data buses.

In the interrupt mode, up to 8 inputs (channels 0 - 7 in the assembly) can be monitored and, when specified system conditions occur, the assembly can send a signal via the 3497A to the controller to "interrupt" its program and take specified action.

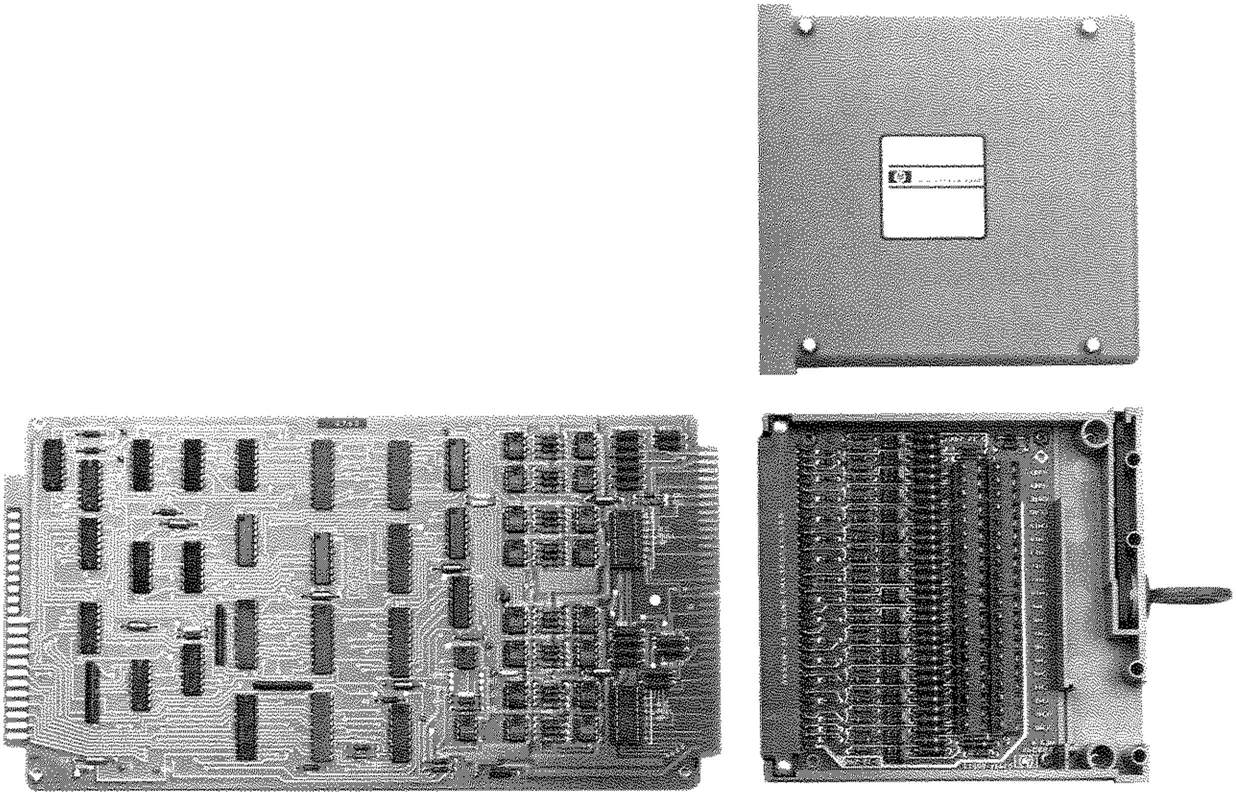
You can use the digital input mode to sense up to 16 lines of digital data such as the outputs of limit switches and position indicators. Use the interrupt mode to interrupt and take corrective action when immediate reaction to a level change is required or when the signal is transient (as in a momentary switch closure).

In addition, you can use the Option 050 assembly with the actuator/digital output assembly (Option 110) to form an independent digital input/output port. Also, the assembly can be configured for 8 channels (0-7) for interrupt and the remaining 8 channels (8-15) for digital input operation.

Description

As shown in Figure 21, the Option 050 assembly consists of a digital input card and a terminal card. The digital input card consists of 16 optically isolated input channels. Eight of the channels (0 through 7) may be used to sense interrupt conditions. In addition, optically isolated handshaking is available for each of the 16 channels to synchronize data transfer between the 3497A and an external peripheral.

The terminal card provides connectors for user inputs on each of the 16 channels and for GATE and FLAG signals used for handshaking. Each channel has a jumper to set logic levels of +5V (factory setting), +12V or +24V and the logic level network has protection against reversed connections.



Digital Input Card

Figure 21. Option 050 - Digital Input/Interrupt Assembly

Interrupt Mode

With interrupt mode, only the first 8 channels (0-7) can be used. Refer to Figure 22 to trace the sequence of operation for interrupt mode. For the sample inputs shown, assume that we want to interrupt the controller when the switch in channel 0 closes, but not interrupt when a switch closes in any other channel.

In the circuit shown, a switch closure causes a high-to-low transition (this can be programmed for low-to-high if desired) which causes the channel bit in the input byte to be set true (''1''). In Figure 22, transitions have occurred on channels 0 and 7, so bits 0 and 7 in the input byte are set to 1.

Since interrupt is desired only for channel 0, we've set the assembly mask (not the same as the SRQ or interrupt mask in the 3497A) with a DE slot#,0 command. Since the mask bit 0 and the input byte bit 0 are both true, channel 0 of the interrupt byte is set. Although bit 7 of the input byte is set, bit 7 of the interrupt byte is NOT set, since the mask bit 7 was not set.

Since the interrupt byte is set, an interrupt is sent to the 3497A mainframe and sets bit 1 in the status register. However, unless the SRQ mask (interrupt mask for Serial Data) is set for digital interrupt with an SE2 (SE102) command, interrupt is not sent to the controller.

Thus, for an input transition to interrupt the controller, a two-level hierarchy of commands is required: (1) set the Option 050 mask with a DE slot#,n command and (2) set the 3497A SRQ or interrupt mask with an SE2 or SE102 command.

You can monitor the status of the interrupt byte at any time (whether or not an interrupt occurs) by sending the DI slot# command. The value returned to the controller is the octal value of the true bits in the interrupt byte.

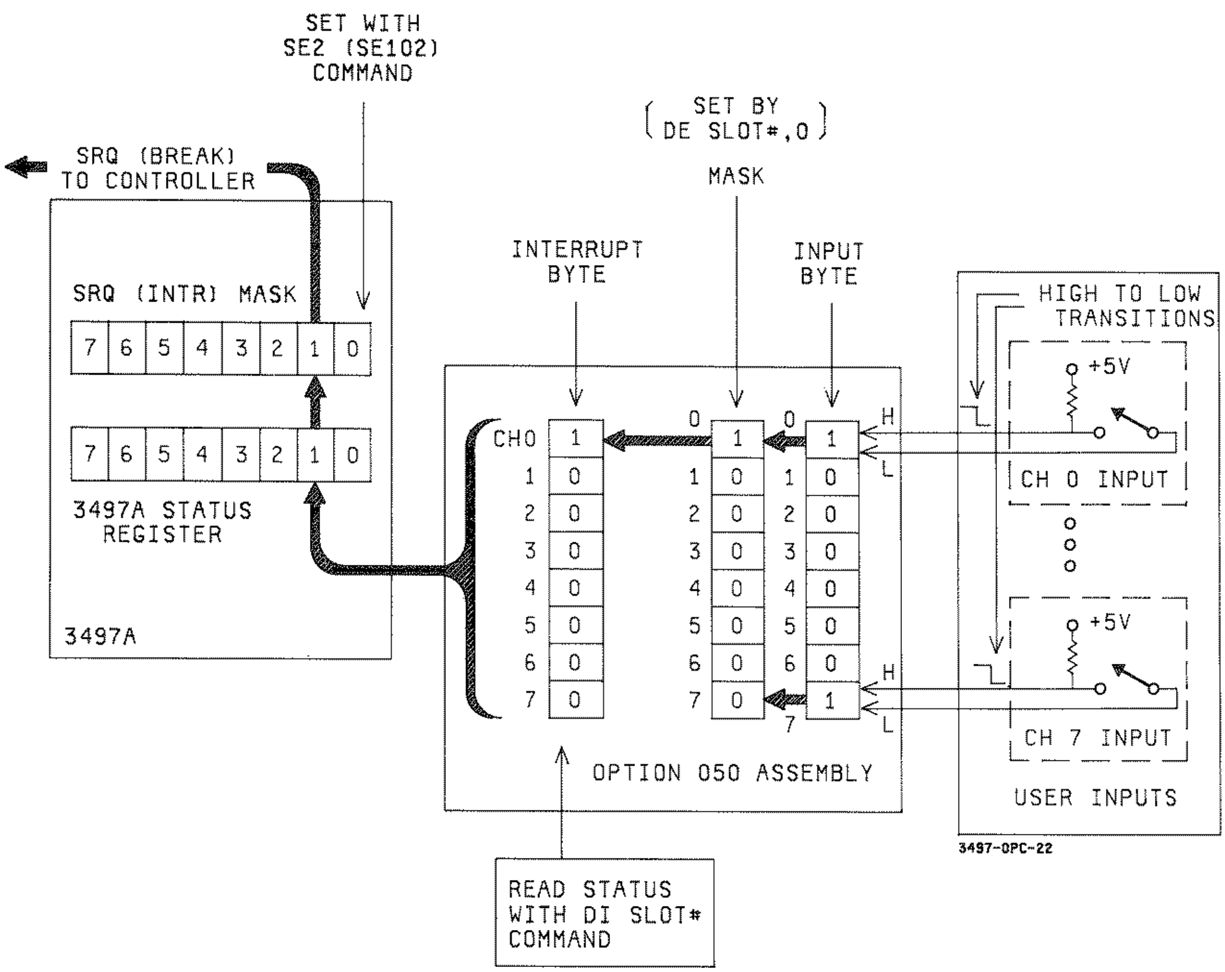


Figure 22. Option 050 - Interrupt Mode

Digital Input Mode

The Option 050 assembly can also be used in the digital input mode to communicate with a 16-bit digital source at a typical maximum read rate of 400 Hz. For digital input mode operation, refer to Figure 23. As shipped from the factory, handshaking on the assembly is disabled. This means that the controller must be programmed to read input data at the appropriate time to insure that data is valid.

By setting a jumper on the digital input card, handshaking can be enabled. Handshaking is used to verify that the 3497A responds to each data transmission, thereby synchronizing the data source with the digital input assembly.

When handshaking is enabled, the sequence is as shown in Figure 23. The 3497A initiates the sequence by signaling a READY condition on the GATE output to the data source. The READY condition occurs when a DR slot# or DL slot# command is sent and tells the source that the 3497A is ready to accept data.

When the data source has data ready (DATA STABLE), the FLAG signal transitions from low to high on the FLAG line. This action, in turn, causes the GATE output to return to the BUSY condition and data transfer occurs.

NOTE

As factory set, the 3497A responds to a low to high FLAG transition as shown. The 3497A can be jumpered to respond to a high to low FLAG transition.

After data has been entered into the 3497A, the condition of the input byte can be read with the DR slot# or DL slot# commands. DR returns a continuous reading while DL returns a single reading/command. Note, however, that the DR and DL commands check the status of the input byte while the DI command checks the status of the interrupt byte.

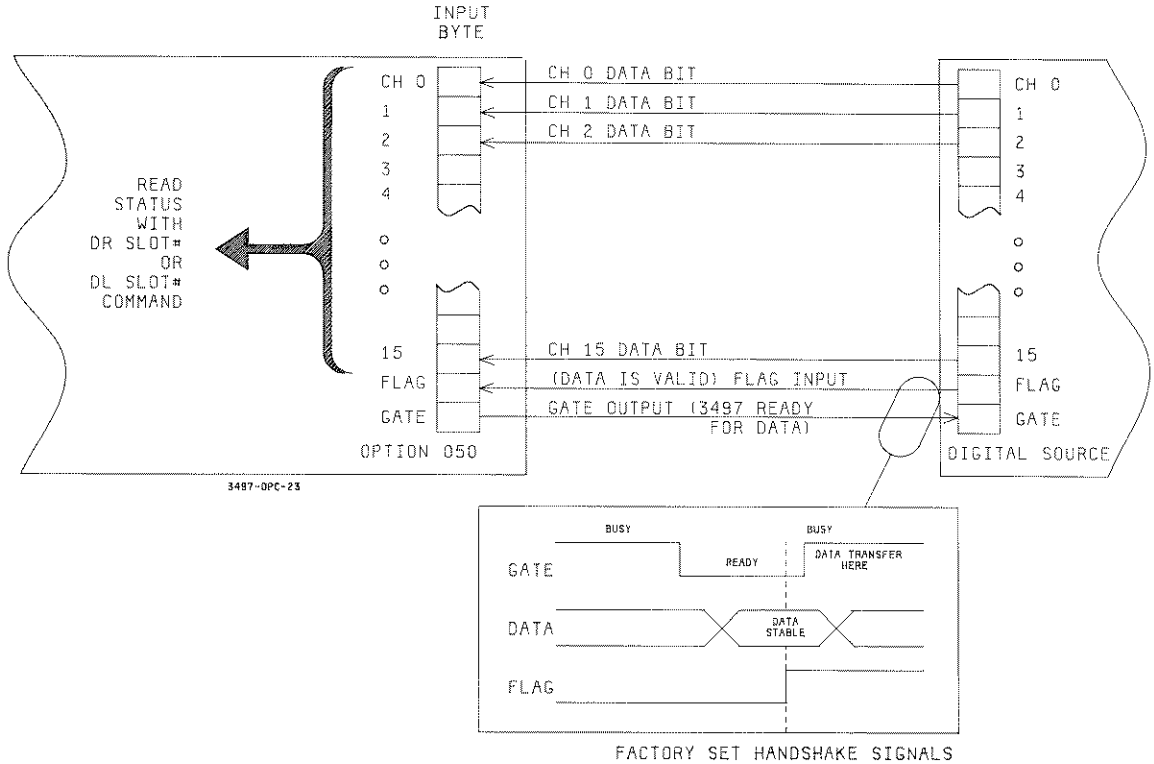


Figure 23. Option 050 · Digital Input Mode

Controlling the Option 050 Assembly

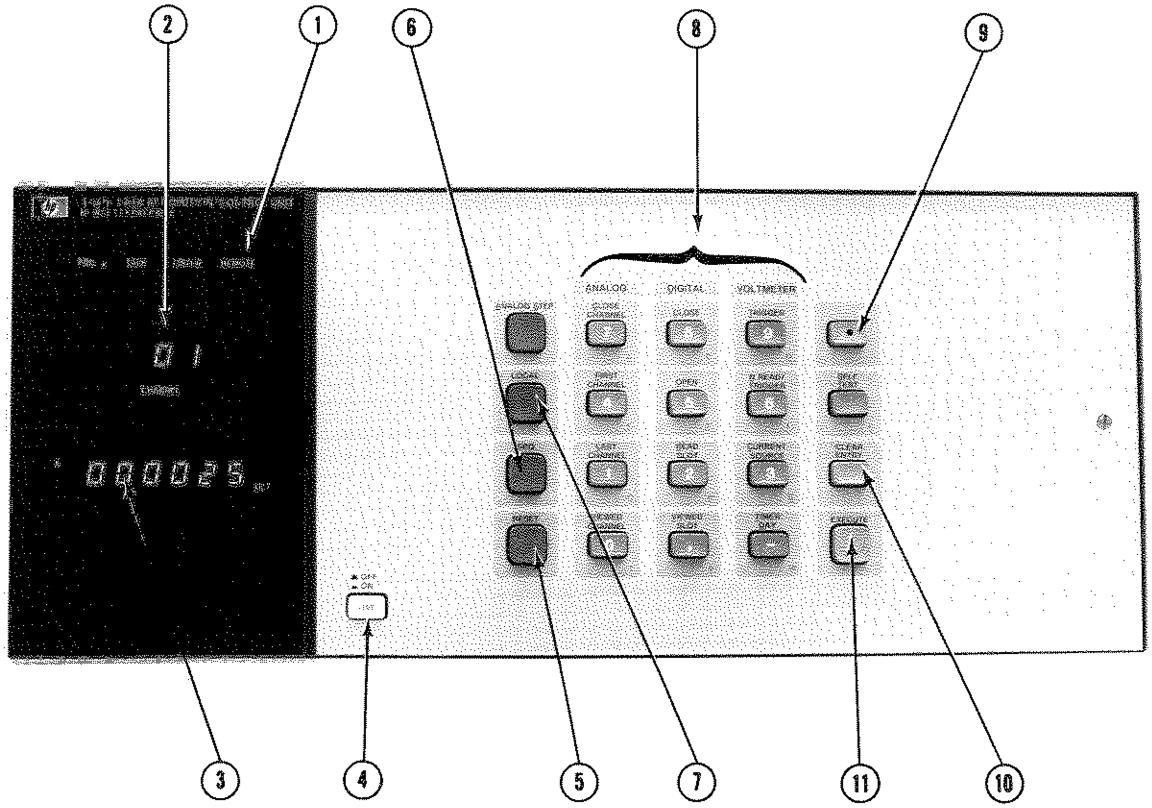
For both interrupt and digital input. the Option 050 assembly is controlled by the DIGITAL command group. The following chart summarizes the DIGITAL commands to which the assembly responds. See the Command Directory in Chapter 6 for details and examples.

COMMANDS FOR THE DIGITAL INPUT/INTERRUPT ASSEMBLY

Command	Description
DE slot#, octal slot# = 0 to 4 octal = 0 to 377	DIGITAL INTERRUPT ENABLE Enables channels selected to cause assembly to send interrupt to the 3497A status register. Channels enabled for interrupt by the octal number (0 to 377). Octal 0 disables all channels.
DI slot# slot# = 0 to 4	DIGITAL INTERRUPT STATUS Checks status of interrupts in the slot addressed. Value returned to controller is octal number (0-377) which indicates the true bits in the interrupt byte.
DS slot#,octal slot# = 0 to 4 octal = 0 to 377	DIGITAL INTERRUPT SENSE Sets the channels selected by the octal value for positive (low to high) transition sense. Channels not included in command are set for negative transition sense. Sending DS slot#,0 sets all channels in the slot for negative transition sense.
DR slot# slot# = 0 to 89	DIGITAL READ Reads the condition of the digital input card on a continuous basis. Data returned to the controller is the octal value of the true bits in channels 0 - 15 for the slot addressed.
DL slot# slot# = 0 to 89	DIGITAL LOAD Returns the same information as the DR slot# command, except that only one reading/command is returned.
DV slot# slot# = 0 to 89	DIGITAL VIEWED SLOT Dedicates the front panel display to the slot specified in the command, but does not affect 3497A operation. Send DV without a slot number to disable the function.

Front Panel Features Used With the Assembly

Figure 24 shows the front panel keys and display used with the Option 050 assembly. Since the Option 050 assembly is a digital assembly, only the digital display is used. Data displayed on the 3-digit display is the slot number addressed and the numbers on the 6-digit display are the octal value of data requested, as shown by the OCT indicator to the right of the display.



Displays

(1) HP-IB STATUS: Indicates HP-IB status when the 3497A is connected to bus. TALK = ON when 3497A is active talker. LISTEN = ON when 3497A is active listener. REMOTE = ON when 3497A controlled externally. SRQ = ON when SRQ action requested by 3497A.

(2) SLOT: Three digit display of slot number. Assembly commands have the form DX slot#,n.

(3) NUMERIC DISPLAY: 6-digit display of octal value of interrupt bits true or channel bits true.

Keys

(4) LINE: AC power on/off switch.

(5) RESET: Clears 3497A. Sets the assembly as follows:

- Interrupts Enable (DE) Disabled
- Interrupt Status (DI) Not Monitored
- Interrupt Sense (DS) Disabled
- Digital Read (DR) Disabled
- Digital Load (DL) Disabled
- Digital View (DV) Disabled

(6) SRQ: Initiates Service Request action to remote (HP-IB) interface.

(7) LOCAL: Places 3497A in local (front-panel) operation.

(8) ALPHA-NUMERIC KEYBOARD: Each key has three modes:

- Primary (upper part)
- Numeric (0-9 plus - and ,)
- Shifted (A, C, D, etc. on lower part). Shifted mode is entered when SHIFT key (9) is pressed.

(9) SHIFT: Shifts keyboard (8) to shifted mode (A, C, D, etc). When pressed, light in center of key is ON.

(10) CLEAR ENTRY: Clears previous entry if EXECUTE Key (11) has not been pressed.

(11) EXECUTE: Implements commands and prepares keyboard for new commands.

Figure 24. Option 050 - Front Panel Features Used With Assembly

Controlling the Assembly for Interrupt Mode

To control the assembly for the interrupt mode, three commands (DE, DI and DS) are used. As factory configured, digital interrupt is NOT available in the 3498A Extender, so interrupt capability is limited to slots 0 through 4. Let's look at an example program to see how the assembly can be programmed for interrupts.

EXAMPLE - SETTING ASSEMBLY FOR INTERRUPTS

For this example, the assembly is in slot 3 and we are using an HP-IB interface. We'll enable channels 2 and 5 for interrupts with a DE command and set the assembly to respond to positive transitions on these channels with a DS command. Then, we'll set the SRQ mask in the 3497A to send SRQ to the controller whenever the assembly sends an interrupt to the 3497A.

Whenever an interrupt condition occurs on channel 2 or 5, the program is shifted to an INTERRUPT subroutine and the octal value of the interrupt channel is entered. If channel 2 received the interrupt, ''CHAN 2 INTERRUPT'' is printed out. If channel 5 received the interrupt, ''CHAN 5 INTERRUPT'' is printed out. If the interrupt was caused by action from another slot, ''NO SLOT 3 INTERRUPT'' is printed out.

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; ''DE3,44DS3,44SE2''
  50 !Main Program
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 STATUS 7,1;A
1020 IF BIT (P,1) GOTO 1040
1030 RETURN
1040 OUTPUT 709; ''DI3''
1050 ENTER 709; A
1060 IF A = 0 PRINT ''NO SLOT 3 INTERRUPT''
1070 IF A = 4 PRINT ''CHAN 2 INTERRUPT''
1080 IF A = 40 PRINT ''CHAN 5 INTERRUPT''
1090 RETURN
```

Lines	Description
20	Instructs the computer to go to line 1000 when an interrupt (SRQ) occurs on interface 7.
30	ENABLE INTR 7;8 actually enables the -hp- 85 to respond to the SRQ. SRQ is octal code ''8'' in the -hp- 85 control register.

40	DE3,44 enables channels 2 & 5 in slot 3 for interrupt. DS3,44 sets channels 2 & 5 in slot 3 to respond to positive transitions. SE2 sets the 3497A SRQ mask for digital interrupt (bit 1 true).
1000	Start of the interrupt subroutine. SPOLL returns the 3497A status byte to variable P.
1010	The STATUS command reads and clears the -hp- 85 Status/Control Register so that it can respond to the next interrupt.
1020	If bit 1 of the status byte is true (digital interrupt has occurred), the program goes to line 1040. IF SRQ resulted from another cause, program returns to point where it was interrupted.
1030-1080	DI3 reads the condition of the interrupt byte in the assembly in slot 3. The octal value of the true bits is returned to variable A by line 1050. Then, depending on the value of A, line 1060, 1070 or 1080 prints the reason for the interrupt.
1090	Returns program control to the point where it was interrupted.

Controlling the Assembly for Digital Input Mode

The DR and DL commands are used to control the assembly for the digital input mode. Recall that the DI slot# command reads the status of the interrupt bits. In contrast, the DR slot# and DL slot# commands read the status of the input bits. Also, in contrast to interrupt mode, digital input is available in the 3498A, so slots 0 to 4 and 10 to 89 are available for this mode.

When a DR slot# or DL slot# command is sent, the octal value returned is a number from 0 (all channels clear) to 177777 (channels 0 through 15 true or "1"). The Digital Read (DR) command causes the 3497A to continuously return data, while the Digital Load (DL) command provides a single read/command.

You can enter the commands either from the front panel or from a controller. The status of the input data bits can be displayed on the front panel or printed out.

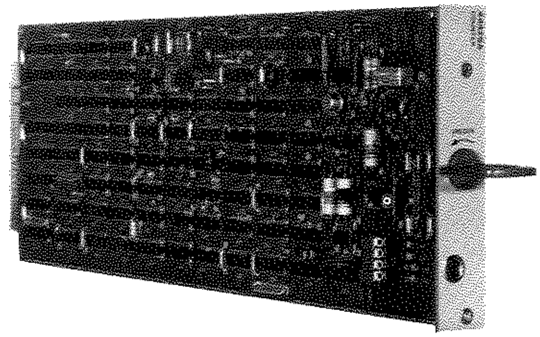
EXAMPLE - READ DIGITAL SLOT

For example, assume that a digital input assembly in slot 2 is connected to a data source. To read the status of the input data, send "DR2". The following program reads the data in slot 2 and prints the results (in octal value of channel bits true).

```
10 CLEAR 709
20 OUTPUT 709; "DR2"
30 ENTER 709;A
40 PRINT A
50 END
```

OPTION 060

100 kHz Reciprocal Counter Assembly



Introduction

Option 060 is a 100 kHz reciprocal counter which can measure the period of input signals up to 100 kHz and the pulse width of signals down to 18 μsec. In addition, the counter can count up or down from a programmable start point and can output a programmable number of square wave pulses for control applications.

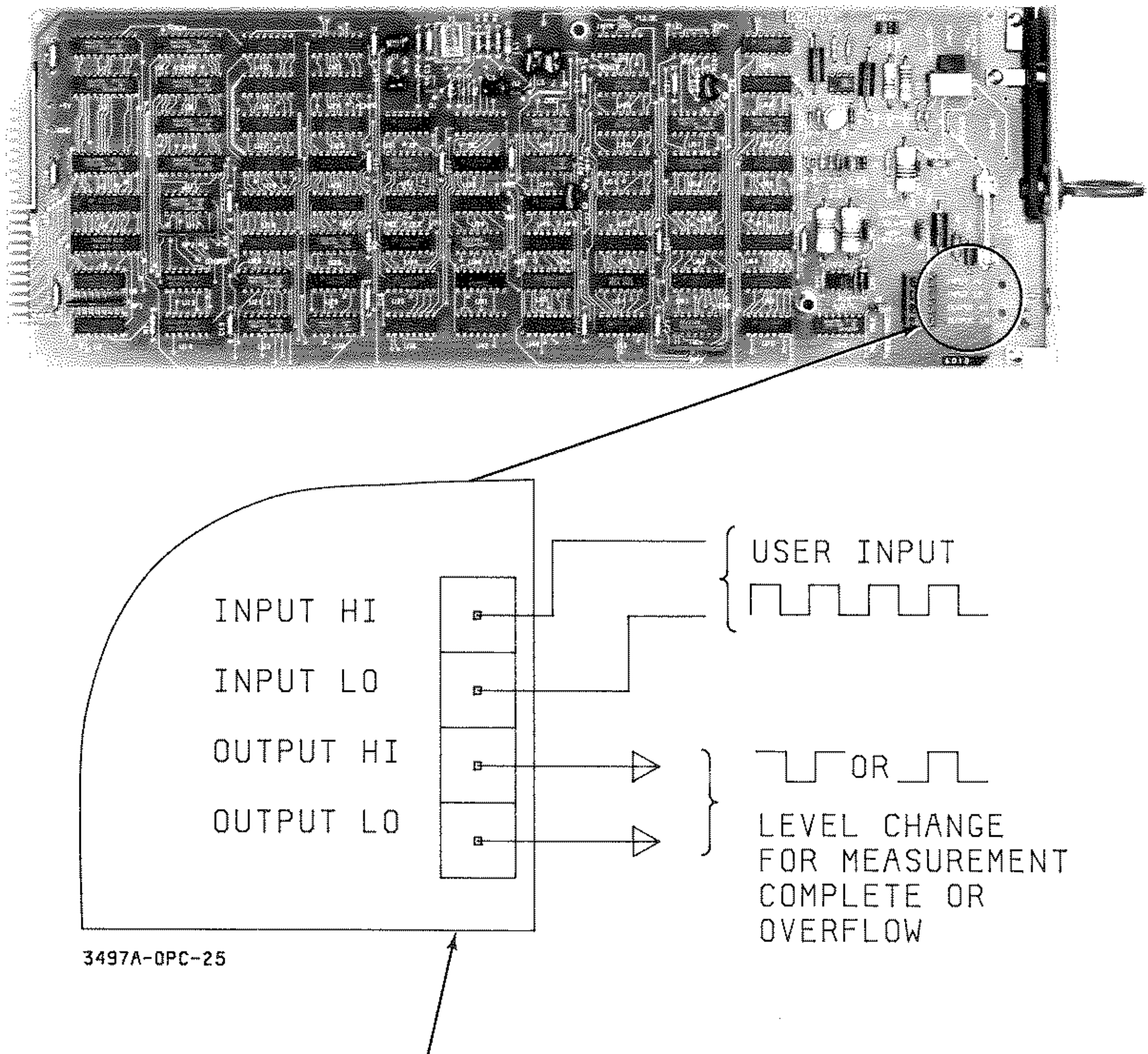
The counter can accept a wide variety of input signals including CMOS, open collector TTL and passive contact closures. The counter is very flexible and can be configured for many measurement configurations. All counter functions, interrupts and trigger modes are fully programmable. The counter can be read during a measurement or can be programmed to respond when a measurement is complete.

As shown in Figure 25, the assembly consists of a counter board with connector terminals for INPUT HIGH, INPUT LOW, OUTPUT HIGH and OUTPUT LOW connections. User signals are input to the INPUT HIGH and INPUT LOW connectors.

The counter can accurately measure a wide variety of input signals, as long as the signal parameters are within specification limits. Although square wave inputs are used for the examples in the manual, you can use other inputs such as triangle or sine wave and still achieve accurate results.

The OUTPUT HIGH and OUTPUT LOW terminals on the counter card provide a means to output a level change (programmable for high to low or low to high) whenever the counter overflows or a measurement is complete. This level change is output whenever these conditions occur and can be used to drive or control external circuits.

For example, when the counter measures more than 999999 counts (an overflow condition), a level change pulse is available at the OUTPUT HIGH terminal which can be used to signal this condition to an external circuit. The terms ''overflow'' and ''measurement complete'' have different interpretations, depending on the mode of operation for the counter.



INPUT/OUTPUT TERMINALS

Use the INPUT HIGH and INPUT LOW terminals to input your system signals for count up (totalize), count down and period or pulse width measurements.

Use the OUTPUT HIGH and OUTPUT LOW terminals for input to an external system. A level change is output at these terminals when a measurement is complete or when the counter overflows.

You can also use the OUTPUT HIGH and OUTPUT LOW terminals to output a programmable number (0 to 499999) of square wave pulses to drive external circuitry.

Figure 25. Option 060 - 100 kHz Reciprocal Counter Assembly

The 100 kHz reciprocal counter has five main operations: count up, count down, period measurement, pulse width measurement and pulse output. Each operation is summarized, with the counter assumed to be set at factory settings. By using the switch and jumpers on the counter card, you can set the counter for a wide variety of configurations for each of these operations. See Figure 26 for a summary of the five modes.

Count Up

In count up, the counter counts up (totalizes) a number of input pulses (up to 999999) from a programmable start point (0 to 999999). At any time after the counter starts counting up, the totalized counts can be displayed on the front panel or sent to the controller.

If the total count in the counter exceeds 999999 counts, an overflow condition occurs and the counter generates a level change output at the OUTPUT HIGH terminal. If interrupt on overflow has been enabled, the counter sends an interrupt to the 3497A status register to set bit 1 (digital interrupt).

EXAMPLE - COUNT UP

Let's set the counter to start counting at 3000 counts and input a 1 kHz square wave pulse. Since the period of a 1 kHz signal is 1 msec, 1000 counts are added to the counter each second. Thus (for example) 5 seconds after the counter is started, 8000 counts have accumulated in the counter (3000 at the start time + 5000 entered 5 seconds after start).

If the total count exceeds 999999 counts, the counter generates a level change at the OUTPUT HIGH terminal. For the 1 kHz input in this example, this would occur after 997 seconds (1000 sec - 3 sec for the 3000 count start point). If interrupt on overflow has been preset, the counter also generates an interrupt signal to the 3497A at this time.

Count Down

In count down, the counter counts down a number of input pulses (999999 counts max) from a programmable start point (0 to 999999). The counter stops at 0 unless the start point is 000000. If the start point is 0, the counter "wraps around" and counts down from 999999 (million counts maximum).

At any time after the counter has started the count down operation, you can display the number of remaining counts on the front panel or send this data to a controller. The counter can be programmed to send an interrupt to the 3497A when zero count is reached. Also, when a zero count is reached, a level change output pulse is available at the OUTPUT HIGH terminal on the counter.

EXAMPLE - COUNT DOWN

We'll assume that the counter is preset to count down from 3000 counts and we'll input a 1 kHz square wave pulse. Since the period of a 1 kHz signal is 1 msec, 1000 counts are subtracted from the counter each second. Thus (for example) 2 seconds after the counter is started, 1000 counts remain in the counter (3000 at the start time - 2000 subtracted 2 seconds after start).

When the count reaches 000000, the counter generates a level change at the OUTPUT HIGH terminal. For the 1 kHz input in this example, this would occur after 3 seconds. If interrupt on overflow has been preset, the counter also generates an interrupt signal to the 3497A on zero counts.

Period Measurement

In period measurement operation, the counter can measure one period or average 100 or 1000 periods of input signals which have frequencies up to 100 kHz. Input signal triggering can be selected to be from rising edge to rising edge or falling edge to falling edge. With appropriate settings of the counter, you can measure the periods of input signals with frequencies from 0.0001 Hz to 100 kHz (periods from 0.00001 sec to 10,000 sec).

You can program the counter to send an interrupt to the 3497A when a measurement is complete and/or when the input signal period cannot be measured (an overflow condition). In addition, a level change is available at the OUTPUT HIGH terminal when either of these two conditions occur and (if enabled) an interrupt is sent to the 3497A status register to set bit 1 (digital interrupt).

EXAMPLE - PERIOD MEASUREMENT

For example, with a 10 kHz input signal, you can set the counter to measure 1 period, average 100 periods or average 1000 periods of the input, with a maximum of 0.2 sec required to measure 1 period and a maximum of 100.1 seconds to average 1000 periods of the input.

If the input signal period can't be measured because the period is too long for the measurement range selected, a counter overflow condition occurs and a level change output and interrupt (when enabled) occurs. For instance, if you tried to measure the period of 1 MHz input, an overflow condition occurs since the input period exceeds the counter limits.

Pulse Width Measurement

In pulse width measurement, the counter can measure one pulse width or average 100 or 1000 pulse widths of an input signal with pulse widths of 18 μsec or wider. You can select input signal triggering from rising edge to falling edge or falling edge to rising edge.

You can program the counter to send an interrupt to the 3497A when a pulse width measurement is complete or when the pulse width cannot be measured by the counter (overflow condition). In addition, a level change pulse is available at the OUTPUT HIGH terminal when either of these two conditions occur, and (if enabled) an interrupt is sent to the 3497A status register to set bit 1 (digital interrupt).

EXAMPLE - PULSE WIDTH MEASUREMENT

For example, with a 10 kHz input signal with 50% duty cycle, you can set the counter to measure 1 pulse width, average 100 pulse widths or average 1000 pulse widths of the input, with a maximum of 0.0003 sec required to measure 1 period and a maximum of 0.3 seconds to average 1000 periods of the input.

If the input signal period can't be measured because the pulse width is too short for the measurement range selected, a counter overflow condition occurs and a level change output and interrupt (when enabled) occurs. For instance, if you tried to measure the pulse width of a 1 MHz square wave input, an overflow condition occurs since the input pulse width exceeds the counter limits.

Pulse Output

The pulse output mode is a variation of the count down operation. In pulse output, the counter outputs a programmable number of square wave pulses (0 to 499999) at a specified frequency (0 to 1kHz). The frequency of output pulses is half the input signal frequency. The input signal must be between 0 and 2 kHz with a pulse width greater than 5 μsec.

EXAMPLE - PULSE OUTPUT MODE

For example, with a 1 kHz input signal, an output pulse train at 500 Hz (½ the input frequency) is generated. The number of pulses output is half the number set by the CS slot#,n command. Thus, to output 100 pulses, use CS slot#,200.

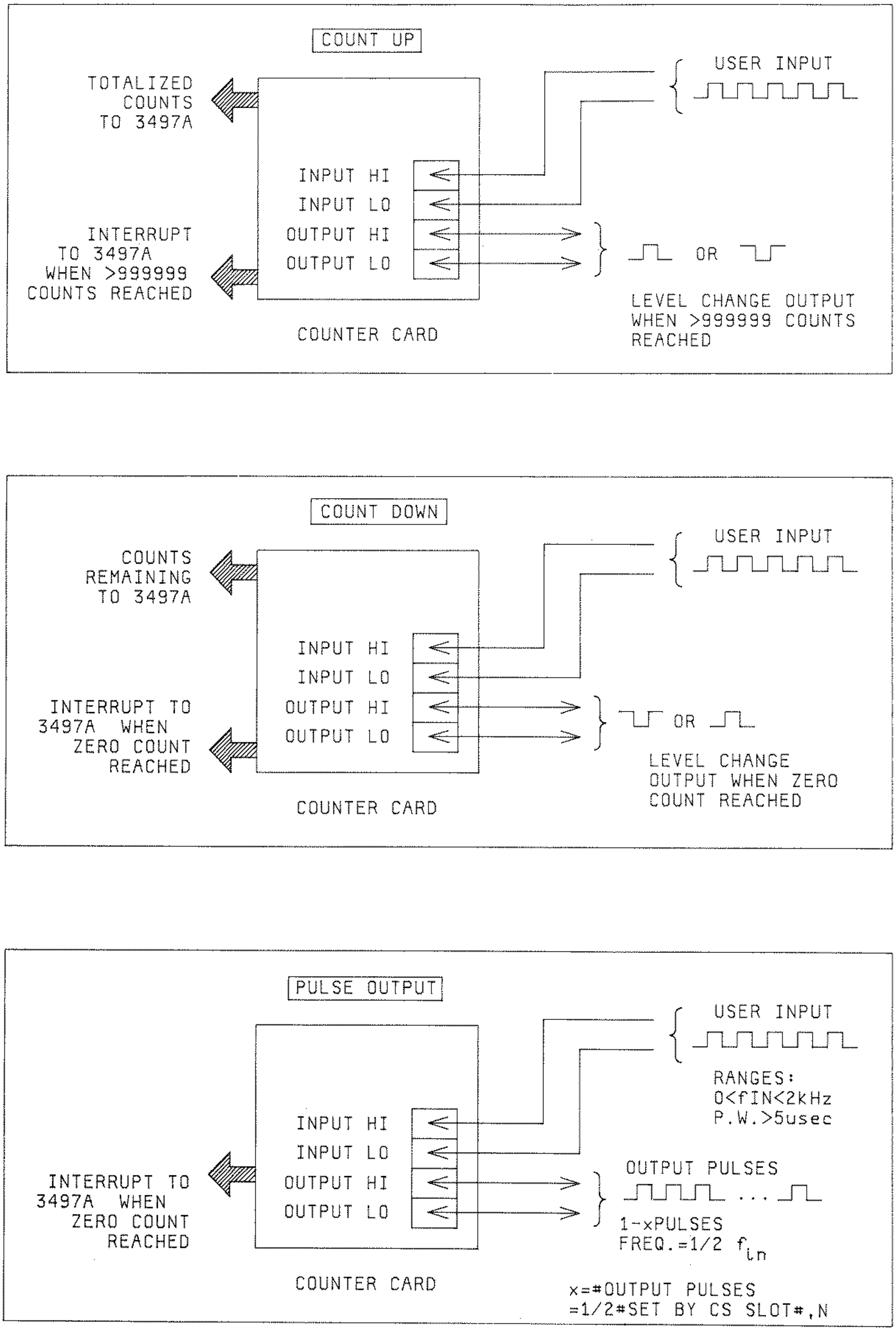
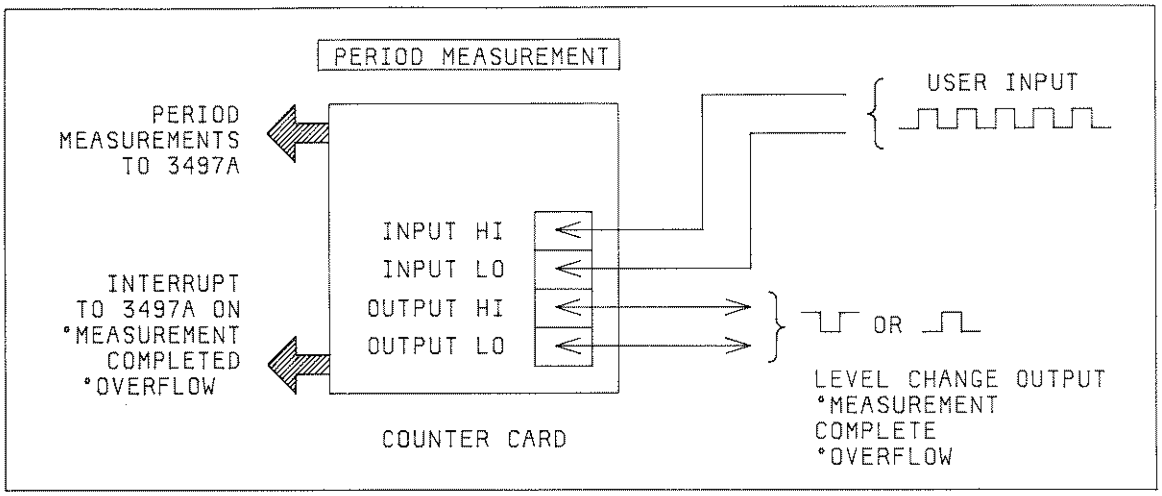
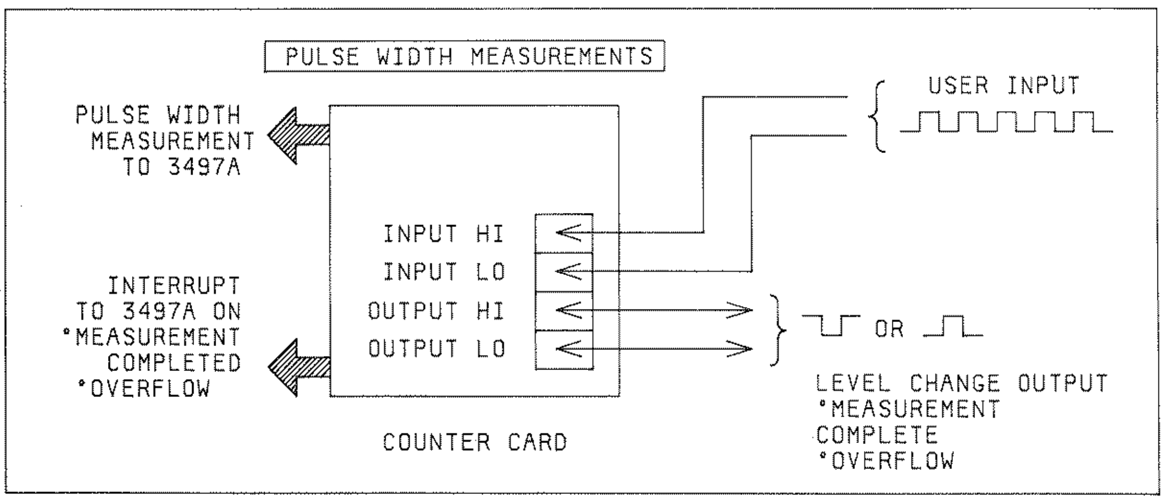


Figure 26. Option 060 - Modes of Operation





3497-OPC-26

Figure 26. Option 060 - Modes of Operation (Cont'd)

Controlling the Counter

This part of the chapter shows how to control the counter using the COUNTER command group. It introduces reciprocal counter techniques, describes counter commands, shows 3497A front panel features used with the counter and lists sample command sequences for local (front panel) and remote (HP-IB and Serial Data) operation.

Counter Measurement Techniques

There are three basic counter techniques: Event, Frequency and Reciprocal. The 100 kHz reciprocal counter uses both event and reciprocal techiques. When used as an event counter, the counter is a totalizer which can be reset on command.

A frequency counter counts the number of transitions in a given time period (gate time) and displays results directly in frequency units. This technique is useful for high frequency applications. However, the reciprocal counter is better suited for low frequency data acquisition and control applications.

The reciprocal counter makes frequency measurements from a single input cycle by counting the number of complete cycles (n) of an internal clock which occur during a specified time period, t. Then, since n and t are known, frequency is computed from f = n/t. For example, as shown in Figure 27, for a gate time t = 1 second, if n = 10 counts are made f = 10/1 = 10 Hz.

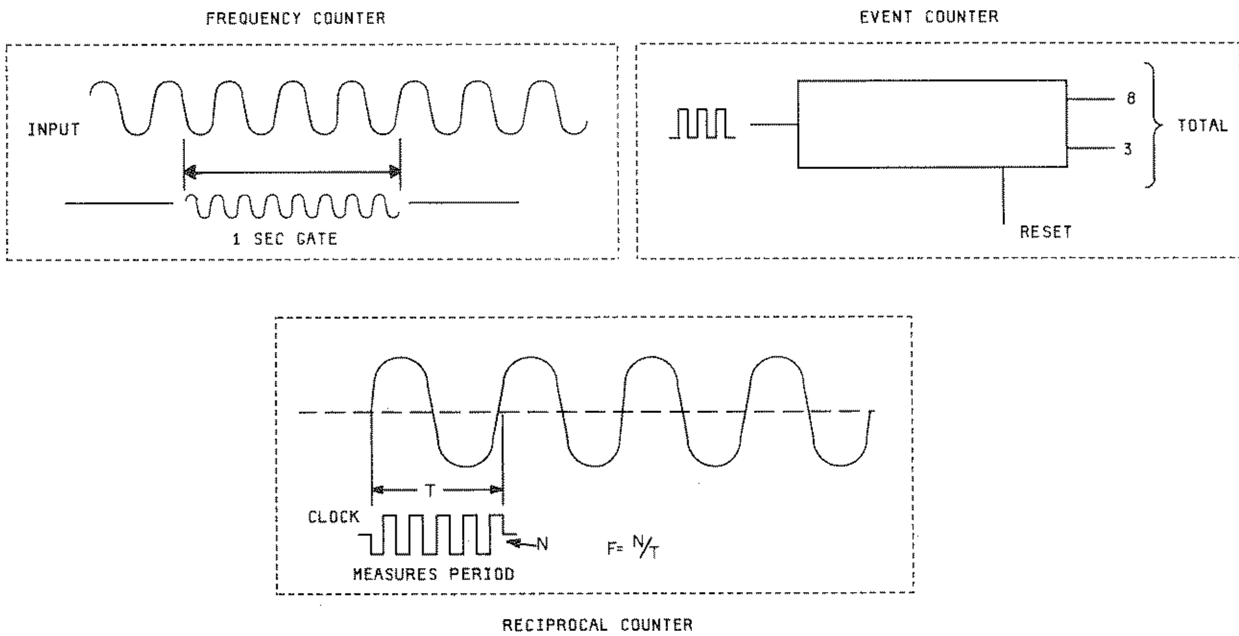


Figure 27. Option 060 - Counter Measurement Techniques

Counter Commands

As shown in the following table, there are five COUNTER commands to control the counter. Each command has the form CX slot#,n where slot# is the slot that the counter is in and n is a number which sets a function within the command. In addition, the DIGITAL command DI slot#,n can be used to determine the type of counter interrupt (overflow or measurement complete).

The CF, CS and CT commands set counter operating conditions. The CR command transfers data from the counter to the 3497A and the CE command enables the counter to generate interrupt signals for counter overflow or measurement complete.

COMMANDS FOR THE COUNTER ASSEMBLY

Command	Description
CF slot#,n slot# = 0 to 89 n = 0 to 6	COUNTER FUNCTION n = 0 Counter Stop. Pauses counter and retains current value. 1 Count Up. Count up from programmable start point to overflow value of 999999 counts. 2 Count Down. Count down to zero from a programmable start point and/or output a programmable number of square wave pulses (0 to 499999). 3 Average 1000 Periods/Pulse Widths. Period range = 10 Hz to 100 kHz P. W. range = 10 μsec to 0.1 sec 4 Average 100 Periods/Pulse Widths. Period range = 1 Hz to 100 kHz P. W. range = 10 μsec to 1.0 sec 5 Measure 1 Period/Pulse Width. Period range = .01 Hz to 100 kHz P. W. range = 10 μsec to 100 sec 6 Measure 1 Period/Pulse Width. Period range = .0001 Hz to 1 kHz P. W. range = .001 sec to 10^4 sec
CS slot#,n slot# = 0 to 89 n = 0 to 999999	PRESET COUNTER Sets counter to preset number for count up, count down or pulse output operations.
CT slot#,n slot# = 0 to 89 n = 0 to 4	SELECT TRIGGER EDGE n = 1 Period Measurement, Trigger Rising Edge to Rising Edge 2 Period Measurement, Trigger Falling Edge to Falling Edge 3 Pulse Width Measurement, Trigger Rising Edge to Falling Edge 4 Pulse Width Measurement, Trigger Falling Edge to Rising Edge
CR slot#,n slot# = 0 to 89 n = 1 to 3	COUNTER READ n = 1 Read Without Wait, one value only 2 Read With Wait, one value only 3 Counter Internal Trigger
CE slot#,n slot# = 0 to 4 n = 0 to 2	ENABLE INTERRUPTS n = 0 No Interrupts Enabled 1 Interrupt on Measurement Complete 2 Interrupt on Overflow
DI slot# slot# = 0 to 4	DIGITAL INTERRUPT STATUS If the counter is enabled for interrupts (with CE slot#,1 or CE slot#,2) AND the SRQ mask (interrupt mask for Serial Data) is enabled for digital interrupt (with SE2 or SE102), sending the DI slot# command returns 0, 1 or 3. 0 = counter did not interrupt. 1 = counter interrupted due to measurement complete. 3 = counter interrupted due to overflow.

Counter Function (CF slot#,n) Command

The counter function (CF slot#,n) command sets the counter for the operation desired (count up, count down, etc.). Depending on the value of n, the counter initiates one of seven actions: counter stop, count up, count down, average or measure periods or average or measure pulse widths.

> **NOTE**
>
> *The counter function commands initiate the counter actions but do not read the results. This is done by the counter read (CR) command.*

Counter Stop (CF slot#,0)

Counter stop temporarily halts a count up or count down operation and retains the count value in the counter. The CF command is set to counter stop when the 3497A is turned on or when a system initialize (SI) command is sent.

Count Up (CF slot#,1)

In count up mode, the counter counts up within the range of 000000 to 999999 beginning with the existing value in the counter. The counter is set to 000000 at 3497A turn on or with an SI command. The initial value can be set to any number within the range with the preset counter (CS) command.

Count up stops at 999999 counts. After 999999 counts, ''OL'' is displayed on the front panel and +9E9 is available over the remote (HP-IB or Serial Data) interface.

Count Down (CF slot#,2)

The counter counts down from a preset value within the range of 000000 to 999999. Unless the counter is preset to 000000, Count Down stops at 0. If the counter is preset to 000000, the countdown sequence is 000000, 999999, 999998, ...,000000 (i.e. a million counts max).

As with count up, the start point is set with the CS command. After 000000 counts are reached, 000000 TOT is displayed on the front panel and 0000000 is available over the remote interface. In addition, if the counter is enabled for interrupt on measurement complete (with a CE slot#,1 command), an interrupt is sent to the 3497A when zero count is reached.

Period/Pulse Width (CF slot#,3 through CF slot#,6)

For counter function commands CF slot#,3 through CF slot#,6 the counter measures either the period or pulse width of an input signal, depending on the CT command. CT slot#,1 and CT slot#,2 set the counter for period measurements. CT slot#,3 and CT slot#,4 set the counter for pulse width measurements.

For counter function commands CF slot#,3 through CF slot#,6 the counter can measure a range of input signal frequencies. To select the CF command required for your application, refer to the Period Ranges Chart (Figure 28) or the Pulse Width Chart (Figure 29).

Each chart shows the range of input frequencies and associated periods or pulse widths which can be measured using the CF command and shows the maximum measurement time, number of counts (max), 3497A display and data available over the remote interface. The Pulse Width Chart is valid only for continuous 50% duty cycle inputs.

EXAMPLE - USING THE PERIOD RANGES CHART

For example, to measure the period of a 100 Hz input signal (.01 sec period), note from the Period Ranges Chart that any of four CF commands can be selected. If CF slot#,6 is used, one period is measured and maximum measurement time is .02 seconds. Ten counts are made, the 3497A front panel display is 0000.01 SEC and 0.000010E+3 is available over the remote interface.

On the other hand, for CF slot#,3 1000 periods of the same input are averaged and measurement time increases to 10.01 seconds. A million counts are made, the 3497A display is .010000 SEC and 1.000000E-2 is available over the remote interface.

These charts are useful to decide the speed versus resolution tradeoff which is best for your application. In this example, when CF slot#,6 is used, data is available with 1 msec resolution and requires 0.02 seconds for measurements. With CF slot#,3 resolution increases to 1 μsec, but requires over 10 seconds to measure the period.

User Input →

Freq (Hz)	10^{-4}	10^{-3}	10^{-2}	.1	1	10	100	1k	10k	100k
Period (sec)	10^4 sec	10^3 sec	10^2 sec	10 sec	1 sec	10^{-1} sec	10^{-2} sec	10^{-3} sec	10^{-4} sec	10^{-5} sec
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)					1000 periods averaged (CF slot#,3)	9.999999E−2 .099999 10^7-1 100.1	1.000000E−2 .010000 10^6 10.01	0.100000E−2 .001000 10^5 1.001	0.010000E−2 .000100 10^4 .1001	0.001000E−2 .000010 10^3 .01001
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)			100 periods averaged (CF slot#,4)		9.999999E−1 .999999 10^7-1 101	1.000000E−1 .100000 10^6 10.1	0.100000E−1 .01000 10^5 1.01	0.010000E−1 .001000 10^4 .101	0.001000E−1 .000100 10^3 .0101	0.000100E−1 .000010 10^2 .00101
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)	1 period averaged (CF slot#,5)		9.999999E+1 99.9999 10^7-1 200	1.000000E+1 10.0000 10^6 20	0.100000E+1 01.0000 10^5 2	0.010000E+1 00.1000 10^4 .2	0.001000E+1 00.0100 10^3 .02	0.000100E+1 00.0010 10^2 .002	0.000010E+1 00.0001 10 .0002	0.000001E+1 00.0000 1 .00002
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)	9.999999E+3 9999.99 10^7-1 20,000	1.000000E+3 1000.00 10^6 2,000	0.100000E+3 0100.00 10^5 200	0.010000E+3 0010.00 10^4 20	0.001000E+3 0001.00 10^3 2	0.000100E+3 0000.10 10^2 .2	0.000010E+3 0000.01 10 .02	0.000001E+3 0000.00 1 .002	1 period averaged (CF slot#,6)	

NOTE: CF slot#,3 thru CF slot#,5 use a 10^5 Hz internal clock; CF slot#,6 uses a 10^3 Hz internal clock.

Figure 28 · Option 060 · Period Ranges Chart

User Input →

Freq (Hz)	10^{-4}	10^{-3}	10^{-2}	.1	1	10	100	1k	10k	100k
Pulse Width (sec)*	10^4 sec	10^3 sec	10^2 sec	10 sec	1 sec	10^{-1} sec	10^{-2} sec	10^{-3} sec	10^{-4} sec	10^{-5} sec
Remote Data (sec) 3497A Disp (sec) Number of Counts (max Maximum Measurement Time (sec)*					1000 pulse widths averaged (CF slot#,3)	0.999999E+0 .999999 10^7-1 300	0.010000E+0 .010000 10^6 30	0.001000E+0 .001000 10^5 3	0.000100E+0 .000100 10^4 .3	0.000010E+0 .000010 10^3 .03
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)*			100 pulse widths averaged (CF slot#,4)		9.999999E+1 99.9999 10^7-1 300	0.100000E+0 .100000 10^6 30	0.010000E+0 .01000 10^5 3	0.001000E+0 .001000 10^4 .3	0.000100E+0 .000100 10^3 .03	0.000010E+0 .000010 10^2 .003
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)*	1 pulse width averaged (CF slot#,5)		0.099999E+0 .099999 10^7-1 300	1.000000E+1 10.0000 10^6 30	0.100000E+1 01.0000 10^5 3	0.010000E+1 00.1000 10^4 .3	0.001000E+1 00.0100 10^3 .03	0.000100E+1 00.0010 10^2 .003	0.000010E+1 00.0001 10 .0003	0.000001E+1 00.0000 1 .00003
Remote Data (sec) 3497A Disp (sec) Number of Counts (max) Maximum Measurement Time (sec)*	9.999999E+3 9999.99 10^7-1 30,000	1.000000E+3 1000.00 10^6 3,000	0.100000E+3 0100.00 10^5 300	0.010000E+3 0010.00 10^4 30	0.001000E+3 0001.00 10^3 3	0.000100E+3 0000.10 10^2 .3	0.000010E+3 0000.01 10 .03	0.000001E+3 0000.00 1 .003	1 pulse width averaged (CF slot#,6)	

*For continuous 50% duty cycle input.

NOTE: CF slot#,3 thru CF slot#,5 use a 10^5 Hz internal clock; CF slot#,6 uses a 10^3 Hz internal clock.

Figure 29 · Option 060 · Pulse Width Chart

Preset Counter (CS slot#,n) Command

The CS command is used with count up, count down and pulse output applications. For count up or count down, the counter starts at the value of n (000000 to 999999). Power on or an SI command sets the counter to 000000. When a CS command is sent, the counter is stopped and set to 000000.

The CS command can also be used to output a programmable number of square wave pulses from the OUTPUT HIGH port on the counter. The pulse output mode is a variation of the count down mode. In pulse output mode, the counter counts down to zero from the value set by the CS command and outputs a number of square wave pulses (0 to 499999) equal to half the preset value.

EXAMPLE - OUTPUT 100 PULSES

For 100 output pulses, the the counter is preset to 200 counts with the CS slot#,200 command (for pulse output mode, n must be an EVEN number from 0 to 999998). To set the counter to count down mode, use CF slot#,2. The counter will then count down from 200 to zero and output 100 pulses from the OUTPUT HI port if the counter is hardware configured for the pulse output mode.

Select Trigger Edges (CT slot#,n) Command

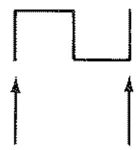
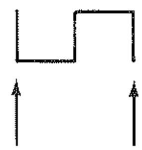
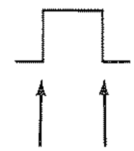
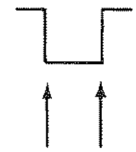
The CT command sets the edges of the input signal on which triggering takes place and is used with the counter function (CF) command. The CT command MUST be set before the CF command, as changing the CT command during a counting operation will change trigger edges and stop the counter. When the counter function command is set to count up (CF slot#,1) or count down (CF slot#,2), CT slot#,1 or CT slot#,3 sets the counter to trigger on the rising edge of the input and CT slot#,2 or CT slot#,4 sets the counter to trigger on the falling edge of the input.

When the counter function command is set for period or pulse width measurement (CF slot#,3 through CF slot#,6), CT slot#,1 or CT slot#,2 sets the counter for period measurements, while the CT slot#,3 or CT slot#,4 sets the counter for pulse width measurements.

For example, with CF slot#,4 and CT slot#,3, the counter is set to average 100 pulse widths with maximum measurement time of 1.0 seconds. Triggering for the counter is from rising (leading) edge to falling (trailing) edge of the input signal. The following chart shows counter operation for combinations of CT and CF commands.

PERIOD/PULSE WIDTH MEASUREMENTS FOR VARIOUS CT COMMANDS

CT slot#,n

CF Slot#,n		1	2	3	4
Trigger Edges Max Meas. Time (Sec)		Rising/Rising 	Falling/Falling 	Rising/Falling 	Falling/Rising 
n= 3	0.1	Average 1000 Periods	Average 1000 Periods	Average 1000 Pulse Widths	Average 1000 Pulse Widths
4	1.0	Average 100 Periods	Average100 Periods	Average 100 Pulse Width	Average 100 Pulse Widths
5	100	Measure 1 Period	Measure 1 Period	Measure 1 Pulse Width	Measure 1 Pulse Width
6	10000	Measure 1 Period	Measure 1 Period	Measure 1 Pulse Width	Measure 1 Pulse Width

Counter Read (CR slot#,n) Command

Counter read commands send count or measurement data to the 3497A front panel and/or over the remote interface. There are three types of counter read (CR) commands: read without wait (n = 1); read with wait (n = 2) or counter internal trigger (n = 3).

Data available after a counter read command is executed as shown. Note that the front panel display is limited to six digits, while seven digits are available over the interface. For sample readouts in period/pulse width measurement, see the Period Ranges Chart (Figure 28) or the Pulse Width Chart (Figure 29).

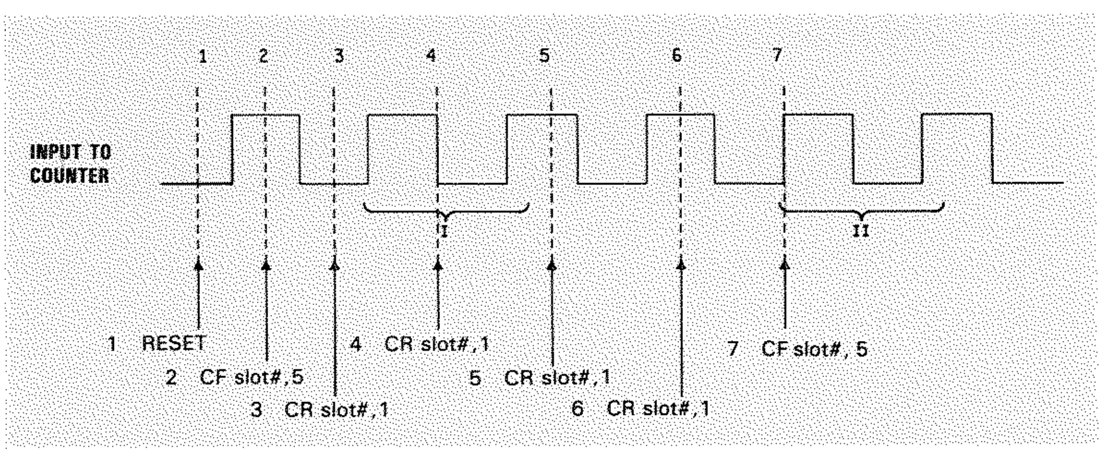
DATA AVAILABLE AFTER A COUNTER READ COMMAND

3497A DISPLAY	INTERFACE	MEANING
DDDDDD TOT	DDDDDDD	Counter in count up/down mode. Read at any time, counting process not interrupted.
------ SEC	−9.000000E9	Input signal trigger starting edge not yet received.
−DDDDDD SEC	−D.DDDDDDED	Minus sign shows partially completed measurement (measurement in progress).
+DDDDDD SEC	+D.DDDDDDED	Plus sign shows measurement complete.
OL	+9E9	Counter Overflow. Overflow for period or pulse width measurement means max measurement time exceeded. Overflow for count up function means that 999999 counts exceeded.

Read Without Wait (CR slot#,1)

With the CR slot#,1 command, the counter is read without disturbing data flow into the counter. If a measurement is in progress, but not yet completed, interim results shown in the previous table can be displayed on the 3497A and passed to the remote interface. An example using the read without wait command to measure one value is shown.

EXAMPLE - READ WITHOUT WAIT - ONE VALUE



1. Counter is reset, which sets CF slot#,0 and CT slot#,1.

2. CF slot#,5 sets counter to measure one period of input. Since CT slot#,1 in effect, triggering is from rising edge to rising edge.

3. Counter hasn't received starting edge yet. ------ SEC is displayed on 3497A and -9E9 available over the remote interface.

4. Counter has started measurement, but has not finished. Partial measurement result of -DDDDDD SEC displayed on 3497A and -DDDDDDD E ± D available over the remote interface. The minus (-) sign indicates measurement not complete.

5. Counter has finished taking measurement (I). +DDDDDD SEC displayed on 3497A and +DDDDDDD E + D available over the remote interface. Plus (+) sign shows completed measurement.

6. The same results as in 5. This is a re-reading of the previous answer.

7. Counter initiates another period measurement (II).

Read With Wait (CR slot#,2)

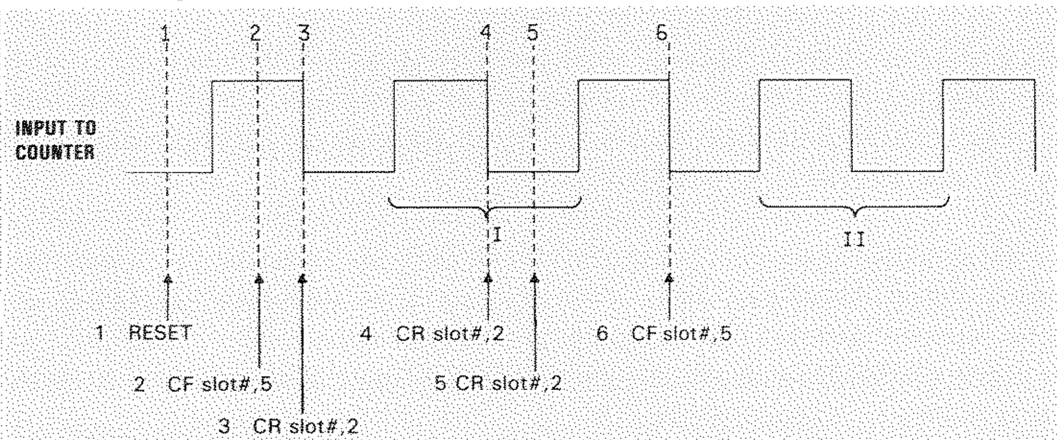
With the read with wait command, results are returned only after the measurement is completed. For period or pulse width measurements, all data is accumulated and averaged (if required) and the 3497A waits for the completed measurement before outputting data to the interface.

For period or pulse width measurements, the interim results shown for the read without wait command can't be displayed or sent over the interface when read with wait is used. In count up or count down, however, since the measurement is always ''complete'', the counter can be read at any time without disturbing the counting process. An example of read with wait for one value follows.

NOTE

A read with wait (CR slot#,2) command will hold up communication between the 3497A and the controller until the measurement is completed. Since this may cause problems, don't use this command if it will adversely affect your application.

EXAMPLE - READ WITH WAIT - ONE VALUE



1. The counter is reset to CF slot#,0 and CT slot#,1.

2. CF slot#,5 command sets the counter to measure one period of the input. Since CT slot#,1 in effect, triggering is from leading edge to leading edge.

3. Measurement is not complete (not even started), so 3497A display is ------ SEC. No partial answer available over the interface.

4. Measurement (I) complete. 3497A display is +DDDDDD, indicating complete measurement and +DDDDDDDE + D available over the interface.

5. Same result as in 4.

6. Counter initiates another period measurement (II).

Counter Internal Trigger (CR slot#,3)

In contrast to the read without wait and read with wait commands, counter internal trigger has different meanings for HP-IB and Serial Data operation.

For HP-IB operation, with CR slot#,3 the 3497A is dedicated to continuous update readings and is not free to perform any other action. For count up/down functions, the counter repeatedly obtains readings and updates them. For period/pulse width measurements, complete measurement cycles (initiate-wait-answer) are repeatedly performed.

For Serial Data operation, the effect of the CR slot#,3 command depends on the System Single/Continuous Output (SOn) command. With SO0 (continuous output), the CR slot#,3 command is the same as for HP-IB operation. With SO1 (single output/command), one internal trigger is initiated and the operation is the same as CR slot#,2, (i.e., the counter does a read with wait operation for one measurement only).

For either type of interface, if another command is sent while CR slot#,3 is in effect, the current measurement must be completed before the new command will be acted on.

Enable Interrupts (CE slot#,n) Command

The CE slot# command, together with the SEn command, enables the counter to send interrupt information to the 3497A and to a controller. The CE command has three functions: No Interrupts Enabled (n = 0); Interrupt on Measurement Complete (n = 1); and Interrupt on Overflow (n = 2).

Depending on the counter function (CF) command used, the terms ''measurement complete'' and ''overflow'' have different meanings. However, regardless of the counter function command used (except when pulse output mode is selected), a logic level change is available at the counter OUTPUT HI port when overflow or measurement complete conditions occur.

COUNTER INTERRUPT MEANINGS

	Count Up (CF slot#,1)	Count Down (CF slot#,2)	Period/Pulse Width (CF slot#,3 thru 6)
Overflow	>999999 counts	------	Maximum measurement time exceeded for range selected.
Measurement Complete	------	000000 count reached	Completed measurement available.

To enable interrupts to a controller, three actions are necessary:

1. Set the 3497A SRQ mask (HP-IB) for digital interrupt with an SE2 command or set the interrupt mask (Serial Data) for digital interrupt with an SE102 command.

2. Use CE slot#,n to set the counter to for a desire interrupt condition. For interrupt on measurement complete, use CE slot#,1. For interrupt on overflow, use CE slot#,2.

3. Enable the controller interface devices to recognize and react to an interrupt input signal. See Front Panel Operation and/or Remote Programming for sample command sequences using interrupts.

You can use the DI slot# command to determine the cause of an interrupt from the counter. Assuming that the counter and the 3497A are set for interrupt, when the DI slot# command is sent, the 3497A returns a 0, 1 or 3. A 0 is returned if the counter in the slot addressed did not cause the interrupt. A 1 is returned if the counter interrupted due to measurement complete and a 3 is returned if the counter interrupted due to overflow. See the previous chart for definitions of ''measurement complete'' and ''overflow''.

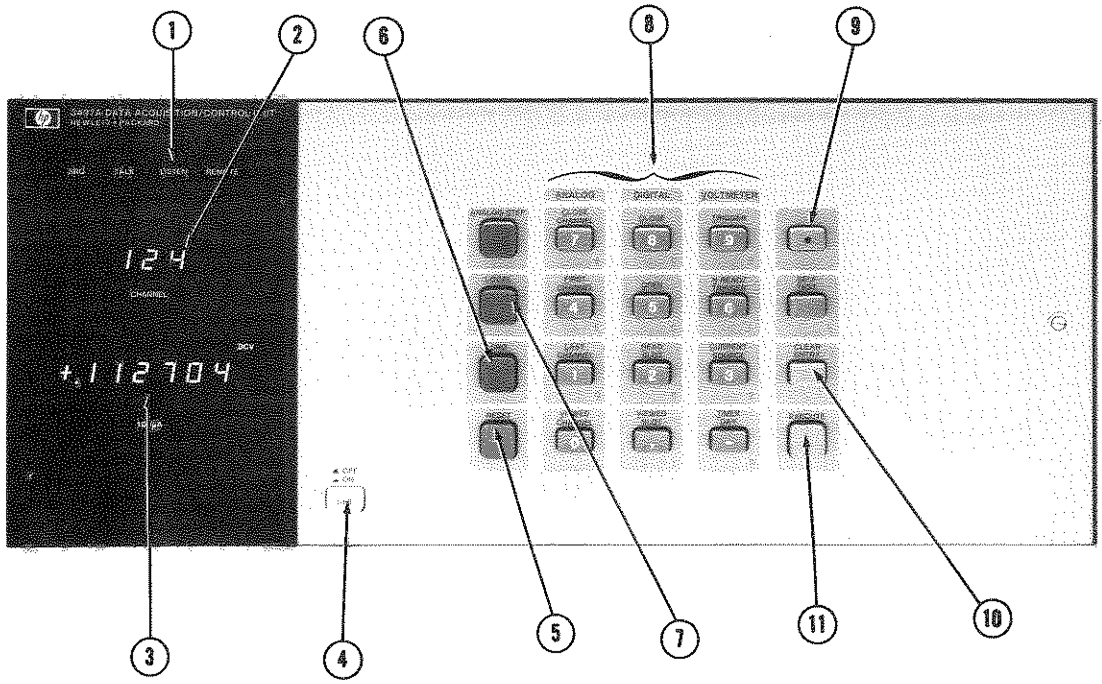
EXAMPLE - SETTING COUNTER FOR INTERRUPT ON COUNT UP OVERFLOW

We'll set a counter in slot 3 to the count up mode and set the counter to interrupt when 999999 counts are exceeded. From the definitions in the previous chart, when 999999 counts are exceeded, an overflow condition occurs. To set the counter for this configuration, use the following commands:

CF 3,1 = Set the counter for count up operation.
CE 3,2 = Enable the counter for interrupt on overflow.
SE 2 = Enable the 3497A for digital interrupt (HP-IB).
OR
SE102 = Enable 3497A for digital interrupt (Serial Data).
DI 3 = Determine cause of interrupt. For this example, "3" is returned when 999999 counts are exceeded.

Front Panel Operation

Figure 30 shows the 3497A front panel keys and display used with the counter. Since all counter commands have the form CX slot#,n, to initiate commands from the front panel first press the SHIFT key to shift the alpha-numeric keyboard to the ALPHA (A,C,D etc.) mode, and then press the desired numeric mode numbers.



Displays

(1) HP-IB STATUS: Indicates HP-IB status when the 3497A is connected to bus. TALK = ON when 3497A is active talker. LISTEN = ON when 3497A is active listener. REMOTE = ON when 3497A controlled externally. SRQ = ON when SRQ action requested by 3497A.

(2) SLOT: Three-digit display of slot number. Counter commands have the form CX slot#,n.

(3) NUMERIC DISPLAY: 6-digit display of quantity measured by counter. TOT indicates total number of counts in Count Up/Down. SEC indicates period or pulse width of input in seconds.

Keys

(4) LINE: AC power on/off switch

(5) RESET: Clears 3497A. Sets the counter as follows:

- CF to Stop (CF slot#,0)
- CE to No Interrupts (CE slot#,1)
- CR to Read Without Wait (CR slot#,1)
- CS to 000000 (CS slot#,0)
- CT to Rising Edge/Rising Edge (CT slot#,1)

(6) SRQ: Initiates Service Request action to remote (HP-IB) interface.

(7) LOCAL: Places 3497A in local (front-panel) operation.

(8) ALPHA-NUMERIC KEYBOARD: Each key has three modes:

- Primary (upper part)
- Numeric (0-9 plus - and ,)
- Shifted (A, C, D, etc. on lower part). Shifted mode is entered when SHIFT key (9) is pressed.

(9) SHIFT: Shifts keyboard (8) to shifted mode (A, C, D, etc). When pressed, light in center of key is ON.

(10) CLEAR ENTRY: Clears previous entry if EXECUTE key (11) has not been pressed.

(11) EXECUTE: Implements commands and prepares keyboard for new commands.

Figure 30. Option 060 - Front Panel Features Used With Assembly

The following chart shows some sample front panel entries for a counter in slot 4 with no input or output networks connected to the assembly. DISPLAY is the 3497A front panel display after the command sequence is completed.

SAMPLE COMMAND SEQUENCE - FRONT PANEL CONTROL

MODE/ACTION	COMMANDS	DISPLAY	COMMENTS
COUNT DOWN Preset counter to 500 counts, count down and trigger on rising edge; read without wait.	RESET: CS4,500; CF4,2; CR4,1	SLOT 04 000500 TOT	000500 TOT shows 500 counts in counter.
PULSE OUTPUT Output 100 pulses (pulse output mode) with trigger on leading edge of input signal.	RESET; CS4,200 CF4,2	SLOT 04 000000 TOT	Must count down from 200 to get 100 output pulses.
PULSE WIDTH MEASUREMENT Average 100 pulse widths of input, trigger rising edge/falling edge, use counter internal trigger for read.	RESET; CT4,3; CF4,4; CR4,3	SLOT 04 -000000 SEC	CR slot#,3 dedicates 3497A to this function.
INTERRUPT 3497A ON OVERFLOW Enable counter to interrupt 3497A on overflow in count up mode (>999999 counts)	RESET; CE4,2 CF4,1	SLOT 04 OL TOT	OL means >999999 counts for count up.

Remote Programming

Procedures for remote programming are the same as for front panel operation, except that command sequences are initiated by the controller and passed to the 3497A via the interface. Several program examples follow to indicate typical command sequences for remote control of the counter.

Except for counter internal trigger (CR slot#,3), all counter commands have the same interpretation for HP-IB and Serial Data. Unless indicated, all programs apply to both HP-IB and Serial Data operation.

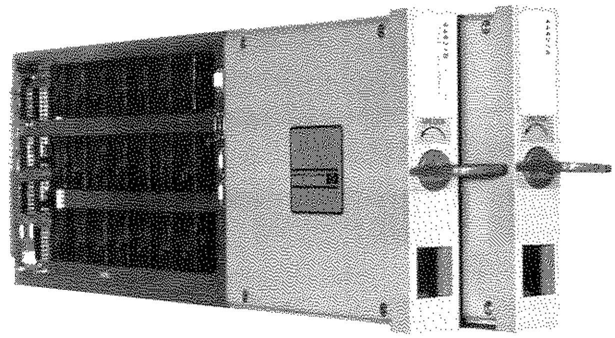
Sample Command Sequences - Remote Control

Action(s)	Command(s)	Example Programs
Count Up from 0, read the number of counts after two seconds.	CF2,1 CR2,1	10 CLEAR 709 20 OUTPUT 709;"CF2,1 " 30 WAIT 2000 40 OUTPUT 709;"CR2,1" 50 ENTER 709;A 6C PRINT "COUNTS = ";A 70 END
Measure 1 period of input signal (100 sec full scale), trigger on falling edge of input, read with wait.	CT2,2; CF2,5; CF2,2	10 CLEAR 709 20 OUTPUT 709;CT2,2CF2,5CR2,2" 30 ENTER 709;B 40 PRINT "INPUT PERIOD = ";B 50 END
Average 1000 pulse widths of input, use counter internal trigger (HP-IB only).	CT2,3; CF2,3; CR2,3	10 CLEAR 709 20 OUTPUT 709;"CT2,3CF2,3CR2,3" 30 ENTER 709;C 40 PRINT "PULSE WIDTH = ";C 50 END
Output 100 square wave pulses at half the input frequency.	CF2,2; CS2,200	10 CLEAR 709 20 OUTPUT 709;"CS2,200CF2,2" 30 END
Interrupt on Overflow in Count Up.	SE2; CE2,1	10 CLEAR 709 20 ON INTR 7 GOSUB 1000 30 ENABLE INTR 7;8 40 OUTPUT 709;"SE2CE2,1" 50 ! Main Program • • 990 ! End Main Program 1000 P = SPOLL (709) 1010 IF P< > 66 THEN RETURN 1020 OUTPUT 709; "DI2" 1030 ENTER 709;A 1040 IF A=3 THEN PRINT "SLOT 2 – OVERFLOW – >999999 COUNTS" 1050 STATUS 7,1;A 1060 RETURN

Figure 31. Option 060 - Sample Programs

OPTIONS 070/071

120/350 Ohm Strain Gauge/ Bridge Completion Assemblies



Introduction

The -hp- Model 44427A 120 Ohm Strain Gauge/Bridge Completion Assembly and -hp- Model 44427B 350 Ohm Strain Gauge/Bridge Completion Assembly provide bridge completion for resistance strain gauges and other resistive transducers such as RTD's and pressure sensors. You can use the assemblies to provide termination for any mixture of ¼, ½ or full bridges and can use 2 or 3-wire (plus shield) transducer connections.

Each strain gauge/bridge assembly can measure up to 10 transducers (strain gauges, RTD's, etc.) when using the internal half bridge shared by all transducers. Each 3497A can hold up to five 44427A and/or 44427B assemblies and each 3498A Extender (Option 298) can hold up to 10 assemblies.

Thus, using the 5 slots in a 3497A and 45 slots in 3498As (maximum which can be used for these assemblies), you can provide up to 500 channels for transducer measurements or up to 133 channels for three element strain gauge rosettes. Of course, the 44427A/B can be used in the same 3497A mainframe with other 3497A assemblies for mixed measurements. For example, you could use the Option 020 thermocouple compensation assembly in one slot and the Option 070 or 071 assembly in another slot to generate apparent strain curves.

Description

As shown in Figure 32, the 44427A/B assemblies consist of a 20 channel relay card and a terminal card. The relay card is identical to the relay card in Options 010 and 020. The terminal card for the 120 ohm assembly (Option 070) is the same as terminal card for the 350 ohm assembly (Option 071) except that the Option 070 assembly uses 120 ohm termination resistors while the Option 071 assembly uses 350 ohm resistors.

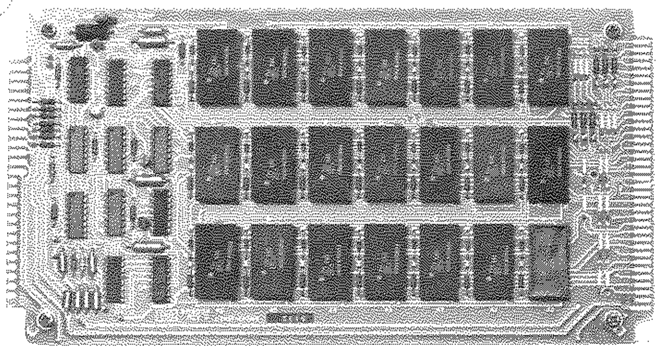
The assemblies require an external (user-supplied) power supply for bridge excitation and a DVM (such as the internal 3497A DVM, -hp- 3456A voltmeter or equivalent DVM). Initial voltmeter readings for bridge excitation and bridge unbalance are used to solve bridge equations, thereby eliminating the need for any span and offset adjustments. To compute strain, the assembly should be used with a controller. Data acquisition and strain calculation can be done manually, however.

Because the excitation voltage, Vs, is always applied, never switched, there are no errors due to dynamic heating and cooling of the transducer. Since the excitation voltage is measured on each assembly, measurement accuracy is independent of long term power supply voltage changes and an inexpensive supply (such as the -hp- Model 6214A or 62005A) is adequate to achieve rated accuracy specifications. The Model 6214A can provide power for 50 channels (5 assemblies) while the 62005A can power up to 80 channels.

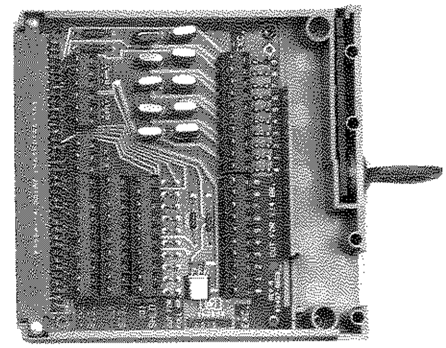
Several diagnostic tests are available on the 44427A/B assemblies to check circuit integrity or enhance measurement accuracy. Diagnostic tests provided include the following.

STRAIN GAUGE ASSEMBLY DIAGNOSTIC TESTS

Test	Description
Shunt Calibration	Either across the transducer or across the internal ½ bridge.
Lead Resistance	For improved 3-wire RTD measurements (available on three channels/assembly).
Gauge Leakage	To detect resistive faults between device under test and transducers.
Internal ½ Bridge Ratio	For self-test and replacement calibration.



RELAY CARD



TERMINAL CARD

Figure 32. Options 070/071 - Strain Gauge Assemblies

Strain Gauge Measurements

The Option 070/071 assemblies allow you to determine strain of bonded resistance strain gauges by measuring voltage changes which occur between the unstrained and the strained state of the gauge. To show how the assemblies do this, we'll summarize strain gauge measurements.

This discussion is not a comprehensive tutorial on strain gauge or bridge measurements, but is intended to show how the assemblies can be used to make these measurements. See -hp- Application Note 290-1, ''Practical Strain Gauge Measurements'' for general background information on strain gauge measurements.

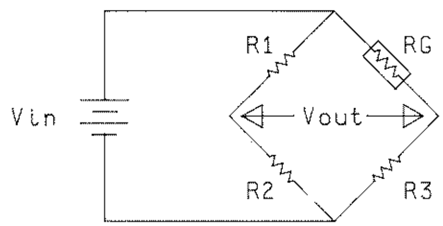
Strain

We'll use the term strain (ϵ) to mean the ratio of a fractional change in length to the unstrained length: $\Delta L/L$. Since the magnitude of ΔL is usually less than 1% of L, the strain gauge assemblies use a Wheatstone Bridge circuit for measurement. The Gauge Factor, GF, relates a change in resistance of the gauge (ΔR) to the strain, where $\Delta R/R$ is the ratio of the change in resistance (ΔR) which is caused by the strain to the original resistance (R) of the gauge in the unstrained state.

$$GF = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\epsilon} \qquad (1)$$

Unbalanced Wheatstone Bridges

As noted, the strain gauge assemblies use an unbalanced Wheatstone Bridge arrangement to measure voltage changes between the strained and unstrained states of strain gauges. For the (balanced) Wheatstone bridge shown in Figure 33, Vin is the input voltage to the bridge; Rg is the resistance of the strain gauge; R1, R2 and R3 are the resistances of the bridge completion resistors and Vout is the bridge output voltage.



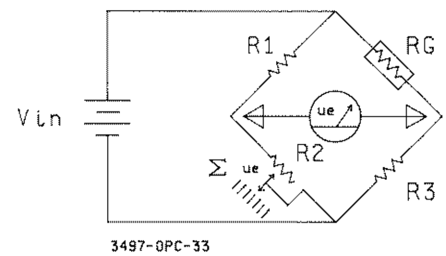


Figure 33. Options 070/071 - Wheatstone Bridge Circuit

In Figure 33, a ¼ bridge configuration is shown since one arm of the bridge is an active gauge and the other arms are fixed value resistors or unstrained gauges. Ideally, the strain gauge, Rg, is the only resistor in the circuit which varies. We can relate the ratio of the input voltage to the output voltage by:

$$\frac{Vout}{Vin} = \left[\frac{R3}{R3 + Rg} - \frac{R2}{R1 + R2}\right] \qquad (2)$$

Equation (2) applies to both strained and unstrained states. To measure strain, two measurements must be taken: (1) measure Vout with the gauge in the unstrained state and then (2) measure Vout with the gauge in the strained state. By combining the strained and unstrained cases, we can define a new term, Vr.

$$VR = \left[\left(\frac{Vout}{Vin}\right)_{strained} - \left(\frac{Vout}{Vin}\right)_{unstrained}\right] \qquad (3)$$

From equation (1), since strain (ϵ) = (ΔR/Rg)/GF, we can write an equation for strain in terms of the gauge factor (GF) and Vr (which is derived from Vin and Vout) as follows:

$$\epsilon = \frac{-4Vr}{GF(1 + 2Vr)} \qquad (4)$$

Since the actual strain figure is quite small (on the order of 0.000200), we will express the results in $\mu\epsilon$ (ϵ x 10^6). In addition we'll assume a Gauge Factor GF = 2.

Multichannel Bridge Measurements

The strain gauge assemblies use a bridge circuit called a ''Chevron Bridge'' for multichannel bridge measurements. Figure 34 shows a circuit setup which switches a DVM between gauges. One channel is shown as a ¼ bridge and the other as a ½ bridge (two active gauges). Resistors R1, R2 and R3 form three sides of the bridge and the excitation voltage (Vin) to the gauges is continuously applied.

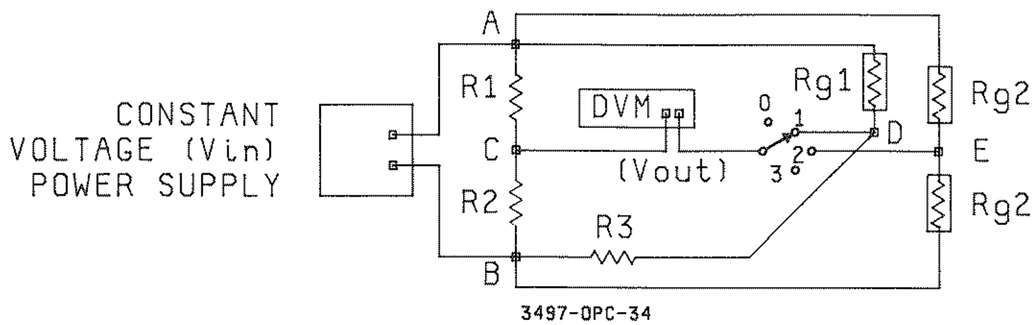


Figure 34. Options 070/071 - Bridge Circuits for Assemblies

To make strain gauge measurements with this circuit, the DVM is switched between points C-D, D-E, etc., and measures Vout for each channel. Although not shown in Figure 34, the DVM can also be switched to measure Vin. The procedure to measure strain with this circuit is as follows (assuming that the Gauge Factor is known). For an example program, see EXAMPLE - SCANNING STRAIN GAUGES.

STRAIN GAUGE MEASUREMENTS

(1) Measure Vin and store the value.

(2) Measure Vout for channel #1 (¼ bridge in Figure 34) with the gauge unstrained.

(3) Measure Vout for channel #1 with the gauge strained.

(4) Compute strain from ϵ = -4Vr/GF(1+ 2Vr). [¼ bridge]

(5) Switch the DVM to channel #2 (shown as a ½ bridge in Figure 34) and repeat steps (2) through (4).

Controlling the Strain Gauge Assemblies

The strain gauge/bridge completion assemblies are controlled by ANALOG commands, as shown in the following table. By using these commands, you can close a channel with the AC chan# command, open all channels with an AR command or scan a sequence of channels by using the AF chan#, AL chan# and AS commands. See the Command Directory in Chapter 6 for details.

For example, to close channel 8 the command is ''AC8''. For this command, all previously closed channels will open before channel 8 is closed. Although the AC command can be used to close up to 4 channels simultaneously, only one channel should be closed at a time for the strain gauge assemblies.

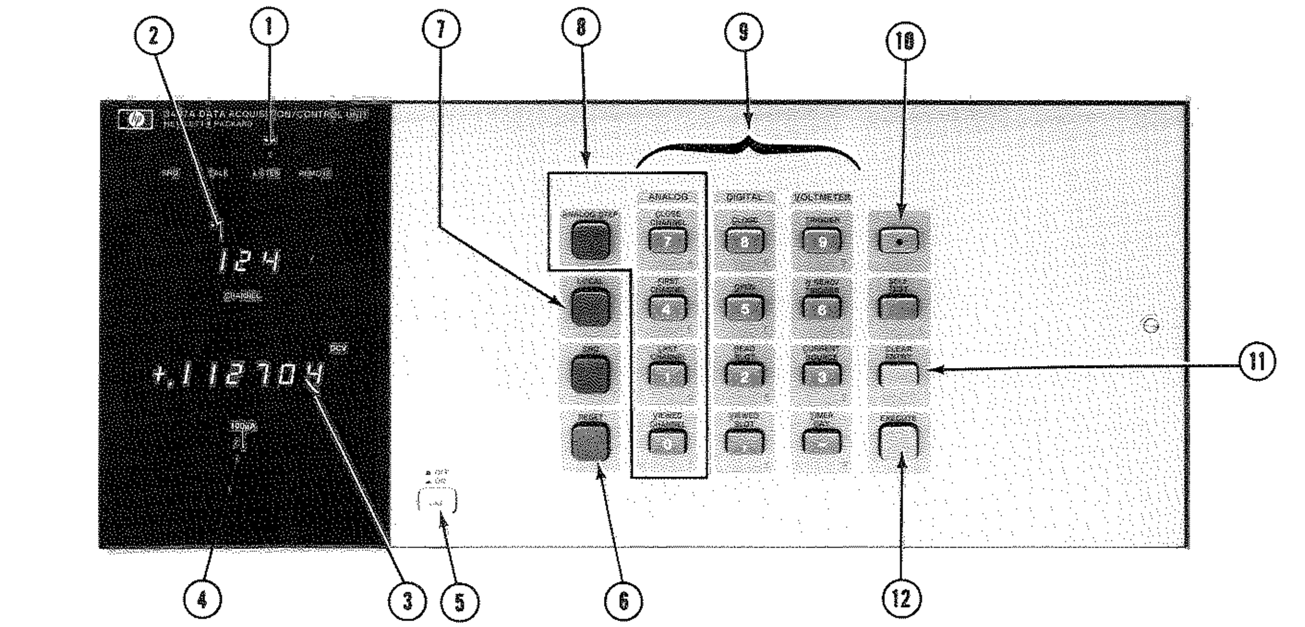
If you want to measure the voltage on a sequence of channels, use the AF, AL and AS commands. For example, to scan channels 0 through 9, set AF0 and AL9. Then sending AS repeatedly will cause relay closure on channel 0,1,...,9,0,.. Note that if AF < AL the sequence is increasing from AF through AL and back to AF. If AF > AL, the sequence is decreasing from AL through AF and back to AL (i. e., if AF9 and AL0 are set, sequence is 9,8,...0,9,..).

Front Panel Features Used With the Strain Gauge Assemblies

Figure 35 shows the front panel keys and display used with the Option 070/071 assemblies. Since the assemblies are analog assemblies, only the analog display is used. When a channel is closed, the 3-digit display shows the number of the channel closed and the 6-digit display shows the value of the DC voltage measured (DCV on the display).

COMMANDS FOR THE STRAIN GAUGE ASSEMBLIES

Command	Description
AC chan# chan# = 0 to 999	CLOSE ANALOG CHANNELS Close channels on the strain gauges. Channels not addressed are opened. To close channel 3, use ''AC3''.
AEn n = 0 to 2	ENABLE EXTERNAL INCREMENT PORT Enable the EXT INCR port. AE0 disables the EXT INCR port and AE1 enables the port. AE2 (FAST SCAN) enables the port and external BBM sync pulse is ignored.
AF chan# chan# = 0 to 999	SET ANALOG FIRST CHANNEL Sets first channel to be closed in a sequence, but does close the channel. To set channel 53 as first channel, use ''AF53''.
AI chan# chan# = 0 to 999	CLOSE A CHANNEL, TRIGGER DVM Closes channel addressed and triggers DVM to take a measurement. To make a reading of channel 23, use ''AI23''.
AL chan# chan# = 0 to 999	SET ANALOG LAST CHANNEL Sets last channel to be closed in a sequence, but does not close the channel. If AF < AL, sequence is increasing. If AF > AL, sequence is decreasing. To set 53 as last channel to be closed, use ''AL53''.
AR	ANALOG RESET Opens all channels on all strain gauge assemblies in a 3497A or 3498A. In addition, AR sets VF1, VT1, VR5, VW0, VS0, AE0, AF0 and AL999.
AS	ANALOG STEP Increments or decrements channel closure between AF and AL channels. If AF < AL, sequence is increasing. If AF > AL, sequence is decreasing. If AF and AL are not specified, sequence increments from presently closed channel (i.e. for channel 30 closed, sequence is 30, 31, ...,999, 0, 1 ... for each AS input).
AV chan# chan# = 0 to 999	DEDICATE DISPLAY TO CHANNEL Dedicates the front panel display to channel addressed. Command does not close channel or affect other 3497A operations. Display is updated when measurement is taken.



DISPLAYS

(1) HP-IB STATUS: Indicates HP-IB status when the 3497A is connected to bus. TALK = ON when 3497A is active talker; LISTEN = ON when 3497A is active listener; REMOTE = ON when 3497A controlled externally.

(2) CHANNEL: 3-digit display of channel being measured through the multiplexer assembly.

(3) NUMERIC DISPLAY: 6-digit display of DC volts measured on channel. DCV indicates DC voltage measurement. Display shows value of voltage measured.

(4) CURRENT SOURCE: Displays range of internal 3497A current source (10μA, 100μA or 1mA). ON only when current source is used.

Keys

(5) LINE: AC power ON/OFF switch.

(6) RESET: Clears 3497A, sets assembly as follows:

AO, AI, AS, AV = Disabled
AE0 = EXT INCR Port OFF
AF000 = First Chan = 000
AL999 = Last Chan = 999

(7) LOCAL: Puts 3497A in local (front-panel) mode of operation.

(8) ANALOG KEY GROUP: Used to control relay multiplexer.

(9) ALPHA-NUMERIC KEYBOARD: Each key has three modes:

Primary (upper part)
Numeric (0-9 plus ,-)
Shifted (A,C,D, etc. on lower part).

(10) SHIFT: Shifts keyboard (9) to shifted mode (A,C,D, etc). When pressed, light in center of key is ON.

(11) CLEAR ENTRY: Clears previous entry if EXECUTE key has not been pressed.

EXECUTE: Implements commands and prepares keyboard for new commands.

Figure 35. Options 070/071 Front Panel Features used with Assemblies

Addressing the Assemblies

To close a specific relay on the assembly, we must first know its address. The strain gauge assemblies consist of 20 channels, divided into two decades, A and B. The A decade consists of channel designators A0 through A9 and the B decade consists of channel designators B0 through B9.

The slot in which the assembly is placed determines the address of the channels. An assembly in slot 0 of a 3497A has channel addresses 0-19; an assembly in slot 1 has addresses 20-39; etc. An assembly in slot 10 of a 3498A Extender (the left-most slot as viewed from the rear of the instrument) has addresses 100 to 119, etc. Recall that slots 5 through 9 do not exist.

The following chart shows the channel numbers associated with the Option 070/071 assemblies for each 3497A slot (for 3498A slots, add 100 to each number shown for the first 3498A, 200 to each number for the 2nd 3498A, etc.). Note that for each slot, the 10 lowest numbers (the A decade) are for strain gauge measurements while the 10 highest numbers (the B decade) are for bridge diagnostics, excitation measurements, etc.

On the terminal card, the strain gauge inputs [+(H) SIG,-(L) SIG and (G) SHLD] have designators A0 through A9, left to right. Thus, for example, a strain gauge input to terminal A0 (leftmost terminal) has channel number 0 for an assembly in slot 0, 10 for an assembly in slot 1, etc.

STRAIN GAUGE ASSEMBLY - CHANNEL ADDRESSING

Terminal Address	Function	Slot Number				
		0	1	2	3	4
			Channel Number(s)			
A0-A9	Reserved for Strain Gauge Inputs.	0-9	20-29	40-49	60-69	80-89
B0	Measure Excitation Voltage.	10	30	50	70	90
B1	Tension Shunt Calibration	11	31	51	71	91
B2	Compression Shunt Calibration	12	32	52	72	92
B3	Guard to Low Resistance (channel A0)	13	33	53	73	93
B4	Guard Voltage	14	34	54	74	94
B5-B6	Internal Half-Bridge Ratio	15-16	35-36	55-56	75-76	95-96
B7-B9	Lead Wire Resistance (channels A7 through A9)	17-19	37-39	57-59	77-79	97-99

Strain Gauge Measurements Equations

Earlier, we developed an equation for strain in terms of the input and output voltages of a ¼ bridge circuit. The assemblies can also be used for ½ and full bridge measurements and a combination of bridges (10 maximum) can be input to a single assembly.

Although the assemblies are specifically designed for use with bonded resistance strain gauges, they can also be used with any resistive transducer, such as RTDs and 3-element rosettes. Figure 36 shows equations for determining strain for strain gauge bridges, biaxial stress state equations, rosette equations, wire resistances and selected materials properties. For further information on using RTDs, see -hp- Application Note 290, Practical Temperature Measurements (-hp- part number 5952-8801).

Material Tables

WIRE RESISTANCE
Solid Copper Wire

AWG	Ohms/Foot (25°C)	Diameter (in.)
18	0.0065	0.040
20	0.0104	0.032
22	0.0165	0.0253
24	0.0262	0.0201
26	0.0416	0.0159
28	0.0662	0.0126
30	0.105	0.010
32	0.167	0.008

AVERAGE PROPERTIES OF SELECTED ENGINEERING MATERIALS
Exact values may vary widely

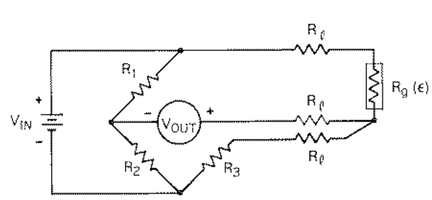
Material	Poisson's Ratio, ν	Modulus of Elasticity, E psi x 10^6	Elastic Strength (a) Tension (psi)
ABS (unfilled)	–	0.2-0.4	4500-7500
Aluminum (2024-T4)	0.32	10.6	48000
Aluminum (7075-T6)	0.32	10.4	72000
Red Brass, soft	0.33	15	15000
Iron-Gray Cast	–	13-14	–
Polycarbonate	0.285	0.3-0.38	8000-9500
Steel-1018	0.285	30	32000
Steel-4130/4340	0.28-0.29	30	45000
Steel-304 SS	0.25	28	35000
Steel-410 SS	0.27-0.29	29	40000
Titanium alloy	0.34	14	135000

(a) Elastic strength may be represented by proportional limit, yield point, or yield strength at 0.2 percent offset.

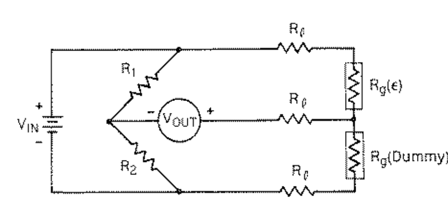
STRAIN GAGE BRIDGE CIRCUITS AND EQUATIONS

Equations compute strain from unbalanced bridge voltages:
sign is correct for V_{IN} and V_{OUT} as shown
GF = Gage Factor: ν = Poisson's ratio:
$V_r = [(V_{OUT}/V_{IN})\text{strained} - (V_{OUT}/V_{IN})\text{unstrained}]$:
ϵ = Strain; Multiply by 10^6 for micro-strain:
tensile is (+) and compressive is (−)

Quarter Bridge Configurations:



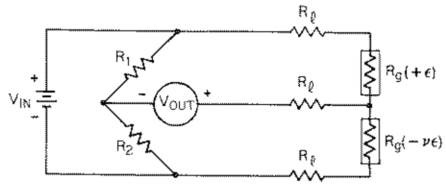
OR



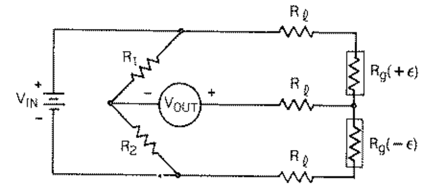
$$\epsilon = \frac{-4V_r}{GF(1+2V_r)} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

Figure 36. Options 070/071 - Strain Gauge/Rosette Equations

Half Bridge Configurations:

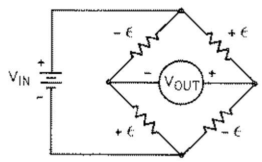


$$\epsilon = \frac{-4V_r}{GF[(1+\nu)-2V_r(\nu-1)]} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

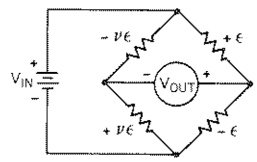


$$\epsilon = \frac{-2V_r}{GF} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

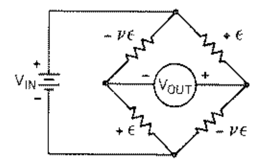
Full Bridge Configurations:



$$\epsilon = \frac{-V_r}{GF}$$



$$\epsilon = \frac{-2V_r}{GF(\nu+1)}$$



$$\epsilon = \frac{-2V_r}{GF[(\nu+1)-V_r(\nu-1)]}$$

Equations

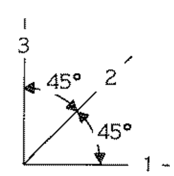
BIAXIAL STRESS STATE EQUATIONS

$$\epsilon_x = \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \epsilon_z = -\nu\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \sigma_y = \frac{E}{1-\nu^2}(\epsilon_y + \nu\,\epsilon_x)$$

$$\epsilon_y = \frac{\sigma_y}{E} - \nu\frac{\sigma_x}{E} \qquad \sigma_x = \frac{E}{1-\nu^2}(\epsilon_x + \nu\,\epsilon_y) \qquad \sigma_z = 0$$

ROSETTE EQUATIONS

Rectangular Rosette:

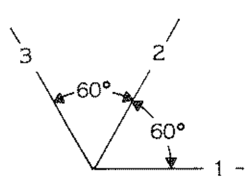


$$\epsilon_{p,q} = \left[\frac{1}{2}\;\epsilon_1 + \epsilon_3 \pm \sqrt{(\epsilon_1-\epsilon_3)^2 + (2\epsilon_2-\epsilon_1-\epsilon_3)^2}\right]$$

$$\sigma_{p,q} = \left[\frac{E}{2}\;\frac{\epsilon_1+\epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{(\epsilon_1-\epsilon_3)^2 + (2\epsilon_2-\epsilon_1-\epsilon_3)^2}\right]$$

$$\theta_{p,q} = \frac{1}{2}\,\mathrm{TAN}^{-1}\,\frac{2\epsilon_2-\epsilon_1-\epsilon_3}{\epsilon_1-\epsilon_3}$$

Delta Rosette:



$$\epsilon_{p,q} = \left[\frac{1}{3}\;\epsilon_1 + \epsilon_2 + \epsilon_3 \pm \sqrt{2[(\epsilon_1-\epsilon_2)^2 + (\epsilon_2-\epsilon_3)^2 + (\epsilon_3-\epsilon_1)^2]}\right]$$

$$\sigma_{p,q} = \left[\frac{E}{3}\;\frac{\epsilon_1+\epsilon_2+\epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{2[(\epsilon_1-\epsilon_2)^2 + (\epsilon_2-\epsilon_3)^2 + (\epsilon_3-\epsilon_1)^2]}\right]$$

$$\theta_{p,q} = \frac{1}{2}\,\mathrm{TAN}^{-1}\,\frac{\sqrt{3}(\epsilon_2-\epsilon_3)}{2\epsilon_1-\epsilon_2-\epsilon_3}$$

WHERE: $\epsilon_{p,q}$ = Principal strains; $\sigma_{p,q}$ = Principal stresses; and $\theta_{p,q}$ = the acute angle from the axis of gage 1 to the nearest principal axis. When positive, the direction is the same as that of the gage numbering and when negative, opposite.

NOTE: Corrections may be necessary for transverse sensitivity, refer to gage manufacturers literature.

Figure 36. Options 070/071 · Strain Gauge/Rosette Equations (Cont'd)

Making Strain Gauge Measurements

To make strain gauge measurements, first determine the exact value of the excitation supply voltage (Vs) and Gauge Factor of the strain gauge(s) you are using. To demonstrate the procedure for making strain gage measurements, we'll take an example for a ¼ bridge arrangement with the assembly in slot 0 with the gauge connected to channel A2 and use a Gauge Factor of 2.

EXAMPLE - ¼ BRIDGE STRAIN GAUGE MEASUREMENTS

Step 1: Determine Excitation Voltage (Vs)

To accurately determine the excitation voltage, Vs, we must close the channel associated with terminal designator B0. Since the assembly is in slot 0, this is channel 10. Thus, to close channel 10, enter "AC10" and read the display voltage, Vs. Record this voltage for future use.

Step 2: Measure Bridge Output with Gauge Unstrained.

The next step is to measure the voltage output from the 1/4 bridge with the gauge in an unstrained condition. Since the gauge is connected to terminal A2, channel 2 must be closed. To close channel 2, send "A2" and record the voltage as Voutu.

Step 3: Measure Bridge Output with Gauge Strained.

The third step is to apply a strain to the gauge and record the voltage displayed as Vouts. Since channel 2 is already closed, we do not have to reclose it.

Step 4: Compute Strain.

For the ¼ bridge arrangement in this example, strain can be computed from ϵ = -4Vr/GF(1 + 2Vr) where Vr = [(Vout/Vs)strained - (Vout/Vs)unstrained]. Let's assume that the following readings were obtained:

Channel 10 (Vs) = 2.000V
Channel 2 (unstrained, Voutu) = 194 μV
Channel 2 (strained, Vouts) = -60 μV

Then, using the equations above, with a Gauge Factor GF = 2, Vr = -.000127 and ϵ = .000254 or 254 $\mu\epsilon$.

Scanning Strain Gauges

The previous example showed how to measure the strain from a single strain gauge and can easily be accomplished from the front panel of the 3497A. However, if you want to connect several strain gauges, multi-channel scanning is best accomplished with a controller. The scanning operation is basically the same as the single channel operation performed several times.

Since a single excitation voltage supply is used for all channels on an assembly, the excitation voltage needs to be measured only once per scan per assembly. A sample BASIC program to scan channels 0 through 9 and print the strain on each channel is shown in the following example. GF =2 and a ¼ bridge arrangement for each channel is assumed. To convert the program for other channels and/or other bridge arrangements, modify lines 40, 60, 170 and 220 as required.

EXAMPLE - SCANNING STRAIN GAUGES

Program

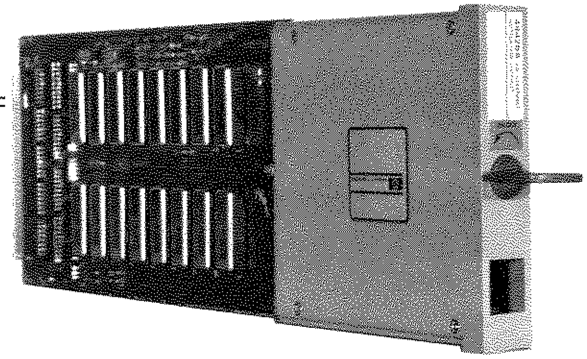
```
 10 CLEAR 709
 20 PRINT ''STRAIN GAUGE MEASUREMENTS''
 30 PRINT
 40 OUTPUT 709; ''AF0AL9AC10''
 50 ENTER 709; V

 60 FOR I = 0 TO 9
 70 OUTPUT 709;''AS''
 80 ENTER 709; A(I)
 90 U(I) = A(I)/V
100 NEXT I

110 DISP ''ADD STRAIN TO GAUGES. THEN,''
120 DISP ''WHEN READY PRESS CONT KEY''
130 DISP ''TO RESUME PROGRAM''
140 PAUSE

150 PRINT ''CHANNEL MICROSTRAIN''
160 PRINT
170 FOR I = 0 TO 9
180 OUTPUT 709;''AS''
190 ENTER 709; B(I)
200 T(I) = B(I)/V

210 X(I) = T(I) - U(I)
220 S(I) = -(4*X(I)/(2*(1+2*X(I)))
230 PRINT I, S(I)*10**6
240 NEXT I
250 END
```

Lines	Description
10-50	Sets first channel to 0, last channel to 9 and measures excitation voltage (Vs) on channel 10 (channel B0).
60-100	Measures unstrained voltage on channels 0 through 9 and computes Vout/Vin unstrained.
110-140	Program halts to allow strain to be applied to gauges.
150-200	Measures strained voltage on channels 0 through 9 and computes Vout/Vin when gauges are strained.
210-230	Computes strain and prints results in microstrain.

A typical printout is:

```
STRAIN GAUGE MEASUREMENTS

CHANNEL        MICROSTRAIN

   0               10.75
   1              -134.3
   .                 .
   .                 .

   9              170.03
```

OPTION 110



Actuator/Digital Output Assembly

Introduction

The -hp- Model 44428A Actuator/Digital Output assembly consists of 16 mercury-wetted Form C (single pole - double throw) relays. The assembly has two functional modes: actuator mode and digital output mode. In the actuator mode, each channel relay can be closed to switch power to (actuate) multiple external devices. Each relay can safely switch up to 1 amp at 100 volts (peak).

In the digital output mode, each relay can be set to the Normal Open (NO) position (logical 1) or to the Normal Closed (NC) position (logical 0) to provide an 8-bit or 16-bit wide digital output. To enhance this capability, the assembly uses ''bounceless'' relays, isolated Gate/Flag handshake lines, +5V non-isolated internal excitation, capability for up to +100V external excitation and can be configured for open collector operation.

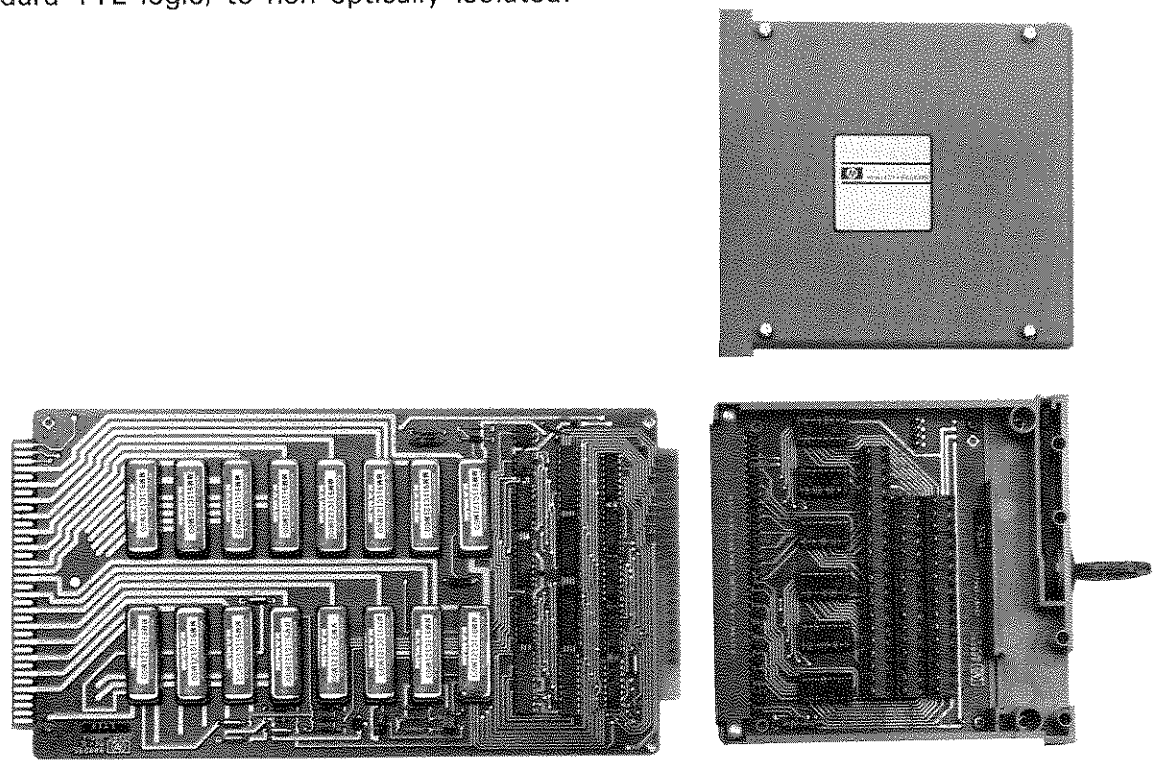
The assembly can be also configured as a 4 x 4 point matrix scanner and additional assemblies can be added to construct larger matrices. Since the Option 110 assembly can switch one amp at 100 volts, it can be used to switch test fixture power or to actuate alarm bells. In addition, the assembly can be used with the 16 channel isolated digital input/interrupt assembly (Option 050) to provide an independent digital input/output port.

Description

As shown in Figure 37, the Option 110 assembly consists of a relay card and a terminal card. The relay card consists of 16 mercury-wetted, Form C (single pole-double throw) relays. Each relay can be individually closed (set to the Normal Open position) or opened (set to the Normal Closed position).

The relay card contains a jumper to select a positive-going (LGT) or negative-going (HGT) gate pulse, a jumper to select a positive-going (LFL) or negative-going (HFL) flag pulse, and a jumper to enable or disable the handshake function for the assembly.

The terminal card contains input connectors for 16 channel relays (NORM OPEN, COMMON and NORM CLOSED) plus connectors for gate and flag lines and DIP connectors for pull-up resistors as required. You can use four optional jumpers on the terminal card to change gate and flag handshake lines from optically isolated (standard TTL logic) to non optically isolated.



RELAY CARD TERMINAL CARD WITH COVER REMOVED

Figure 37. Option 110 · Actuator/Digital Output Assembly

Actuator (Switching) Mode

As shown in Figure 38, when the assembly is used in actuator mode, each of the 16 channel relays (K0 through K15) can be switched from the Normal Open position to the Normal Closed position and thus switch power to or from loads. When a relay is de-energized, the Normal Closed line is connected to common. When a relay is energized, the Normal Open line is connected to common.

By using the DC slot#, chan#,chan#... and DW slot#,octal value commands, from one to 16 relays can be closed (set to the Normal Open position) and each relay can be individually closed or opened. By using a DR slot# or DL slot# command, you can read the status (open or closed) of each relay. By using the SR slot#,0 command, you can verify that the assembly in the slot addressed is an Option 110 (or Option 115) assembly if 000041 OCT is returned.

In some cases (highly inductive loads, for example), contact protection may be required to prevent switch contact damage. Note that contact protection is required across BOTH the Normal Open and Normal Closed lines if loads are to be switched on each line. Chapter 8 gives guidelines for relay contact protection.

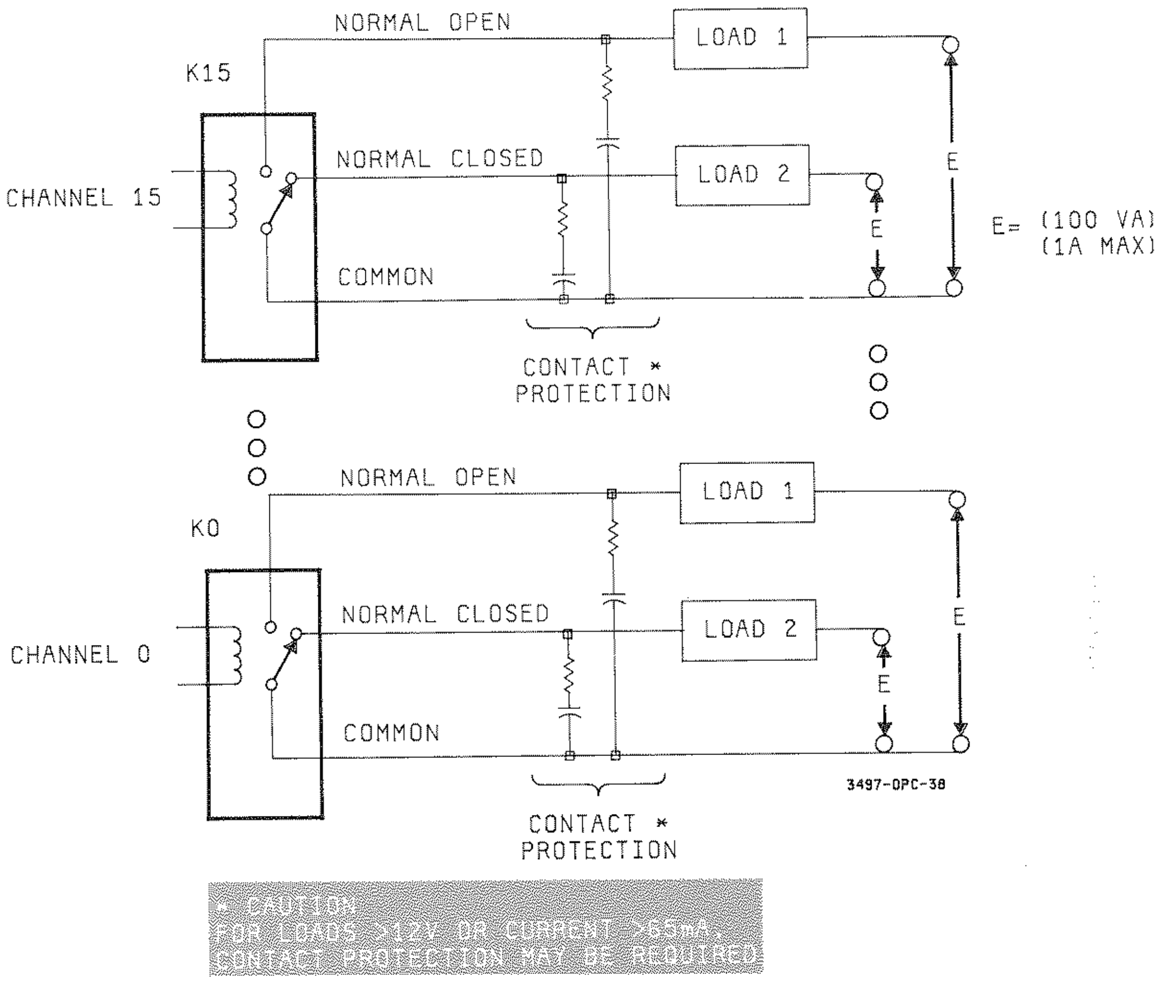


Figure 38. Option 110 · Actuator (Switching) Mode

The assembly can be used in many applications, as long as the load circuits are fused for 1A or less and less than 100 VA. To indicate some of the ways that the assembly can be used in the actuator mode, Figure 39 shows a relay actuated alarm circuit, voltage switching and matrix switching.

For the alarm circuit, closing the relay applies power to sound the alarm device. For example, the relay closure could be computer-controlled and generated as a result of an interrupt from the Option 050 assembly. For the voltage switching application shown, closing the relay switches +5V from load #1 to load #2.

As a specialized application of the actuator mode, the assembly can be configured as a 4 x 4 matrix switch. For example, as shown in Figure 39, signal sources S1 through S4 can be connected to measuring instruments I1 through I4 by closing relays K0 through K15 as required (i. e., to connect source S3 to instrument I2, close relay K6, etc.).

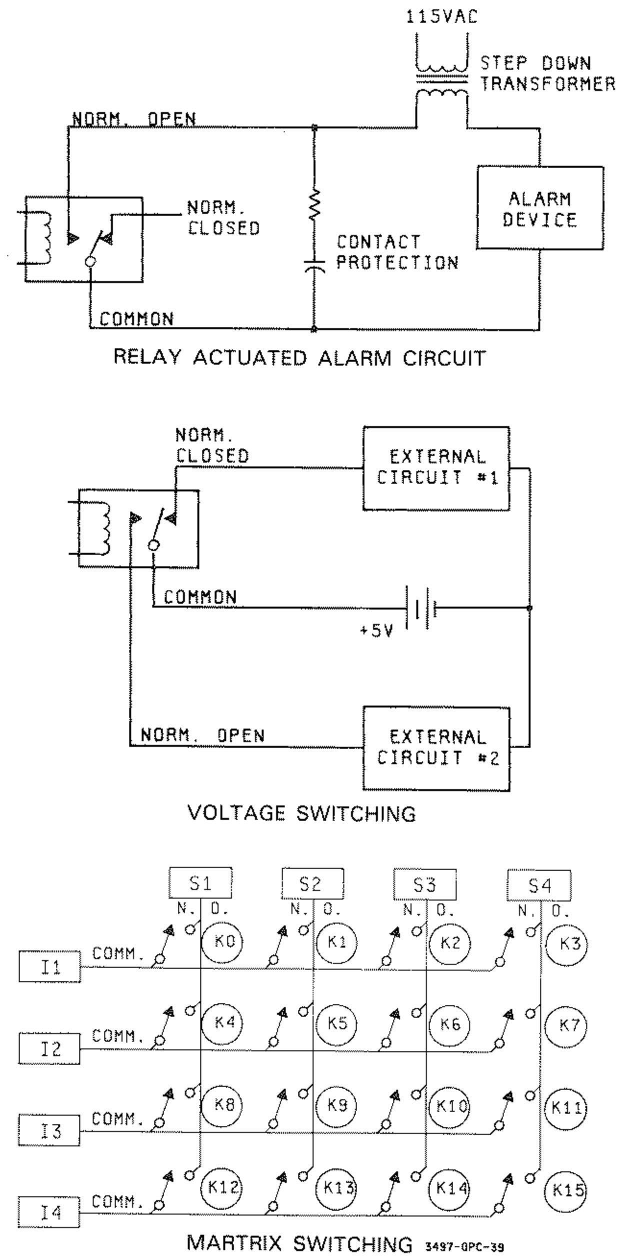


Figure 39. Option 110 - Actuator Mode Examples

Digital Output Mode

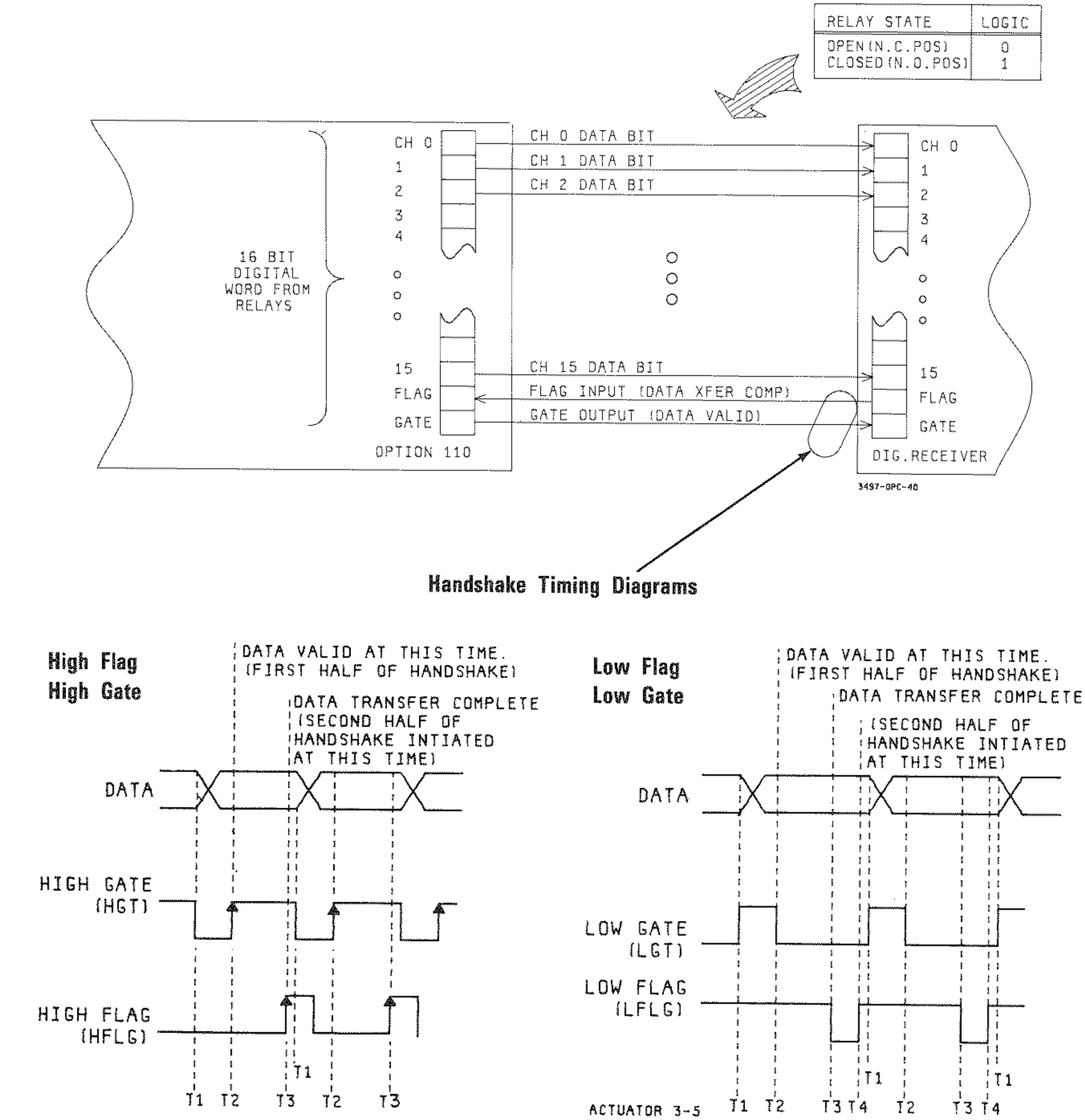
The Option 110 assembly can also be used in digital output mode to communicate with a 16-bit digital receiver at a typical maximum read rate of 400 Hz. As shown in Figure 40, a 16-bit wide digital word is input to the relays (channels 0 through 15) and the word is transferred to a digital receiver. As with the actuator mode, relay status (open or closed) can be read with a DR slot# or DL slot# command.

As factory set, handshaking is disabled. If desired, you can set a jumper on the relay assembly to enable handshaking and (with other jumpers) can select either High Gate, High Flag or Low Gate, Low Flag handshaking. Also, as factory configured, the handshake lines are optically isolated. You can select non isolated mode by connecting pullups across four terminal card jumpers.

When handshaking is enabled, the handshake sequence for either High Gate, High Flag or Low Gate, Low Flag operation is as shown in Figure 40. When a 16-bit wide word is entered into the assembly and settling time has occurred, the assembly sends a Gate output to the receiver to signal Data Valid condition. Then, after the word is transferred to the receiver, the receiver returns a Flag message to show that data transfer is complete and the receiver is ready for more data.

Controlling the Actuator/Digital Output Assembly

As noted, the actuator/digital output assembly has two modes of operation: actuator (switching) and digital output. For both modes, the assembly is controlled by DIGITAL commands. The following chart shows the DIGITAL commands used to control the assembly. See the Command Directory in Chapter 6 for details and examples.



High Flag / High Gate

- T1 . . . . 16 bit wide data word transferred to actuator card relays
- T1-T2 . . Settling time for relays and drive circuits (≈3ms.)
- T2 . . . . Data Valid, ready for transfer to external device
- T2-T3 . . Data transfer executed during this time period
- T3 . . . . Data transfer complete. Actuator card and 3497A wait until positive going flag pulse received

Low Flag / Low Gate

- T1 . . . . 16 bit wide data word transfered to actuator card relays
- T1-T2 . . Settling time for relays and drive circuits (≈3ms.)
- T2 . . . . Data valid, ready for transfer to external device (first half of handshake)
- T2-T3 . . Data transfer executed duing this time period
- T3 . . . . Data transfer complete. External device transmits flag pulse
- T4 . . . . Positive going (trailing edge) transition occurs to complete handshake

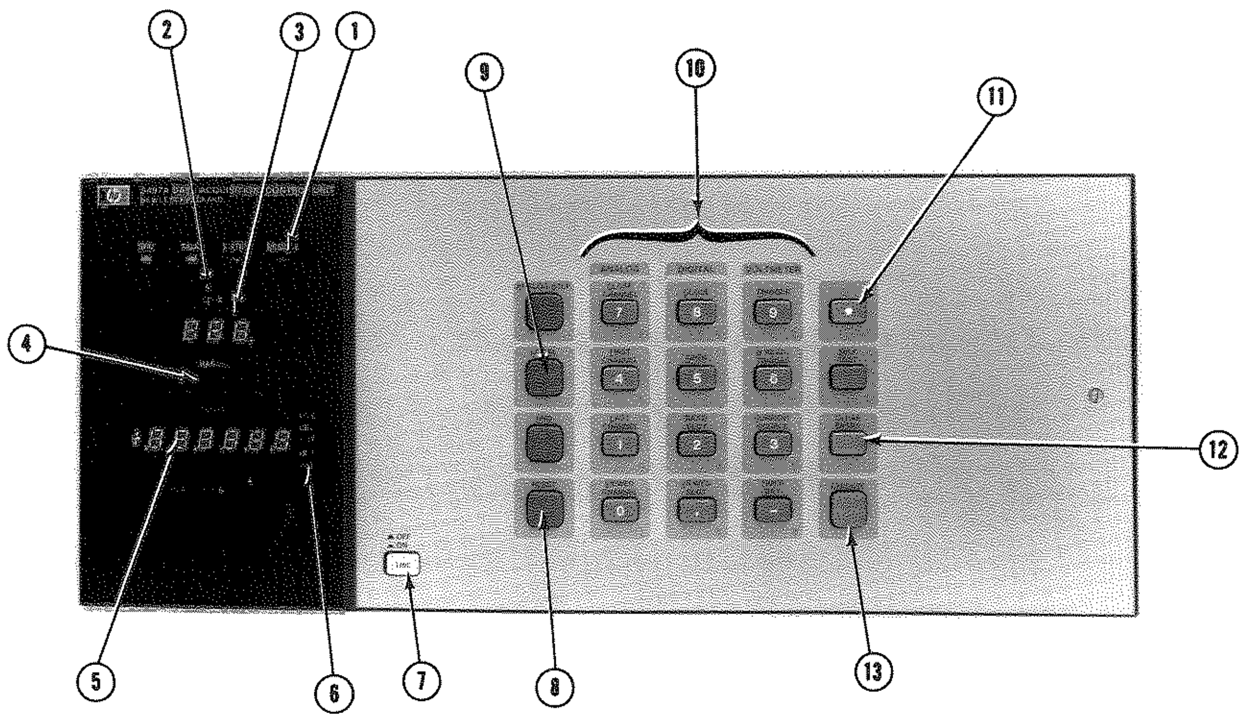
Figure 40. Option 110 - Digital Output Mode

COMMANDS FOR THE ACTUATOR/DIGITAL OUTPUT ASSEMBLY

Command	Description
DC slot#,chan#,... slot# = 0 to 89 chan# = 0 to 15	DIGITAL CLOSE Closes relay contacts in channels addressed. From one to 16 channels of an actuator in slot addressed may be closed with a single command. Channels not listed in the command remain in their previous state.
DO slot#,chan#,... slot# = 0 to 89 chan# = 0 to 15	DIGITAL OPEN Opens relay contacts in channels addressed. From one to 16 channels of an actuator in slot addressed may be opened by a single command. Channels not listed in the command remain in their previous state.
DL slot# slot# = 0 to 89	DIGITAL LOAD Returns current state of the 16 relays (open or closed) of an actuator in slot addressed. Value returned is octal representation of the state. Only one reading/command is returned.
DR slot# slot# = 0 to 89	DIGITAL READ Same as the DIGITAL LOAD command, except that repeated reads of the actuator card are made and updated on the display and on the interface bus.
DV slot# slot# = 0 to 89	DIGITAL VIEWED SLOT Dedicates the 3497A front panel display to a slot. Exit from this mode by using the command DV without the slot designation.
DW slot#, octal slot# = 0 to 89 octal = 0 to 177777	DIGITAL WRITE Outputs an octal value to all channels in slot addressed. Octal value corresponds to desired digital state of the relays (digital 1 = closed, 0 = open). DW command affects the entire assembly, while DC and DO affect only the channels specified.
SR slot#,0 slot# = 0 to 89	SYSTEM READ Reads the "signature" of the assembly in slot addressed. The actuator (and high voltage actuator) have signature 000041 OCT.

Front Panel Features Used With the Assembly

Figure 41 shows the front panel keys and display used with the actuator/digital output assembly. Since the assembly is a digital assembly, only the digital display is used. The slot number addressed is shown on the 3-digit display and the 6-digit display shows the octal value of data requested.



Displays

(1) REMOTE = LED ON for control by ext controller, OFF for local (3497A) control.

(2) SLOT: ON when assembly accessed.

(3) SLOT DISPLAY: 3-digit readout of slot accessed.

(4) CHANNEL INDICATORS: Displays contents of channel 0 thru 15 of actuator card. ON – relay is closed.

(5) NUMERIC DISPLAY: 6-digit display. Shows octal equivalent of digital channels status. (i.e., 000377 OCT = channels 0 thru 7 on; 11111111 binary.)

(6) DISPLAY FUNCTIONS: Only OCT and ENT used with actuator. OCT shows display is octal representation of digital channels ENT means data can be entered.

Keys

(7) LINE: AC power on/off switch.

(8) RESET: Clears 3497A. Sets all relays to open.

(9) LOCAL: Puts 3497A in local mode of operation.

(10) ALPHA-NUMERIC KEYBOARD

3 functions for each key
- Primary (upper part)
- Numeric (0-9 plus -)
- Shifted (A, C, D, etc. on lower part).

(11) SHIFT KEY: Shifts keyboard (10) to shifted mode (A, C, D, etc). When pressed, light in center of key is on.

(12) CLEAR ENTRY: Clears previous entry if EXEcute Key (13) not pressed.

(13) EXECUTE KEY: Implements commands and clears keyboard.

Figure 41. Option 110 - Front Panel Features Used With Assembly

EXAMPLES - ACTUATOR ASSEMBLY COMMANDS

For the Option 110 actuator, any combination of channels can be opened or closed simultaneously. As shown in the commands chart, primary commands for the actuator are DC slot#, chan#; DO slot#,chan#; and DW slot#, octal. Remember that ''open'' means that the NC contact of the relay is connected to common and ''closed'' means that the NO contact is connected to common.

Digital Open (DO) and Digital Close (DC) are used to open or close specific channels, while leaving channels not specified in their previous state. For example, to close channels 4 and 5 for an actuator in slot 3, the command is DC3,4,5. With this command, relays in channels 0,1,2,3,6 and 7 remain in their previous state (opened or closed).

The Digital Write (DW) command, in contrast, affects the state of all the relays in the assembly. For example, the octal value for relays 4 and 5 only closed (digital 0000 0000 0011 0000) is 060. So, to close channels 4 and 5 and simultaneously open all other channels for an actuator in slot 2, the command is DW2,060.

With the DW command you must use an octal value to represent the desired state AFTER the command is executed. For example, assume that all relays in an assembly are closed. Then, DW slot#,060 opens all relays except channels 4 and 5 (digital 0000 0000 0011 0000). In contrast, DO slot#,4,5 opens ONLY channels 4 and 5, with all other relays remaining closed (digital 1111 1111 1100 1111).

Octal values for the DW command range from 0 to 177777. The following chart shows how to determine the octal value for a specified digital state. See Chapter 2 for details.

OCTAL NUMBERS FOR ACTUATOR CHANNELS

chan#	15	14 13 12	11 10 9	8 7 6	5 4 3	2 1 0
octal	MSD	2nd #	3rd #	4th #	5th #	LSD

For example, to set channels 5, 7, 10 and 15 closed and the remaining channels open, the command is DW slot#, 102240 where the octal value is derived as follows.

chan#	15	14 13 12	11 10 9	8 7 6	5 4 3	2 1 0
chan state	1	0 0 0	0 1 0	0 1 0	1 0 0	0 0 0
octal value	1	0	2	2	4	0

Controlling the Assembly for Actuator Mode

Using the DIGITAL commands shown, you can control the assembly in the actuator mode either from the front panel or from a controller. In addition, you can read the status of the relays at any time by using the DR or DL commands.

EXAMPLE - SEQUENTIAL VOLTAGE SWITCHING

For this example, we want to switch a voltage E from load 1 to load 2 for each of the 16 channels of an actuator in slot 3, as shown in Figure 42. In addition, we want to check that the switching actually took place, so we'll read the status of the relays after each channel is switched. A sample program follows which shows a way to accomplish these actions.

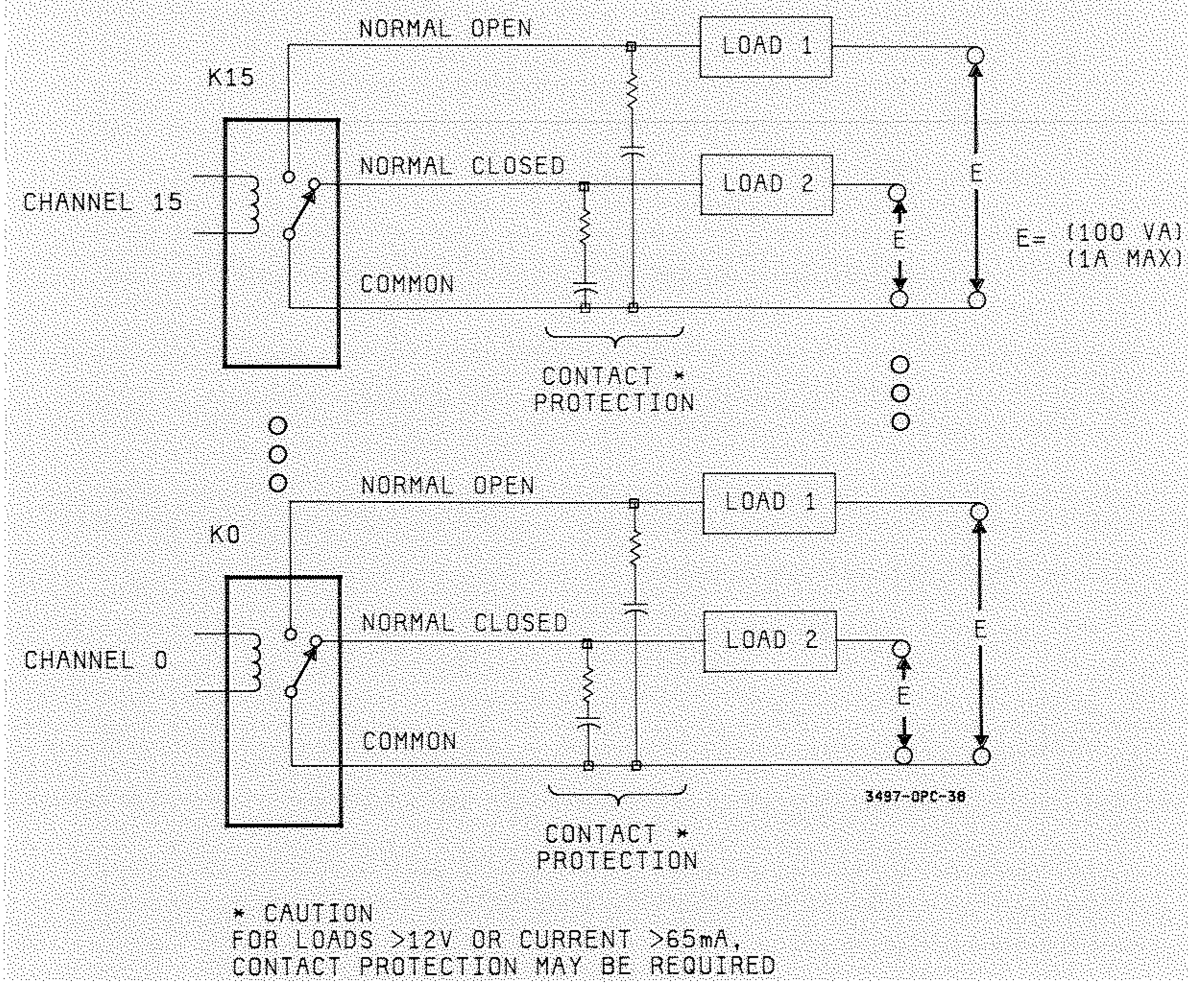


Figure 42. Option 110 - Sequential Voltage Switching Example

In this program, all relays are first opened (NC contact connected to common) and sequentially switched, starting with channel 0. If the channel switches (relay closes), the program prints out the time the channel switched and advances to the next channel. If a relay does not close, the program prints an error message and halts.

Program

```
 10 CLEAR 709
 20 OUTPUT 709; ''TD0629130000''
 30 PRINT ''SEQUENTIAL VOLTAGE SWITCHING''
 40 PRINT
 50 PRINT ''TIME'';TAB(20);''CHANNEL''
 60 PRINT

 70 FOR I = 0 TO 15
 80 OUTPUT 709; ''DC3'';'','';I
 90 OUTPUT 709; ''DO3'';'','';I-1
100 OUTPUT 709; ''DR3''
110 ENTER 709; A$
120 X = OTD(A$)
130 IF ABS (X) = 2    I THEN GOTO 160
140 PRINT ''CHANNEL'';I; ''DID NOT CLOSE''
150 GOTO 210

160 OUTPUT 709; ''TD''
170 ENTER 709; T$
180 PRINT T$;TAB (21); I
190 WAIT 1000
200 NEXT I
210 END
```

Lines	Description
10-20	Line 10 opens all relays and line 20 sets the time of day to June 29, 1:00:00 PM (Option 230 format).
70-90	Line 70 sequences program from channel 0 to channel 15. Line 80 closes channel I and Line 90 opens the previously closed channel (I-1).
100-130	The value returned to A$ by the DR command is in octal, so line 120 performs an octal to decimal (OTD) conversion. In line 130, the decimal value is compared to an expected (2 I) value, since 2 I = the decimal value for the Ith relay closed.
140-200	If the value returned equals the expected value, the program prints the time of day and the channel number closed for each of the 16 channels. Line 160 reads the time of day for each channel closure. If the value returned does not match the expected value, an error message is printed out and the program halts.

A typical printout if all channels close is:

```
SEQUENTIAL VOLTAGE SWITCHING

        TIME          CHANNEL

   06:29:13:00:02        0
   06:29:13:00:04        1
         .               .
         .               .
   06:29:13:00:31       15
```

If, for example, channel 1 does not close, a typical printout is:

```
SEQUENTIAL VOLTAGE SWITCHING

        TIME          CHANNEL

   06:29:13:00:02        0
   CHANNEL 1 DID NOT CLOSE
```

Controlling the Assembly for Digital Output Mode

The primary commands used to control the assembly for the digital output mode are the DR and DL commands. When a DR slot# or DL slot# command is sent, the octal value returned is a number from 0 (all channels open) to 177777 (channels 0 through 15 true or ''1'').

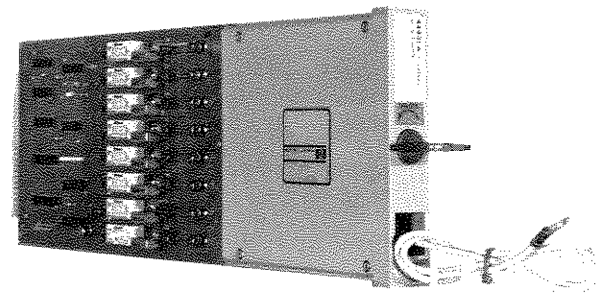
The Digital Read (DR) command causes the 3497A to continuously return data, while the Digital Load (DL) command provides a single read/command. You can enter the commands either from the front panel or from a controller. The status of the data bits can be displayed on the front panel or printed out.

EXAMPLE - READ DIGITAL SLOT

For example, assume that a digital input assembly in slot 2 is connected to a data source. To read the status of the input data, send ''DR2''. An example program follows which reads input data in slot 2 and prints the results (in octal value of channel bits true).

```
10 CLEAR 709
20 OUTPUT 709; ''DR2''
30 ENTER 709;A
40 PRINT A
50 END
```

OPTION 115



8 Channel High Voltage Actuator Assembly

Introduction

The -hp- Model 44431A High Voltage Actuator assembly (Option 115) is an 8 channel actuator which can be used to switch voltages up to 252 volts RMS and currents up to 2 amperes peak. Each channel consists of an individually fused and protected normally open dry relay. Contacts are opened only on command or on loss of power.

Each channel can be closed individually or any combination of channels can be closed simultaneously. In addition, the assembly contains a readback circuit so that the status of each channel can be determined. Because of its high voltage capability, you can use the Option 115 assembly to switch power line voltages to small motors, alarm bells and lights, motor starters and solenoids.

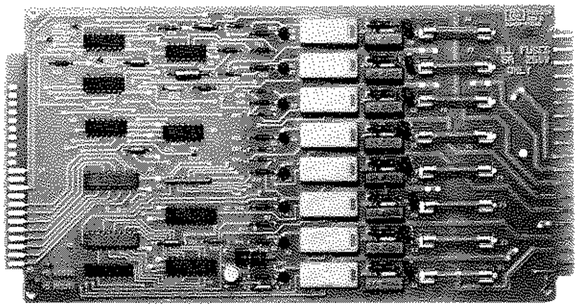
Description

As shown in Figure 43, the Option 115 assembly consists of an actuator card, a terminal card and a grounding strap for connecting the assembly to customer (earth) ground.

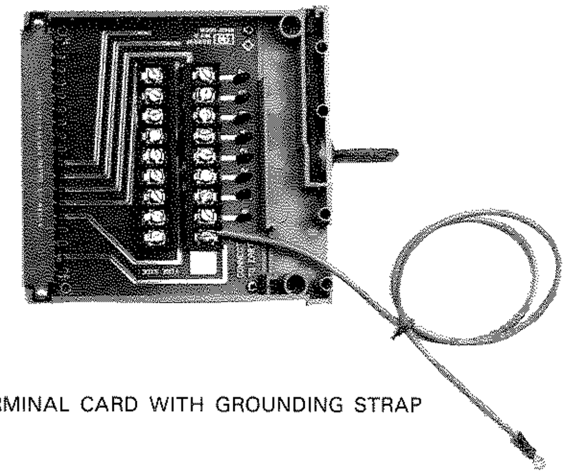
The actuator is an 8 channel high voltage switch which can be used to close or open circuit paths for voltages up to 252 VRMS (AC) at 2 amps or 48 VDC at 2 amps. Because of its high voltage switching capabilities, the actuator is ideal for switching line voltages to alarm bells, motor starters and solenoids where total power requirements are less than 500 VA per channel (AC) or less than 60 VA per channel (DC).

The actuator card consists of 8 identical channels. Each channel consists of an individually fused and protected normally open dry relay. A contact in parallel with the customer contact allows readback of relay status. Each channel can be closed individually or any combination of channels on an assembly can be closed simultaneously.

Each channel is individually fused at 5 amps and contains an RC network for relay contact protection. In the power on condition, all relays are open. After relays are closed, contacts are opened only on command or on loss of power. A maximum of 680 channels can be attached to actuator outputs using 3498A Extenders (5 cards in the 3497A plus 10 cards in each of 8 extenders).



ACTUATOR CARD



TERMINAL CARD WITH GROUNDING STRAP

Figure 43. Option 115 · High Voltage Actuator Assembly

Simplified Operation

In typical applications (see Figure 44), actuator channels are connected to external circuits at the terminal card outputs. In the power on state of the 3497A, the relays are open which opens the load circuit. When a command is sent from the 3497A to the actuator, relays are closed for desired channels, closing the circuits for these loads.

Relay status (open or closed) is sent to the 3497A via readback circuits for front panel display and/or to the interface bus. The readback circuits are actuated in parallel with the load contacts, but are electrically separate. Thus, no load current flows through the readback contacts and they have no effect on load operation.

The actuator card has an RC relay contact protection circuit in each channel (R = 47 ohms, C = 0.047 μF). With the protection network, maximum leakage current at 250V and 60Hz is 6mA RMS. The protection network can be removed from individual channels by removing appropriate jumpers on the actuator card. With no protection network, maximum leakage current is 1mA RMS at 250V and 60Hz.

Any combination of channels can be closed simultaneously. Programming and execution of a single or multiple channel closure or open requires 40 ms. Repetitive changes of the same actuator assembly require a minimum of 1.5 sec. Changes of the same assembly up to 25 per second can be jumper enabled but will result in decreased relay lifetime when switching full loads.

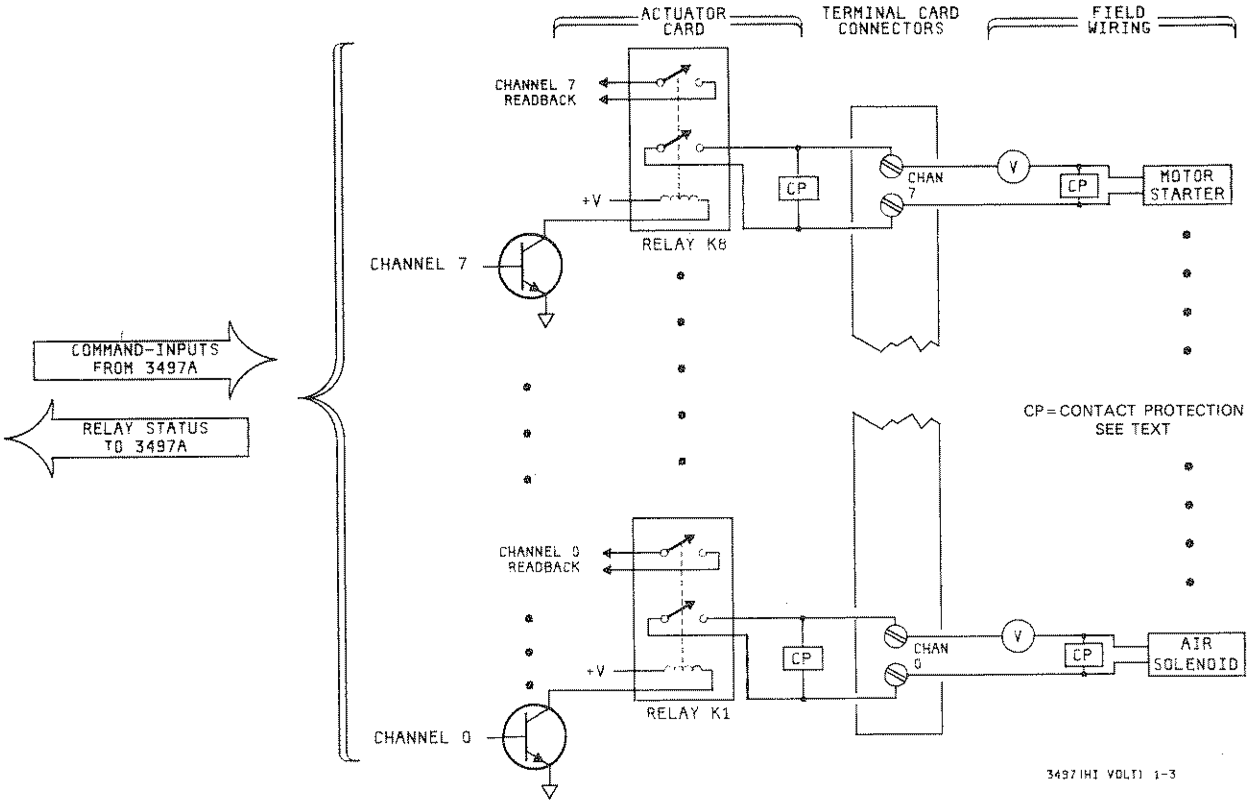


Figure 44. Option 115 · Actuator Typical Applications

Controlling the High Voltage Actuator Assembly

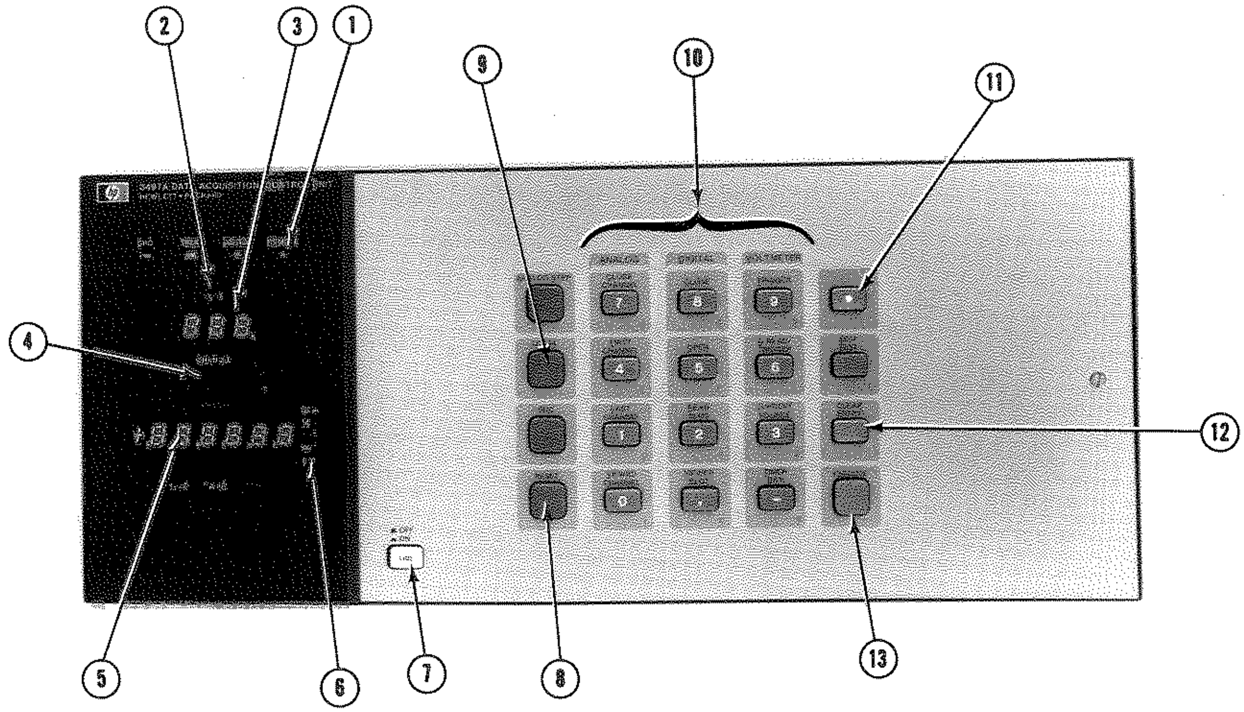
The high voltage actuator assembly is controlled by DIGITAL commands, as shown in the following chart. See the Command Directory in Chapter 6 for details and examples.

Front Panel Features Used With the Assembly

Figure 45 shows the front panel keys and display used with the assembly. Since the Option 115 assembly is a digital assembly, only the digital display is used. The slot number addressed is shown on the 3-digit display and the 6-digit display shows the octal value of data requested.

COMMANDS FOR THE HIGH VOLTAGE ACTUATOR ASSEMBLY

Command	Description
DC slot#,chan#,... slot# = 0 to 89 chan# = 0 to 7	DIGITAL CLOSE Closes relay contacts in channels addressed. From one to 8 channels of an actuator in slot addressed may be closed with a single command. Channels not listed in the command remain in their previous state.
DO slot#,chan#,... slot# = 0 to 89 chan# = 0 to 7	DIGITAL OPEN Opens relay contacts in channels addressed. From one to 8 channels of an actuator in slot addressed may be opened by a single command. Channels not listed in the command remain in their previous state.
DL slot# slot# = 0 to 89	DIGITAL LOAD Returns current state of the 8 relays (open or closed) of an actuator in slot addressed. Value returned is octal representation of the state. Only one reading/command is returned.
DR slot# slot# = 0 to 89	DIGITAL READ Same as the DIGITAL LOAD command, except that repeated reads of the actuator card are made and updated on the display and on the interface bus.
DV slot# slot# = 0 to 89	DIGITAL VIEWED SLOT Dedicates the 3497A front panel display to a slot. Exit from this mode by using the command DV without the slot designation.
DW slot#, octal slot# = 0 to 89 octal = 0 to 377	DIGITAL WRITE Outputs an octal value to all channels in slot addressed. Octal value corresponds to desired digital state of the relays (digital 1 = closed, 0 = open). DW command affects the entire assembly, while DC and DO affect only the channels specified.
SR slot#,0 slot# = 0 to 89	SYSTEM READ Reads the ''signature'' of the assembly in slot addressed. The high voltage actuator has signature 000041 OCT.



Displays

(1) REMOTE = LED ON for control by EXT controller, OFF for local (3497A) control.

(2) SLOT: ON *only* when digital cards accessed (ON for HV act).

(3) SLOT DISPLAY: 3-digit readout of slot accessed.

(4) CHANNEL INDICATORS: Displays contents of channel 0 thru 7 of actuator card. ON → relay is closed.

(5) NUMERIC DISPLAY: 6-digit display. Shows octal equivalent of digital channels status. (i.e., 000377 OCT = channels 0 thru 7 on; 11111111 binary.)

(6) DISPLAY FUNCTIONS: Only OCT and ENT used for HV Act. *OCT* shows display is octal representation of digital channels. *ENT* means data can be entered.

Keys

(7) LINE: AC power on/off switch.

(8) RESET: Clears 3497A, sets all relays to open.

(9) LOCAL: Puts 3497A in local mode of operation.

(10) ALPHA-NUMERIC KEYBOARD

3 functions for each key
- Primary (upper part)
- Numeric (0-9 plus, -)
- Shifted (A, C, D, etc. on lower part).

(11) SHIFT KEY: Shifts keyboard (10) to shifted mode (A, C, D, etc.). When pressed, light in center of alpha key is ON.

(12) CLEAR ENTRY: Clears previous entry if execute key (13) not pressed.

(13) EXECUTE KEY: Implements commands and clears keyboard.

Figure 45. Option 115 - Front Panel Features Used With Assembly

EXAMPLES - ACTUATOR ASSEMBLY COMMANDS

In the Option 115 actuator, any combination of channels can be opened or closed simultaneously, by opening or closing the relay(s) for the channel(s) desired. As shown in the commands table, primary commands for the high voltage actuator are DC slot#, chan#; DO slot#,chan#; and DW slot#, octal.

Digital Open (DO) and Digital Close (DC) are used to open or close specific channels, while leaving channels not specified in their previous state. For example, to close channels 4 and 5 for an actuator in slot 3, the command is DC3,4,5. Note that relays in channels 0,1,2,3,6 and 7 remain in their previous state (opened or closed).

The Digital Write (DW) command, in contrast, affects the state of ALL the relays in the assembly. For example, the octal value for relays 4 and 5 only closed (digital 0011 0000) is 060. So, to close channels 4 and 5 and simultaneously open all other channels for an actuator in slot 2, the command is DW2,060.

With the DW command you must use an octal value to represent the desired state AFTER the command is executed. For example, assume that all relays in an assembly are closed. Then, DW slot#,060 opens all relays except channels 4 and 5 (digital 0011 0000). (In contrast, DO slot#,4,5 opens ONLY channels 4 and 5, with all other relays remaining closed (digital 1100 1111). See the following chart.

CHANNEL STATE AFTER A DW slot#,060 COMMAND

chan#	7	6	5	4	3	2	1	0
chan state	0	0	1	1	0	0	0	0
octal value	0			6			0	

EXAMPLE - MOTOR STARTER APPLICATION

A typical application for the high voltage actuator is to turn on motor starters. The actuator can directly switch motors up to ⅔ horsepower. However, the range of motors it can handle can be greatly increased by using motor starters. The actuator can be used to control the motor starter, essentially supplying the signals to turn the starter on.

Although motor starters do not have standard control inputs, the high voltage actuator will control common motor starters up to NEMA class 5. This starter, in turn, will handle motors up to 100 horsepower (220V) or 200 horsepower (440-550V).

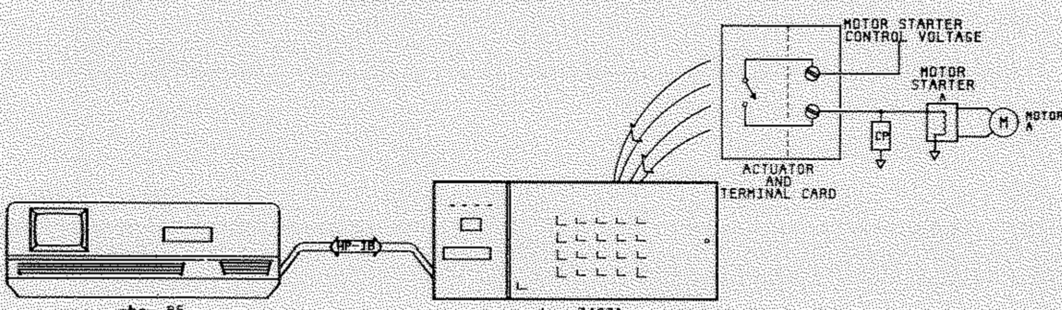
As an example use of the high voltage actuator to control motor starters, let's say that an assembly process requires that three 80 horsepower motors be turned on by using motor starters, according to the following sequence. For this example, we'll assume that each motor is stopped by an external control after the run time shown in the chart.

MOTOR STARTER	CHANNEL NUMBER	RUN TIME (MINUTES)	SEQUENCE NUMBER
A	0	5	1
B	1	6	2
C	2	4	3

A simplified connection diagram and sample program for this sequence follow. In the program, channel 0 relay is closed, thus supplying voltage to motor starter A which starts motor A. Five minutes later, channel 0 relay is opened, thus removing power from motor starter A.

Then, channel 1 relay closes, waits six minutes and opens. Channel 2 relay then closes, waits four minutes and opens, completing the first cycle. Cycles two and three are then completed, and the process stops.

If the (optional) DR command is used, relay status is displayed on the 3497A front panel. If the relays do not open or close as required, the program prints a ''RELAY FAILED'' message and halts the operation.



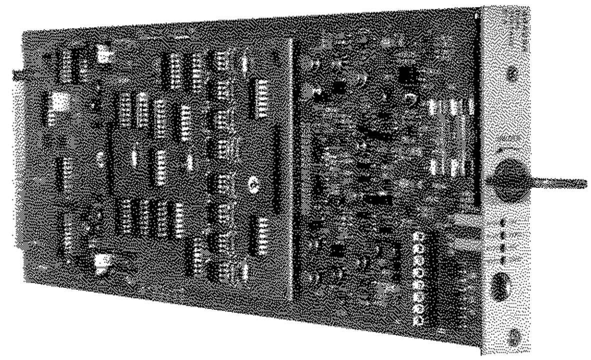
Program

```
10 PRINT "MOTOR STARTER"
20 PRINT
30 PRINT
40 CLEAR 709
50 FOR I = 1 TO 3

60 OUTPUT 709; "DC2,0DR2"
70 ENTER 709;A
80 IF A<>1 THEN 290
90 WAIT 300000
100 OUTPUT 709; "DO2,0"
110 ENTER 709;B
120 IF B<>0 THEN 290

130 OUTPUT 709; "DC2,1"
140 ENTER 709;C
150 IF C<>2 THEN 290
160 WAIT 360000
170 OUTPUT 709; "DO2,1"
180 ENTER 709;D
190 IF D<>0 THEN 290

200 OUTPUT 709; "DC2,2"
210 ENTER 709;E
220 IF E<>4 THEN 290
230 WAIT 240000
240 OUTPUT 709; "DO2,2"
250 ENTER 709;F
260 IF F<>0 THEN 290

270 NEXT I
280 GOTO 300
290 PRINT "CHAN";I; "RELAY FAILED"
300 END
```

Lines	Description
40-50	Line 40 opens all relays and line 50 repeats cycle 3 times.
60-120	Sequence closes channel 0, waits 5 minutes then opens channel 0. If relay does not open or close, program prints CHAN 0 RELAY FAILED and halts. DR2 in line 60 is optional command for front panel display.
130-190	Repeats sequence in lines 60-120 for channel 1, except for a 6 minute delay after relay closure.
200-260	Repeats sequence in lines 60-120 for channel 2, except for a 4 minute wait after relay closure.
290	If a relay does not open or close properly, number of channel which failed is printed out.

OPTION 120

Dual Output, 0 to ± 10 V Voltage D/A Converter



Introduction

The Option 120 assembly consists of two 0 to ± 10V programmable voltage sources (two channels). Each channel outputs a DC voltage with programmable range from -10.2375 volts to +10.2375 volts in increments of 2.5 millivolts.

Each voltage source is isolated from the other and from ground which breaks possible ground loops and permits control of devices floated up to 170 volts above ground. You can use the Option 120 assembly to provide a programmable test stimulus or to control voltage programmed devices such as power supplies and VCOs.

Description

As shown in Figure 46, the Option 120 Voltage D/A Converter consists of a single board with a voltage source terminal block and a piggy-back board. The voltage source terminal block has connectors for HI, LO, +SENSE and - SENSE for each of two channels (channel 0 and channel 1).

The assembly is a programmable constant-voltage source which has an output range from -10.2375 V to +10.2375 V in 2.5 mV increments. This means that (for example) if you program the assembly to output +5.0000 V to your load, +5.0000 V will be available at the load, regardless of lead resistance or other voltage drops between the assembly and the load (when the SENSE feature of the assembly is used).

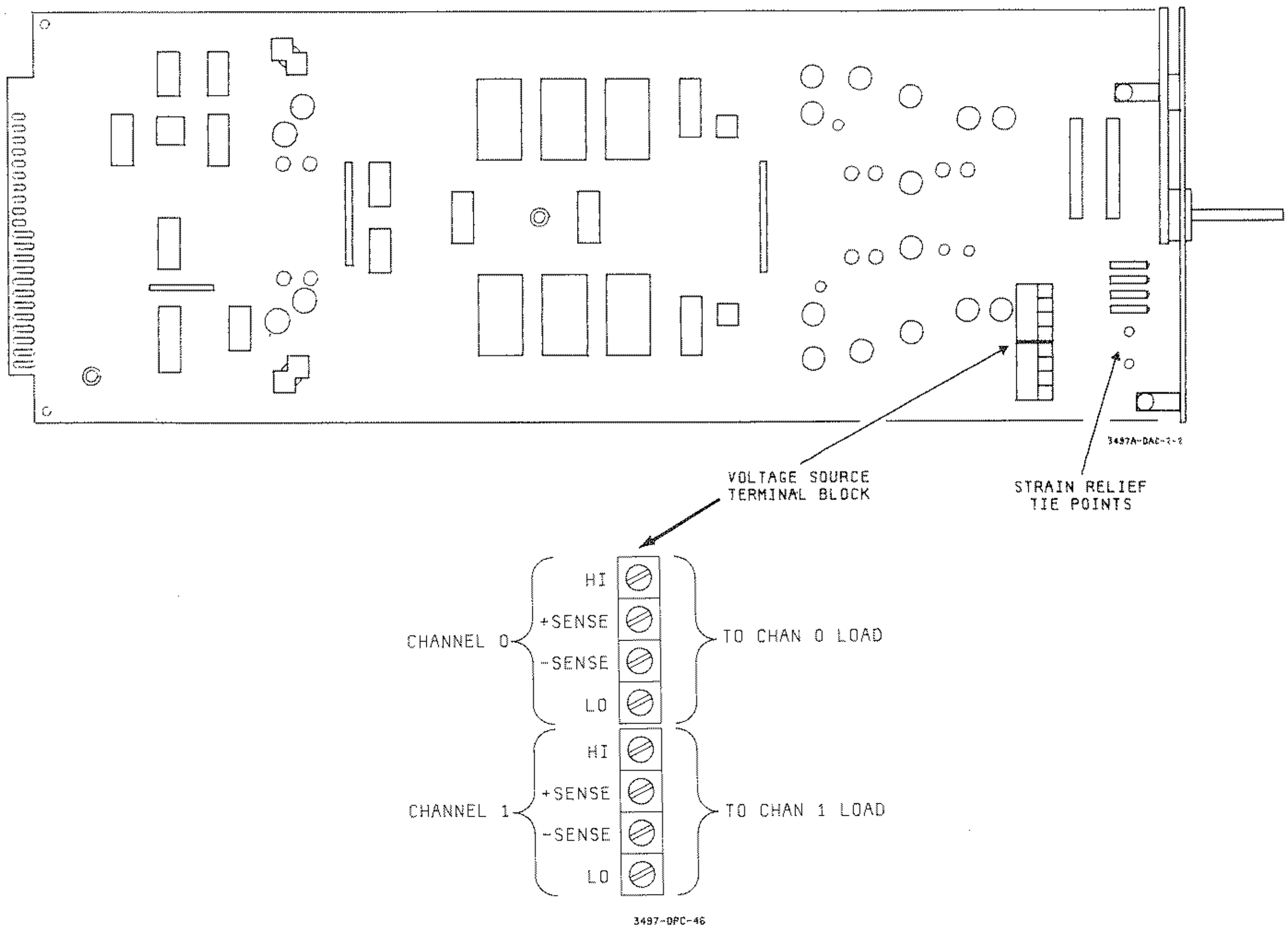


Figure 46. Option 120 · Dual Output, 0 to ± 10 V Voltage D/A Converter (VDAC)

Remote Sensing

The remote sensing feature of the Option 120 assembly is especially valuable when a constant, accurate voltage is required at the load. To see why this is so, consider the simplified circuit in Figure 47 (a) which does not use SENSE leads.

In this circuit, we've programmed the Option 120 assembly (which we'll call the VDAC from now on) to output +1.0000 V to a load resistance R. However, because of lead resistance R_l, the actual voltage to R is less than 1.0000 V because of the voltage drop across the leads.

Now, if we add remote sensing (+ SENSE and - SENSE leads) as shown in Figure 47(b), we can measure the actual voltage across R. With remote sensing, the VDAC automatically adjusts its output to compensate for the IR drop in the leads. For example, with remote sensing if you program the VDAC for a +1.0000V output and the IR drop in the leads is 0.1000 V, the VDAC will output +1.1000V so that the load voltage remains constant at +1.0000V.

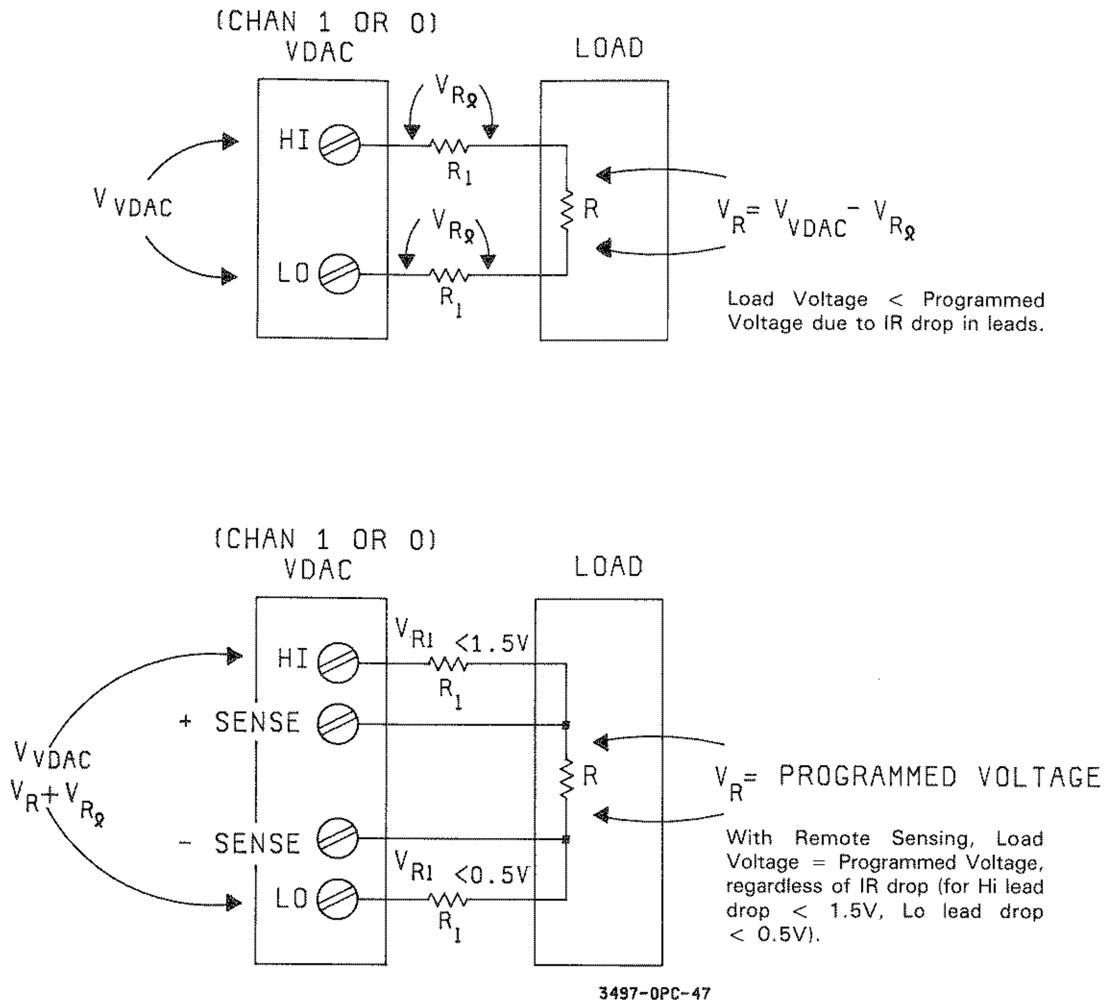


Figure 47. Option 120 · VDAC Remote Sensing

Monotonicity

Another important feature of the VDAC is monotonicity. The VDAC has monotonicity over its operating range which guarantees that the output will never change in a direction different than that programmed. For example, if the VDAC is set for a 5 mV output and is then programmed for a 10 mV output, the actual output will not be less than 5 mV. Or, if the VDAC is set for 5 mV and is then programmed for a 2.5 mV output, the actual output will not be greater than 5 mV.

Controlling the Assembly

To control the VDAC, only one command [AO slot#,chan#,value] is required. In this command, slot# refers to the slot in which the assembly is located, chan# refers to the channel to be output (0 or 1) and value is a digital value input to the assembly which programs the VDAC for a specific output. For example, AO 3,0,160 programs a VDAC in slot 3 to output +0.160 V from channel 0.

To provide a desired voltage output to your load circuit, the VDAC is programmed using the AO slot#,chan#,value command, where the command parameters have the following meanings:

COMMAND FOR THE VOLTAGE D/A CONVERTER

Command	Description
AO slot#,chan#,value	ANALOG OUTPUT
slot# = 0 to 4 and 10 to 89 chan# = 0 or 1 value = 0 to ± 10238	Programs the VDAC to output a specified voltage from -10.2375V to +10.2375V in 2.5 mV increments.

For the AO command, the value can be programmed from 0 to ±10238 in units of millivolts. However, the voltage output is in units of 2.5 mV, so for programmed values other than integer multiples of 2.5 mV, the 3497A will round off the value to the nearest integer multiple of 2.5 mV.

For example, if the command AO3,0,1 is entered, the 3497A rounds the "1" to "0" and sends this to the VDAC, so no output is generated. If AO3,0,3 is sent, the VDAC generates a 2.5 mV output on channel 0.

To program a negative voltage output, the form is AO slot#, chan#, -value (i.e. AO3,1,-40 causes the VDAC to output -0.040 volts on channel 1). The following table shows the output voltage for selected program values. For example, AO slot#,chan#,160 outputs 0.160 volts on slot and chan selected.

NOTE

Slots 5 through 9 do not exist for the 3497A or 3498A. Do not attempt to use these slot numbers as spurious voltages may be generated.

VDAC OUTPUTS FOR SELECTED COMMAND VALUES

AO Command Value	VDAC Output (V)
0	0.0
2	0.0025
5	0.0050
10	0.0100
20	0.0200
40	0.0400
80	0.0800
160	0.1600
320	0.3200
640	0.6400
1280	1.2800
2560	2.5600
5120	5.1200

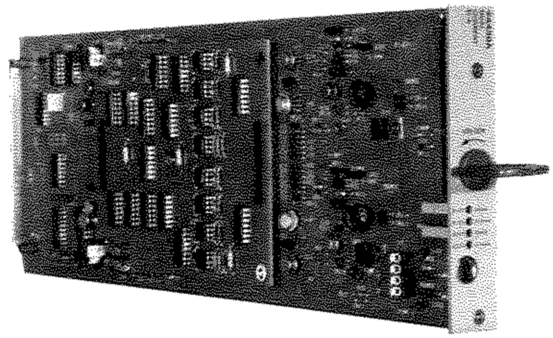
EXAMPLE - SET VDAC FOR VOLTAGE OUTPUT

The following program sets the VDAC to output 120 mV on channel 0 of an assembly in slot 4.

```
10 CLEAR 709
20 OUTPUT 709; ''AO4,0,120''
30 LOCAL 709
40 END
```

OPTION 130

Dual Output, 0-20 mA/ 4-20 mA Current D/A Converter



Introduction

The Option 130 assembly provides two 0 - 20 mA or 4 - 20 mA programmable current sources. Each channel outputs a DC current with programmable range from 0 to 20.475 mA in 5 μA increments (for the 0-20 mA range) or from 4 to 20.380 mA in 4 μA increments (for the 4-20 mA range).

Each current source is isolated from the other and from ground which breaks possible ground loops and permits control of devices floated up to 170 volts above ground. Each source can be configured to operate in the 0-20 mA or 4-20 mA range.

Option 130 assemblies, especially when the 4 - 20 mA range is used, can be used as transmitters in an industrial current loops. Each output will drive an industrial current loop with up to 600 ohms of total loop resistance.

Description

As shown in Figure 48, the Option 130 Current D/A Converter consists of a single board with a current source terminal block and a piggy-back board. The current source terminal block has connectors for a current source (SOURCE) and current sink (SINK) for each of two channels (channel 0 and channel 1).

The assembly is a programmable constant current source which has an output range from 0 to 20.475 mA (for the 0-20 mA range) or from 4 to 20.380 mA (for the 4-20 mA range). This means that (for example) if you program the assembly to output 10.000 mA to your load, 10.000 mA will be available at the load, regardless of voltage drop across the load as long as the assembly compliance voltage of 12V is not exceeded.

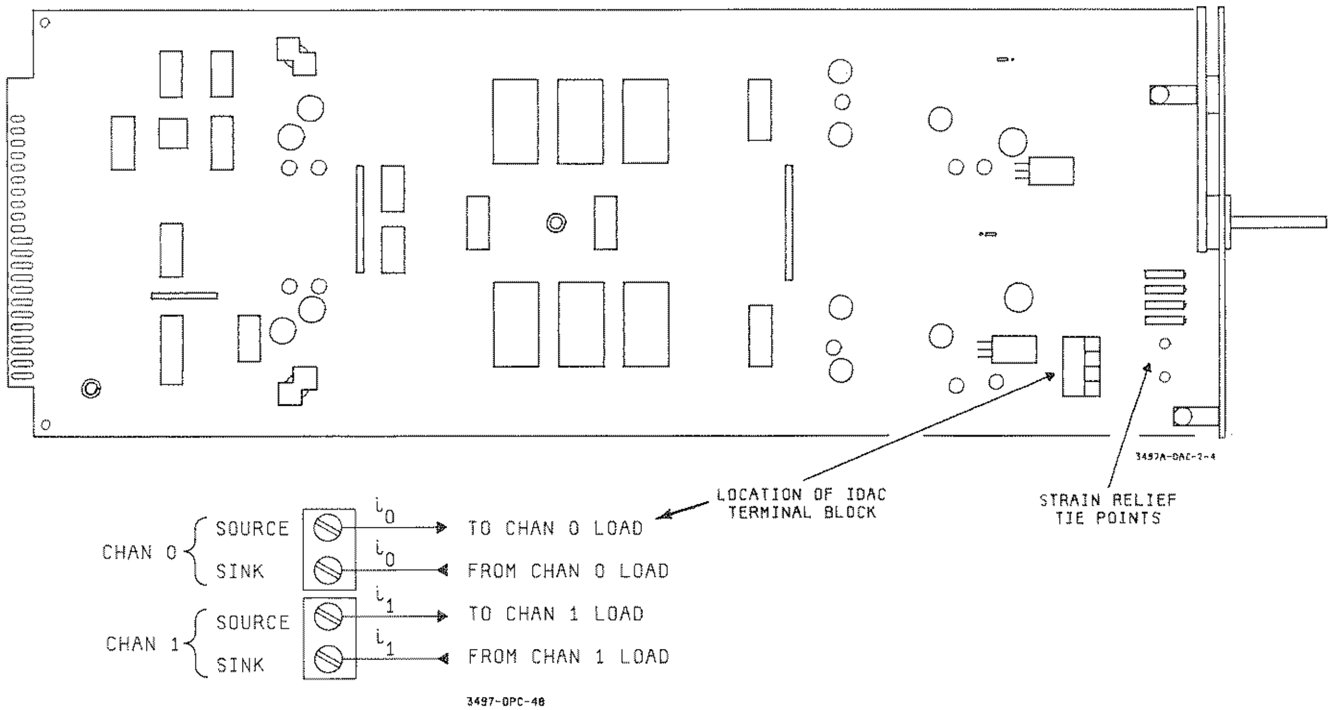


Figure 48. Option 130 - Dual Output, 0-20 mA/4-20 mA Current D/A Converter (IDAC)

Compliance Voltage

The Option 130 assembly (which we'll call the IDAC from now on) is a constant current source for 0-20 mA range, as long as the compliance voltage of 12 volts is not exceeded. As shown in Figure 49, this means that the total voltage between the SOURCE and SINK terminals must not exceed 12 volts for the IDAC to supply constant current in the 0 - 20 mA range.

Since the compliance voltage equals the total circuit resistance times the output current, this means that for a 20 mA output the maximum load resistance for the IDAC is 600 ohms (and may be less if lead resistance is relatively high). For example, in Figure 49 if R_l = lead resistance = 0.5 ohms in each lead and R_L = 600 ohms, R_T = 601 ohms and compliance voltage for 20 mA is 12.2V which exceeds the IDAC limit.

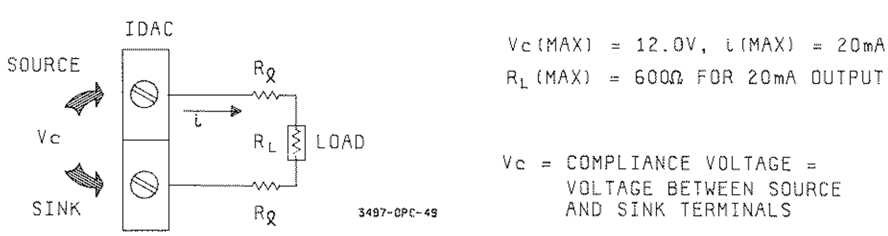


Figure 49. Option 130 - IDAC Compliance Voltage

Monotonicity

Another important feature of the IDAC is monotonicity. The IDAC has monotonicity over its operating range which guarantees that the output will never change in a direction different than that programmed. For example, if the IDAC is set for a 5 mA output and is then programmed for a 10 mA output, the actual output will not be less than 5 mA. Or, if the IDAC is set for 5 mA and is then programmed for a 2 mA output, the actual output will not be greater than 5 mA.

Controlling the IDAC Assembly

To operate the IDAC, only one command [AO slot#,chan#,value] is required. In this command, slot# refers to the slot in which the assembly is located, chan# refers to the channel to be output (0 or 1) and value is a digital value input to the assembly which programs the IDAC for a specific output, depending on the range (0-20 mA or 4-20 mA) selected.

For example, the command AO slot#,chan#,160 sets the IDAC for a constant current output of 4.256 mA for the 4-20 mA range, but sets the IDAC for an output of 0.160 mA in the 0-20 mA range. The IDAC is factory set for the 0-20 mA range but can be jumper-enabled for 4-20 mA range on channel 0 or 1 or both.

To provide a desired current output to the load, the IDAC is programmed using the AO slot#,chan#,value command, where the command parameters have the following meanings:

COMMAND FOR THE CURRENT D/A CONVERTER

Command	Description
AO slot#,chan#,value slot# = 0 to 4 and 10 to 89 chan# = 0 or 1 value = 0 to 10238	ANALOG OUTPUT Programs the IDAC to output a specified current from 0 to 20.475 mA (0-20 mA range) or 4 to 20.380 mA (4-20 mA range).

The IDAC has two jumper-selectable output ranges: 0-20 mA or 4-20 mA. The IDAC is factory preset for the 0-20 mA range. The incremental step in the 0-20 mA range is 5 μA and is 4 μA in the 4-20 mA range. In either range, the current output is set by the ''value'' part of the AO command.

The IDAC is programmed in units of 0.01% of the "span" where the span is 20 mA for the 0-20 mA range and 16 mA for the 4-20 mA range. However, the output can change only in increments of 0.025% of span. The 3497A will round off the AO command value to the nearest integer multiple of 0.025% of span. If the 4-20 mA range is selected, the minimum output is 4.000 mA.

Note that it is possible to program more than 100% of range. For example, in the 0-20 mA range, programming a value of 10238 gives 102.38% of range or 20.475 mA. The following chart gives output currents for selected AO program values for both the 0 - 20 mA range and the 4 - 20 mA range. Note that the same AO command will give a different output for the 0-20 mA range and 4-20 mA range.

NOTE

The IDAC is factory set to the 0 to 20 mA range. Reconfiguring the assembly to the 4-20 mA range requires recalibration for output current accuracy.

SELECTED AO PROGRAM VALUES VS IDAC OUTPUTS

Program Value	IDAC Output	
	0-20 mA Range (mA)	4-20 mA Range (mA)
0	0.000	4.000
2	0.005	4.004
5	0.010	4.008
10	0.020	4.016
20	0.040	4.032
40	0.080	4.064
80	0.160	4.128
160	0.320	4.256
320	0.640	4.512
640	1.280	5.024
1280	2.560	6.048
2560	5.120	8.096
5120	10.240	12.192

EXAMPLES - PROGRAMMING THE IDAC

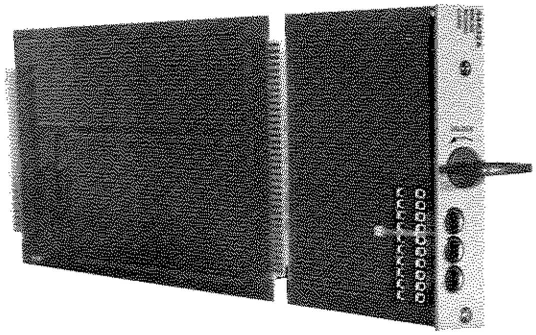
If the IDAC is configured for the 0 - 20 mA range, the span is 20 mA. Thus, a program value of 5000 [AO slot#,chan#,5000] is 50% of span and gives an output of 10.00 mA. So, send AO3,0,5000 to output 10.00 mA from channel 0 of an IDAC in slot 3 when the IDAC is in the 0-20 mA range.

If the IDAC is configured for the 4 - 20 mA range, the span is 16 mA. Thus, a program value of 5000 [AO slot#,chan#,5000] which is 50% of span gives an output of 12 mA (i. e. 50% of 16 mA = 8 mA + 4 mA minimum). So, send AO2,1,5000 to output 12.00 mA from channel 1 of an IDAC in slot 2 when the IDAC is in the 4-20 mA range.

The following program sets the IDAC to output 10.00 mA from channel 0 of an IDAC in slot 3 if the assembly is set for 0-20 mA range or to output 12.00 mA from channel 0 of an IDAC in slot 3 if the assembly is set for 4-20 mA range.

```
10 CLEAR 709
20 OUTPUT 709; ''AO3,0,5000''
30 LOCAL 709
40 END
```

OPTION 140



Breadboard Card Assembly

Introduction

In contrast to the other plug-in assemblies, Option 140 provides a "breadboard" for the design engineer or technician to custom design circuits for use with the 3497A or 3498A. You can use Option 140 when you have a specialized measurement or control application which can't be satisfied by using the other option card assemblies. Possible applications include matrix and RF switches; multichannel totalizers and stepper motor controllers.

Instructions can be sent to the Option 140 assembly and data read from the assembly at a rate of 20 individual operations per second using the -hp- 85 and 90 operations per second using the -hp- 9826 computer.

Description

The Option 140 assembly is shown in Figure 50. The board has three grid networks to mount components (ICs, resistors, capacitors, etc.). Two of the grids are labeled ANALOG SECTION and DIGITAL SECTION. Either grid, however, can be used for either type of circuit depending on requirements. The third grid can be used as an extension of the analog and/or digital grids, or (if a terminal card is to be used) can be cut off and removed.

Interconnected holes across both the top and bottom of each grid form buses for power supply and ground connections. The analog grid has two power supply and two ground buses which can be used to connect two power supplies. Or, by using two jumpers, a single power supply bus can be configured.

Analog Section

The analog section of the assembly pertains to 3497A backplane signals which are controlled by ANALOG commands (e.g. AC chan#,chan#,..). The control signals themselves are digital in nature. The result of executing an analog command, however, may return an analog result, such as a voltmeter reading using the HI COM, LO COM and GUARD COM lines. The analog section also contains two different power supply references.

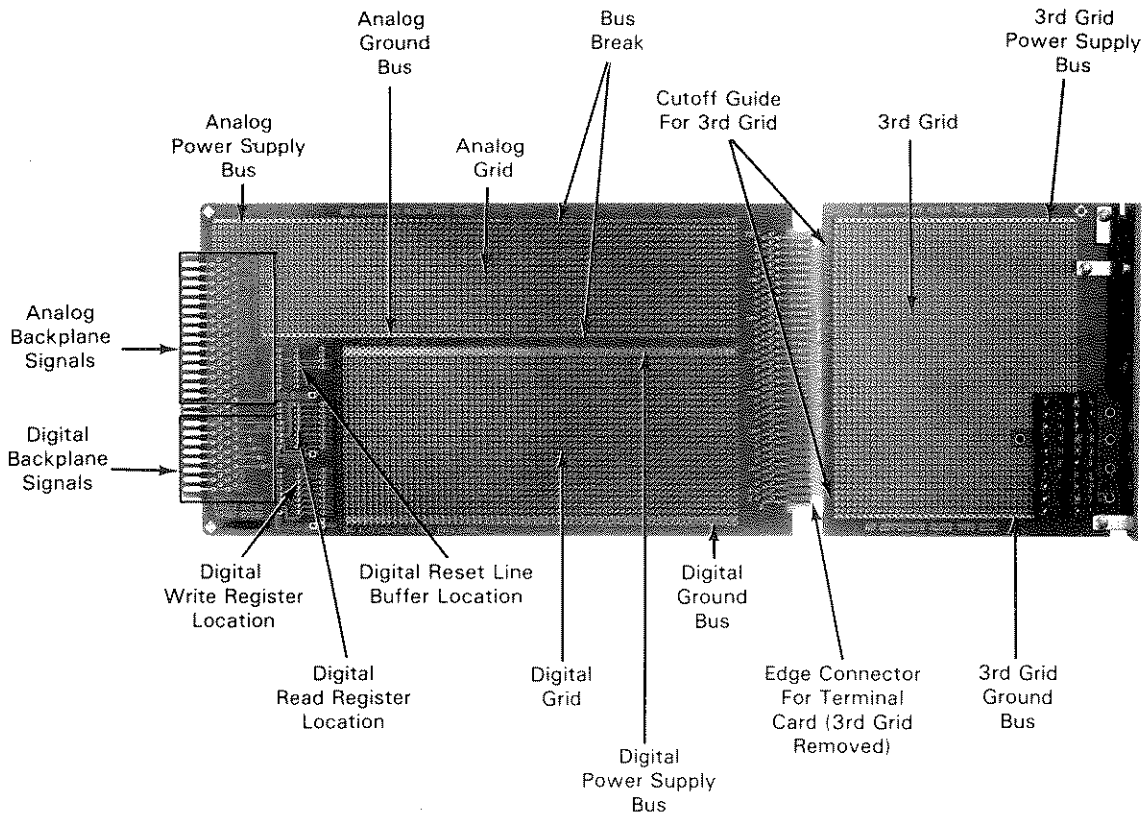


Figure 50. Option 140 - Breadboard Card Assembly

Digital Section

The digital section of the breadboard card assembly pertains to 3497A backplane signals which are controlled by one of three SYSTEM commands: SI, SR slot#,register or SW slot#,register#,octal value. DIGITAL commands or other SYSTEM commands will not be recognized by the digital section because, except for the three SYSTEMS commands shown previously, the 3497A software requires an identifying response from a digital assembly when a DIGITAL or SYSTEM command is executed.

Controlling the Breadboard Card Assembly

As mentioned, the digital section of the breadboard card assembly is controlled by three SYSTEM commands (SI, SR and SW) while the analog section of the assembly is controlled by the ANALOG commands. In this part, we'll first describe the response of the digital section to the three SYSTEM commands and then discuss the response of the analog section to the ANALOG commands.

Controlling the Digital Section

The following table shows the response of the digital section of the assembly to the three SYSTEM commands. The assembly does not respond to DIGITAL commands or to other SYSTEM commands, because when these other commands are used, the 3497A software requires an identifying response from the assembly being addressed.

DIGITAL SECTION RESPONSE TO SYSTEM COMMANDS

Command Name	Description	What Execution Does
SI	System Initialize	Activates Digital Reset Line.
SRn,r	System Read	Reads the register specified by r (0-7) from the slot specified by n (0-89). Activates the READ line. Data returned in octal (0-377).
SWn,r,v	System Write	Write to register r (0-7) on the card occupying slot n (0-89). Activates the WRITE line. Data sent in octal value v (0-377).
—	Reset or Power On. DCL or SDCL (HP-IB). Break or System Reset Serial I/O).	Activates Digital Reset Line.

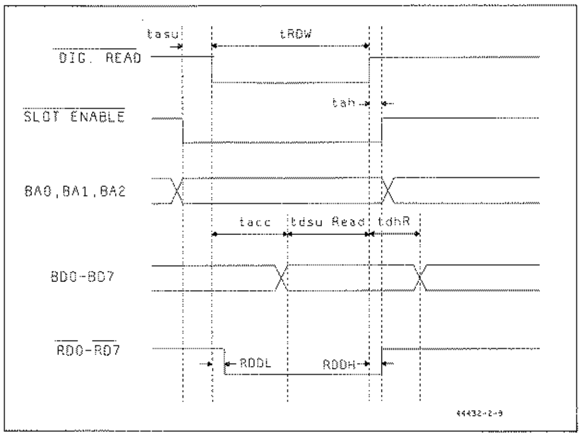
When using the SW and SR commands, the read and write cycle timing diagrams are important. See Figure 51 for these timing cycles. The SRn,r and SWn,r are the read and write commands used to specify slot address and register number. For example, to read the contents of register 6 from an assembly in slot 1, send ''SR1,6''.

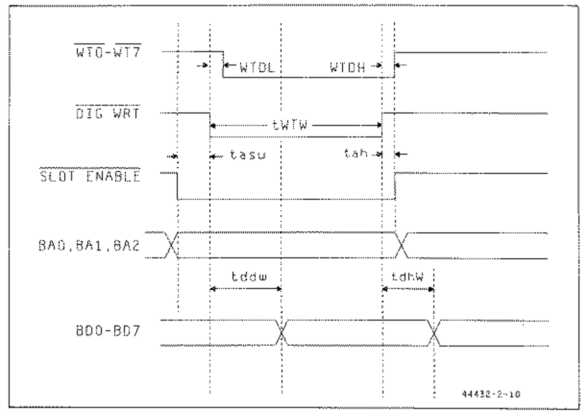
When a card is addressed, the SLOT ENABLE line goes true. The register number is specified by the address lines. For example, to specify register 6, the address lines would be:

BA2	BA1	BA0
1	1	0

The READ line goes true when the SR command is executed. The WRITE line goes true when the SW command is executed. If the two ICs labeled on the board (2 SN74LS138) are loaded, execution of SR2,5 activates the line labeled RD5 on the breadboard in slot 2. Likewise, execution of SW2,5 activates the line labeled WT5 on the breadboard in slot 2.

The data bus (BD0-BD7) is common to all cards in the same 3497A mainframe or 3498A Extender connected to the mainframe.





Name	Symbol	Min.	Typ.	Max.	Units
Decoder Delay	WTDH		17	26	nS
	RDDH		17	26	nS
	WTDL		25	38	nS
	RDDL		25	38	nS
Write Pulse Width	tRDW	450	500		nS
	tWTW	450	500		nS
Address Setup Time	tasu	100	125		nS
Address Hold Time	tah	30	40		nS
Data Delay From Write	tddw		250	300	nS
Data Setup Time From Read	tdsu	60		nS	
Data Hold Time (Read)	tdhr	20			nS
Data Access Time (Read)	tacc			300	nS
+ 5V Power Supply	Vcc	4.75	4.90	5.25	Vdc
Data, Read, Write, Enable Address Lines:					
High Level Output Current	IOH			40	μA
Low Level Output Current	IOL			.8	mA
High Level Output Voltage	VOH	2.4	3.0		V
Low Level Output Voltage	VOL		0.3	0.5	V
Power Supply Current	Icc			400	mA*
High Level Input Voltage	VIH	2.7	3.5		V
Low Level Input Voltage	VIL		.4	.5	V
High Level Input Current	IIH			20	μA
Low Level Input Current	IIL			-0.2	mA
Short Curcuit Output Current	IOS	-40		-225	mA**
Operating Temperature	TA	0		55	C***

* With no other power supply on card used.

** Only one output may be shorted at a time and the duration of the short may not exceed 1 second.

*** Ambient temperature for 3497A.

Figure 51. Option 140 - Read and Write Cycle Timing

Controlling the Analog Section

The following table shows the response of the analog section to ANALOG commands. Each analog section can input up to 20 channels, divided into A and B decades. Address lines UN0 through UN3 (see Figure 51) contain the BCD code of the selected channel. The BCD codes range from 0000 (channel 0) to 1001 (channel 9). When a channel is not specified, the address lines are all high (1111, an invalid BCD code). This represents an ''all channels open'' condition.

Analog Section Response to Analog Commands

Command Name	Description	What Execution Does
ACn	Analog Close	When ''ACn'' is executed, the channel number specified by n is placed on the UN0 - UN3 channel address lines in a BCD code. Example - Execution of ''AC5'' causes the following bit pattern to appear: UN3 UN2 UN1 UN0 0 1 0 1
ACn,n,n,n	Analog Close	Allows four channels to be closed simultaneously. Each channel must be in a different decade. See Latch Mode discussion.
AIn	Analog Input	Causes the 3497A to go to the channel specified by n (0-999), close the channel, and trigger the internal voltmeter (when VM is present).
AEn	Analog External Enable	n = 0: OFF n = 1: ON n = 2: Fast Scan This command enables and disables the External Increment BNC connector on the 3497A rear panel. When AE1 or AE2 are in effect, the negative going edge of a TTL pulse input to this BNC connector causes the next channel in sequence to close.
AS	Analog Step	Causes the next channel in sequence to close.
AR	Analog Reset	Execution of ''AR'' causes all channel address lines (UN0-UN3) to go to a high logic state. This represents an ''all channels open'' condition.

DECA is the decade A select line and DECB is the decade B select line. These lines go low to select the respective decade. For example, if the breadboard card is in slot 0, execution of the AC0 command activates the DECA line while execution of AC10 activates the DECB line.

Single channel opening and closure operations are performed with ''Break-Before-Make (BBM) synchronization. Multiple channel closures (up to 4) are performed in the Latch Mode. These two modes are described in the following paragraphs.

Break-Before-Make Synchronization

When a channel closure (AC chan#) command is executed, the unit lines all go high (an invalid BCD code) which tells all analog channels to open. The analog card with the closed channel then pulls the BREAK line low. This informs the mainframe and other assemblies which share this line that a channel opening is about to take place.

Other channel closures are not allowed until the closed channel has been opened. When the channel is opened, the BREAK line is released. This is important because, unless the BREAK line is released (goes high), there is no assurance that the previously closed channel has been opened.

The MAKE line is pulled low to inform the mainframe that a channel close command was detected and that the closing operation is in progress. The mainframe waits for the line to be released before proceeding with the next operation. This is important for relays because it prevents the mainframe from proceeding with operations faster that the relays can react. Figure 52 shows a typical Break-Before-Make channel scanning sequence.

Latch Mode

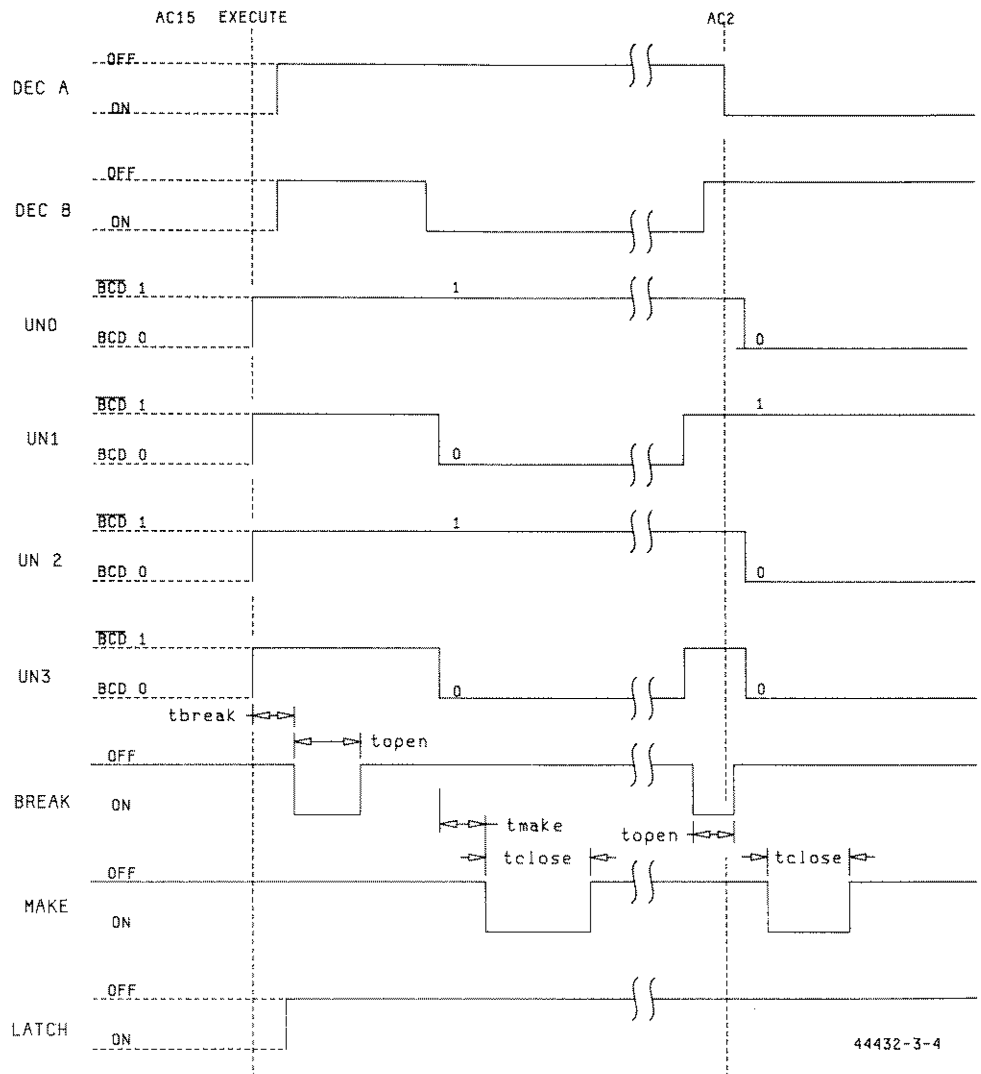
To enter the Latch mode, the LATCH line goes low. In this mode, multiple channel closures (up to 4 with one channel closed per decade) are permitted. For example, AC2,12,22,32 is a valid command, since it selects channels in four different decades, but AC2,3,4,5 is not.

The Latch mode is entered automatically (i.e. the LATCH line goes low) when multiple channel closures are specified. If multiple channel closures are attempted for the same decade, the 3497A BEEPS and the command is ignored.

Since there are only four channel address lines (UN0-UN3), circuitry must be provided to hold (or latch) the channel address information for a certain decade while a channel in another decade is specified. The timing diagram for a typical Latch Mode scanning sequence is shown in Figure 53.

NOTE

This diagram assumes that a channel is closed when "AC15" is executed.

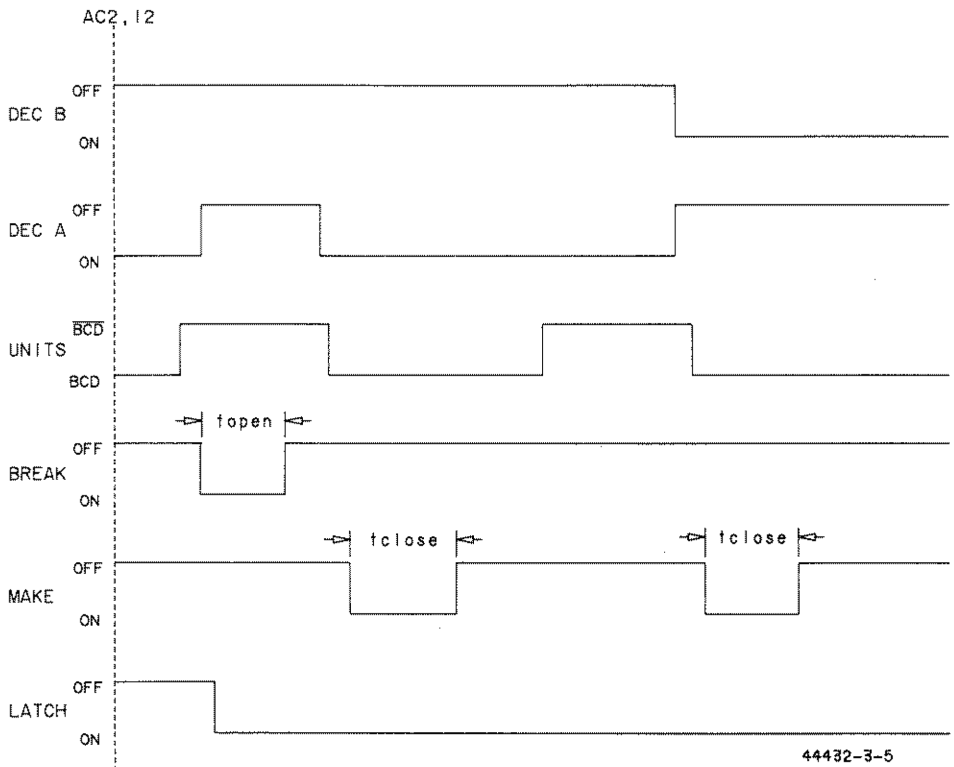


topen = time required to open a channel, if closed
tclose = time required to close a channel
tbreak, tmake = $\leq$ 10 μS

Figure 52. Option 140 - BBM Synchronization Typical Scan Sequence

NOTE

This diagram assumes that prior to execution of "AC2,12" a previous channel was closed.



tclose = time needed to close a channel
topen = time needed to open a channel

Figure 53. Option 140 - Latch Mode Typical Scan Sequence

Chapter 6
COMMAND DIRECTORY

INTRODUCTION

This chapter summarizes the six command groups (ANALOG, COUNTER, DIGITAL, SYSTEM, TIMER and VOLTMETER) used with the 3497A. The chapter is divided into two parts: POWER ON COMMAND SETTINGS and COMMAND DESCRIPTIONS. Power On Command Settings shows the command state when the 3497A is turned on.

COMMAND DESCRIPTIONS lists commands alphabetically by command group. In most cases, commands are identical for HP-IB or Serial Data operation. When a command has different interpretations for HP-IB or Serial Data, the command is shown twice. Three commands (SC, SL and SR) are unique to Serial Data.

The format for a typical entry in COMMAND DESCRIPTIONS follows. If a symbol appears in the upper right-hand corner of the command box, the information for that command applies only to HP-IB or Serial Data. If no symbol appears, the information for that command applies to both HP-IB and Serial Data operation.

CAUTION

To avoid possible unwanted actions by the 3497A, always consult the notes for a command before sending the command to the instrument.

3497A COMMAND DESCRIPTIONS - FORMAT

Description includes command function and assemblies controlled.

Command format and parameter ranges.

No symbol means information applicable to HP-IB and Serial Data.

ANALOG CLOSE

AC chan#,chan#,... chan# = 0 to 999

Description

Closes from 1 to 4 channels, one per decade, simultaneously. Used to control analog assemblies (Options 010, 020, 070 and 071).

Examples

```
10 OUTPUT 709; "AC3"              !Close channel 3 (HP-IB)
20 OUTPUT 10; "AC3,13,23,33"      !Close channels 3, 13, 23 and 33 (Serial Data)
```

Notes

1. Up to 4 channels (1/decade) may be closed simultaneously.
2. AC command opens all previously closed channels.
3. AC without chan# opens all channels.
4. Power On State: Analog Close disabled.

Examples are typical BASIC language statements for HP-IB or Serial Data operation as applicable.

Notes include power on state for the command and special operating considerations.

POWER ON COMMAND SETTINGS

The following chart shows the 3497A command states at power on. It includes the title of the command, command mnemonics, setting at power on and a brief description of the command state. See COMMAND DESCRIPTIONS for further information on each of the commands.

3497A COMMAND SETTINGS AT POWER ON

ANALOG COMMANDS

Analog Close Channel	(AC)	----	Disabled
Analog EXTERNAL INCR	(AE)	AE0	EXT INCR port OFF
Analog First Channel	(AF)	AF000	First channel to 0
Analog Input	(AI)	----	Disabled
Analog Last Channel	(AL)	AL999	Last channel to 999
Analog Output	(AO)	----	No outputs
Analog Reset	(AR)	AR	Once at power on
Analog Step	(AS)	----	Disabled
Analog Viewed Channel	(AV)	----	Disabled

COUNTER COMMANDS

Counter Enable Interrupts	(CE slot#,n)	----	Disabled
Counter Function	(CF slot#,n)	----	Disabled
Counter Read	(CR slot#,n)	----	Disabled
Counter Set	(CS slot#,n)	----	Disabled
Counter Trigger	(CT slot#,n)	----	Disabled

DIGITAL COMMANDS

Digital Close	(DC slot#,n)	----	All channels open
Digital Intr Enable	(DE slot#,n)	----	Disabled
Digital Intr Status	(DI slot#)	----	Not monitored
Digital Load	(DL slot#)	----	Disabled
Digital Open	(DO slot#,n)	----	All channels open
Digital Read	(DR slot#,n)	----	Disabled
Digital Intr Sense	(DS slot#,n)	----	Disabled
Digital View	(DV slot#)	----	Disabled
Digital Write	(DW slot#,n)	----	All channels open

SYSTEM COMMANDS

System Alarm	(SA)	SA	One BEEP
System Clear	(SC)	----	Disabled
System Display	(SD)	SD1	Display ON
Service Request Enable	(SE)	SE0	SRQ disabled
System Initialize	(SI)	----	One System Initialize
System Lock	(SL)	SL0	Keyboard enabled
System Output Wait	(SO)	SO0	No system wait
System Single/Cont Out	(SO)	SO0	Continuous output mode
System Read	(SR)	----	Disabled
Status Register Read	(SR)	----	Disabled
Self Test	(ST)	ST1	One Self Test
System View	(SV)	----	Disabled
System Write	(SW)	----	Disabled

TIMER COMMANDS

Time Alarm (Set)	(TA)	----	Disabled
Time of Day (Set)	(TDn)	----	Sets clock to Jan 1, 000000
Time of Day (Read)	(TD)	----	Disabled
Time Elapsed (Cntl)	(TEn)	----	Timer halted and set to 0
Time Elapsed (Read)	(TE)	----	Disabled
Time Interval	(TI)	----	Disabled
Time Output	(TO)	----	Disabled

VOLTMETER COMMANDS

Voltmeter Autozero	(VA)	VA1	Autozero ON
Voltmeter Current Source	(VC)	VC0	Current Source OFF
Voltmeter Display	(VD)	VD5	5½ digit display
Voltmeter Format	(VF)	VF1	ASCII output format
Voltmeter No. Rdgs/Trig	(VN)	VN1	One reading/trigger
Voltmeter Range	(VR)	VR5	Autorange
Voltmeter Storage	(VS)	VS0	Internal storage OFF
Voltmeter Trigger	(VT)	VT1	Internal trigger
Voltmeter Wait	(VW)	VW0	No wait between trig

COMMAND DESCRIPTIONS

This part of the chapter summarizes the six command groups (ANALOG, COUNTER, DIGITAL, SYSTEM, TIMER and VOLTMETER) used with the 3497A. See the INTRODUCTION part of this chapter for format used with each command.

ANALOG COMMANDS

ANALOG CLOSE

AC chan#,chan#,...	chan# = 0 to 999

Description

Closes from 1 to 4 channels, one per decade, simultaneously. Used to control analog assemblies (Options 010, 020, 070 and 071).

Examples

```
10 OUTPUT 709; "AC3"              !Close channel 3. (HP-IB)
20 OUTPUT 10; "AC3,13,23,33"      !Close channels 3, 13, 23 and 33. (Serial Data)
```

Notes

1. Up to 4 channels (1/decade) may be closed simultaneously.
2. AC command opens all previously closed channels.
3. AC without chan# opens all channels.
4. Power On State: Analog Close disabled.

ANALOG EXTERNAL INCREMENT

AEn (n = 0 to 2)	AE0 = EXT INCR port OFF AE1 = EXT INCR port ON AE2 = FAST SCAN

Description

Enables or disables the EXT INCR (External Increment) port on the rear panel of the 3497A. In AE2 (Fast Scan), the 3497A will ignore multiframe (two 3497As) Break-Before-Make (BBM) synchronization, but BBM synchronization between channels in analog assemblies continues.

In AE1 or AE2, each external pulse input to the EXT INCR port increments channel closed to next channel for analog assemblies (Options 010, 020, 070 and 071). However, approximately 100 to 200 msec required to enable port after AE1 or AE2 sent.

Examples

```
10 OUTPUT 709; "AE1"              !Enables EXT INCR port. (HP-IB)
20 OUTPUT 10; "AE0"               !Disables EXT INCR port. (Serial Data)
```

Notes

1. AE2 takes 3497A out of any previous measurement mode.
2. In AE2 interface bus displays are turned OFF.
3. Any data request while in AE2 reverts mode to AE1.
4. Power On State: AE0 - EXT INCR port OFF.

ANALOG FIRST CHANNEL

AF chan#	chan# = 0 to 999

Description

Selects first channel to be closed in a scan sequence, but does not close the channel (see ANALOG STEP command). Used to control analog assemblies (Options 010, 020, 070 and 071).

Examples

```
10 OUTPUT 709; ''AF30''        !Sets channel 30 as first channel. (HP-IB)
20 OUTPUT 10; ''AF5''          !Sets channel 5 as first channel. (Serial Data)
```

Note

1. Power On State: AF0 = First Channel is 000.

ANALOG INPUT

AI chan#	chan# = 0 to 999

Description

Closes the channel indicated and triggers the DVM to take a single reading. The measurement result is formatted by the VFn command (see VOLTMETER TRIGGER command). Used to control analog assemblies (Options 010, 020, 070 and 071).

Examples

```
10 OUTPUT 709; ''AI15''        !Voltage measurement on channel 15. (HP-IB)
20 OUTPUT 10; ''AI3''          !Voltage measurement on channel 3. (Serial Data)
```

Note

1. Power On State: Analog Input disabled.

ANALOG LAST CHANNEL

AL chan#	chan# = 0 to 999

Description

Selects last channel to be closed in a scan sequence, but does not close the channel (see ANALOG STEP command). Used to control analog assemblies (Options 010, 020, 070 and 071).

Examples

```
10 OUTPUT 709; ''AL30''        !Sets channel 30 as last channel. (HP-IB)
20 OUTPUT 10; ''AL5''          !Sets channel 5 as last channel. (Serial Data)
```

Note

1. Power On State: AL999 = Last channel is 999.

ANALOG OUTPUT

AO slot#,chan#,integer	slot#	=	0 to 89
	chan#	=	0 or 1
	integer	=	0 to ± 10238 (VDAC)
		=	0 to 10238 (IDAC)

Description

Sets the output voltage level for the Voltage D/A converter (VDAC) [Option 120] or the output current level for the Current D/A converter (IDAC) [Option 130].

Output voltage range for the VDAC is from - 10.2375v to + 10.2375v in 2.5mV increments. Any integer input which is not a multiple of 2.5mV is automatically rounded to the nearest integer multiple of 2.5mV (i.e., sending 1365 or 1366 results in a 1.365V output).

The IDAC has two jumper selectable ranges: 0-20mA (5μA increments) or 4-20mA (4A increments). The IDAC can be programmed in units of 0.01% of value range. However, the output can only change in increments of 0.025% of range. Some selected integers and associated voltage and current levels are shown.

Value (Integer)	VDAC (V)	IDAC, 4-20mA (mA)	IDAC, 0-20mA (mA)
0	0.0	4.000	0.000
10	0.010	4.016	0.020
80	0.080	4.128	0.160
160	0.160	4.256	0.320
640	0.640	5.024	1.280
1280	1.280	6.048	2.560
5120	5.120	12.192	10.240

Examples

```
10 OUTPUT 709;"AO15,0,-2500"   !Outputs -2.5V on channel 0 of a VDAC in slot 15. (HP-IB)
20 OUTPUT 10;"AO15,1,160"      !Outputs 4.256 mA on channel 1 of an IDAC in slot 15, if assembly is set for
                               4-20 mA operation. Outputs 0.320 mA on channel 1 of an IDAC in slot 15 if
                               assembly is set for 0 - 20 mA operation. (Serial Data)
```

Notes

1. Slots 5 through 9 do not exist. Attempted access to these slots may cause errors in data transfer.
2. Only one channel may be addressed at a time.
3. Current output can be 0-102.4% of full-scale.
4. Power On State: Analog Output disabled (no output).

ANALOG RESET

AR

Description

Opens all channels for analog assemblies (Options 010, 020, 070/071) in both the 3497A and the 3498A Extender. In addition, AR sets VF1, VT1, VR5, VW0, VS0, AE0, AF0 and AL999 commands.

Examples

```
10 OUTPUT 709; "AR"     !Analog Reset. (HP-IB)
20 OUTPUT 10; "AR"      !Analog Reset. (Serial Data)
```

Notes

1. Although VS0 is set, AR does not clear the storage buffer.
2. After AR is performed, approximately ¼ sec is required before another ANALOG command can be sent.
3. Power On State: "AR" - Analog Reset once at turn on.

ANALOG STEP

AS

Description

Performs a software channel advance from the presently closed analog channel to the next analog channel between the limits set by the AF and AL commands (see ANALOG FIRST CHANNEL and ANALOG LAST CHANNEL commands).

Repeating the AS command causes channels to sequence from AF to AL and then to repeat the sequence starting at AF (i.e., for AF30 and AL40, sequence is 30,31,...,40,30,31...).

Examples

```
10 OUTPUT 709;"AR"    !Causes the 3497A to close channel 000, since AF was not specified. (HP-IB)
20 OUTPUT 10;"AR"     !Closes channel 30, since AF30 specifies 30 as first channel to be closed. (Serial Data)
```

Notes

1. If AF<AL, channels increment. If AF>AL, channels decrement.
2. If multiple channels are closed and AS command is given, only the LAST channel in sequence will increment. The other channels will be opened.
3. Power On State: Analog Step disabled.

ANALOG VIEWED CHANNEL

AV chan#	chan# = 0 to 999

Description

Dedicates the 3-digit display and the 6-digit display to the channel specified in the command. Command does NOT close channel and does not affect other 3497A operations. Display is updated when the channel is closed and a measurement taken.

Examples

```
10 OUTPUT 709; "AV8"     !Dedicates display to channel 8. (HP-IB)
20 OUTPUT 10; "AV3"      !Dedicates display to channel 3. (Serial Data)
```

Note

1. Power On State: Analog Viewed disabled.

COUNTER COMMANDS

COUNTER ENABLE INTERRUPTS

CE slot#,n	n = 0 = No interrupts enabled
	1 = Interrupt on measurement complete
slot# = 0 to 4	2 = Interrupt on overflow

Description

Enables the counter to send an interrupt signal to the 3497A when a preset condition occurs. The interrupt signal sets bit 1 (digital interrupt) in the 3497A status register. Thus, bit 1 in the 3497A SRQ mask (bits 1 and 6 in the interrupt mask for Serial Data) must also be set for the 3497A to interrupt the controller.

Examples

10 OUTPUT 709; "SE2CE4,1"	!SE2 sets the SRQ Mask in the 3497A to respond to a digital interrupt. CE4,1 enables a counter in slot 4 to send an interrupt signal to the 3497A when a measurement complete condition occurs. (HP-IB)
20 OUTPUT 10; "SE102CE3,2"	!SE102 sets the interrupt mask in the 3497A to respond to a digital interrupt. CE3,2 enables a counter in slot 3 to send an interrupt signal to the 3497A when an overflow condition occurs. (Serial Data)

Notes

1. Counter cards in the 3498A Extender cannot directly interrupt the controller and they must be connected to a digital input assembly (or equivalent connection) in the 3497A to interrupt the controller.
2. After a counter interrupt is generated, another CE command cannot be sent unless the counter is reset with a CS command or the CF command is changed.
3. When the 3497A sends a digital interrupt SRQ to the controller, to find out which digital assembly caused the interrupt, send the DI slot# command. If a counter assembly is in the slot addressed, this command returns a 0, 1 or 3.
   - 0 = Counter did not interrupt.
   - 1 = Interrupt due to measurement complete.
   - 3 = Interrupt due to overflow.
4. When a counter has sent an interrupt signal to the 3497A, the counter cannot send another interrupt signal until a DI slot# command has been sent to it.
5. Power On State: Counter Interrupts disabled.

C
O
U
N
T
E
R

COUNTER FUNCTION

CF slot#,n	n =	0 = Counter Stop 1 = Count Up 2 = Count Down
slot# = 0 to 89 n = 0 to 6		3 = Average 1000 Periods/P.W. 4 = Average 100 Periods/P.W. 5 = Measure 1 Period/P.W. 6 = Measure 1 Period/P.W.

Description

Sets the mode of operation for the counter and automatically starts the counting function. The trigger edge select command (CT) must be specified BEFORE the CF command is chosen. For n = 3 to 6, with CT slot#,1 and CT slot#,2, period measurements are made. With CT slot#,3 and CT slot#,4, pulse width measurements are made. The function descriptions for n = 0 through 6 are:

n	Function	Description	
0	Stop Counter	Pauses counter and retains current value.	
1	Count Up	Count up from a programmable start point to overflow value of 999999.	
2	Count Down	Count down to 0 from a programmable start point or output programmable number of square wave pulses (0 to 499999).	
		Period Range	Pulse Width Range
3	Average 1000 Periods/P.W.	10Hz to 100kHz	10 μsec to 0.1 sec
4	Average 100 Periods/P.W.	1Hz to 100kHz	10 μsec to 1.0 sec
5	Measure 1 Period/P.W.	.01Hz to 100kHz	10 μsec to 100 sec
6	Measure 1 Period/P.W.	10^{-4}Hz to 1kHz	.001 sec to 10^4 sec

Examples

10 OUTPUT 709; "CT2,1CF2,1"	!Sets a counter in slot 2 to average 1000 periods of an input signal, since CT2,1 was sent. (HP-IB)
20 OUTPUT 10; "CT2,3CF2,3"	!Sets a counter in slot 2 to average 1000 pulse widths of an input signal, since CT2,3 was sent. (Serial Data)

Notes

1. Except for Counter Read (CR) commands, do not send other commands to a "busy" counter during the counting process, as count errors may occur.
2. Once a CF command is initiated, the 3497A is free to execute other commands without loss of count data, unless a CR slot#,3 command has been set for HP-IB and (in some cases) for Serial Data.
3. Power On State: Counter Function Disabled.

COUNTER READ

CR slot#,n	n =	1 = Read without wait, one value
		2 = Read with wait, one value
slot# = 0 to 89		3 = Read without wait continuously

Description

Allows the results of measurements accumulated in the counter to be read in one of three different ways:

Read Without Wait (n = 1)

Can instantaneously read the count accumulated in the counter without disturbing data flow into the counter. Useful for determining how far a long measurement has progressed.

Read With Wait (n = 2)

The results are returned only after the conditions for a completed measurement are satisfied. If a measurement is not complete, the 3497A will wait until the complete reading can be delivered. Communication over the HP-IB between the 3497A and the controller is halted until the measurement is complete.

Read With Wait Continuously (n = 3)

For count up and count down functions, the counter repeatedly obtains readings and continuously updates. For period/pulse width measurements, complete measurement cycles (initiate - wait - answer) are repeatedly performed. In this mode, the 3497A is NOT free to perform any other tasks.

Examples

10 OUTPUT 709; "CF2,1CR2,1"	!Immediately reads the count accumulated in a counter in slot 2 which is in count up mode. (HP-IB)
20 OUTPUT 10; "CT2,1CF2,3CR2,2"	!A counter in slot 2 is averaging 1000 periods of an input. The result will be returned only after measurement is complete (over 100 sec for a 10 Hz input signal for example). (Serial Data)

Note

1. Power On State: Counter Read disabled.

COUNTER

COUNTER

COUNTER SET

CS slot#,start point value	slot# = 0 to 89 value = 0 to 999999

Description

Sets the starting point (0 to 999999) for the count up or count down functions. CS also sets the number of output pulses in the pulse output mode (start point value = twice the number of output pulses).

Examples

10 OUTPUT 709; "CS2,1000CF2,1"	!A counter in slot 2 starts the count up (totalize) operation from a start point of 1000. (HP-IB)
20 OUTPUT 10; "CS2,1000CF2,2"	!A counter in slot 2 starts the count down operation from a start point of 1000. If the counter is properly configured, 500 square-wave pulses are also output from the counter. (Serial Data)

Notes

1. In count down, to output square-wave pulses, the value must be an even integer from 0 to 999998 and input signal frequency must be 2 kHz or less.
2. When a CS command is sent to the counter, the counter is stopped and then set to the value specified. A CF command is required to restart the counting function.
3. Power On State: Counter Set Disabled.

COUNTER TRIGGER

CT slot#, n	n = 1 = Rising Edge to Rising Edge
	2 = Falling Edge to Falling Edge
	3 = Rising Edge to Falling Edge
slot # = 0 to 89	4 = Falling Edge to Rising Edge

Description

Selects the edge of the input signal on which to trigger the counter. For count up or count down mode, CT slot#,1 and CT slot#3 perform the same function, as do CT slot#,2 and CT slot#,4. In period/pulse width modes, CT command determines whether input period or pulse width is measured.

CT slot#, n

CF slot#,n

	n = 1	2	3	4
n= 3	Average 1000 Periods	Average 1000 Periods	Average 1000 Pulse Widths	Average 1000 Pulse Widths
4	Average 100 Periods	Average 100 Periods	Average 100 Pulse Widths	Average 100 Pulse Widths
5	Measure 1 Period	Measure 1 Period	Measure 1 Pulse Width	Measure 1 Pulse Width
6	Measure 1 Period	Measure 1 Period	Measure 1 Pulse Width	Measure 1 Pulse Width

Examples

10 OUTPUT 709;''CT0,1CF0,1''	!Sets a counter in slot 0 to average 100 periods of the input and trigger from rising edge to rising edge. (HP-IB)
20 OUTPUT 10; ''CT0,3CF0,5''	!Sets a counter in slot 0 to measure 1 pulse width of the input and to trigger from rising edge to falling edge. (Serial Data)

Notes

1. The CT command MUST be specified BEFORE the counter function (CF) command is sent. Changing the CT command during a counting operation changes the trigger edges and stops the counter.
2. Power On State: Counter Trigger disabled.

COUNTER

DIGITAL COMMANDS

D
I
G
I
T
A
L

DIGITAL CLOSE

DC slot#,chan#,chan#,...	slot# = 0 to 89
	chan# = 0 to 15 (Option 110) = 0 to 7 (Option 115)

Description

The Digital Close (DC) command is used with the actuator assemblies. For the actuator/digital output assembly (Option 110), DC connects the Normal Open (NO) position of the channel relay to common. For the high voltage actuator (Option 115), DC closes the relay(s) in the channel(s) specified.

Examples

10 OUTPUT 709; "DC2,5"	!For an Option 110 assembly in slot 2, DC command connects channel 5 relay Normal Open position to common. For an Option 115 assembly in slot 2, DC command closes relay in channel 5. (HP-IB)
20 OUTPUT 10;"DC3,5,6,7"	!For an Option 110 assembly in slot 3, connects channel 5, 6 and 7 relays Normal Open position to common. For an Option 115 assembly in slot 3, DC closes relays in channels 5, 6 and 7. (Serial Data)

Notes

1. Channels not specified in the DC command remain in previous state.
2. Up to 16 channels may be included in the DC command.
3. Power On State (Option 110): All relays in Normal Closed position.
4. Power On state (Option 115): All relays open.

DIGITAL INTERRUPT ENABLE

DE slot#, value	slot# = 0 to 4 value = 0 to 377 (octal)

Description

DE is used only with the digital input/interrupt assembly (Option 050). Enables the Option 050 assembly to send an interrupt signal to the 3497A when interrupt conditions occur which set the selected bit(s) in the assembly channels true.

If the 3497A has previously been set to respond to a digital interrupt (by sending "SE2" for HP-IB or by sending "SE102" for Serial Data), the 3497A sends an SRQ (BREAK for Serial Data) to the controller.

Examples

```
10 OUTPUT 709; "DE4,7"      !DE4,7 enables bits 0,1 and 2 of an Option 050 assembly in slot 4, since octal 7 = 00 000
                            111 digital. When bit 4 is set by an interrupt condition into channel 4, interrupt signal sent
                            to 3497A. (HP-IB)
20 OUTPUT 10;"DE4,120"      !DE4,120 enables bits 4 and 6 of an Option 050 assembly in slot 4, since octal 120 = 01
                            010 000 digital. When bit 4 or 6 is set by an interrupt condition, interrupt signal is sent to
                            3497A. (Serial Data)
```

Notes

1. Only channels 0-7 of Option 050 assemblies in slots 0-4 can be used for digital interrupt, so a maximum 40 channels per 3497A is available for interrupt inputs.
2. Once an interrupt signal has been sent to the 3497A, a new DE command is required to re-enable the interrupt capability of the assembly.
3. Unless the 3497A has been previously enabled to send an SRQ (or BREAK) to the controller (by an SE2 or SE102 command), interrupts from the Option 050 assembly will not interrupt the controller.
4. Power On State: digital interrupt enable is disabled.

DIGITAL INTERRUPT STATUS

DI slot#	slot# = 0 to 4

Description

DI is used with the digital input/interrupt assembly (Option 050) to determine the interrupt status of bits 0-7 for the assembly in slot addressed. Octal value returned after a DI command is 0 to 377, where a "1" in a bit position indicates that interrupt occurred in that channel.

DI can also be used with the 100 kHz Reciprocal Counter (Option 060) to determine the cause of an interrupt from the counter. After a DI slot# command is sent, if the counter is set for interrupts (with a CE slot#,1 or CE slot#,2 command), a "1" is returned for interrupt on measurement complete and a "3" is returned for interrupt on overflow.

Examples

```
10 OUTPUT 709;"DI4"     !Returns octal value of true bits 0-7 for an Option 050 assembly in slot 4. For example, if 010
                        is returned, bit 4 was set true ("1") by an interrupt from input connected to channel 4 (HP-IB)
20 OUTPUT 10; "DI4"     !See HP-IB example. (Serial Data)
```

Note

1. Power On State: Digital Interrupt Status not monitored.

D I G I T A L

DIGITAL LOAD

DL slot#	slot# = 0 to 89

Description

DL is used with the digital input/interrupt assembly (Option 050); the actuator/digital output assembly (Option 110) and the high voltage actuator (Option 115).

For the Option 050 assembly, DL returns the octal value (0-177777) of the contents of the 16 input channels and initiates a handshake if the handshake jumper on the assembly is enabled.

For the Option 110 assembly, DL returns the octal value (0-177777) of the output condition of the 16 channels in the assembly, where a "1" in a channel indicates that the relay is in the Normal Open position.

For the Option 115 assembly, DL returns the octal value (0-377) of the condition of the 8 channels in the assembly, where a "1" in a channel indicates that the channel relay is closed.

Examples

10 OUTPUT 709; "DL4"	!Returns octal value of contents of 16 channels in Option 050 or 110 assembly in slot 4. Returns octal value of contents of 8 channels in Option 115 assembly in slot 4. (HP-IB)
20 OUTPUT 10; "DL4"	!See HP-IB example. (Serial Data)

Notes

1. Power On State: Digital Load Disabled.
2. Digital Load returns the same information as Digital Read command, except that only one reading is produced for each command.

DIGITAL OPEN

DO slot#,chan#,chan#,...	slot# = 0 to 89 chan# = 0 to 15 (Option 110) = 0 to 7 (Option 115)

Description

For the actuator/digital output assembly (Option 110), DO connects the Normal Closed position of the channel relay(s) addressed to common. For the high voltage actuator (Option 115), DO opens the relay(s) in the channel(s) specified. For both assemblies, channel relays not specified in the DO command remain in their previous state.

Examples

10 OUTPUT 709; "DO2,5"	!For an Option 110 assembly in slot 2, DO command connects channel 5 relay Normal Closed position to common. For an Option 115 assembly in slot 2, DO command opens relay in channel 5. (HP-IB)
20 OUTPUT 10; "DO3,5,6,7"	!For an Option 110 assembly in slot 3, DO connects channel 5, 6 and 7 relay Normal Closed position to common. For an Option 115 assembly in slot 3, DO opens relays in channels 5, 6 and 7. (Serial Data)

Notes

1. Channels not specified in the DO command remain in previous state.
2. Up to 16 channels may be included in the DO command.
3. Power On State (Option 110): All relays in Normal Closed position.
4. Power On state (Option 115): All relays open.

DIGITAL READ

DR slot#	slot# = 0 to 89

Description

DR is used with the digital input/interrupt assembly (Option 050); the actuator/digital output assembly (Option 110) and the high voltage actuator (Option 115).

For the Option 050 assembly, DR returns the octal value (0-177777) of high true input bits for the 16 channels and initiates a handshake if the handshake jumper on the assembly is enabled.

For the Option 110 assembly, DR returns the octal value (0-177777) of the output condition of the 16 channels in the assembly, where a "1" in a channel indicates that the relay is in the Normal Open position.

For the Option 115 assembly, DR returns the octal value (0-377) of the condition of the 8 channels in the assembly, where a "1" in a channel indicates that the channel relay is closed.

Examples

10 OUTPUT 709; "DR4"	!Returns octal value of contents of 16 channels in Option 050 or 110 assembly in slot 4. Returns octal value of contents of 8 channels in Option 115 assembly in slot 4. (HP-IB)
20 OUTPUT 10; "SO1DR4"	!Returns same octal value as for HP-IB example. However, since SO1 is in effect, only one reading is returned per DR command. (Serial Data)

Notes

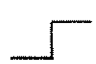
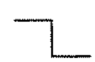
1. For HP-IB, Digital Read returns the same information as Digital Load command, except that readings are continuously updated for Digital Read.
2. For Serial Data, with SO0 in effect, Digital Read returns continuously updated readings. With SO1 in effect, one reading is returned per DR command.
3. The Option 050 assembly can be reconfigured so that the value returned (0 to 177777) indicates low true bits.
4. Power On State: Digital Read disabled.

DIGITAL INTERRUPT SENSE

DS slot#, value	slot# = 0 to 4 value = 0 to 377 (octal)

Description

Selects edge transition sense which will cause channel 0-7 bits to be set in a digital input/interrupt assembly (Option 050). The octal value sets the polarity sense for each channel. Sense bit = 1 causes channel bit to be set by a low to high transition. Sense bit = 0 causes channel bit to be set by a high to low transition.

Polarity Sense 1 =  0 = 

Examples

10 OUTPUT 709; "DS2,110"	!For an Option 050 assembly in slot 2, sets channel 3 and 6 interrupt bits for low to high transitions and bits 0,1,2,4,5 and 7 for high to low transitions. (HP-IB)
20 OUTPUT 10; "DS2,110"	!See HP-IB example. (Serial Data)

Note

1. Power On State: Edge transition polarity sense = high to low (i.e., same as sending DS0).

DIGITAL VIEWED SLOT

DV slot#	slot# = 0 to 89

Description

Dedicates the 3497A front panel display to a digital slot. To exit the Digital Viewed Slot mode, send "DV" without a slot number.

Examples

```
10 OUTPUT 709; "DV3"      !Dedicates display to slot 3. (HP-IB)
20 OUTPUT 10; "DV"        !Takes 3497A out of Digital Viewed Slot mode. (Serial Data)
```

Note

1. Power On State: Digital Viewed Slot disabled.

DIGITAL WRITE

DW slot#,value	slot# = 0 to 89
	value = 0 to 177777 (octal) [Option 110]
	= 0 to 377 (octal) [Option 115]

Description

For the actuator/digital output assembly (Option 110), DW connects the Normal Open position of the channel relay(s) to common. For the high voltage actuator (Option 115), DW closes the relay(s) in the channel(s) specified.

Channels are set by the octal value sent. In contrast to DC or DO, the DW command affects all channels simultaneously, while DC and DO affect only the channels specified in the command.

Examples

```
10 OUTPUT 709;"DW2,40"   !For an Option 110 assembly in slot 2, DW command connects channel 5 relay Normal Open
                          position to common and connects the other 15 relay Normal Closed relay positions to common.
                          For an Option 115 assembly in slot 2, DW command closes relay in channel 5 and opens
                          relays in other 7 channels. (HP-IB)
20 OUTPUT 10;"DW2,40"    !See HP-IB example. (Serial Data)
```

Notes

1. All channels in assembly addressed are affected by DW command.
2. Power On State (Option 110): All relays in Normal Closed position.
3. Power On State (Option 115): All relays open.

SYSTEM COMMANDS

SYSTEM

SYSTEM ALARM

SA

Description

System Alarm initiates an audible alarm (BEEP) in the 3497A. A BEEP is generated internally by the 3497A when it receives illegal syntax.

Examples

```
10 OUTPUT 709; "SA"      !Cause 3497A to BEEP. (HP-IB)
20 OUTPUT 10; "SA"       !Cause 3497A to BEEP. (Serial Data)
```

Note

1. Power On State: "SA" - one BEEP.

SYSTEM CLEAR

Serial Data

SC

Description

The System Clear (SC) command is similar to the BREAK message, except that SC does not clear the command (input) buffer or return the 3497A to local mode. Also, SC clears all system errors.

If SC is entered from the front panel, its effect is the same as pressing the front panel RESET key. The 3497A actions following an SC command are:

1. All command execution is terminated.
2. All data transmission stops.
3. All analog and digital channels are opened.
4. The interrupt mask and status registers are cleared.
5. Initializes all analog and digital assemblies.
6. Sets the DVM for internal trigger (VT1).
7. Sets first analog channel = 000 and last analog channel = 999.

Example

```
10 OUTPUT 10; "SC"      !Sends System Clear to the 3497A.
```

Notes

1. SC command does not reset VF2 or VF3 or clear the voltmeter storage buffer.
2. SC command does not return the 3497A to local mode or clear the 3497A command (input) buffer.
3. Power On State: System Clear disabled.

SYSTEM

SYSTEM DISPLAY

SD0 = OFF	SD1 = ON

Description

SD0 turns off the 6-digit display and the CHANNEL annunciators for faster reading rates and to allow only data entered with an SV (SYSTEM VIEW) command to affect the data display.

Examples

```
10 OUTPUT 709; "SD0"      !Turns off display for faster reading rates. (HP-IB)
20 OUTPUT 10; "SD1"       !Turns display on. (Serial Data)
```

Note

1. Power On State: "SD1" - Display ON.

SERVICE REQUEST ENABLE [HP-IB]

HP-IB

SEn	n = 0 to 377 (Octal)

Description

The SE command sets the SRQ mask bits. This enables the 3497A to interrupt the controller when the specified interrupt condition(s) occur. Definitions of the SRQ mask bits and the SEn command which set mask bits true follow.

SRQ MASK - BIT DEFINITIONS AND BIT SET COMMANDS

Bit 7	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Man SRQ	Pon SRQ	Msg Not Exec	Time Interv	Time Alarm	Dig Intr	Data Ready
SE200		SE20	SE10	SE4	SE2	SE1

BIT 5 CANNOT BE SET BY SEn COMMAND. POWER ON SRQ ENABLE SWITCH IN THE 1 POSITION SETS BIT 5 TRUE.

Bit	Title	Purpose
7	Manual SRQ	(Front Panel SRQ key) - for manual interrupts to the controller.
5	Pon SRQ	Power On SRQ (Set with SRQ ENABLE switch) - to flag the controller when 3497A powers up if the SRQ ENABLE switch is set.
4	Msg Not Exec	Message Not Executed - allow interrupt when one of 6 conditions occurs to cause message not to be executed.
3	Time Interv	Time Interval - used to interrupt when a specified time interval has occurred.
2	Time Alarm	Time Alarm - use as interrupt when time of day matches a preset time.
1	Dig Intr	Digital Interrupt - use to send interrupt to controller when a digital input or counter assembly interrupts.
0	Data Ready	Data Ready SRQ - use when any of three actions completed: (1) voltmeter reading complete (single trigger) (2) "n" voltmeter readings complete (when VNn and VS1 or VS2 commands used) (3) DR, DL, DI, CR or TD commands have been executed.

Example

```
10 OUTPUT 709; "SE12"     !Sets the SRQ mask for time interval and digital interrupt SRQ (sets bits 3 and 1), since 12
                          octal = 00 001 010 digital.
```

Notes

1. Once the status register is set (as a result of an interrupt), it must be read (polled) to reset the SRQ function and enable another interrupt. However, the SRQ mask is NOT reset by the polling function. It is reset only by RESET, power-on or another SEn command.
2. To read the status register, send a Serial Poll (SPOLL) command. The value returned is the DECIMAL equivalent of the true bits in the status register.
3. Setting the SRQ mask also sets registers in the interface which must be cleared after each SRQ in order to re-enable SRQ interrupt.
4. Power On State: "SE000"– SRQ disabled.

SYSTEM

SERVICE REQUEST ENABLE [SERIAL DATA]

Serial Data

SEn n = 0 to 377 (Octal)

Description

The SE command sets the interrupt mask bits. This enables the 3497A to interrupt the controller when the specified interrupt condition(s) occur. Definitions of the interrupt mask bits and the SEn command which set mask bits true follow.

INTERRUPT MASK - BIT DEFINITIONS AND BIT SET COMMANDS

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Interv	Time Alarm	Dig Intr	I/O Error
SE200	SE100	SE40	SE20	SE10	SE4	SE2	SE1

Bit	Title	Purpose
7	Manual SRQ	(Front Panel SRQ key) - for manual interrupts to controller.
6	SRQ	Bit 6 MUST be set for any interrupts to send BREAK Message to controller.
5	Pon SRQ	Power On SRQ - to flag the controller when the 3497A powers up.
4	Msg Not Exec	Message Not Executed - allow interrupt when one of eight conditions occurs which causes message not to be executed.
3	Time Interv	Time Interval - used to interrupt when a specified time interval has occurred.
2	Time Alarm	Time Alarm - use to interrupt when the time of day matches a preset time.
1	Dig Intr	Digital Interrupt - use to send interrupt to controller when a digital input or counter assembly interrupts.
0	I/O Error	Input/Output Error - use when parity, overrun or framing error is detected by the UART.

Example

```
10 OUTPUT 10; "SE12"        !Sets the interrupt mask for time interval and digital interrupt SRQ (sets bits 3 and 1), since
                            12 octal = 00 001 010 digital.
```

Notes

1. Once the status register is set (as a result of an interrupt), it must be read (polled) to reset the SRQ function and enable another interrupt. The interrupt mask is NOT reset by the polling function. It is reset only by RESET, power-on or another SEn command.
2. To read the status register, send an SR command (see STATUS REGISTER READ command). The value returned (0-377) is the octal value of the true bits in the status register.
3. Power On State: "SE000" - SRQ disabled.

SYSTEM INITIALIZE

SI

Description

The SI command sets the digital assemblies and the DVM to initial conditions as shown below. The SI command does not affect the analog assemblies (Options 010, 020, 070 and 071).

Opt	Title	State
001	DVM	VA0,VC0,VD5,VF1,VN1,VR5,VS0,VT1,VW0.
050	Digital Input	Handshake and interrupts disabled.
060	Counter	All counter functions disabled.
110	Actuator	All relays NC connected to common.
115	HV Actuator	All relays open.
120	VDAC	No voltage output.
130	IDAC	No current output.
140	Breadboard	Activates digital reset line.

Examples

```
10 OUTPUT 709; "SI"     !Initialize DVM and digital assemblies.
20 OUTPUT 10; "SI"      !Initialize DVM and digital assemblies. (Serial Data)
```

Notes

1. A 3 msec wait is included to allow actuator relays to open (Option 115) or to connect the NC position to common (Option 110).
2. Power On State: "SI" for one system initialization.

SYSTEM LOCK

Serial Data

SL0 = keyboard enabled SL1 = keyboard disabled

Description

System Lock is used to disable the front panel keys so that commands cannot be entered from the keyboard. With SL1, all keys are disabled and the 3497A cannot be returned to local mode unless SL0 is sent or the power is turned off.

Example

```
10 OUTPUT 10;     "SL1"!Disables front panel keyboard.
```

Note

1. Power On State: "SL0" - front panel keyboard enabled.

SYSTEM

SYSTEM OUTPUT WAIT

HP-IB

SO0 = Output reading to bus immediately after measurement
SO1 = Output reading to bus when requested by controller

Description

Controls when readings made by 3497A are output to the HP-IB bus. When "SO1" is in effect, there are two modes to return data to the controller:

Mode 1: With VS0 in effect, the 3497A takes a measurement and holds up further measurements until the controller requests data output.

Mode 2: With VS1 or VS2 in effect, the 3497A takes n readings (as set by the VNn command) and waits for controller request to transfer readings.

Example

10 OUTPUT 709; "VS1VN5SO1" !Tells the 3497A to take 5 readings/trigger, store the 5 readings and wait for an ENTER statement to output readings to controller.

Notes

1. Any device dependent (OUTPUT) command will abort the present wait (and existing measurement will be lost), but will not change the SO mode set.
2. Power On State: "SO0" - No system wait.

SYSTEM SINGLE/CONTINUOUS OUTPUT

Serial Data

SO0 = Continuous output to controller
SO1 = Single output/command to controller

Description

SO1 enables the 3497A to send a single reading/command for commands which normally return continuous data, such as ST, VT1, DR slot#,3, TD and CR slot#,3.

Example

10 OUTPUT 10; "SO1VT1" !Normally, VT1 returns data continuously to the controller. With SO1 in effect, a single reading is returned for the VT1 command.

Notes

1. The 3497A powers on in continuous (SO0) mode, but goes to single output (SO1) mode when the first command is received over the interface. To return to continuous mode, transmit SO0 command.
2. Power On State: "SO0" - Continuous Output Mode.

SYSTEM READ

SR slot#,0 = Read type of assembly in slot (0 to 89)
SR slot#,0 through 7 = Read register (0-7) in slot (0-89) [Option 140 ONLY]

Description

Use the SR slot#,0 command to determine the type of assembly (except analog assemblies) in each 3497A or 3498A Extender slot. Also, for the breadboard card assembly (Option 140), use SR slot#, 0 through SR slot#,7 to read from register specified by 0-7.

Except for Option 140, for SR slot#,0, data returned is a six-digit (octal) value XXXXXC, where C identifies the type of assembly in the slot. For Option 140, a 3-digit octal value (0 to 377) returned for SR slot#,n specifies condition of register n in slot addressed.

C	Assembly	Option(s)
0	Digital Input	050
1	Actuator or HV Actuator	110,115
2	D/A Converter	120,130
3	Counter	060
7	Empty or Analog Assembly	010,020, 070,071
Option 140 returns 0 to 377 (octal), depending on register true bits.		

Examples

10 OUTPUT 709; "SR3,0" !Requests identity of assembly in slot 3. If (for example) 000363 (octal) is returned, the "3" in the LSD shows a counter in slot 3. (HP-IB)

20 OUTPUT 10; "SR3,1" !For an Option 140 assembly in slot 3, reads the contents of register #1. (Serial Data)

Notes

1. All analog assemblies return "7" as the LSD, D/A Converters return "2" as the LSD and actuator and HV actuator return "1" as the LSD.
2. Power On State: "SR" disabled.

STATUS REGISTER READ

Serial Data

SR

Description

The SR command returns a six-bit octal value of the status register true bits. Definitions of the bits in the status register follow.

STATUS REGISTER - SERIAL DATA BIT DEFINITIONS

15	14	13	12	11	10	9
0	Data rcd/no MODEM	(CD) Recvr Ready	No/lost Carrier Disconn	(CTS) Clear To Send	(DSR) Data Set Ready	System Over-Run
MSD (Always Zero)	5th digit			4th digit		

8	7	6	5	4	3	2	1	0
Buffer Over-Flow	Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
3rd digit			2nd digit			LSD		

Bit	Description
15	Always 0.
14	Data is received when MODEM not connected.
13	Data Carrier Detect (RS-232C); Receiver Ready (RS-449).
12	No or Lost Carrier (after 20 seconds).
11	Clear to Send (CTS).
10	Data Set Ready (RS-232C); Data Mode (RS-449).
9	System overrun if a command is received when the 3497A is executing a previous command.
8	Buffer overflow if command string exceeds 42 characters.
7	Manual service request for front panel SRQ.
6	Service request. Shows BREAK due to interrupt.
5	Power On SRQ.
4	Message not executed.
3	Time interval.
2	Time alarm.
1	Digital interrupt.
0	I/O error.

Example

10 OUTPUT 10; "SR" !Reads the status register bits. If, for example, bits 1,4,10 and 14 in the status register are true, the bit pattern is 0 100 010 000 010 010 and the octal value returned is 042022.

Note

1. Power On State: "SR" disabled.

SYSTEM

SELF TEST

STO = OFF	ST1 = ON

Description

ST1 causes the 3497A to perform an internal verification of its operation. Data returned indicates the results, as shown below. Use STO to turn the Self Test function OFF.

Data	Definition
8E8	Self Test Passes
1E1	Cross Guard Fails
2E2	Voltmeter Fails
3E3	Timer Fails

Examples

10 OUTPUT 709; "ST1" !Initiates 3497A Self Test. If 8E8 is returned (after an ENTER 709 command) the Self Test passes. (HP-IB)

20 OUTPUT 10; "STO" !Turns Self Test OFF. (Serial Data)

Notes

1. When STO is sent, the 3497A reverts to state it was in before ST1 initiated.
2. Pressing any front panel key (other than SELF TEST) exits the Self Test Mode.
3. For Serial Data ONLY, continuous output mode for SO0 and ST1. Single output mode for SO1 and ST1.
4. Power On State: "ST1" - one test.

SYSTEM VIEW

SVn	n = -999999 to +999999

Description

System View writes data to the 6-digit display on the 3497A, if the display has previously been turned off by the SD0 command.

Examples

10 OUTPUT 709;"SD0SV23.6700" !Turns front panel display off, then displays +23.6700 on the 6-digit display. (HP-IB)

20 OUTPUT 10;"SD0SV-23.6700" !Turns front panel display off, then displays -23.6700 on the 6-digit display. (Serial Data)

Notes

1. A decimal point may be placed after the V in the command or between any two digits. If no sign is used, + is displayed. The minus (-) sign can be used only after the V in the command. Also, SD0 must be sent before SV is valid.
2. When the DVM is set for internal trigger (VT1) mode, the SV command may appear not to work since the display is cleared by the next DVM trigger before the previous measurement can be displayed. To see the results of the SV command place the DVM in trigger hold (VT4) mode.
3. Power On State: "SV" disabled.

SYSTEM

SYSTEM WRITE

SW slot#,register#,data	slot#	=	0 to 89
	register#	=	0 to 7
	data	=	0 to 377 (octal)

Description

System Write is used to write data to any assembly directly controlled by the main processor (i.e., digital assemblies).

Examples

10 OUTPUT 709; "SW3,1,120"	!Writes 1 010 000 to register 1 of assembly in slot 3. (HP-IB)
20 OUTPUT 10; "SW3,1,120"	!See HP-IB example. (Serial Data)

Note

1. Power On State: System Write disabled.

TIMER COMMANDS

TIMER

TIME ALARM (SET)

TA HoursHours MinMin SecSec	Hours	=	0 to 24
	Min	=	0 to 59
	Sec	=	0 to 59

Description

Sets the 3497A timer. If the SRQ mask (interrupt mask for Serial Data) has been previously set for time alarm, the 3497A sends an interrupt to the controller when the time set by the TA command matches the 3497A real-time clock time.

Examples

10 OUTPUT 709;"SE4TA180000"	!SE4 enables SRQ mask (time alarm) so SRQ will be sent at 6:00:00 PM (24-hour clock). (HP-IB)
20 OUTPUT 10;"SE104TA18000"	!SE104 enables interrupt mask (time alarm) so BREAK message will be sent to controller at 6:00:00 PM (24-hour clock). (Serial Data)

Notes

1. Time alarm SRQ in effect until disabled with an SEn command.
2. Time alarm has maximum repeatable period of 24 hours.
3. Power On State: Time alarm disabled.

TIME OF DAY (SET)

TD MonthMonth DayDay HourHour MinMin SecSec (Option 230)
TD DayDay MonthMonth HourHour MinMin SecSec (Option 231)

Description

Sets real-time clock to programmed time. Formats available are MM:DD:HH:MM:SS (Option 230) or DD:MM:HH:MM:SS (Option 231).

Examples

10 OUTPUT 709; "TD0524183230"	!Sets the clock for May 24 @ 6:32:30 PM (24-hour clock) for Option 230 format. (HP-IB)
20 OUTPUT 10; "TD2405183230"	!Sets the clock for 24 May @ 6:32:30 PM (24-hour clock) for Option 231 format. (Serial Data)

Notes

1. After RESET or power loss, clock is set to 01:01:00:00:00 and does not start counting until a new TDn command is sent.
2. Programming an invalid month (month >12) resets the clock to 01:01:00:00:00.
3. Dates up to 31 will be accepted regardless of the month. If programmed correctly, clock will turn over to the next month at the appropriate date (i. e., Feb 28 to Mar 1), except for leap year, so clock must be adjusted on Feb 29.
4. Programming a date >31 causes a BEEP and the clock to remain unchanged.
5. Power-On State: "TD0101000000" - Set clock to Jan 1 @ 000000.

TIME OF DAY (READ)

TD

Description

Read time of day from the 3497A real-time clock. Data received after the TD command has the format MM:DD:HH:MM:SS (Option 230 or DD:MM:HH:MM:SS (Option 231).

Examples

```
10 DIM A$[16]          !Reads time of day. For example, if time of day is May
20 OUTPUT 709; "TD"    24, 6:32:30 PM when TD command received, data
30 ENTER 709; A$       returned has the format 05:24:18:32:30 (Option 230)
40 DISP A$             or 24:05:18:32:30 (Option 231). (HP-IB)
50 END

10 DIM A$[16]          !See HP-IB example. (Serial Data)
20 OUTPUT 10; "TD"
 .
 .
50 END
```

Notes

1. For Serial Data, data returned is same as for HP-IB, but continuous output mode for SO0 and single output mode for SO1.
2. Real-time clock uses 24-hour convention.
3. Power-On State: "TD" Read - Disabled.

T
I
M
E
R

TIME ELAPSED (CONTROL)

TE0 = RESET	TE1 = HALT	TE2 = START

Description

Use elapsed time control to monitor elapsed time from the start on an operation - in one second increments. Use the TE command (without a number) to read the time elapsed since the TE2 command was received.

Examples

```
10 OUTPUT 709; ''TE2''        !Starts elapsed time (at 0) when the TE2 command received. (HP-IB)

10 OUTPUT 10; ''TE1TE''       !Halts elapsed time count process and displays time (in sec) since elapsed timer
20 ENTER USING ''#,K'';A      started. (Serial Data)
30 DISP A
40 END
```

Note

1. Power-On State: ''TE1'' - Time Elapsed timer halted and set to zero.

TIME ELAPSED (READ)

TE

Description

Use time elapsed read (TE) to read time (in one second increments) since the elapsed timer was started by the TE2 command. Data returned after the TE command has the format DDDDDD seconds.

Examples

```
10 OUTPUT 709; ''TE2''        !Starts elapsed time (at 0).
20      .                     !Main Program.
 .      .
50
60 OUTPUT 709; ''TE''         !Reads and displays number of seconds elapsed on the timer since the TE2
70 ENTER 709; A               command was received. (HP-IB)
80 DISP
90 END

10 OUTPUT 10; ''TE2''         !See HP-IB example. (Serial Data)
      .
      .
90 END
```

Note

1. Power-On State: Time Elapsed (Read) disabled.

TIME INTERVAL

TI HoursHours MinMin SecSec

Description

Use the TI command to generate output pulses from the TIMER port with periods from 1 second to 24 hours. If the SRQ mask (interrupt mask for Serial Data) is set for time interval interrupt, the 3497A sends an SRQ (BREAK for Serial Data) each time a pulse is output.

Examples

10 OUTPUT 709;''SE10TI200''	!Every 2 minutes, a pulse is output at the TIMER port and SRQ is generated, since the SRQ mask is enabled for time interval interrupt by the SE10 command. (HP-IB)
20 OUTPUT 10;''SE102TI200''	!Every 2 minutes, a pulse is output at the TIMER port and a BREAK message is generated, since the interrupt mask is enabled for time interval interrupt by the SE1 10 command. (Serial Data)

Notes

1. Leading zeroes not required in TIn command (i.e., for 2 minutes only TI200 rather than TI000200 is required).
2. When TI command sent, pulses are available at TIMER port even if SRQ is not enabled.
3. Maximum period for TI command is 24 hours.
4. Send ''TI0'' to disable the time interval function.
5. Power-On State: Time Interval disabled.

TIME OUTPUT

TOn	n = 0 to 9999

Description

Use the TO command to generate output pulses from the TIMER port with periods from 100 μsec to 0.9999 sec (in 100 μsec increments). SRQ (BREAK for Serial Data) is not available for the TOn command.

Examples

10 OUTPUT 709; ''TO100''	!Generate pulses from TIMER port every 10 msec. (HP-IB)
10 OUTPUT 10; ''TO100''	!See HP-IB example. (Serial Data)

Notes

1. Time Output (TOn) overrides Time Interval (TIn) command. However, time interval may be used for SRQ (BREAK) even when time output is active.
2. Use ''TO0'' to disable the time output function.
3. Power-On State: Time output disabled.

VOLTMETER

VOLTMETER COMMANDS

VOLTMETER AUTO ZERO

VA0 = OFF VA1 = ON

Description

With auto zero ON, the voltmeter takes an auto zero measurement between each reading. This results in greater accuracy but only about half the reading rate with auto zero OFF.

With auto zero OFF, the voltmeter makes an auto zero measurement before the first reading and one measurement when the voltmeter is switched to a new range.

Examples

```
10 OUTPUT 709; ''VA1''    !Turns auto zero ON. (HP-IB)
20 OUTPUT 10; ''VA0''     !Turns auto zero OFF. (Serial Data)
```

Note

1. Power On State: ''VA1'' - auto zero ON

VOLTMETER CURRENT SOURCE RANGE

VC range (range = 0 to 3)	0 = OFF 1 = 10 μA 2 = 100 μA 3 = 1 mA

Description

Programs the output of the current source in the voltmeter to one of three values: 10 μA, 100 μA or 1 mA. The current source is used in combination with the voltmeter for 4-wire resistance measurements.

Examples

```
10 OUTPUT 709; ''VC2''    !Sets current source output to 100 μA. (HP-IB)
20 OUTPUT 10; ''VC''      !Turns current source output OFF. (Serial Data)
```

Notes

1. Send either ''VC0'' or ''VC'' to turn current source OFF.
2. Power On State: ''VC0'' - current source OFF.

VOLTMETER

VOLTMETER DISPLAY

	n	DIGITS	PLC
VDn (n = 3 to 5)	3	3½	0.01
	4	4½	0.10
	5	5½	1.00

Description

Selects the number of digits displayed on the front panel and sets the voltmeter integration time in power line cycles [PLC] (i. e., for 60 Hz operation, 1 PLC = 16.67 msec; for 50 Hz operation, 1 PLC = 20 msec). Maximum reading rates for 60 Hz operation follow. For 50 Hz operation, multiply readings shown by 5/6.

VDn	Digits	Max Readings/Sec (60 Hz)	
		Auto Zero ON	Auto Zero OFF
VD3	3½	150	300
VD4	4½	100	200
VD5	5½	25	50

Examples

10 OUTPUT 709; "VD3"	!Sets voltmeter for 3½ digit display and 0.01 PLC integration. Maximum reading speed = 300 readings/ second with auto zero OFF. (HP-IB)
20 OUTPUT 10; "VD3"	!See HP-IB example. (Serial Data)

Notes

1. Resolution and noise rejection are higher (but reading speed is lower) for 5½ digit display than for 3½ digit display.
2. Power On State: "VD5" - 5½ digit display.

VOLTMETER

VOLTMETER FORMAT

VF1 = ASCII
VF2 = Packed BCD
VF3 = Time of Day, ASCII, Analog Channel Number

Description

When 3497A voltmeter storage is OFF (VS0), the VF command selects the output format for transmission of data over the interface bus. Formats are:

VF1	Each reading is output in standard ASCII format. Multiple readings (as set by the VN command) are separated by commas and last reading followed by CR LF.
VF2	Each reading is output in packed BCD format. Multiple readings (as set by the VN command) are output every 3 bytes with no delimiters between readings.
VF3	Each reading is output as: time of day (string), CR LF voltage (ASCII), analog channel number (ASCII) of last voltage reading. For multiple readings (as set by VN command), time of day is sent only with each new trigger, rather than with each reading and CR LF is sent after the last channel.

Examples

```
10 OUTPUT 709; "VF2"        !Sets Packed BCD format for DVM measurement to be output over HP-IB bus. (HP-IB)
20 OUTPUT 10; "VN2VF1"      !Sets DVM to take two readings/trigger and output readings in ASCII format. (Serial Data)
```

Notes

1. For Serial Data ONLY: For VF commands shown, delete LF in format.
2. Power On State: "VF1" - ASCII Output.

VOLTMETER NUMBER READINGS/TRIGGER

VN #readings/trigger   #readings/trigger = 1 to 999

Description

Sets number of readings taken per trigger pulse. Readings are taken sequentially and are output to the interface in the format set by the VF command. VN is used in conjunction with software trigger (VT3) or external trigger (VT2) commands.

If the SO1 command (System Wait for Output in HP-IB; Single Output Mode for Serial Data) is used, the 3497A will not output the next reading until the present reading is transmitted across the interface.

Examples

```
10 OUTPUT 709; "SO1VT2VN10"    !Sets DVM to external trigger, then take ten readings/trigger and output each reading
                               before taking the next reading. (HP-IB)
20 OUTPUT 10; "SO1VT2VN10"     !See HP-IB example. (Serial Data)
```

Note

1. Power On State: "VN1" - One reading per trigger.

VOLTMETER RANGE

VR1 = 0.1 V
VR2 = 1.0 V
VR3 = 10 V
VR4 = 100 V
VR5 = Autorange

Description

Sets the range of the voltmeter. Maximum overrange capability for each range is 20%. In Autorange mode, the DVM upranges at 120% of full-scale and downranges at 11% of full-scale.

Examples

10 OUTPUT 709; "VR2"	!Sets voltmeter to 1V range. Maximum voltage which can be measured is ± 1.19999V for 5½ digit resolution. (HP-IB)
20 OUTPUT 10; "VR2"	!See HP-IB example. (Serial Data)

Note

1. Power On State: "VR5" - Autorange.

VOLTMETER STORAGE

VS0 = Voltmeter Storage OFF
VS1 = Store readings in ASCII
VS2 = Store readings in Packed BCD

Description

Allows readings to be stored in the 3497A rather than being sent across the interface. Use the VS command (without a number) to output the stored readings, starting with the first reading. The storage capacity of the 3497A storage buffer is:

	HP-IB	Serial Data
VS1	60 ASCII	50 ASCII
VS2	100 Packed BCD	85 Packed BCD

Examples

10 OUTPUT 709; "VN60VS1VT2"	!VN60 sets the DVM to take 60 readings/ trigger, VS1 sets the DVM to store the 60 readings in ASCII format and VT2 sets the DVM for external trigger. (HP-IB)
20 OUTPUT 10; "VN50VS1VT2"	!See HP-IB example. Maximum storage for serial data is 50 readings in ASCII format. (Serial Data)

Notes

1. The stored readings can be read (sequentially) on the front panel by entering "VS" to get the first reading, then repeatedly pressing the CLEAR ENTRY key for the 2nd, 3rd,....,nth readings.
2. Power On State: "VS0" - Voltmeter Storage OFF.

VOLTMETER

VOLTMETER TRIGGER

VT1 = INTERNAL
VT2 = EXTERNAL
VT3 = SOFTWARE
VT4 = HOLD

Description

The VT command programs the voltmeter to one of four trigger modes:

VT1	INTERNAL	Trigger signal generated internally. Voltmeter automatically takes another reading as soon as the present reading is completed.
VT2	EXTERNAL	Trigger signal is generated externally and input through the EXT TRIG port. The number of readings/trigger is set by VNn. If a trigger pulse arrives while the 3497A is making a measurement, the trigger will be ignored.
VT3	SOFTWARE	Causes the voltmeter to trigger and take the number of readings set by the VNn command.
VT4	HOLD	Causes the voltmeter to pause so that no further measurements are taken.

Examples

```
10 OUTPUT 709; "VT3VN10"    !Causes the DVM to single-trigger and take 10 readings. (HP-IB)
20 OUTPUT 10; "VT2VN10"     !Causes DVM to make 10 readings when an external trigger is received at the EXT TRIG
                            port. (Serial Data)
```

Notes

1. For Serial Data ONLY: In VT1 mode, single output for each trigger when SO1 in effect. Continuous output when SO0 in effect.
2. Power On State: "VT1" - Internal Trigger.

VOLTMETER WAIT

VWn   n = 0 to 999999

Description

Causes the voltmeter to wait n*100 μsec between each reading. Maximum wait time is 99.9999 seconds.

Examples

```
10 OUTPUT 709; "VW60"    !Causes the voltmeter to wait 6 msec between readings. (HP-IB)
20 OUTPUT 10; "VW500"    !Causes the voltmeter to wait 50 msec between readings. (Serial Data)
```

Notes

1. When using the VW function, consider the voltmeter PLC integration period (see the VDn command).
2. Power On State: "VW0" - No wait between readings.

WARNING

Only qualified, service-trained personnel who are aware of the hazards involved should install or configure the 3497A, 3498A or plug-in assemblies.

WARNING

Voltages as high as 357 volts may be present within the protective safety covers and cabinet enclosures on the 3497A and/or 3498A. These voltages may be accessible on exposed chassis parts once the safety cover has been removed.

LETHAL voltages may be present even though the instrument is disconnected from the LINE power. BEFORE touching or configuring plug-in assemblies, make certain that all external power sources are either turned off or disconnected.

Chapter 7
INSTALLATION AND MAINFRAME CONFIGURATION

INTRODUCTION

This chapter shows how to install and checkout your new 3497A and how to configure various operating modes for the 3497A mainframe. The chapter does not include servicing or repair information which is contained in the 3497A Mainframe Installation and Service Manual (-hp- part number 03497-90020).

This chapter is divided into six parts: INITIAL INSPECTION; MAINFRAME INSTALLATION; HP-IB INSTALLATION; RS232C INSTALLATION; RS449/423 INSTALLATION and MAINFRAME CONFIGURATION. See Chapter 8 for details on configuring plug-in assemblies (Options 010 through 140 and the 3498A Extender (Option 298)).

- INITIAL INSPECTION shows how to initially inspect your new 3497A, how to turn the instrument on and perform the self-test to verify proper operation before you connect the 3497A to your system.
- MAINFRAME INSTALLATION gives guidelines to install the 3497A in bench or rack-mount installation or as part of a 3054A, 3054C or 3054DL system.
- HP-IB INSTALLATION shows how to connect the 3497A to an HP-IB system and how to check the instrument for proper operation when connected to a controller (also before you connect the instrument to your system).
- RS232C INSTALLATION shows how to connect the 3497A to an RS232C Serial Data system and how to check the instrument for proper operation when connected to a controller.
- RS449/423 INSTALLATION shows how to connect the 3497A to an RS449/423 Serial Data system and how to check the instrument for proper operation when connected to a controller.
- MAINFRAME CONFIGURATION shows how to change some operating modes for the 3497A mainframe. In many cases, the factory settings for the 3497A will be correct for a required application. However, if you need to change the operational settings for the 3497A, refer to this part for details.

WARNING

For each part of this chapter, the instructions and guidelines assume that the 3497A is NOT connected to your system. If you need to reconfigure your 3497A, disconnect all system power sources and turn the 3497A/3498As OFF before attempting reconfiguration.

NOTE

Since the 3497A is an integral part of the 3054DL Data Logger and the 3054A/C Automatic Data Acquisition/Control System, some of the installation guidelines shown may not apply to a 3497A installed in these systems. If you ordered the 3497A as part of a 3054 system, consult the appropriate installation manuals for these systems.

INITIAL INSPECTION

Your 3497A was carefully inspected before it left the factory. It should be free of mars or scratches and in proper working order on receipt. However, when you receive your new instrument, you should carefully inspect it for damage.

If the 3497A has mechanical damage or if there are missing parts or accessories, or if the 3497A does not pass the electrical performance tests specified in the 3497A Mainframe Installation and Service Manual (-hp- part number 03497-90020) which accompanies the instrument, notify your nearest Hewlett-Packard Sales and Service Office. A list of these offices is at the back of this manual.

If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as -hp- and save the shipping materials for the carrier.

Factory Configurations

This chart shows factory configurations for your new 3497A. If any items are missing or the configuration you received is incorrect, contact your nearest -hp- Sales and Service Office. For further information on 3497A options, see the 3497A Ordering and Configuration Guide in Appendix B.

3497A FACTORY CONFIGURATIONS

IF YOU ORDERED:	YOU SHOULD RECEIVE:
Standard 3497A (HP-IB)	Data Acquisition/Control Unit with front panel keyboard and display; Real-time clock; HP-IB interface and power cord plus plug-in assemblies (Options 010 through 140) ordered. Plug-in assemblies are factory installed in the 3497A card cage. Documentation includes this manual, a 3497A Mainframe Installation and Service Manual (-hp- part number 03497-90020) and a Plug-In Assemblies/ 3498A Extender Service Manual (-hp- part number 03497-90021). If you ordered Option 910 (extra set of documentation), an additional set of these three manuals is included.
Standard 3497A plus Option 001 (DVM)	Same as standard plus a 5½ digit DVM with current source (installed in 3497A).
3497A with Option 232 (RS232C or RS449/423)	Same as standard, except delete HP-IB interface and add RS232C (CCITT V.24)/RS423 (CCITT V.10) interface. Includes 13222N (13222-60001) U.S. MODEM cable.
3497A with Option 232 and Option 001	Same as Option 232 plus a 5½ digit DVM with current source (installed in 3497A).
3497A with Option 260 (delete front panel)	Same as standard or Option 232 except front panel keyboard and display are deleted.
Standard 3497A or 3497A with Option 232 plus Option 298	Same as standard or Option 232 plus connectors for analog extender (blue) and digital extender (white) cables and three-conductor analog interface cable.

Checking Your 3497A

When you received your new 3497A, it was factory preset for the configuration options you specified. Before you connect the instrument to an AC power line or connect it to your system, take a minute to verify that you received the 3497A configuration you specified.

Figure 54 shows the front and rear views of the 3497A. As shipped from the factory, a protective safety cover is installed over a portion of the rear panel. If you ordered a 3497A with a DVM (Option 001), you'll need to remove this cover temporarily to check on the DVM installation. However, because of potentially high voltages (up to 357 volts peak) on the rear panel, this cover MUST be in place whenever the 3497A is connected to an external system.

To check your 3497A configuration, refer to Figure 55 or 56 and follow the sequence shown. Figure 55 shows a standard (HP-IB) 3497A and Figure 56 a 3497A with Option 232 (RS232C/RS423). DON'T PLUG THE 3497A INTO AN AC LINE UNTIL YOU MAKE ALL THE CHECKS SHOWN.

WARNING

As shipped, a safety cover is installed over the DVM terminals and the 5-slot card cage. For illustration, Figures 55 and 56 show the cover removed. However, because of potentially high voltages at the back of the instrument, the protective cover MUST be installed whenever the 3497A is connected to external power sources.

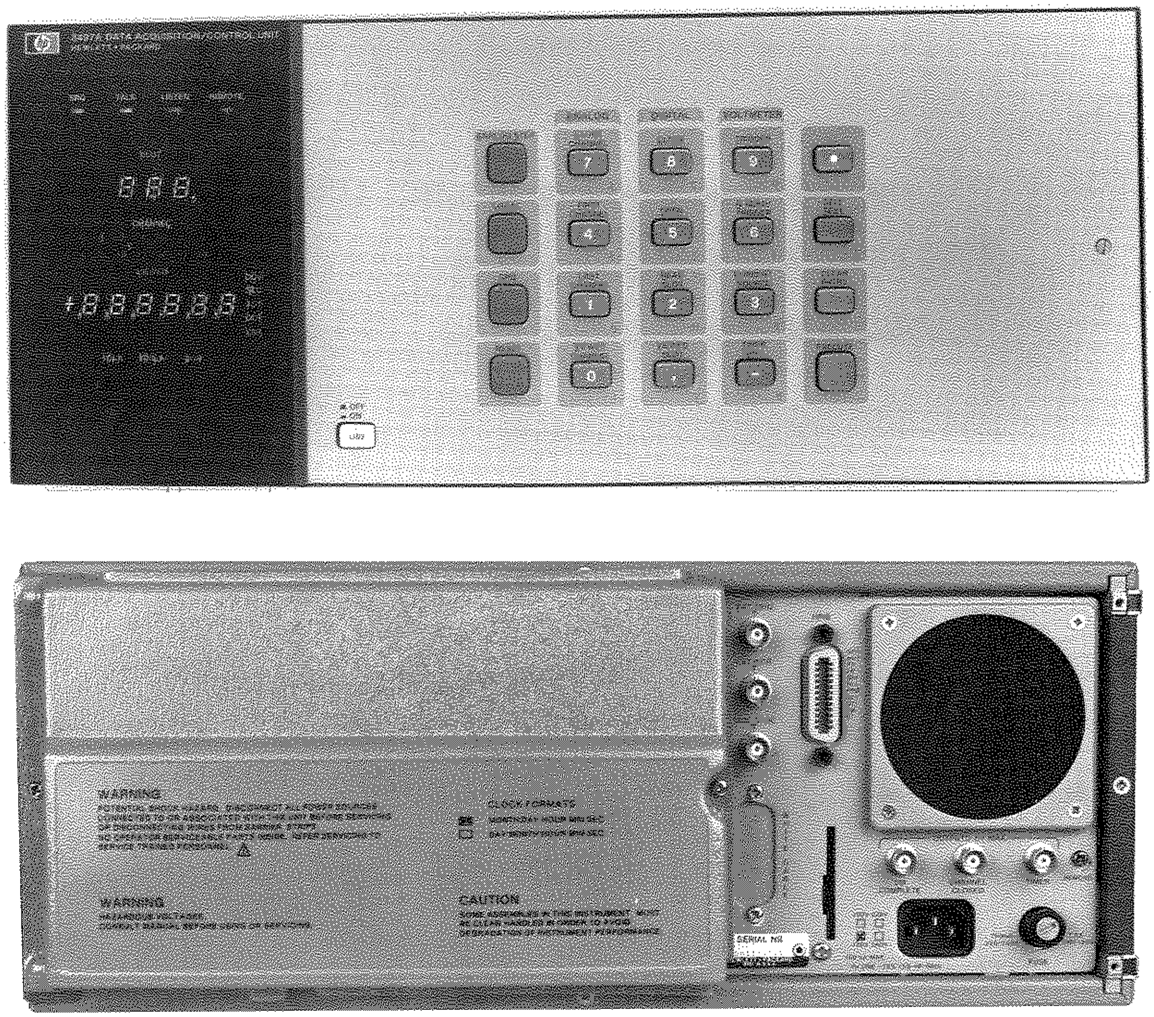
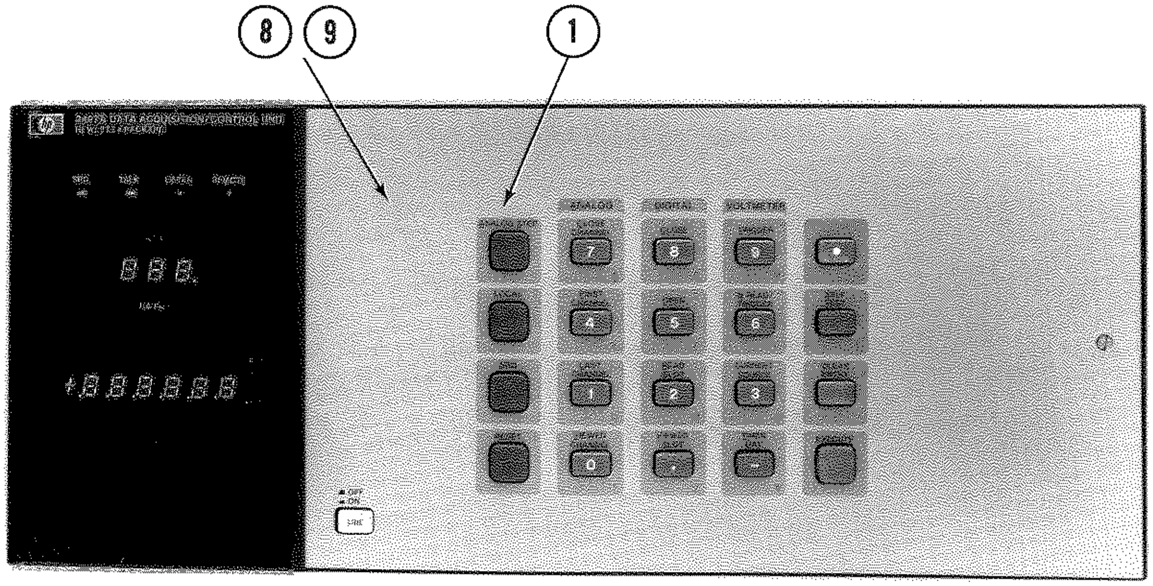


Figure 54. 3497A Front and Rear Views



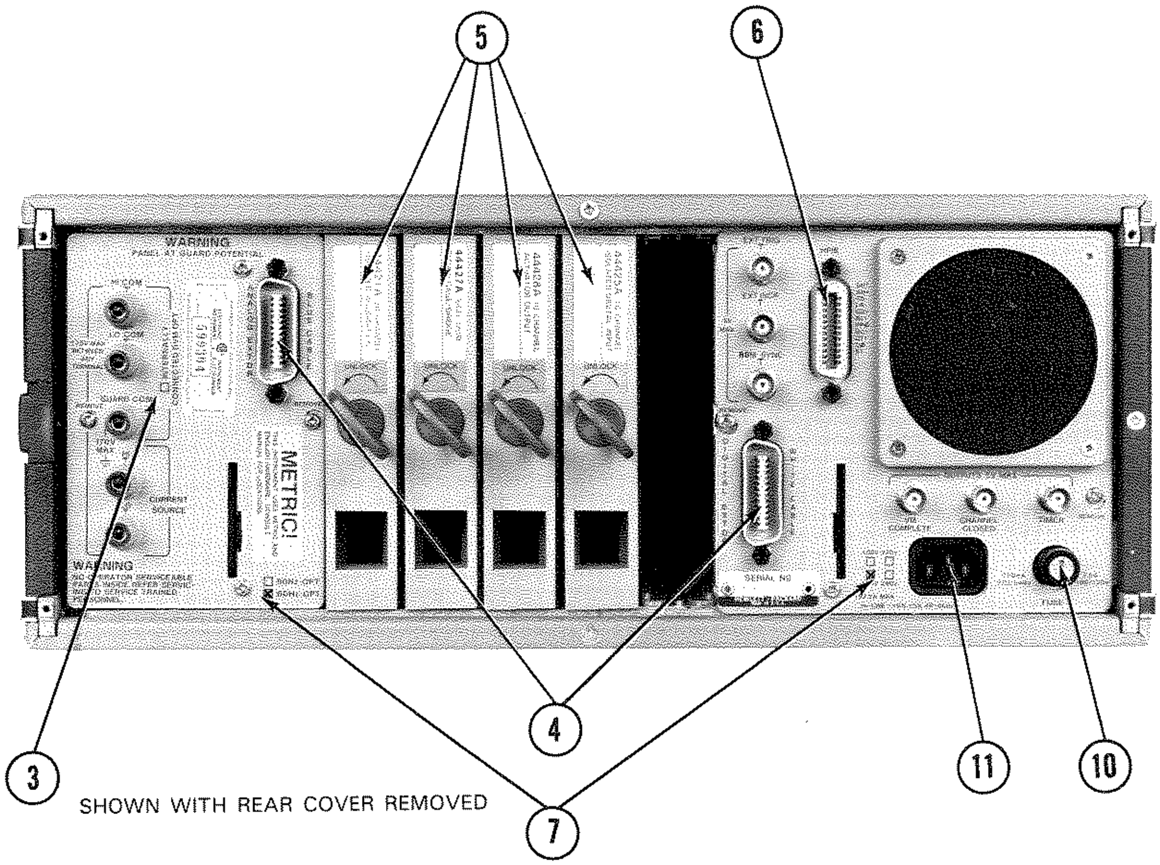


Figure 55. Standard (HP-IB) 3497A - Front and Rear Panels

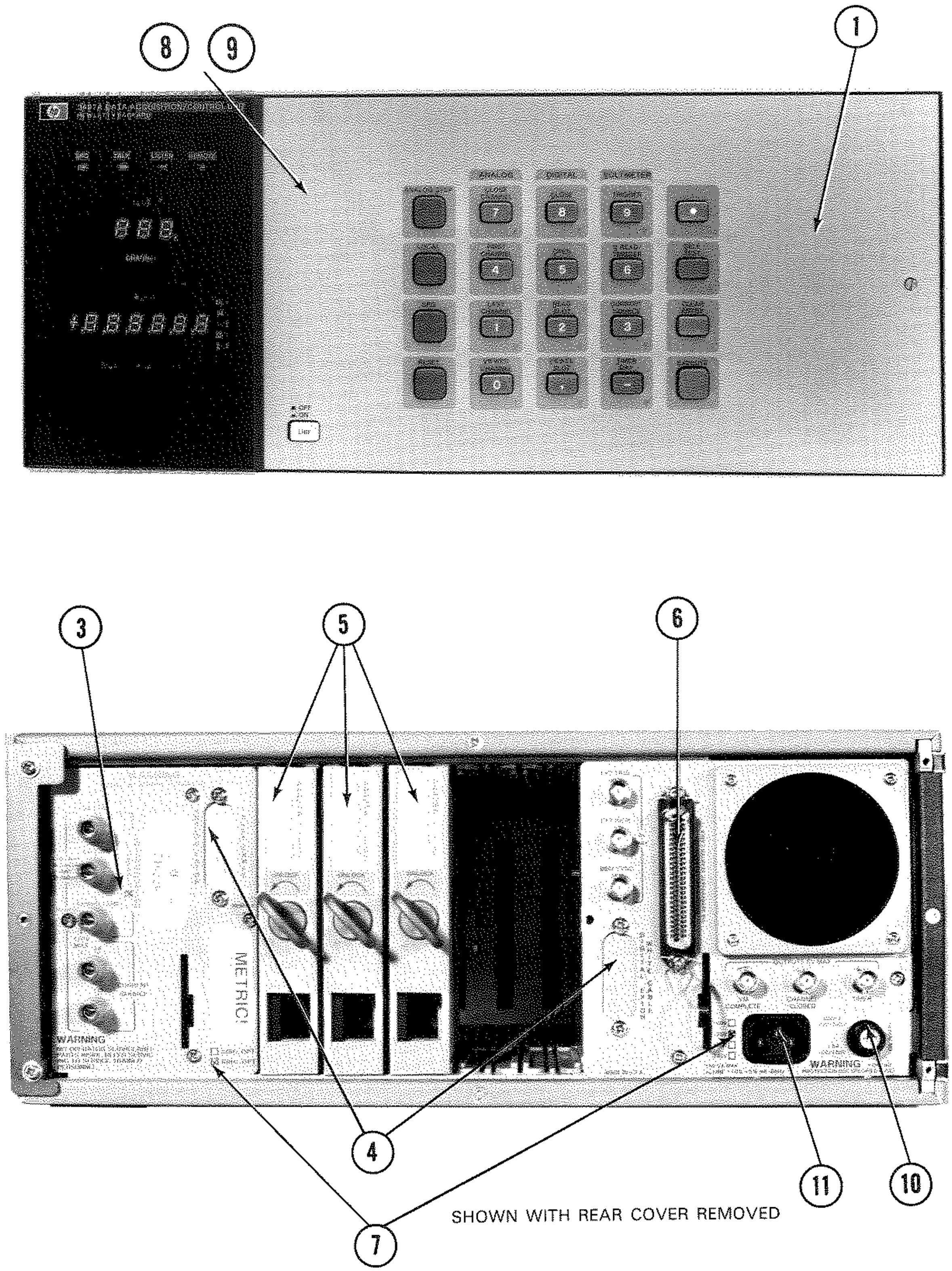


Figure 56. 3497A with Option 232 · Front and Rear Panels

3497A INITIAL INSPECTION CHECKS

STEP	CHECK
①	Front Panel Display and Keyboard (Deleted for Option 260).
②	Clock Format (marked on rear panel cover). Option 230 = Month:Day:Hours:Min:Sec Option 231 = Day:Month:Hours:Min:Sec
③	Remove the rear panel cover and check for DVM installation. If you ordered Option 001, the box marked INTERNALLY CONNECTED DVM OPT is checked (the 5 DVM terminals are present even if Option 001 is not ordered).
④	3498A Extender Cable Connectors If you ordered Option 298 (Add 3498A Extender), the ANALOG EXTENDER and DIGITAL EXTENDER cable connectors should be installed. If you didn't order Option 298, blank panels are in these spots.
⑤	Plug-In Assemblies The plug-in assemblies you ordered (Options 010 through 140) are installed in the 5-slot card cage. To identify the assemblies, refer to the 444xx number on each assembly. You may want to list the slot in which each assembly is located for future reference. Slots are numbered from 0 to 4, with slot 0 at the left of the card cage. A cross-reference between the 444xx numbers and option numbers for the assemblies follows. Plug-In Assemblies Option Number — 444xx Number 010 — 44421A 020 — 44422A 050 — 44425A 070 — 44427A 071 — 44427B 110 — 44428A 115 — 44431A 120 — 44429A 130 — 44430A 140 — 44432A
⑥	Interface Connector If you ordered a Standard (HP-IB) 3497A, an HP-IB Interface connector is installed. If you ordered a 3497A with Option 232, a Serial Data (RS232C/RS423) interface connector is installed.
⑦	Power and Frequency Options Check the box in the lower right-hand corner of the rear panel for the power option marked (100V, 120V, 220V or 240V). Check the box in the lower left-hand corner for the frequency option (50 Hz or 60 Hz) marked.
⑧	Line Voltage Selector Switches To verify that the Line Voltage Selector Switches are in the correct position for the power option specified, open the front panel on the 3497A by loosening the screw at the right side and swinging the panel open. Then, refer to Figure 57 which shows the location of the Line Voltage Selector Switches and the settings for each of the four power options. Leave the front panel open for the next step.
⑨	Battery Backup for Real Time Clock When AC power is removed from the 3497A, a 6V battery inside the 3497A keeps the clock operational for up to 24 hours. There are two types of battery backup, depending on the setting of the Continuous Clock Select Plug (see Figure 57 for location). Check this Plug to insure that the setting meets your operational requirements and then reclose the front panel. * Plug in OFF Position: Battery Backup supplied ONLY when the LINE switch on the 3497A is in the ON position when AC power is disconnected (this is the factory setting). * Plug in ON Position: Battery Backup supplied ANYTIME the AC power is disconnected, regardless of setting of the 3497A LINE switch.
⑩	Fuse Remove the fuse from the fuseholder and check to make sure that it is proper size for your line voltage (750 mA for 100/120 volts, 1.5A for 220/240 volts).
⑪	Power Cord Figure 58 shows power cord configurations available to provide AC power to the 3497A. The -hp- part number below each cable refers to the power cord equipped with an appropriate mating plug for that receptacle. Check to ensure that the power cord supplied with the 3497A is appropriate for operation with your local power and frequency conditions. Each of the power cords shown in Figure 58 is a three-conductor which, when plugged into an appropriate receptacle, grounds the instrument cabinet.

This completes the initial inspection of the 3497A. Replace the protective cover over the rear panel and the 3497A is now ready for turn on and self test. However, before plugging the 3497A into the AC line, please read the following safety considerations carefully to avoid personal injury or equipment damage.

Safety Considerations

General safety precautions must be adhered to during all phases of operation and/or configuration of the 3497A. Failure to comply with these precautions or with specific warnings or cautions in this manual violates safety standards of design, manufacture and intended use of the instrument. Hewlett-Packard company assumes no liability for the customer's failure to comply with these requirements.

Operating personnel must not remove instrument covers or configure the 3497A, 3498A or plug-in assemblies. Component replacement must be made by qualified, service-trained personnel who are aware of the hazards involved. Do not operate the instrument in the presence of flammable gases or fumes and do not expose the 3497A or 3498A to rain or moisture.

Warnings or cautions precede any potentially dangerous procedures throughout this manual. Instructions contained in the warnings and cautions must be followed. Safety symbols used on the instrument or in the manual include:

WARNING	WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like which, if not correctly performed or adhered to, could result in death or injury to personnel.
CAUTION	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like which, if not correctly performed or adhered to, could result in damage or destruction to all or part of the instrument.
NOTE	The NOTE sign denotes important information. It calls attention to a procedure, practice, condition or the like which is essential to highlight.
⚠	Instruction Manual Symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.
ϟ	Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).
∼	Alternating Current
⎓	Direct Current

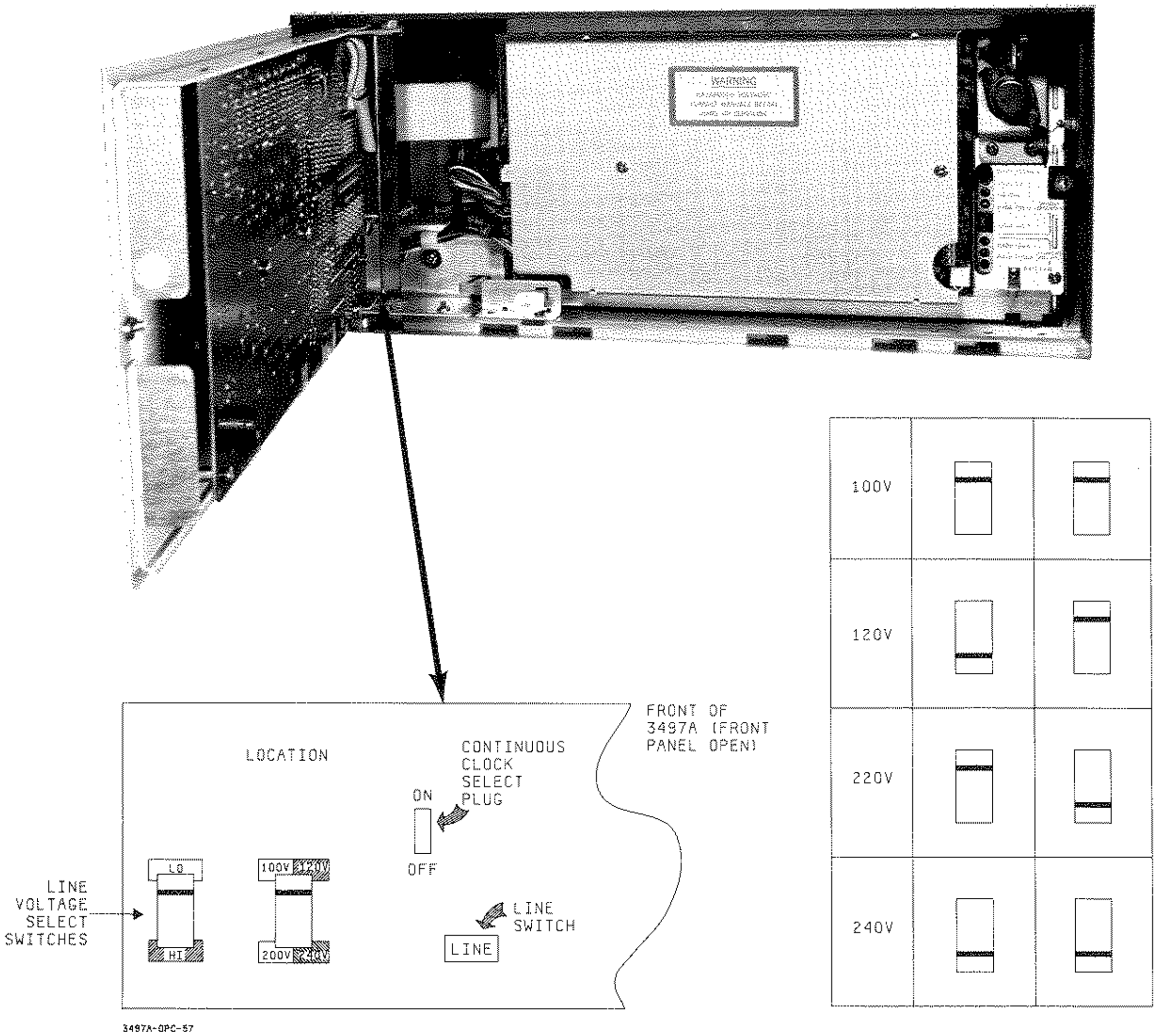


Figure 57. Line Voltage Selector Switches and Continuous Clock Select Plug

Turning the 3497A On

When you have checked out your 3497A, before you connect the instrument to your controller or your system, perform a self-test to verify that the 3497A is operating properly. If the 3497A does not pass the self-test, DO NOT CONNECT IT TO YOUR CONTROLLER OR TO YOUR SYSTEM. Refer to the 3497A Mainframe Installation and Service Manual for information.

After you have verified that the line voltage, volt-amps and frequency are correct for your 3497A, connect the power cord to the 3497A and plug the cord into your AC line (see Figure 55 or 56 for power cord plug-in location).

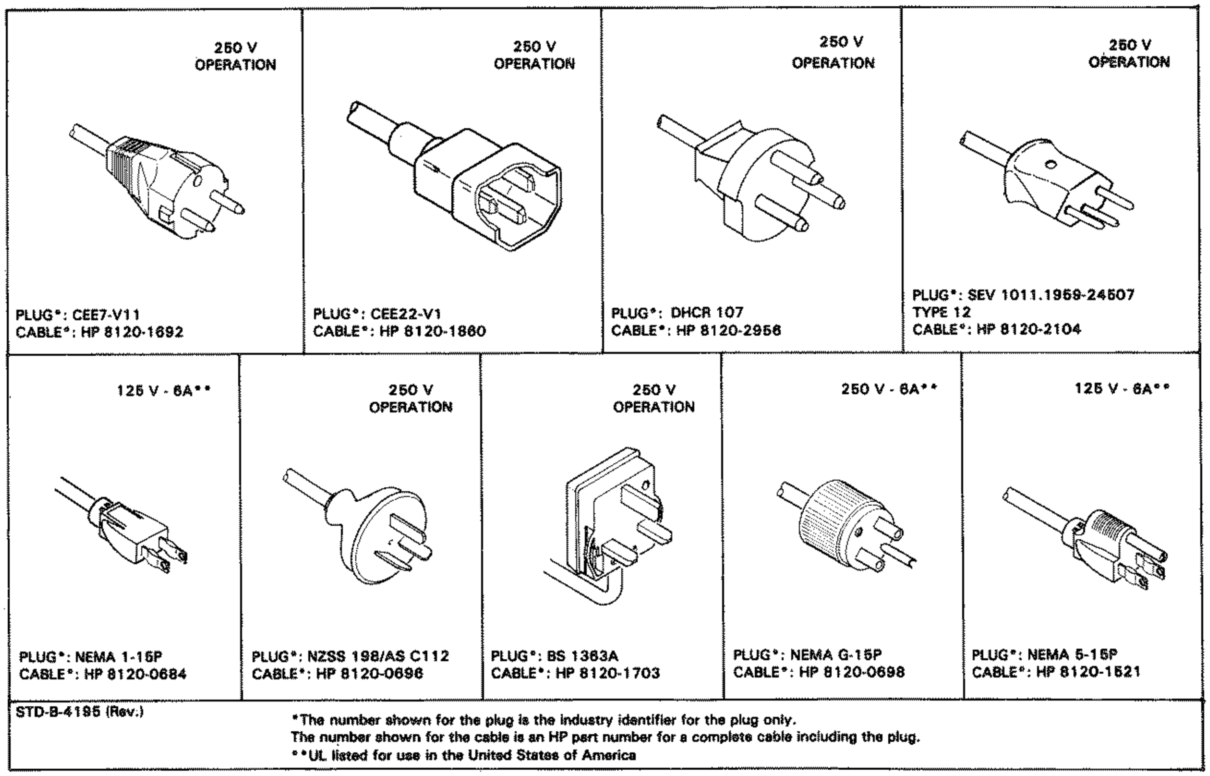


Figure 58. AC Power Cords for the 3497A/3498A

> **NOTE**
>
> *If your 3497A has the delete front panel option (Option 260), the front panel has only the LINE switch and a power ON indicator light. For Option 260 versions, the turn-on sequence is limited to pressing the LINE switch ON and noting that the power ON indicator lights.*

Turn the 3497A on by pressing the LINE switch ON (see Figure 55 or 56 for location) and carefully observe the 6-digit display on the front panel as it cycles through sequences (a) through (e) as shown. Since the display cycles very quickly, you may want to press the LINE key ON and OFF a few times to better observe the sequence.

You should also hear an audible BEEP when you first press the LINE switch ON. For a standard 3497A, if POWER-ON SRQ has been set, the SRQ indicator will turn ON. (POWER-ON SRQ is set to OFF at the factory). If the display does not match that shown, an error message is displayed and you should not use the instrument until it is properly repaired.

POWER-ON SEQUENCE

	6-Digit Display	Meaning
(a)	+.8.8.8.8.8.8	The 3497A goes through a complete self-test at power-on.
(b)	HP 3497	Identifies the instrument as the -hp- 3497A.
(c)	-Add 009	Shows that the 3497A is set to address of 09.
(d)	------	This is the final step of the power-on sequence if the DVM (Option 001) is not installed.
(e)	DCV +.32323 Blinking Light	This is the final step of the sequence when the DVM is installed. The blinking light shows internal triggering of the DVM and the + indicates completed measurement.
		The six-digit display shows the background DC voltage measured by the DVM and changes continuously as the DVM is triggered.

Self-Test

When the 3497A passes the power-on test, do the self-test by pressing the SELF-TEST key ON (see Figure 55 or 56 or location of the SELF-TEST key). At the completion of the self-test, the display should be as shown in Figure 59. If the self-test fails, the 3497A will display an error message and should not be used until it is repaired by a service-trained person.

After you press the SELF-TEST key, note that the light in the center of the blue SHIFT key is ON. If your 3497A has a DVM, the light at the upper left-hand corner of the six-digit display is blinking, indicating internal triggering of the DVM. This completes the self-test procedure. Turn the 3497A OFF by pressing the LINE switch. The 3497A is now ready for installation and connection to your controller and system.

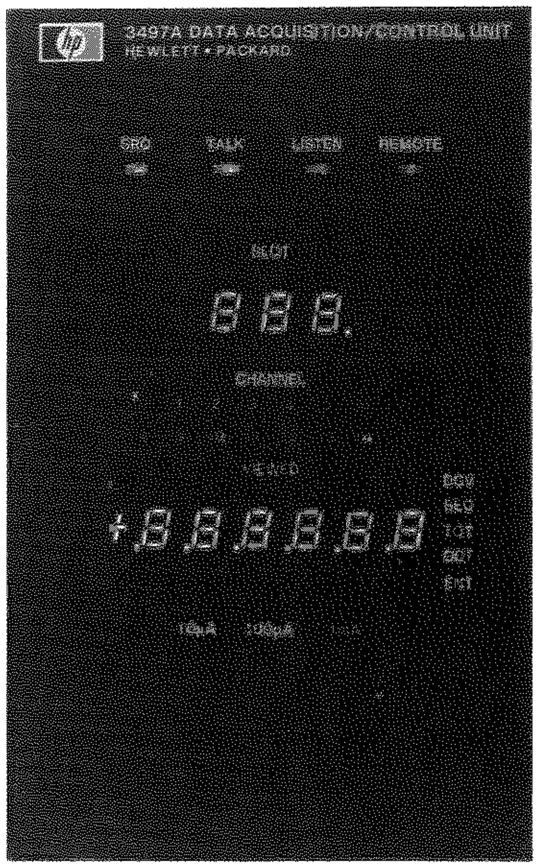


Figure 59. Self-Test Display

MAINFRAME INSTALLATION

The first step in designing a data acquisition/control system using the 3497A is to install the 3497A in a desired location. If you are using a controller with the instrument, the next step is to connect the 3497A to the controller via an HP-IB or Serial Data interface bus. The final step is to connect the 3497A to your user system. This part of the chapter shows some guidelines for installing your 3497A, beginning with environmental considerations for the 3497A.

Environmental Considerations

Environmental requirements for the 3497A or 3498A follow. To meet the specifications shown in Appendix B, the 3497A should be operated within ± 5°C (±9°F) of the calibration (or reference) temperature. As it comes from the factory, the 3497A should be operated within an ambient temperature range of 23°C ± 5°C (73°F ± 9°F). The instrument may also be operated within an ambient temperature range of 0°C to 55°C (+32°F to 131°F), but with reduced accuracy.

3497A/3498A ENVIRONMENTAL REQUIREMENTS

Warm Up Time	1 Hour
Operating Temperature	0°C to 55°C
Non-Operating Temperature	-40°C to 75°C
Humidity	To 95% except as noted in Specifications.
Shock	30 G, 11 msec, sine wave on each of six sides.
Vibration	10 Hz to 55 Hz at .010 inch peak to peak excursion.
Operating Power	Switch selection of 110 volts, 120 volts, 220 volts, 240 volts (- 10% to +5%); 48-66 Hz, 150 VA (3497A); 150 VA (3498A).

Bench Installation

The 3497A can be used as a bench instrument or can be installed in a standard 19" rack. The 3497A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument. The plastic feet are shaped so that the instrument can be mounted on top of other -hp- instruments.

When the 3497A is used as a bench instrument, choose a location which provides at least 3 inches (8 cm) of clearance at the rear of the instrument and at least 1 inch (3 cm) on each side. If adequate clearance is not provided, excessive temperatures may be generated inside the 3497A and reduce instrument reliability. Clearances provided by the plastic feet in bench stacking allow adequate air passage across the top and bottom cabinet surfaces.

Rack Mount Installation

Options 907, 908 and 909 (Rack Mounting Kits) enable the 3497A to be mounted in a standard EIA (19" wide) rack. Installation instructions are included with the Rack Mount Kit ordered. For further information on -hp- rack mounting kits, order -hp- SYSTEM II Rack Mounting Kits & Accessories Manual (-hp- part number 5952-0095) which is available from your nearest -hp- Sales and Service Office.

NOTE

If you ordered the 3497A as part of the 3054DL Data Logger or as part of the 3054A/C Automatic Data Acquisition/Control System, refer to the appropriate system manual for installation instructions.

Installing Plug-In Assemblies

To install plug-in assemblies (Options 010 through 140) in the 3497A or the 3498A, select the slot desired for the assembly and insert the assembly as shown in Figure 60 which depicts a sample installation for the High Voltage Actuator assembly (Option 115). To install the 3498A Extender, see Chapter 8.

WARNING

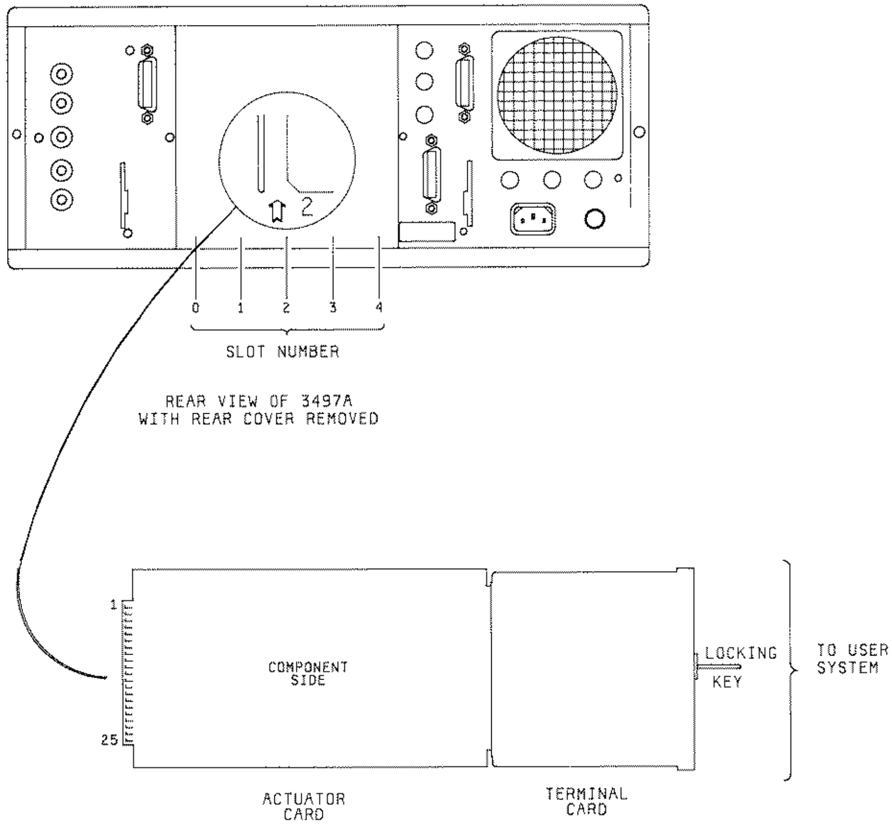
Do not install or remove plug-in assemblies until you remove the AC power cords from the 3497A/3498A and remove ALL external power sources from these instruments.

CAUTION

All assemblies require clean handling techniques to avoid degraded performance.

NOTE

Some assemblies require that a shield or cover be removed if the assembly is to be installed in slot 4 of a 3497A or in slot 4 or 9 of a 3498A. See Chapter 8 before installing any assembly.



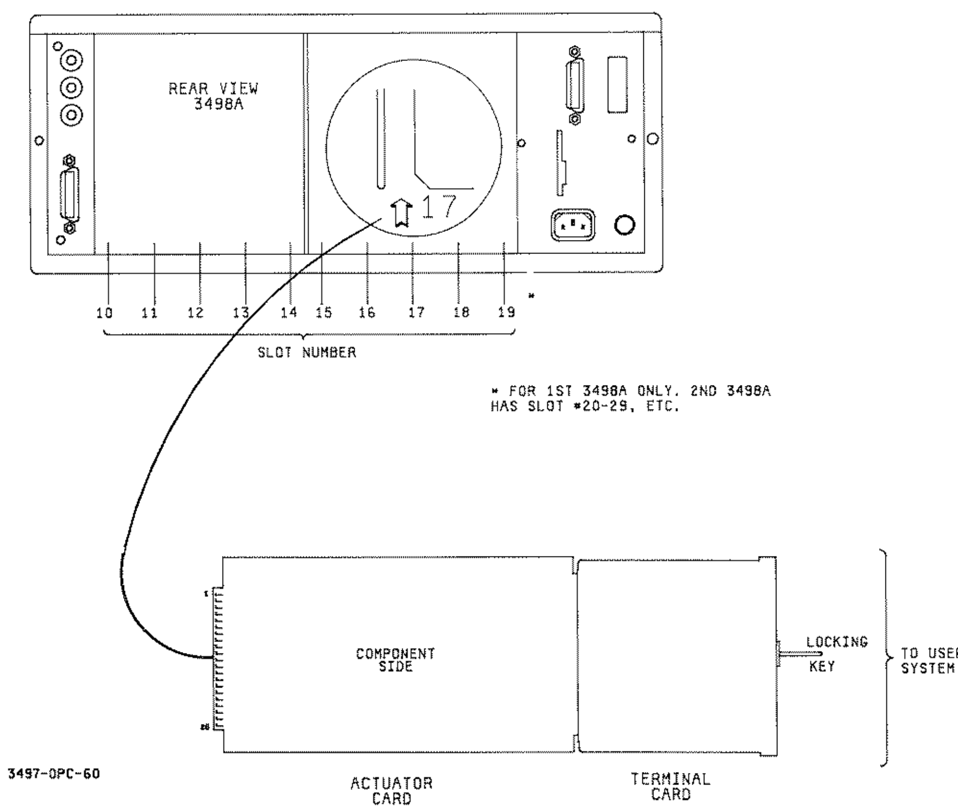


Figure 60. Installing Plug-In Assemblies (Example)

HP-IB INSTALLATION

This part of the chapter shows how to connect the 3497A to an HP-IB bus and provides guidelines for designing an HP-IB system. This information applies only to 3497As with HP-IB capability. See RS232C Installation or RS449/423 Installation for a 3497A with RS232C or RS 449/423 capability.

NOTE

The Hewlett-Packard Interface Bus (HP-IB) is the Hewlett-Packard implementation of IEEE Standard 488-1978, "Standard Digital Interface for Programmable Instrumentation" and ANSI Standard MC 1.1.

Configuring the HP-IB

As factory configured, the 3497A is set for HP-IB address 09, TALK ONLY mode disabled and no POWER ON SRQ capability. If your operation requires a different address for the 3497A or if you need to set power-on interrupt (SRQ) or set the 3497A for TALK ONLY mode, see Changing HP-IB Addresses in the MAINFRAME CONFIGURATION part of this chapter before connecting the 3497A to the HP-IB interface bus.

After you have set the HP-IB address, TALK ONLY and POWER ON SRQ ENABLE switches as required for your operation, the next step is to connect the 3497A to the HP-IB. To do this, first decide how many instruments are going to be on the bus and their locations.

A total of 15 HP-IB compatible instruments can be connected to the bus. HP-IB cables have identical "piggy-back" connectors on both ends so that several cables can be connected to a single source. A typical HP-IB system interconnection and sample system setup is shown in Figure 61.

A good rule to follow is not to stack more than two cables on any one connector. If the stack is too large, any force on the stack can break connectors and affect HP-IB operation.

For best HP-IB performance, total cable length for the system must be less than or equal to 20 meters (65 feet). Total cable length must be less than or equal to 2 meters (6 feet) times the total number of devices connected to the HP-IB (i.e., 4 meters total for 2 instruments).

NOTE

You can order 1 meter, 2 meter or 4 meter HP-IB cables from -hp- as optional accessories. See the Ordering and Configuration Guide in Appendix B.

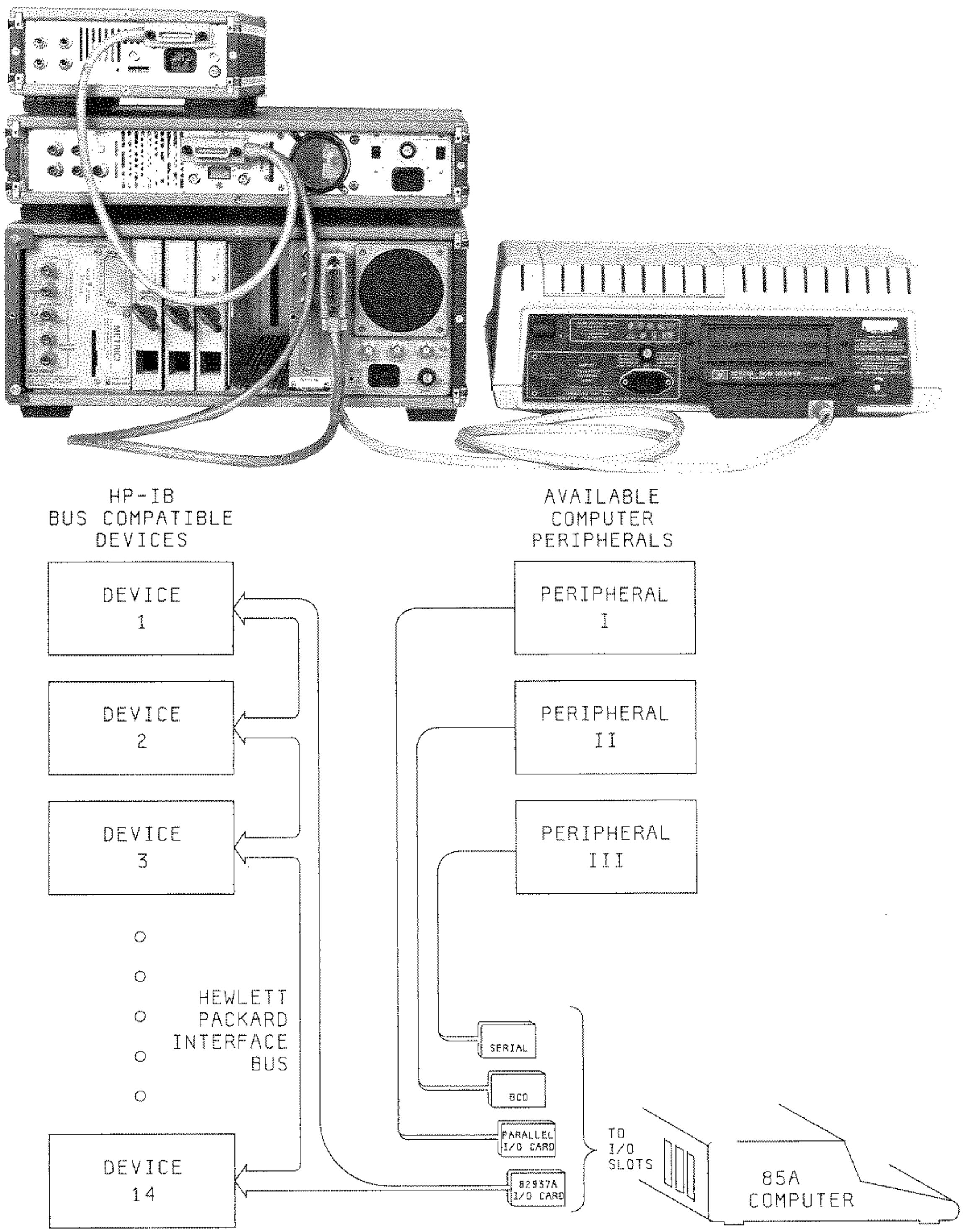


Figure 61. Typical HP-IB System Interconnection

HP-IB Worksheet

As you are setting up your HP-IB system, you may want to use the HP-IB Worksheet shown to record the capability of each of the devices on your system. In the worksheet shown, the capabilities of the 3497A are already filled in. Refer to your controller manual(s) and device manuals for their bus message capabilities. When this worksheet is filled out, you'll have a permanent record of the device capabilities of your HP-IB system.

HP-IB WORKSHEET

DEVICE

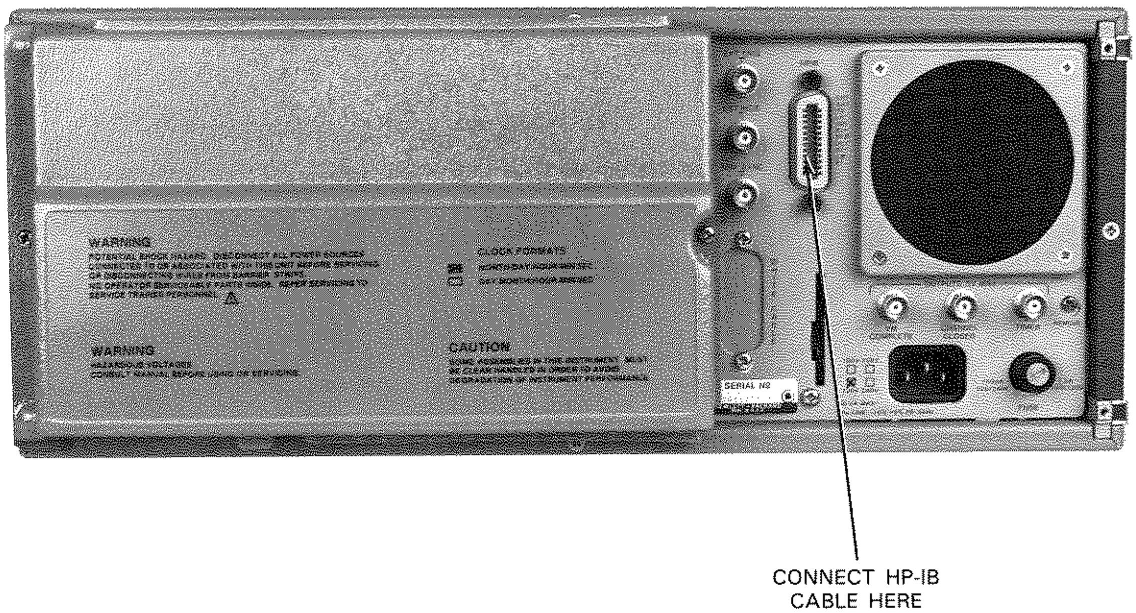
MODEL	3497A							
ADDRESS	09							
TALK/LISTEN	T&L							

BUS MESSAGE CAPABILITY								
ABORT	N							
CLEAR	R							
DATA	S&R							
LOCAL	R							
LOCAL LOCKOUT	R							
CLEAR LOCKOUT & SET LOCAL	R							
PASS CONTROL	N							
REMOTE	R							
REQUIRE SERVICE	S							
STATUS BIT	N							
STATUS BYTE	S							
TRIGGER	R							

S = SEND ONLY R = RECEIVE ONLY S&R = SEND & RECEIVE
N = NOT IMPLEMENTED T&L = TALK & LISTEN

Connecting the 3497A to the HP-IB

To interface the 3497A to the HP-IB, connect an appropriate HP-IB interface cable to the HP-IB connector on the 3497A rear panel, as shown in Figure 62. See your controller I/O manual for the interface cable to use.



CAUTION

The 3497A/3498A contains metric threaded HP-IB cable mounting studs as opposed to English threads. Metric threaded -hp- 10631A, B, or C HP-IB cable lockscrews must be used to secure the cable to the instrument. Identification of the two types of mounting studs and lockscrews is made by their color. English threaded fasteners are colored silver and metric threaded fasteners are colored black. DO NOT mate silver and black fasteners to each other or the threads of either or both will be destroyed. Metric threaded HP-IB cable hardware illustrations and part numbers follow.

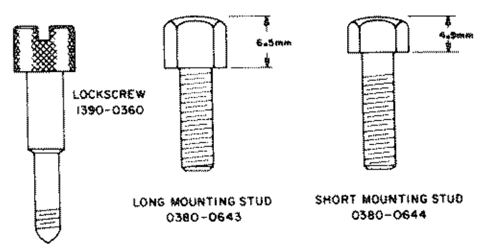


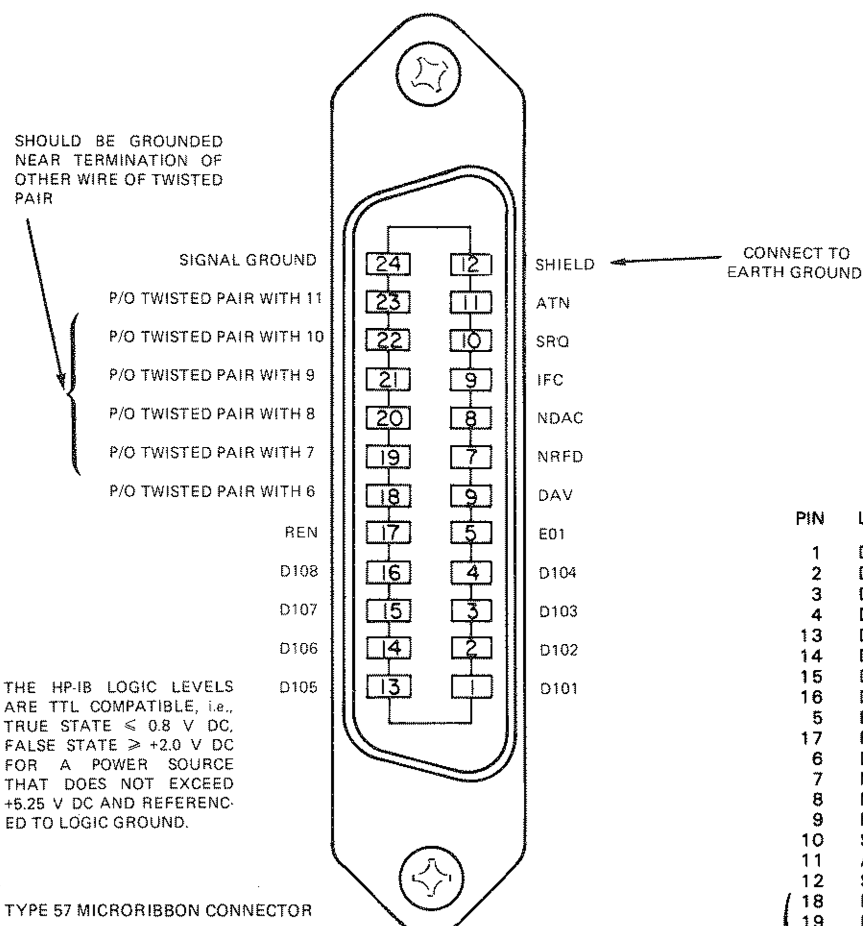
Figure 62. Connecting the 3497A to the HP-IB

3497A Device Capability

The 3497A interfaces to the HP-IB as defined by IEEE Standard 488-1978. Figure 63 shows the HP-IB connector and pin designations. The interface functional subset which the 3497A implements follows.

3497A DEVICE CAPABILITY

SH1	Source Handshake complete capability
AH1	Acceptor Handshake complete capability
T5	Basic Talker with serial poll, talk only mode and unaddress with MLA
L4	Basic listener, unaddress when MTA
SR1	Service Request complete capability
RL1	Remote-Local complete capability
PP0	No parallel poll capability
DC1	Device Clear complete capability
DT1	Device Trigger complete capability
C0	No controller capability
E1	Open Collector Drivers



PIN	LINE
1	D101
2	D102
3	D103
4	D104
13	D105
14	D106
15	D107
16	D108
5	E01
17	REN
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	SHIELD-CHASSIS GROUND
18	P/O TWISTED PAIR WITH PIN 6
19	P/O TWISTED PAIR WITH PIN 7
20	P/O TWISTED PAIR WITH PIN 8
21	P/O TWISTED PAIR WITH PIN 9
22	P/P TWISTED PAIR WITH PIN 10
23	P/O TWISTED PAIR WITH PIN 11
24	ISOLATED DIGITAL GROUND

THESE PINS ARE INTERNALLY GROUNDED (pins 18–24)

Figure 63. HP-IB Connector Pin Designators

Checking the 3497A in the HP-IB System

After the 3497A has been connected to the HP-IB, to check its performance connect the AC power plug to the AC line and press the LINE key ON. ALLOW AT LEAST ONE HOUR OF WARM-UP TIME and then send a self-test command from your controller. A sample program in extended BASIC (applicable to -hp- 85 and similar controllers) is shown.

Following command execution, the 3497A front panel display should be as shown in Figure 59 and 8E8 (or equivalent format) should be displayed at the controller. If the self-test fails, an error message is returned and you should consult the 3497A Mainframe Installation and Service Manual for further information.

EXAMPLE - HP-IB OPERATION SELF-TEST

Program	Lines	Description
10 OUTPUT 709; "ST1" 20 ENTER 709; A	10	Turns self-test ON.
30 DISP A 40 WAIT 1000 50 OUTPUT 709; "STO"	20-30	Enters and displays 8E8 if self-test passes.
60 END	40-50	Waits 10 seconds and turns self-test OFF.

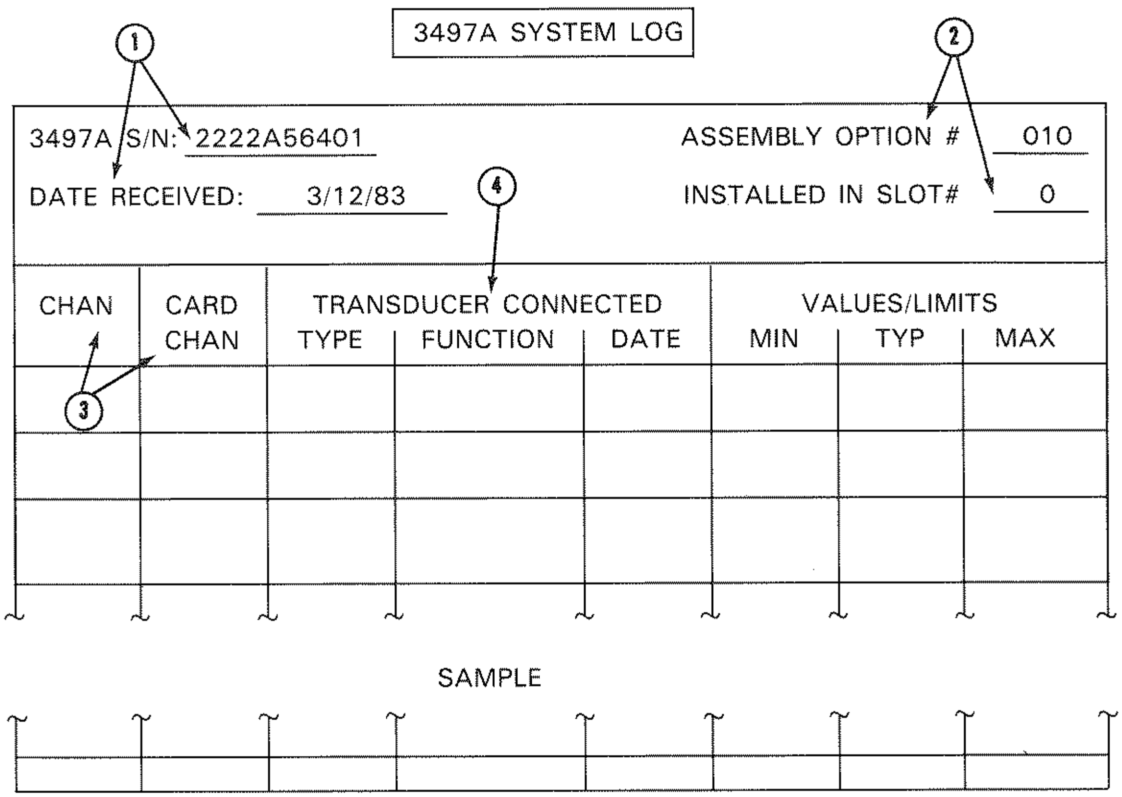
When the 3497A passes the self-test, it is ready for operation and can be connected to your system. When you connect your 3497A for your specific application, you may want to see Chapter 9 for example ways to make voltage, resistance, thermocouple, frequency or pressure measurements or to do control applications such as interrupts, switching and control sources.

To connect your system to the 3497A, inputs must be connected to appropriate terminals on the plug-in assemblies (Options 010 through 140). Before attaching any system inputs to the assemblies, see Chapter 8 which shows how to configure each assembly for various modes of operation and operating precautions.

3497A System Log

When you are connecting your system inputs to the assemblies, you may want to complete a 3497A System Log similar to the example which follows so that you will have a permanent record of the inputs connected to each channel of the 3497A.

A blank 3497A System Log is located in Appendix B so that you can copy it if desired. For ease of reference, we suggest that you complete a separate form for each plug-in assembly at initial installation and that all forms be filed in a folder to accompany the 3497A.



(1) Enter the 3497A serial number and the date the instrument was received.

(2) List the option number (010 through 140) of the plug-in assembly for this log and show the 3497A/3498A slot number that the assembly is installed in.

(3) For each channel used, enter the channel number and terminal connectors to which the transducer is connected. For example, with an Option 010 assembly in slot 1, channel numbers are 0 to 19. For an Option 010 assembly in any slot, terminal connectors range from A0 (H, L and G) to B9 (H, L and G). Note: CHANNEL NUMBER column not applicable for Options 050, 060, 110, 115 and 140.

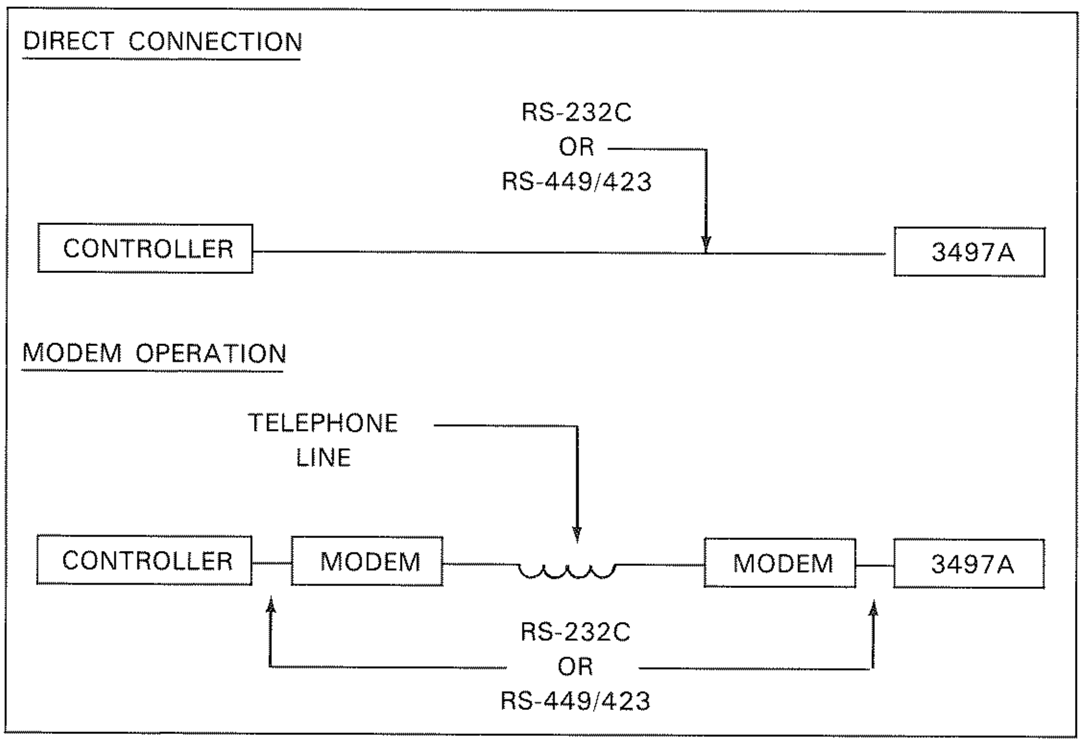
(4) For each transducer connected to a channel, list the transducer type, function and date installed. Then, list a typical measurement value for that transducer. If action is required when limits are exceeded, enter measurement limits under MAX and MIN.

RS232C INSTALLATION

This part of the chapter provides installation guidelines for the 3497A for RS232C Serial Data operation. With Option 232, the 3497A is compatible with Electronic Industries Association (EIA) standard RS-232C and with RS449 (RS423 subset). It is also compatible with CCITT (Comite Consultatif International Telephonique et Telegraphique) standards CCITT V.24 (for RS232C) and CCITT V.10 (for RS449/423).

The 3497A can be operated from a controller in one of two ways: (1) directly connected to a controller via RS-232C or RS-449/423 or (2) connected to an asynchronous, full duplex MODEM via RS-232C or RS-449/423 for remote site operation using dedicated telephone lines, as shown.

3497A SERIAL DATA CONFIGURATIONS



The 3497A can operate only with asynchronous, full duplex MODEMS (data sets). The instrument has been functionally tested to operate with the following (or equivalent) MODEMS:

. Bell 103A, 212A, 103J
. Vadic 3400, 3451
. U.D.S. 103JLP
. -hp- Model 82950A MODEM Interface for the -hp- 85A

The 3497A can be configured for a wide variety of operating conditions, depending on controller and speed requirements. The following chart shows operating conditions for the 3497A with factory preset conditions outlined. If you need to reset the 3497A for operating conditions other than factory configuration, see MAINFRAME CONFIGURATION in this chapter for details.

3497A OPERATING CONFIGURATIONS

Type of Operation	RS-449/423 Operation RS-232C Operation*	
Type of Connection	Direct Connection to Controller* Connect to MODEM	
Type of Handshake	ENQ/ACK DC1 ON DC1 OFF*	
Speed of Operation/ # Stop Bits	Speed	#Bits
	19,200	1
	9,600	1
	4,800	1
	2,400	1
	1,200	1
	600	1
	300*	1*
	110	2
Word Length & Parity	8-bit ASCII w/odd parity 7-bit ASCII w/odd parity* 8-bit ASCII w/no parity 7-bit ASCII w/even parity	

* = Factory Setting

RS232C Pre-Installation Checks

Before connecting the 3497A to your controller, review the following checklist to ensure that the 3497A configuration is compatible with your controller operation.

RS232C PRE-INSTALLATION CHECKLIST

Are the 3497A character length, parity bit, speed of operation and number of stop bits compatible with your controller?
Will ENQ/ACK or DC1 handshake be used? ENQ/ACK is implemented by software (see Chapter 4), while DC1 is set by placing the DC1 Handshake switch (S1, position #4) to the "1" position (see MAINFRAME CONFIGURATION).
Will MODEMs be used? If used, MODEMs must be asynchronous and full-duplex (preferably one of the MODEMs listed earlier in this chapter).
Is S2 set for RS232? (see MAINFRAME CONFIGURATION).
If your controller has an ECHO function, is this turned OFF? Does the controller accept CR (only) as a terminator?

Connecting the 3497A to a Controller

When the 3497A has been set for desired operation, the next step is to connect it to your controller, either by direct connection or via MODEMS.

Supplied with each 3497A Option 232 is a US MODEM cable 13222N (-hp- part number 13222-60001) for interface between the 3497A and your controller or MODEM. This cable consists of a 50-pin male connector to connect to the 3497A and a standard 25-pin RS233C male connector for connection to a MODEM or to a controller. Figure 64 shows the pin definitions for the 13222N cable.

13222 N
(13222-60001)

Name on Hood: U.S. MODEM CABLE

Cable Length: 5 meters, 16.7 feet

Uses: 262X Terminal connection to HP 1000, 2000, 3000 Multiplexors; 103A; 202C, D, S, T; 212A and VADIC 3400 modems; Acoustic Couplers (signal compatible only). Shielded.

For HP 1000, 2000, 3000 Systems.

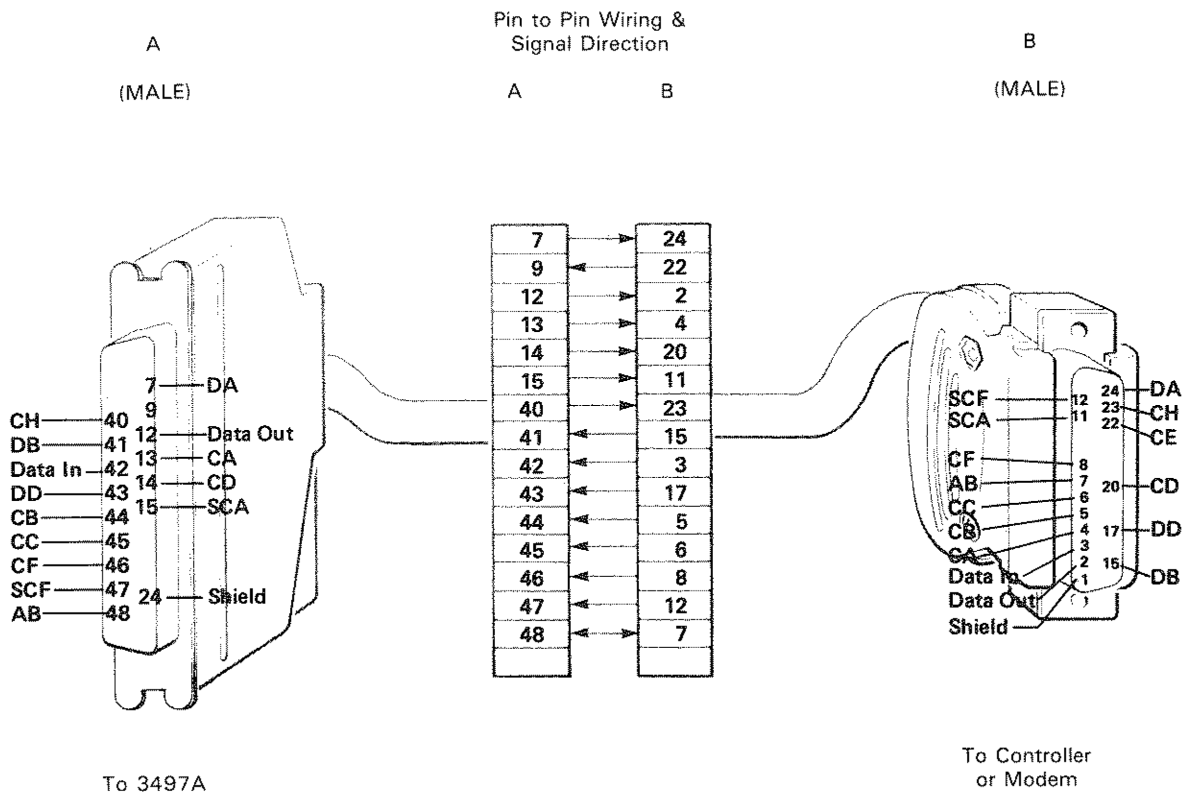


Figure 64. 13222N Pin Definitions

In general, RS232C operation limits cable length to a maximum of 50 feet (15.24 meters), depending on total load capacitance. Also, load capacitance at the interface point should not exceed 2500 pF. Longer cables may be used if total load capacitance does not exceed 2500 pF.

For any interface used, certain lines are required for connection between the 3497A and a controller (direct connection) or between the 3497A and a MODEM (MODEM Operation), as shown. Other pins, even if connected, are not monitored or controlled by the 3497A.

RS232C OPERATION - LINES REQUIRED

LINES REQUIRED WHEN DIRECTLY CONNECTED TO A CONTROLLER
Transmitted Data Received Data Signal Ground

LINES REQUIRED WHEN CONNECTED TO A MODEM
Transmitted Data Received Data Signal Ground Data Terminal Ready Data Carrier Detect Request to Send Clear to Send Data Set Ready

To connect the interface cable to the 3497A, see Figure 65. Plug the 50-pin male connector into the female connector on the rear of the 3497A and snap the two wire clips in place to secure the connector. Then, connect the 25-pin male connector to your controller or MODEM as required. This completes the installation for RS232C operation.

WARNING

The 50-pin male connector for the 13222N cable has a metal housing which is internally connected to the cable shield. Pin 1 (Protective Ground) of the 25-pin male connector for this cable is also connected to the shield. If Pin 1 of the 25-pin male connector is connected to your controller or MODEM chassis, ensure that the chassis has an earth ground so that the exposed metal housing on the 3497A will not be at a hazardous voltage level.

NOTE

When connecting the 13222N cable, ensure that the pin connectors are correct. Pin 2 (TX Line) from the cable is an output and Pin 3 (RX Line) is an input line. At the controller or MODEM, however, pins 2 and 3 may be inputs or outputs, depending on interface specifications. These connections are shown in Figure 65.

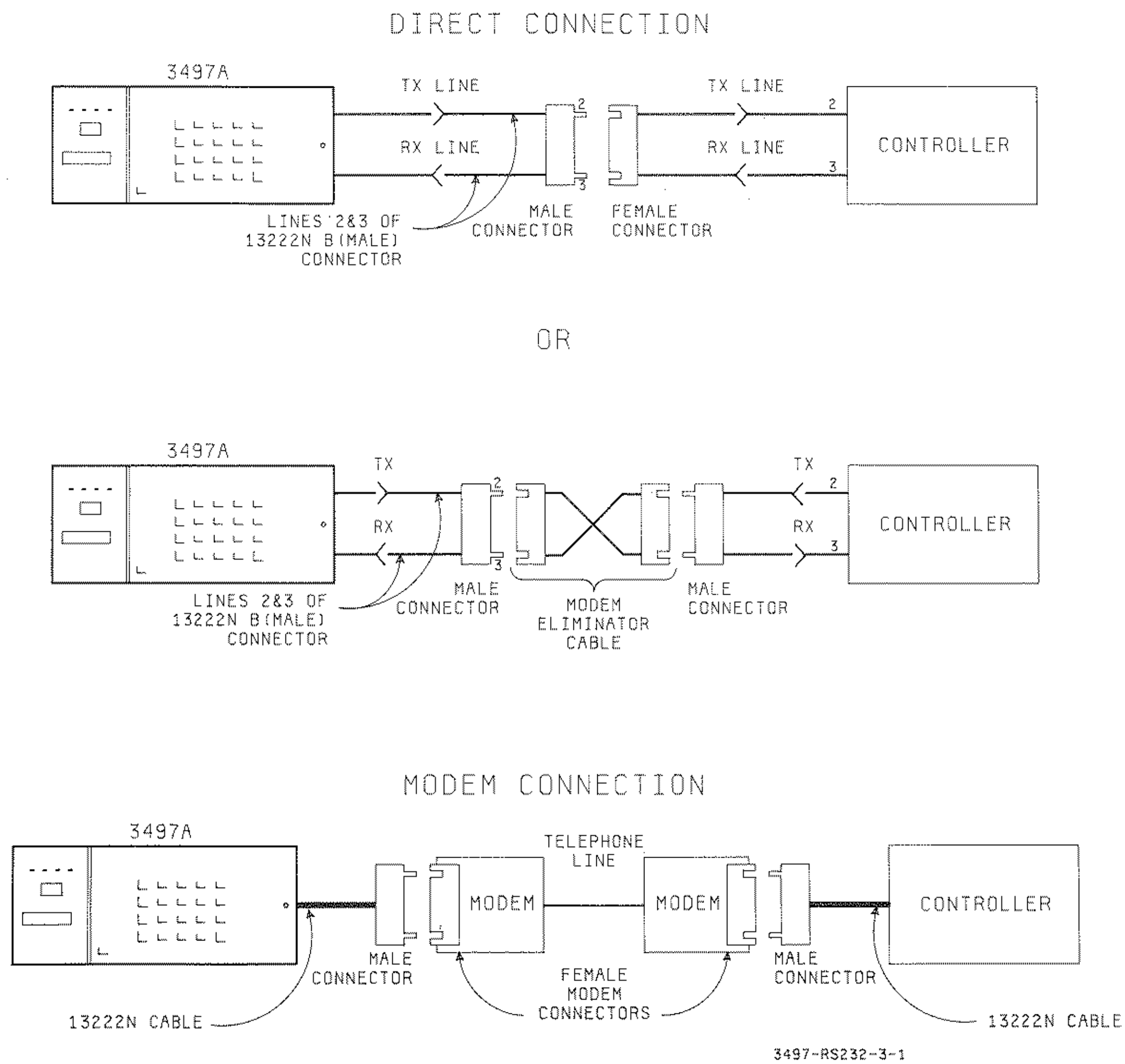


Figure 65. Connecting the 13222N Cable

Checking the 3497A For RS232C Operation

After the 3497A has been connected to your controller, perform a self-test of the 3497A to check for proper operation and to ensure that data is transferred across the interface. To do this, turn on the 3497A and enter the following program if you use a BASIC language controller or an equivalent program for other types of controllers.

At the completion of the program, if the 3497A returns 8E8 it passes the self-test and is ready for operation. If another reading is returned, refer to the 3497A Mainframe Installation and Service Manual.

EXAMPLE - RS232C OPERATION SELF-TEST

Program	Lines	Description
10 RESET 10	10	Clears interface with ISC of 10.
20 OUTPUT 10; "ST1"		
30 ENTER USING "#,K"; A	20	Turns self-test ON.
40 DISP A		
50 OUTPUT 10; "ST0"	30-40	Displays result of self-test. 8E8 returned if self-test passes.
60 END		
	50	Turns self-test OFF.

Connecting the 3497A to Your System

When the 3497A passes the self-test, it is ready for operation and can be connected to your system. When connecting the 3497A to your system, you may want to see Chapter 9 for example ways to make voltage, resistance, thermocouple, frequency or pressure measurements or to do control applications such as interrupts, switching and control sources.

To connect your system to the 3497A, inputs must be connected to appropriate terminals on the plug-in assemblies (Options 010 through 140). Before attaching any system inputs to the assemblies, see Chapter 8 which shows how to configure each assembly for various modes of operation.

NOTE

When you are connecting your system inputs to the assemblies, you may want to complete a 3497A System Log similar to the one shown in HP-IB INSTALLATION in this chapter so that you'll have a permanent record of the inputs connected to each channel of the 3497A.

A blank 3497A System Log is located in Appendix B so that you can copy it if desired. For ease of reference, we suggest that you complete a separate form for each plug-in assembly at initial installation and that all forms be filed in a folder to accompany the 3497A.

RS449/423 INSTALLATION

This part of the chapter provides installation guidelines for the 3497A for RS449/423 Serial Data operation. With Option 232, the 3497A is compatible with Electronic Industries Association (EIA) standard RS232C and with RS449 (RS423 subset). It is also compatible with CCITT (Comite Consultatif International Telephonique et Telegraphic) standards CCITT V.24 (for RS232C) and CCITT V.10 (for RS449/423).

Operation for RS449/423 is very similar to that for RS232C. So, for information on 3497A capabilities, operating configurations and compatible MODEMS and pre-installation checks, see RS232C INSTALLATION earlier in this chapter.

RS449 encompasses two standards for standards for voltage requirements: RS422 and RS423. RS423 is implemented by the 3497A and specifies the electrical characteristics for unbalanced voltage digital interface circuits. RS449 designates a standard 37-pin connector or an optional 9-pin connector for ''reverse channel'' or ''backward channel'' operation.

For RS-449/423 operation, the 13222N cable supplied with the 3497A cannot be used. Contact your nearest -hp- Sales and Service office if you need to order an interface cable for RS-449/423 operation.

NOTE

An overlap in values of certain parameters of RS423C and RS232C has been established so that it is possible to achieve satisfactory interoperation of RS232C and RS423 equipment. Interface circuits implemented with RS422 drivers will not directly interoperate with RS232C receivers. An important point to keep in mind when operating with RS423 and RS232C is that performance is limited to that associated with RS232C.

Connecting the 3497A to a Controller

After you have set switches S1 and S2 in the 3497A for desired operation as shown in the RS232C Pre-Installation Checklist, the next step is to determine appropriate cable connections and cable lengths for proper operation. The following chart shows the lines required for RS-449/423 operation for direct connection to your controller and for MODEM connection.

RS449/423 OPERATION - LINES REQUIRED

LINES REQUIRED FOR DIRECT CONNECTION
Send Data Ground for Send Data Received Data Ground for Received Data Signal Ground

LINES REQUIRED FOR MODEM OPERATION
Send Data Ground for Send Data Received Data Ground for Received Data Signal Ground Terminal Ready Ground for Terminal Ready Receiver Ready Ground for Receiver Ready Request to Send Ground for Request to Send Clear to Send Ground for Clear to Send Data Mode Ground for Data Mode

Cable length limits imposed by RS449/423 operation depend on the speed of operation, as shown in Figure 66. For example, with a cable length of 4000 feet (1220 meters), maximum operating speed is 1000 bits per second. After the cable has been selected, connect the cable to the 3497A rear panel connector. This completes the installation for RS449/423 operation.

WARNING

RS449/423 does not specify either protective ground or safety ground as an interchange circuit. Thus, for RS449/423 operation, if bonding of equipment chassis is required, use a separate conductor which conforms to national or local electrical codes. In all cases, any device being interfaced should have an earth grounded chassis.

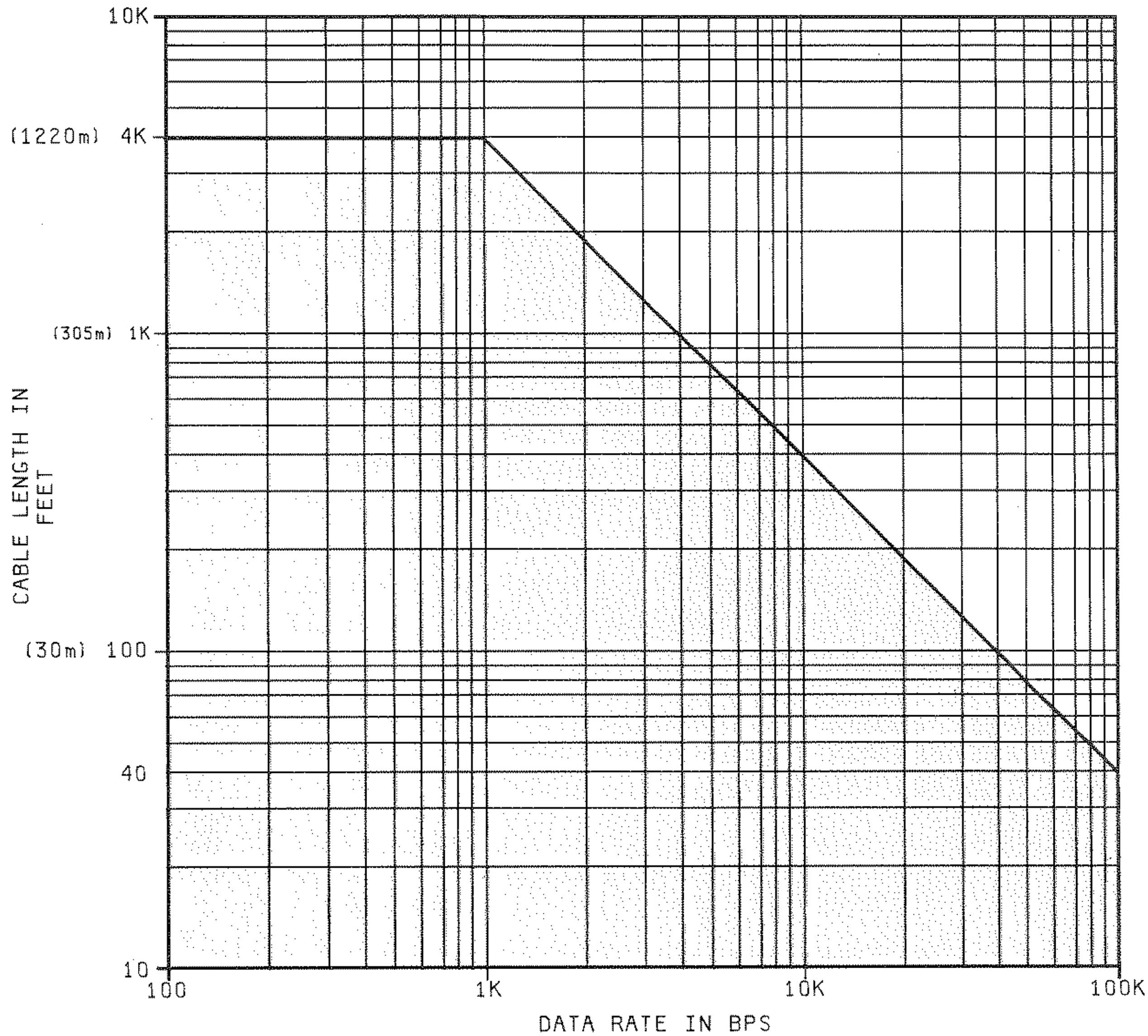


Figure 66. RS449/423 Cable Length Restrictions

Checking the 3497A For RS449/423 Operation

After the 3497A has been connected to your controller, perform a self-test of the 3497A to check for proper operation and to ensure that data is transferred across the interface. To do this, turn on the 3497A and enter the following program if you use a BASIC language controller or an equivalent program for other types of controllers.

At the completion of the program, if the 3497A returns 8E8 it passes the self-test and is ready for operation. If another reading is returned, refer to the 3497A Mainframe Installation and Service Manual.

EXAMPLE - RS449/423 OPERATION SELF-TEST

Program	Lines	Description
10 RESET 10	10	Clears interface with ISC of 10.
20 OUTPUT 10; "ST1"		
30 ENTER USING "#,K"; A	20	Turns self-test ON
40 DISP A		
50 OUTPUT 10; "ST0"	30-40	Displays result of self-test. 8E8 returned if self-test passes.
60 END		
	50	Turns self-test OFF.

Connecting the 3497A to Your System

When the 3497A passes the self-test, it is ready for operation and can be connected to your system. When connecting the 3497A to your system, you may want to see Chapter 9 for example ways to make voltage, resistance, thermocouple, frequency or pressure measurements or to do control applications such as interrupts, switching and control sources.

To connect your system to the 3497A, inputs must be connected to appropriate terminals on the plug-in assemblies (Options 010 through 140). Before attaching any system inputs to the assemblies, see Chapter 8 which shows how to configure each assembly for various modes of operation and operating precautions.

NOTE

When you are connecting your system inputs to the assemblies, you may want to complete a 3497A System Log similar to the one shown in HP-IB INSTALLATION in this chapter so that you'll have a permanent record of the inputs connected to each channel of the 3497A.

A blank 3497A System Log is located in Appendix B so that you can copy it if desired. For ease of reference, we suggest that you complete a separate form for each plug-in assembly at initial installation and that all forms be filed in a folder to accompany the 3497A.

MAINFRAME CONFIGURATION

When you received your new 3497A, it was factory preset for the configuration you specified. In many cases, factory settings will be correct for your application. If, however, you need to change the configuration of the 3497A mainframe, see this part of the chapter for details. If you need to change the configuration of the plug-in assemblies or the 3498A, see Chapter 8.

This part of the chapter shows how to make hardware changes to the 3497A mainframe, but does not show how to make alignments or adjustments. See the 3497A Mainframe Installation and Service Manual for this information. See the following chart to locate the specific configuration function required.

3497A MAINFRAME CONFIGURATION

FUNCTION	DESCRIPTION	PAGE
Change Analog Addresses	Change analog addressing scheme so that up to 10 channels (1/decade, 2/slot) can be closed with a single command.	356
Set Clock Format	Set real-time clock for Option 230 or 231 format.	360
Clock Battery Back-Up	Reset the 3497A so that battery back-up for the real-time clock is supplied whenever the AC power is disconnected.	362
Change Line Volts	Set the 3497A for AC line input of 100V, 120V, 220V or 240V.	363
Change HP-IB Address Switch	For a 3497A with HP-IB capability, reset the HP-IB address and set TALK ONLY and POWER ON SRQ capabilities.	363
Set Serial Data Operating Conditions	For a 3497A with Serial Data (RS-232 or RS449/423), set RS-233 or SS-449/423 operation, direct or MODEM connection to controller, handshake, speed of operation/number of stop bits, word length and parity for desired operation.	366

Change Analog Addresses

As factory preset, a maximum of four channels can be closed simultaneously by using the AC chan#,chan#,chan#,chan# command, as long as only one channel/decade is closed (i.e. AC3,13,23,33 is a valid command, but AC3,4,5,6 is not). However, by reconfiguring the 3497A, up to 10 channels (one per decade, two per slot) can be simultaneously closed with a single AC command.

For applications which require that more than four channels be closed simultaneously, the 3497A can be reconfigured so that the two decades (A and B) in each slot can contain any century or decade addresses from 000 to 999.

For factory configuration, the 5 slots in the 3497A are assigned addresses as shown, where the first number is the ''century address'' and the second number is the ''decade'' address. Each slot is assigned 20 numbers, with the first 10 assigned to the A decade within the slot and the second ten numbers assigned to the B decade within the slot.

3497A FACTORY-SET ADDRESSES

SLOT	DECADE	ADDRESSES
0	A0	000 - 009
	B0	010 - 019
1	A1	020 - 029
	B1	030 - 039
2	A2	040 - 049
	B2	050 - 059
3	A3	060 - 069
	B3	070 - 079
4	A4	080 - 089
	B4	090 - 099

To reconfigure the analog addresses, it is necessary to remove the Inguard Controller Board from the 3497A, as shown in Figure 67.

WARNING

Before touching the 3497A, disconnect the AC line cords from the 3497A and 3498A and remove ALL external voltage sources from these instruments.

CAUTION

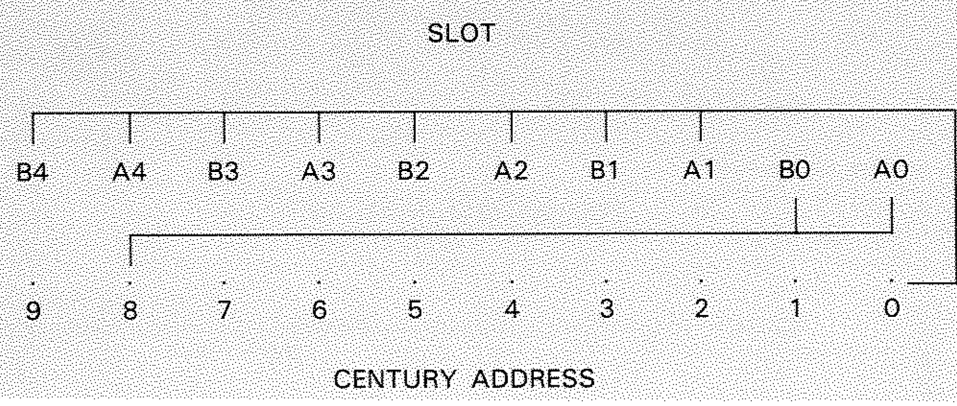
After reconfiguring the 3497A, to prevent unwanted channel closures, a label showing the type of reconfiguration and channel addresses should be placed on the instrument.

To remove the Inguard Controller Board, first remove the protective safety cover and loosen the two fasteners on the left rear panel (as viewed from the rear of the instrument). Then pull out the Inguard Controller Board by using the plastic pull ring and position the assembly as shown in Figure 67.

As factory configured, the century address for the 3497A is set to 0 since decades A0, B0, A1, ..., B4 are all tied to the ''0'' point. To change the century address for a decade or a slot, disconnect existing jumpers to those slots and connect jumpers from decades to desired century number.

EXAMPLE - SLOT 0 SET FOR CENTURY ADDRESS ''8''

For example, to set slot 0 for century address ''8'', configure the board as shown below. Then, to address decades A and B in slot 0, the command is AC800 through AC819 (rather than AC0 through AC19 as factory preset).



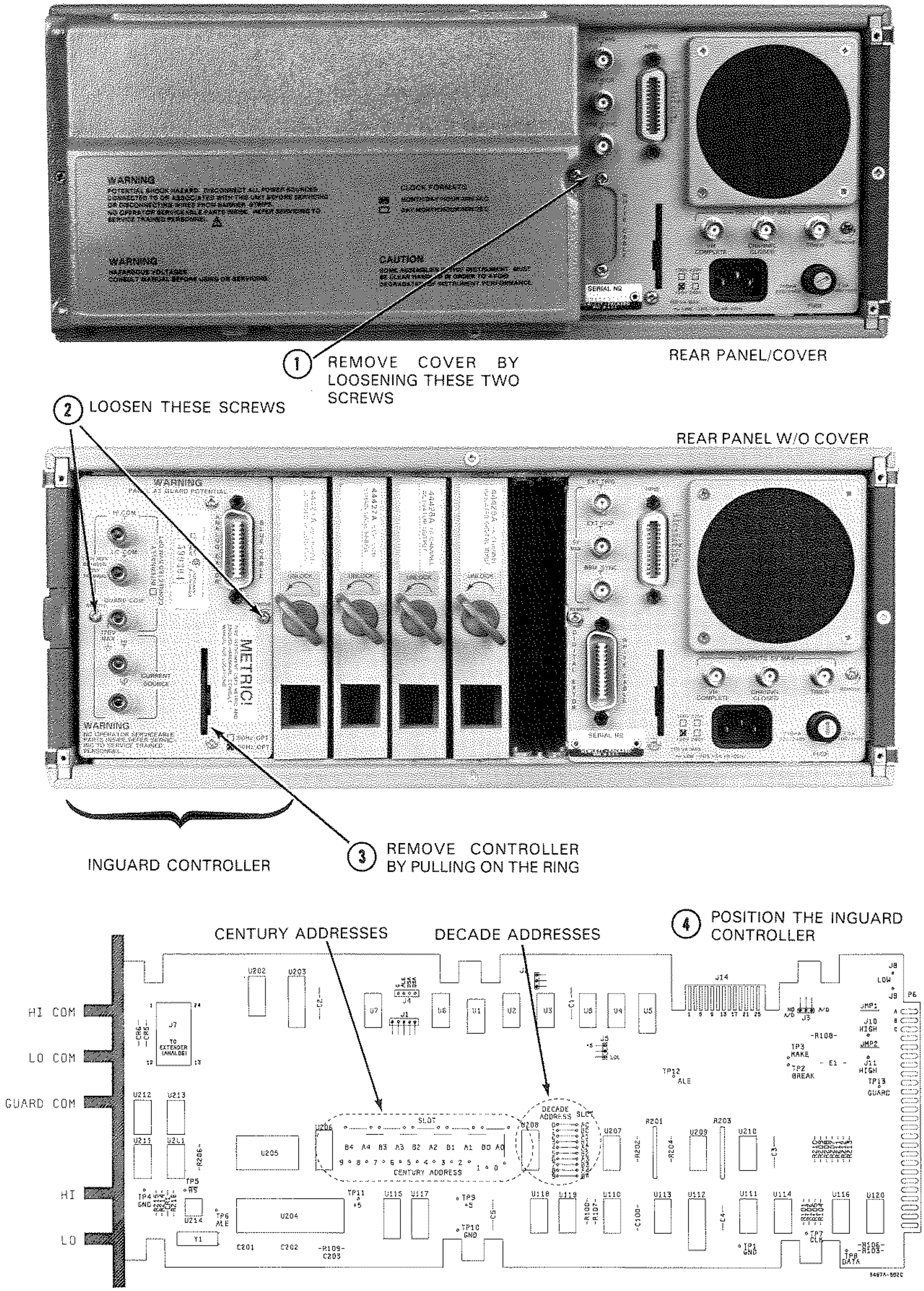
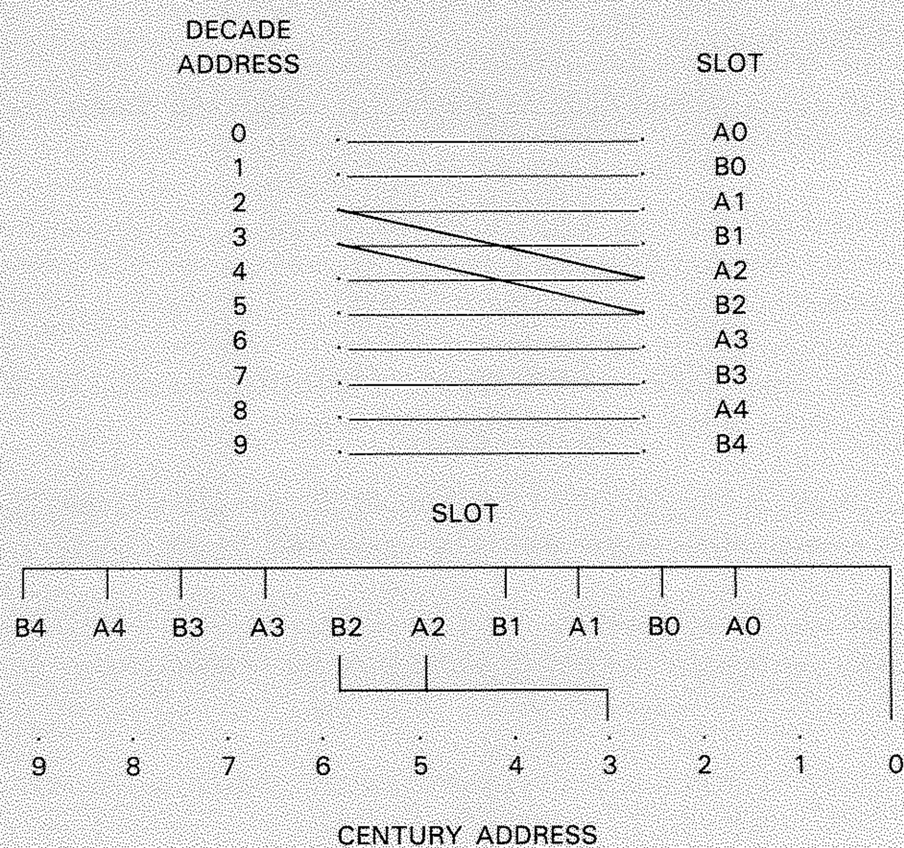


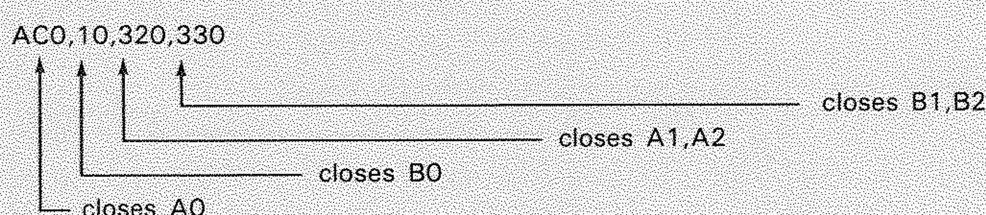
Figure 67. Century and Decade Address Jumpers

EXAMPLE - SLOT 2 SET TO ADDRESSES 320 TO 339

To set the decade addresses, follow the same procedure as setting the century addresses. See Figure 67 for location of the decade address jumpers. For example, as factory preset, slot 2 has addresses 040 through 059. To reconfigure slot 2 for addresses 320 through 339, set the DECADE ADDRESS jumpers and the CENTURY ADDRESS jumpers as shown.



With this configuration, a single AC command can close up to six channels simultaneously. For example, AC0,10,320,330 closes six channels simultaneously, as shown.



Note that the 3497A can simultaneously close a maximum of 10 channels, regardless of type of reconfiguration used. When you have reconfigured the jumpers, replace the Inguard Controller Board and replace the protective cover.

Set Clock Format

As specified, the 3497A real-time clock is configured for Option 230 format (Month:Day:Hour:Minute:Second) or for Option 231 format (Day:Month:Hour:Minute:Second). To reconfigure from Option 230 to 231, it is necessary to install a jumper (W1) on the Timer Board which is connected to the Outguard Controller Board in the 3497A. To install the jumper (or to remove the jumper to convert from Option 231 to 230 format), see Figure 68 and use the following procedure:

* Remove all power sources from the 3497A and 3498A and remove the AC line plug from the 3497A.

* Remove the protective cover from the 3497A rear panel. Then loosen the fastening screw on the Outguard Controller Board and remove the board by pulling on the plastic pull ring.

* Remove the Timer Board from the Outguard Controller Board by loosening the screw in the middle of the Outguard Controller Board.

* Install a jumper at W1 (for Option 231 format) or remove the jumper at W1 (for Option 230 format) on the Timer Board. See Figure 68 for W1 location.

* Reconnect the Timer Board to the Outguard Controller Board. Reinstall the Outguard Controller Board in the 3497A and replace the protective cover on the rear panel.

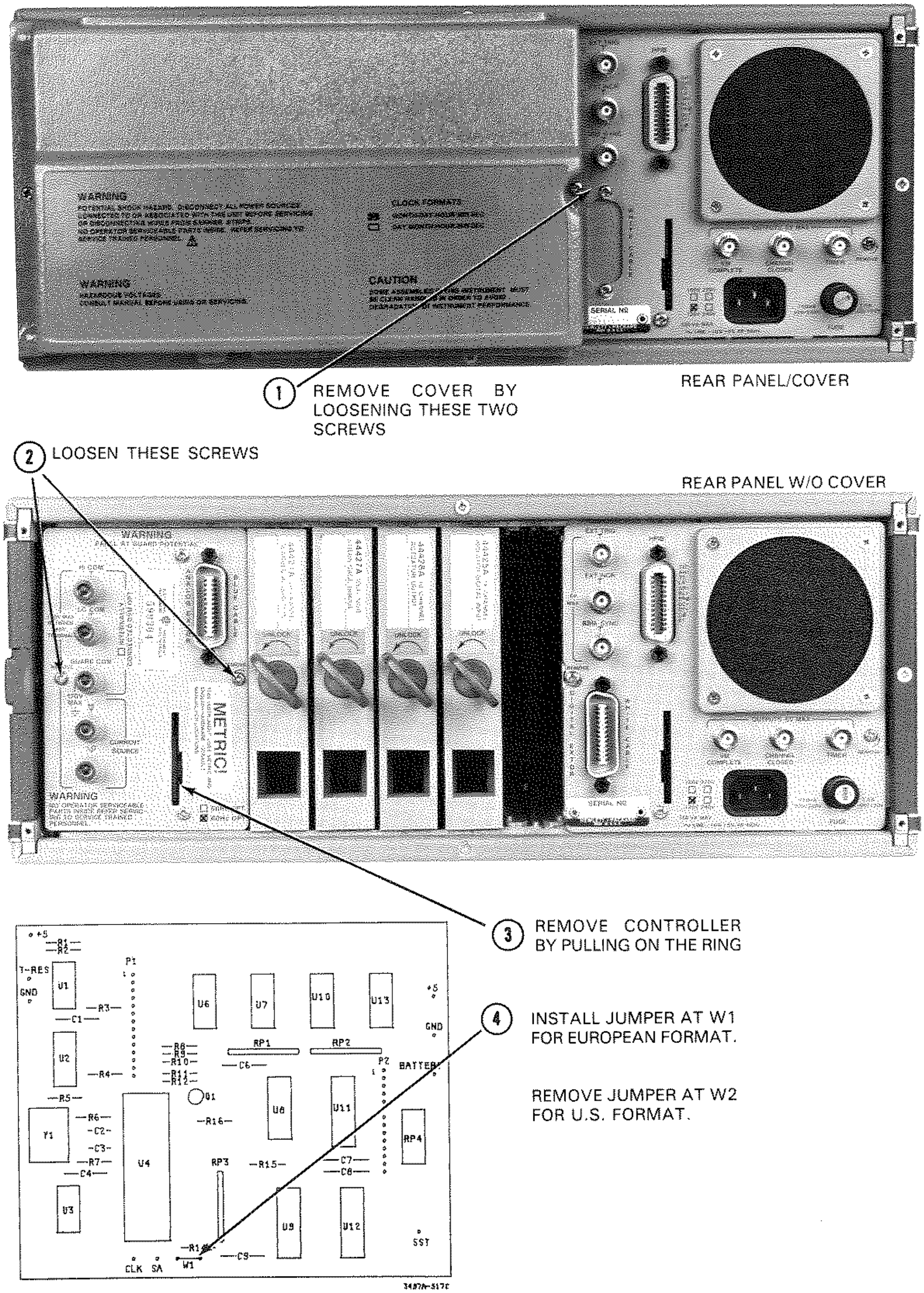


Figure 68. Setting the Clock Format

Clock Battery Back-Up Modes

When AC power is removed from the 3497A, a 6V lead-acid battery supplies back-up power to the real-time clock. There are two modes of operation, depending on the setting of the Continuous Clock Select Plug, located on the Power Supply Board inside the 3497A behind the front panel. The two modes are:

BATTERY BACK-UP MODES

Mode 1: Plug in OFF position

Battery back-up is supplied ONLY when the LINE switch is in the ON position (factory setting).

Mode 2: Plug in ON position

Battery back-up supplied ANYTIME the AC power is disconnected, regardless of the setting of the LINE switch.

The real time clock can remain on battery power for periods greater than 24 hours. The battery is automatically on charge whenever the 3497A is operating on line power. However, if the battery is allowed to completely discharge, it will take 14 to 16 hours to fully recharge.

To change the mode of operation of battery back-up, use the following procedure:

* Remove all power sources from the 3497A and 3498A and remove the AC line plug on the 3497A.

* Loosen the screw on the right side of the 3497A front panel and swing the front panel open.

* Set the Continuous Clock Select Plug for desired operation: OFF = back-up ONLY when the LINE switch is ON; ON = back-up always. See Figure 57 for location of the plug.

* Close the front panel and tighten the screw fastener.

Change Line Voltage Settings

The 3497A can operate from AC line voltages of 110 volts, 120 volts, 220 volts or 240 volts (-10% to +5%) at 48 - 66 Hz, 150 VA (3497A) 150 VA (3498A). To set the 3497A for one of four voltage settings, use the Line Voltage Select Switches located behind the front panel of the 3497A. To set these switches, use the following procedure:

* Remove all voltage sources from the 3497A and 3498A and remove the AC line plug from the 3497A.

* Loosen the screw on the right side of the 3497A front panel and swing the front panel open.

* Set the switches for line voltage required, as shown in Figure 57.

* Close the front panel and tighten the screw fastener.

Change HP-IB Address Select Switch

As factory preset, the 3497A with HP-IB option is set to HP-IB address of 09. If required for your application, the address of the 3497A can be changed by setting the INSTRUMENT ADDRESS switches on the 7-section HP-IB ADDRESS SELECT switch.

The HP-IB ADDRESS SELECT switch also contains the POWER ON SRQ SWITCH and the TALK ONLY switch. This part shows how to set the HP-IB addresses, how to set POWER ON SRQ and how to set the 3497A for TALK ONLY mode.

(a) Changing the HP-IB Address

The 3497A is factory preset to address setting of decimal ''09'' which corresponds to ASCII listen address of ''('' and talk address of ''I''. The 3497A may be left at its factory setting or may be changed to alternate address setting as shown in Figure 69.

ASCII Code Character		Address Switches					5-bit
Listen	Talk	A5	A4	A3	A2	A1	Decimal Code
SP	@	0	0	0	0	0	00
!	A	0	0	0	0	1	01
"	B	0	0	0	1	0	02
#	C	0	0	0	1	1	03
$	D	0	0	1	0	0	04
%	E	0	0	1	0	1	05
&	F	0	0	1	1	0	06
'	G	0	0	1	1	1	07
(	H	0	1	0	0	0	08
)	I	0	1	0	0	1	09 ← FACTORY SETTING
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
,	L	0	1	1	0	0	12
—	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
Ø	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;	[	1	1	0	1	1	27
<	\	1	1	1	0	0	28
=	]	1	1	1	0	1	29
>	~	1	1	1	1	0	30

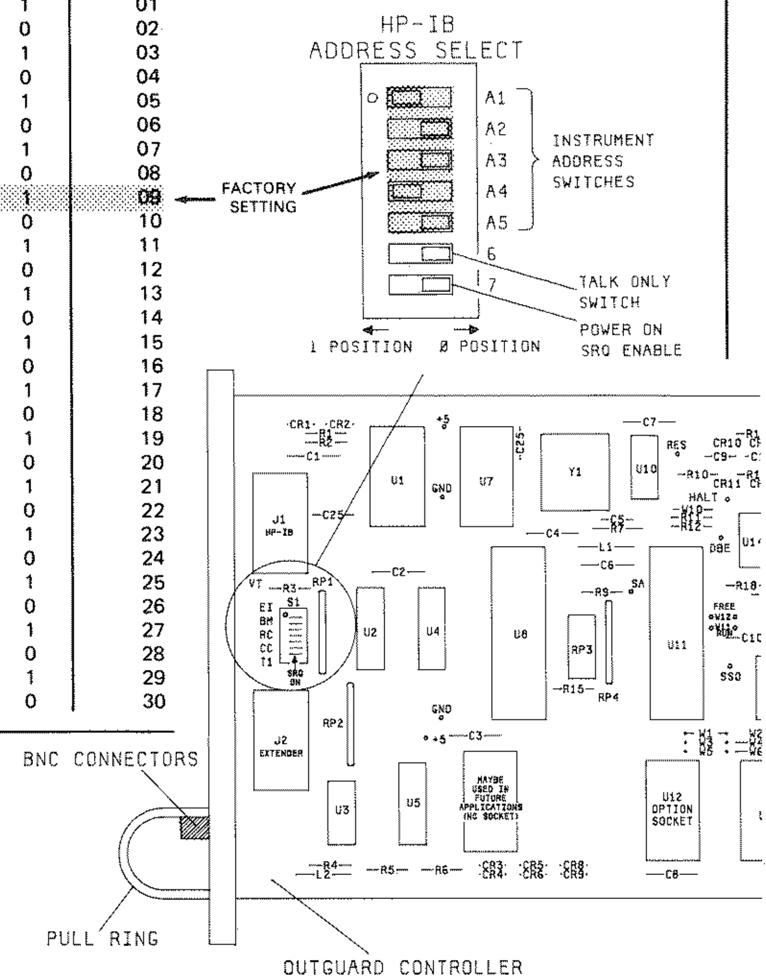


Figure 69. HB-IB Address Selection

To change the address of the 3497A from 09 to another value, it is necessary to remove the Outguard Controller Board. To do this, refer to Figures 69 and 70 and the following steps.

* Remove all power sources from the 3497A and 3498A and remove the AC line plug from the 3497A.

* Remove the safety cover and loosen the screw holding the Outguard Controller Board. Then, use the plastic pull ring to remove the board, as shown in Figure 70.

* From Figure 69, locate the HP-IB ADDRESS SELECT switch and set switches A1 through A5 for address required. For example, to set decimal address 10 (ASCII * and J), set A5, A3 and A1 to the ''0'' position and set A4 and A2 to the ''1'' position.

* If you want to set the 3497A for TALK ONLY mode and/or set POWER ON SRQ, see following paragraphs. If not, replace the Outguard Controller Board and the protective cover.

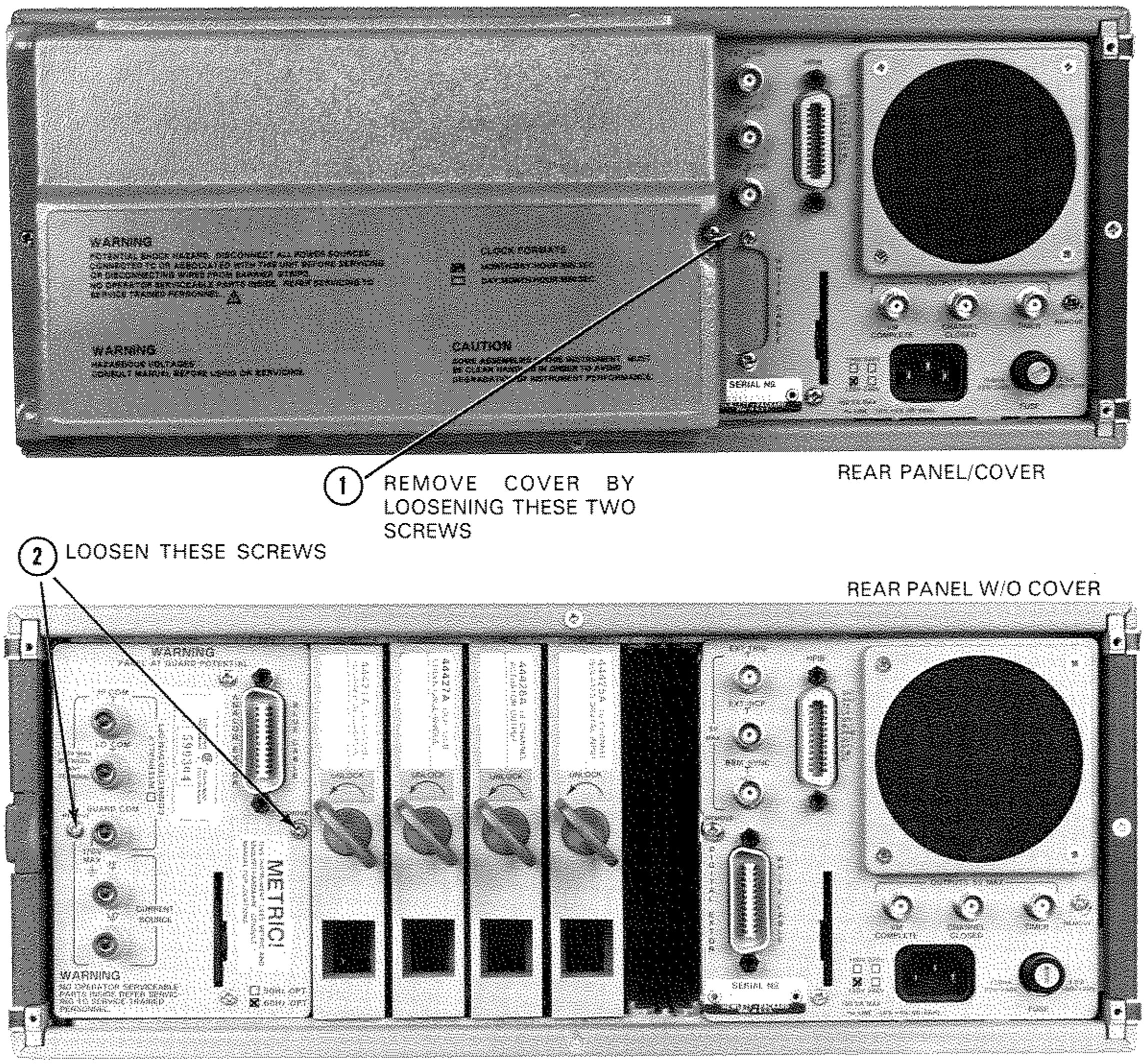


Figure 70. Removing the Outguard Controller (HP-IB)

(b) Setting TALK ONLY Mode

Position 6 of the HP-IB ADDRESS SELECT switch is the TALK ONLY switch (see Figure 69). When the TALK ONLY switch is placed in the "1" position, the 3497A cannot be controlled from a controller and commands must be entered from the front panel.

As factory set, the TALK ONLY switch is in the "0" position (mode disabled). To enable the TALK ONLY function, follow the instructions above to remove the Outguard Controller Board. Set the TALK ONLY switch to the "1" position and replace the Outguard Controller Board and replace the protective cover.

(c) Setting POWER ON SRQ

If you want the 3497A to send a Service Request (SRQ) to the controller at power on, set the POWER ON SRQ ENABLE switch (postion 7 on the HP-IB ADDRESS SELECT switch - see Figure 69) to the "1" position. As factory set, the POWER ON SRQ function is disabled (switch position 7 set to "0").

To do this, remove the Outguard Controller as shown in Figure 70, and set switch position 7 to the "1" position. Then replace the Outguard Controller Board and the protective cover.

Set Serial Data Operating Conditions

For a 3497A with Serial Data capabilities, (Option 232), the instrument can be configured for a wide variety of operating conditions, depending on controller and speed requirements. See RS232C INSTALLATION for 3497A operating conditions and factory preset conditions.

If your application requires a setup different from the factory configuration, you can change the configuration by setting switches S1 and S2 which are located on the Outguard Controller Board inside the 3497A. Figure 71 shows the functions of each of the positions for S1 and S2.

S2 is used only for setting RS232C or RS449/423 operation. With all S2 switches set to the "1" position, the 3497A is enabled for RS449/423 operation. With S2 switches set to the "0" position (factory configuration), the 3497A is set for RS232C operation.

S1 sets Direct/MODEM connection; 7 or 8-bit operation; even, odd or no parity bit; DC1 handshake on or off; speed of operation and number of stop bits. See Figure 71 for definitions.

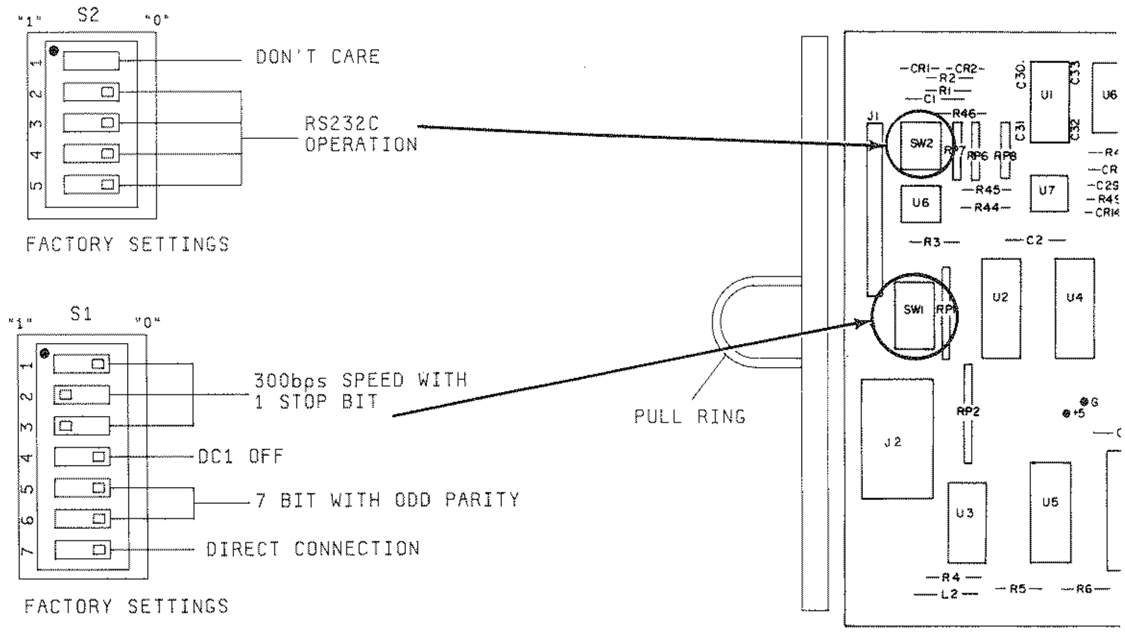


Figure 71. S1 and S2 Settings

To change the settings of S1 and S2, it is necessary to remove the Outguard Controller Board. To do this, see Figure 72 and the following steps.

* Remove all power sources from the 3497A and 3498A and disconnect the AC power cord from the 3497A.

* Remove the safety cover from the rear panel. Loosen the screw holding the Outguard Controller Board and use the plastic pull ring to remove the board, as shown in Figure 72.

* From Figure 71, locate switches S1 and S2 on the Outguard Controller Board. Note that the ''0'' and ''1'' switch positions are not shown on the board, so orient the Outguard Controller Board as shown in Figure 71 to set the switches. A ''0'' is set when the switch is in the right-hand position and a ''1'' is set when the switch is in the left-hand position.

* Using the configuration settings in Figure 72, set S1 and S2 for desired operation. Then, replace the Outguard Controller Board and the safety cover.

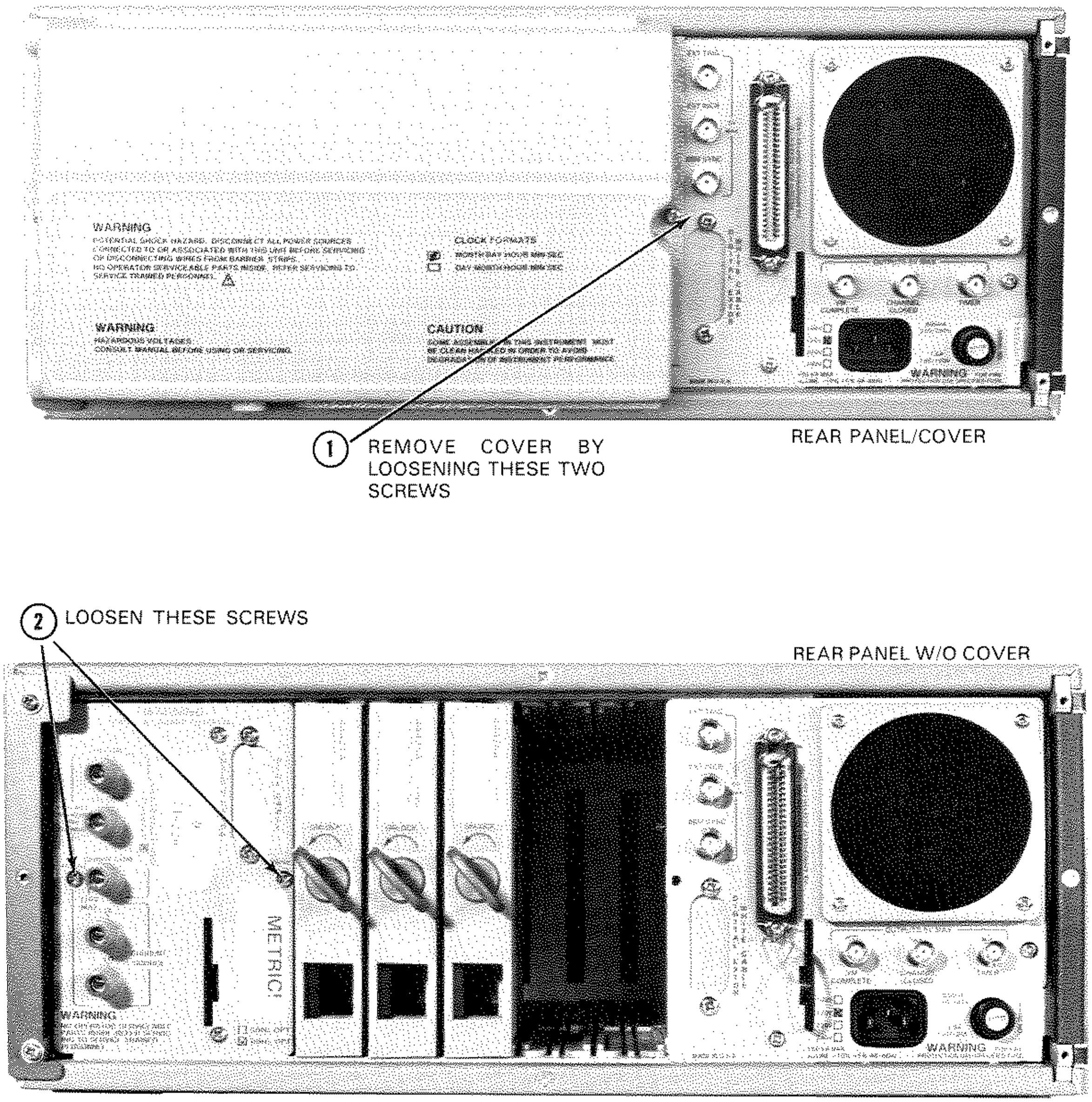


Figure 72. Removing the Outguard Controller (Serial Data)

Chapter 8
PLUG-IN ASSEMBLY CONFIGURATION

This chapter shows how to initially inspect, install and hardware configure each of the 11 plug-in assemblies for the 3497A (Options 010 through 140) and how to inspect and install the 3498A Extender (Option 298). Information is presented by assembly option number, beginning with Option 010. For each assembly, information is divided into three parts: INTRODUCTION, INSTALLING THE ASSEMBLY and CONFIGURING THE ASSEMBLY.

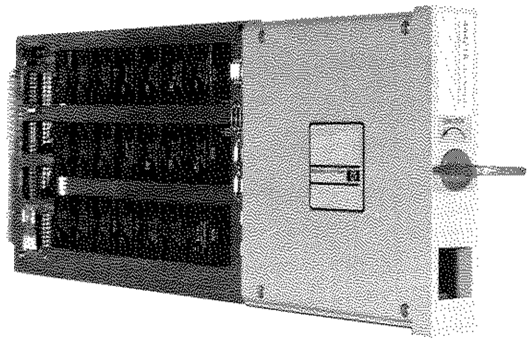
- INTRODUCTION includes a description of the assembly, assembly specifications and applicable documentation for the assembly.
- INSTALLING THE ASSEMBLY shows how to initially inspect and install the assembly in the 3497A or 3498A.
- CONFIGURING THE ASSEMBLY shows hardware settings (switch and jumper settings) to configure the assembly for various operating modes.

Each assembly is factory-preset for specified operating conditions. In many cases, the factory settings will be appropriate for your application. If you need to reconfigure an assembly, see the following chart to find configuration information for specific assemblies.

PLUG-IN ASSEMBLY CONFIGURATION

OPTION	MODEL	ASSEMBLY TITLE	SEE PAGE
010	44421A	20 Channel Relay Multiplexer	371
020	44422A	Relay Multiplexer/Thermocouple Compensation	382
050	44425A	16 Channel Isolated Digital Input/Interrupt	399
060	44426A	100 kHz Reciprocal Counter	410
070	44427A	120 Ohm Strain Gauge/Bridge Completion	433
071	44427B	350 Ohm Strain Gauge/Bridge Completion	433
110	44428A	Actuator/Digital Output	457
115	44431A	8 Channel High Voltage Actuator	472
120	44429A	Dual Output, ±10V Voltage D/A Converter	491
130	44430A	Dual Output, 0-20 mA/4-20 mA Current D/A Converter	501
140	44432A	Breadboard Card	509
298	3498A	3498A Extender	533

OPTION 010



20 Channel Relay Multiplexer Assembly

INTRODUCTION

Option 010 is a 20 channel analog signal multiplexer assembly which is used to switch (multiplex) signals from up to 20 channels to the 3497A DVM or to other assemblies or instruments.

Each of the 20 channels consists of three reed-actuated relays, one each for High, Low and Guard lines. The channels are organized into two decades of 10 channels and one channel can be closed in each decade. Relays can be closed in a random fashion or can be incremented between programmable limits.

Because the 20 channel relay multiplexer has low thermal offset characteristics, this assembly is ideal for precise low-level measurements of transducers and temperature measuring devices. Since two channels (one per decade) can be closed at a time, one Option 010 assembly can be used to make four-terminal resistance measurements.

Simplified Operation

As shown in Figure 73, the relay multiplexer assembly consists of a relay card and a terminal card. Inputs from system sensors, such as voltage sources, etc., are input to the terminal card connectors on channels A0 through B9 and are sent to the relays on the relay card. Each channel consists of a HIGH, LOW and GUARD line. Relays are divided into two groups (decades): A decade and B decade.

In normal operation, a close channel (AC chan#) command from the 3497A closes the relay in the channel selected and simultaneously closes the tree switch relay. When this happens, the input signal is sent to four places: the A COMMON and B COMMON connectors on the terminal card and (through the tree switch relay) to the 3497A DVM and to the rear panel (HI COM, LO COM and GUARD COM) terminals.

For example, for an assembly in slot 0, the channel A0 address is 0, channel A1 address is 1, ... and channel B9 address is 19. Thus, the command AC0 closes the relay in channel A0 (and the tree switch) and the voltage at channel A0 is sent to the A COMMON and B COMMON terminals on the terminal card, to the rear panel connectors on the 3497A and to the DVM.

Four optional configurations are available by removing jumpers JMP1 through JMP6. For example, by removing JMP1, JMP2 and JMP3, channel inputs are not sent to the 3497A. Or, by removing JMP4, JMP5 and JMP6, the A decade outputs can be separated from the B decade outputs for four-wire ohms measurements.

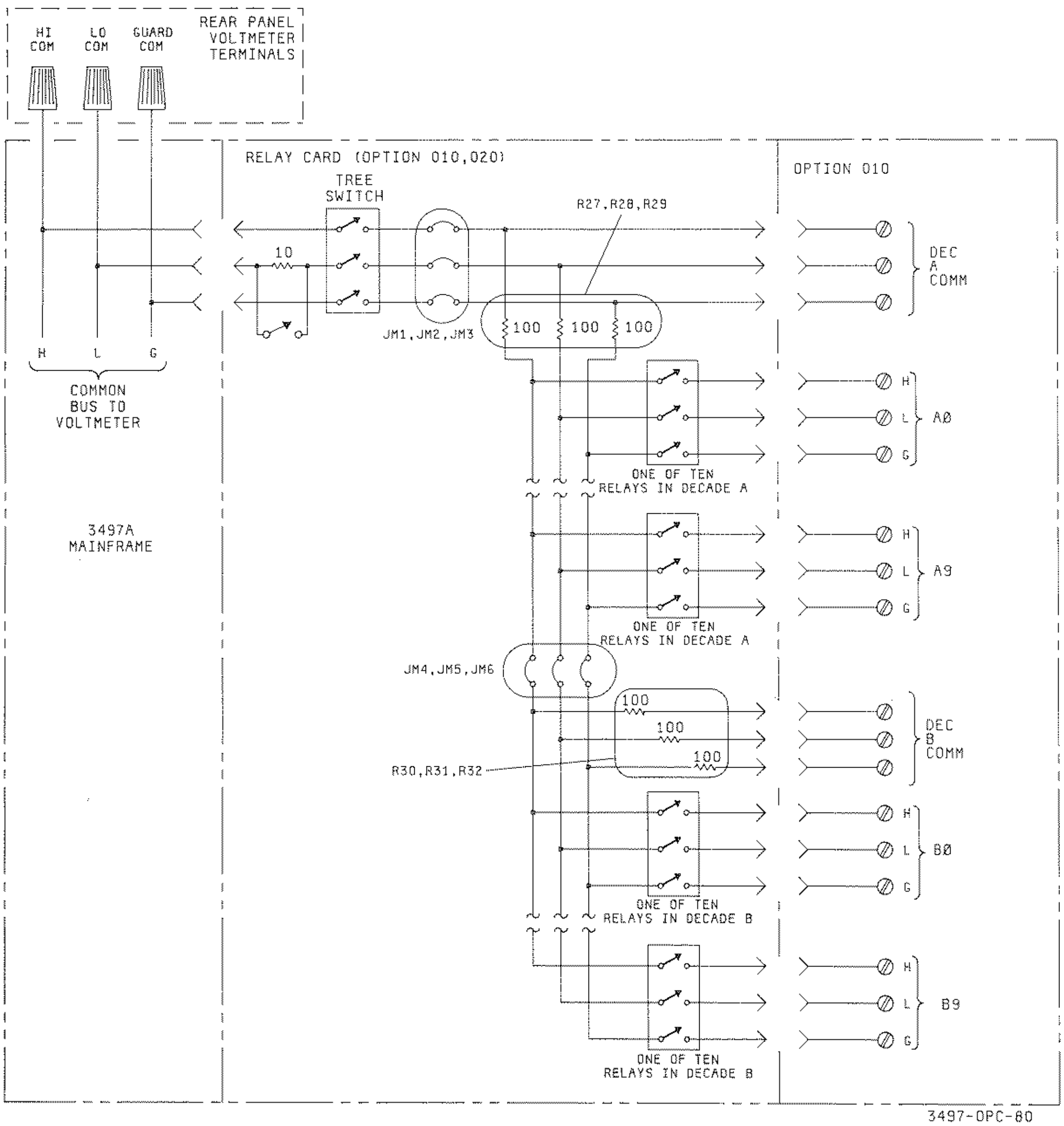


Figure 73. Option 010 · Simplified Schematic

Specifications

Specifications for the 20 channel relay multiplexer assembly follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 010
20 CHANNEL RELAY MULTIPLEXER ASSEMBLY

Input Characteristics

Maximum Input Voltage: <170V peak between any two input terminals

Maximum Current: 50 mA per channel non-inductive

Maximum Power: 1 VA per channel

Thermal Offset: Direct Switched: < 1μV Differential
Tree Switched: <2 μV Differential

Closed Channel Resistance:
In Series: 100 Ω ± 10% in High, Lo and Guard Relays
Contacts Only: <1 Ω per contact

Open Channel Isolation:

			25°C, <85% R.H. 40°C, <60% R.H.	40°C, >95% R.H.
Hi to Lo	Option 010		$>10^{10}\Omega$	$>10^{9}\Omega$
	Option 020	Open	$<10^{10}\Omega$	$>10^{9}\Omega$
		Closed	$>10^{8}\ \Omega$	$>10^{7}\Omega$
Lo to Guard			$<10^{8}\ \Omega$	$>10^{7}\Omega$
Guard to Chassis			$>10^{10}\Omega$	$>10^{9}\Omega$

Operating Characteristics

Maximum Switch Rate: Random Channels;
Using Hardware Increments: 475/second

Rated Switch Life at 1 VA: 10^7 operations

All Relays are Break Before Make

AC Performance

High to Low Capacitance: Channel Open: < 10 pF/per channel
Channel Closed: <220 pF/per channel

Interchannel Capacitance: < 10 pF

	100 kHz	1 MHz
Frequency Response (1 MΩ Termination, 10 kHz Reference)	± .3 dB	±.5 dB
Cross Talk		
Channel to Common		
50 Ohm Termination	−70 dB	−50 dB
1M Ohm Termination	−50 dB	−40 dB
Channel to Channel		
50 Ohm Termination	−60 dB	−40 dB
1M Ohm Termination	−40 dB	−30 dB

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual (-hp- part number 03497-90021). Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany this manual. See Appendix B for details.

Application Note

As an aid to using the Option 010 assembly, you may want to order -hp- Application Note 123 ''Floating Measurements and Guarding'' (-hp- part number 5952-2153) from your nearest -hp- Sales and Service office.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the relay multiplexer assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the relay multiplexer assembly as Option 010, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44421A, the shipping container should contain the relay card and a terminal card without thermocouple compensation networks.

For the field installation kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a relay card or terminal card to -hp-, follow the shipping guidelines in Appendix B.

How to Install the Relay Multiplexer Assembly

WARNING

Before touching any installed assemblies or attempting to install the relay multiplexer in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The relay multiplexer assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the relay card. Handle the circuit board by its edges and do not subject the components to static discharges or excessive voltages.

Figure 74 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING and CAUTION notes above, plug the assembly into an unused slot in the 3497A or 3498A. To minimize thermal offsets (voltage errors), it is good practice to install the assembly in slot 0 (or the leftmost slot available).

Note from Figure 74 that the temperature shield must be removed if the assembly is installed in slot 4 of a 3497A or slot 4 or 9 of a 3498A.

INSTALLATION IN 3498A INSTALLATION IN 3497A

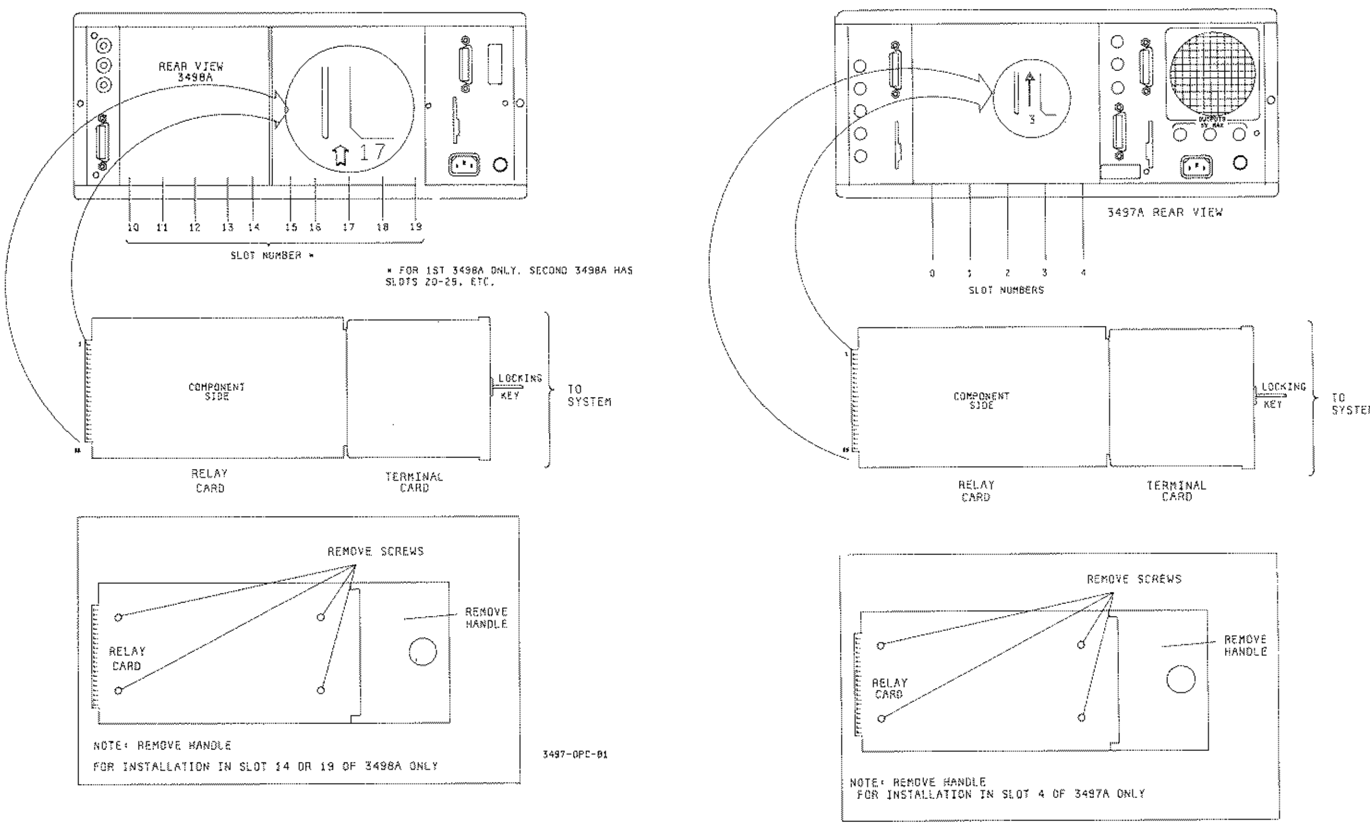


Figure 74. Option 010 · Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

Assembly configuration is divided into two parts: relay card configuration and terminal card configuration. This section shows the functions of the jumpers and resistors on the cards and their locations. See Chapter 9 for example ways that the assembly can be configured for voltage and resistance measurements.

Relay Card Configuration

By using jumpers JMP1 through JMP6 you can configure the assembly for four modes of operation. In addition, by removing resistors R27, 28, 29 and/or R30, 31, 32 you can make accurate two-wire ohms measurements. The following chart shows the function of these components and Figure 75 shows their locations. REF refers to the numbers in Figure 75.

RELAY CARD - FUNCTIONS

REF	TITLE	FUNCTION
1	T/C COMP JUMPER	Leave set to NO T/C COMP position.
2	TREE SWITCH JUMPERS (JMP1,2,3)	Enables signals from the A decade and B decade relays to be passed to the tree switch relay. Remove these jumpers when you don't want signals input to the 3497A mainframe.
3	DECADE A TO DECADE B JUMPERS (JMP4,5,6)	These jumpers connect decade A relays output to decade B relay outputs. Remove these jumpers for four-wire ohms measurements. With jumpers removed, A decade output ONLY is available to the DVM (when tree switch is closed).
4	A DECADE SERIES RESISTORS (R27,28,29)	Provide current limiting protection for A decade. Short the resistors (by soldering across the shorting pins) when making two-wire ohms measurements on the A decade.
5	B DECADE SERIES RESISTORS (R30,31,32)	Provide current limiting protection for B decade. Short the resistors (by soldering across the shorting pins) when making two-wire ohms measurements on the B decade.

Shorting the Series Resistors

As factory configured, there are three 100 ohm resistors in series with the A decade common output (R27, R28 and R29) and three 100 ohm resistors in series with the B decade common output (R30, R31 and R32). For more accurate two-wire resistance measurements, these resistors can be shorted out.

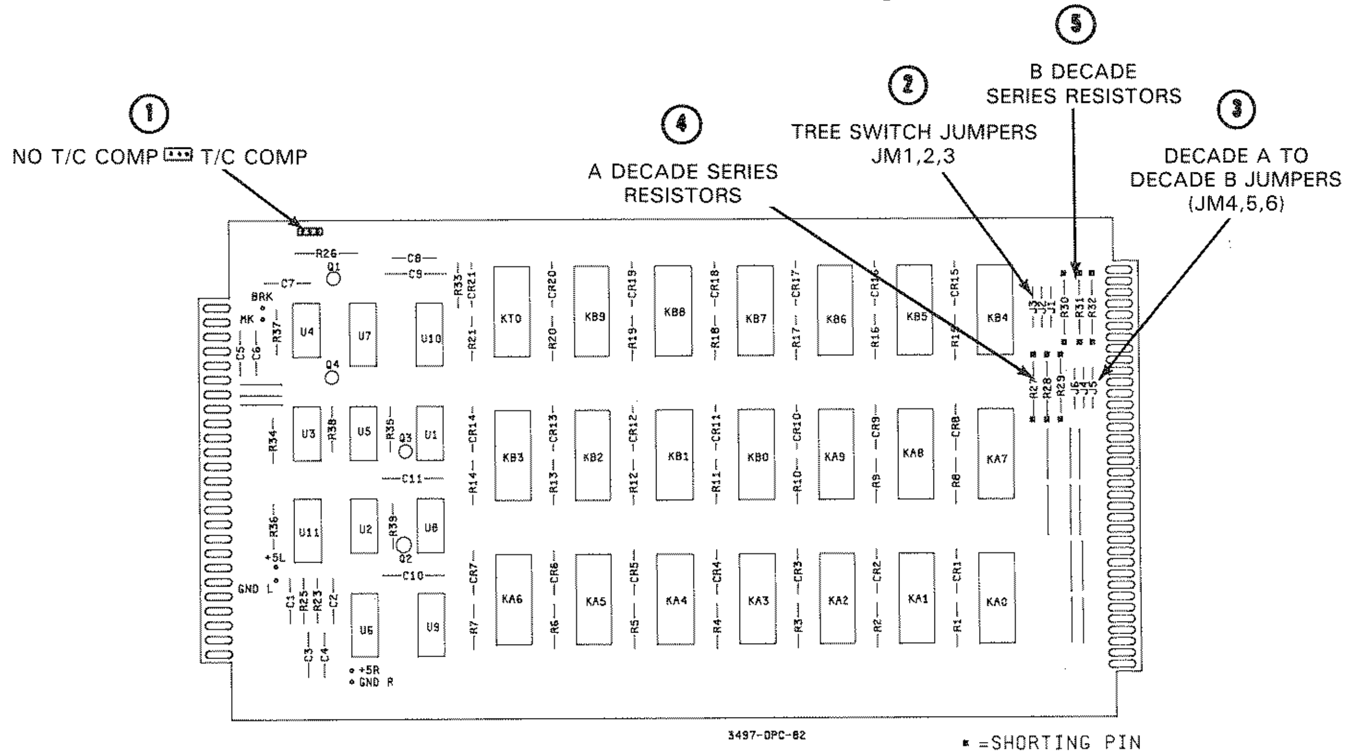


Figure 75. Option 010 - Relay Card Jumpers, Resistors

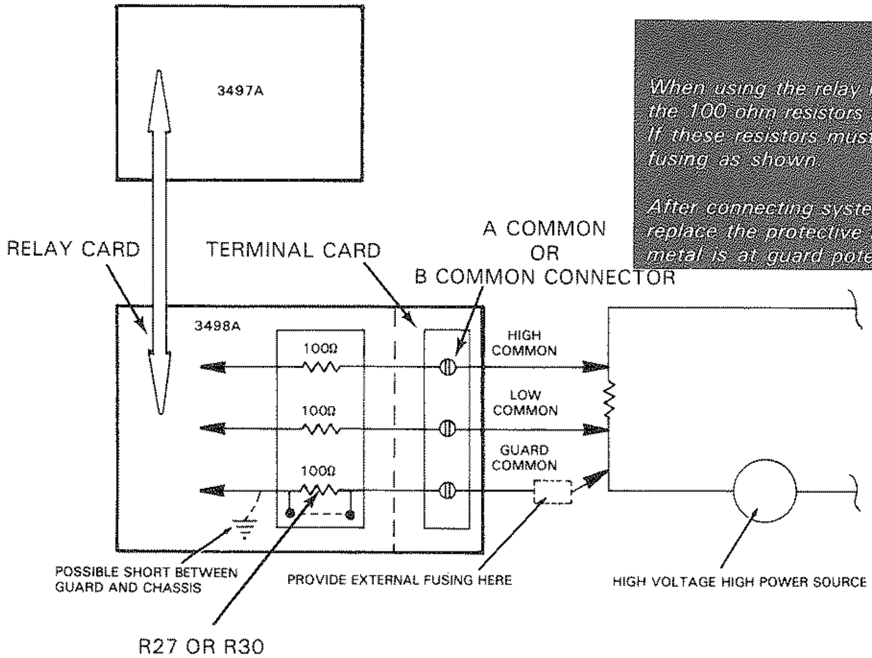
For two-wire ohms measurements on A decade channels, short out R27, R28 and R29, using the shorting pins on the relay card. For two-wire ohms measurements on B decade channels, short out R30, R31 and R32 using the shorting pins. See Figure 75 for resistor and pin locations. If the assembly is to be used in a 3498A Extender, see the following WARNING note.

WARNING

When the assembly is used in some earlier versions of the 3498A, a possible hazard may exist when making measurements in a system containing a high voltage, high power source (100 VA or above).

In these 3498As, the GUARD sheet metal may short to the chassis sheet metal because of close mechanical spacing. If the 100 ohm resistors have been shorted as previously described and this happens, a current path to ground can exist, as shown in Figure 76.

If the GUARD common line is in contact with a high voltage, high power source (100 VA or above) or could come in contact with such a source and the 100 ohm resistor (R27 or R30) in the GUARD common line has been shorted, a possible shock or fire hazard could exist.



WARNING

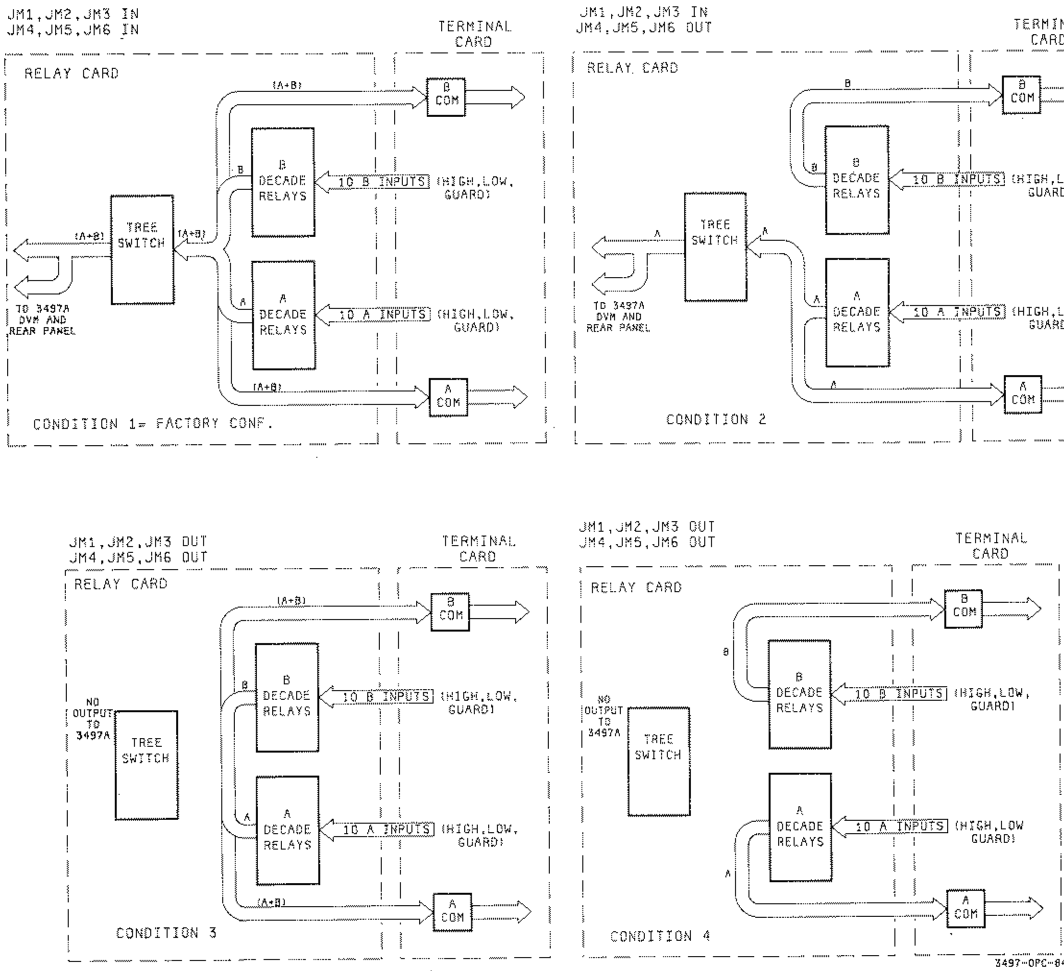
When using the relay multiplexer in the 3498A, do NOT jumper the 100 ohm resistors in the guard common lines (R27 and R30). If these resistors must be jumpered, provide adequate external fusing as shown.

After connecting system inputs to the terminal card connectors, replace the protective rear cover on the 3498A, since the sheet metal is at guard potential (as high as 170 volts).

Figure 76. Option 010 - Fusing the Relay Card

Setting Jumpers JMP1 through JMP6

By removing jumpers JMP1, JMP2, JMP3 and/or JMP4, JMP5, JMP6 on the relay card, you can configure the assembly for four modes of operation. Figure 77 shows the four operating modes for the assembly and a truth table for these modes. With JMP4, JMP5 and JMP6 OUT (removed from the board), only the A decde inputs can be sent to the 3497A (i.e., an input on channel B0 through B9 can be output ONLY at the B COM terminal on the terminal card).



Relay Multiplexer Assembly Truth Table

Jumper Position			Output To:		
Oper Cond	JM1,JM2 JM3	JM4,JM5 JM6	Term Card A Common	Term Card B Common	3497A DVM+Panel
1***	IN	IN	(A+B)*	(A+B)	(A+B)
2	IN	OUT	A**	B**	A
3	OUT	IN	(A+B)	(A+B)	—
4	OUT	OUT	A	B	—

* (A+B) = either A decade or B decade output (one of 20 channels).
** A = One of 10 A inputs; B = One of 10 B inputs.
*** Condition 1 is factory configuration.

Figure 77. Option 010 - Card Configurations and Truth Table

Terminal Card Configuration

The terminal card provides the interface between the relay card and your system transducers. To connect your system inputs to the terminal card, see Figure 78. Note that each channel has a separate set of three connectors (HI, LO and GUARD), so three wires must be connected for each channel.

To connect your inputs, remove the terminal card cover by loosening the four screws and route wires as shown in Figure 78 to provide strain relief for the wires.

CAUTION

To avoid equipment damage, NEVER input voltages at the 3497A rear panel terminals and at the relay multiplexer at the same time. When the tree switch and the channel relays are closed, voltages input from the rear panel are applied directly to user inputs and may damage the equipment.

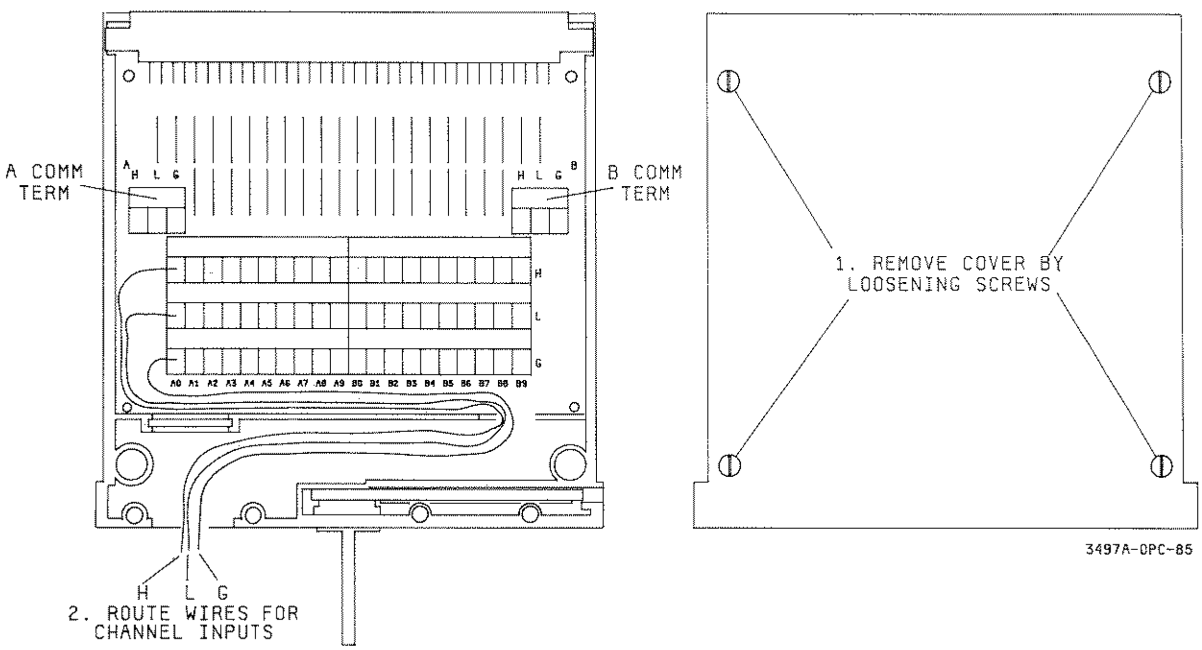


Figure 78. Option 010 · Connecting Inputs to the Assembly

Input Signal Conditioning

You can also reconfigure the terminal card by adding customer-supplied signal conditioning elements. Figure 79 shows some example current shunt and low pass filter circuits added for input signal conditioning.

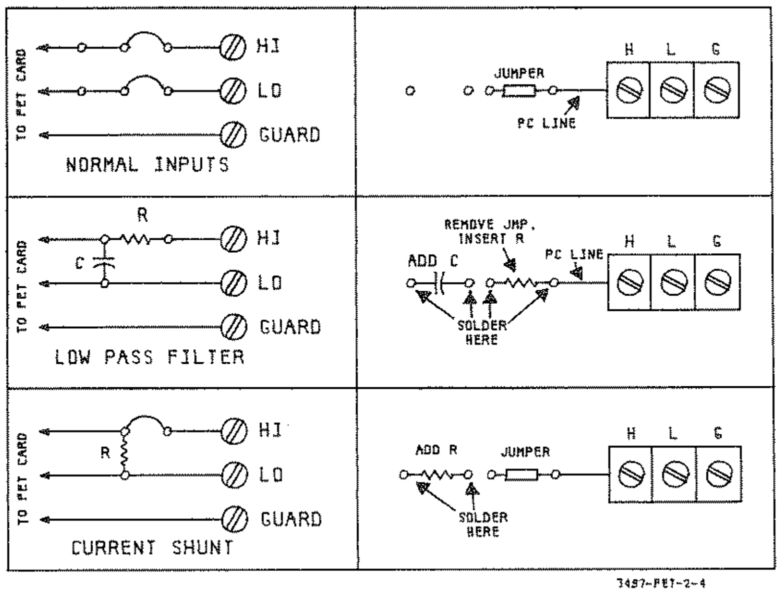
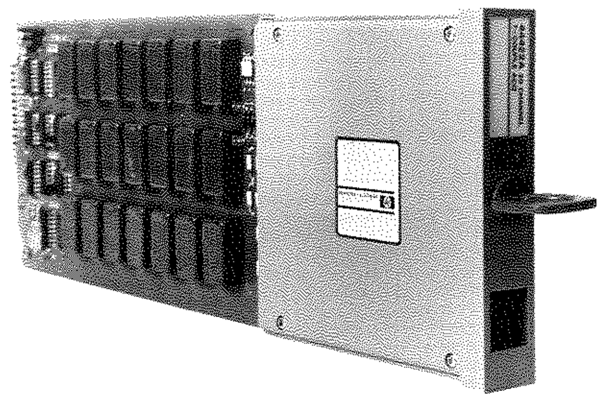


Figure 79. Option 010 - Input Signal Conditioning

OPTION 020

Relay Multiplexer Assembly With Thermocouple Compensation



INTRODUCTION

The relay multiplexer assembly with thermocouple compensation can be used for voltage, temperature and resistance measurements, but is primarily used with thermocouples for temperature measurements. The assembly consists of a relay card and a terminal card. The terminal card, which can be disconnected from the relay card, has temperature compensation circuits for thermocouple measurements.

Description

The Option 020 assembly uses the same relay multiplexer card as the Option 010 assembly, but adds a special isothermal connector block on the terminal card to eliminate unwanted measurement errors when measuring thermocouple voltages.

Both hardware and software thermocouple compensation techniques are available. Hardware compensation can be used to measure the inputs of up to 20 thermocouples per assembly, but is limited to one thermocouple type per assembly. Software compensation can be used to measure the outputs of up to 19 thermocouples, with any mixture of thermocouples.

You can use the Option 020 assembly with hardware compensation to measure the output of up to 20 B, E, J, K, R, S or T type thermocouples (one type per assembly). You can use the assembly with software compensation to measure the output of up to 19 thermocouples (any mixture of these types).

In addition, with appropriate computer programs, you can use software compensation to determine the temperature measured by specially designed thermocouples.

Simplified Operation

As shown in Figure 80, the assembly consists of a relay card and a terminal card. Inputs from system sensors, such as thermocouples, etc. are input to the terminals on channels A0 through B9 and sent to the relay card relays. Each channel consists of a HIGH, LOW and GUARD line. Relays are divided into two groups (decades): A Decade and B Decade.

In normal operation, an AC chan# command from the 3497A closes the relay in one of the channels and also closes the tree switch relay. When this happens, the input signal is sent through the closed relay to four places: the A COMMON and B COMMON connectors on the terminal board and (through the tree switch) to the 3497A DVM and to the rear panel (HI COM, LO COM and GUARD COM) terminals.

For example, for an assembly in slot 0, channel A0 address is 0, channel A1 address is 1, and channel B9 address is 19. Thus, AC0 closes the relay in channel A0 and the channel A0 voltage is sent to the A COMMON and B COMMON connectors on the terminal board, to the rear panel connectors on the 3497A and to the DVM.

Several optional configurations are available by removing jumpers JMP1 through JMP6. For example, by removing JM1, JM2 and JM3, channel inputs are not sent to the 3497A. Or, by removing JMP4, JMP5 and JMP6, the A Decade outputs can be separated from the B Decade outputs for 4-wire ohms measurements.

Thermocouple Compensation

Since a primary function of the assembly is temperature measurements using thermocouples, the thermocouple compensation circuits require a word of explanation. The 3497A does not directly measure temperature, but rather measures voltage generated by thermocouples. This measured voltage, which is proportional to temperature, can then be converted to an equivalent temperature by reference to standard tables or through a computer program.

The problem with this approach is that the voltage measured by the 3497A is different than the actual thermocouple voltage (due to junction voltages) unless some compensating technique is used. The Option 020 assembly has two types of thermocouple compensation techniques: software and hardware.

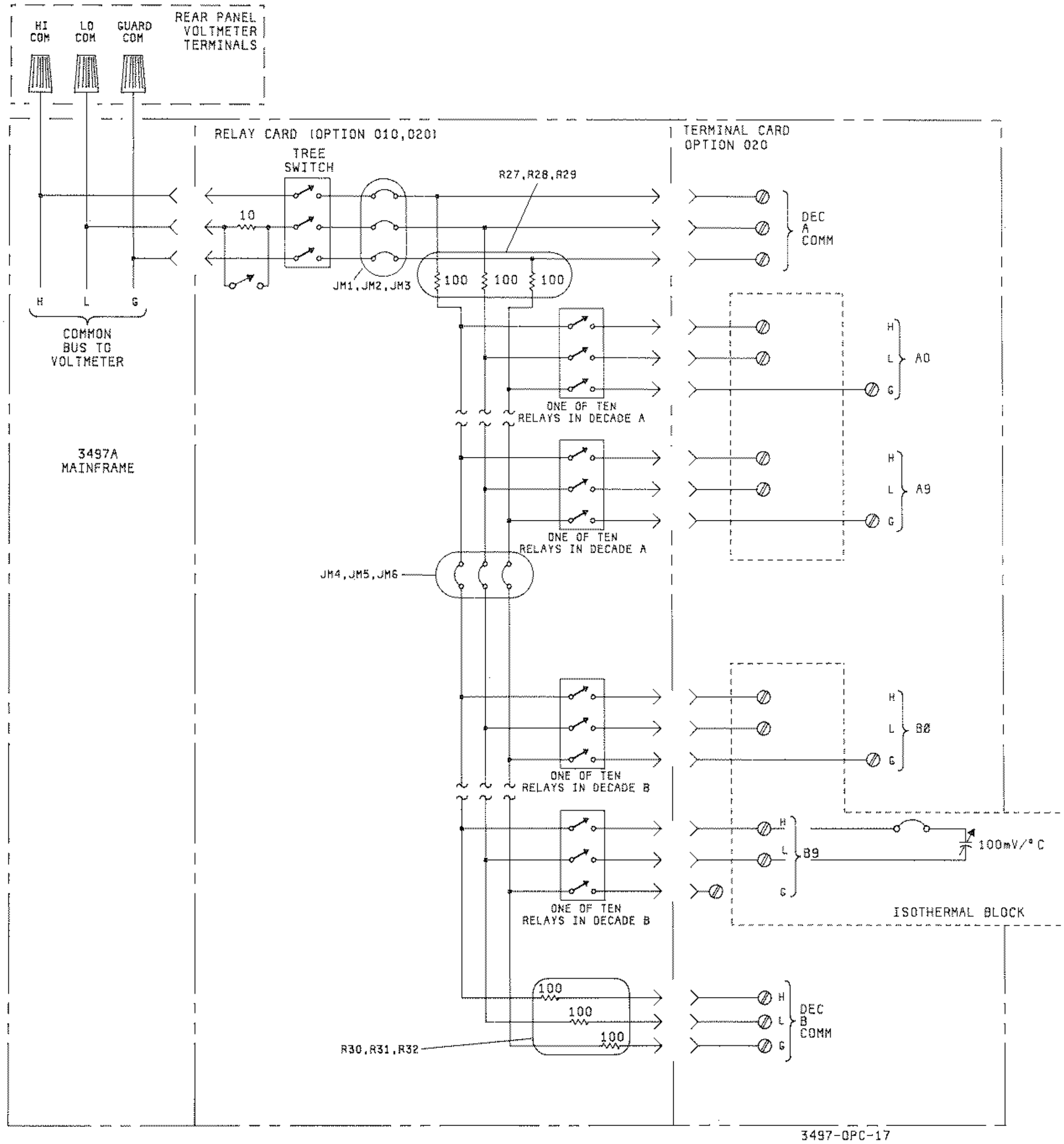


Figure 80. Option 020 - Simplified Schematic

Software Compensation

As factory configured, the assembly is set for software compensation. With software compensation, a reference junction transducer measures the voltage of an isothermal block. The voltage measured is a function of the temperature of the block and is connected to channel B9 (channel 19) as shown in Figure 80.

Thus, with software compensation, only 19 channels are available for inputs, since the 20th channel (B9) is dedicted to the reference junction transducer circuits. However, you can use a mix of thermocouples on a single assembly.

Hardware Compensation

Software compensation has the advantage of being able to mix various types of thermocouples on a single assembly. However, the measurement process is rather slow, since the reference voltage on channel 19 should be measured frequently to avoid isothermal block temperature drift errors.

If you have only one type of thermocouple to measure, the assembly can be configured for hardware compensation and thermocouple voltages can be measured directly. With hardware compensation, the reference junction transducer is removed from the circuit and 20 channels can be used for input.

For hardware compensation, the compensation voltage is determined by two resistors installed on the terminal card, whose value is dependent on the type of thermocouple being measured. Thus, the voltage displayed on the front panel or at the controller is the true (compensated) thermocouple voltage and can be directly used with a standard look up table to determine equivalent temperature.

Specifications

Specifications for the 20 channel relay multiplexer assembly with thermocouple compensation follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 020
RELAY MULTIPLEXER ASSEMBLY WITH THERMOCOUPLE COMPENSATION

Reference Junction Compensation Comparison

	Compensation Type: Software	Compensation Type: Hardware
Compatible Thermocouples	Any Mixture	One of the Following Types: B,E,J,K,R,S,T
Measurement Channels Available per Assembly	19	20
Reference Junction Compensation Accuracy (23°C ± 5°C)	1°C	

Valid for thermocouple compensation only. The total accuracy of 3497A based temperature measurement systems including compensation accuracy, 3497A scanner offsets. DVM accuracy and software accuracy is shown below.

Temperature Coefficient (0°C – 18°C, 28°C – 55°C)	.009°C/°C	
Stability	.075°C/1000 Hours	
Temperature Difference Across Isothermal Block:	< .2°C	
Software Compensation Output: (Channel B9)	100mV/0C 2.5V@25°C	
Additional In Series Resistance: (Hardware Compensation only).		10Ω

Temperature Measurement Accuracy

For a 3497A based temperature measurement system. Includes all errors introduced by the 3497A and the HP 3054A/C Data Acquisition/Control System Software.

Input Characteristics

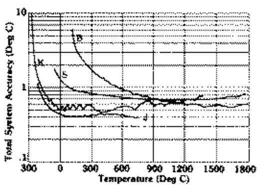
Maximum Input Voltage: < 170 V peak between any two input terminals

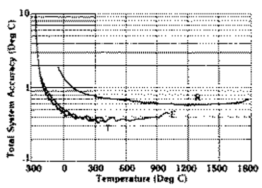
Maximum Current: 50 mA per channel non-inductive

Maximum Power: 1 VA per channel

Thermal Offset: Direct Switched: < 1 μV Differential
Tree Switched: < 2 μV Differential

Closed Channel Resistance:
In Series: 100 Ω ± 10% in High, Lo and Guard
Relays Contacts Only: < 1 Ω per contact





Open Channel Isolation:

			25°C, <85% R.H. 40°C, <60% R.H.	40°C, >95% R.H.
Hi to Lo				
	Option 010		$>10^{10}\Omega$	$>10^{9}\Omega$
	Option 020	Open	$<10^{10}\Omega$	$>10^{9}\Omega$
		Closed	$>10^{8}\ \Omega$	$>10^{7}\Omega$
Lo to Guard			$<10^{8}\ \Omega$	$>10^{7}\Omega$
Guard to Chassis			$>10^{10}\Omega$	$>10^{9}\Omega$

Operating Characteristics

Maximum Switch Rate: Random Channels;
Using Hardware Increments: 475/second

Rated Switch Life at 1 VA: 10^7 operations

All Relays are Break Before Make

AC Performance

High to Low Capacitance: Channel Open: < 10 pF/per channel
Channel Closed: <220 pF/per channel

Interchannel Capacitance: < 10 pF

	100 kHz	1 MHz
Frequency Response (1 MΩ Termination, 10 kHz Reference)	± .3 dB	± .5 dB
Cross Talk		
Channel to Common		
50 Ohm Termination	−70 dB	−50 dB
1M Ohm Termination	−50 dB	−40 dB
Channel to Channel		
50 Ohm Termination	−60 dB	−40 dB
1M Ohm Termination	−40 dB	−30 dB

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual (-hp- part number 03497-90021). Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany this manual. See Appendix B for details.

Application Notes

As an aid to using the Option 020 assembly, you may want to order -hp- Application Note 123 "Floating Measurements and Guarding" (-hp- part number 5952-2153) and -hp- Application Note 290 "Practical Temperature Measurements" (-hp- part number 5952-8801) from your nearest -hp- Sales and Service office.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the relay multiplexer assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the relay multiplexer assembly as Option 020, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44422A, the shipping container should contain a relay card and a terminal card with thermocouple compensation networks (see Figure 80).

For the field installation kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a relay card or terminal card to -hp-, follow the shipping guidelines in Appendix B.

How to Install the Relay Multiplexer Assembly

WARNING

Before touching any installed assemblies or attempting to install the relay multiplexer in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The relay multiplexer assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the relay card. Handle the circuit board by its edges and do not subject the components to static discharges or excessive voltages.

Figure 81 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING and CAUTION notes above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.

To minimize thermal offsets (voltage errors), it is good practice to install the assembly in slot 0 (or the leftmost slot available). Note that the temperature shield must be removed if the assembly is installed in slot 4 of a 3497A or slot 4 or 9 of a 3498A.

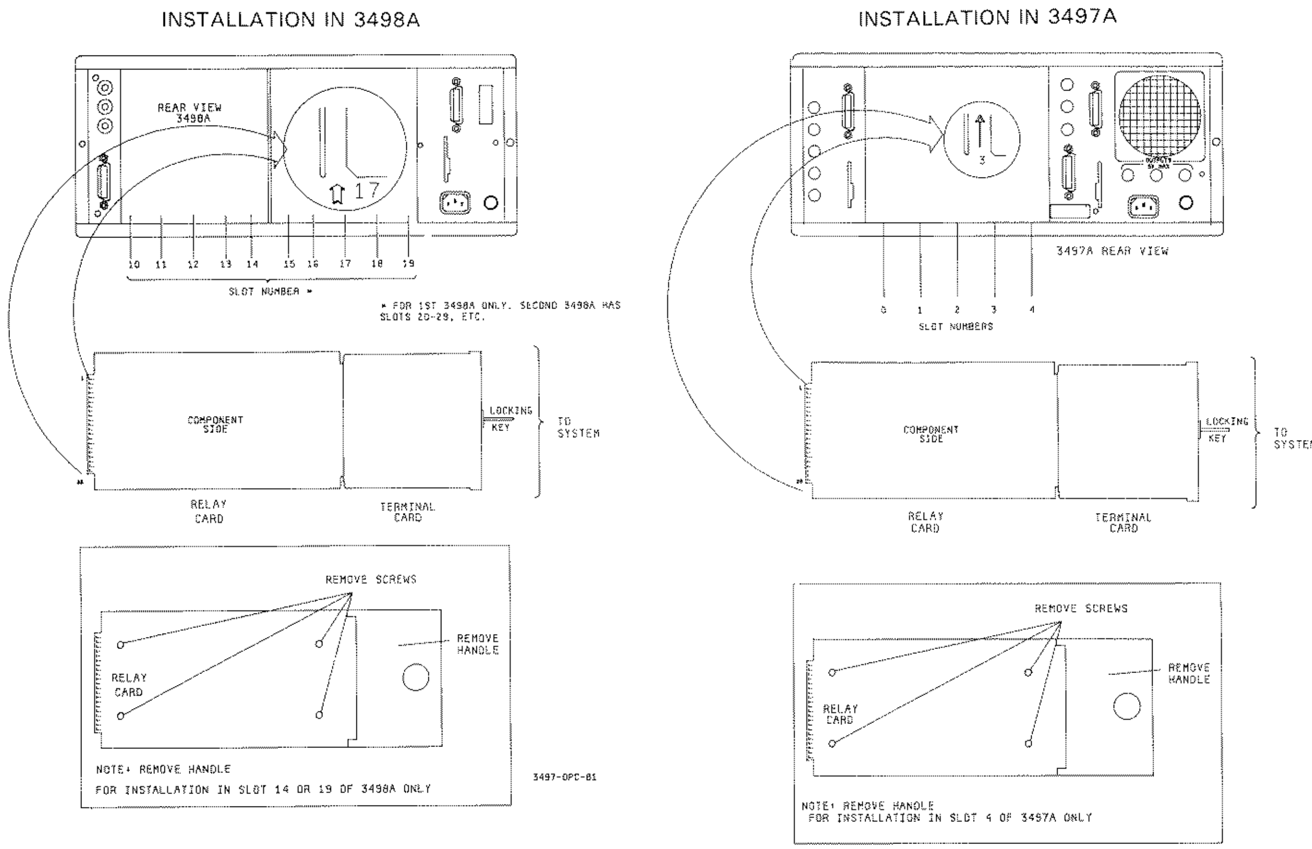


Figure 81. Option 020 · Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

Assembly configuration is divided into two parts: relay card configuration and terminal card configuration. This section shows the functions of the jumpers and resistors on the cards and their locations. See Chapter 9 for some ways that the assembly can be configured for voltage, temperature and resistance measurements.

Relay Card Configuration

By using jumpers JMP1 through JMP6, the T/C COMP jumper and resistors R27 through R32, the relay card can be configured for a wide variety of operating modes. The following chart shows the function of each of these components and Figure 82 shows their locations.

RELAY CARD - FUNCTIONS

REF	TITLE	FUNCTION
1	T/C COMP JUMPER	Sets the assembly for hardware or software thermocouple compensation. Set to NO T/C COMP position for software compensation. Set to T/C COMP position for hardware compensation.
2	TREE SWITCH JUMPERS (JMP1,2,3)	Enables signals from the A decade and B decade relays to be passed to the tree switch relay. Remove these jumpers when you don't want signals input to the 3497A mainframe.
3	DECADE A TO DECADE B JUMPERS (JMP4,5,6)	These jumpers connect decade A relay outputs to decade B relay outputs. Remove these jumpers for four-wire ohms measurements. With jumpers removed, A decade output ONLY is available to the DVM (when tree switch is closed).
4	A DECADE SERIES RESISTORS (R27,28,29)	Provide current limiting protection for A decade. Short these resistors (by soldering the shorting pins) when making two-wire ohms measurements on the A decade.
5	B DECADE SERIES RESISTORS (R30,31,32)	Provide current limiting protection for B decade. Short these resistors (by soldering the shorting pins) when making two-wire ohms measurements on the B decade.

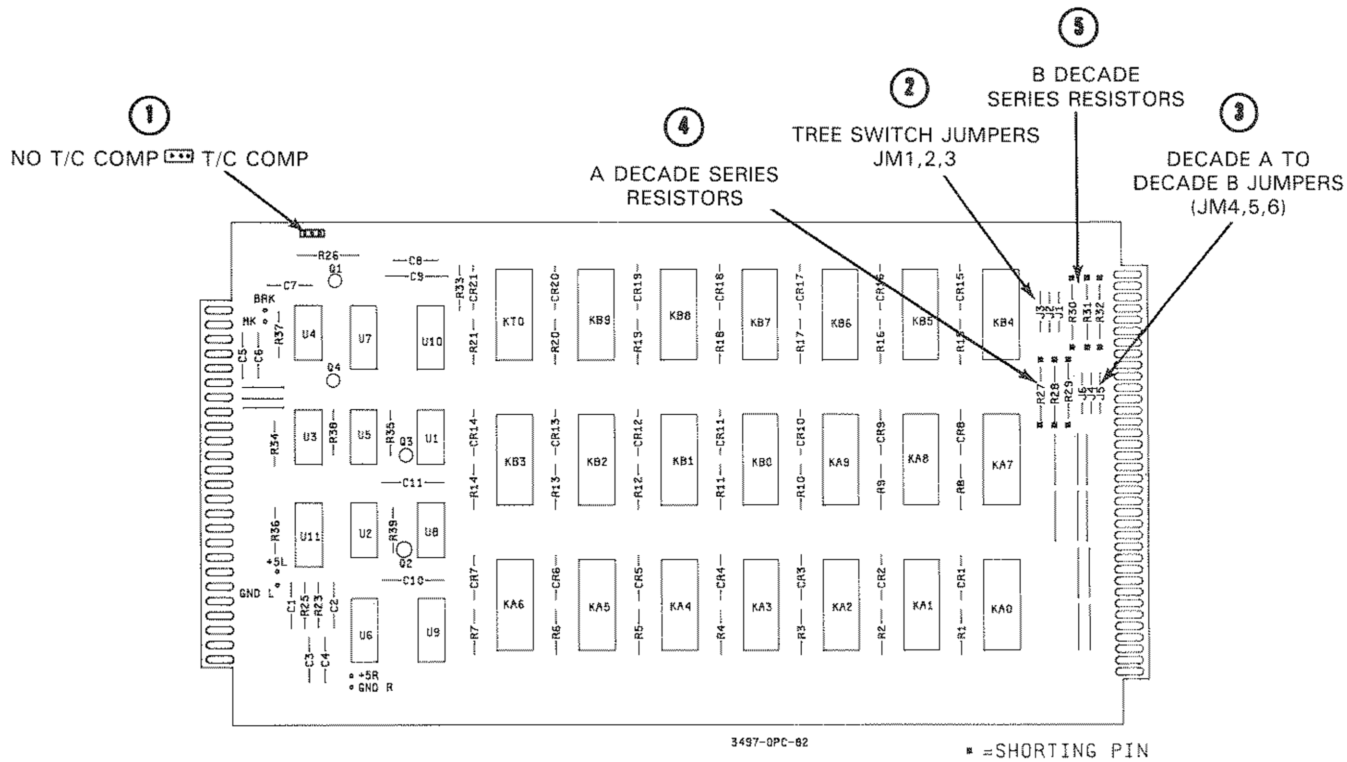


Figure 82. Option 020 - Relay Card Jumpers/Resistors

Shorting the Series Resistors

As factory configured, there are three 100 ohm resistors in series with the A decade COMMON output (R27, R28 and R29) and three 100 ohm resistors in series with the B decade COMMON output (R30, R31 and R32). For more accurate two-wire resistance measurements, these resistors can be shorted out.

For two-wire ohms measurements on A decade channels, short out R27, R28 and R29, using the shorting pins on the relay card. For two-wire ohms measurements on B channels, short out R30, R31 and R32, using the shorting pins. See Figure 82 for resistor and pin locations. If the assembly is to be used in the 3498A, see the WARNING note which follows.

WARNING

When the assembly is used in earlier versions of the 3498A, a possible hazard may exist when making measurements in a system containing a high voltage, high power source (100 VA or above).

In these versions of the 3498A, the GUARD sheet metal may short to the chassis sheet metal because of close mechanical spacing. If the 100 ohm resistors have been shorted as described above and this happens, a current path to chassis ground can exist, as shown in Figure 83.

If the GUARD common line is in contact with a high voltage, high power source (100 VA or above) or could come in contact with such a source and the 100 ohm resistor (R27 or R30) in the GUARD COMMON line has been shorted, a possible shock or fire hazard could exist.

WARNING

When using the relay multiplexer in the 3498A, do NOT jumper the 100 ohm resistors in the guard common lines (R27 and R30). If these resistors must be jumpered, provide adequate external fusing as shown.

After connecting system inputs to the terminal card connectors, replace the protective rear cover on the 3498A, since the sheet metal is at guard potential (as high as 170 volts).

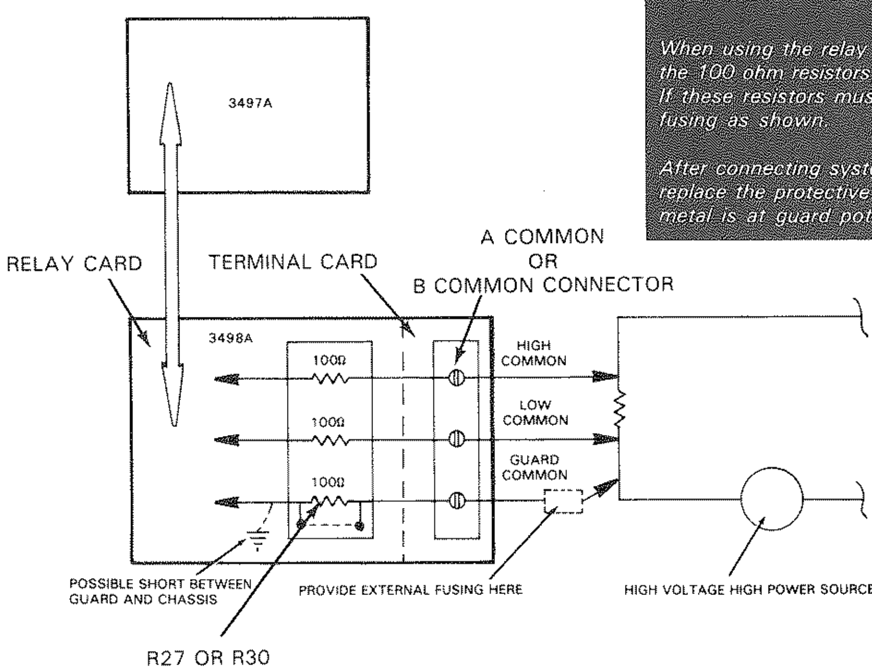


Figure 83. Option 020 · Fusing the Relay Card

Setting Jumpers JMP1 through JMP6

By removing jumpers JMP1, JMP2, JMP3 and/or JMP4, JMP5, JMP6 on the relay card, you can configure the assembly for four modes of operation. In addition, by repositioning the T/C COMP jumper on this card, you can select hardware or software thermocouple compensation.

Figure 84 shows the four operating modes for the assembly and a truth table for these modes. Note that with JMP4, JMP5 and JMP6 OUT (removed from the board), only the A decade inputs are sent to the 3497A (i.e., an input on channel B0 through B9 can be output ONLY at the B COM terminal on the terminal board).

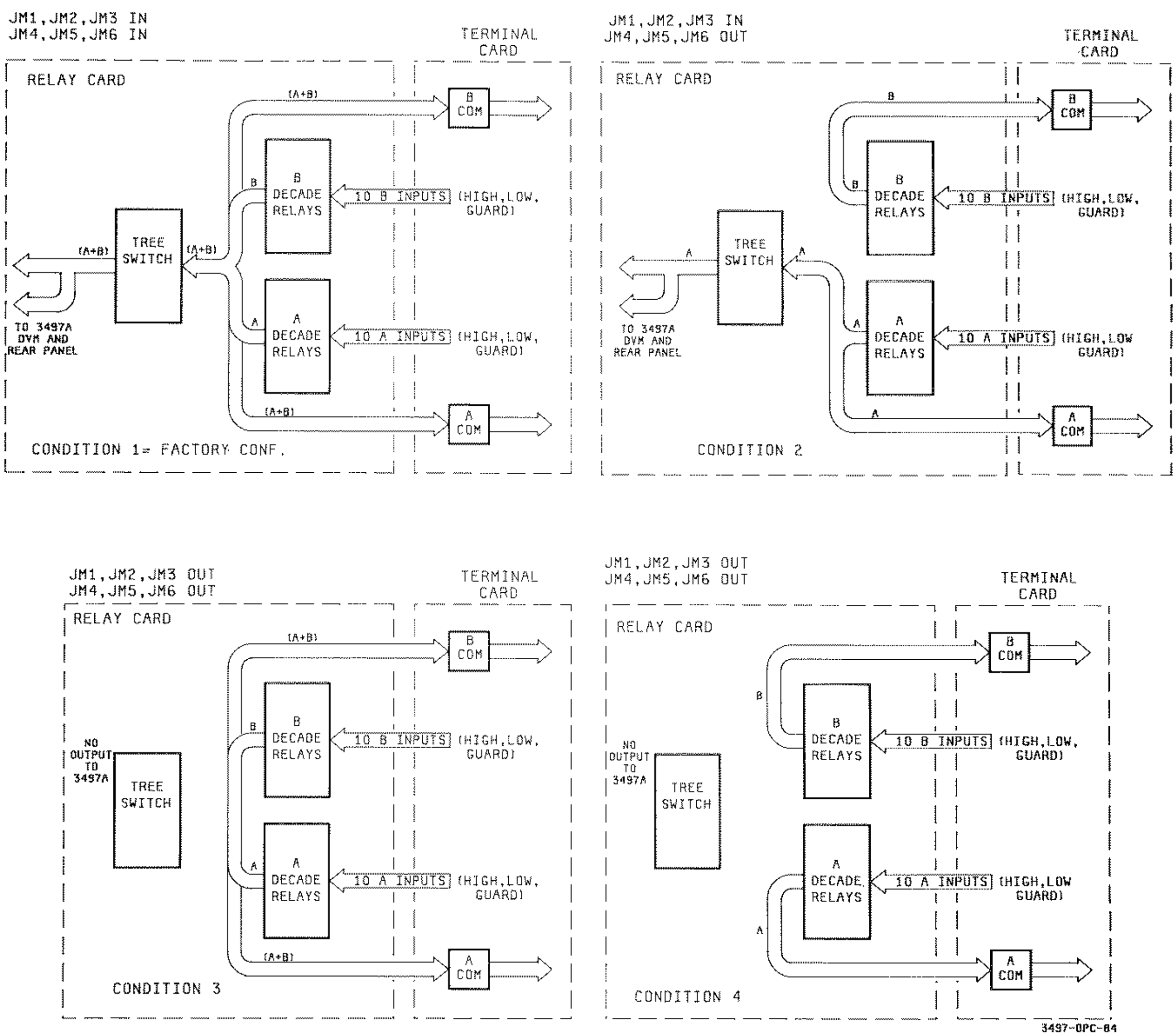


Figure 84. Option 020 · Card Configurations and Truth Table

Relay Multiplexer Assembly Truth Table

Jumper Position			Output To:		
Oper Cond	JM1,JM2 JM3	JM4,JM5 JM6	Term Card A Common	Term Card B Common	3497A DVM+Panel
1***	IN	IN	(A+B)*	(A+B)	(A+B)
2	IN	OUT	A**	B**	A
3	OUT	IN	(A+B)	(A+B)	—
4	OUT	OUT	A	B	—

* (A+B) = either A decade or B decade output (one of 20 channels).
** A = One of 10 A inputs; B = One of 10 B inputs.
*** Condition 1 is factory configuration.

Figure 84. Option 020 · Card Configurations and Truth Table (Cont'd)

Terminal Card Configuration

The terminal card provides the interface between the relay card and your system transducers. This section shows how to set the terminal card for hardware and software compensation, how to connect signal conditioning inputs to the card and how to connect voltage and thermocouple inputs to the card.

CAUTION

To avoid equipment damage, NEVER input voltages at the 3497A rear panel terminals and at the relay multiplexer at the same time. When the tree switch and the channel relays are closed, voltages input from the rear panel are applied directly to user inputs and may damage the equipment.

Configuring for Hardware Compensation

As factory configured, the Option 020 assembly is set for software thermocouple compensation. Hardware compensation is available for J, K, T, E, R and S type thermocouples. However, only one type of thermocouple can be used per assembly. To configure the terminal card for hardware compensation, it is necessary to reconfigure terminal block J1.

As shown in Figure 85, resistors R100 and R120 must be added on J1 and the shorting jumper wire removed from J1. The value of R100 and R120 for each type of thermocouple is shown in the following table. For example, to configure the terminal card for J-type thermocouples, add R100 = 3.650 Kohm and R120 = 619 ohms and remove the shorting jumper. Note that for hardware compensation, the T/C COMP JUMPER on the relay card must be set to the T/C COMP position.

NOTE

A kit containing resistors to configure the terminal card for J, K, T, E, R and S type thermocouples is available from -hp- (-hp- part number 03497-69541).

Thermocouple Compensation Resistors
(All values ± 1%)

Type	R120	R100
J	3.650 Kohms	691 ohms
K	3.400 Kohms	357 ohms
T	8.210 Kohms	1.24 Kohms
E	435 ohms	909 ohms
R	149.625 Kohms	2.55 Kohms
S	149.635 Kohms	2.1 Kohms

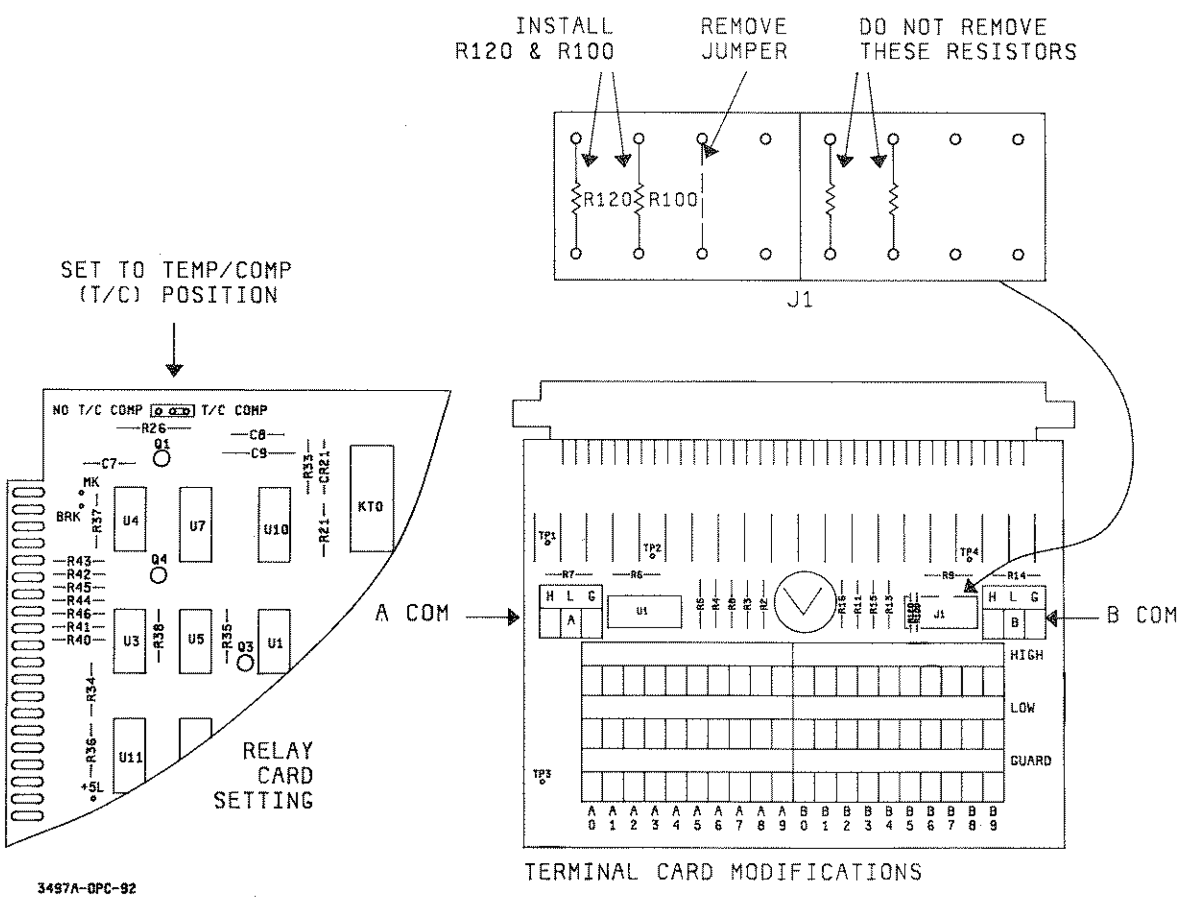


Figure 85. Option 020 - Hardware Compensation

Configuring for Software Compensation

With hardware compensation, only one type of thermocouple can be used per assembly. If you want to mix thermocouple types on an assembly, it is necessary to use software compensation. In software compensation, channel B9 is NOT available as an input, as the voltage measured on this channel is used as the reference voltage. The assembly is factory configured for software compensation.

To reconfigure the terminal card for software compensation, see Figure 86. If resistors R100 and R120 are installed on J1, remove them and add the shorting jumper in the position shown. Also, for software compensation the T/C COMP jumper on the relay card must be set to the NO T/C COMP position.

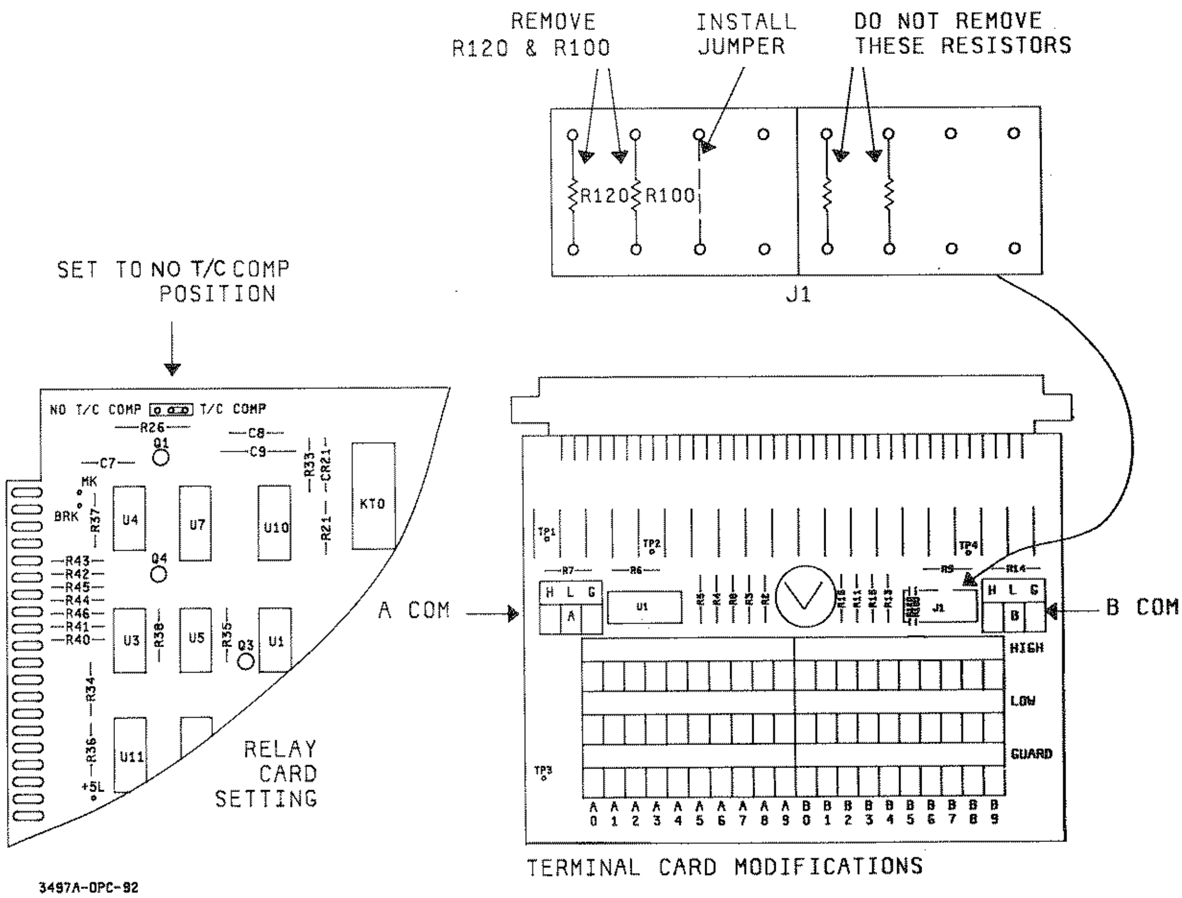


Figure 86. Option 020 - Software Compensation

Input Signal Conditioning

You can also reconfigure the terminal card by adding customer-supplied signal conditioning elements. Figure 87 shows some example current shunt and low pass filter circuits which can be added for input signal conditioning.

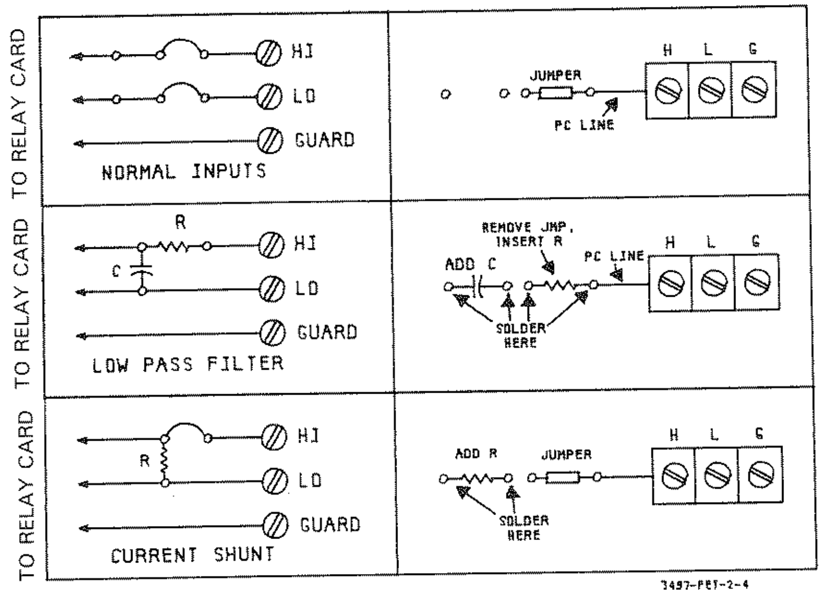


Figure 87. Option 020 - Input Signal Conditioning

Other Modifications to the Terminal Card

By adding shorting jumpers at various parts of the J1 terminal block, you can measure portions of the terminal junction temperature reference circuits on channels indicated. For example, by connecting a jumper at the right side of J1 (closest to the B COM terminal), you can use channel B8 to measure the -8V T/C reference voltage.

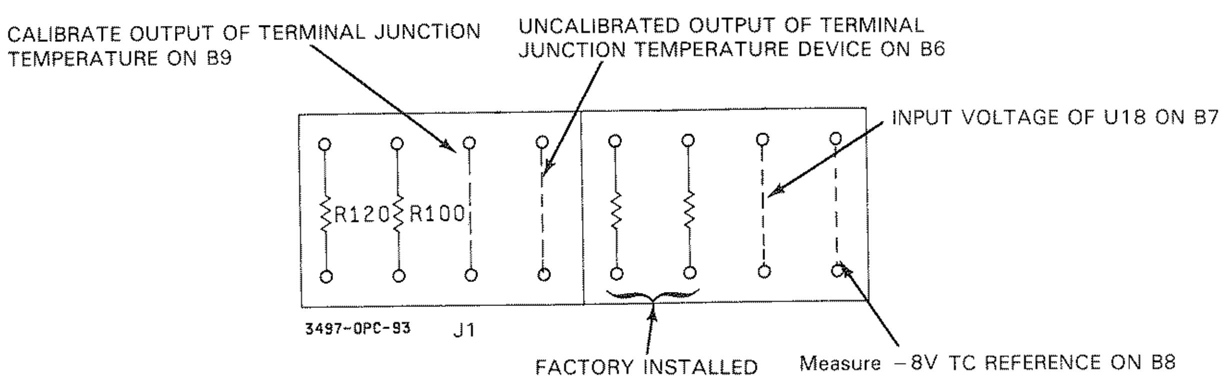


Figure 88. Option 020 - Other Terminal Card Modifications

Connecting Thermocouples

To connect thermocouples to the terminal card, first remove the terminal card cover by loosening the four screws and then route wires as shown in Figure 89. Note that the - metal (red) lead is connected to the GUARD (G) terminal on the terminal card. Three alternate wiring possibilities are shown in Figure 89 for different types of thermocouples.

When connecting thermocouples to the terminal card, for best results consider the following suggestions. For further information on using thermocouples, see -hp- Application Note 290 ''Practical Temperature Measurements''.

GUIDELINES FOR CONNECTING THERMOCOUPLES

1. Use the largest wire possible which will not shunt heat away from the thermocouple area.
2. Use thermocouple wire which is well within its rating.
3. Avoid mechanical stress and vibration which could strain the wires.
4. For long runs, connect the shield to the GUARD terminal of the card and use twisted pair connector cables.
5. Avoid steep temperature gradients.
6. In hostile environments, use proper sheathing material to reduce adverse effects on thermocouple wires.

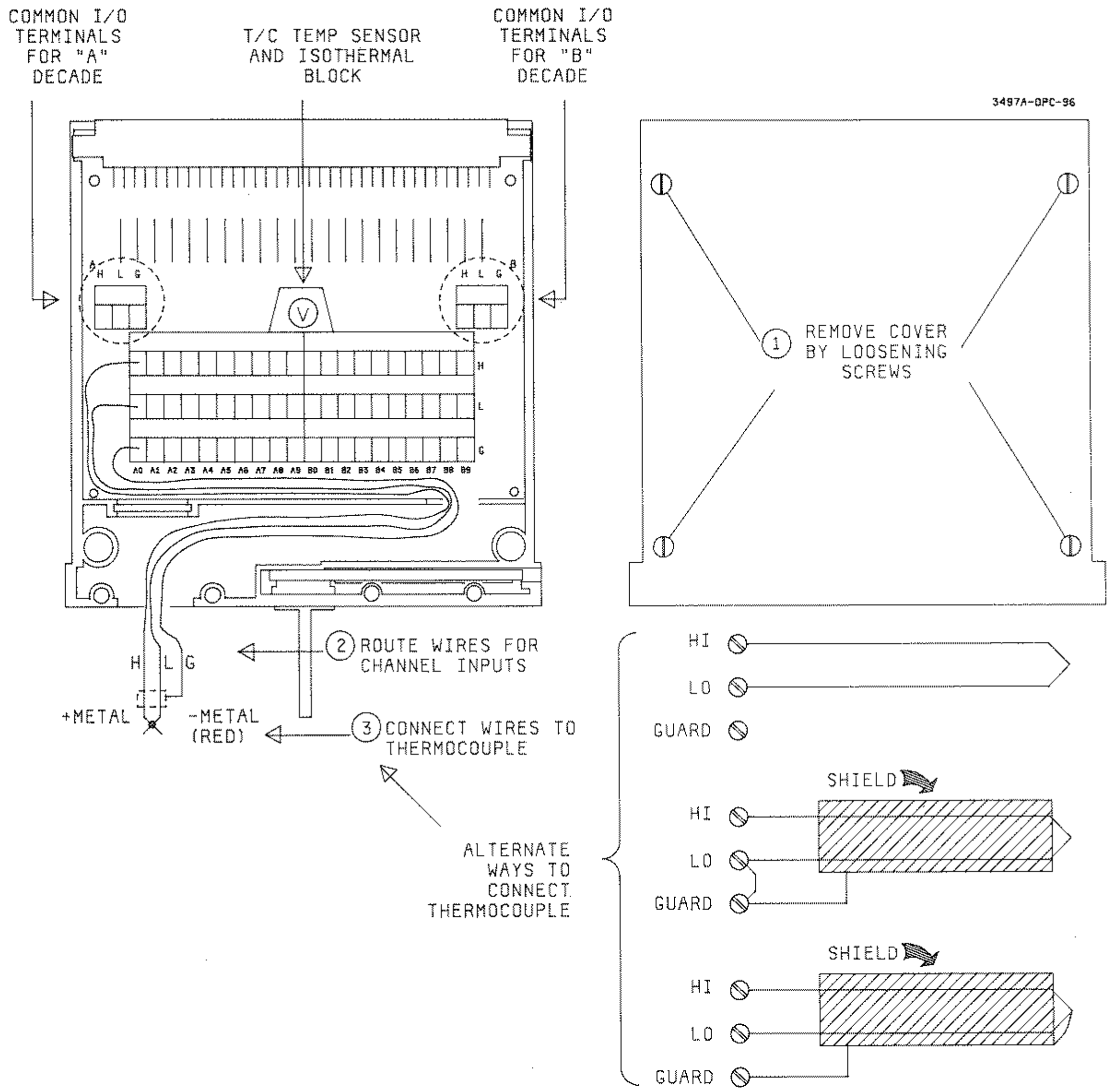
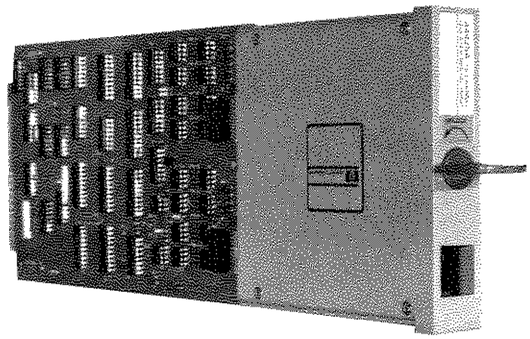


Figure 89. Option 020 - Connecting Thermocouples

OPTION 050

16 Channel Isolated Digital Input/Interrupt Assembly



INTRODUCTION

The Option 050 assembly has two functional modes: Digital Input Mode and Interrupt Mode. In digital input mode, up to 16 digital inputs (ON, OFF; OPEN, CLOSE; etc.) can be input to the assembly. The assembly can also listen to digital data buses.

In the interrupt mode, up to eight inputs (channels 0 - 7 in the assembly) can be monitored and, when specified system conditions occur, the assembly can send a signal via the 3497A to the controller to ''interrupt'' its program and take specified action.

You can use the digital input mode to sense up to 16 lines of digital data such as the outputs of limit switches and position indicators. Use the interrupt mode to interrupt and take corrective action when immediate reaction to a level change is required or when the signal is transient (as in a momentary switch closure).

In addition, you can use the Option 050 assembly with the Actuator/Digital Output assembly (Option 110) to form an independent digital input/output port.

Description

As shown in Figure 90, the Option 050 assembly consists of a digital input card and a terminal card. The digital input card consists of 16 optically isolated input channels. Eight of the channels (0 through 7) may be used to sense interrupt conditions. In addition, optically isolated handshaking is available for each of the 16 channels to synchronize data transfer between the 3497A and an external peripheral.

The terminal card provides connectors for user inputs on each of the 16 channels and for GATE and FLAG signals used for handshaking. Each channel has a jumper to set logic levels of +5V (factory setting), +12V or +24V and the logic level network has protection against reversed connections.

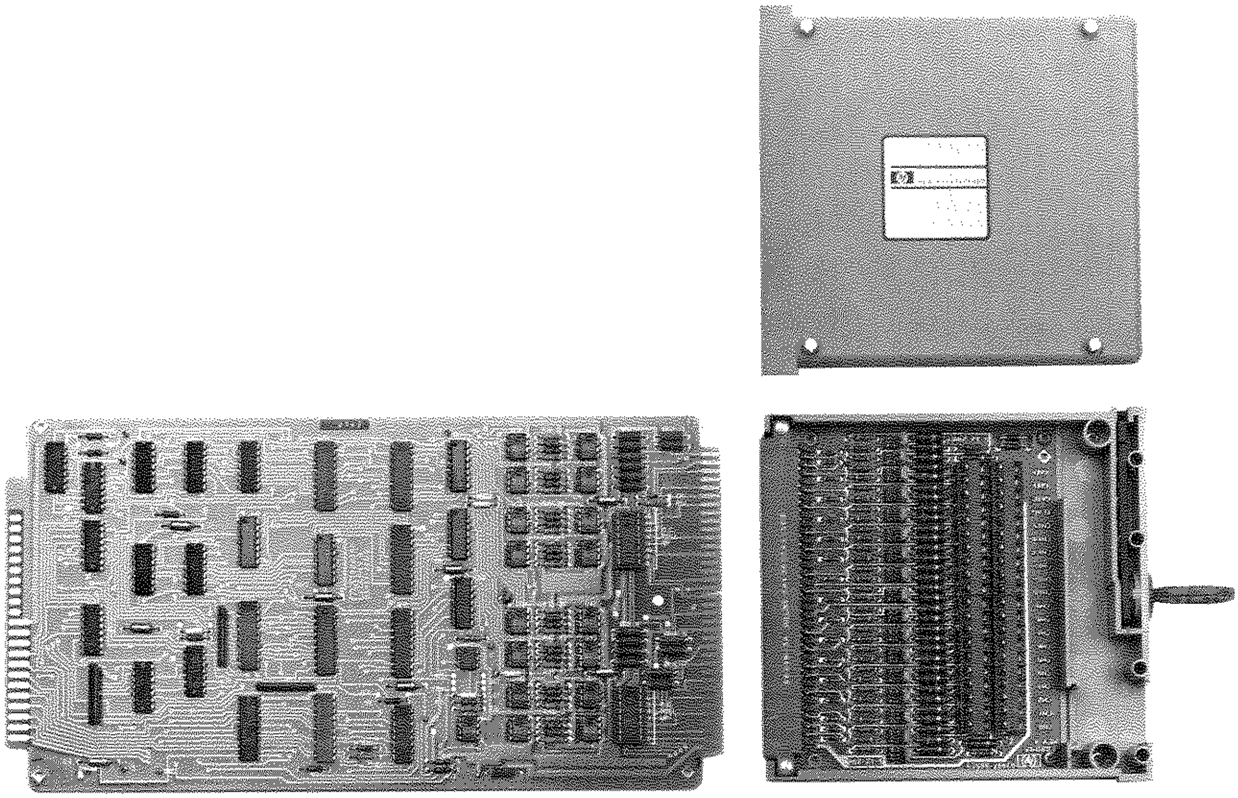


Figure 90. Option 050 - Digital Input/Interrupt Assembly

Interrupt Mode

With interrupt mode, only the first eight channels (0-7) can be used. Refer to Figure 91 which shows sample input connections to trace the sequence of operation for interrupt mode. For the inputs shown, assume that we want to interrupt the controller when the switch in channel 0 closes, but not interrupt when a switch closes in any other channel.

In the circuit of Figure 91, a switch closure causes a high-to-low transition (can be configured for low-to-high) which causes the channel bit in the input byte to be set true ("1"). In Figure 91, transitions have occurred on channels 0 and 7, so bits 0 and 7 in the input byte are set to 1.

Since interrupt is desired only for channel 0, we've set the assembly mask (not the same as the SRQ or interrupt mask in the 3497A) with a DE slot#,0 command. Since the mask bit 0 and the input byte bit 0 are both true, channel 0 of the interrupt byte is set. Note that even though bit 7 of the input byte is set by the transition of channel 7 input, bit 7 of the interrupt byte is NOT set, since the mask bit 7 is not set.

Since a bit in the interrupt byte is set, an interrupt is sent to the 3497A mainframe and sets bit 1 in the 3497A status register. However, unless the SRQ mask (interrupt mask for Serial Data) is set for digital interrupt with an SE2 (SE102) command, an interrupt is not sent to the controller.

Thus, for an input to interrupt the controller, a two-level hierarchy of commands is required: (1) set the Option 050 assembly mask with a DE slot#,n command and (2) set the 3497A SRQ or interrupt mask with an SE2 or SE102 command.

You can monitor the status of the interrupt byte at any time (whether or not an interrupt occurs) by sending the DI slot# command. The value returned to the controller is the octal value of the true bits in the interrupt byte.

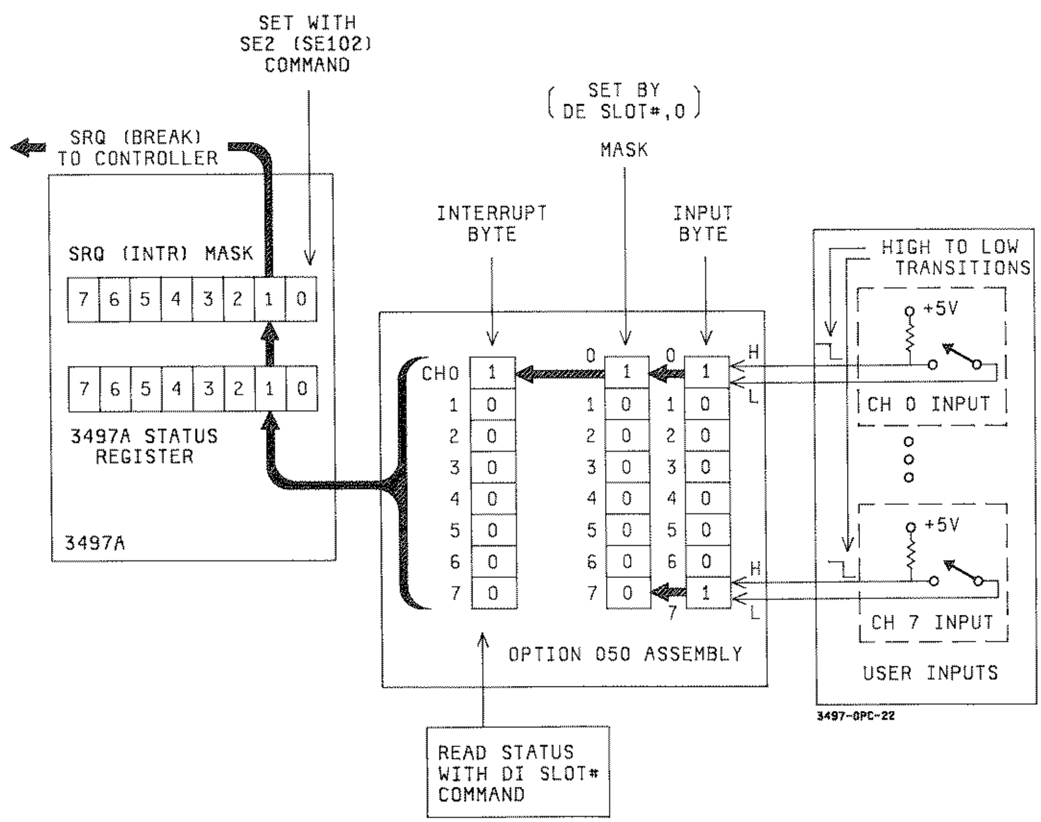


Figure 91. Option 050 - Interrupt Mode

Digital Input Mode

The Option 050 assembly can also be used in the digital input mode to communicate with an 8-bit or 16-bit digital source at a typical maximum read rate of 400 Hz. For digital input mode operation, refer to Figure 92. As shipped from the factory, handshaking on the assembly is disabled. This means that the controller must be programmed to read input data at the appropriate time to ensure that data is valid.

By setting a jumper on the digital input card, handshaking can be enabled. Handshaking is used to verify that the 3497A responds to each data transmission, thereby synchronizing the data source with the digital input assembly.

When handshaking is enabled, the sequence is as shown in Figure 92. The 3497A initiates the sequence by signaling a READY condition on the GATE output to the data source. The READY condition occurs when a DR slot# or DL slot# command is sent and tells the source that the 3497A is ready to accept data.

When the data source has data ready (DATA STABLE), the FLAG signal transitions from low to high on the FLAG line. This action, in turn, causes the GATE output to return to the BUSY condition and data transfer occurs.

NOTE

As factory set, the 3497A responds to a low to high FLAG transition as shown. The 3497A can be jumpered to respond to a high to low FLAG transition. See CONFIGURING THE ASSEMBLY for details.

After data has been entered into the 3497A, the condition of the input byte can be read with the DR slot# or DL slot# commands. DR returns a continuous reading while DL returns a single reading/command. Note that the DR and DL commands check the status of the input byte while the DI command checks the status of the interrupt byte.

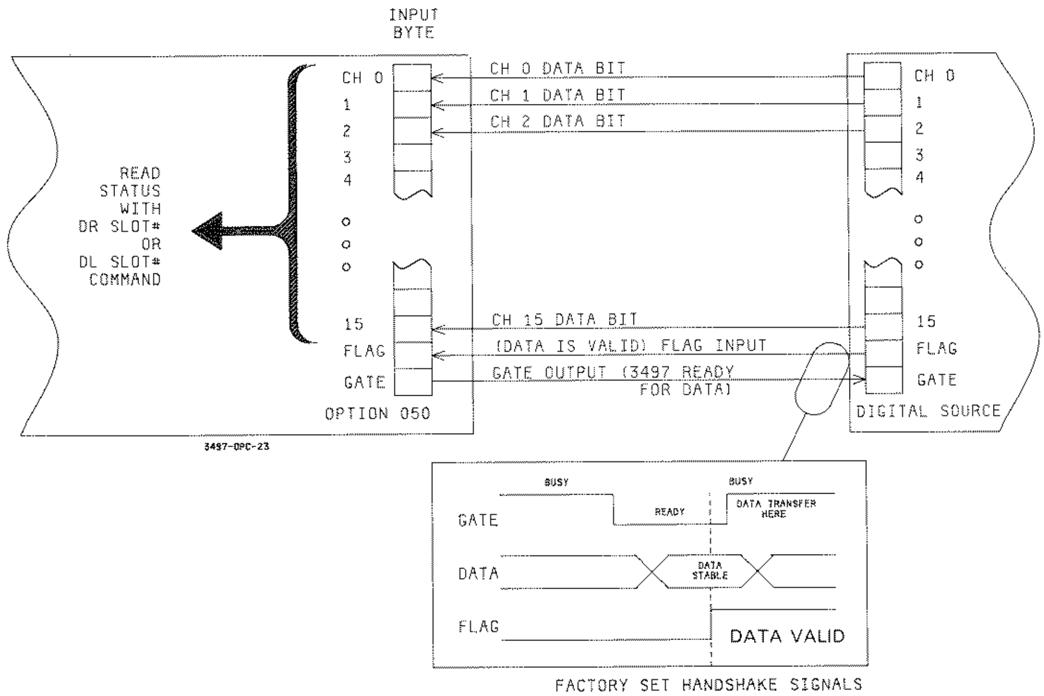


Figure 92. Option 050 - Digital Input Mode

Specifications

Specifications for the 16 Channel Isolated Digital Input/Interrupt assembly follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 050
16 CHANNEL ISOLATED DIGITAL INPUT/INTERRUPT ASSEMBLY

Input Signal Characteristics

Input Level	V_{LO}(max.)	V_{HI}(min.)	Max. Input Voltage	Min. Input Current
5V	0.8V	2.4V	30V	400 μA
12V	3.0V	7.0V	42V	1 mA
24V	6.0V	13.0V	42V	2 mA

(5 volt level is standard, 12 and 24 volt levels are jumper selectable. Other voltage levels can be accepted using customer supplied resistors).

Maximum Isolation Voltage: < 170V peak between any input terminal and ground.

Digital Input Mode (Bits 0-15)

Logic Polarity: Positive True (Negative True is jumper selectable)

Handshaking: Gate and Flag Lines are optically isolated. Gate output is open collector. Flag input is identical to input lines. Polarity of gate/flag is jumper selectable. The assembly may be configured to operate with no handshaking.

Interrupt Mode (Bits 0-7)

Minimum Pulse Width: 100 microseconds

Triggering: Each interrupt line is individually programmable for positive or negative edge triggering.

Masking: Each interupt line may be enabled or disabled using a programmable mask.

Multiple Interrupts: Multiple interrupts are latched and are dealt with at a computer dependent rate.

Interrupt Timing: The Option 050 assembly will respond to an interrupt within 1 millisecond of a programmed interrupt condition change.

Five Volt Supply: Source up to 20 mA per assembly.

Operating Consideration: Digital Interrupt (SRQ) is not available in the 3498A Extender.

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual (-hp- Part number 03497-90021). Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany this manual. See Appendix B for details.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the Digital Input/Interrupt assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the Digital Input/Interrupt assembly as Option 050, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44425A, the shipping container should contain a digital input card and a terminal card (see Figure 90).

For the field installation kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a relay card or terminal card to -hp-, follow the shipping guidelines in Appendix B.

How to Install the Digital Input/Interrupt Assembly

WARNING

Before touching any installed assemblies or attempting to install the digital input assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The Digital Input/Interrupt assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

Figure 93 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING note above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the digital input card. Handle the card by its edges and do not subject the components to static discharges or excessive voltages.

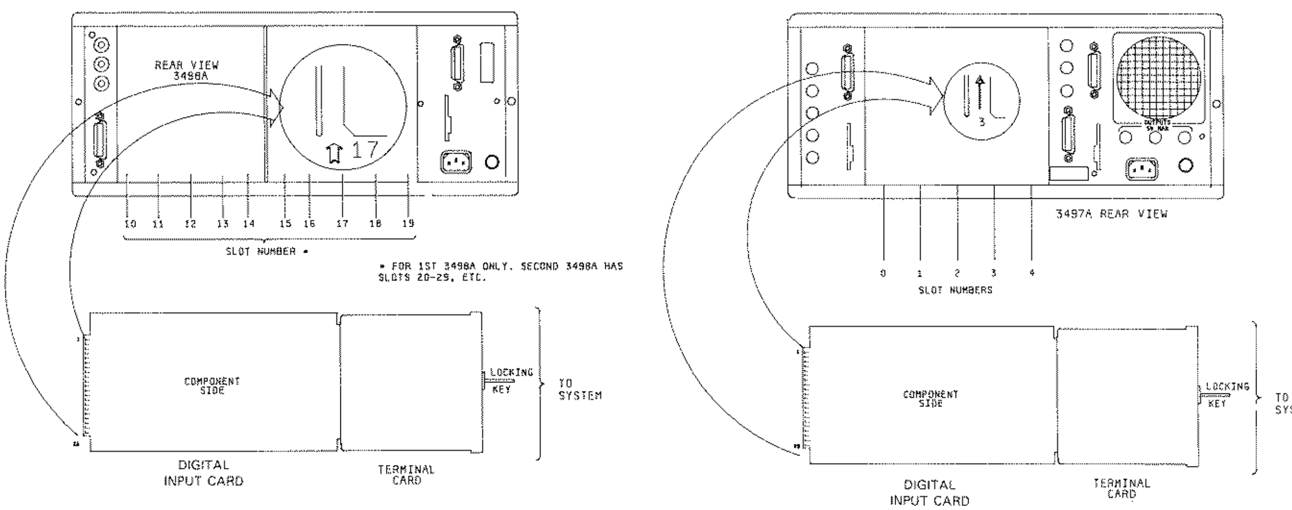


Figure 93. Option 050 - Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

Assembly configuration is divided into two parts: digital input card configuration and terminal card configuration. This section shows the functions of the jumpers on the cards and their locations. See Chapter 9 for some ways that the assembly can be configured for interrupt applications.

Digital Input Card Configuration

By changing jumper positions and adding resistors to the digital input card, you can configure the assembly for a wide variety of operating conditions. In addition, by using the DS slot#,n (n = 0 to 377 octal) command, you can set the assembly to generate interrupts for positive (low to high) or negative (high to low) transitions from your input circuits.

To configure the digital input card for your requirements, refer to the following chart which shows the function and factory configuration for the card and see Figure 94 for location of the jumpers.

DIGITAL INPUT CARD - JUMPER FUNCTIONS

#	TITLE	REF	DESCRIPTION
1	FLAG SENSE	LFL	Sense FLAG input on high to low transition.
		HFL	Sense FLAG input on low to high transition (FACTORY SETTING).
2	INVERT LOGIC	INVT	Inverts data logic to low true (applies to DR slot# and DL slot# commands).
3	ENABLE HANDSHAKE	HS	Enables Handshake (FACTORY SETTING = NOT ENABLED).
4	OPEN COLLECTOR PULLUPS	O.C. PULLUPS	Install a 2 Kohm resistor for each channel which uses an input circuit with an open collector.*
5	GATE SENSE	HGT	High GATE: BUSY = Low, READY = High.
		LGT	Low GATE: BUSY = High, READY = Low. (FACTORY SETTING)
6	GATE, FLAG PULLUPS	GPU	GATE Pullup: Install 2 Kohm resistor if data source does not have pull up.*
		FPU	FLAG Pullup: Install 2 Kohm resistor if data source does not have pull up.*

* Must connect system grounds between data source and 3497A.

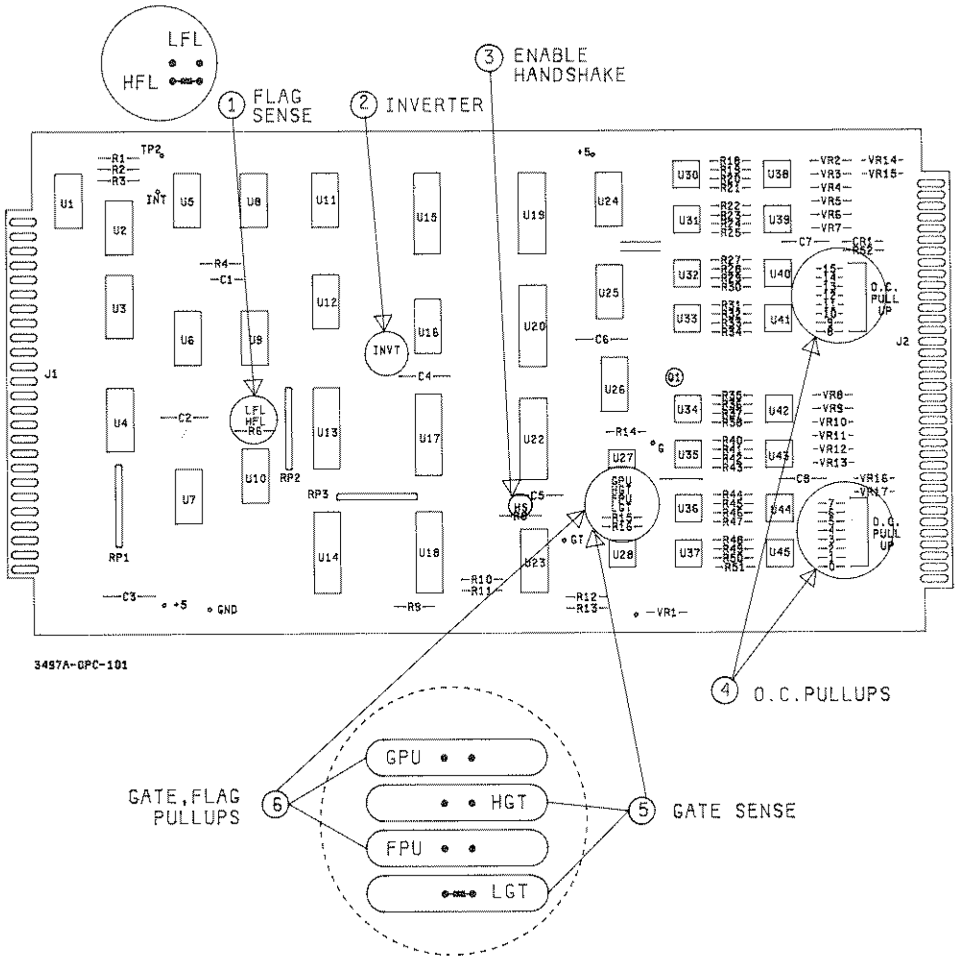


Figure 94. Option 050 - Digital Input Card Jumper Locations

Terminal Card Configuration

Each digital channel requires two inputs (HI and LO) to complete the optical isolator circuit. With this connection, each channel is isolated from the other input channels, unless common connections are made between SYSTEM GROUND on the terminal card and user SYSTEM GROUND.

When the data source or input system uses open collectors, you must connect SYSTEM GROUNDS between your system and the SYSTEM GROUND on the terminal card (as well as connecting 2 Kohm resistors).

You can select +5V (Factory Set), +12V or +24V logic level for each channel input by changing the position of the jumpers as shown in Figure 95. Note that the Chassis and Earth Ground terminals on the card are tied together to form a SYSTEM GROUND.

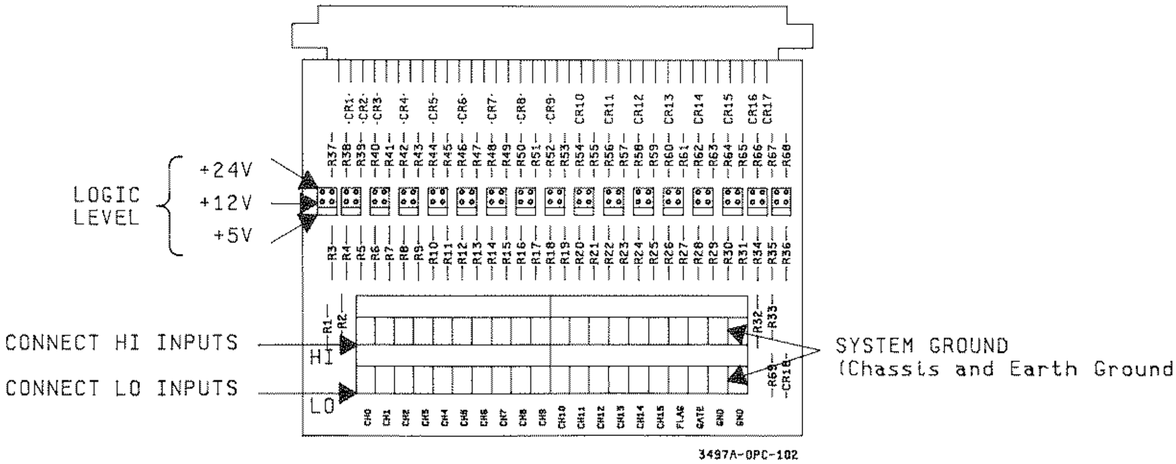


Figure 95. Option 050 - Terminal Card Connections

To connect inputs to the terminal card, remove the cover by loosening the four screws and route the wires as shown in Figure 96. Note that the FLAG and GATE connections are the same as channel inputs and must have HIGH and LOW connections. (The assembly does have protection against reversed connections). After the connections are made, replace the terminal card cover.

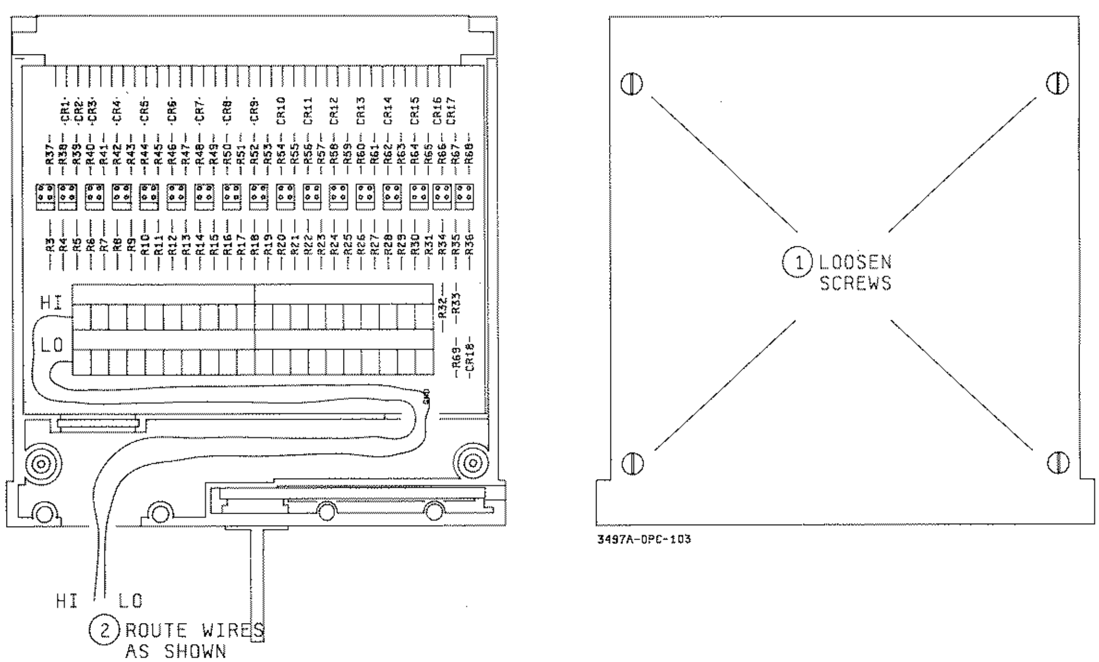


Figure 96. Option 050 - Routing Terminal Card Wiring

Contact Closure to Ground

Another configuration which requires that SYSTEM GROUNDS be connected is for contact closure to ground. As shown in Figure 97, a contact connected to the LOW terminal of a channel is used for interrupt. Note that the SYSTEM GROUNDS are tied together at the GND terminal on the terminal board and that a 2 Kohm resistor is installed in the O. C. PULLUP block.

NOTE

To enable interrupts on channels 0-7, input signal pulse width must be greater than 100 μsec.

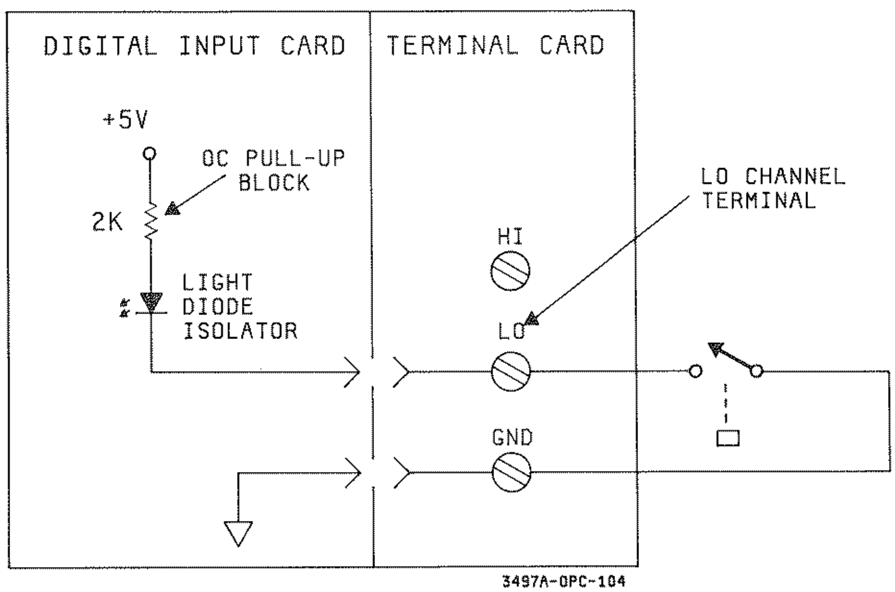
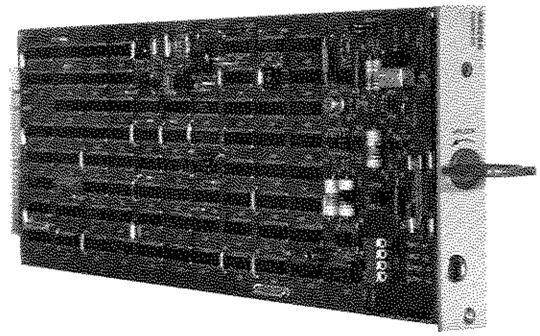


Figure 97. Option 050 - Contact Closure to Ground

OPTION 060



100 kHz Reciprocal Counter Assembly

INTRODUCTION

Option 060 is a 100 kHz reciprocal counter which can measure the period of input signals up to 100 kHz and the pulse width of signals down to 18 usec. In addition, the counter can count up or down from a programmable start point and can output a programmable number of square wave pulses for control applications.

The counter can accept a wide variety of input signals including CMOS, open collector TTL and passive contact closures. All counter functions, interrupts and trigger modes are fully programmable. The counter can be read during a measurement or can be programmed to respond when a measurement is complete.

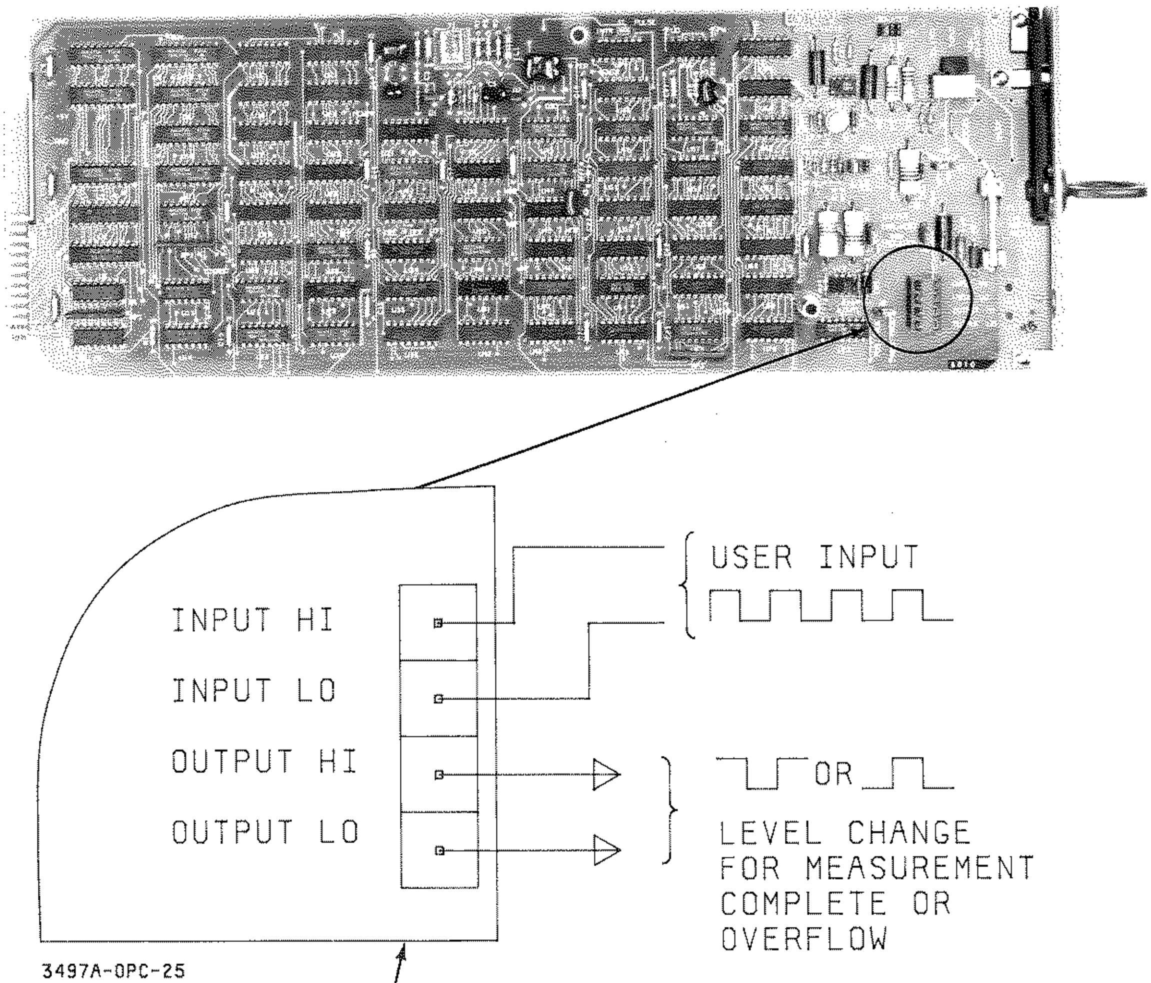
Description

As shown in Figure 98, the assembly consists of a counter board with connector terminals for INPUT HIGH, INPUT LOW, OUTPUT HIGH and OUTPUT LOW connections. User signals are input to the INPUT HIGH and INPUT LOW connectors.

The counter can accurately measure a wide variety of input signals, as long as the signal parameters are within the limits shown in the specification table. Although square wave inputs are used for the examples in the manual, you can use other inputs such as triangle or sine wave and still achieve accurate results.

The OUTPUT HIGH and OUTPUT LOW terminals on the counter card provide a means to output a level change (programmable for high to low or low to high) whenever the counter overflows or a measurement is complete. This level change is output whenever these conditions occur and can be used to drive or control external circuits.

For example, when the counter measures more than 999999 counts (an overflow condition), a level change pulse is available at the OUTPUT HIGH terminal which can be used to signal the error to an external circuit. (Note: the terms ''overflow'' and ''measurement complete'' have different interpretations, depending on the mode of operation for the counter. See Simplified Operation for details)



INPUT/OUTPUT TERMINALS
Use the INPUT HIGH and INPUT LOW terminals to input your system signals for count up (totalize), count down and period or pulse width measurements. Use the OUTPUT HIGH and OUTPUT LOW terminals for input to an external system. A level change is output at these terminals when a measurement is complete or when the counter overflows. You can also use the OUTPUT HIGH and OUTPUT LOW terminals to output a programmable number (0 to 499999) of square wave pulses to drive external circuitry.

Figure 98. Option 060 - 100 kHz Reciprocal Counter

NOTE

The OPTION ROM shown in Figure 98 MUST be installed in the 3497A if HP-IB option is used and the counter is ordered as a Model 44426A Field Installation Kit. See INSTALLING THE ASSEMBLY for details.

Simplified Operation

The 100 kHz reciprocal counter has five main operational modes: count up, count down, period measurement, pulse width measurement and pulse output. Each operation is summarized, with the counter at factory settings. By using the switch and jumpers on the counter card, you can set the counter for a wide variety of configurations for each of these operations. See Figure 99 for a summary of the five modes.

Count Up

In count up, the counter counts up (totalizes) a number of input pulses (up to 999999) from a programmable start point (0 to 999999). At any time after the counter starts counting up, the totalized counts can be displayed on the front panel or sent to the controller.

If the total count in the counter exceeds 999999 counts, an overflow condition occurs and the counter generates a level change output at the OUTPUT HIGH terminal. If interrupt on overflow has been enabled, the counter sends an interrupt to the 3497A status register to set bit 1 (digital interrupt).

Count Down

In count down, the counter counts down a number of input pulses (999999 counts max) from a programmable start point (0 to 999999). The counter stops at 0 unless start point is 000000. If the start point is 0, counter ''wraps around'' and counts down from 999999 (million counts maximum).

After the counter has started the count down operation, you can display the number of remaining counts on the front panel or send this data to a controller. The counter can be programmed to send an interrupt to the 3497A when zero count is reached. Also, when a zero count is reached, a level change output is available at the OUTPUT HIGH terminal.

Period Measurement

In period measurement, the counter can measure one period or average 100 or 1000 periods of input signals which have frequencies up to 100 kHz. Input signal triggering can be selected from rising edge to rising edge or falling edge to falling edge. With appropriate settings of the counter, you can measure the periods of input signals with frequencies from 0.0001 Hz to 100 kHz (periods from 0.00001 sec to 10,000 sec).

You can program the counter to send an interrupt to the 3497A when a measurement is complete and/or when the input signal period cannot be measured (an overflow condition). In addition, a level change is available at the OUTPUT HIGH terminal when either of these two conditions occur and (if enabled), an interrupt is sent to the 3497A status register to set bit 1 (digital interrupt).

If the input signal period can't be measured because the period is too long for the measurement range selected, a counter overflow condition occurs and a level change output and interrupt (when enabled) occurs. For example, if you tried to measure the period of 1 MHz input, an overflow condition occurs since the input period exceeds the counter limits.

Pulse Width Measurement

In pulse width measurement, the counter can measure one pulse width or average 100 or 1000 pulse widths of an input signal with pulse widths which are 18 μsec or wider. You can select input signal triggering from rising edge to falling edge or falling edge to rising edge.

You can program the counter to send an interrupt to the 3497A when a pulse width measurement is complete or when the pulse width cannot be measured by the counter (overflow condition). In addition, a level change pulse is available at the OUTPUT HIGH terminal when either of these two conditions occur and (if enabled), an interrupt is sent to the 3497A status register to set bit 1 (digital interrupt).

If the input signal period can't be measured because the pulse width is too short for the measurement range selected, a counter overflow condition occurs and a level change output and interrupt (when enabled) occurs. For example, if you tried to measure the pulse width of a 1 MHz input, an overflow condition occurs since the input pulse width exceeds the counter limits.

Pulse Output

The pulse output mode is a variation of the count down operation. In pulse output, the counter outputs a programmable number of square wave pulses (0 to 499999) at a specified frequency (0 to 1kHz). The frequency of output pulses is half the input signal frequency. The input signal must be between 0 and 2 kHz with a pulse width greater than 5 μsec.

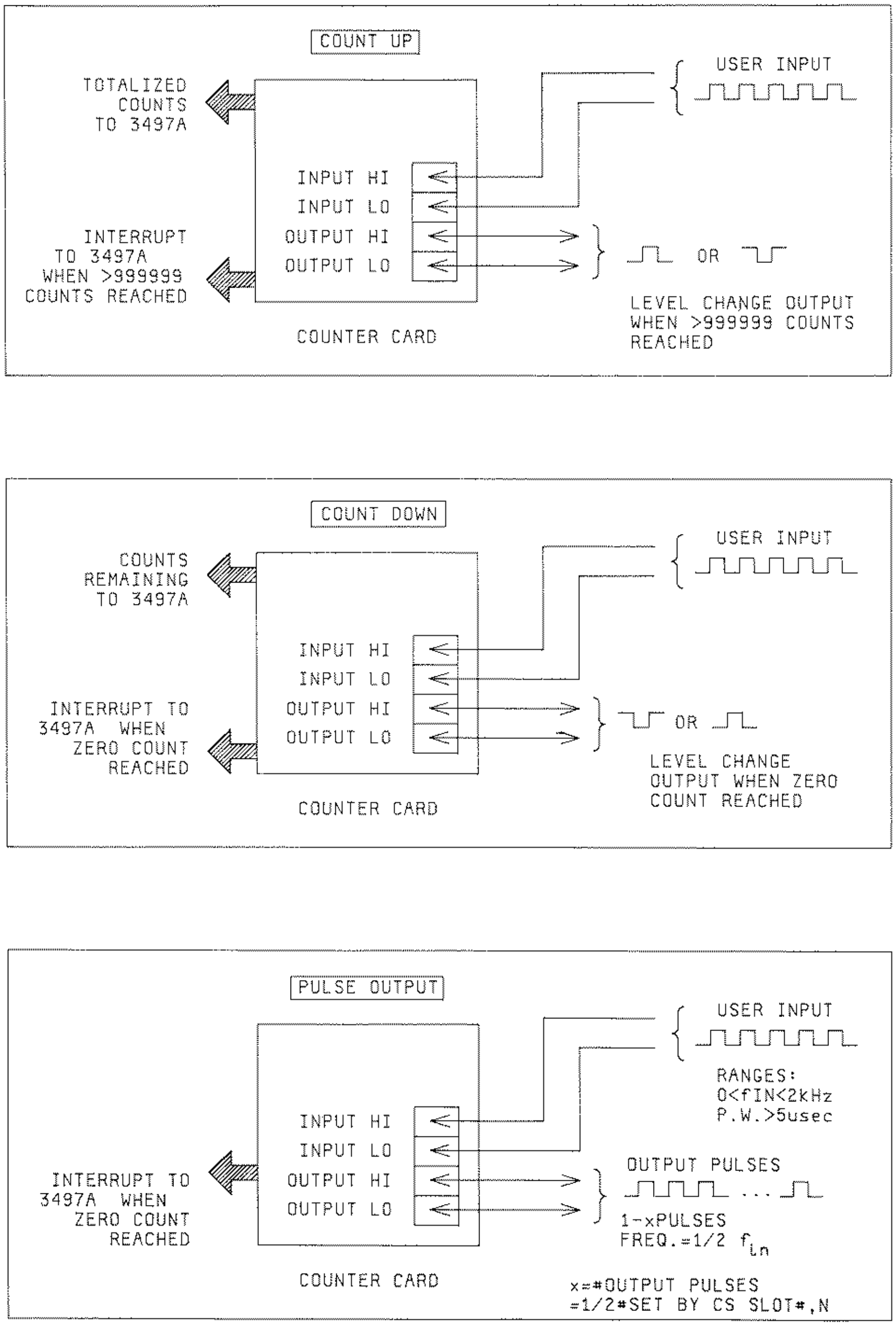
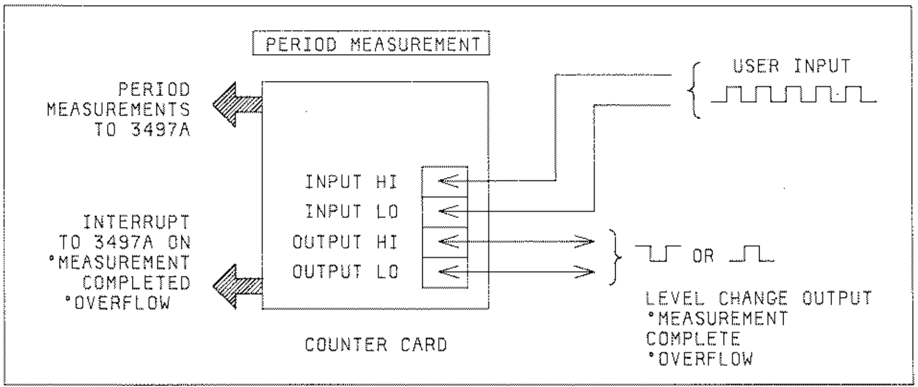
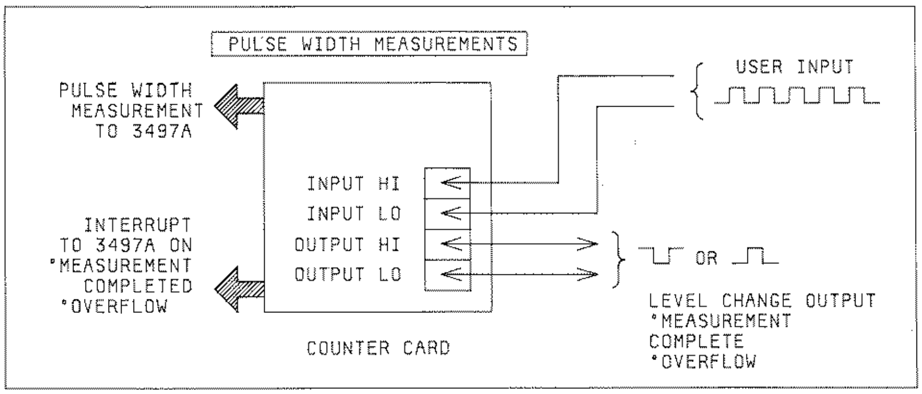


Figure 99. Option 060 - Counter Modes of Operation





3497-OPC-26

Figure 99. Option 060 - Counter Modes of Operation (Cont'd)

Specifications and General Information

Specifications and general information for the counter follow. Specifications are performance standard or limits against which the counter is tested. General information is supplied as additional information.

OPTION 060
100 kHz RECIPROCAL COUNTER ASSEMBLY

Period Mode:

Input Signal Characteristics:
Maximum Input Frequency: 100 kHz
Minimum On Time: 5 μs
Minimum Off Time: 5 μs

Range Charactristics:

Range	Least Significant Digit (LSD) HP-IB	Least Significant Digit (LSD) Display	Periods Averaged
9999.999 s	1 ms	10 ms	1
99.99999 s	10 μs	100 μs	1
0.9999999 s	100 ns	1 μs	100
.09999999 s	10 ns	1 μs	1000

Input Signal Characteristics:

Input Levels:

Input Level Range	V(Lo) (maximum) Isolated	V(Lo) (maximum) Non-iso	V(Hi) (minimum) Isolated	V(Hi) (minimum) Non-iso	Max Input Voltage
5V	1.0V	1.0V	4.2V	4.2V	±12.0V
12V	1.8V	2.7V	10.3V	8.0V	±21.0V
24V	2.6V	6.0V	18.4V	16.5V	±32.0V

Input Circuit: Switch selection of optically isolated or non-isolated input. Non-isolated input has 19.5 kΩ minimum input impedance. Non-isolated mode is standard.

Minimum Current:
Isolated: (all ranges) 8 mA
Non-isolated: 5V range: 30 μA
12V range: 250 μA
24V range: 750 μA

Input Fuse: 125 mA

Maximum Isolation Voltage: 170 V peak between any terminal and ground. Frequency ≤ 60 Hz.

Accuracy: ±(.01% of reading + 2 LSDs + Trigger Error)

Trigger Error: Maximum Transition Time for input voltage to go from V(Lo) to V(Hi) or V(Hi) to V(Lo)

Pulse Width:

Input Signal Characteristics:
Minimum Start to Stop Time (Pulse Width): 18 μs
Minimum Stop to Start Time: 18 μs

Range Characteristics:

Range	Least Significant Digit (LSD) HP-IB	Display	Periods Averaged
9999.999 s	1 ms	10 ms	1
99.99999 s	10 μs	100 μs	1
0.9999999 s	1 μs	1 μs	100
.099999 s	1 μs	1 μs	1000

Accuracy: ±(.01% of reading + Trigger Error + 2 LSDs or 18 μs, whichever is greater)

Trigger Error: Maximum Transition Time for input voltage to go from V(Lo) to V(Hi) + V(Hi) to V(Lo)

Totalize/Down Count Mode:

Input Signal Characteristics:
Maximum Input Frequency: 100 kHz
Minimum Pulse Width: 5 μs

Range: 0 to 999,999

Preset Value Range: 0 to 999,999

General Information

Level Change Output: Level change occurs on measurement complete, overflow and zero count (down count mode only).
Output Circuit: Open Collector
Isolated mode is standard; non-isolated is jumper selectable. Interrupt mode is standard; square wave output is jumper selectable. Negative true logic is standard; positive true is jumper selectable.
Maximum Current: 1.6 mA
Maximum Voltage: 12 volts
Maximum Low Level Voltage: .65 V at 1.6 mA

Square Wave Output Operation: The output line can be configured to act as a square wave output with a frequency equal to ½ of the counter input signal. When used in the count down function with the counter input connected to the 3497A Timer output (or other external source), the counter output line can be used to output a programmable number of square wave pulses. This feature may be useful in driving devices controlled by square wave pulse trains like stepper motor controllers.
Maximum Input Frequency: 2 kHz
Maximum Output Frequency: 1 kHz (½ of input frequency)
Output Range: 0-499,999 pulses programmable

+ 5 Volt Supply: Jumper selectable to sense contact closures and open collector outputs on the non-isolated input. May also be used to supply open collector level change output. Connected through supplied pull up resistors.

Operating consideration: Digital Interrupt (SRQ) is not available in the 3498A Extender.

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual (-hp- part number 03497-90021). Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany the manual. See Appendix B for details.

As shown in Figure 100, each counter has a revision letter in the upper right-hand corner of the component side of the board. This manual does NOT apply to REV A counters. If you have a REV A counter, see -hp- Model 44426A 100 kHz Reciprocal Counter Assembly Operating and Service Manual (-hp- part number 44426-90000).

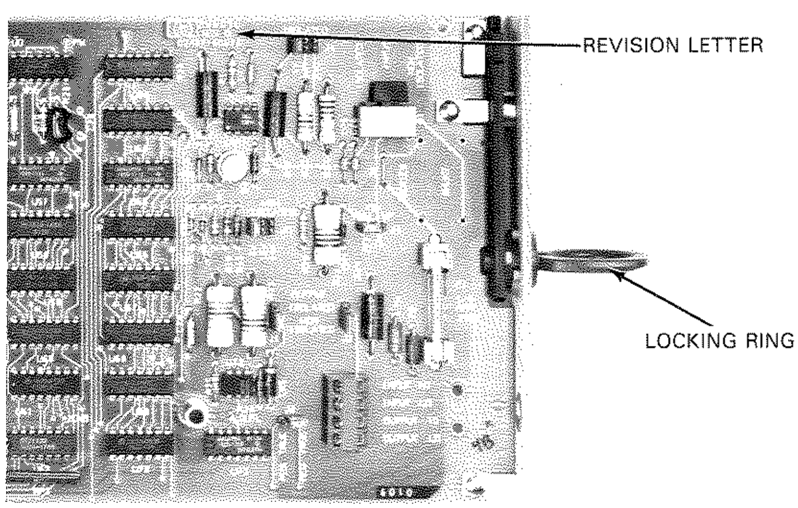


Figure 100. Option 060 - Revision Letter Location

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the 100 kHz counter assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the 100 kHz reciprocal counter assembly as Option 060, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44426A, the shipping container should contain a counter card and an option ROM (see Figure 98).

For the Field Installation Kit, if either item is missing or if there is mechanical damage or defect to the items, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a counter card or option ROM to -hp-, follow the shipping guidelines in Appendix B.

Installing the Option ROM

If you ordered the counter as Model 44426A (Field Installation Kit 44426A) AND you have a 3497A with HP-IB option, it is necessary to install the Option ROM (-hp- part number 1818-1615) onto the Outguard Controller Board in the 3497A before the counter can be operated.

If you purchased the counter as Option 060 to the 3497A (HP-IB version), the counter card and associated Option ROM are already installed. If you purchased the 3497A with Option 232 (Serial Data), an option ROM is not necessary for counter operation.

53.92

03497-65502

CAUTION

The Option ROM is sensitive to electrostatic discharge. Before unpacking it or handling it, observe the following precautions:

** Reduce static build-up by using personnel grounding devices and techniques.*

** Do not place the ROM on plastic surfaces or within plastic enclosures that are not specifically designed to suppress static voltage.*

** Do not use ungrounded tools to install or remove the ROM from the socket.*

To install the Option ROM on the 3497A Outguard Controller Board, first remove all power from the 3497A and 3498A, including LINE and voltage sources connected to any installed option cards.

Next, remove the protective cover from the rear panel of the 3497A and loosen the fastener on the Outguard Controller Board (right rear panel of the 3497A as seen from the rear). Then pull out the Outguard Controller using the plastic pull ring.

Finally, position the circuit board assembly with the component side up and install the Option ROM in location U12, as shown in Figure 101. Then replace the Outguard Controller Board and the protective cover.

CAUTION

The Outguard Controller circuit board and components may be damaged by static discharge. Use clean handling techniques when installing the Option ROM.

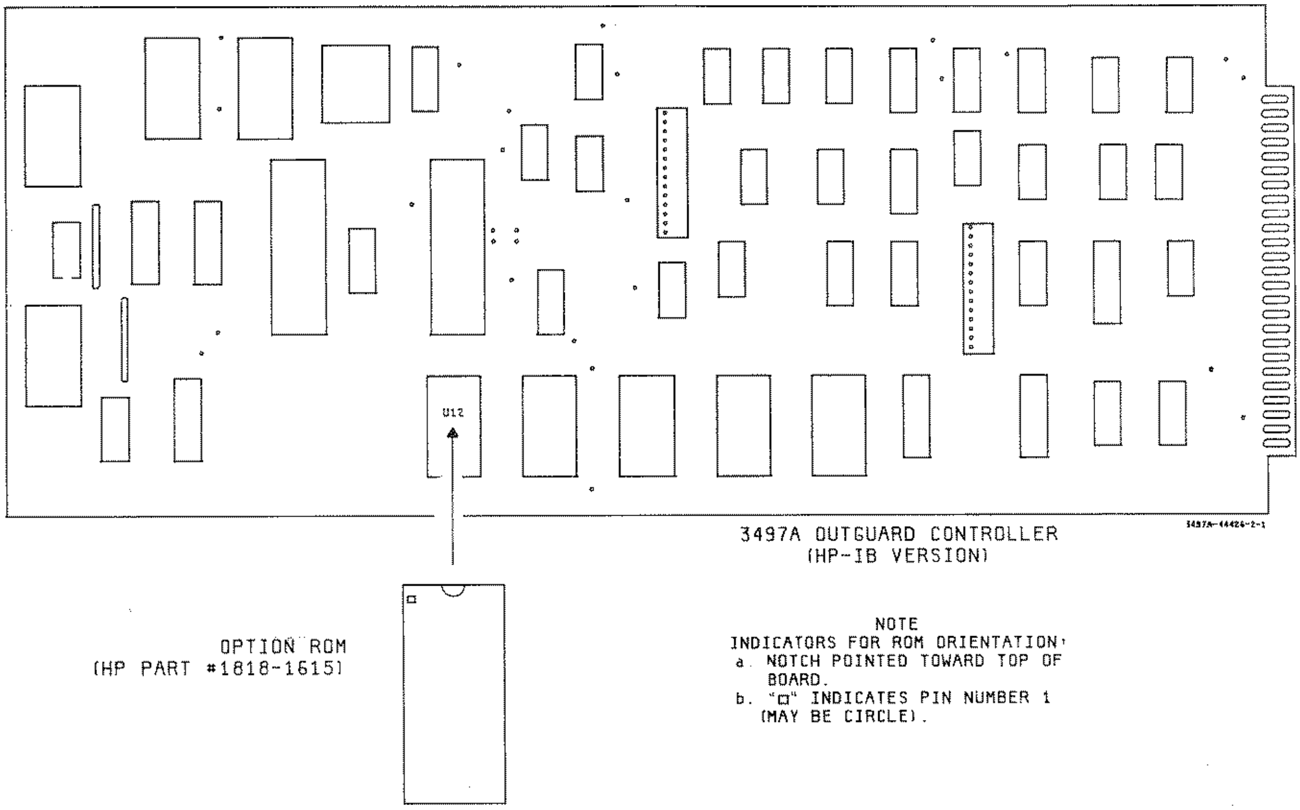


Figure 101. Option 060 - Option ROM Installation

How to Install the Counter

WARNING

Before touching any installed assemblies or attempting to install the counter assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove voltage sources from ALL installed assemblies.

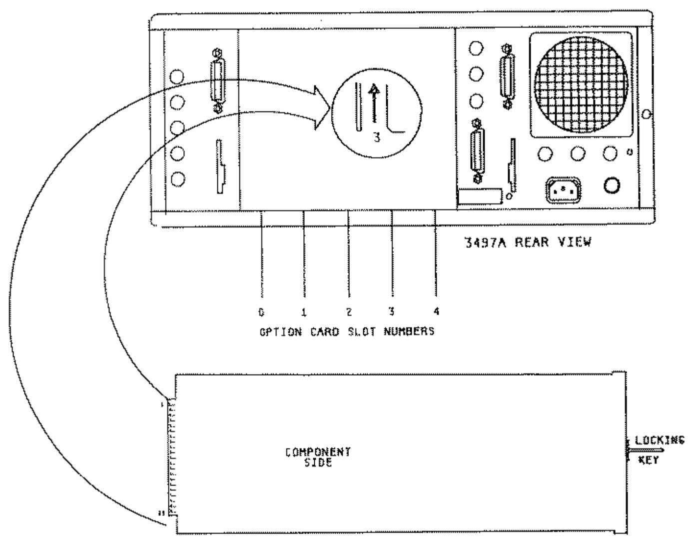
CAUTION

Use clean handling techniques when installing, removing or reconfiguring the counter assembly. Handle the circuit board by its edges and do not subject the components to static discharges or excessive voltages.

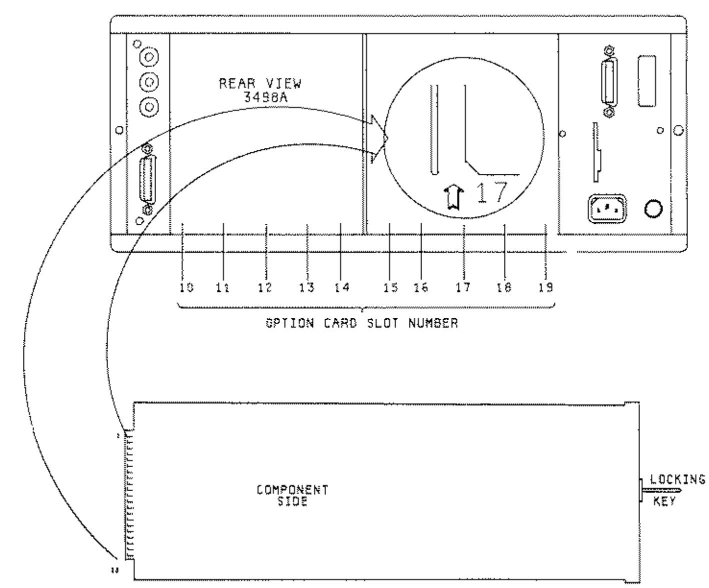
NOTE

To comply with Electromagnetic Interference standards, it is good practice to use shielded cable or twisted pair leads for all input and output connections to the counter. Connect shields to local earth grounds via low impedance paths.

After taking the precautions shown in the WARNING, CAUTION and NOTE above, you can install the assembly into any of the 5 slots in the 3497A or any of the 10 slots in a 3498A. To install the assembly, see Figure 102. After the assembly is installed, turn the locking key clockwise to lock the assembly into the slot.



INSTALLATION IN 3497A



INSTALLATION IN 3498A

Figure 102. Option 060 - Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

To configure the counter for your application, first determine the operation you want the counter to perform (count up, count down, period measurement, pulse width measurement or pulse output). Then, determine the parameters (voltage, current and frequency) of the input signal to the counter and the current and voltage requirements of the circuitry to be connected to the counter output terminals.

After these parameters are decided, the counter can be set for desired operation by setting switch S1 and jumpers J1 through J8. To see how this is done, we'll first cover counter configurations and show the functions of the switch and jumper functions. Then, we'll show how to set the counter input and output circuits for some sample applications.

Counter Configurations

As shown in Figure 103, we'll divide counter configurations into input circuit and output circuit configurations. For the input circuits, switch S1 selects isolated or nonisolated mode of operation. For isolated mode, jumper J4 selects +5V, +12V or +24V logic level. For nonisolated mode, jumper J3 connects an internal voltage source (called a pullup) into the counter circuits and jumper J4 selects +5V, +12V or +24V logic level.

For the output circuits, jumper J7 selects interrupt mode or pulse output mode. In the interrupt mode, an internal pullup can be added to the counter circuits by jumpers J1 and J2. The output from the OUTPUT HI terminal is a level change from high to low or low to high, as set by J8.

In pulse output mode, jumpers J1 and J2 are used to add an internal pullup (as for interrupt mode), but the output from the OUTPUT HI terminal is a pulse train with polarity set by J8.

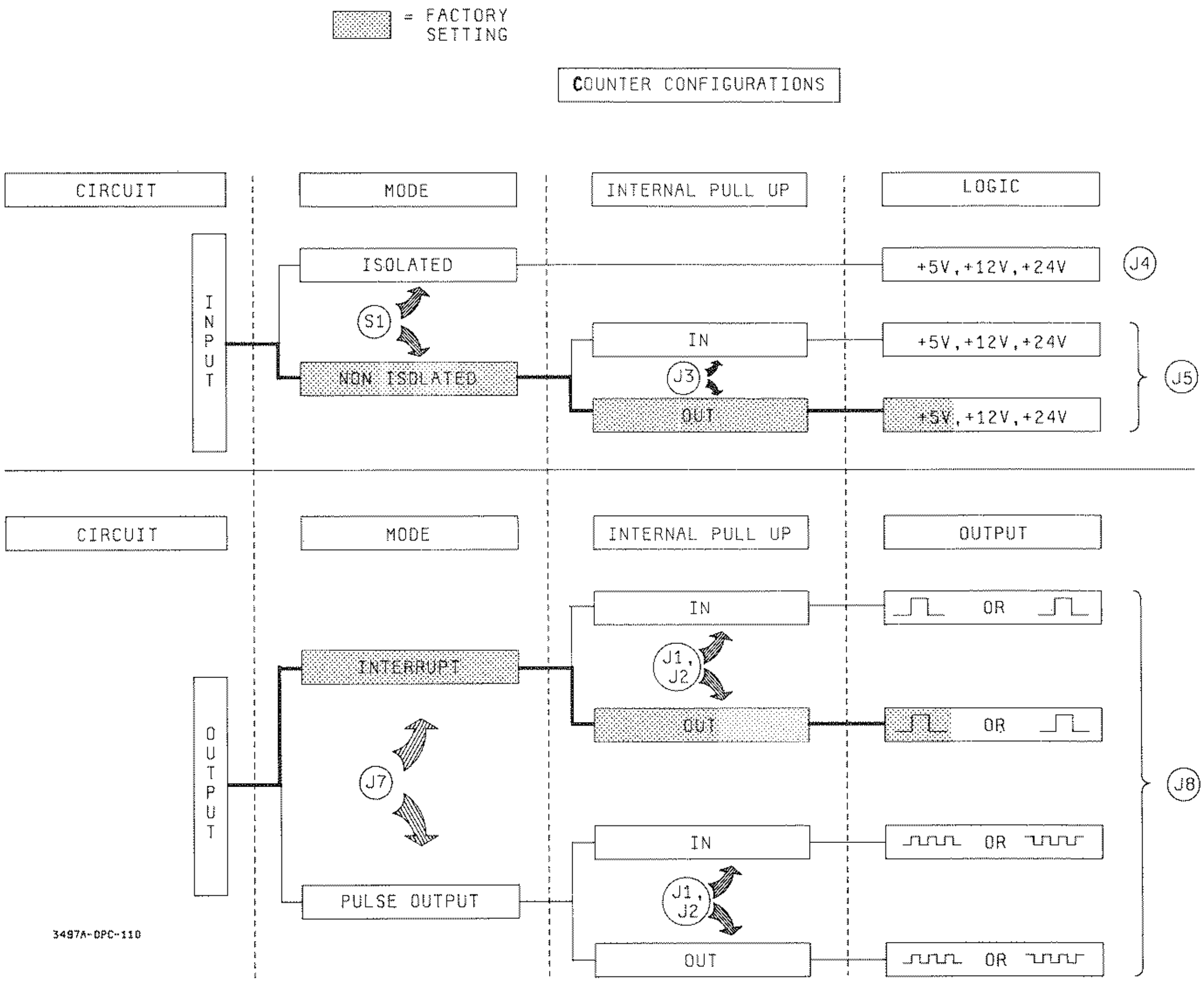


Figure 103. Option 060 - Counter Configurations

Counter Switch/Jumper Settings

As mentioned, counter configuration is set by switch S1 and jumpers J1 through J8. Figure 104 shows switch and jumper locations and factory settings and the following table describes their functions.

For example, to set the counter input circuits to nonisolated mode, internal pullup and +12v logic level, set S1 to NONISOLATED, J3 to ON and J5 to 12V. To set the output circuits for interrupt mode, isolated pullup and positive true logic, set J7 to INTR, J1 and J2 to ISOLATED and J8 to POS TRUE.

COUNTER SWITCH/JUMPER FUNCTIONS

JUMPER/SWITCH	POSITION	FUNCTION
	INPUT CIRCUITS	
S1	ISOLATED NONISOLATED	Sets Isolated Mode. Sets Nonisolated Mode.
J3	ON (S1 NONISOLATED) OFF	Adds +5V pullup. Removes +5V pullup.
J4	5V (S1 ISOLATED) 12V 24V	Sets +5V logic level. Sets +12V logic level. Sets +24V logic level.
J5	5V (S1 NONISOLATED) 12V 24V	Sets +5V logic level. Sets +12V logic level. Sets +24V logic level.
J6*	IN OUT	Connector for input circuits. Can add signal conditioners.
	OUTPUT CIRCUITS	
J1**	ISOLATED NONISOLATED	Removes +5V pullup. Adds +5V pullup.
J2**	ISOLATED NONISOLATED	N/A Provides ground path for +5V pullup.
J7	INTERRUPT PULSE OUTPUT	Sets level change output. Sets pulse train output.
J8	POS TRUE NEG TRUE	Output starts and stops in high state. Output starts and stops in low state.

* When J6 is removed, can add one series and/or one shunt input signal condition ing element.

** J1 and J2 must be set to same position.

Setting the Counter Input Circuits

As shown in the preceeding table, S1 and jumpers J3, J4 and J5 set the counter input circuits. Figure 105 is a simplified block diagram of the counter input circuits (for isolated mode or nonisolated mode) and associated user input signal requirements.

Switch S1 sets the mode of operation for the counter. With S1 in the ISOLATED position, the counter is in isolated mode. This means that you can use floating voltage inputs to the counter, as long as the more positive voltage is connected to INPUT HI, the voltage difference between the inputs does not exceed 32V and the low input does not exceed 170V.

With S1 in NONISOLATED position, the counter is in nonisolated mode. In this mode, the INPUT LO terminal is the same as chassis ground for all practical purposes, so you can't use floating voltages as inputs. However, your signal input current can be much smaller than for isolated mode (30 to 750 μA as opposed to 8 mA for isolated mode).

In nonisolated mode, you can use either the internal +5V voltage source on the counter (referred to as an internal pullup) or an external source voltage to drive your circuit. Jumper J3 in the ON position puts the internal pullup in the circuit and J3 in the OFF position removes it from the circuit.

For either isolated or nonisolated mode, you can select +5V, +12V or +24V logic levels for your input circuits by using J4 when S1 is in the ISOLATED position or J5 when S1 is in the NONISOLATED position.

FACTORY SETTINGS

S1 NON-ISOLATED
J1 ISOLATED
J2 ISOLATED
J3 OFF
J4 5V
J5 5V
J6 IN
J7 INTR
J8 NEG TRUE

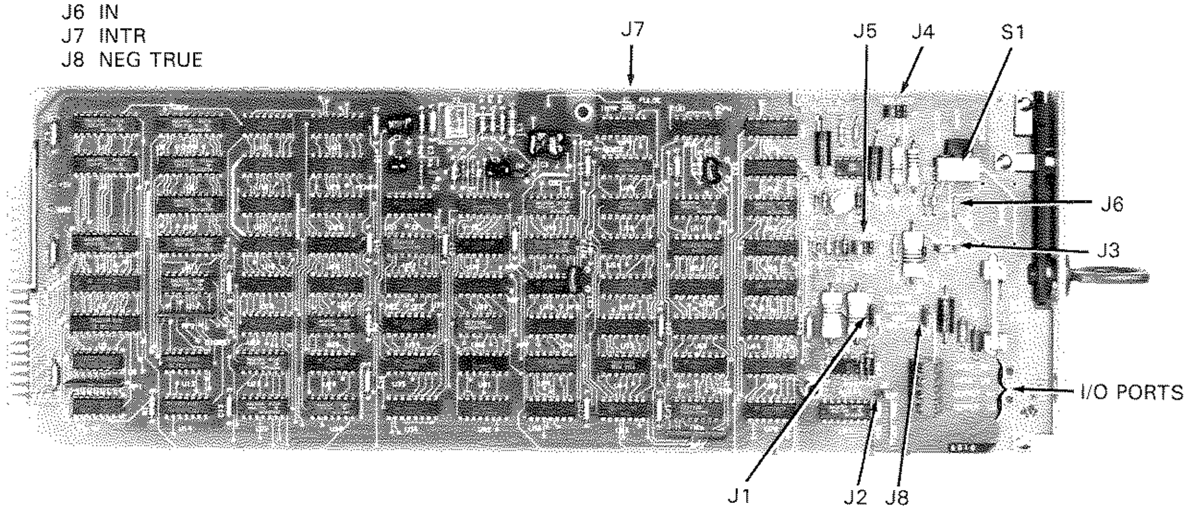


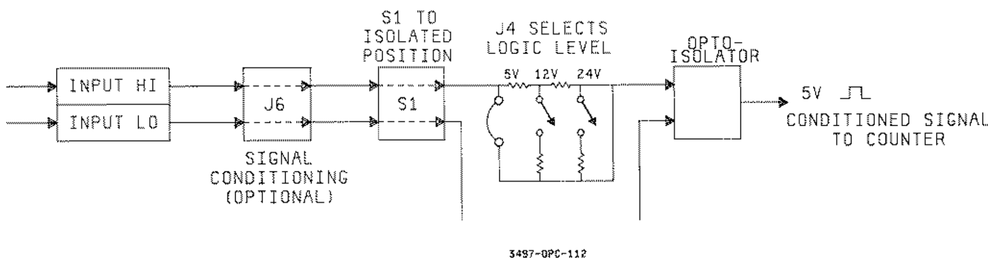
Figure 104. Option 060 · Switch/Jumper Positions

INPUT SIGNAL LEVELS

ISOLATED MODE

Logic Level	V(Lo) (max)	V(Hi) (min)	Minimum Current	Maximum Input V
5V	1.0V	4.2V	8 mA	±12.0V
12V	1.8V	10.3V	8 mA	±21.0V
24V	2.5V	18.4V	8 mA	±32.0V

INPUT CIRCUITS-ISOLATED MODE



INPUT SIGNAL LEVELS

NON ISOLATED MODE

Logic Level	V(Lo) (max)	V(Hi) (min)	Minimum Current	Maximum Input V
5V	1.0V	4.2V	20 μA	±12.0V
12V	2.7V	8.0V	250 μA	±21.0V
24V	6.0V	16.5V	750 μA	±32.0V

INPUT CIRCUITS-NON-ISOLATED MODE

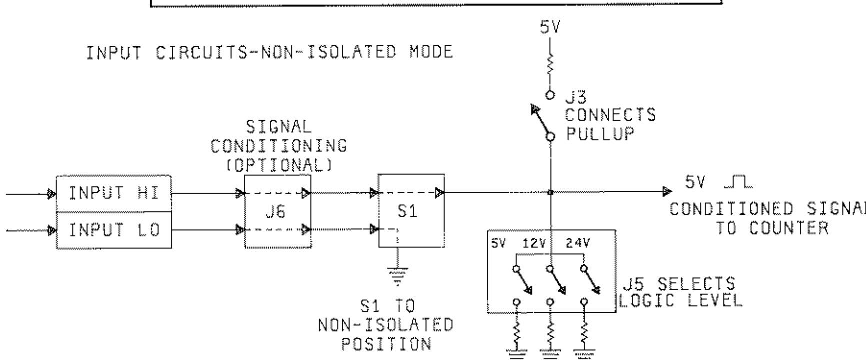


Figure 105. Option 060 · Input Circuit Signal Flow

Isolated versus Nonisolated Inputs

Since the counter can be set for either isolated or nonisolated input mode, which is best for your application? Naturally, the choice depends on your input signal characteristics. However, some advantages and disadvantages for each mode are summarized as guidelines for your application.

ISOLATED VS NONISOLATED INPUT MODE

ISOLATED MODE

Advantages

Uses its own pullup, so external pullup not required. Floating voltages can be input and optical isolator reduces ground loops and common mode noise.

Disadvantages

Requires higher input current (8 mA minimum) than nonisolated mode.

NONISOLATED MODE

Advantages

Can use either internal or external pullup. Because of low (30-750 μA) input current requirements, may be able to use a "totem-pole" input and thus not require an external pullup.

Disadvantages

Uses chassis ground as low input, so floating voltages can't be input. May have higher common mode noise than isolated mode.

Input Circuit Signal Conditioning

By removing jumper J6, you can add one series and/or one shunt input signal conditioning element, as shown in Figure 106. Some applications include mechanical contact debouncing (series R, shunt C); rectification (series diode, shunt C) or adding a series resistor so that logic levels other than +5v, +12v or +24v can be used.

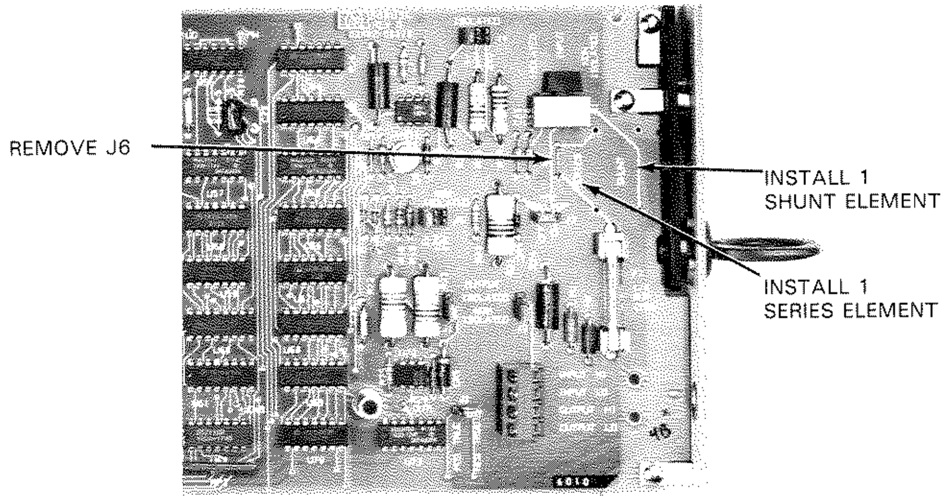
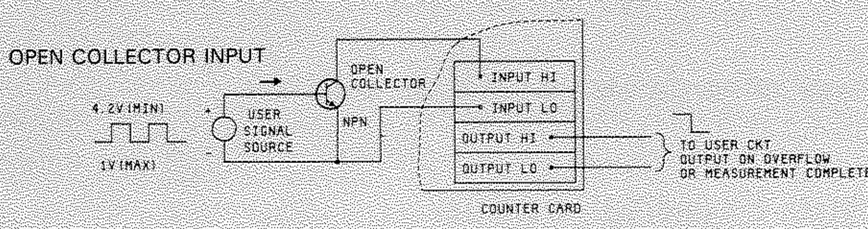


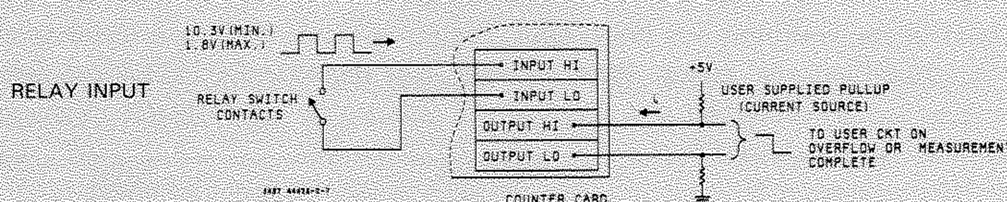
Figure 106. Option 060 - Signal Conditioning Connections

EXAMPLE - OPEN COLLECTOR INPUT CONNECTIONS

To illustrate a way that the counter input circuits can be configured, this example shows typical connections for an open collecter transistor circuit and a relay input with the counter set for nonisolated input mode (S1 in NONISOLATED position) with internal pullup (J3 in the ON position) and a +5v logic level (J5 in 5V position).

Since nonisolated input mode is used, the INPUT LO terminal is at chassis ground and floating voltages can't be input. Also, since the internal pullup is used, no external power source is required for the transistor. Finally, since +5v logic level and nonisolated mode are used, the input voltage and limits are as shown.





Setting the Output Circuits

As noted, the counter output circuits are configured with jumpers J1,J2,J7 and J8. Figure 107 shows a simplified signal flow diagram for the counter output circuits. J7 selects either interrupt mode or pulse output mode, J7 selects positive true or negative true logic and J1,J2 allow the internal pullup to be connected into the circuit.

With J8 in the NEG TRUE position, the output starts and stops in the high state. With J8 in the POS TRUE position, the output starts and stops in the low state. The output for the interrupt mode (J7 in INTR position) is a level change for counter overflow or measurement complete conditions. The output for the pulse output mode (J7 in PULSE position) is a square wave pulse train with frequency equal to half the input frequency.

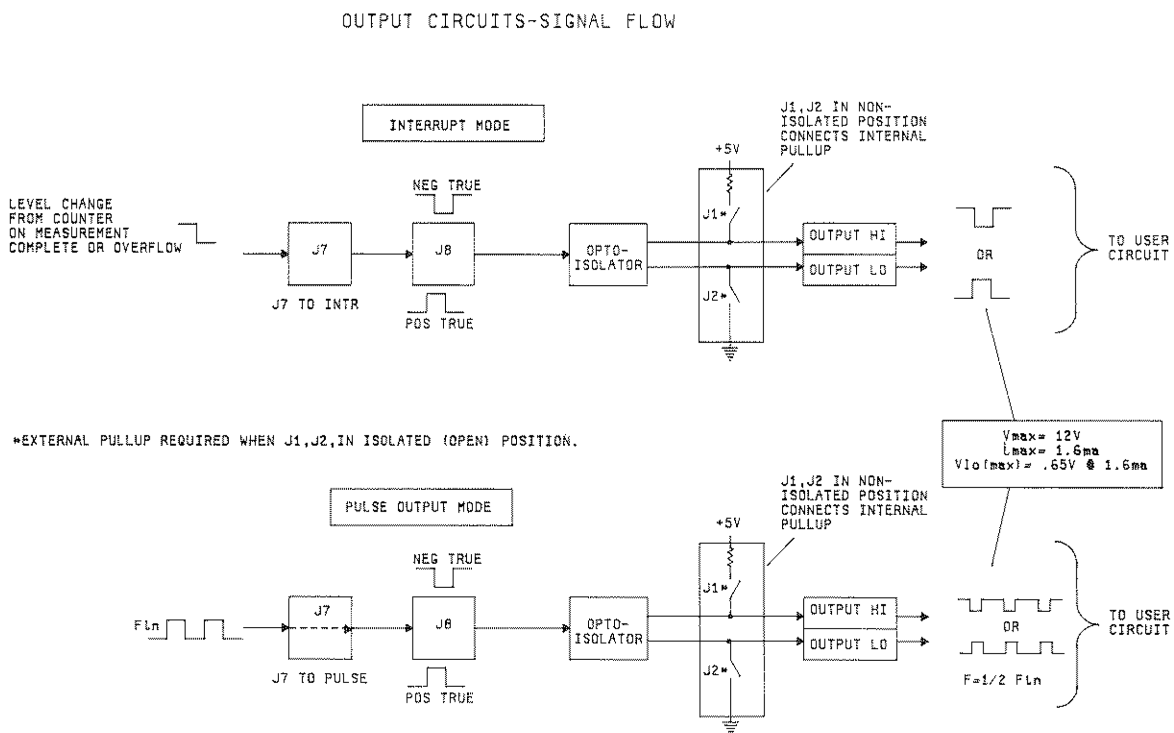


Figure 107. Option 060 - Output Circuit Signal Flow

Internal Versus External Pullup

A special consideration for the output circuits is whether to use the internal pullup or to use an external pullup. With J1 and J2 in the NONISOLATED position, the internal pullup is connected and supplies a 5 volt signal with 1.6 mA of current (maximum) to an external circuit.

If your application requires a different logic level or more than 1.6 mA of current, you can set J1 and J2 to the ISOLATED position which removes the internal pullup from the circuit. However, you must supply a current source to the optoisolator on the card. A sample connection is shown in Figure 108. Connect + to OUTPUT HI and - to OUTPUT LO for proper operation.

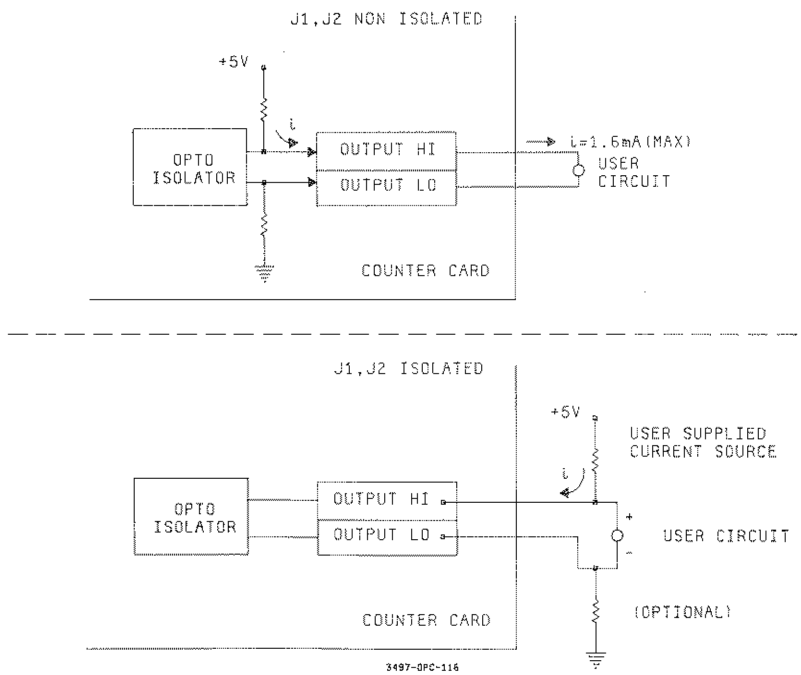


Figure 108. Option 060 - Output Circuit Pullup Configurations

To illustrate some ways that the counter can be configured, two examples follow. The first example uses an open collector input to produce a level change output for measurement complete or overflow. The second example uses a square wave input to produce a pulse train output. Although both examples show a square wave input, the counter can accurately handle a wide variety of inputs, including sine waves.

EXAMPLE - OPEN COLLECTOR INPUT/INTERRUPT OUTPUT

For this example, a 5v square wave signal is to be input to the counter through an open collector NPN transistor. From Figure 105, limits for a 5v input signal range are V(Hi) = 4.2v minimum and V(Lo) = 1.0v max for either isolated or nonisolated input mode. Since the input meets these criteria, select nonisolated input mode by setting S1 to NONISOLATED position.

With nonisolated mode, either an internal or external pullup can be used, so set J3 to ON to connect the counter internal pullup. For the input signal used, select +5v logic level by setting J5 to 5V position.

For the output circuits, assume that a level change output from high to low is required when measurement is complete or on overflow. For this logic level change, set the output circuits to interrupt mode by setting J7 to INTR position.

We'll use the counter internal pullup for the output network and set J1 and J2 to NONISOLATED position to connect the internal pullup. For a logic level change from high to low, set J8 to NEG TRUE position. See the following diagram for a sample connection diagram and switch/jumper settings.

COUNTER SETUP

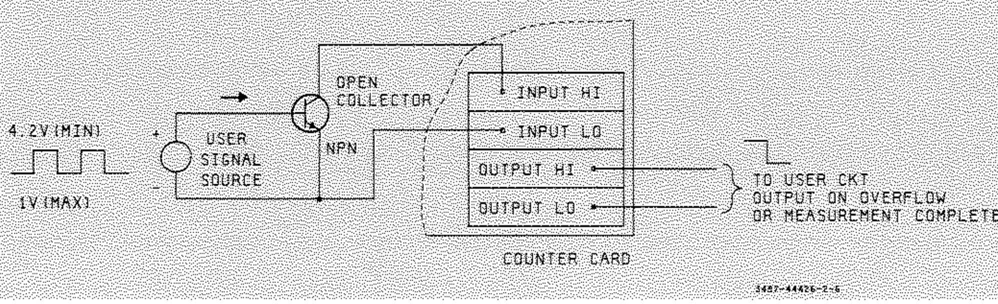
Circuit	To Select	Set
Input	Nonisolated mode	S1 to NONISOLATED
	Internal pullup	J3 to ON
	+5v Logic Level	J5 to 5V
Output	Interrupt mode	J7 to INTR
	Internal pullup	J1,J2 to NONISOLATED
	Negative True logic	J8 to NEG TRUE

SWITCH/JUMPER SETTINGS

S1	J1	J2	J3	J4	J5	J6	J7	J8
N	N	N	ON	X	5V	IN	INTR	NEG TRUE

N = NONISOLATED
X = DON'T CARE

CONNECTION DIAGRAM



EXAMPLE - NONISOLATED INPUT/PULSE OUTPUT

For this example, we'll use a 12v square wave input to produce 100 square wave output pulses at 500 Hz. We'll set the input circuits to nonisolated mode, internal pullup and +12v logic level and set the output circuits for pulse output mode, external pullup and positive true logic.

For nonisolated mode, input signal limits for 12v logic level are V(Lo) = 2.7v maximum, V(Hi) = 8.0v minimum with 250 μA minimum current. To produce 500 Hz output pulses, the input frequency must be 1 kHz since output pulse frequency is half the input frequency. Note that for any operation with Pulse Output mode, input signal limits are f $\leq$ 2 kHz and pulse width $\geq$ 5 μsec.

Set the output circuits for pulse output (square wave) mode by setting J7 to PULSE position. For external output pullup, set J1 and J2 to ISOLATED position. For positive true logic (output starts and stops in the low state), set J8 to POS TRUE.

Since the number of output pulses is programmed using the CS slot#,n command, for 100 pulses use CS slot#,200. A sample connection diagram and jumper/switch settings follow.

COUNTER SETTINGS

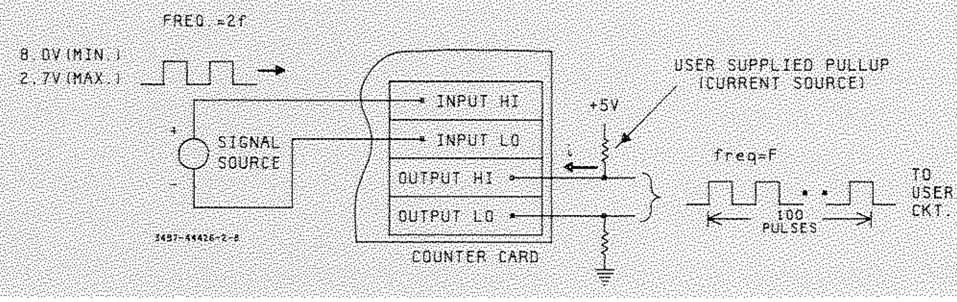
Circuit	To Select	Set
Input	Nonisolated mode Internal pullup +12v Logic Level	S1 to NONISOLATED J3 to ON J5 to 12V
Output	Pulse Output mode Isolated pullup Positive True logic	J7 to PULSE J1,J2 to ISOLATED J8 to POS TRUE

SWITCH/JUMPER SETTINGS

S1	J1	J2	J3	J4	J5	J6	J7	J8
N	I	I	ON	X	12V	IN	PULSE	POS TRUE

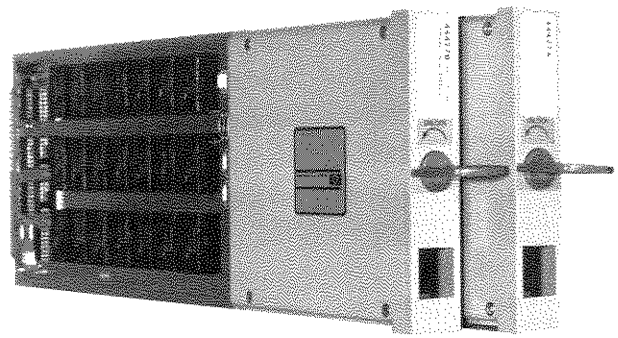
N = NONISOLATED
I = ISOLATED
X = DON'T CARE

CONNECTION DIAGRAM



OPTIONS 070/071

120/350 Ohm Strain Gauge/ Bridge Completion Assemblies



INTRODUCTION

-hp- Model 44427A 120 Ohm Strain Gauge/Bridge Completion assembly and -hp- Model 44427B 350 Ohm Strain Gauge/Bridge Completion assembly provide bridge completion for resistance strain gauges and other resistive transducers such as RTD's and pressure sensors. You can use the assemblies to provide termination for any mixture of ¼, ½ or full bridges and can use 2 or 3-wire (plus shield) transducer connections.

Each strain gauge/bridge assembly can measure up to 10 transducers (strain gauges, RTD's, etc.) when using the internal half bridge shared by all transducers. Each 3497A can hold up to five 44427A and/or 44427B assemblies and each 3498A Extender (Option 298) can hold up to 10 assemblies.

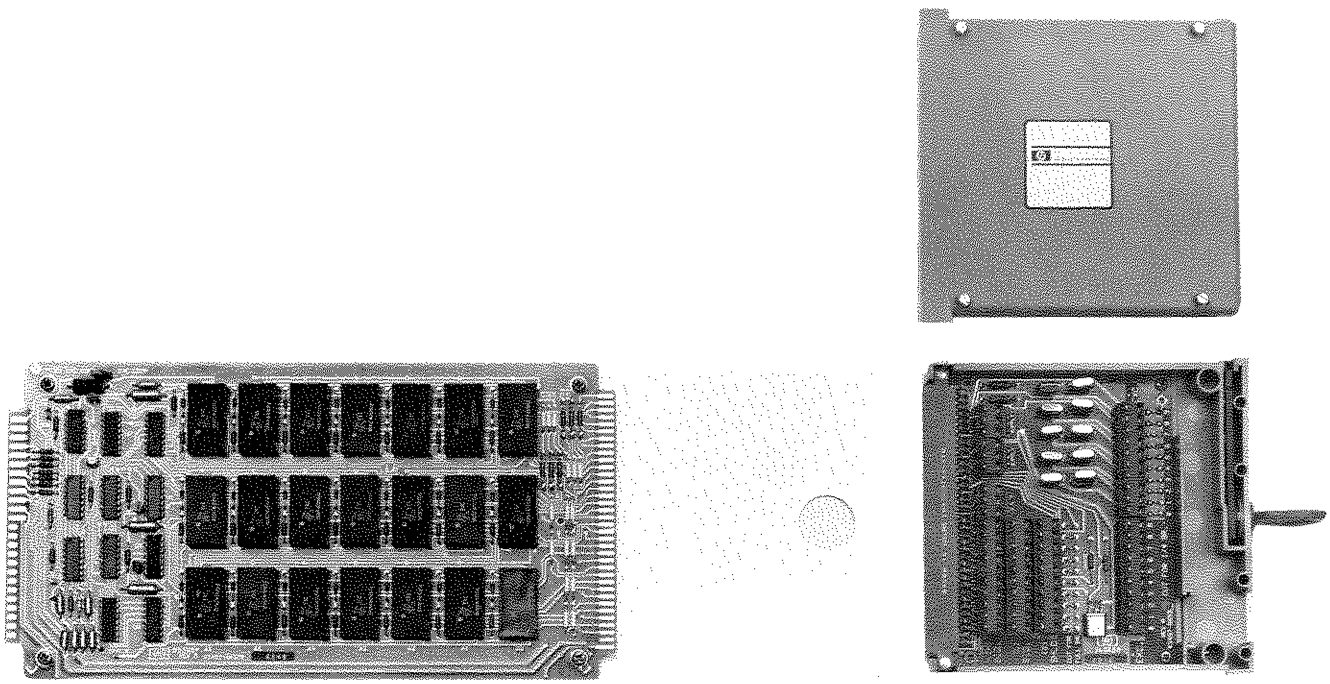
Thus, using the 5 slots in a 3497A and 45 slots in 3498As (maximum which can be used for these assemblies), you can provide up to 500 channels for transducer measurements or up to 133 three element strain gauge rosettes. Of course, the 44427A/B can be used in the same 3497A mainframe with other 3497A assemblies for mixed measurements. For example, you could use the Option 020 thermocouple compensation assembly in one slot and an Option 070 or 071 in another slot to generate apparent strain curves.

Description

As shown in Figure 109, the 44427A/B assemblies consist of a 20 channel relay card and a terminal card. The relay card is identical to that used in Options 010 and 020. The terminal card for the 120 ohm assembly (Option 070) is identical to the 350 ohm assembly (Option 071) except that Option 070 uses 120 ohm bridge termination resistors while Option 071 uses 350 ohm resistors.

The assemblies require an external power supply for bridge excitation and a DVM (such as the internal 3497A DVM, -hp- 3456A voltmeter or equivalent DVM). Initial voltmeter readings for bridge excitation and bridge unbalance are used to solve the bridge equation, eliminating the need for any span and offset adjustments. To compute strain, the assembly should be used with a controller. Data acquisition and strain calculation can be done manually, however.

The excitation voltage, Vs, is always applied, never switched, so there are no errors due to dynamic heating and cooling of the transducer. Since the excitation voltage is measured on each assembly, measurement accuracy is independent of long term power supply voltage changes and an inexpensive supply (such as the -hp- Model 6214A or 62005A) is adequate to achieve listed specifications. The Model 6214A can provide power for 50 channels (5 assemblies) while the 62005A can power up to 80 channels.



RELAY CARD TERMINAL CARD

Figure 109. Options 070/071 - Strain Gauge/Bridge Assemblies

Diagnostic Tests

Several diagnostic tests are available on the 44427A/B assemblies to check circuit integrity or enhance measurement accuracy. Each assembly consists of 20 channels with the first 10 channels reserved for strain gauge inputs. The remaining 10 channels (B0 through B9) can be used for measuring the excitation voltage and for diagnostic tests.

The following chart shows the channel numbers associated with the 44427A/B assembly for each 3497A slot (for 3498A slots, add 100 to each number shown for the first 3498A, 200 to each number for the 2nd 3498A, etc). Note that for each slot, the 10 lowest numbers (the A decade) are for strain gauge measurements, channel B0 is used to measure the excitation voltage and the rest of the B decade channels are for bridge diagnostics, excitation measurements, etc.

On the terminal card, the strain gauge inputs [+(H) SIG,-(L) SIG and (G) SHLD] have designators A0 through A9, left to right. Thus, for example, a strain gauge input to terminal A0 (leftmost terminal) has channel number 0 for an assembly in slot 0, 10 for an assembly in slot 1, etc. See CONFIGURING THE ASSEMBLY for details.

STRAIN GAUGE ASSEMBLY - DIAGNOSTIC TESTS

Terminal Card Designator	Function	3497A Slot Number				
		0	1	2	3	4
				Channel Number(s)		
A0-A9	Reserved for Strain Gauge Inputs.	0-9	20-29	40-49	60-69	80-89
B0	Measure Excitation Voltage.	10	30	50	70	90
B1	Tension Shunt Calibration*	11	31	51	71	91
B2	Compression Shunt Calibration*	12	32	52	72	92
B3	Guard to Low Resistance (channel A0)*	13	33	53	73	93
B4	Guard Voltage*	14	34	54	74	94
B5-B6	Internal Half-Bridge Ratio*	15-16	35-36	55-56	75-76	95-96
B7-B9	Lead Wire Resistance (channels A7 through A9)*	17-19	37-39	57-59	77-79	97-99

* See CONFIGURING THE ASSEMBLY, Measurement Accuracy Considerations.

Strain Gauge Measurements

The Option 070/071 assemblies allow you to determine strain of bonded resistance strain gauges by measuring voltage changes which occur between the unstrained and the strained state of the gauge. To indicate how the assemblies accomplish this, we'll summarize strain gauge measurements.

This discussion is not a comprehensive tutorial on strain gauge or bridge measurements, but is intended to show how the assemblies may be used to make these measurements. See -hp- Application Note 290-1, ''Practical Strain Gauge Measurements'' for general information on strain gauge measurements.

Strain

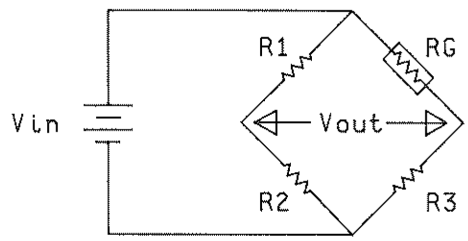
We'll use the term strain (ϵ) to mean the ratio of a fractional change in length to the unstrained length: $\Delta L/L$. Since the magnitude of ΔL is usually less than 1% of L, the Model 44427A/B assemblies use a Wheatstone Bridge circuit for measurement. The Gauge Factor, GF, relates a change in resistance of the gauge (ΔR) to the strain:

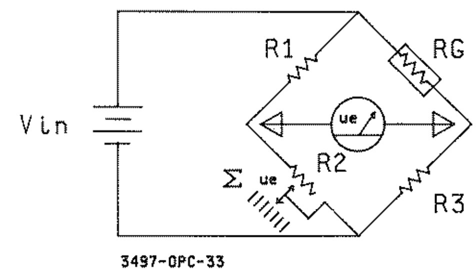
$$GF = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\epsilon} \qquad (1)$$

where $\Delta R/R$ is the ratio of the change in resistance (ΔR) caused by the strain to the original resistance (R) of the gauge in the unstrained state.

Unbalanced Wheatstone Bridges

As mentioned, the strain gauge assemblies use an unbalanced Wheatstone Bridge arrangement to measure voltage changes between the strained and unstrained states of strain gauges. For the (balanced) Wheatstone bridge shown in Figure 110, Vin is the input voltage to the bridge, Rg is the resistance of the strain gauge, R1, R2 and R3 are the resistances of the bridge completion resistors and Vout is the bridge output voltage.





WHEATSTONE BRIDGE CIRCUIT

BRIDGE CIRCUIT WITH PROVISION FOR BALANCING THE BRIDGE

Figure 110. Options 070/071 · Wheatstone Bridge Circuit

A ¼ bridge configuration is shown since one arm of the bridge is an active gauge and the other arms are fixed value resistors or unstrained gauges. Ideally, the strain gauge resistance, Rg, is the only resistor in the circuit which varies. We can relate the ratio of the input voltage to the output voltage by:

$$\frac{Vout}{Vin} = \left[\frac{R3}{R3 + Rg} - \frac{R2}{R1 + R2}\right] \qquad (2)$$

Equation (2) applies to both strained and unstrained states. To measure strain, two measurements must be taken: (1) measure Vout with the gauge in the unstrained state and then (2) measure Vout with the gauge in the strained state. By combining the strained and unstrained cases, we can define a new term, Vr.

$$VR = \left[\left(\frac{Vout}{Vin}\right)_{strained} - \left(\frac{Vout}{Vin}\right)_{unstrained}\right] \qquad (3)$$

From equation (1), since strain (ϵ) = (ΔR/Rg)/GF, we can write an equation for strain in terms of the gauge factor (GF) and Vr (which is derived from Vin and Vout) as follows:

$$\epsilon = \frac{-4Vr}{GF(1 + 2Vr)} \qquad (4)$$

Since the actual strain figure is quite small (on the order of 0.000200), we will express the results in $\mu\epsilon$ (ϵ x 10^6). In addition we'll assume a Gauge Factor GF = 2.

Multichannel Bridge Measurements

The strain gauge assemblies use a bridge circuit called a ''Chevron Bridge'' for multichannel bridge measurements. Figure 111 shows the circuit setup which switches a DVM between gauges. One channel is shown as a ¼ bridge and the other as a ½ bridge (two active gauges). Resistors R1, R2 and R3 form three sides of the bridge and the excitation voltage (Vin) to the gauges is continuously applied.

To make strain gauge measurements with this circuit, the DVM is switched between points C-D, D-E, etc. and measures Vout for each channel. Although not shown in Figure 111, the DVM can also be switched to measure Vin. The procedure to measure strain with this circuit is (assuming that the Gauge Factor is known):

STRAIN GAUGE MEASUREMENTS

(1)	measure Vin and store the value.
(2)	measure Vout for channel #1 (¼ bridge in Figure 111) with the gauge unstrained.
(3)	measure Vout for channel #1 with the gauge strained.
(4)	compute strain from ϵ = -4Vr/GF(1+ 2Vr). [¼ bridge]
(5)	switch the DVM to channel #2 (shown as a ½ bridge in Figure 111) and repeat steps (2) through (4).

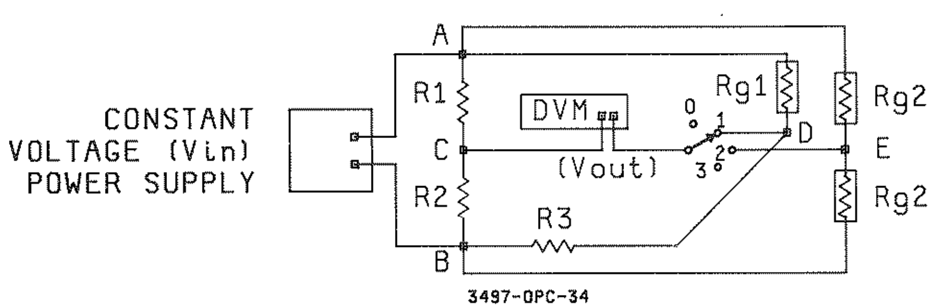


Figure 111. Option 070/071 - Bridge Circuits for Assemblies

Specifications

Specifications for the 120/350 ohm strain gauge/bridge completion assemblies follow. Specifications are performance standards, or limits, against which the assemblies may be tested.

OPTION 070/071
120/350 OHM, STRAIN GAUGE/BRIDGE COMPLETION ASSEMBLIES

No Manual Adjustments
The assembly is used with an external supply and either the 3497A voltmeter or an external 3456A voltmeter. The initial voltmeter readings for bridge excitation and bridge unbalance are used by the system computer to solve the bridge equation, eliminating the need for any span and offset adjustments. To compute strain, this assembly must be used in conjunction with a system computer.

Bridge Excitation
The excitation voltage V_S is always applied, never switched, so there are no errors due to the dynamic heating and cooling of the gauge. Since the excitation voltage is measured on each strain gauge/bridge card, the strain accuracy is independent of long-term supply voltage changes. An inexpensive power supply, such as the HP 6214A, is adequate to achieve the accuracy specification shown. It also has enough current capability to provide power for up to 50 channels (5 cards).

Excitation Supply Requirements:
(½ bridge configuration)
V_S max: ±5.4 volts DC
I_S: 250 mA per 10 channels (120 ohm gauges)
80 mA per 10 channels (350 ohm gauges)

General Information:

Isolation Voltage: ≥ 170 V peak between any terminal and chassis

Sensitivity vs. Supply Voltage

Bridge Type	V_S = 100 mV	V_S = 1 volt	V_S = 5 volts
Full	0.5 $\mu\epsilon$	0.05 $\mu\epsilon$	0.01 $\mu\epsilon$
½	1 $\mu\epsilon$	0.1 $\mu\epsilon$	0.02 $\mu\epsilon$
¼	2 $\mu\epsilon$	0.2 $\mu\epsilon$	0.04 $\mu\epsilon$

(GF = 2, System Voltmeter = 3456A. For 3497A Voltmeter, multiply numbers by 10).

Accuracy
These specifications include all system-related errors: bridge resistor tolerance and drift, thermal offsets of bridge scanner and voltmeter, voltmeter accuracy, injected currents, self-heating of bridge resistors and system noise. The only exceptions are lead wire mismatch and the accuracy of the gauge itself. Specifications are valid for either the 3497A or the 3456A voltmeter with integration time set to one power line cycle.

Accuracy at V_S = 5 volts

Bridge Type	24 Hr. ± 1°C	90 Day 23 ± 5°C	≤90 Days 23 ± 5°C	Temperature Coefficient (0-18,28-55°C)
Full	1 $\mu\epsilon$	1 $\mu\epsilon$	0.04 $\mu\epsilon$/Mo.	0.025 $\mu\epsilon$/°C
½	4 $\mu\epsilon$	5 $\mu\epsilon$	0.4 $\mu\epsilon$/Mo.	0.3 $\mu\epsilon$/°C
¼	7 $\mu\epsilon$	25 $\mu\epsilon$	1.8 $\mu\epsilon$/Mo.	1.8 $\mu\epsilon$/°C

Accuracy At V_S = 1 Volt

Bridge Type	24 Hr. ± 1°C	90 Day 23 ± 5°C	≤90 Days 23 ± 5°C	Temperature Coefficient (0-18,28-55°C)
Full	3 $\mu\epsilon$	3.5 $\mu\epsilon$	0.04 $\mu\epsilon$/Mo.	0.1 $\mu\epsilon$/°C
½	5 $\mu\epsilon$	10 $\mu\epsilon$	0.9 $\mu\epsilon$/Mo.	0.4 $\mu\epsilon$/°C
¼	10 $\mu\epsilon$	35 $\mu\epsilon$	6.8 $\mu\epsilon$/Mo.	1.8 $\mu\epsilon$/°C

Accuracy At V_S = 100 mV

Bridge Type	24 Hr. ± 1°C	90 Day 23 ± 5°C	≤90 Days 23 ± 5°C	Temperature Coefficient (0-18,28-55°C)
Full	20 $\mu\epsilon$	35 $\mu\epsilon$	0.04 $\mu\epsilon$/MO.	0.8 $\mu\epsilon$/°C
½	40 $\mu\epsilon$	75 $\mu\epsilon$	0.9 $\mu\epsilon$/Mo.	1.7 $\mu\epsilon$/°C
¼	80 $\mu\epsilon$	150 $\mu\epsilon$	6.8 $\mu\epsilon$/Mo.	3.5 $\mu\epsilon$/°C

All Specifications Are ±
These figures assume a gauge factor of 2.

Maximum self-heating offset due to change in the number of gauges on one assembly: 0.3 $\mu\epsilon$ per gauge (V_S = +5, R_g = 120 Ω, ¼ bridge)

Maximum self-heating offset due to .1 V change in supply voltage: 0.38 $\mu\epsilon$ (V_S = +5, R_g = 120 Ω, ¼ bridge).

Manual Information

This manual contains configuration and installation information for these assemblies. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual (-hp- part number 03497-90021). Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany the manual. See Appendix B for details.

Application Note

When using the Option 070/071 assemblies, you may want to refer to -hp- Application Note 290-1 "Practical Strain Gauge Measurements" (-hp- part number 5952-2153) which is available from your nearest -hp- Sales and Service office.

Ordering the Terminal Card Separately

If you already have a relay assembly (such as from Option 010 or 020) or if you want to have several strain gauge terminal cards, you may order terminal cards separately by using the following part numbers:

Option 070 (120 Ohm). . . . .-hp- part number 03497-64109
Option 071 (350 Ohm). . . . .-hp- part number 03497-64110

INSTALLING THE ASSEMBLIES

WARNING

There is no operator installation or configuration for the strain gauge assemblies. Only qualified, service-trained personnel should install or configure the assemblies.

Initial Inspection

If you ordered a strain gauge assembly as Option 070 or 071, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44427A or 44427B, the shipping container should contain a relay card and a terminal card with 120 ohm or 350 ohm bridge completion networks.

For the Field Installation Kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a relay card or terminal card to -hp-, follow the shipping guidelines in Appendix B.

How to Install the Strain Gauge Assemblies

WARNING

Before touching any installed assemblies or attempting to install the strain gauge assemblies in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The strain gauge assemblies are not intended for outdoor use. Do not expose the assemblies to rain or excessive moisture.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the relay card. Handle the circuit board by its edges and do not subject the components to static discharges or excessive voltages.

Should the circuit board become contaminated, promptly wash the area with isopropyl alcohol. Then rinse the area with deionized water. Let the assembly completely dry before reinserting it in the mainframe.

Figure 112 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING and CAUTION notes above, plug the assembly into an unused slot in the 3497A or 3498A.

CONFIGURING THE ASSEMBLY

As noted, the strain gauge assemblies consist of a relay card and a terminal card. The relay card acts as a multiple channel switcher to connect the DVM to a specified channel. The terminal card provides the connections to provide excitation voltage to the strain gauges and form the bridge completion networks for voltage measurement.

To make strain gauge measurements, the relay card must be set for no thermocouple compensation. As shown in Figure 113, the jumper in the upper left-hand corner of the relay card should be set to the NO T/C COMP position.

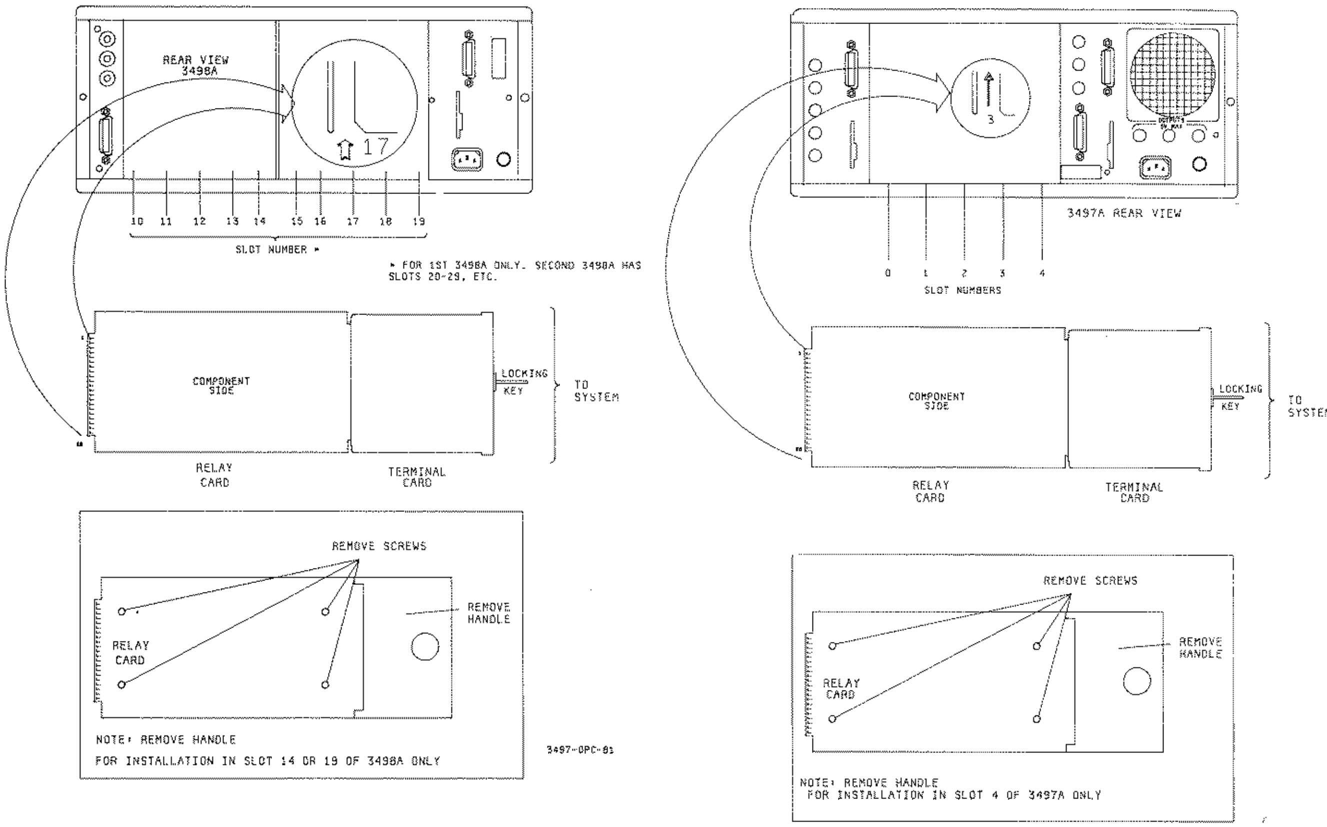


Figure 112. Options 070/071 - Installation in 3497A/3498A

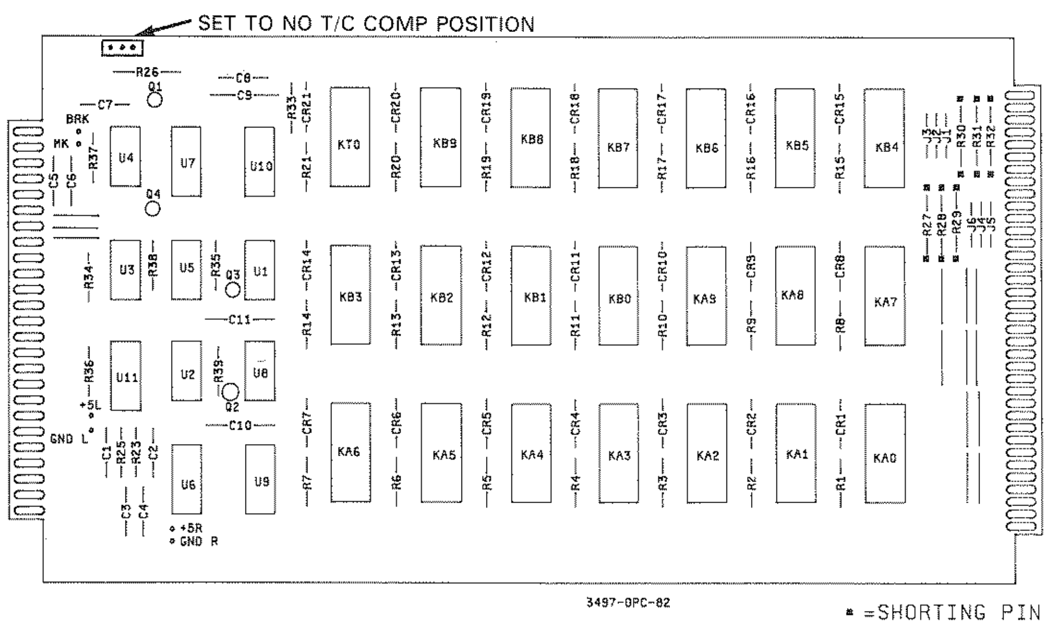
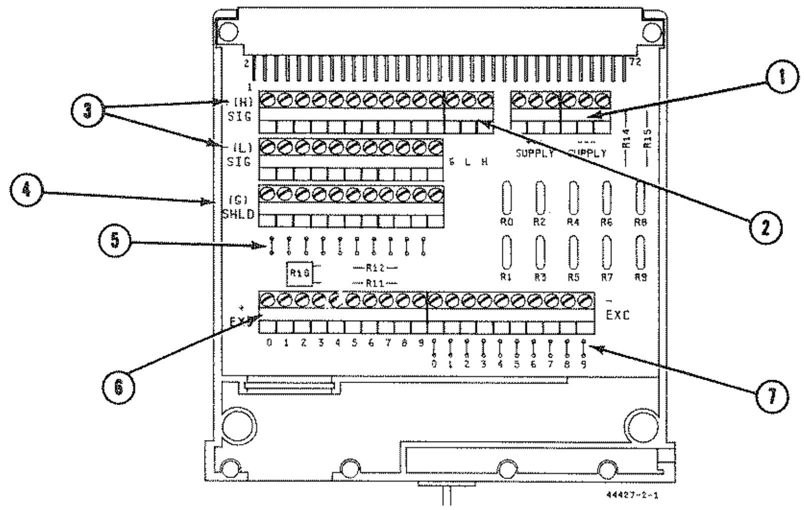


Figure 113. Options 070/071 - Relay Card T/C COMP Jumper Setting

CONFIGURATION CONSIDERATIONS

The assembly can be configured for ¼ bridge, ½ bridge or full bridge operation. Figure 114 shows the terminal card connections and describes the functions of the connectors. Before you begin connecting strain gauges to the terminal card, you should consider three items: shielding the measurement leads; excitation supply requirements and connecting an external voltmeter.



(1) Excitation Power Supply Connections. These six connectors (three for positive and three for negative) are used for connecting the excitation supply to the terminal card. The extra connectors may be used to "Daisy Chair" the supply to other terminal cards.

(2) Common Bus Connections. High, Low, and Guard common (common to all channels after relay closure) may be accessed on these terminals. An external DVM may be connected to these terminals or to the High Common, Low Common, and Guard Common on the back panel of the 3497A.

(3) Bridge Signal Connections. The output voltage from the bridge is measured here. The relays connected to these terminals are used to switch the DVM from one bridge to the next.

(4) Bridge Shield Connections. The shield connections (Guard potential) are made on these terminals.

(5) Full Bridge Modification Jumpers. These jumpers are to be cut when using a full bridge configuration. Be sure the appropriate 1/4 bridge jumpers are in place.

(6) Excitation Connections. The excitation supply connections to the strain gage is made here. Note that the negative supply terminals are to the right of the positive terminals and have bridge label numbers below the 1/4 bridge jumpers.

(7) 1/4 Bridge Modification Jumpers. To configure a bridge for 1/4 bridge operation, cut the appropriate jumper. Be sure the appropriate Full bridge jumper is in place.

Figure 114. Options 070/071 - Terminal Card Identification

Shielding the Measurement Leads

In some cases, strain gauges are located some distance from the instrument which may cause desensitization errors due to lead resistance. For this reason, we recommend that a three-wire connection be used for ¼ bridge and ½ bridge measurements as shown in Figure 115.

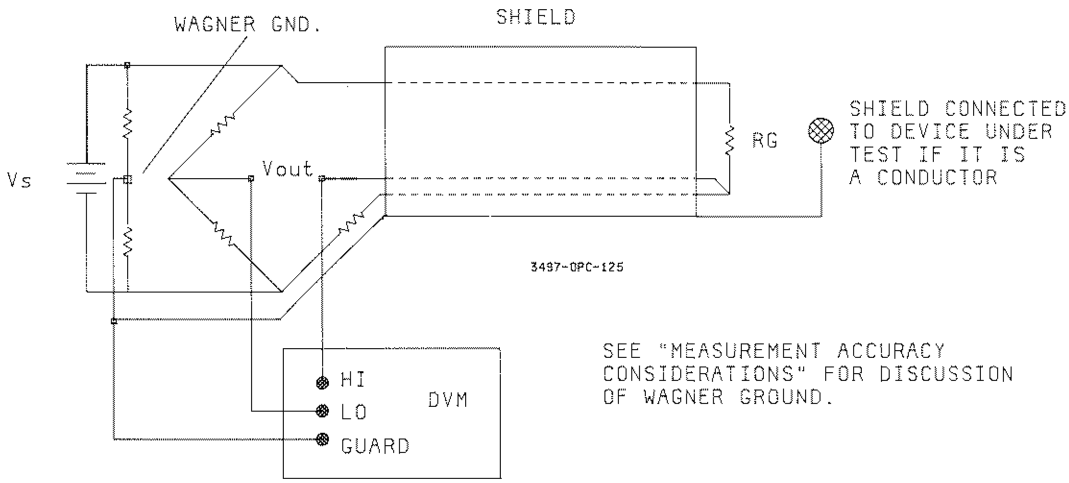


Figure 115. Options 070/071 - Connecting the Shield

Excitation Supply Requirements

The strain gauge assemblies require that an external excitation voltage source be supplied. The excitation supply (Vs) should have enough output capability to drive all connected gauges, since the assemblies switch the bridge measuring device and not the gauges. This means that the gauges are connected to Vs at all times. See the specifications table for more information.

For best common mode noise rejection, the excitation supply should drive only one assembly (10 channels) and should have floating output and low noise characteristics. One supply may be used for several assemblies if the strain gauges are mounted close to each other on the specimen being tested. If gauges are mounted some distance apart, use separate supplies.

For best results, the excitation supply voltage output should be between 0.1V and 5.4V, with less than 1 mV of noise. The supply should be linear regulated, not a switching supply.

CAUTION

Use extreme care when using power supplies with output voltages greater than 5.4V as the strain gauge and bridge resistors may be permanently damaged if exposed to over-voltage conditions.

Using an External DVM

If desired, an external voltmeter such as the -hp- Model 3456A, can be used as the DVM in place of the internal 3497A DVM. The external DVM can be connected to the HI COM, LO COM and GUARD COM terminals on the rear panel of the 3497A or to the HIGH, LOW and GUARD terminals.

Sample Bridge Configurations

The following paragraphs describe how to configure the terminal card for sample ¼ bridge, ½ bridge, full bridge and combined bridge applications and show the equivalent circuit when the connections are made. The diagrams show Option 070 (120 ohms) but are identical for Option 071 (350 ohms).

Although the figures show only one channel connection, up to 10 bridge connections (1 per channel) can be made, and you can mix ¼ bridge, ½ bridge and full bridge arrangements on a single assembly.

¼ Bridge Configuration

Figure 116 shows a sample connection diagram and equivalent circuit for a ¼ bridge configuration with a strain gauge tied to channel 0. Note that jumpers J0 through J9 must be cut for the channels to be used for ¼ bridge circuits (i. e., cut J0 for ¼ bridge on channel 0, J0 and J1 for ¼ bridge on channels 0 and 1, etc.). Be sure to leave full bridge jumpers J10 through J19 intact.

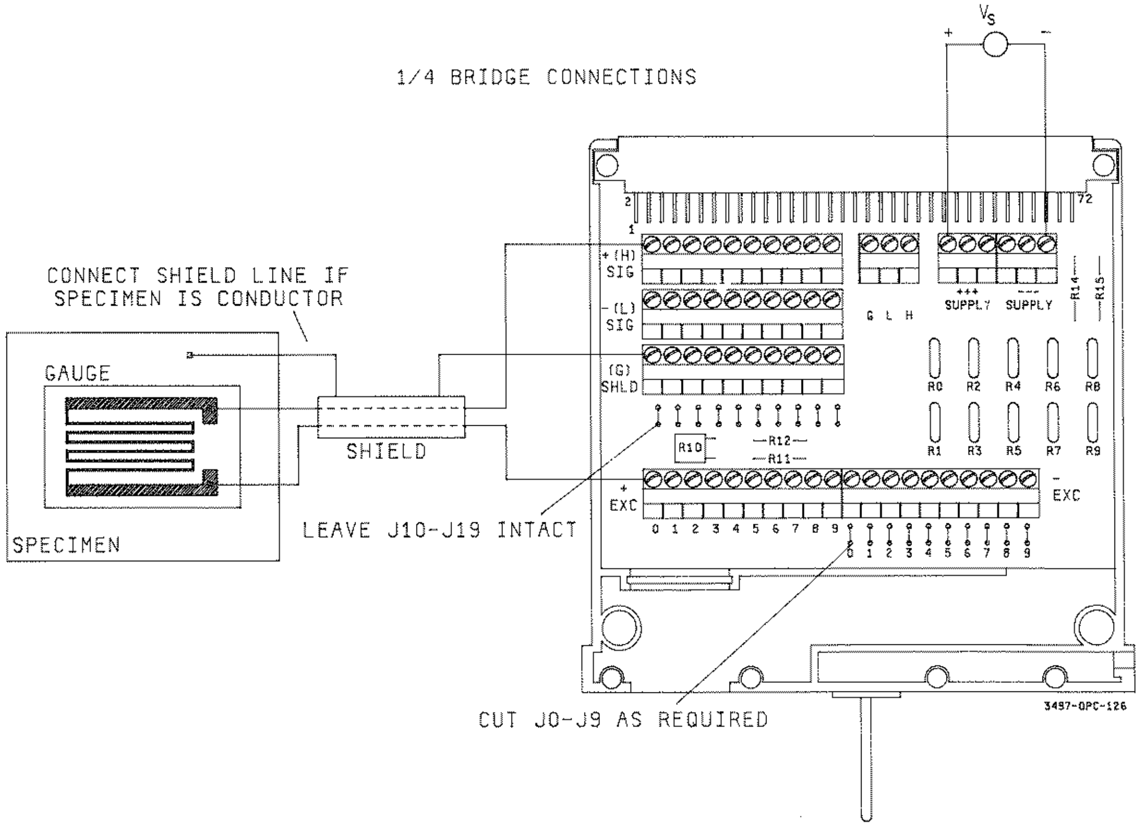
When a relay (A0H and A0L, for example) is closed on the relay card, the DVM measures the bridge output voltage. The excitation supply, Vs, is connected internally on the terminal card to the +EXC and -EXC terminal blocks for all channels in parallel.

½ Bridge Configuration

Figure 117 shows a sample connection diagram and equivalent circuit for a ½ bridge configuration with strain gauges tied to channel 0. Note that jumpers J0 through J9 and jumpers J10 through J19 remain in place. Bridge completion resistors R0 through R9 are shorted by jumpers J0 through J9 (respectively) and are replaced by strain gauges RG01 (for channel 0) through RG91 (for channel 9).

Full Bridge Configuration

Figure 118 shows a sample connection diagram and equivalent circuit for a full bridge configuration with strain gauges tied to channel 0. Note that jumper J10 is cut to isolate the ½ bridge resistor R10 and R0 is shorted by jumper J0.



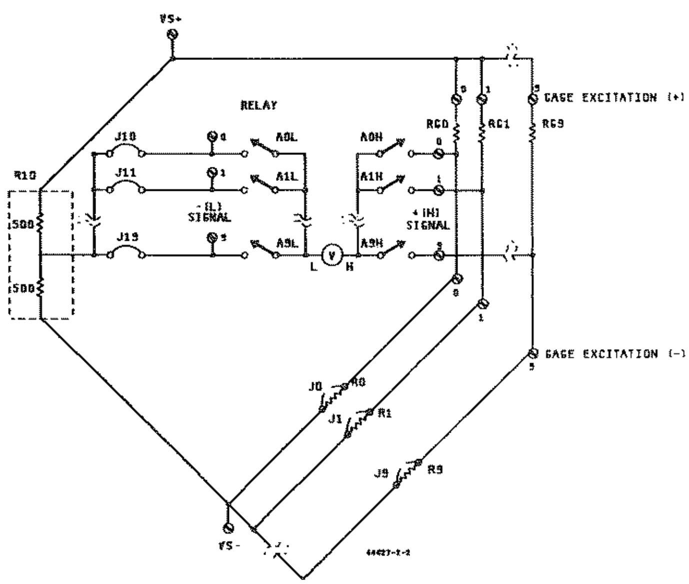


Figure 116. Options 070/071 - Sample ¼ Bridge Connections

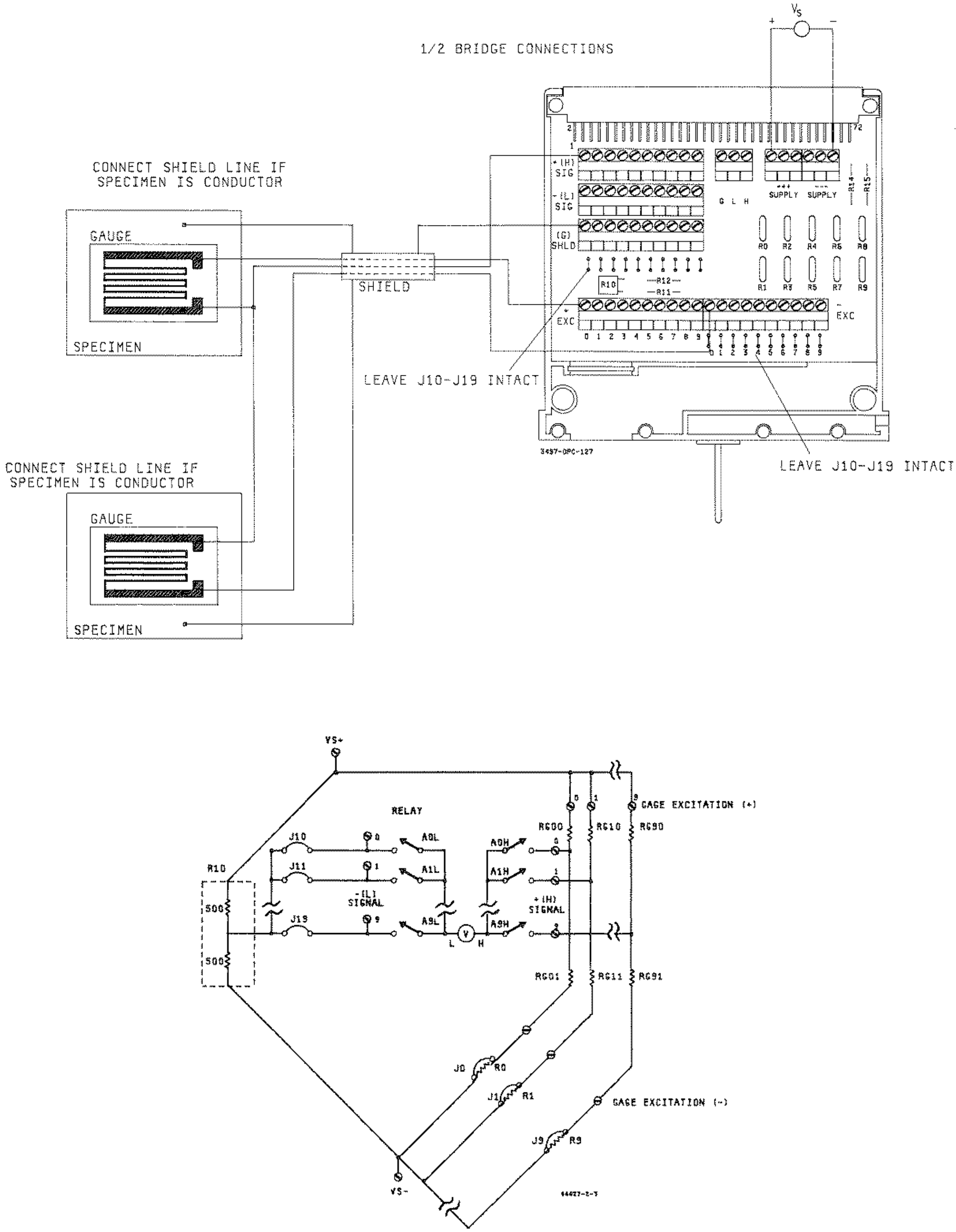


Figure 117. Options 070/071 · Sample ½ Bridge Connections

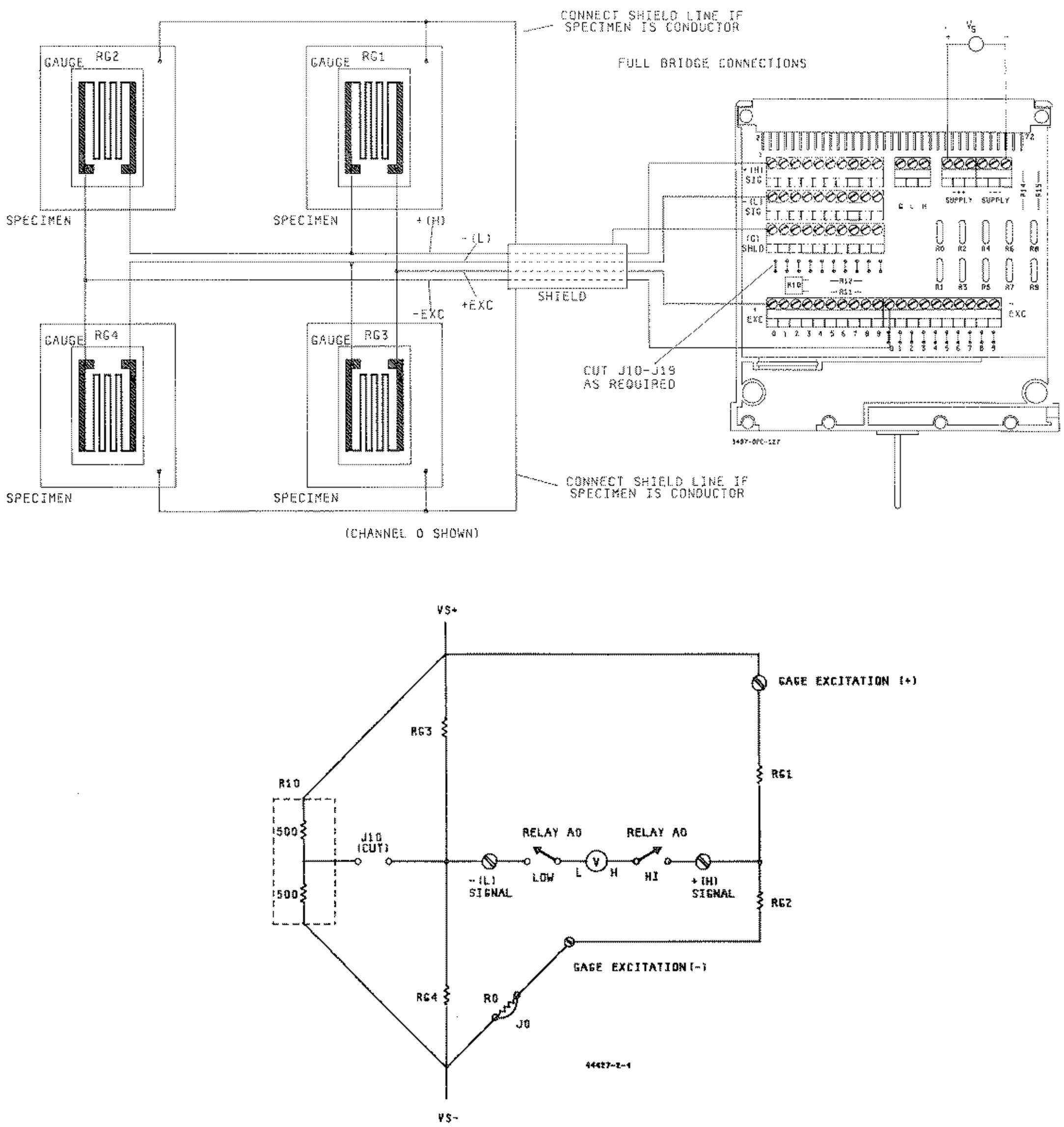


Figure 118. Options 070/071 - Sample Full Bridge Connections

Combining Bridge Configurations

You can also configure the terminal card for any combination of ¼, ½ and full bridge measurements (up to 10 bridges per assembly). Figure 119 shows an example connection with a ¼ bridge in channel 0, a ½ bridge in channel 1 and a full bridge in channel 2. The Option 070 assembly (120 ohm) is shown, but the connections are the same for the Option 071 (350 ohm) assembly. Refer to Figures 116, 117 and 118 for connection details.

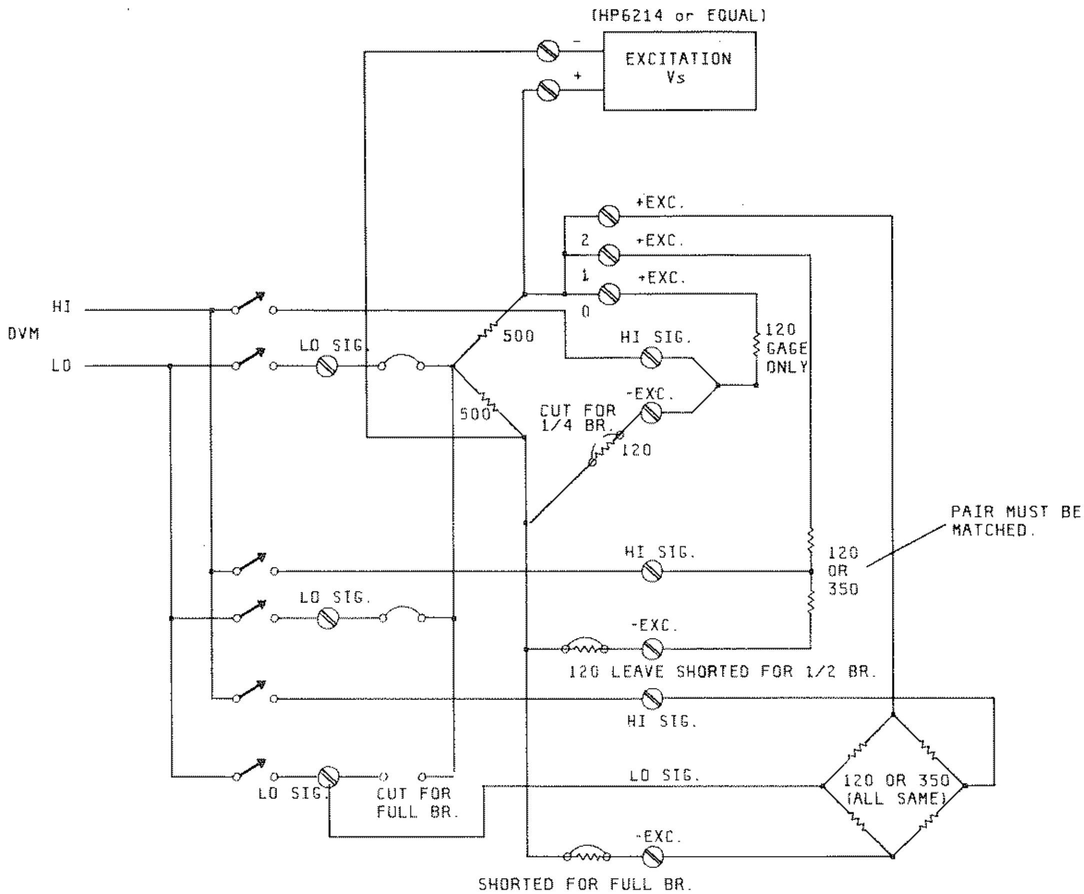


Figure 119. Options 070/071 - Combined Bridge Configurations

Strain Gauge Equations

Recall that we developed an equation for strain in terms of the input and output voltages of a ¼ bridge circuit. The assemblies can, of course, be used for ½ and full bridge measurements and a combination of bridges (10 maximum) can be input to a single assembly.

Although the assemblies are specifically designed for use with bonded resistance strain gauges, they can also be used with any resistive transducer, such as RTDs and 3-element rosettes. For these reasons, Figure 123 (at the end of this section) shows equations for determining strain for strain gauge bridges, biaxial stress state equations, rosette equations, wire resistances and selected materials properties.

Measurement Accuracy Considerations

In our previous discussions, we assumed that no errors were introduced into the measurement by the instrumentation (i.e., no lead wire resistance, no heating or power line effects, etc.). However, for practical measurements, errors may be introduced by the measurement system. The following discussion summarizes how to minimize some of these errors. See -hp- Application Note 290-1 for details.

Self-Heating

The 44427A/B uses a shared half bridge when the terminal card is set for ¼ or ½ bridge operation. This means that half the bridge is common to all bridges on the card. Also, all gauges connected to the card remain powered by the excitation supply even though only one bridge is being measured. This setup minimizes thermal drift due to gauge self-heating and maintains constant power dissipation of the gauges.

If self-heating is a concern, use a 350 ohm gauge with the Option 071 (350 ohms) assembly. Another method is to reduce the excitation supply voltage. This, however, may increase noise level and impair accurate readings.

Power Line Noise

If power line interference may be a problem, use an integrating type DVM. The DVM error is significantly reduced if the voltmeter integrates the input for a period equal to an integer number of power line cycles (1, 10, 100, etc.). Exact amount of error reduction is determined by the DVM's Normal Mode Rejection. For example, the 3456A DVM has 60 dB rejection at one power line cycle integration and up to 80 dB at 100 power line cycles.

Voltage Offsets

When calculating strain, you can ignore voltage offsets if the offsets do not change between unstrained and strained measurements. If, however, changing offsets may be a problem (for example, thermally induced offsets), two compensation techniques may be used:

a. First, take an unstrained reading. Then disconnect the excitation supply and take a second measurement. Subtract the second (offset) reading from the unstrained reading. This calculated value can then be used as Voutu in equation (3). Similarly, take a strained measurement and an offset strained measurement. The difference can then be used as Vouts in equation (3).

b. The second method uses a reversible excitation supply. For each unstrained and strained measurement, reverse the supply polarity and take a second measurement. Average each pair of measurements and use these values in equation (3). In this method, offsets are cancelled and there is no waiting for the gauges to cool.

Lead Wire Resistance

The equations previously used do not include compensation terms for lead wire resistance (see Figure 123 at the end of this section for bridge equations which include lead resistance). Although the bridges can be connected with two wire configurations, we highly recommend a three-wire arrangement (with shielding) to reduce the effects of lead wire resistance.

If lead wire resistance is a critical factor for your application, choose a 350 ohm gauge and use the 44427B assembly, since this gauge is less susceptible to lead wire resistance effects. If you are using ¼ bridge configuration, you can measure the lead wire resistance on channels A7, A8 and A9, as follows.

As shown in Figure 120, the lead wire resistance (R_α) can be computed from the following equation. Since R3 is specified to ± 0.12%, this is the overall accuracy of the measurement.

$$R_\alpha \quad \left[\frac{(\text{Voltage A-B})}{(\text{Voltage B-D})}\right] (R3) \quad [\pm\ .12\%] \qquad (5)$$

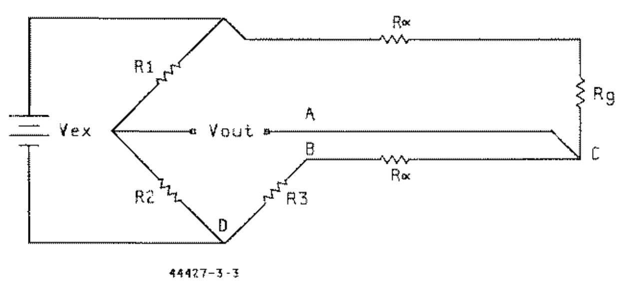


Figure 120. Options 070/071 - Lead Wire Resistance

EXAMPLE - COMPUTE LEAD WIRE RESISTANCE

For example, to compute lead wire resistance for channel A9, use the following steps. Remember, only channel A7, A8 or A9 lead resistance can be determined.

1. Close channel A9 and record the voltage as VA9.
2. Close channel B9 and record the voltage as VB9.
3. Close channel B6 and record the voltage as VB6.
4. Compute R_α from:

$$R_\alpha = \left[\frac{VA9 - VB9}{VB6 + VB9}\right] (R3) \quad [\pm\ 0.12\%] \qquad (6)$$

½ Bridge Resistor Ratio

The ratio of the common ½ bridge resistors (R10) on the terminal card should be 1 (± 0.024%) since this ratio is used as a reference for ten bridges. If the ratio is outside this range, replace R10. To determine the ratio, first close channel B5 and record the voltage as VB5. Then close channel B6 and record the voltage as VB6. The ratio is then VB5/VB6.

A good integrating DVM (such as the -hp- 3456A) should be used for the test. The 3456A has accuracy greater than +10 ppm when set to 10 power line cycles integration.

Shunt Verification

To verify that the measured values for strain are close to the theoretical values, you can add a shunt resistor to one leg of the bridge to simulate either a tension strain or a compression strain measurement. Channel B1 is used to simulate tension strain and channel B2 is used to simulate compression strain. See Figure 121.

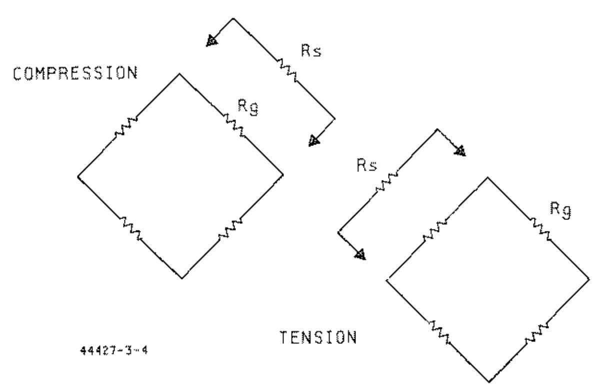


Figure 121. Options 070/071 - Shunt Verification

For either type of simulation, the procedure is to first calculate the theoretical strain from the following equation:

$$\epsilon = [Rg-((Rg*Rs)/(Rg+Rs))]/(GF*Rg*n) \qquad (7)$$

where: Rg = resistance of paralleled gauge
Rs = 79.81K (tension) or 59.41K (compression)
GF = Gauge Factor
n = 1 for ¼ bridge, 2 for ½ bridge or 4 for full bridge.

The second step is to make an unstrained measurement of the gauge under test and record this voltage as Voutu and then measure the excitation voltage and record it as Vs.

The third step is to use the AC chan#,chan# command to close channel B1 (for tension strain) or channel B2 (for compression strain) AND the channel for the gauge under test. This will simulate a strained measurement. Record the voltage as Vouts.

For example, with an assembly in slot 0 and a gauge connected to channel A3, the command for tension strain measurement is AC3,11 and the command for compression strain is AC3,12.

The final step is to compute the simulated strain using the following equations and compare it with the theoretical strain calculated with equation (7).

$$Vr = (Vouts/Vs) - (Voutu/Vs) \qquad (8)$$

$$= -4Vr/[GF(1 + 2Vr)] \qquad (9)$$

Gauge Leakage Resistance

A properly mounted gauge with fully cured adhesive usually has 1000 Megohms or more isolation resistance between the gauge and the specimen. A measured value of 500 Megohms or less usually indicates some type of surface contamination and resultant gauge leakage. At least 150 Megohms should be maintained, as gauge leakage resistance appears as a high impedance in parallel with the gauge which causes measurement errors.

To measure the gauge to specimen resistance, use a high resolution DVM. Do not use a high voltage insulation tester as damage to the gauge may result. Turn the excitation supply OFF before making the measurement. Connect the DVM OHMS terminals to the 3497A HI COM and LO COM terminals and close channel B3 to make the measurement.

One way to reduce undesirable offsets due to gauge leakage is to use a Wagner Ground as shown in Figure 122. The Wagner Ground uses a guard shield whose voltage is approximately the same as the signal leads (excitation voltage).

The Wagner Ground is formed by dividing the excitation supply in half by using two equal value resistors. This ground is connected to the shield lead to establish a voltage reference. To check the Wagner Ground, close relay B4. The measured voltage should be within ± 4% of one-half the excitation voltage.

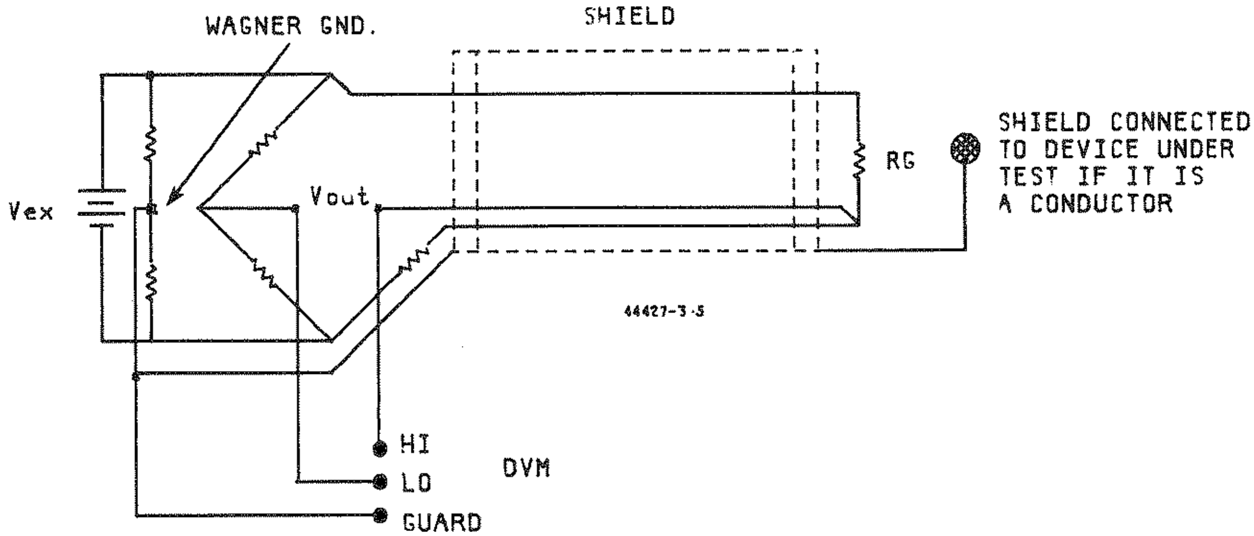


Figure 122. Options 070/071 - Wagner Ground

MATERIAL TABLES

WIRE RESISTANCE Solid Copper Wire		
AWG	Ohms/Foot (25°C)	Diameter (in.)
18	0.0065	0.040
20	0.0104	0.032
22	0.0165	0.0253
24	0.0262	0.0201
26	0.0416	0.0159
28	0.0662	0.0126
30	0.105	0.010
32	0.167	0.008

AVERAGE PROPERTIES OF SELECTED ENGINEERING MATERIALS
Exact values may vary widely

Material	Poisson's Ratio, ν	Modulus of Elasticity, E psi x 10^6	Elastic Strength (a) Tension (psi)
ABS (unfilled)	–	0.2-0.4	4500-7500
Aluminum (2024-T4)	0.32	10.6	48000
Aluminum (7075-T6)	0.32	10.4	72000
Red Brass, soft	0.33	15	15000
Iron-Gray Cast	–	13-14	–
Polycarbonate	0.285	0.3-0.38	8000-9500
Steel-1018	0.285	30	32000
Steel-4130/4340	0.28-0.29	30	45000
Steel-304 SS	0.25	28	35000
Steel-410 SS	0.27-0.29	29	40000
Titanium alloy	0.34	14	135000

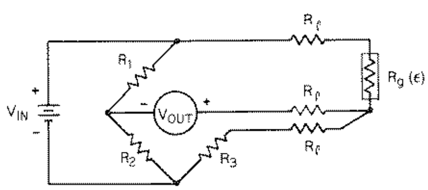
(a) Elastic strength may be represented by proportional limit, yield point, or yield strength at 0.2 percent offset.

BRIDGE CIRCUITS

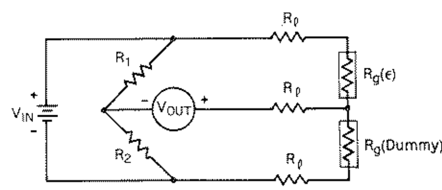
STRAIN GAGE BRIDGE CIRCUITS AND EQUATIONS

Equations compute strain from unbalanced bridge voltages:
sign is correct for V_{IN} and V_{OUT} as shown
GF = Gage Factor: ν = Poisson's ratio:
$V_r = [(V_{OUT}/V_{IN})\text{strained} - (V_{OUT}/V_{IN})\text{unstrained}]$:
ϵ = Strain; Multiply by 10^6 for micro-strain:
tensile is (+) and compressive is (−)

Quarter Bridge Configurations:

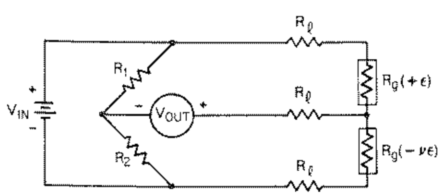


OR

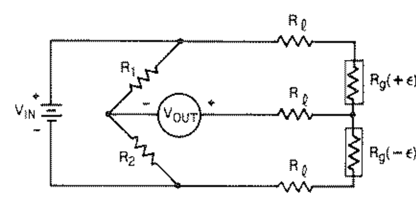


$$\epsilon = \frac{-4V_r}{GF(1+2V_r)} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

Half Bridge Configurations:

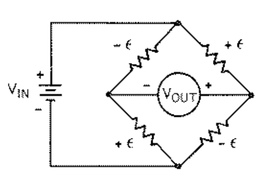


$$\epsilon = \frac{-4V_r}{GF[(1+\nu) - 2V_r(\nu-1)]} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

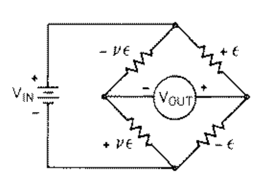


$$\epsilon = \frac{-2V_r}{GF} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

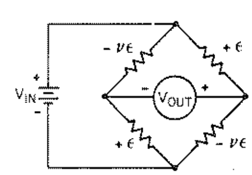
Full Bridge Configurations:



$$\epsilon = \frac{-V_r}{GF}$$



$$\epsilon = \frac{-2V_r}{GF(\nu+1)}$$



$$\epsilon = \frac{-2V_r}{GF[(\nu+1) - V_r(\nu-1)]}$$

Figure 123. Options 070/071 · Strain Gauge/Rosette Equations

EQUATIONS

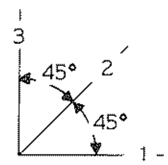
BIAXIAL STRESS STATE EQUATIONS

$$\epsilon_x = \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \epsilon_z = -\nu\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \sigma_y = \frac{E}{1-\nu^2}(\epsilon_y + \nu\,\epsilon_x)$$

$$\epsilon_y = \frac{\sigma_y}{E} - \nu\frac{\sigma_x}{E} \qquad \sigma_x = \frac{E}{1-\nu^2}(\epsilon_x + \nu\,\epsilon_y) \qquad \sigma_z = 0$$

ROSETTE EQUATIONS

Rectangular Rosette:

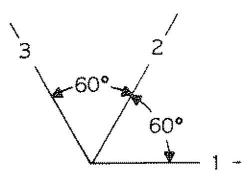


$$\epsilon_{p,q} = \left[\frac{1}{2}\ \epsilon_1 + \epsilon_3 \pm \sqrt{(\epsilon_1 - \epsilon_3)^2 + (2\epsilon_2 - \epsilon_1 - \epsilon_3)^2}\right]$$

$$\sigma_{p,q} = \left[\frac{E}{2}\ \frac{\epsilon_1 + \epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{(\epsilon_1 - \epsilon_3)^2 + (2\epsilon_2 - \epsilon_1 - \epsilon_3)^2}\right]$$

$$\theta_{p,q} = \frac{1}{2}\ \mathrm{TAN}^{-1}\frac{2\epsilon_2 - \epsilon_1 - \epsilon_3}{\epsilon_1 - \epsilon_3}$$

Delta Rosette:



$$\epsilon_{p,q} = \left[\frac{1}{3}\ \epsilon_1 + \epsilon_2 + \epsilon_3 \pm \sqrt{2[(\epsilon_1 - \epsilon_2)^2 + (\epsilon_2 - \epsilon_3)^2 + (\epsilon_3 - \epsilon_1)^2]}\right]$$

$$\sigma_{p,q} = \left[\frac{E}{3}\ \frac{\epsilon_1 + \epsilon_2 + \epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{2[(\epsilon_1 - \epsilon_2)^2 + (\epsilon_2 - \epsilon_3)^2 + (\epsilon_3 - \epsilon_1)^2]}\right]$$

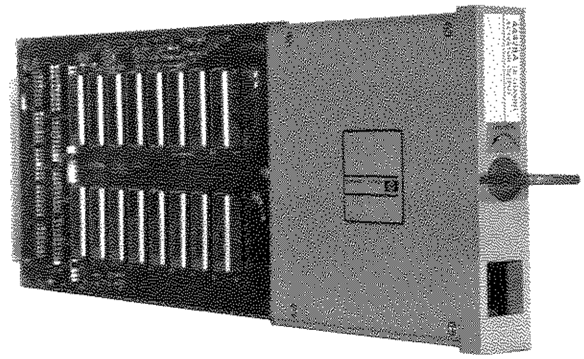
$$\theta_{p,q} = \frac{1}{2}\ \mathrm{TAN}^{-1}\frac{\sqrt{3}(\epsilon_2 - \epsilon_3)}{2\epsilon_1 - \epsilon_2 - \epsilon_3}$$

WHERE: $\epsilon_{p,q}$ = Principal strains; $\sigma_{p,q}$ = Principal stresses; and $\theta_{p,q}$ = the acute angle from the axis of gage 1 to the nearest principal axis. When positive, the direction is the same as that of the gage numbering and when negative, opposite.

NOTE: Corrections may be necessary for transverse sensitivity, refer to gage manufacturers literature.

Figure 123. Options 070/071 - Strain Gauge/Rosette Equations (Cont'd)

OPTION 110



Actuator/Digital Output Assembly

INTRODUCTION

The Option 110 assembly consists of 16 mercury-wetted form C (single-pole double-throw) relays. The assembly has two functional modes: Actuator Mode and Digital Output Mode. In the actuator mode, each channel relay can be closed to switch power to (actuate) multiple external devices. Each relay can safely switch up to 1 amp at 100 volts (peak).

In the digital output mode, each relay can be set to the Normal Open (NO) position (logical 1) or to the Normal Closed (NC) position (logical 0) to provide an 8-bit or 16-bit wide digital output. The assembly uses ''bounceless'' relays, isolated Gate/Flag Handshake lines and +5V nonisolated internal excitation. The assembly has capability for up to +100V external excitation and can be configured for open collector operation.

The actuator can be configured as a 4 x 4 point matrix scanner and additional assemblies can be added to construct larger matrices. Since the actuator assembly can switch one amp at 100 volts, it can be used to switch test fixture power or to actuate alarm bells. In addition, the assembly can be used with the 16 Channel Isolated Digital Input/Interrupt Assembly (Option 050) to provide an independent digital input/output port.

Description

As shown in Figure 124, the Option 110 assembly consists of a relay card and a terminal card. The relay card consists of 16 mercury-wetted, Form C (single-pole double-throw) relays. Each relay can be individually closed (set to the Normal Open position) or opened (set to the Normal Closed position).

In addition, the relay card contains a jumper to select a positive-going (LGT) or negative-going (HGT) gate pulse, a jumper to select a positive-going (LFL) or negative-going (HFL) flag pulse, and a jumper to enable or disable the handshake function for the assembly.

The terminal card contains input connectors for 16 channel relays (NORM OPEN, COMMON and NORM CLOSED) plus connectors for gate and flag lines and DIP connectors for pull-up resistors as required. In addition, you can use four optional jumpers on the terminal card to change gate and flag handshake lines from optically isolated (standard TTL logic) to nonoptically isolated.

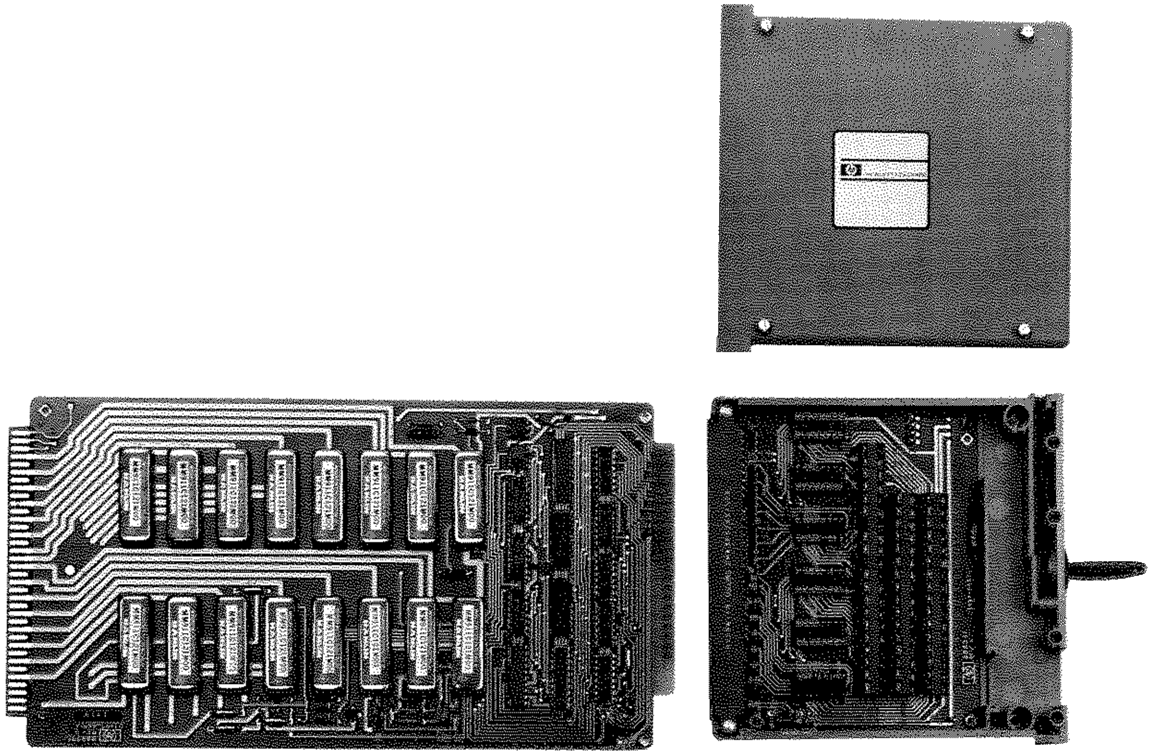


Figure 124. Option 110 - Actuator/Digital Output Assembly

Actuator (Switching) Mode

As shown in Figure 125, when the assembly is used in actuator mode, each of the 16 channel relays (K0 through K15) can be switched from the Normal Open position to the Normal Closed position and thus switch power to or from loads. When a relay is deenergized, the NORMAL CLOSED contact is connected to COMMON. When a relay is energized, the NORMAL OPEN contact is connected to COMMON.

By using DC slot#, chan#,chan#,.. and DW slot#,octal value, from one to 16 relays can be closed and each relay can be individually closed or opened. By using a DR slot# or DL slot# command, you can read the status (open or closed) of each relay. In addition, by using the SR slot#,0 command, you can verify that the assembly in the slot addressed is an Option 110 (or Option 115) assembly if 000041 OCT is returned.

In some cases (highly inductive loads, for example), contact protection may be required to prevent switch contact damage. Note that contact protection is required across BOTH the Normal Open and Normal Closed lines if loads are to be switched on each line.

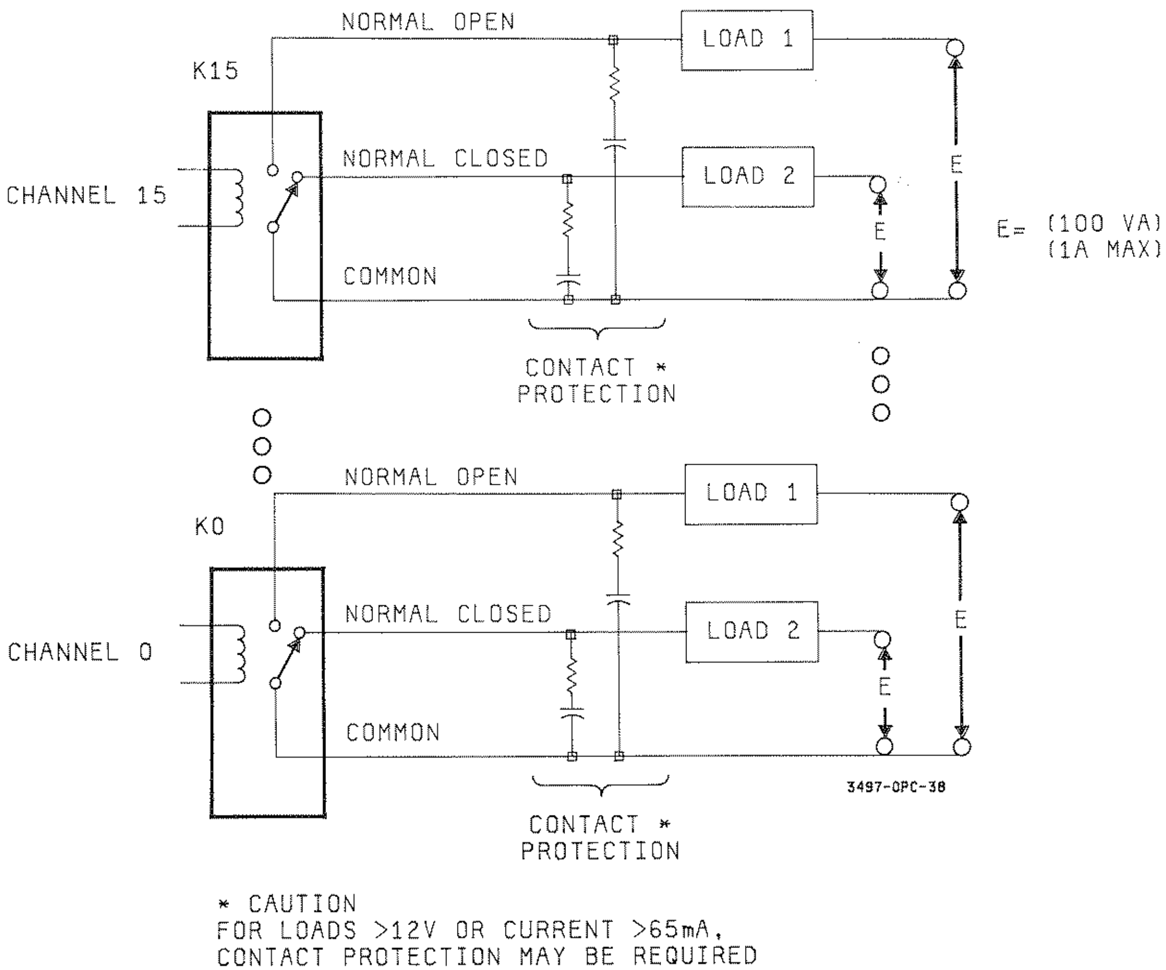
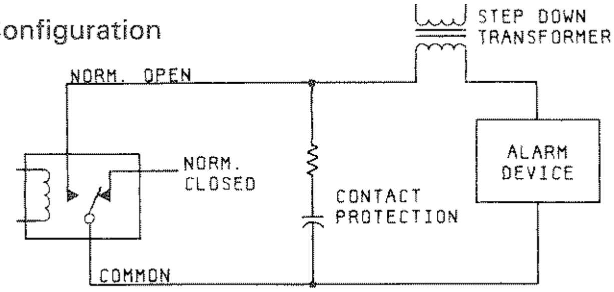


Figure 125. Option 110 · Actuator (Switching) Mode

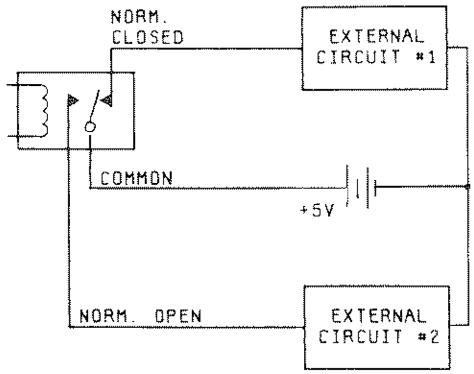
The assembly is very versatile and can be used in many applications, as long as the load circuits are fused for 1A or less and for less than 100 VA. To indicate some of the ways that the assembly can be used in the actuator mode, Figure 126 shows examples of a relay actuated alarm circuit, voltage switching and matrix switching.

In the alarm circuit, closing the relay applies power to activate the alarm device. For example, the relay closure could be computer-controlled and generated as a result of an interrupt from the Option 050 assembly. For the voltage switching application shown, closing the relay switches +5V from load #1 to load #2.

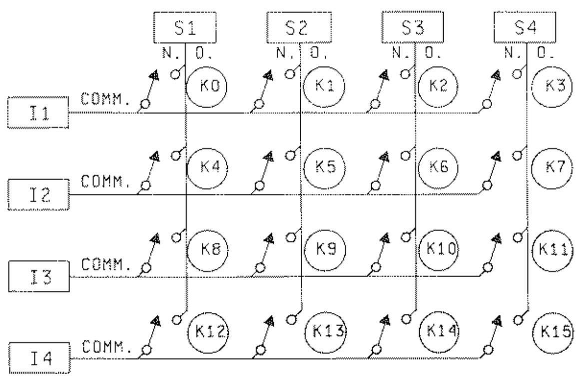
As a specialized application of the actuator mode, the assembly can be configured as a 4 x 4 matrix switch. For example, as shown in Figure 126, signal sources S1 through S4 can be connected to measuring instruments I1 through I4 by closing relays K0 through K15 as required (i. e., to connect source S3 to instrument I2, close relay K6, etc.).



RELAY ACTUATED ALARM CIRCUIT



VOLTAGE SWITCHING



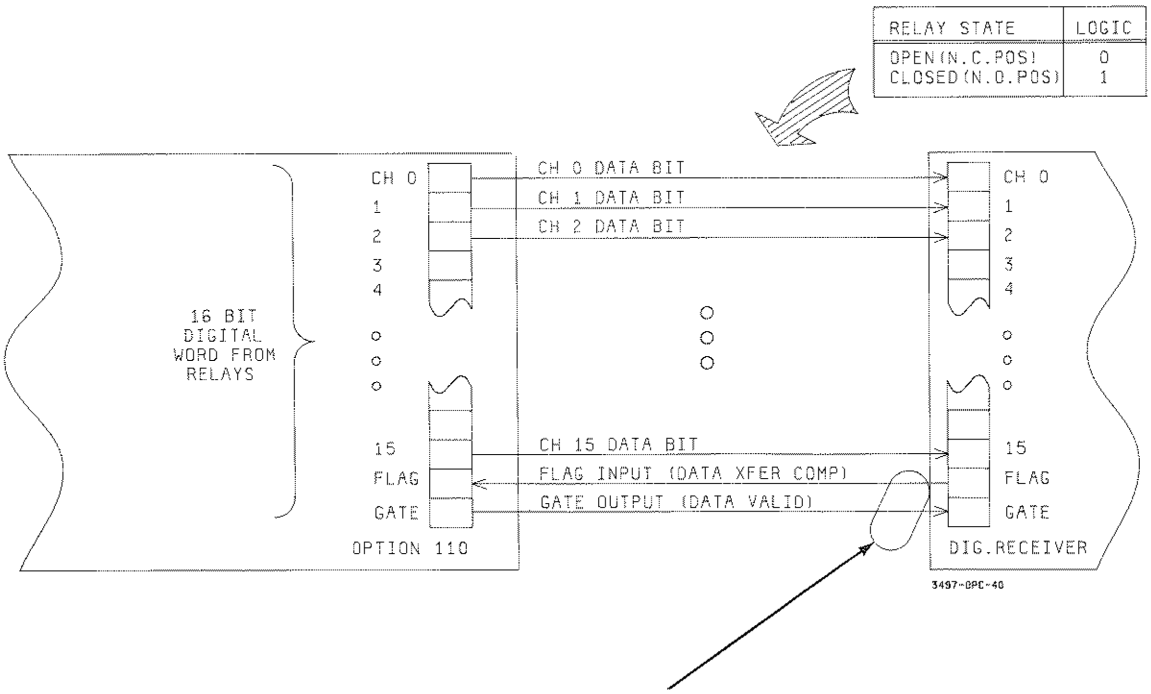
MARTRIX SWITCHING 3497-OPC-39

Figure 126. Option 110 - Actuator Mode Examples

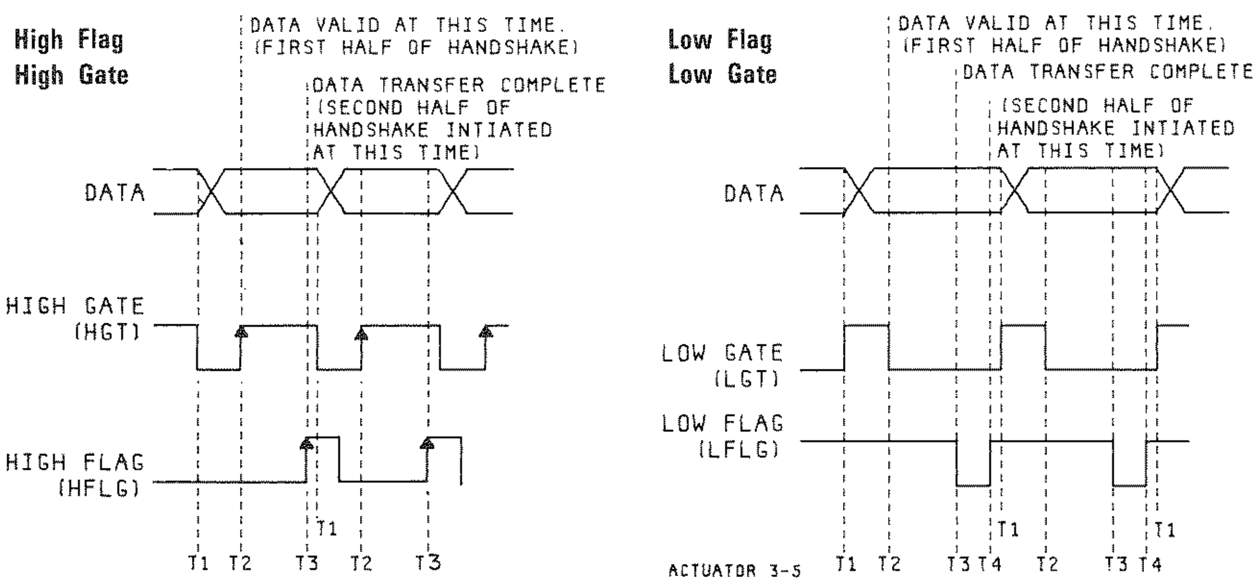
Digital Output Mode

The actuator assembly can also be used in digital output mode to communicate with an 8-bit or 16-bit digital receiver at a typical maximum read rate of 400 Hz. As shown in Figure 127, a 16-bit wide digital word is input to the relays (channels 0 through 15) and the word is transferred to a digital receiver. In addition (as with the actuator mode), relay status (open or closed) can be read with a DR slot# or DL slot# command.

As factory configured, handshaking is disabled. If desired, you can set a jumper on the relay assembly to enable handshaking and (with other jumpers) can select either High Gate, High Flag or Low Gate, Low Flag handshaking. Also, as factory configured, the handshake lines are optically isolated. You can select nonisolated mode by connecting pullups across four terminal card jumpers (see CONFIGURING THE ASSEMBLY for details).



Handshake Timing Diagrams



T1 . . . . 16 bit wide data word transferred to actuator card relays
T1-T2 . . Settling time for relays and drive circuits ($\simeq$3ms.)
T2 . . . . Data Valid, ready for transfer to external device
T2-T3 . . Data transfer executed during this time period
T3 . . . . Data transfer complete. Actuator card and 3497A wait until positive going flag pulse received

T1 . . . . 16 bit wide data word transfered to actuator card relays
T1-T2 . . Settling time for relays and drive circuits ($\simeq$3ms.)
T2 . . . . Data valid, ready for transfer to external device (first half of handshake)
T2-T3 . . Data transfer executed duing this time period
T3 . . . . Data transfer complete. External device transmits flag pulse
T4 . . . . Positive going (trailing edge) transition occurs to complete handshake

Figure 127. Option 110 - Digital Output Mode

When handshaking is enabled, the handshake sequence for either High Gate, High Flag or Low Gate, Low Flag operation is as shown in Figure 127. When a 16-bit wide word is entered into the assembly and settling time has occured, the assembly sends a Gate output to the receiver to signal Data Valid condition. Then, after the word is transferred to the receiver, the receiver returns a Flag message to show that data transfer is complete and the receiver is ready for more data.

Specifications

Specifications for the Actuator/Digital Output assembly follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 110
ACTUATOR/DIGITAL OUTPUT ASSEMBLY

Input Characteristics

Contact Ratings: Voltage: ±100 V peak
Current: 1 ampere/channel
Power: 100 volt amperes/channel

CAUTION: For use only in circuits fused at 1 ampere or less and less than 100 VA.

Thermal Offset: < 20 μV

Contact Resistance: < 400 milliohms

Isolation: > 10^6 Ω common to open

Isolation Voltage: 170V peak any terminal to chassis

General Information

Single Channel Closure Rate: > 27/second (Using 9835A)

Switch Life: > 10^{10} with contact protection

+ 5V Supply: Source up to 50 mA per assembly

Operating Considerations: Should not be used in a position greater than 30° above horizontal

Handshake Lines: Optically isolated, TTL compatible, open collector output

AC Performance

Contact Capacitance: < 15 pF

Interchannel Capacitance: < 30 pF

Frequency Response

(10 kHz Reference)	f<100 kHz	f<1 MHz
50 Ohm Termination	±.3 dB	±.5 dB
1M Ohm Termination	±.3 dB	±.5 dB

Cross Talk

1M Ohm Termination	<30 dB	<30 dB

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual. Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany the manual. See Appendix B for details.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the Actuator/Digital Output assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the Actuator/Digital Output assembly as Option 110, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44428A, the shipping container should contain a relay card and a terminal card (see Figure 124).

For the Field Installation Kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a relay card or terminal card to -hp-, follow the shipping guidelines in Appendix B.

CAUTION

Before installing this assembly or connecting external circuits, a qualified, service-trained person should verify the electrical performance of the assembly by using the performance checks shown in the 3497A Plug-In Assembly/3498A Extender Service Manual.

How to Install the Actuator/Digital Output Assembly

WARNING

Before touching any installed assemblies or attempting to install the Actuator/Digital Output assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments. The Actuator/Digital Output assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the relay card. Handle the card by its edges and do not subject the components to static discharges or excessive voltages.

NOTE

Since mercury-wetted relays are used in the assembly, the arrows on the relay card must always point upward to the 12 o'clock position. Do not operate the assembly with the relays more than 30 degrees from the vertical position. After installing the assembly in the 3497A or 3498A, gently tap the assembly to settle the mercury to the bottom of the relays.

Figure 128 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING, CAUTION and NOTE above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.

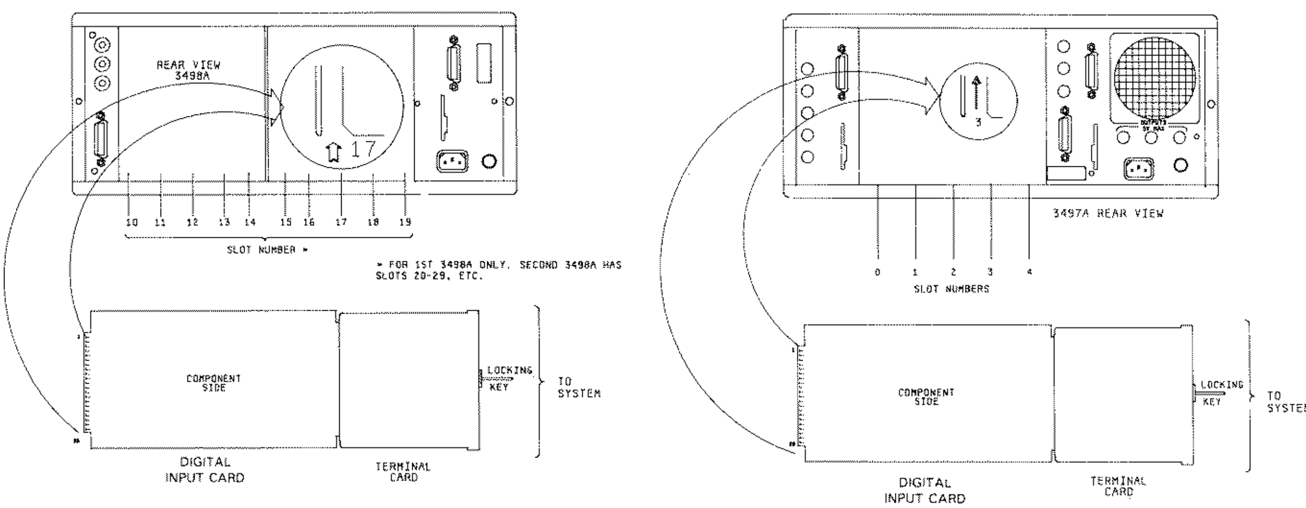


Figure 128. Option 110 - Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

As mentioned, the assembly can be configured for actuator (switching) mode or for digital output mode. The paragraphs which follow show how to configure the assembly for these two modes and provide guidelines for relay contact protection.

Actuator Mode Configuration

Previously, we showed that the assembly can be used in applications such as voltage switching, alarm circuit actuation and matrix switching. To configure the assembly for actuator mode, refer to Figure 129 which shows the jumper connections on the relay card and the terminal card.

WARNING

To avoid personnel injury or equipment damage, disconnect the 3497A and 3498A line cords and ALL voltage sources from these instruments before installing or removing assemblies.

External circuits connected to the Option 110 assembly must be fused at 1 ampere or less and rated at 100 VA or less. Voltages must not exceed ± 100 volts peak.

For maximum relay contact life and to prevent RFI if arcing occurs, relay contact protection is required for inductive loads greater than 12 volts at 65 mA. See text for relay contact protection design.

Relay Contact Protection

Loads which may cause relay contact arcing can cause contact failure unless contact protection is provided. The nomograph in Figure 130 provides guidelines for R-C network design which is suitable for most loads. For the actuator assembly, you should provide relay contact protection if the load to be switched is greater than 12 volts at 65 mA.

EXAMPLE - USING CONTACT PROTECTION NOMOGRAPH

For example, if the load to be switched is 50 volts at 300 mA, from the nomograph R = 500 ohms and C = 0.009 μF (remember that for the actuator assembly, E = 100 volts max). This R-C network should be mounted as close to the relay contacts as possible. Note from the nomograph that for 70<E<100 volts, R can be ± 50% of nominal chart value.

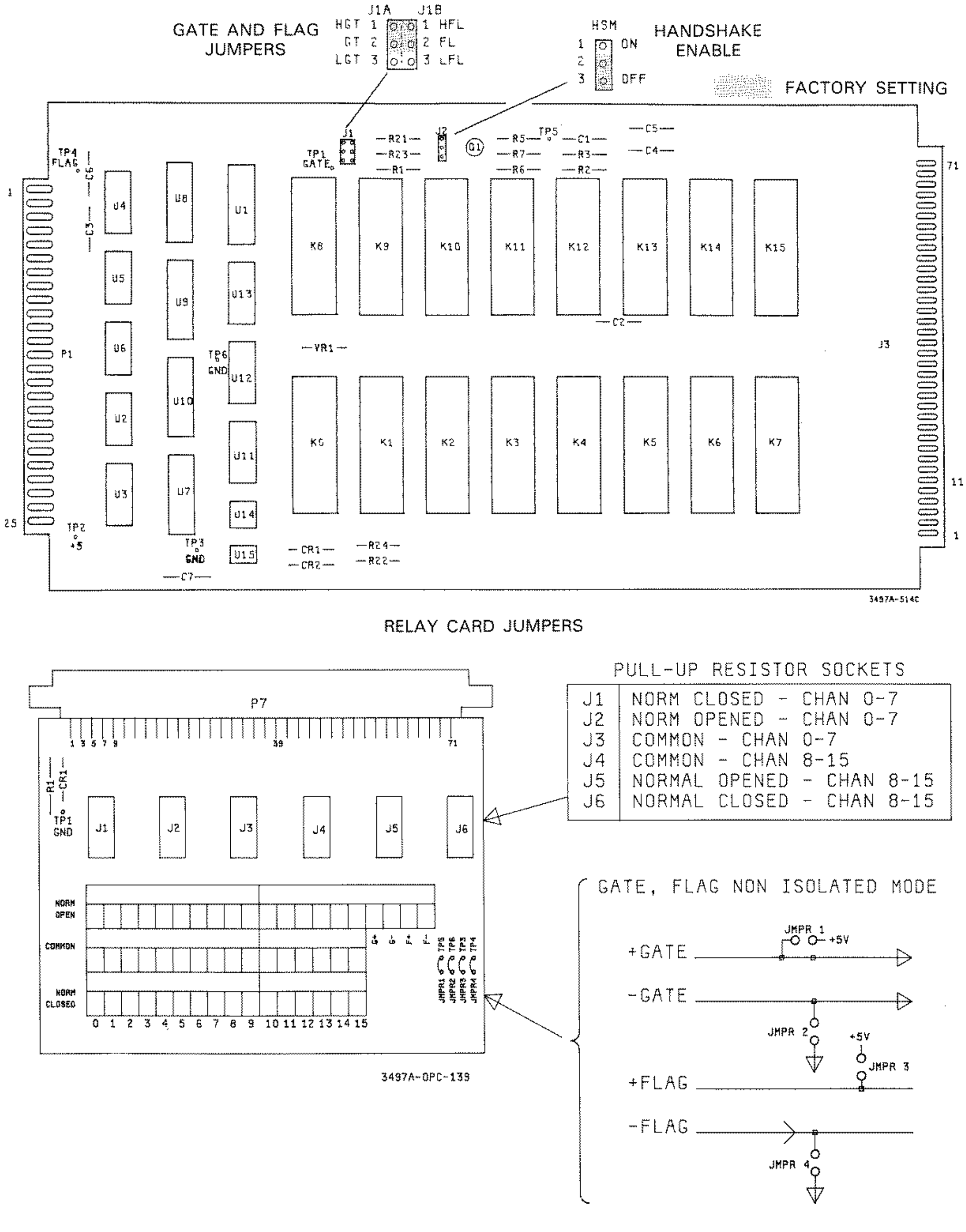


Figure 129. Option 110 - Relay and Terminal Card Jumpers

CONTACT PROTECTION

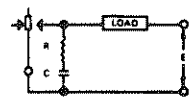
Contact loads that can cause arcing may result in contact failure unless contact protection is provided. It should be wired close to the relay terminals.

The R-C network shown is suitable for most loads. Component values may be obtained from the nomograph. Capacitance may be increased (up to 10 times) to minimize inductive load transients. Use peak values for ac circuits.

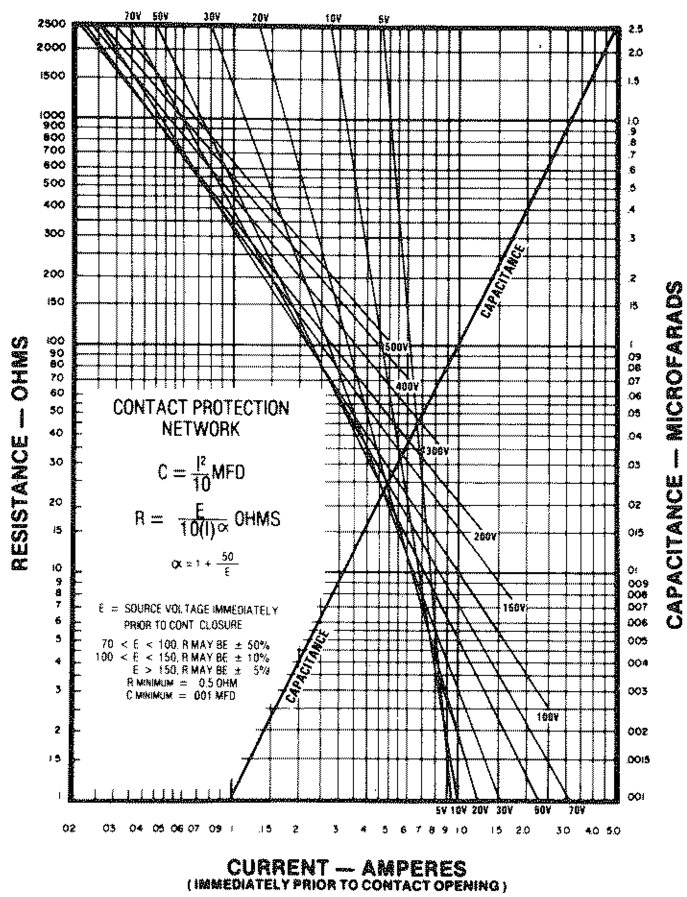
No protection is required for voltages below 12 volts or currents below 65ma.

The resistor may be eliminated for voltages below 50 volts with currents below 0.5A. The capacitor should not exceed the chart value.

Highly capacitize loads do not require protection.



CONTACT PROTECTION NOMOGRAPH



HOW TO USE THE NOMOGRAPH

To determine C, the load current value is found on the CURRENT axis. Reading directly up to the sloping capacitance line, the C value is determined from the right hand CAPACITANCE scale. To determine R, read directly up from the load current value to its intersection with the appropriate load voltage line. The value of R is then read from the left hand RESISTANCE scale. For ac loads, peak current and voltage values must be used.

Figure 130. Option 110 · Contact Protection Nomograph

After determining the values for R and C from the nomograph, place the protection networks as close to the relays as possible. Also, use R-C networks on both the NO and NC contacts are switching power levels which require protection. See Figure 131.

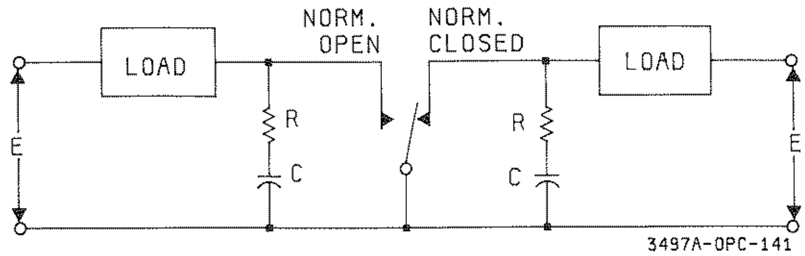


Figure 131. Option 110 - Relay Contact Protection Networks

Configuring the Assembly for Actuator Mode

To configure the assembly for actuator mode, check the relay card to ensure that the handshake enable (HSM) jumper is in the OFF position (handshake disabled). Then, to connect your inputs to the assembly, remove the cover on the terminal card and route the wires as shown in Figure 132 to the appropriate terminals - NORM OPEN, NORM CLOSED and COMMON. Replace the cover and install the assembly in a slot in the 3497A or 3498A. Then, connect relay contact protection (if required) as shown in Figure 131.

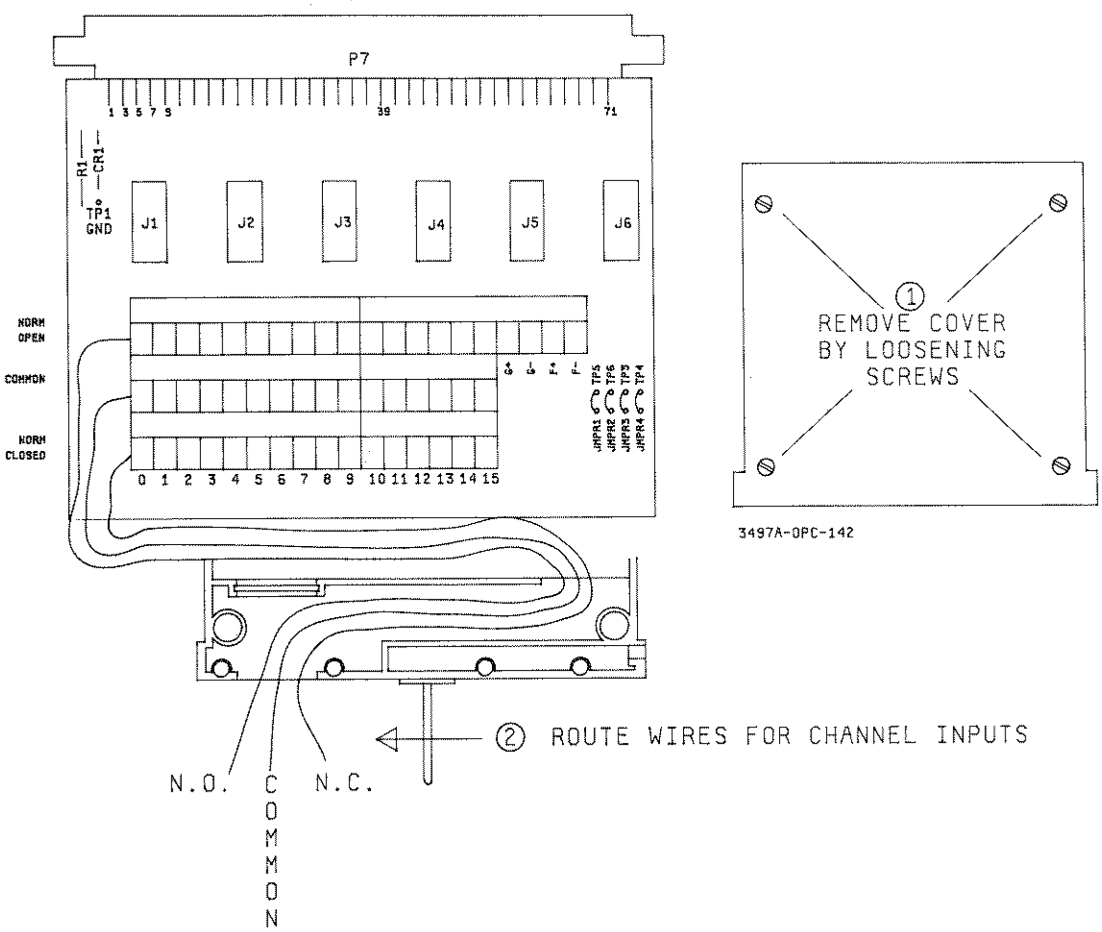
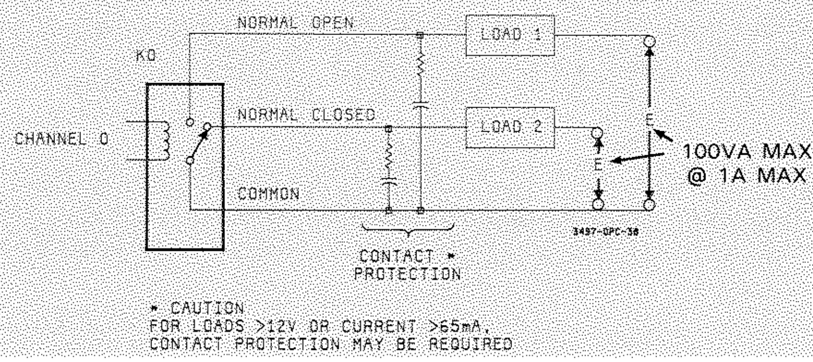


Figure 132. Option 110 - Wiring the Terminal Card

EXAMPLE - ACTUATOR MODE VOLTAGE SWITCHING

This example shows a configuration in which load voltage E is switched from load #1 to load #2 when the relay in that channel is closed (E does not have to have the same value for both loads).

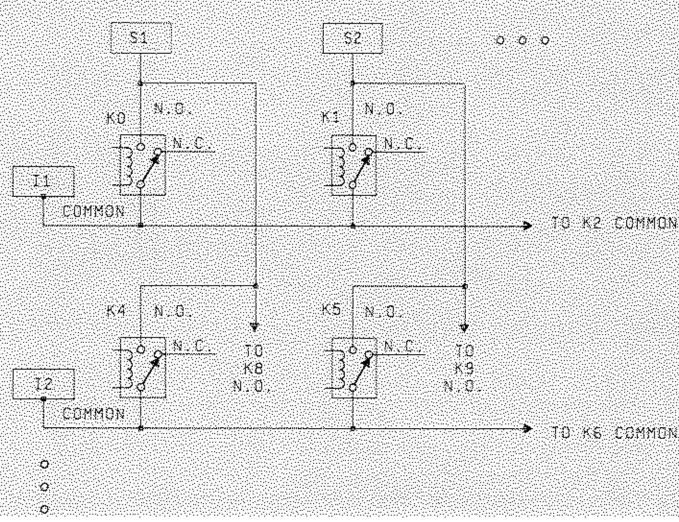
When the relay is open, the NC contact is connected to COMMON and when the relay is closed, the NO contact is connected to COMMON. If contact protection is required, it should be connected across both the NO and NC contacts, as close to the relay as possible.

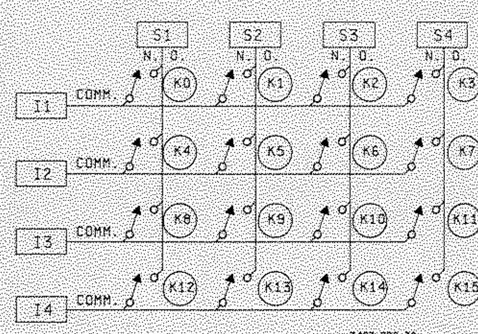


EXAMPLE - ACTUATOR MODE MATRIX SWITCHING

Previously, we noted that the assembly could be wired as a 4 X 4 matrix switch to switch source inputs to measuring instruments. This example shows a setup in which the common terminals of relays K0-K3 are connected to I1 common, etc., and the NO contacts of relays K0, K4, K8 and K12 are connected together, etc.

To connect any source to any instrument, merely send DC slot#,chan# to close the appropriate relay. For example, to connect source S2 to instrument I3, send DC slot#,9 to close K9.





Digital Output Mode

To configure the assembly for digital output mode, first decide whether to use the internal +5V pullup on the assembly or an external pullup. Figure 133 shows sample configurations for both internal and external pullup with 4.7K resistors used. You can select other values, but don't use less than 2K resistors.

With either internal or external pullup (assuming a +5V supply), the bit output is high (+5V) when the relay is closed (NO contact connected to COMMON) and low (0V) when the relay is opened (NC contact connected to COMMON). To connect internal pullup resistors, see Figure 129. For example, to connect +5V to channel 0 NO contact, connect a 4.7K resistor across the top contacts of J1, etc.

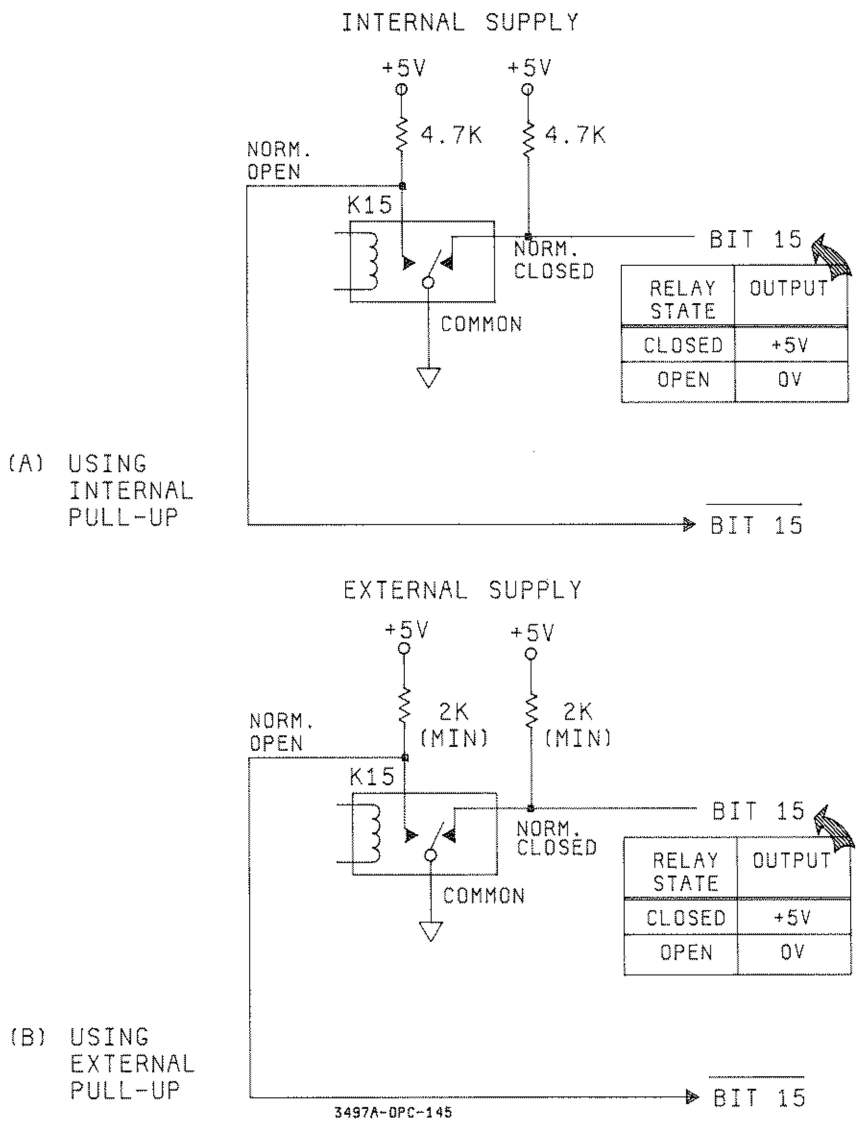


Figure 133. Option 110 - Digital Output Mode Example

Handshake Modes

As factory configured, handshake mode is disabled for the actuator assembly. To set the handshake mode, set the handshake enable (HSM) jumper on the relay card to ON (see Figure 129). Then decide whether you want to use High Gate, High Flag or Low Gate, Low Flag operation and set the Gate and Flag jumpers as required. The jumpers are factory preset for High Gate (HGT), High Flag (HFL) operation.

A typical application may have the Gate negative (-) terminal connected to external circuit common and the Gate positive (+) terminal connected to a TTL input (via a 10K min value pullup resistor). The same application may have the Flag positive (+) line connected to external circuitry +5V supply and the Flag negative (-) line driven by a TTL device.

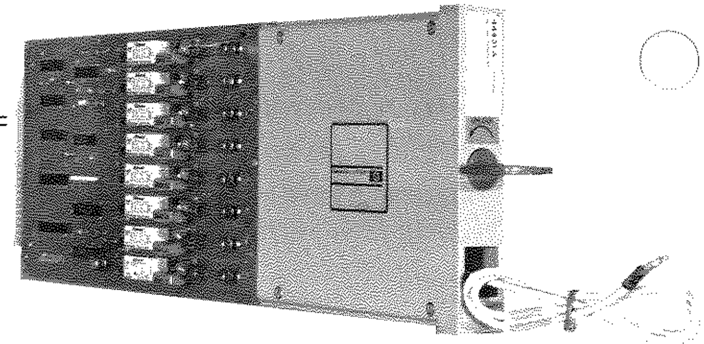
The Gate and Flag handshake lines operate with standard TTL logic levels and diode protection is used with both lines. When jumpers J1 through J4 on the terminal card are open, the lines are optically isolated from the relay card.

Gate, Flag Nonisolated Mode

As factory configured, the handshake lines are optically isolated. If you desire to have nonisolated operation, you can install appropriate pullups in positions J1 through J4 on the terminal card. See Figure 129 for location.

For example, connect a 10K ohm resistor across J1 and a short across J2 for nonisolated Gate line operation. Or, connect a short across J3 and a switch across J4 to activate Flag handshake when the switch is closed.

OPTION 115



8 Channel High Voltage Actuator Assembly

INTRODUCTION

Option 115 is an 8 channel high voltage actuator which can be used to switch voltages up to 252 volts RMS and currents up to 2 amperes peak. Each channel consists of an individually fused and protected normally open dry relay. Contacts are opened only on command or on loss of power.

Each channel can be closed individually or any combination of channels can be closed simultaneously. In addition, the assembly contains a readback circuit so that the status of each channel can be determined. Because of its high voltage capability, you can use the high voltage actuator to switch power line voltages to small motors, alarm bells and lights, motor starters and solenoids.

Description

As shown in Figure 134, the high voltage actuator consists of an actuator card, a terminal card and a grounding strap for connecting the assembly to customer (earth) ground.

The actuator card consists of 8 identical channels. Each channel can be closed individually or any combination of channels on an assembly can be closed simultaneously. Each channel is individually fused (at 5 amps) and contains an RC network for relay contact protection.

At power on, all relays are open. After relays are closed, contacts are opened only on command or on loss of power. A maximum of 680 channels can be attached to actuator outputs using 3498A Extenders (five cards in the 3497A plus 10 cards in each of eight extenders).

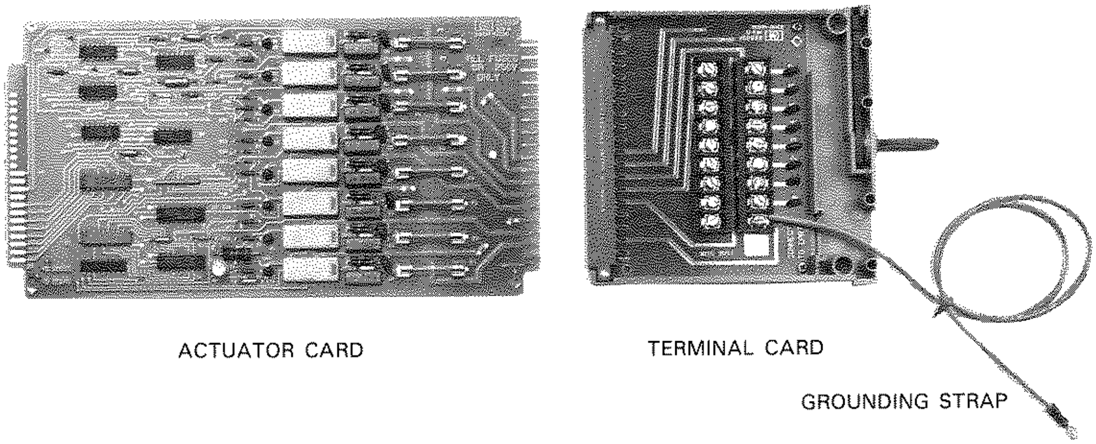


Figure 134. Option 115 · High Voltage Actuator Assembly

Simplified Operation

In typical applications (see Figure 135), actuator channels are connected to external circuits at the terminal card outputs. At power on, relays are opened which opens the load circuit. When a command is sent from the 3497A to the actuator, relays are closed for desired channels, closing the circuits for these loads.

Relay status (open or closed) is sent to the 3497A via readback circuits for front panel display and/or to the interface bus. The readback circuits are actuated in parallel with the load contacts, but are electrically separate. Thus, no load current flows through the readback contacts and they have no effect on load operation.

The actuator card has an RC relay contact protection circuit in each channel (R = 47 ohms, C = 0.047 μF). With the protection network, maximum leakage current at 250V and 60Hz is 6 mA RMS. The protection network can be removed from individual channels by removing appropriate jumpers on the actuator card. With no protection network, maximum leakage current is 1mA RMS at 250V and 60Hz. See RELAY CONTACT PROTECTION GUIDELINES for conditions under which the protection network may be removed.

Any combination of channels can be closed simultaneously. Programming and execution of a single or multiple channel closure or open requires 40 ms. Repetitive changes of the same actuator assembly require a minimum of 1.5 sec. Changes of the same assembly up to 25 per second can be jumper enabled (see CONFIGURING THE ASSEMBLY) but will result in decreased relay lifetime when switching full loads.

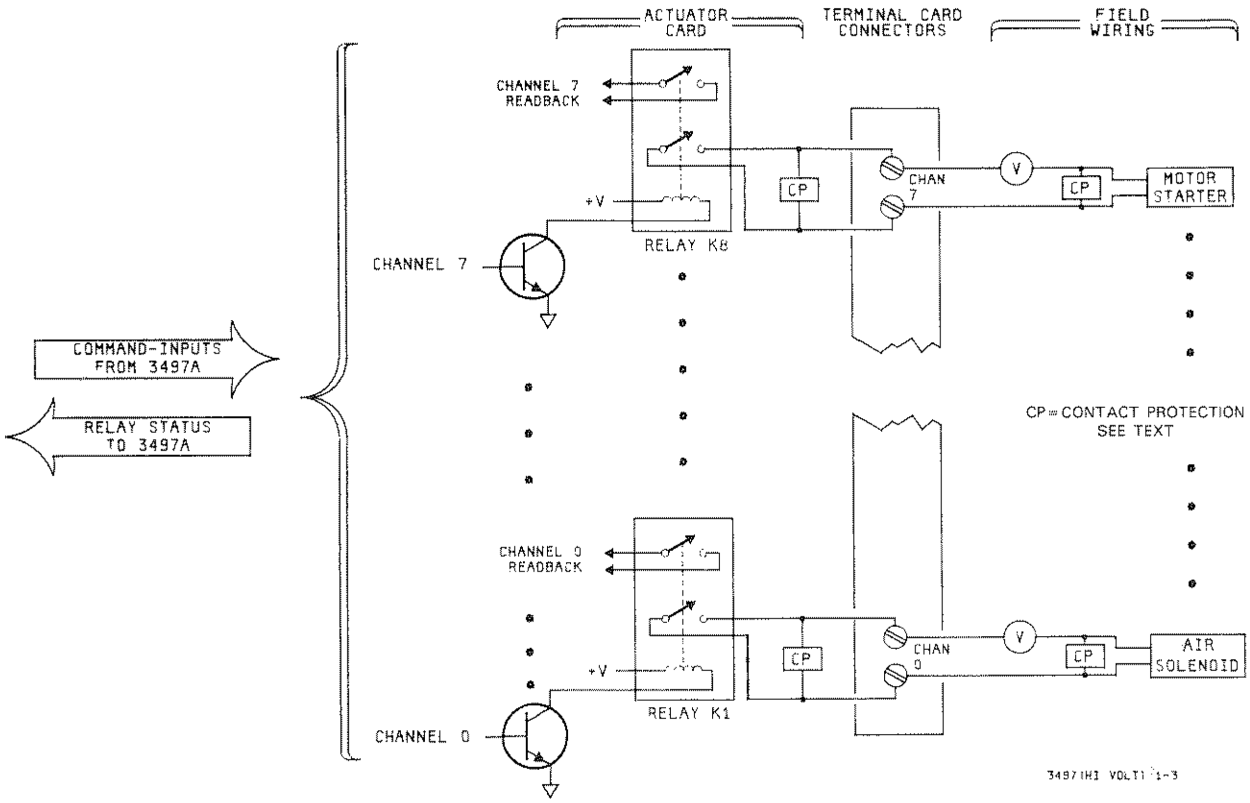


Figure 135. Option 115 · Typical Applications

Specifications

Specifications for the high voltage actuator assembly follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 115
8 CHANNEL HIGH VOLTAGE ACTUATOR ASSEMBLY

Maximum Contact Ratings:

Voltage AC 252 VRMS DC 48 VDC
Current AC 2 amps RMS DC 2 ADC
Power AC 500 VA per chan. DC 60 VA per chan.
Peak Surge Current: 10 Amps RMS
Thermal Offset: $<20\mu V$
Series Resistance: $<500\ m\Omega$

Isolation Impedance: $>10^6$ ohms, input to output with no protection network

Isolation Voltage: >400 V peak input to output
>1500 VRMS to chassis

Minimum Input: 100 μA, 100 mV DC (for contact cleansing)

Relay Lifetime: $> 10^8$ at minimum load, $> 10^5$ at full load

Switching Speed: Any combination of channels can be closed simultaneously. Programming and execution of a single or multiple channel closure or open requires 40 ms. Repetitive changes of the same Option 115 assembly are limited to one every 1.5 seconds. Changes of the same assembly up to 25 a second can be jumper enabled but will result in decreased lifetime at full load.

Maximum Leakage Current:
(at 250 VRMS and 60 Hz)
1 mA RMS with no protection network
6 mA RMS with protection network

Protection Network: R = 47 Ohms ± 20%.
C = .047 μF ± 10%

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual. Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany the manual. See Appendix B for details.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the high voltage actuator assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the high voltage actuator assembly as Option 115, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44431A, the shipping container should contain an actuator card, a terminal card and a grounding strap (see Figure 134).

For the Field Installation Kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a relay card or terminal card to -hp-, follow the shipping guidelines in Appendix B.

CAUTION

Before installing this assembly or connecting external circuits, a qualified, service-trained person should verify the electrical performance of the assembly by using the performance checks shown in the 3497A Plug-In Assemblies/3498A Extender Service Manual.

How to Install the High Voltage Actuator Assembly

WARNING

Before touching any installed assemblies or attempting to install the High Voltage Actuator assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The High Voltage Actuator assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

CAUTION

Do not connect external loads to the actuator, remove the internal contact protection network or change switching speeds of the actuator before reading CONFIGURING THE ASSEMBLY.

Figure 136 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING and CAUTION notes above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.

CONFIGURING THE ASSEMBLY

Before connecting loads to the actuator, you should consider three configuration requirements for the assembly: (1) Peak Voltage, Current and Volt-Amps; (2) Switching Speed and (3) Contact Protection.

Peak Voltage, Current and Volt-Amps

Do not connect loads which exceed the maximum ratings in the following table.

HIGH VOLTAGE ACTUATOR MAXIMUM RATINGS

	Voltage	Current	Volt-Amps
AC	250 VRMS	2A RMS	500 VA/Channel
DC	48V	2A	60 VA/Channel

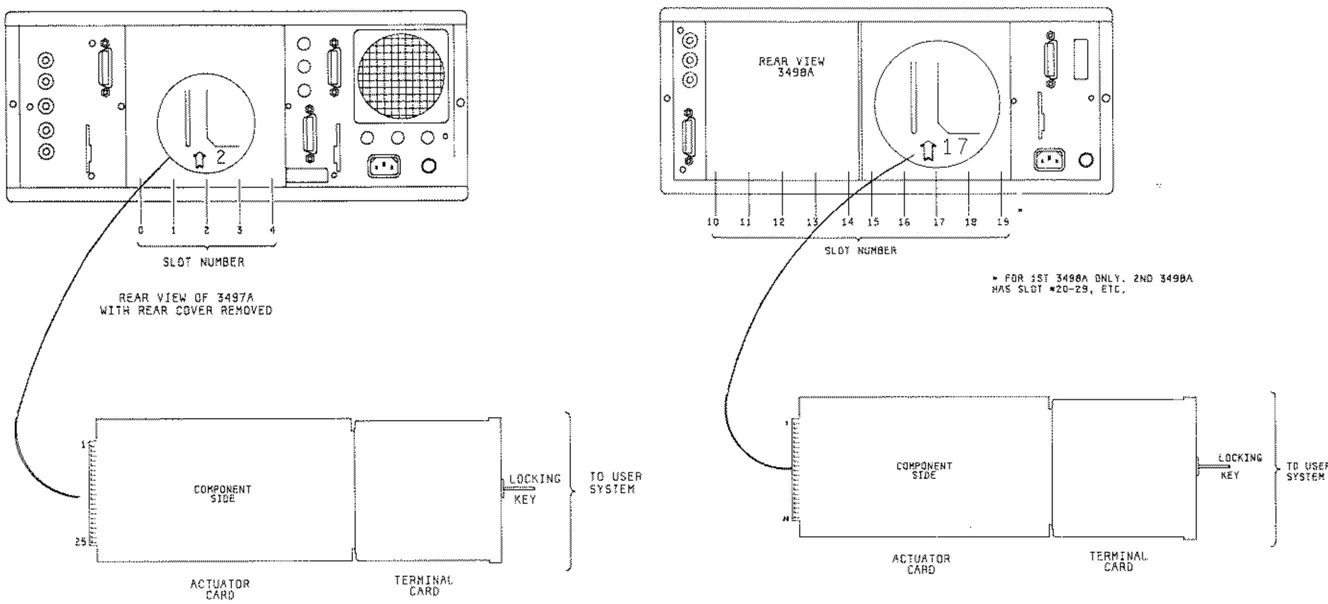


Figure 136. Option 115 - Installation in 3497A/3498A

Switching Speed

As factory configured, the actuator has a restriction on repetitive switching. Programming and execution of a single or multiple channel closure or open requires 40ms. However, repetitive changes of the same actuator assembly requires 1.5 sec between commands.

For example, if a command is sent at t=0 to an actuator in slot n (n = 0 to 7), the 3497A delays a subsequent command to this actuator for a minimum of 1.5 seconds. This restriction does not affect other assemblies and a command can be sent to an another slot immediately after the command to the slot n actuator.

If required for proper load operation, card operation can be changed to 25 operations/second (40 msec delay) by removing jumper JMP 9 on the actuator card. See Figure 137 for JMP 9 location. This change will allow high speed switching for all channels on the assembly.

CAUTION

With JMP 9 removed, high speed switching of heavy loads may not allow relays to dissipate enough heat and may greatly reduce relay lifetime.

Relay Contact Protection

An RC relay contact protection network (R = 47 ohms, C = 0.047 μF) is installed on each channel of the actuator for two reasons. First, when an inductive load is switched, if contact protection is not used, an arc can form across the contacts. This arc ionizes some of the contact material and reduces relay lifetime. Second, the arc generates RF interference which could cause the 3497A logic to malfunction.

For these reasons, do NOT remove the internal RC contact protection network unless the load meets ALL the following requirements: (1) load is resistive (noninductive); (2) load draws less than 400mA (the minimum arcing current of the high voltage actuator relays) and (3) load uses a supply voltage less than 300 V peak (212 V RMS).

With the contact protection network installed, maximum leakage current at 250V RMS and 60 Hz is 6 mA. If this current is too high AND the load meets the criteria above, the RC network can be removed by removing jumpers (JMP1-JMP8) for the channel(s) desired. Note that jumper JMP1 is associated with channel 0, JMP 2 with channel 1, etc. See Figure 137 for JMP1-JMP8 locations.

Connecting Loads to the Actuator

WARNING

A 6mA current can exist on the actuator and terminal card channels, even when the relays are open. This is a shock hazard. Do not touch any installed assemblies in the 3497A or 3498A before disconnecting all input power sources.

CAUTION

Do not connect loads without adequate contact protection, especially highly inductive loads with supply voltages over 100VAC. See RELAY CONTACT PROTECTION GUIDELINES for contact protection network design suggestions.

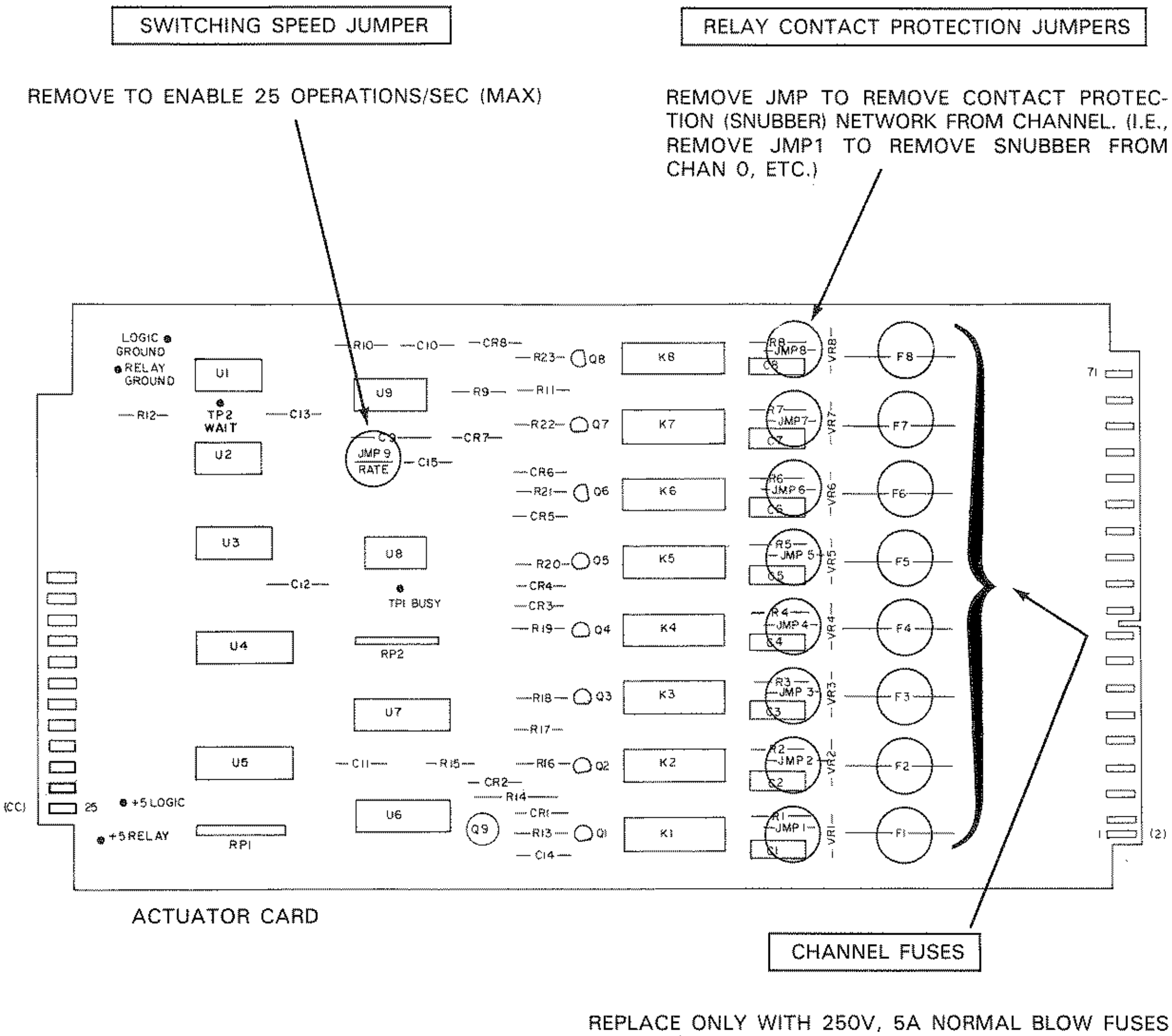


Figure 137. Option 115 · Relay Contact Protection/Speed Jumpers

After you have tested the actuator for proper operation and have established the assembly configuration for each load, connect the load lead-in wires to the terminal card connectors using the following steps. (The terminals can accommodate wire up to 12 gauge).

CONNECTING LOADS TO TERMINAL CARD

1. Turn off power to the 3497A and 3498A. If there are other assemblies in the 3497A or 3498A, disconnect all voltage sources before touching ANY assemblies. Remove all voltage and current sources from the 3497A and 3498A input/output terminals.

2. If the actuator assembly is installed in the 3497A or 3498A, remove the protective cover from the rear panel and turn the locking key counterclockwise to unlock the actuator assembly.

3. Remove the actuator assembly from the 3497A or 3498A. Separate the actuator and terminal card and remove the terminal card cover by loosening the 4 screws at the corners of the terminal card.

4. If any load requires higher switching speeds, disconnect jumper JMP9 on the actuator card to allow higher speed switching to all channels of the actuator assembly.

5. If any load requires that the internal contact protection be removed, remove the appropriate jumper(s) for the channel(s) involved. A jumper must be removed for each channel involved. (i.e., if loads to be connected to channels 0 and 4 require that the RC network be removed, remove jumpers JMP1 and JMP5 only).

6. If loads require additional contact protection, connect the network across the load, as close to the load terminals as possible.

7. Disconnect all voltage sources from the lead-in wires. Then, connect leads to desired terminal card channels and connect the ground strap from the CONNECT TO EARTH terminal to the customer ground as shown in Figure 138.

8. Reconnect the actuator and terminal cards and reinsert the actuator assembly into the 3497A or 3498A and replace the protective cover. Then connect your user inputs to lead-in wires.

RELAY CONTACT PROTECTION GUIDELINES

As discussed, the high voltage actuator assembly has an internal RC relay contact protection network (snubber) across the relay contacts in each of the eight channels. For many loads, this snubber network provides adequate relay protection.

However, for inductive loads or loads with high inrush currents (such as lamps, motors and capacitive loads), additional protection across the load may be required. These guidelines show how to determine the type of contact protection required and some sample protection networks.

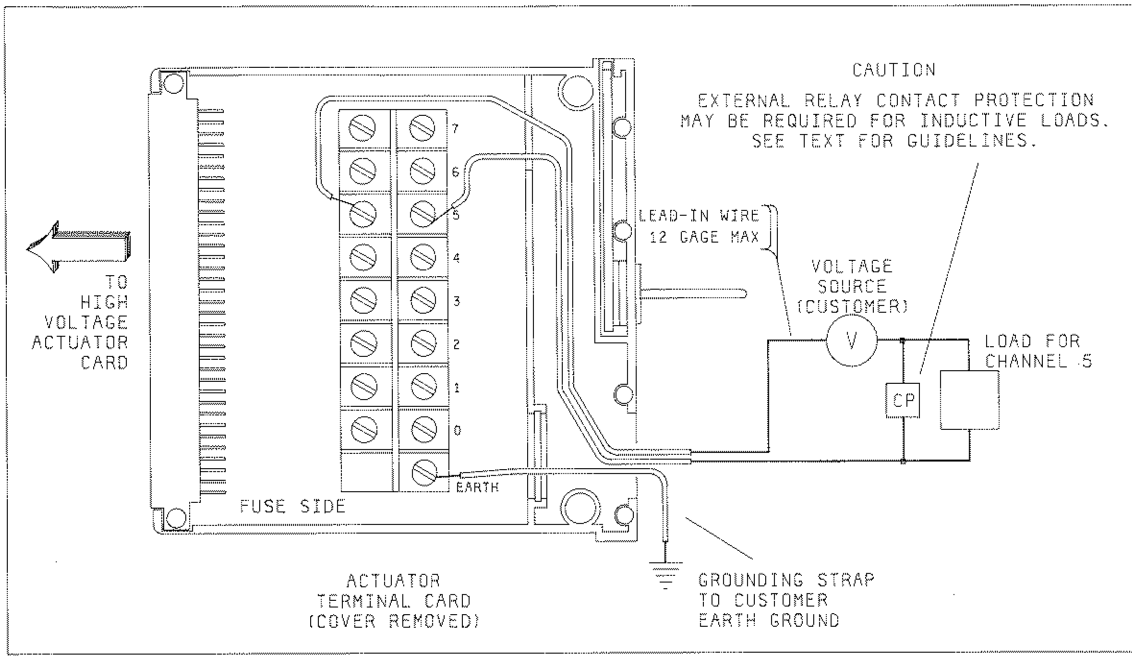


Figure 138. Option 115 - Connecting Loads to the Assembly

Contact Protection Fundamentals

Whenever relay contacts open or close, electrical breakdown can occur between the contacts which can cause high frequency radiation, voltage and current surges and physical contact damage. Two types of breakdown are important in switching contacts: glow discharge and metal-vapor or arc discharge.

Glow discharge occurs when the gas between the contacts is ionized. The voltage required to start a glow discharge between contacts depends on the gas, the gas pressure and the space between the contacts. After a glow discharge has been started, a slightly smaller voltage (about 300V in air) will keep the gas ionized. This voltage is approximately constant, regardless of the separation of the contacts.

An arc discharge starts whenever an energized contact is opened or closed. The minimum arcing voltage (Va) and arcing current (Ia) necessary to start an arc discharge depend on the type of relay contact material. Typical values range from Va = 9V, Ia = 400mA for gold alloy up to Va = 17.5V, Ia = 700 mA for platinum contacts. For the high voltage actuator, Ia = 400 mA.

After an arc discharge has been started, the arc must be broken as quickly as possible to minimize damage to the contacts. If it is not broken quickly, some material transfers from one contact to the other.

To minimize arc and glow discharge damage, certain loads may require that external (customer-supplied) contact protection networks be added. For the high voltage actuator, two parameters are important in determining if a load requires external protection networks: contact voltage (Vc) and contact current (Io).

For the high voltage actuator, the relay manufacturer has specified that acceptable relay lifetime can be achieved by keeping the contact voltage below 353V peak (252V RMS) and limiting contact current to 4 amps. Using these parameters, relay lifetime will be shortened from 10^8 operations down to 10^5 operations when heavy loads are switched, but this is still considered acceptable lifetime for normal operation.

NOTE

Although peak contact current is specified as 4 amps, do not connect loads for which the steady-state current exceeds 2 amps RMS (2.82 amps peak)

How to Determine Contact Protection Requirements

To determine if a proposed load requires external contact protection, it is first necessary to calculate Vc and Io. Then, if Vc > 353V peak OR if Io > 4 amps, external networks will usually be required for inductive loads.

To determine Vc and Io for a proposed load, refer to the circuit in Figure 139 which shows a typical inductive load connected to a battery through a switch S. Io is the current flowing just as the switch is opened and C is the total circuit capacitance. Vc is the contact voltage which would be produced across the switch if no arc discharge or glow discharge breakdown occurs.

The total circuit capacitance C is composed of the parallel capacitances of the snubber (Cact) and the wiring (Cwiring). Because the wiring capacitance is usually difficult to accurately determine, we'll use Cwiring ~ 0.053 μF. Since the capacitance of the snubber is Cact = 0.047 μF, C = 0.1 μF is assumed for this analysis.

Since Io is the peak current flowing with the contact closed (which shunts Ract), we can compute Io from:

$Io = V/R_L$	where V	=	peak value of source voltage
	R_L	=	load resistance

Once we know Io, we can calculate the contact voltage Vc from:

$Vc = Io \sqrt{L/C}$	where L	=	load inductance
	C	=	total circuit capacitance

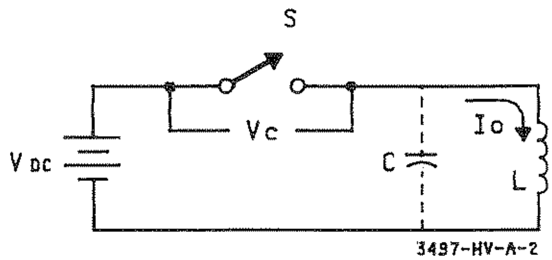


Figure 139. Option 115 - Contact Controlling Inductive Load

When Io and Vc are known, we can then determine load contact protection requirements, as summarized in the following chart where the types of loads are arbitrarily categorized as type 1, 2 or 3. Note that ONLY type 3 loads in which Vc > 353V peak OR Io > 4 amps require external contact protection (in addition to the snubber network).

If the proposed load meets type 3 requirements, see Designing External Contact Protection Networks for design samples. If the proposed load meets type 1 or 2 criteria, you don't have to add any networks and the actuator can be used as factory configured. To indicate the analysis method, some example solutions are shown for type 1, 2 and 3 loads. After you determine the type of load, refer to the appropriate section for details.

LOAD CONTACT PROTECTION CRITERIA

LOAD TYPE	PROTECTION REQUIRED	CRITERIA FOR LOAD	COMMENTS
1	NONE	Load is resistive, Vc < 353V peak AND Io < 400 mA.	Can remove the snubber network if required.
2	SNUBBER ONLY	Load is inductive, Vc < 353V peak AND Io < 4 A.	All three conditions must be met.
3	SNUBBER AND EXTERNAL NETWORK	Load is inductive, Vc > 353V peak OR Io > 4 A.	If either Vc or Io exceed limits, external network is required.
Note: Io = V(peak)/R_L and Vc = Io $\sqrt{L/C}$ where C = total circuit capacitance = 0.1 μF (assumed).			

Type 1 Load - No Contact Protection Required

No contact protection is required if the load is resistive (noninductive) and contact current Io is less than the minimum arcing current (Ia) of the relay contacts. For the high voltage actuator, since Ia = 400mA, no contact protection is required for resistive loads in which Io < 0.4A.

To compute Io, use Io = V/R_L (since L = 0 for a purely resistive circuit, Vc = 0). If Io < 400 mA, the load is type 1 and the internal snubber network can be removed if required. Note that Io is the peak current BEFORE the relay is opened, which shunts Ract so Ract is not used to calculate Io.

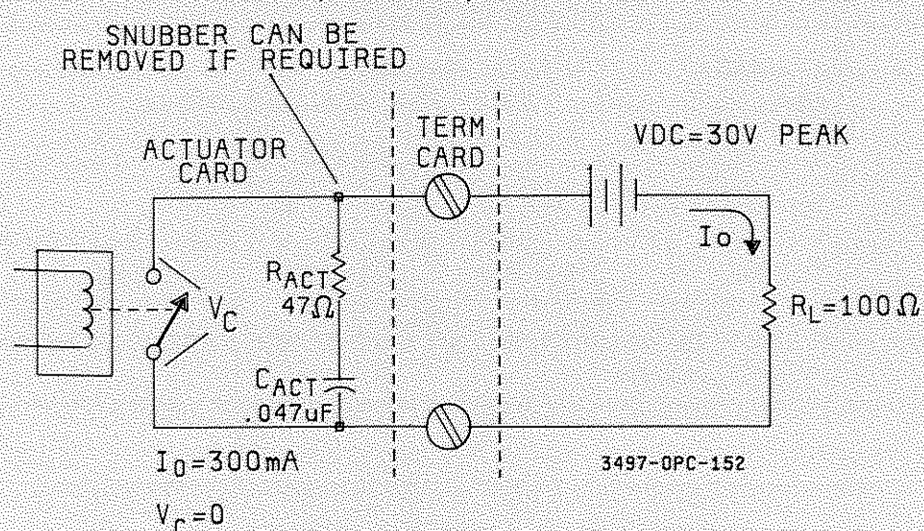
CAUTION

To protect against unwanted effects on the 3497A logic circuitry, do NOT remove the snubber network unless absolutely necessary.

EXAMPLE - TYPE 1 LOAD

This example shows a load which meets the criteria for a type 1 load. A purely resistive load of 100 ohms is connected to a channel of the actuator and a 30 volt DC power supply is used as the source voltage.

To determine that this a type 1 load, compute Io = V/R_L = 30/100 = 300 mA. For a resistive load, since L = 0, Vc = Io $\sqrt{L/C}$ = 0. Since Io = 300 mA is less than Ia = 400 mA, the load meets the criteria for type 1 and no contact protection is required. However, leave the snubber network in unless absolutely necessary to remove it.



TYPE 1 LOAD CONNECTED TO THE ACTUATOR

Type 2 Load - Snubber Network Only Required

The majority of loads fall into type 2 where the snubber network in the actuator provides adequate contact protection. To determine if a proposed load meets the criteria for type 2, compute Io from $Io = V/R_L$. The total circuit capacitance C = Cact + Cwiring. Since we assumed Cwiring ~ 0.05 μF and since Cact = 0.047 μF, we'll use C = 0.1 μF and compute Vc from:

$$Vc = Io \sqrt{L/C} = Io \sqrt{L/0.1 \times 10^{-6}}$$

For an inductive load if Io < 4 A AND Vc < 353V peak, the snubber network provides adequate contact protection and no external network is required.

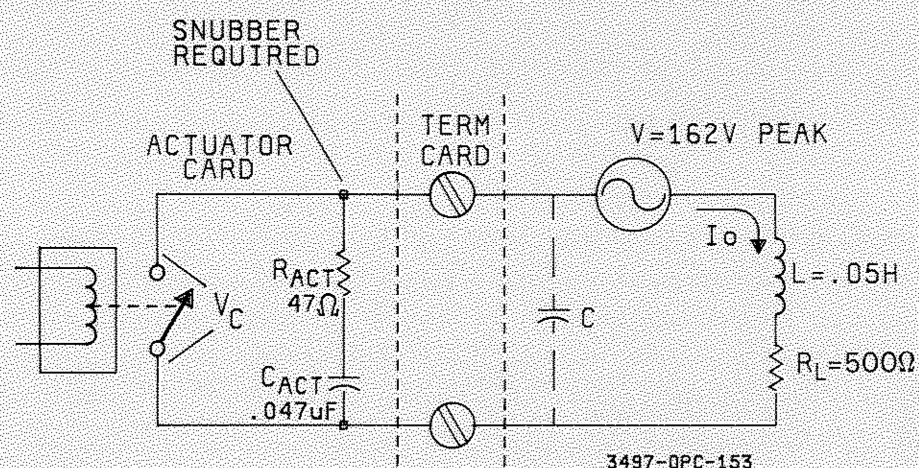
EXAMPLE - TYPE 2 LOAD

This example shows a load with R_L = 500 ohms, L = 0.05H and V = 115 volts (162 volts peak). For C = 0.1 μF,

$$Io = V/R_L = 162\ V/500\ ohms = 0.32\ A = \underline{320\ mA}$$

$$Vc = Io \sqrt{L/C} = (0.32) \sqrt{0.05/0.1 \times 10^{-6}} = \underline{226\ v}\ peak$$

Since this load meets all three criteria for type 2 loads (inductive, Io < 4 A and Vc < 353 V peak), the snubber network provides adequate protection and an external contact protection network is not needed.



I_0=320mA

V_C=226V PEAK (FOR C=.1uF)

TYPE 2 LOAD CONNECTED TO THE ACTUATOR

Type 3 Load - External Contact Protection Required.

As mentioned, the vast majority of loads require no external contact protection network. However, for an inductive load if Io > 4 Amps OR Vc > 353V peak, contact protection across the load - in addition to the snubber network - is necessary.

To determine if a load requires additional contact protection, first compute Io from $Io = V/R_L$ and compute $Vc = Io \sqrt{L/C}$. As with type 1 or 2 loads, we'll assume a total circuit capacitance of 0.1 μF.

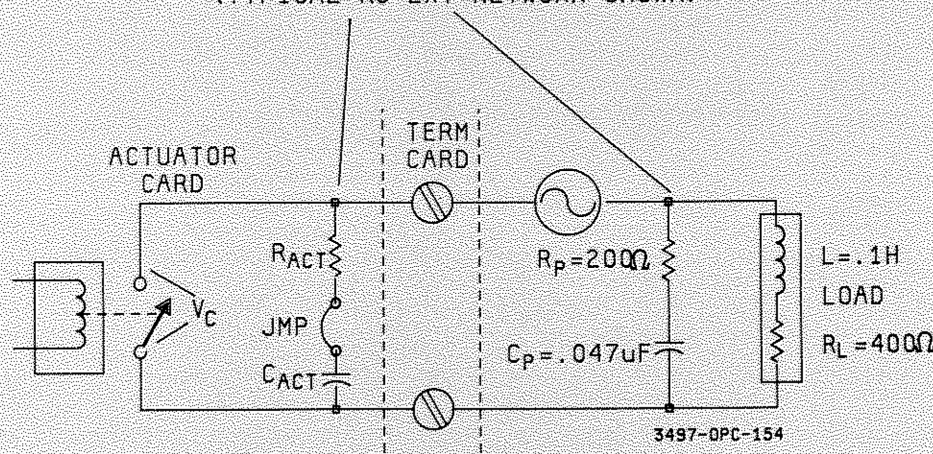
EXAMPLE - TYPE 3 LOAD

This example shows a load with 0.1H inductance and 400 ohms resistance which is operated from a 120V AC line (170 volts peak). For this load, $Io = V/R_L = 170/400 = 0.425$ A. With C = 0.1 μF assumed:

$$Vc = (0.425)\sqrt{0.1/0.1 \times 10^{-6}} = \underline{425\ V}\ \text{peak.}$$

Since Io > 400 mA and Vc > 353 volts peak, this is a type 3 load and requires contact protection across the load contacts in addition to the snubber network. The next step is to design an appropriate contact protection network as shown in the following section.

SNUBBER AND EXTERNAL C/P REQUIRED
(TYPICAL RC EXT NETWORK SHOWN)



CIRCUIT PARAMETERS IF EXTERNAL
C/P NOT ADDED:
I_O=.425A
V_C=425V PEAK

TYPE 3 LOAD CONNECTED TO ACTUATOR

Designing External Contact Protection Networks

After establishing that the load is type 3 and thus requires additional contact protection, the next step is to design an appropriate contact protection network. Although many types of networks can be used, guidelines for design of RC, diode and Zener diode protection networks are described.

RC Network

In designing RC networks, the protection resistor Rp is selected as a compromise between two values. The minimum value of Rp is determined by the maximum acceptable relay contact current (Io) of 4 amps. Thus, the mimimum value of Rp is V/4, where V is the peak value of the supply voltage. The maximum value is Rp is usually made equal to the load resistance, R_L. So, the limits on Rp are: $V/4 < Rp < R_L$.

To select a value for the protection network capacitor, Cp, first compute the total circuit capacitance C desired when the protection network is added. Then, Cp can be computed from C = Cact + Cwiring + Cp. For the high voltage actuator, C must be such that the peak voltage across the relay contacts does not exceed 353 V. To compute the value of C required, use:

$$C \geq (Io/353)^2 L$$

where L = load inductance, Io is the current through L just before the relay contacts open and C is the total circuit capacitance.

EXAMPLE - RC CONTACT PROTECTION NETWORK

For example, let's take another look at the type 3 load example discussed previously and see what the values of a typical RC protection network might be. The original circuit without contact protection is shown as (a). Recall that even with the snubber network the peak contact voltage Vc of 425 V exceeded 353V and thus additional contact protection was required.

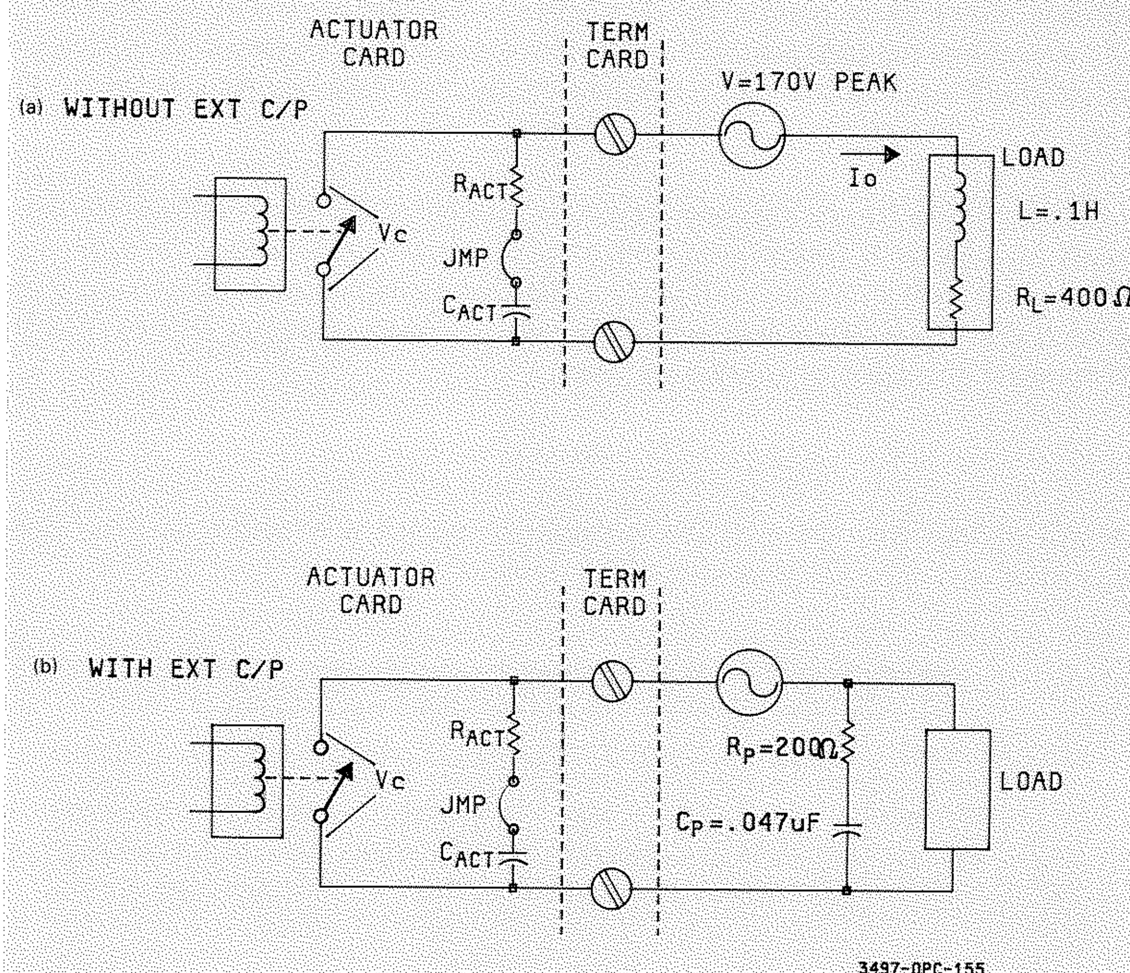
To keep the maximum contact current below 4 amps, set Rp (min) = V/4 = 170/4 = 42.5 ohms. Set Rp (max) equal to the load resistance of 400 ohms. To keep the peak contact voltage below 353V peak, the total circuit capacitance C is calculated from:

$$C \geq (Io/353)^2\,(0.1) = (0.425/353)^2\,(0.1) = 0.144\ \mu F$$

If we assume that the wiring capacitance is about 0.05 μF, we can compute the required value of Cp from:

$$Cp = C - (Cact + Cwiring) = 0.144 - (0.047 + 0.05) = 0.047\ \mu F$$

Since Rp can vary between 42.5 ohms and 400 ohms, an appropriate network to be connected across the load is Rp = 200 ohms, Cp = 0.047μF as shown in (b). Naturally, other combinations within these ranges can be used as long as the peak current and contact voltage limits for the actuator are not exceeded.



	I_0	V_C
WITHOUT EXT C/P	.425A	425V PEAK
WITH EXT C/P	1.3A	353V PEAK

Diode Protection

The RC contact protection network can be used for both AC and DC sources. If a DC voltage source is used, diode protection as shown in Figure 140 can also be used. When the switch is closed, no current flows through the diode. When the contact opens, the inductor voltage polarity is opposite to the DC source polarity.

This forward biases the diode and limits the transient voltage across the inductor to a very low value (the forward voltage drop of the diode plus any IR drop in the diode). Therefore, the voltage drop across the opening contact is approximately equal to the supply voltage.

The diode circuit is very effective in suppressing transient voltages, but the time required for the inductor voltage to decay is longer than with the RC circuit, which may cause operational problems. For example, if the inductor is a relay, its release time is increased. A small resistor can be added in series with the diode which will decrease the release time but will give a higher transient voltage.

The diode used must have a voltage rating greater than the maximum supply voltage and the diode current rating must be greater than the maximum load current. If the relay contacts operate only occasionally, the peak current rating can be used. If the contacts operate several times per minute, use the continuous current rating of the diode.

Zener Diode Protection

Another protection network which can be used in the Zener Diode arrangement is also shown in Figure 140. The Zener network is useful for an AC supply or for circuits which must operate from two DC polarities, especially when the load current, Io, exceeds the minimum relay arcing current of 0.4 amps.

Each Zener must have a voltage breakdown rating greater than the peak value of the supply voltage and a current rating equal to or greater than the maximum load current. For example in the sample load described for RC contact protection networks above, if Zener Diodes were used instead of the RC network, the Zeners must have voltage ratings greater than 170 volts and current ratings greater than 0.5 amps.

Diode Protection

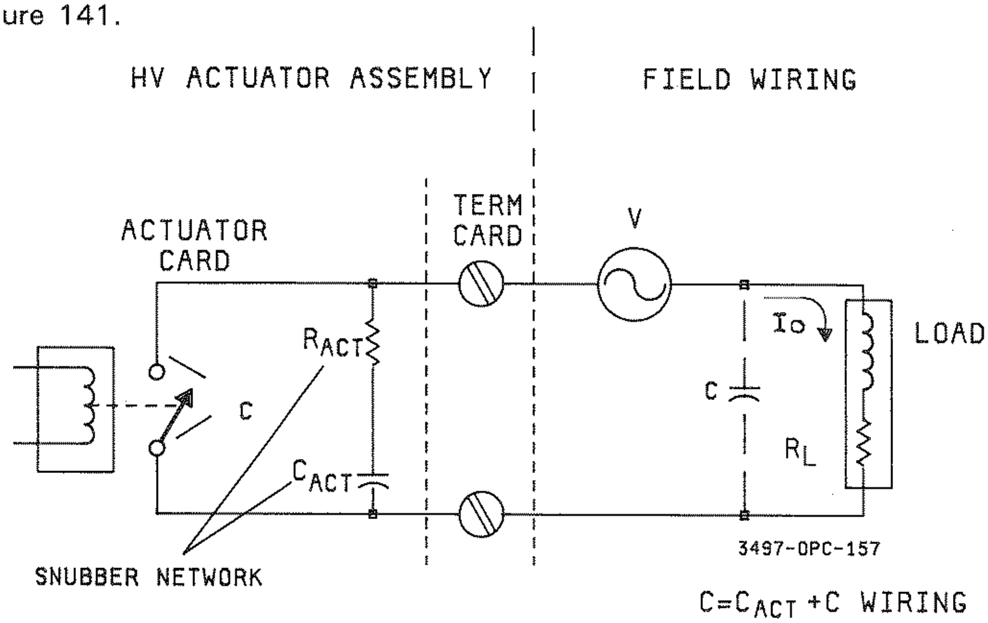
Note: For DC Source E **only**.

Zener Diode

Note: For AC or DC Source.

Figure 140. Option 115 - Diode/Zener Diode Protection Networks

For a summary of the three load types and definitions of circuit parameters, see Figure 141.



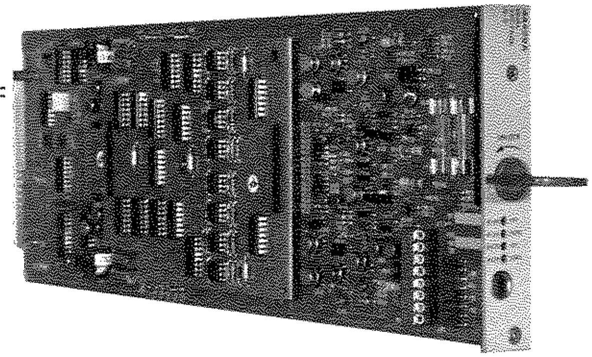
LOAD TYPES

Type	Load	Circuit Parameters $Io = V/R_L$, $Vc = Io\sqrt{L/C}$	Protection Required	Comments
1	Resistive	$Io < Ia = 0.4A$ AND $Vc < 353V$ peak	None	All three conditions must be met for Snubber to be removed.
2	Inductive	$Io < 4A$ AND $Vc < 353V$ peak	Snubber Only	BOTH Io, Vc condition must be met for Snubber only.
3	Inductive	$Io > 4A$ OR $Vc > 353V$ peak	Snubber plus external network	If EITHER $Io > 4A, Vc > 353$ peak, external network required.

Figure 141. Option 115 - Relay Contact Protection Summary

Reference: H. W. Ott: "Noise Reduction Techniques in Electronic Systems", John Wiley & Sons, Inc., New York, 1976.

OPTION 120



Dual Output, 0 to ± 10 V Voltage D/A Converter

INTRODUCTION

The Option 120 assembly consists of two 0 to ± 10 volt programmable voltage sources (two channels). Each channel outputs a DC voltage with programmable range from -10.2375 volts to +10.2375 volts in increments of 2.5 millivolts.

Each voltage source is isolated from the other and from ground which breaks possible ground loops and permits control of devices floated up to 170 volts above ground. You can use the Option 120 assembly to provide a programmable test stimulus or to control voltage programmed devices like power supplies and VCOs.

Description

As shown in Figure 142, the Option 120 Voltage D/A Converter consists of a single board with a voltage source terminal block and a piggy-back board. The voltage source terminal block has connectors for HI, LO, +SENSE and - SENSE for each of two channels (channel 0 and channel 1).

The assembly is a programmable constant-voltage source which has an output range from -10.2375 V to +10.2375 V in 2.5 mV increments. This means that (for example), if you program the assembly to output +5.0000 V to your load, +5.0000 V will be available at the load, regardless of lead resistance or other voltage drops between the assembly and the load when the SENSE feature of the assembly is used.

Remote Sensing

The remote sensing feature of the voltage D/A converter is especially valuable when a constant, accurate voltage is required at the load. To see why this is so, consider the simplified circuit in Figure 143 (a) which does not use sense leads.

In this circuit, we've programmed the Option 120 assembly (which we'll call the VDAC from now on) to output +1.0000 V to a load resistance R_l. However, because of lead resistance R_l, the actual voltage to R_L is less than 1.0000 V because of the voltage drop across the leads.

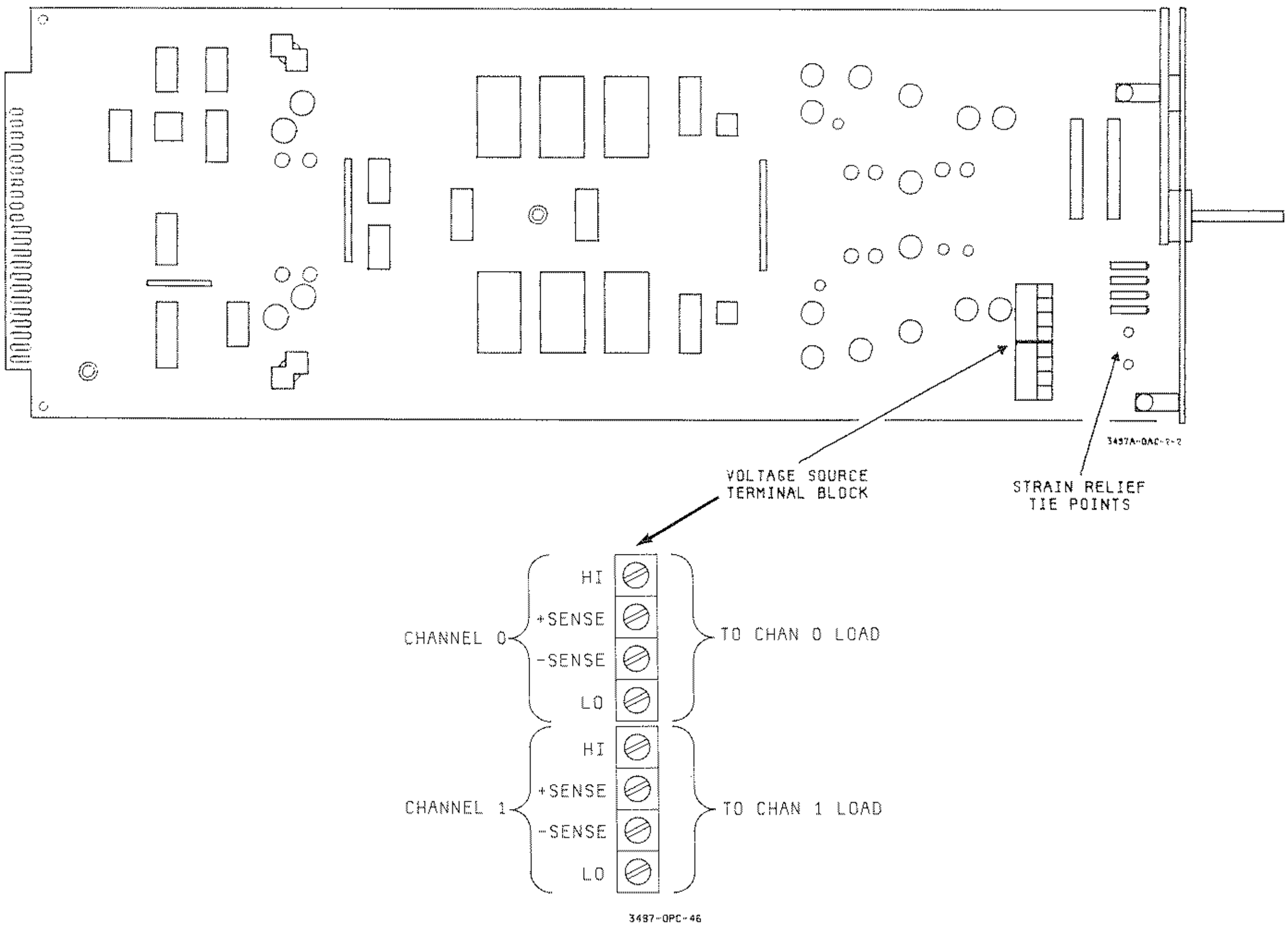


Figure 142. Option 10 - Dual Output, 0 to ± 10 V Voltage D/A Converter (VDAC)

Now, if we add remote sensing (+ SENSE and - SENSE leads) as shown in Figure 143 (b), we can measure the actual voltage across R_L. With remote sensing, the VDAC automatically adjusts the output to compensate for the IR drop in the leads. Thus, for example, if you now program the VDAC for a +1.0000V output and the IR drop in the leads is 0.1000 V, the VDAC will output +1.1000V so that the load voltage remains constant at +1.0000V.

Monotonicity

Another important feature of the VDAC is monotonicity. The VDAC has monotonicity over its operating range which guarantees that the output will never change in a direction different than that programmed. For example, if the VDAC is set for a 5 mV output and is then programmed for a 10 mV output, the actual output will not be less than 5 mV. Or, if the VDAC is set for 5 mV and is then programmed for a 2.5 mV output, the actual output will not be greater than 5 mV.

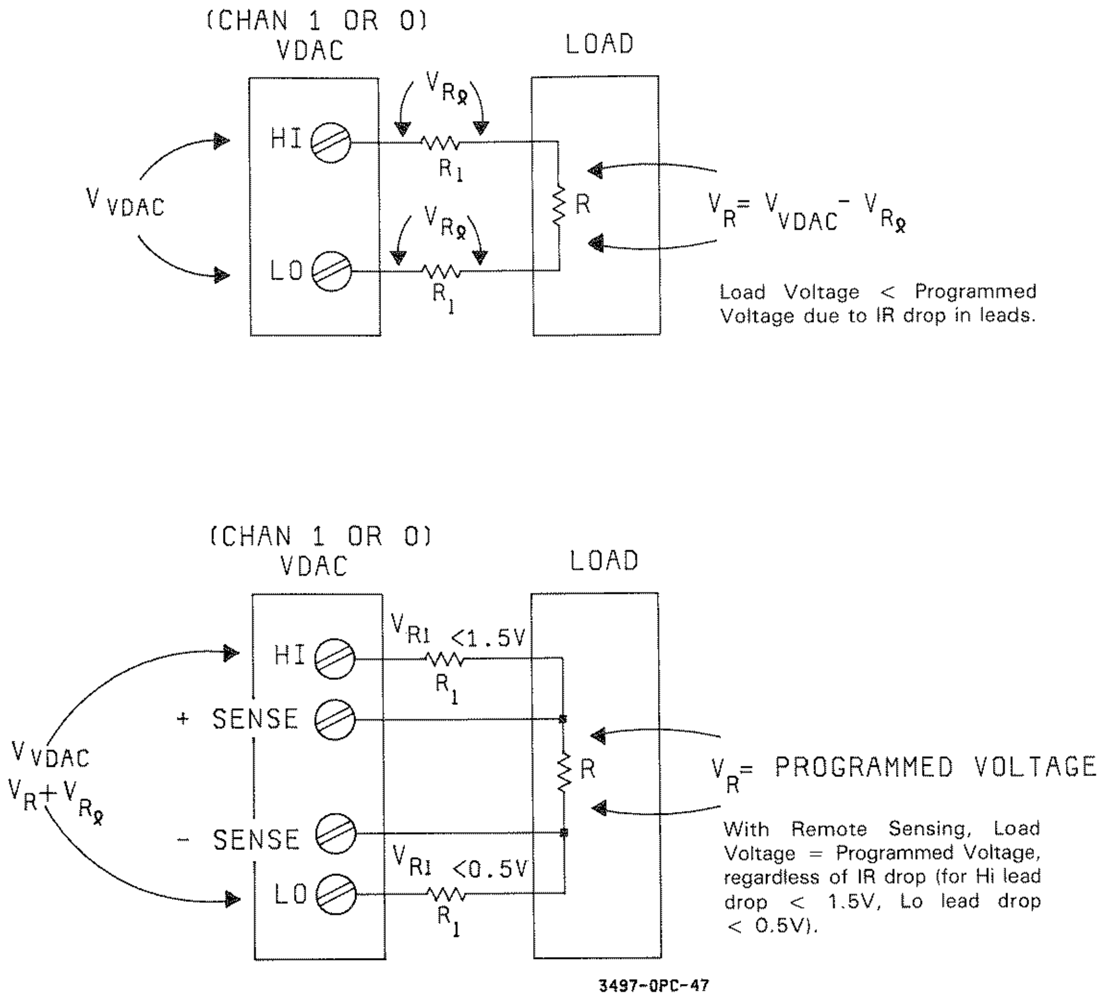


Figure 143. Option 120 - VDAC Remote Sensing

Simplified Operation

To operate the VDAC, only one command AO slot#,chan#,value is required. In this command, slot# refers to the slot in which the assembly is located, chan# refers to the channel to be output (0 or 1) and value is a digital value which programs the VDAC for a specific output. For example, AO 3,0,160 programs a VDAC in slot 3 to output +0.160 V from channel 0.

Specifications

Specifications for the VDAC assembly follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 120
DUAL OUTPUT, 0 TO ± 10V VOLTAGE D/A CONVERTER

Output: 13 bits including polarity

Least Significant Bits: 2.5 mV

Output Range: -10.2375 V to +10.2375 V

Accuracy: (Using remote sense)
24 Hours,
23°C ± 1°C: ± .024% of programmed value ± 2.8 mV
90 Days,
23°C ± 5°C: ± .070% of programmed value ± 4.0 mV

Temperature Coefficient: (0-18°C, 28-50°C) ± .0045% of programmed value/°C ± 100 μV/°C

Ripple and Noise: 2.5 mV rms, 20 Hz to 250 kHz into 1 kΩ

Load Regulation: 600 μV(0-15 mA)

Maximum Output Current: 15 mA (output within specifications)

Short Circuit Current: (maximum) 50 mA

Maximum Voltage Drop in Source Leads Using Remote Sense:
Low Lead: .5 V
High Lead: 1.5 V

Monotonicity: Over operating range (Monotonicity guarantees that the output will never change in a direction different than that programmed)

Settling and Programming Time: (Using 9835A Computer, 3497A DVM in Trigger Hold, R(L) = 1 kΩ, C(L) = 1000 pF)
To within ± 1.0 mV of final value: 100 ms

Isolation: > 170 V peak between any terminal and chassis

Protection: Can withstand indefinite open or short circuit

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual. Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany this manual. See Appendix B for details.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the Voltage D/A Converter assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the Voltage D/A Converter assembly as Option 120, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44429A, the shipping container should contain a converter card with a piggyback card attached (see Figure 142).

For the Field Installation Kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return an assembly to -hp-, follow the shipping guidelines in Appendix B.

CAUTION

Before installing this assembly or connecting external circuits, a qualified, service-trained person should verify the electrical performance of the assembly by using the performance checks shown in the 3497A Plug-In Assemblies/3498A Extender Service Manual.

How to Install the Voltage D/A Converter Assembly

WARNING

Before touching any installed assemblies or attempting to install the Voltage D/A Converter assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The Voltage D/A Converter assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the assembly. Handle the voltage card by its edges and do not subject the components to static discharges or excessive voltages.

Figure 144 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING and CAUTION notes above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.

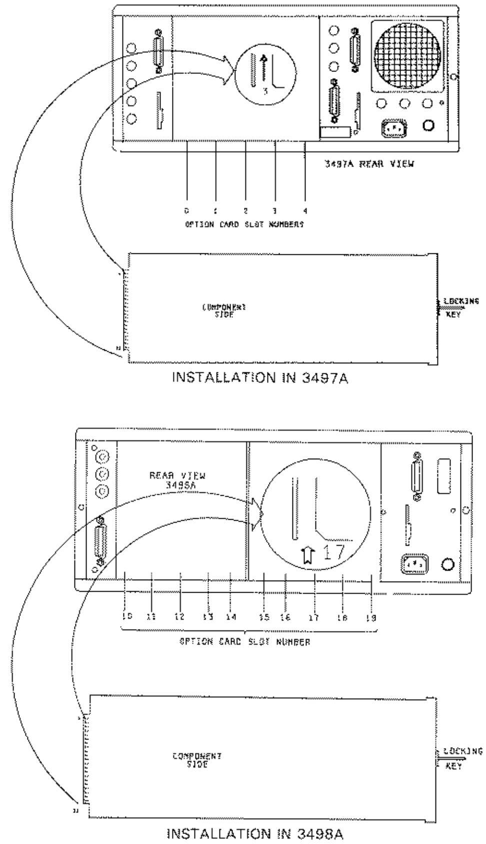


Figure 144. Option 120 - Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

To configure the assembly for operation, simply connect the HI and LO load connectors and the +SENSE and - SENSE connectors (if desired) on the assembly to your load. The VDAC has connectors for two optically isolated channels, so you can provide inputs to two separate loads simultaneously.

This section shows how to connect the assembly to a typical resistive load. Since the channels are optically isolated, you can control devices which are floated up to 170 volts above ground. To begin, we'll list some connection considerations.

Connection Considerations

WARNING

To avoid personnel injury or equipment damage, disconnect the 3497A and 3498A line cords and ALL voltage sources from these instruments before installing or removing assemblies. External circuits connected to the Option 120 assembly must not be floated more than 170 volts above ground.

Before connecting loads to the assembly, it is important to select proper wire type, size and length for your application and to properly connect the SENSE lines for accurate load voltages. Even the shortest leads can degrade the VDAC performance because of the IR drop in the leads.

For example, approximately 15 feet of 22 AWG wire has a resistance of 0.242 ohms. At the full (15 mA) output of the VDAC, this results in a 3.63 mV voltage drop which is more than 1 LSB. If this drop is not compensated, it results in an error in the load voltage.

For this reason, it is important to connect the SENSE leads to the load so that the VDAC output can be automatically adjusted to compensate for errors due to lead resistance. Some considerations for connecting the SENSE leads and a wire chart are shown in Figure 145.

The SENSE leads (+SENSE and - SENSE) should be applied as close as possible to the point where the voltage is to be measured. Also, the voltage drop in the HI source line should not exceed 1.5V and the voltage drop in the LO source line should not exceed 0.5V. To achieve specified voltage regulation, the HI lead resistance should not exceed 100 ohms and the LO lead resistance should not exceed 50 ohms.

Although the load leads are shown as straight lines (for clarity), some immunity from stray magnetic field pickup can be achieved by twisting each pair of HI (+) and LO (-) leads.

NOTE

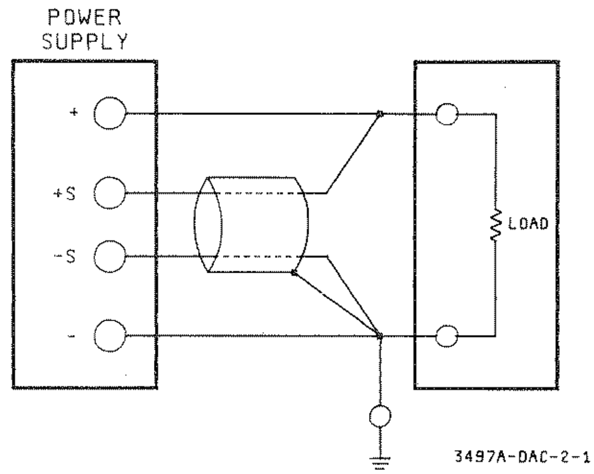
If sensing is not used, +SENSE should be connected to HI and -SENSE should be connected to LO at the terminal block. If this is not done, voltage output errors may occur.

If a shield is used for the SENSE lines, do not use the shield as one of the sensing conductors. Also, one end of the shield should be tied to the low side of the load and the other end left unconnected. In general, it is desirable to connect the shield as close as posssible to the low side of the load, as shown in Figure 145.

AWG (B&S) Wire Size	Annealed Copper Resistance at 20°C milliohms/ft.	Nominal Current Rating (amps)*
22	16.1	5
20	10.2	7
18	6.39	10
16	4.02	13
14	2.53	20
12	1.59	25
10	0.999	40
8	0.626	55
6	0.395	80
4	0.249	105
2	0.156	140
0	0.0993	195
00	0.0779	260

* Single Conductor in Free Air at 30°C with rubber or thermoplastic insulation.

WIRE CHART



Remote Sensing Connnections.

One end of the shield should be connected to a ground reference and the other end should be left unconnected. In nearly all cases this method of connecting the sensing shield will minimize ripple at the load terminals. However, in rare cases a different ground return point of this shield is preferable - it is important in such cases to experimentally verify that this relative advantage applies under all possible combinations of load and line.

Figure 145. Option 120 - Connection Considerations

Connecting Loads to the VDAC

After deciding on the wire size, type and length, to connect loads to the VDAC, route the wires as shown in Figure 146 which shows connections for both channel 0 and channel 1. Then, install the assembly in a desired slot in the 3497A or 3498A. If strain relief for lead wires is needed, use a tie wrap to secure the wires to the board at the strain relief points (see Figure 146).

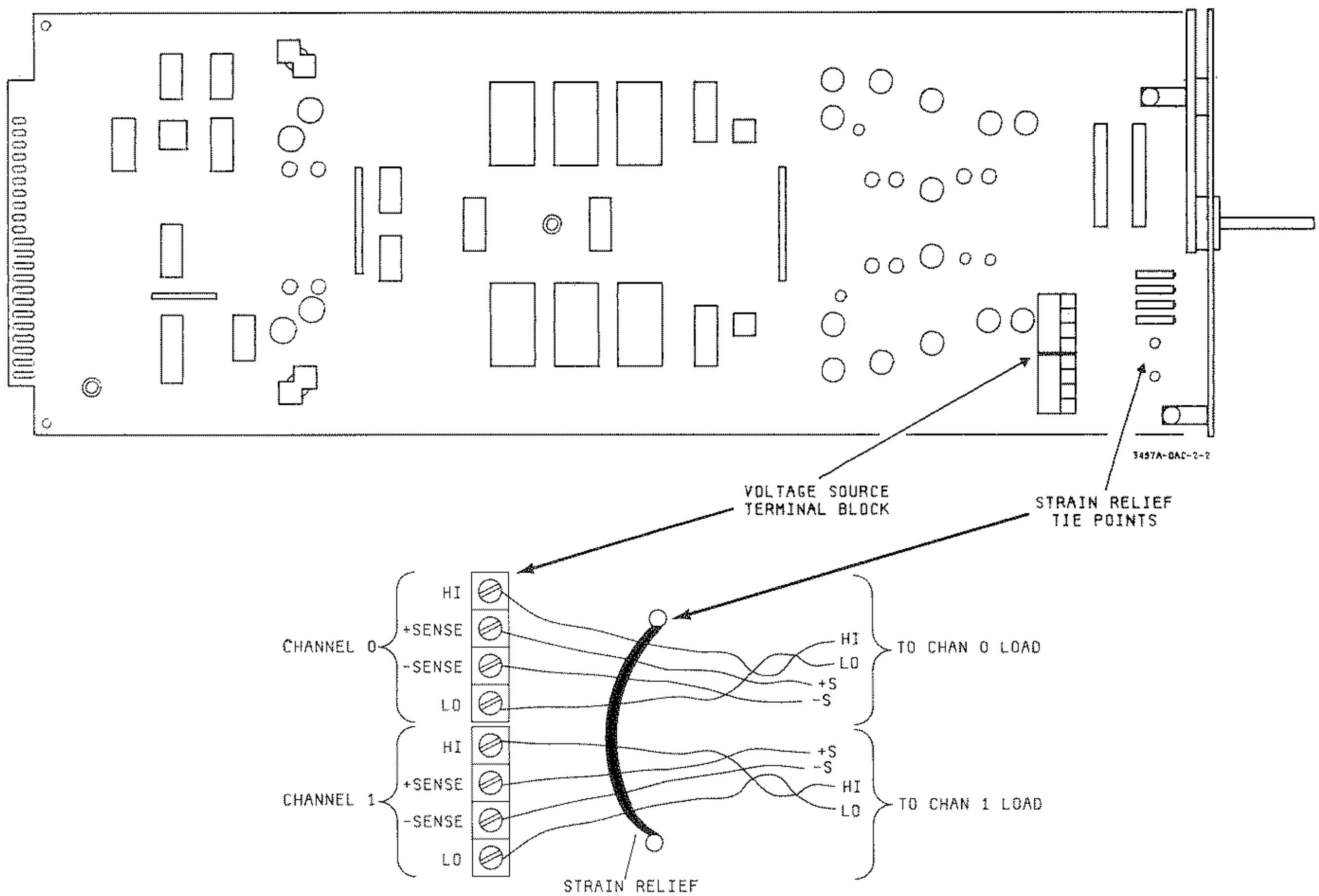
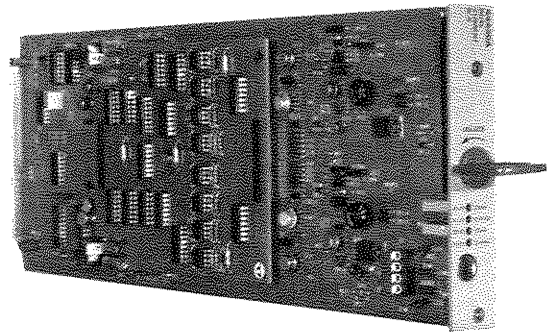


Figure 146. Option 120 - Connecting Loads to the VDAC

OPTION 130



Dual Output, 0-20 mA/ 4-20 mA Current D/A Converter

INTRODUCTION

The Option 130 assembly provides two 0 - 20 mA or 4 - 20 mA programmable current sources. Each channel outputs a DC current with programmable range from 0 to 20.475 mA in 5 μA increments (for the 0-20 mA range) or from 4 to 20.380 mA in 4 μA increments (for the 4-20 mA range).

Each current source is isolated from the other and from ground which breaks possible ground loops and permits control of devices floated up to 170 volts above ground. Each source can be configured to operate in the 0-20 mA or 4-20 mA range.

Option 130 assemblies, especially when the 4 - 20 mA range is used, can be used as transmitters in an industrial current loops. Each output will drive an industrial current loop with up to 600 ohms of total loop resistance.

Description

As shown in Figure 147, the Option 130 Current D/A Converter consists of a single board with a current source terminal block and a piggy-back board. The current source terminal block has connectors for a current source (SOURCE) and current sink (SINK) for each of two channels (channel 0 and channel 1).

The assembly is a programmable constant current source which has an output range from 0 to 20.475 mA (in the 0-20 mA range) or from 4 to 20.380 mA (for the 4-20 mA range). For example, if you program the assembly to output 10.000 mA to the load, 10.000 mA will be available at the load (regardless of load voltage drop) as long as the assembly compliance voltage of 12V is not exceeded.

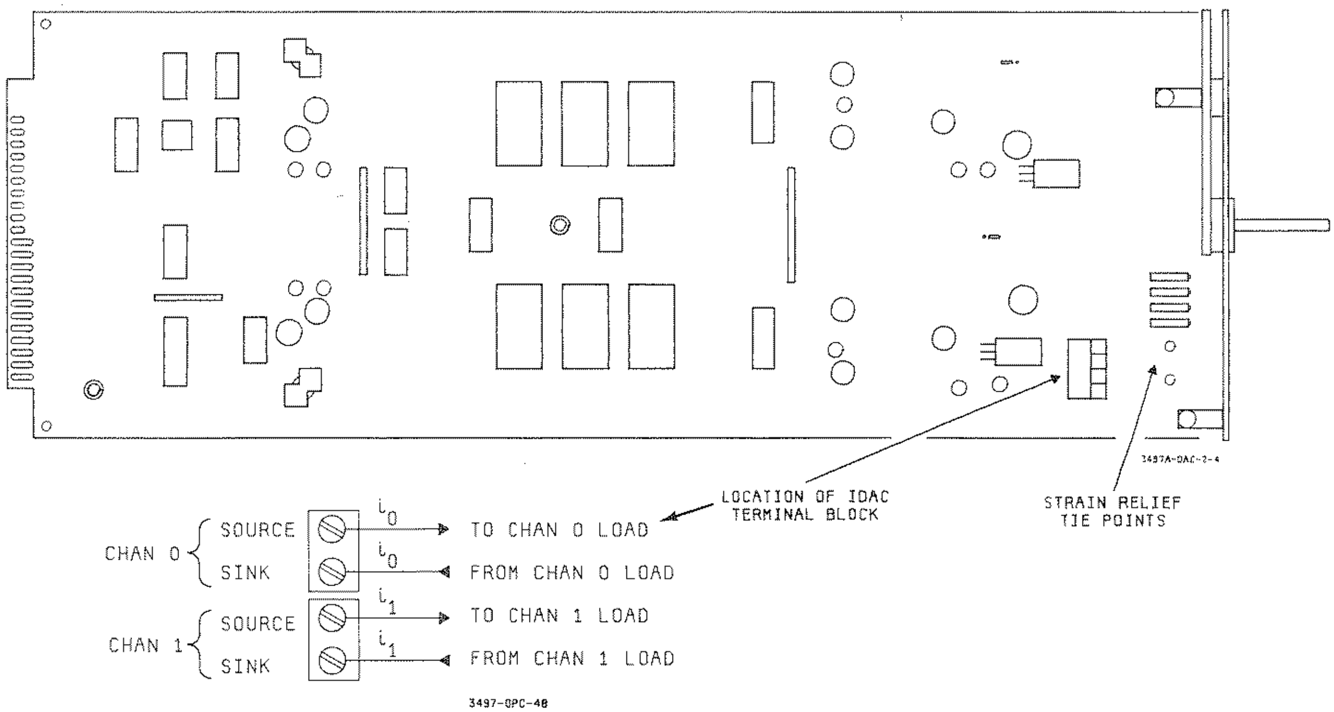


Figure 147. Option 130 - Current D/A Converter (IDAC)

Compliance Voltage

The Option 130 assembly (which we'll call the IDAC from now on) is a constant current source for 0-20 mA range, as long as the compliance voltage of 12 volts is not exceeded. As shown in Figure 148, this means that the total voltage between the SOURCE and SINK terminals must not exceed 12 volts for the IDAC to supply constant current in the 0 - 20 mA range.

Since the compliance voltage equals the total circuit resistance times the output current, for a 20 mA output the maximum load resistance for the IDAC is 600 ohms and may be less if lead resistance is relatively high.

For example, in Figure 148 if R_l = lead resistance = 0.5 ohms in each lead and load resistance R_L = 600 ohms, the total circuit resistance = 601 ohms. Thus, compliance voltage for 20 mA is 12.2V which exceeds the IDAC limit.

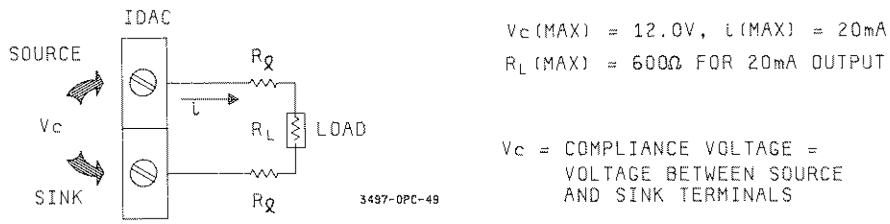


Figure 148. Option 130 - IDAC Compliance Voltage

Monotonicity

Another important feature of the IDAC is monotonicity. The IDAC has monotonicity over its operating range which guarantees that the output will never change in a direction different than that programmed. For example, if the IDAC is set for a 5 mA output and is then programmed for a 10 mA output, the actual output will not be less than 5 mA. Or, if the IDAC is set for 5 mA and is then programmed for a 2 mA output, the actual output will not be greater than 5 mA.

Simplified Operation

To operate the IDAC, only one command [AO slot#,chan#,value] is required. In this command, slot# refers to the slot in which the assembly is located, chan# refers to the channel to be output (0 or 1) and value is a digital value which programs the IDAC for a specific output, depending on the range (0-20 mA or 4 - 20 mA) selected.

For example, AO slot#,chan#,160 sets the IDAC for a constant current output of 4.256 mA for the 4-20 mA range, but sets the IDAC for an output of 0.160 mA in the 0-20 mA range. The IDAC is factory-set for the 0-20 mA range but can be jumper-enabled for 4-20 mA range on either or both channel 0 or 1.

Specifications

Specifications for the IDAC assembly follow. Specifications are performance standards, or limits, against which the assembly may be tested.

OPTION 130
DUAL OUTPUT, 0-10 mA/4-20 mA CURRENT D/A CONVERTER

Analog Output: 12 bits

Least Significant Bit: 5 μA (0-20 mA range)
4 μA (4-20 mA range)

Output Current Range: 0 to 20.475 mA or 4 to 20.380 mA (each source jumper selectable)

Accuracy:
24 Hours,
23°C ± 1°C: ± .03% of programmed value ± 6.5 μA
90 Days,
23°C ± 5°C: ± 0.07% of programmed value ± 10.0 μA

Temperature Coefficient (0-18°C, 28-50°C):
± .0075%/°C of programmed value ± 650 nA/°C

Ripple and Noise: 5 μA rms, 20 Hz to 250 kHz into 100 ohms

Compliance Voltage: 12.0 volts

Load Regulation: ± 2.0 μA (2.0 V to 12.0 V)

Monotonicity: Over operating range (Monotonicity guarantees that the output will never change in a direction different than that programmed)

Settling and Programming Time: (Using 9835A Computer, 3497A DVM in Trigger Hold, R(L) = 100 Ω)
To within ± 3.0 μA of final vlaue: 100 ms

Isolation Voltage: > 170 V peak between any terminal and chassis

Protection: Can withstand indefinite open or short circuit

Manual Information

This manual contains configuration and control information for this assembly. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual. Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany this manual. See Appendix B for details.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the Current D/A Converter assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the Current D/A Converter assembly as Option 130, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44430A, the shipping container should contain a converter card with a piggy-back card attached (see Figure 147).

For the Field Installation Kit, if either card is missing or if there is mechanical damage or defect to the cards, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return an assembly to -hp-, follow the shipping guidelines in Appendix B.

CAUTION

Before installing this assembly or connecting external circuits, a qualified, service-trained person should verify the electrical performance of the assembly by using the performance checks shown in the 3497A Plug-In Assemblies/3498A Extender Service Manual.

How to Install the Current D/A Converter Assembly

WARNING

Before touching any installed assemblies or attempting to install the Current D/A Converter assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The Current D/A Converter assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

CAUTION

Use clean handling techniques when installing, removing or reconfiguring the assembly. Handle the cards by the edges and do not subject the components to static discharges or excessive voltages.

Figure 149 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING and CAUTION notes above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.

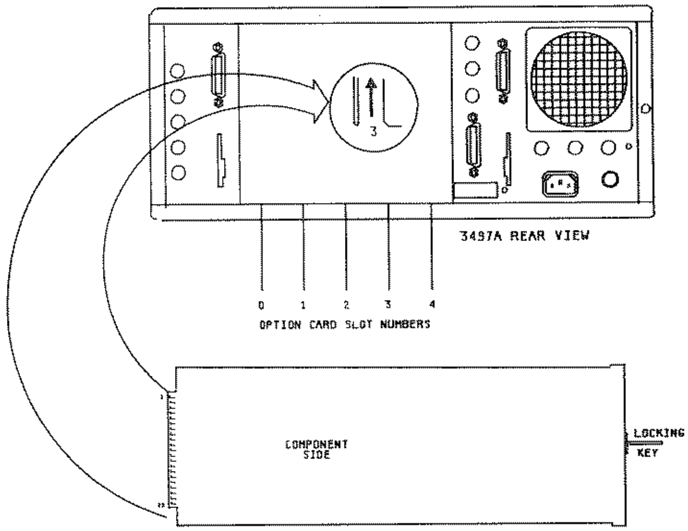
CONFIGURING THE ASSEMBLY

To configure the IDAC for operation, simply connect the SOURCE and SINK connectors on the assembly to your load. The IDAC has connectors for two optically isolated channels, so you can provide inputs to two separate loads simultaneously.

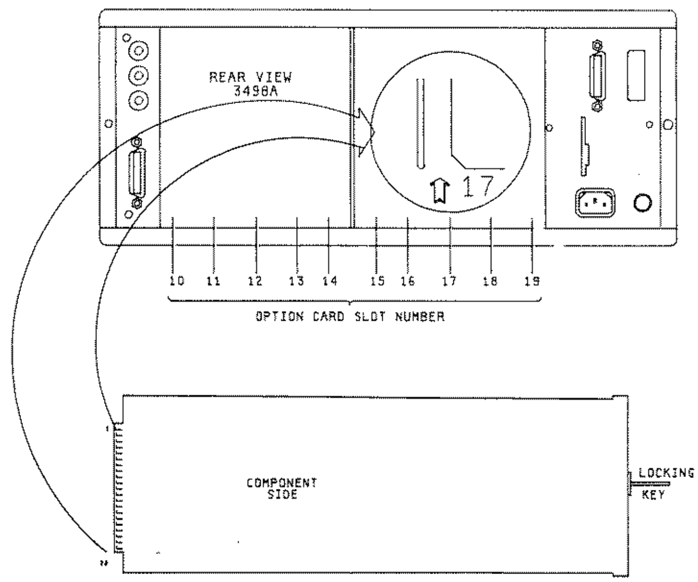
This section shows how to connect the assembly to a typical resistive load. Since the channels are optically isolated, you can control devices which are floated up to 170 volts above ground. To begin, let's discuss some load considerations.

WARNING

To avoid personnel injury or equipment damage, disconnect the 3497A and 3498A line cords and ALL voltage sources from these instruments before installing or removing assemblies. External circuits connected to the IDAC must not be floated more than 170 volts above ground.



INSTALLATION IN 3497A



INSTALLATION IN 3498A

Figure 149. Option 130 · Installation in 3497A/3498A

LOAD CONSIDERATIONS

Before connecting loads to the IDAC, it is important to select proper wire type, size and length for your application. Even the shortest leads can degrade the IDAC performance because of the IR drop in the leads.

For example, approximately 15 feet of 22 AWG wire has a resistance of 0.242 ohms. At the full (20 mA) output of the IDAC, this results in a 4.84 mV voltage drop. If the load resistance is at or very close to 600 ohms, this added resistance could cause the compliance voltage in the IDAC to exceed 12 volts. Figure 150 is a wire chart showing nominal current ratings and resistances of various sizes of Annealed Copper wire.

AWG (B&S) Wire Size	Annealed Copper Resistance at 20°C milliohms/ft.	Nominal Current Rating (amps)*
22	16.1	5
20	10.2	7
18	6.39	10
16	4.02	13
14	2.53	20
12	1.59	25
10	0.999	40
8	0.626	55
6	0.395	80
4	0.249	105
2	0.156	140
0	0.0993	195
00	0.0779	260

* Single Conductor in Free Air at 30°C with rubber or thermoplastic insulation.

Figure 150. Option 130 · Wire Chart

Also, some immunity from stray magnetic field pickup can be achieved by twisting each pair of SOURCE and SINK leads together before connecting to the load.

After deciding on the wire size, type and length, to connect loads to the assembly route the wires as shown in Figure 151, which shows connections for channel 0 and channel 1. Then install the assembly in a desired slot in the 3497A or 3498A.

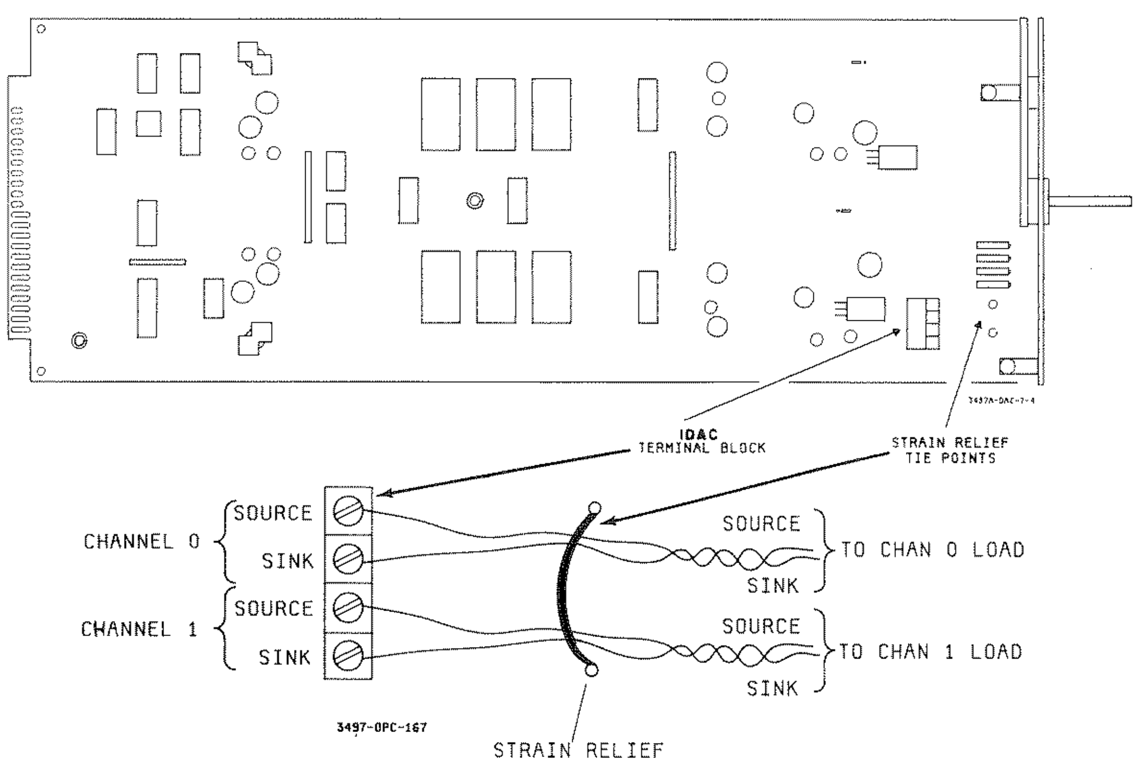
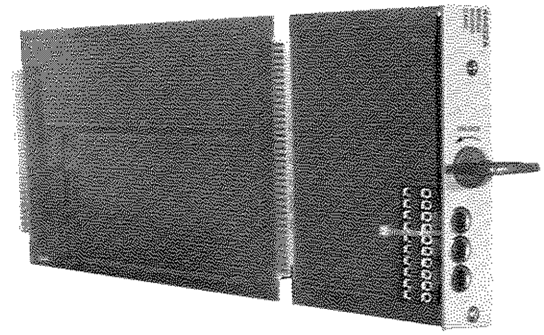


Figure 151. Option 130 · Connecting Loads to the IDAC

Reconfiguring the IDAC for 4-20 mA Output

The IDAC is factory set for the 0 - 20 mA output range. You can reconfigure channel 0 or channel 1 or both for 4-20 mA output by jumper selection. However, when the IDAC is reconfigured for 4-20 mA output, the IDAC requires recalibration for output accuracy. A qualified, service-trained technician should perform this recalibration using the procedures outlined in the 3497A Plug-In Assemblies/3498A Extender Service Manual.

OPTION 140



Breadboard Card Assembly

INTRODUCTION

In contrast to the other plug-in assemblies, Option 140 provides a ''breadboard'' for the design engineer or technician to custom design circuits for use with the 3497A or 3498A.

You can use Option 140 when you have a specialized measurement or control application which can't be satisfied by using the other option card assemblies. Possible applications include matrix and RF switches; multichannel totalizers and stepper motor controllers.

Instructions can be sent to the Breadboard Card assembly and data read from the assembly at a rate of 20 individual operations per second using the -hp- 85 and 90 operations per second using the -hp- 9826 computer.

Description

The breadboard card assembly is shown in Figure 152. The board has three grid networks to mount components (ICs, resistors, capacitors, etc.). Two of the grids are labeled ANALOG SECTION and DIGITAL SECTION. Either grid, however, can be used for either type of circuit depending on requirements. The third grid can be used as an extension of the Analog and/or Digital grids, or (if a terminal card is used) can be cut off and removed.

Interconnected holes across both the top and bottom of each grid form buses for power supply and ground connections. The analog grid has two power supply and two ground buses which can be used to connect two power supplies. Or, by using two jumpers, a single power supply bus can be configured.

Analog Section

The analog section of the assembly pertains to 3497A backplane signals which are controlled by the ANALOG command group (e.g., AC chan#,chan#,..). The control signals themselves are digital in nature. The result of executing an analog command, however, may return an analog result, such as a voltmeter reading using the HI COM, LO COM and GUARD COM lines. The analog section also contains two different power supply references.

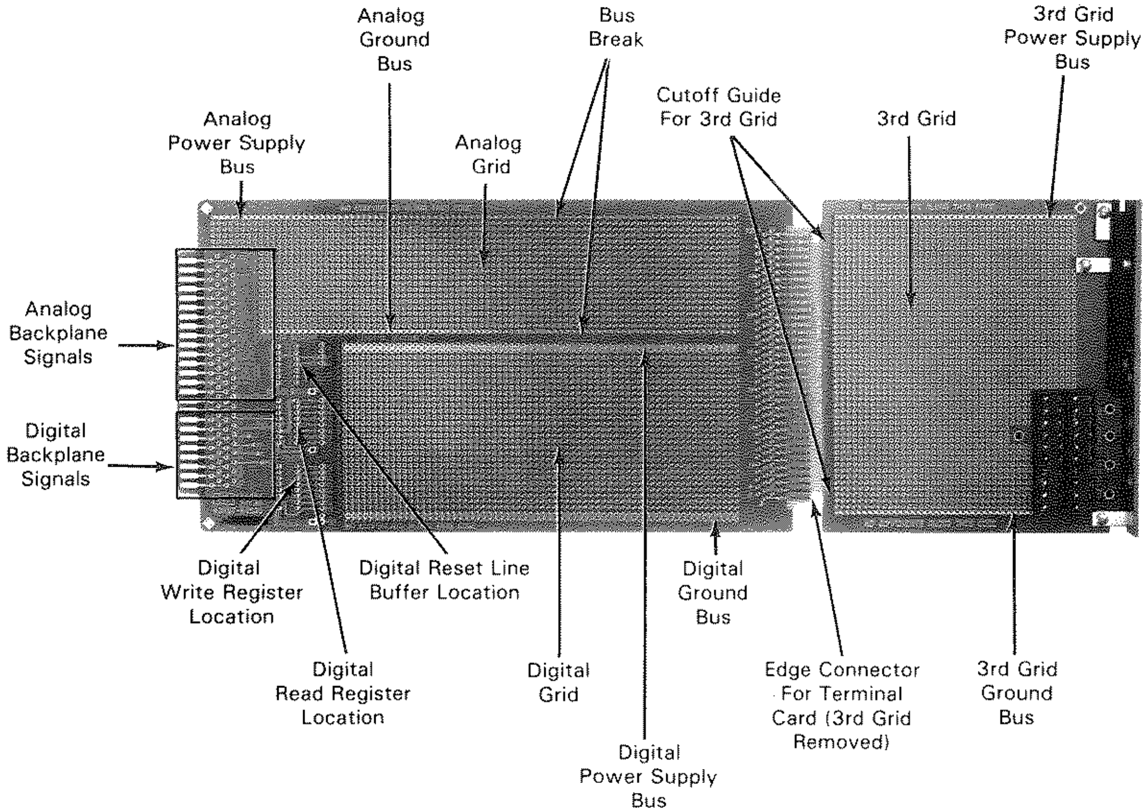


Figure 152. Option 140 - Breadboard Card Assembly

Digital Section

The digital section of the breadboard card assembly pertains to 3497A backplane signals which are controlled by one of three SYSTEM commands: SI; SR slot#,register or SW slot#,register#,octal value. DIGITAL commands or other SYSTEM commands will not be recognized by the digital section because, except for the three SYSTEMS commands mentioned, the 3497A software requires an identifying response from a digital assembly when a DIGITAL or SYSTEM command is executed.

Specifications

Specifications are performance standards, or limits, against which the assembly may be tested. Figure 153 shows the overall dimensions of the card and component height/protrusion restrictions. The component height/protrusion restrictions assume that other assemblies will be installed in slots on either side of the assembly or that the assembly will occupy the far left or far right slot.

OPTION 140
BREADBOARD CARD

Component Area: (consisting of plated thru .1168 cm. (.046") inside diameter holes spaced .254 cm. (.100") apart

368 cm.^{2} 57.13 in.^{2}

Maximum Component Height: 1.4 cm. (.55 in.)

Maximum Component Lead Length: .51 cm. (.2 in.)

Maximum Power Dissipation: (total per assembly from all supplies): 2 watts

Power Supply Rating: S: (supplied by the 3497A, maximum per card, up to 5 cards per 3497A cardcage)

Digital Supplies (Nonisolated): + 5 V @ 400 mA max.

Analog Supplies (Isolated):

		Maximum Current
Low Related Supplies	+ 5 V	50 mA
	+ 15 V	2 mA
	− 8 V	100 μA
Guard Related Supplies	+ 19 V	20 mA
	− 19 V	20 mA

To avoid design difficulty and possible damage to the 3497A, analog (isolated) and digital (nonisolated) supplies should not be interconnected.

General Communication Rate: Instructions can be sent to the 3497A breadboard card and data read from the 3497A breadboard card at a rate of 20 individual operations per second using the HP 85, and 90 operations per second using the HP 9826 computer.

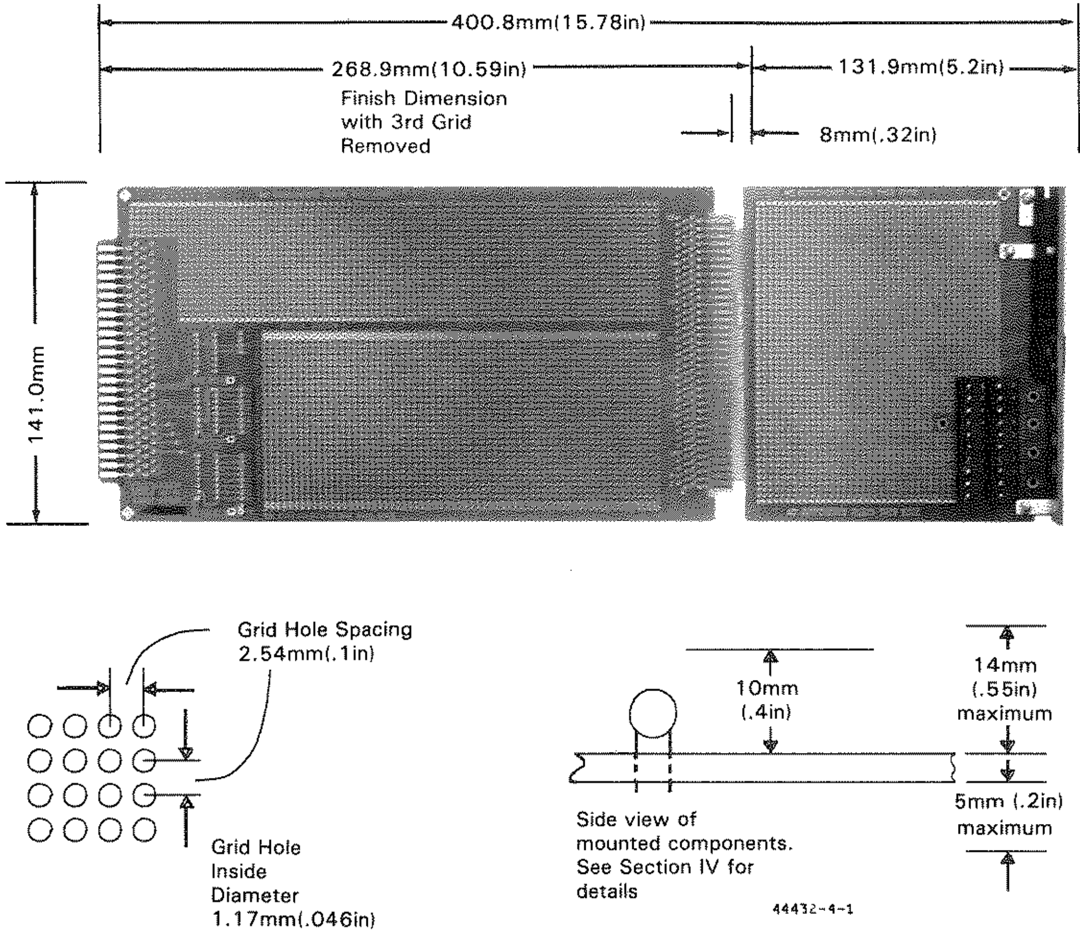


Figure 153. Option 140 - Dimensions and Component Height/Protrusion Restrictions

Manual Information

This manual contains configuration and control information for this assembly. Assemblies manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany this manual. See Appendix B for details.

Warranty

The Breadboard Card assembly warranty (shown in Appendix B) is different than the standard -hp- warranty for the 3497A and associated assemblies. While -hp- is responsible for defects in materials and workmanship of the blank board and supplied hardware, -hp- is not responsible for the performance of the customer's circuit.

In addition, -hp- is not responsible for damage or improper operation of the 3497A, 3498A or plug-in assemblies when the Breadboard Card assembly is installed in either the 3497A or the 3498A. See Appendix B for a complete warranty statement for the breadboard card assembly.

INSTALLING THE ASSEMBLY

WARNING

There is no operator installation or configuration for the Breadboard Card assembly. Only qualified, service-trained personnel should install or configure the assembly.

Initial Inspection

If you ordered the breadboard card assembly as Option 140, the assembly is already installed in the 3497A. If you ordered the assembly as Field Installation Kit 44432A, the shipping container should contain a breadboard card assembly. Figure 154 shows the replaceable parts on the assembly.

For the Field Installation Kit, if the card is missing or if there is mechanical damage or defect to the card, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a breadboard card assembly to -hp-, follow the shipping guidelines in Appendix B.

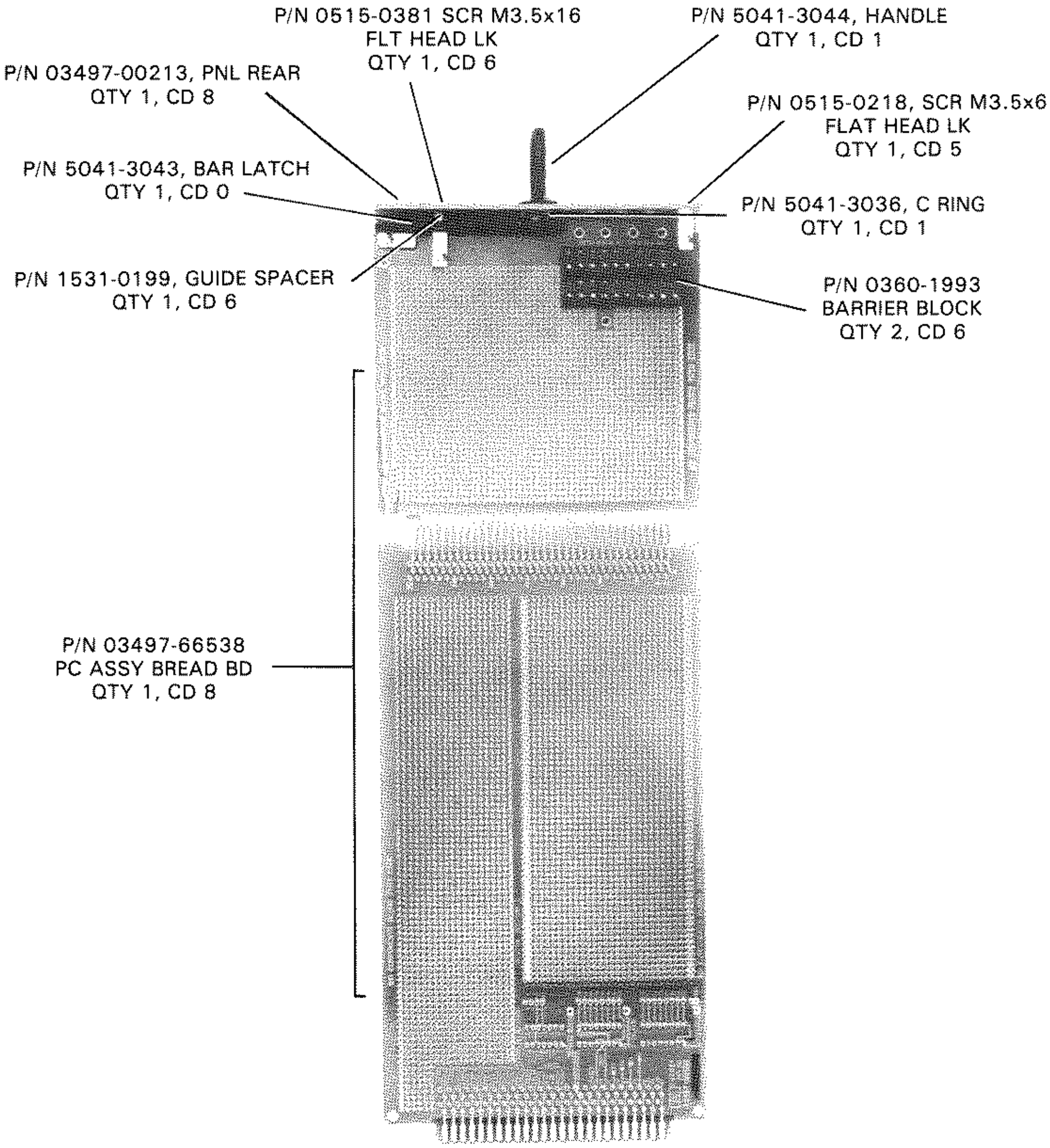
How to Install the Breadboard Card Assembly

WARNING

Before touching any installed assemblies or attempting to install the Breadboard Card assembly in the 3497A or 3498A, disconnect the power cords to the 3497A and 3498A and remove ALL voltage sources from these instruments.

The Breadboard Card assembly is not intended for outdoor use. Do not expose the assembly to rain or excessive moisture.

Figure 155 shows how to install the assembly in the 3497A and 3498A. After taking the steps shown in the WARNING above, plug the assembly into an unused slot in the 3497A or 3498A and turn the locking key clockwise to lock the assembly in place.



Suggested Parts For Custom Circuit Design

Description	Mfg P/N	-hp- P/N
3-to-8 Line Decoders/Multiplexers	SN74LS138	1820-1216
HEX Schmitt-Trigger	SN74LS14	1820-1416
Octal Buffers	SN74LS240 SN74LS241 SN74LS244 DM81LS97	1820-1917 1820-1918 1820-2024 1820-1759
Octal Latch	SN74LS273	1820-1720
Barrier Block (Terminal Strip), 10 Connections	—	0360-1993
Optoisolator	—	1990-0577

Figure 154. Option 140 - Replaceable Parts

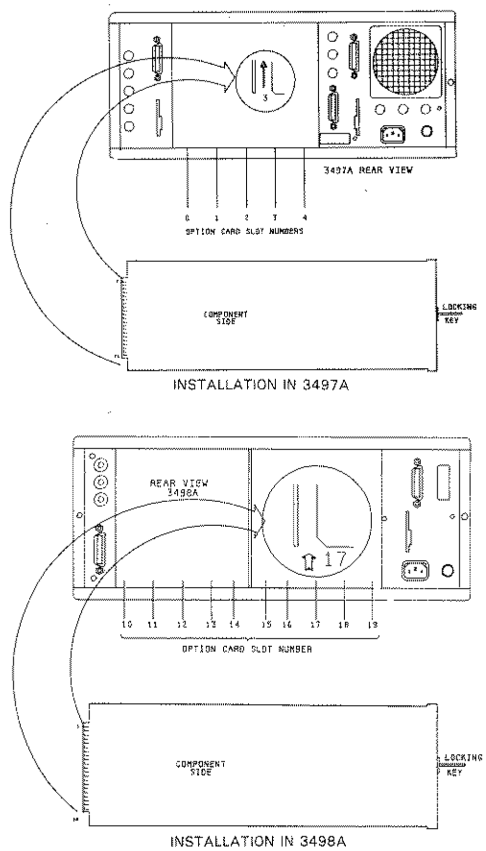


Figure 155. Option 140 · Installation in 3497A/3498A

CONFIGURING THE ASSEMBLY

Since the breadboard card assembly consists of an analog and a digital section, we'll divide assembly configuration into digital command signals and divide assembly configuration into digital command signals and analog command signals. For each section, some suggestions and examples are provided to aid you in designing your circuits. Also, some precautions to avoid damage to the 3497A or your system are listed.

Before designing or mounting any circuit, familiarize yourself with the 3497A analog and digital backplane signals available from the 3497A. Some precautions and helpful hints are:

DESIGN PRECAUTIONS

- Observe all WARNING and CAUTION notes in the manual.
- Do NOT interconnect the analog and digital sections.
- Observe all power supply limitations.

- Observe component height/protrusion restrictions.
- Don't mount components along the top or bottom edges of the board.

- Remember that other assemblies installed in the 3497A or 3498A will share the same analog or digital lines as your custom circuit.

3497A Digital Command Signals

The 3497A backplane signals are divided into analog and digital signals. For the breadboard card assembly, the digital signals which are available from the 3497A backplane and a description of the signals are shown in Figure 156. Remember, however, that the breadboard card digital section is controlled ONLY by the SI, SR or SW commands.

The 3497A backplane connector which supplies analog and digital signals to the assembly is also shown in Figure 156. The digital signals appear on pins 16 through 25 and T through CC (pins 15 and S are not used). Analog signals appear on the remaining pins and are discussed in the 3497A Analog Command Signals section.

CAUTION

The digital and analog sections contain separate power supplies which are referenced to different potentials. Analog power supplies are referenced to GUARD potential (up to 170 volts above ground). For these reasons, NEVER interconnect the digital and analog sections. If these sections are interconnected, 3497A performance will be affected and equipment may be damaged.

CAUTION

All 3497A backplane signals are brought to the breadboard card and all are susceptible to damage from static discharge. To prevent damage to the 3497A, use anti-static techniques on all lines used for your custom circuit (i.e., buffering, voltage transient suppression, novistors, etc.).

Component Side			Circuit Side
HCOM	1	A	LCOM
HCOM BOOT	2	B	LCOM BOOT
GUARD GND	3	C	GUARD GND
T.C. GND	4	D	UN3
-8V T.C.	5	E	UN2
+15V L	6	F	DECA1
(L) LATCH	7	H	DECB1
BREAK	8	J	UN1
MAKE	9	K	UN0
+5V LOGIC	10	L	+5V RELAY
LOGIC GND	11	M	RELAY GND
GUARD GND	12	N	GUARD GND
-19V G	13	P	+19V G
GUARD GND	14	R	GUARD GND
	15	S	
O.C. GND	16	T	O.C. GND
DIG. INTERRUPT	17	U	DIG. RESET
BD0	18	V	SLOT ENABLE
BD1	19	W	DIG. READ
BD2	20	X	DIG. WRITE
BD3	21	Y	BA2
BD4	22	Z	BA1
BD5	23	AA	BA0
BD6	24	BB	+5V O.C.
BD7	25	CC	-5V O.C.

3497A DIGITAL SECTION BACKPLANE SIGNALS

DIGITAL LINE DESCRIPTION

Signal Name	Pin No	Description and/or Use
GND	T, 16	Ground for +5V digital supply. Referenced to Outguard (earth) GND.
+5V	BB, CC	+5V Digital Power Supply. Referenced to Outguard (earth) GND. Tolerance ±5% (4.75V to 5.25V). Filter and bypass capacitors recommended.
BA0, BA1, BA2	AA, Z, Y	Register Address Select Lines. BA2 Example: to select register 6, these lines would have the following logic states: BA2 BA1 BA0 1 1 0
DIG READ	W	Digital Read. A 500 nS low signal activated by executing the "SR" command.
DIG WRITE	X	Digital Write. A 500 nS low signal activated by executing the "SW" command.
DIG RESET	U	Digital Reset. A 500 nS low signal activated by executing the "SI" command or when the 3497A is reset.
DIG INTERRUPT	17	Interrupt line to 3497A μP. This line is not to be used by the breadboard card. This line is reserved for use by digital input and counter cards to interrupt the 3497A μP.
BD0 - BD7	18 - 25	Bi-directional Data Bus Lines. Transfers data between 3497A and option cards.
SLOT ENABLE	V	Slot Enable. A 750 nS low signal that is activated when a "SR" or "SW" command is being executed. This line is used to enable the slot that is being addressed by the "SR" or "SW" commands.

Figure 156. Option 140 · 3497A Digital Backplane Signals

Design Suggestions for the Digital Section

The following paragraphs provide some suggestions and precautions for designing custom circuits using the digital section. See Chapter 6 for commands to control the digital section.

+5V Digital Power Supply

There is only one +5V (±.25V) power supply provided for the digital section. It is referenced to the outguard section of the 3497A mainframe and appears on the backplane edge connector as follows: +5V at pins BB and CC and GND at pins 16 and T.

Maximum power dissipation allowed by a card is 2 watts, including when both analog and digital section power supplies are used. Circuit traces bring the +5V and GND close to their respective buses so that only short jumpers are needed to the buses. Take care not to mount a component on a bus. IC power supply connections should be as shown in Figure 157.

It is recommended that bypass and filter capacitors always be used between +5V and ground. A good rule to follow is to use one 1μF tantalum filter capacitor and two .01 μF ceramic bypass capacitors for every eight (or less) ICs.

Buffering the Digital Reset Line

A location is provided on the breadboard card to mount a SN74LS14 IC to buffer the Digital Reset Line (pin U on the backplane connector). This IC provides a high true and low true version of the Digital Reset Line, as shown in Figure 158.

Buffering the Data Bus

The data bus drive capability is limited and may require buffering depending on your application. If the data direction is always from the 3497A to the breadboard card (write only), data latches can be placed directly on the data bus as shown in Figure 159 (a).

Whenever the data direction is from the breadboard card to the 3497A (read), the data bus must be buffered with a tri-state device(s). The buffering device must be able to drive 20 LS loads (20 Low Power Schottky inputs) such as the SN74LS24X SERIES or 81LS97. A typical data bus configuration for read operation is shown in Figure 159 (b).

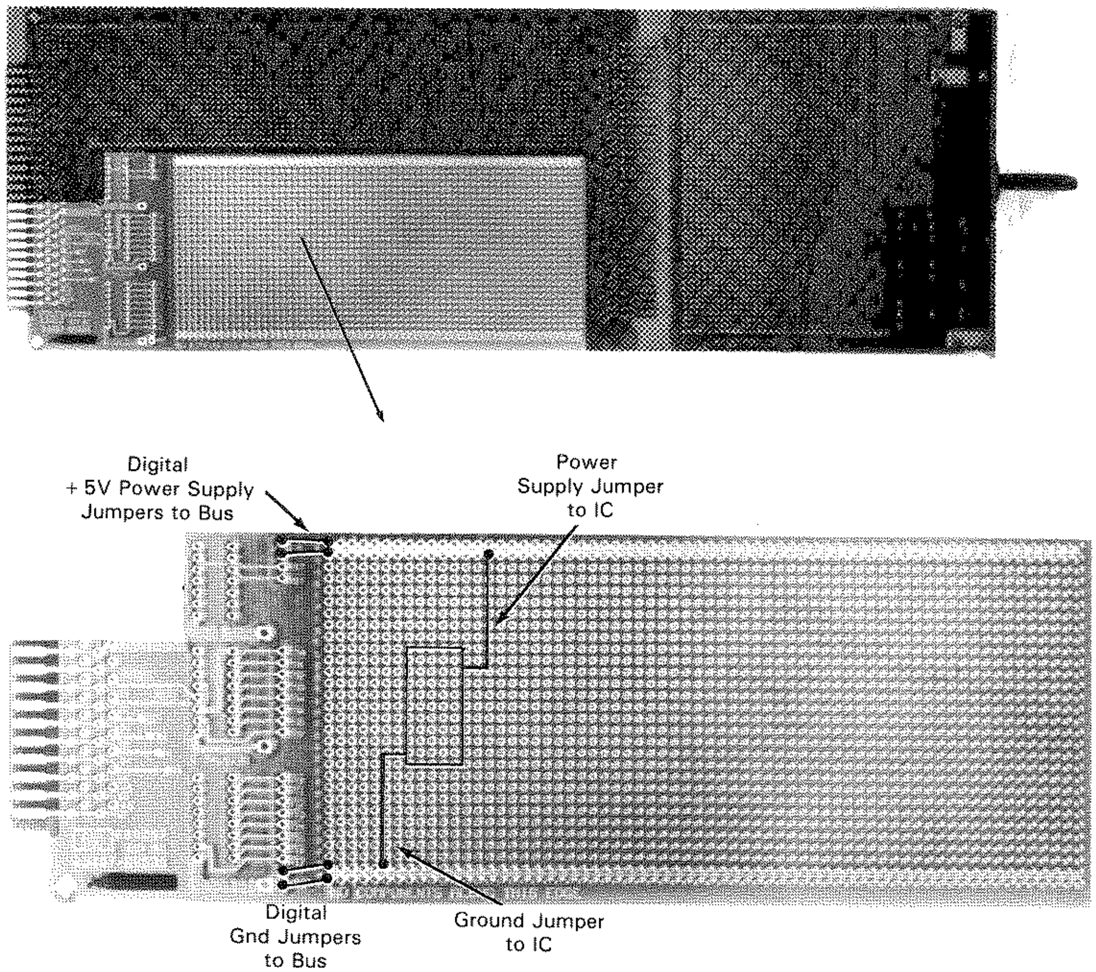


Figure 157. Option 140 - Digital Power Supply Connections

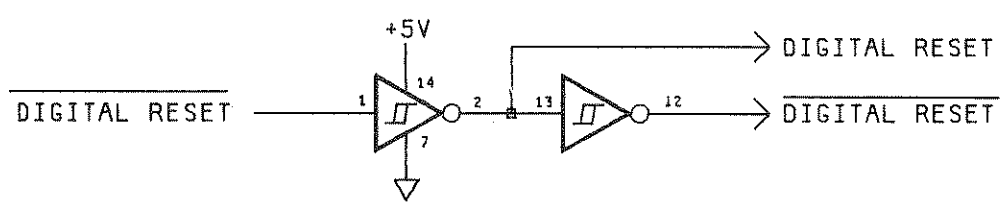


Figure 158. Option 140 - Buffering the Digital Reset Line

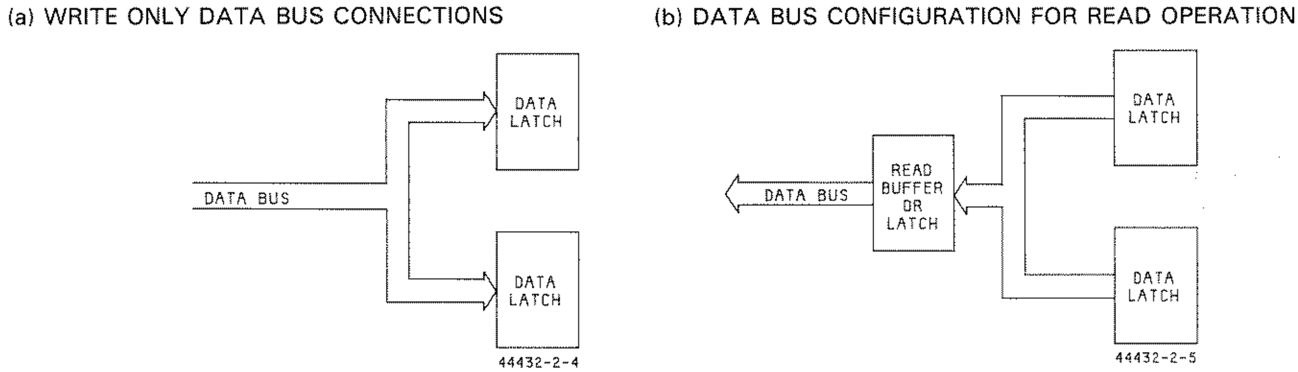


Figure 159. Option 140 · Rear and Write Data Bus Connections

Controlling Noise on the Signal Lines

Because of the distributed nature of the 3497A backplane signals, noise may be present on the control and data bus lines. The noise can be controlled somewhat by filtering. The preferred method is to buffer the lines with Schmitt Triggers, using ICs such as an SN74LS14.

Regardless of the method used to control noise, it will introduce some signal delay. Be sure to account for these delays so that timing requirements are not violated.

Typically, an oscilloscope is used to check signal lines for proper levels, noise, etc. When doing these measurements, make the measurement at the signal source and keep the ground lead of the scope as short as possible. An effective way to minimize ground lead length is to use a probe tip ground spring.

Power Switching

Two terminal blocks are provided on the board which permit up to 20 external connections. These terminal blocks are rated at 100 VA or 170V peak betwen any two terminals or any input to chassis and must be fused accordingly.

Inductive loads may require contact protection (arc suppression). If your application requires switching inductive loads, see the discussion on contact protection in the Option 115 (High Voltage Actuator) part of this chapter.

To minimize interference caused by high voltage switching, maintain maximum isolation between the switched voltages and the 3497A logic circuitry and choose relays which have a low contact-to-coil capacitance.

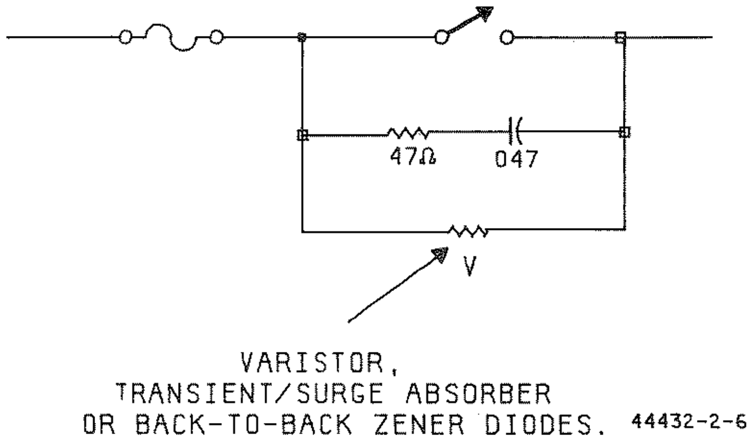


Figure 160. Option 140 - Transient Protection Circuit

To ensure compliance with applicable standards for Electromagnetic Interference, circuits should be constructed using good RF practice, such as ensuring that all interconnections are enclosed by shields connected to local earth grounds via low impedance paths.

When your application involves bringing the power line onto the board, the power line may require a transient suppression circuit to minimize interference with 3497A operation. A typical transient protection circuit is shown in Figure 160.

Read and Write Registers

Locations are provided on the card for two SN74LS138 ICs which can be used to implement a read and write register circuit. Figure 161 shows how these ICs are used in the circuit. In this circuit only three read and three write registers are shown. You can, however, have as many as eight read and eight write registers.

Direct Digital Backplane Interfacing

Direct interface to the digital backplane signals can be made without using Read and Write Registers. This type of configuration, as shown in Figure 162, can be used for counting, interval timing, interfacing UARTs, programmable peripheral interface, etc.

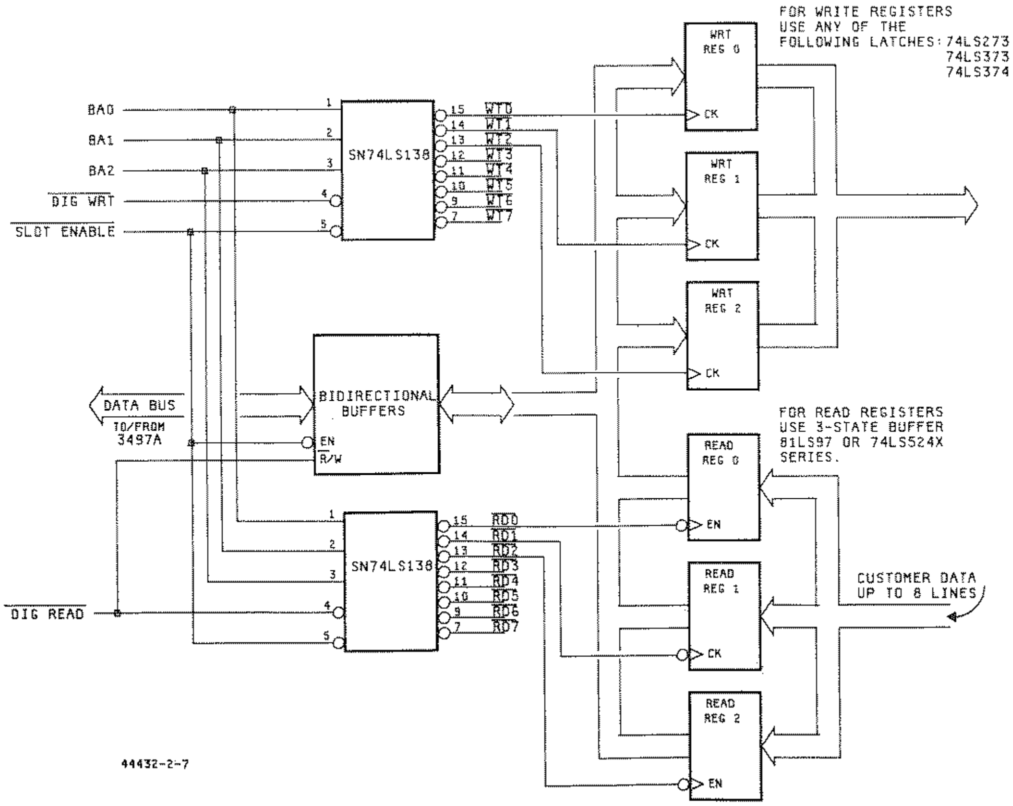


Figure 161. Option 140 - Typical Read and Write Register Circuit

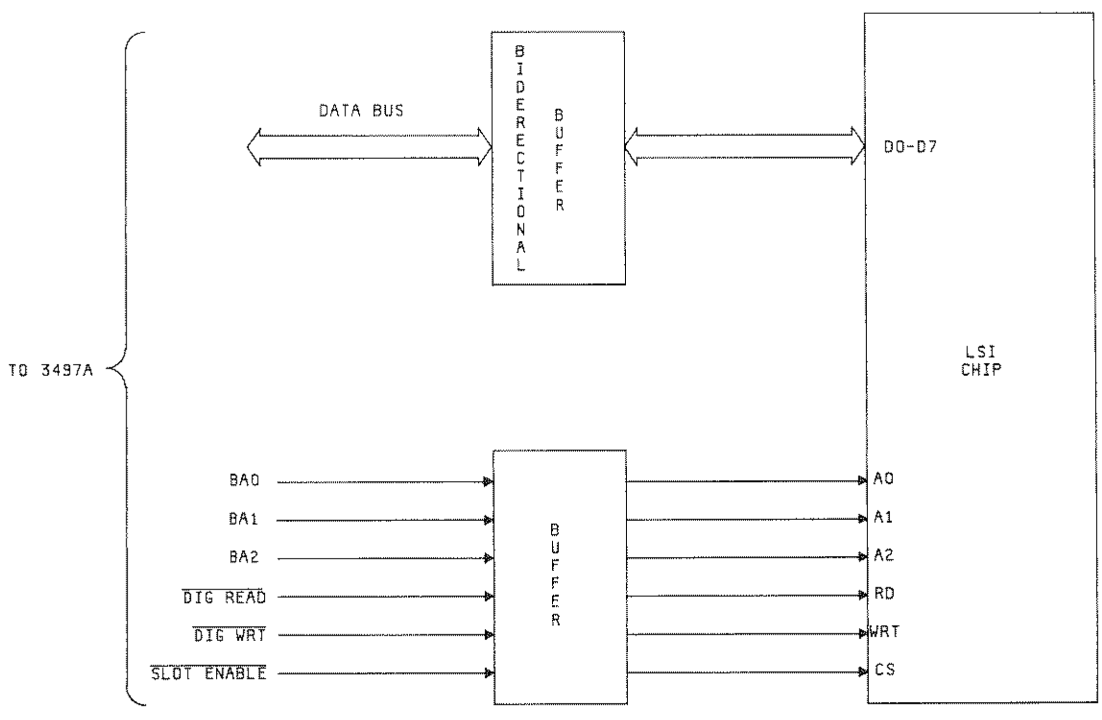


Figure 162. Option 140 - Direct Digital Backplane Interfacing

3497A Analog Command Signals

As noted, 3497A backplane signals are divided into analog and digital signals. For the breadboard card assembly, the analog signals which are available from the 3497A backplane and a description of the signals are shown in Figure 163. See Chapter 6 for a description of the ANALOG commands used with the breadboard card assembly.

The 3497A backplane connector which supplies analog and digital signals to the assembly is also shown in Figure 163. The analog signals appear on pins 1 through 14 and A through R (pins 15 and S are not used). Digital signals appear on the remaining pins and are discussed in the 3497A Digital Command Signals section.

Component Side			Circuit Side
HCOM	1	A	LCOM
HCOM BOOT	2	B	LCOM BOOT
GUARD GND	3	C	GUARD GND
T.C. GND	4	D	UN3
-8V T.C.	5	E	UN2
+15V L	6	F	DECA1
(L) LATCH	7	H	DECB1
BREAK	8	J	UN1
MAKE	9	K	UN0
+5V LOGIC	10	L	+5V RELAY
LOGIC GND	11	M	RELAY GND
GUARD GND	12	N	GUARD GND
-19V G	13	P	+19V G
GUARD GND	14	R	GUARD GND
	15	S	
O.C. GND	16	T	O.C. GND
DIG. INTERRUPT	17	U	DIG. RESET
BD0	18	V	SLOT ENABLE
BD1	19	W	DIG. READ
BD2	20	X	DIG. WRITE
BD3	21	Y	BA2
BD4	22	Z	BA1
BD5	23	AA	BA0
BD6	24	BB	+5V O.C.
BD7	25	CC	-5V O.C.

3497A ANALOG SECTION BACKPLANE SIGNALS

ANALOG LINE DESCRIPTION

IMPORTANT

Signals UN0-UN3, DECA1, DECB1, MAKE, BREAK, and LATCH are generated by CMOS devices and should only be used to drive CMOS inputs.

Signal Name	Pin No	Description and /or Use
UN0	K	Address Line, LSB. UN0 through UN3 indicates which channel is to be closed.
UN1	J	Address Line. See UN0 description.
UN2	E	Address Line. See UN0 description.
UN3	D	Address Line, MSB. See UN0 description.
DECA1	F	Decade A Select. Low true signal that allows a channel to be selected in decade A.
DECB1	H	Decade B Select. Low true signal that allows a channel to be selected in decade B.
MAKE	9	Make Strobe. An open collector line, used for break-before-make synchronization. This line is normally high via a 300 Ω mainframe pull-up resistor to the +5V In-guard Power Supply. A card pulls this line low when closing a channel. This informs the 3497A mainframe and other cards that a channel closure is about to take place so they will not attempt another channel closure until the channel has been opened. The MAKE line goes to every slot in the mainframe and the 3498A Extenders. This means that up to 50 cards can share this line. The voltage requirements of this line are as follows: VOL <.5V VOH >3.5V
BREAK	8	Break Strobe. An open collector line used for break-before-make synchronization. This line is normally high via a 300 Ω mainframe pull-up resistor to the +5V In-guard Power Supply. This line is the counterpart of the MAKE strobe. A card pulls this line low for the period required to open a closed channel. This line must be high for any scanning to take place. Like the MAKE strobe, this line can also be shared by up to 50 cards. The voltage requirements are the same as MAKE strobe.
LATCH	7	Latch Mode. An open collector line that is normally high via a 3 kΩ mainframe pull-up resistor to the +5V Inguard Power Supply. This line is driven low by the 3497A mainframe to permit multiple simultaneous channel closures (up to 4), with the restriction that each closed channel is in a different decade. For example, execution of "AC2,12,22,32" is valid, and will cause the LATCH line to go low.
HCOM	1	High Common. Connects to high lead of voltmeter.
LCOM	A	Low Common. Connects to low lead of voltmeter.
+19V G −19V G	P 13	+19V Guard Referenced Supply. −19V Guard Referenced Supply.
GUARD	3,12, 14, C, N, R	Guard Common or GCOM. Connects to Guard terminal of voltmeter.
+5V LOGIC	10	+5V Logic Low Reference Supply.
LOGIC GND	11	+5V Logic Supply Return Path.
+5V RELAY	L	+5V Relay Low Reference Supply.
RELAY GND	M	+5V Relay Supply Return Path.
+15V L	6	+15V Thermocouple Supply.
-8V TC	5	-8V Thermocouple Supply.
TC GND	4	Reference For +15V L and -8V TC Supplies.
BBM SYNC	Rear Panel BNC	Break-before-make synchronization pulse. This signal appears on the rear panel of the 3497A and is TTL compatible. BBM SYNC is similar to the MAKE strobe in that channel closures are not permitted when it is low (except in "AE2" mode where this signal is ignored).

Figure 163. Option 140 - 3497A Analog Backplane Signals

CAUTION

The digital and analog sections contain separate power supplies which are referenced to different potentials. Analog power supplies are referenced to GUARD potential (up to 170 volts above ground). For these reasons, NEVER interconnect the digital and analog sections. If these sections are interconnected, 3497A performance will be affected and equipment may be damaged.

CAUTION

All 3497A backplane signals are brought to the breadboard card and all are susceptible to damage from static discharge. To prevent damage to the 3497A, use anti-static techniques on all lines used for your custom circuit (i.e., buffering, voltage transient suppression, novistors, etc.).

Design Suggestions for the Analog Section

The following paragraphs provide some suggestions and precautions for designing custom circuits using the analog section. See Chapter 6 for commands to control the analog section.

Inguard Low Referenced Power Supplies

There are two power supply references associated with the analog section (the reference is that point from which the power supply voltage(s) is measured). One reference is Inguard ''LOW'' and the other is ''GUARD''. There are four power supplies which are referenced to Inguard LOW: +5V Relay, +5V Logic, +15V L and -8V TC. Total circuit dissipation allowed is 2 watts per assembly even if both the analog and digital sections are used.

The +5V Relay, +5V Logic and +15V and -8V TC supplies are referenced to Inguard LOW. The +5V Relay and +5V Logic supplies have the same origin, but the ground returns keep any noise generated by switching relays from entering the logic circuitry.

Maximum total current which can be drawn from these supplies is 50 mA. The range of both supplies is 4.85V to 5.25V and will typically be about 5.1V. The supplies appear on the backplane connector as follows: +5V Relay at pin L; Relay Gnd at pin M; +5V Logic at pin 10 and Logic Gnd at pin 11.

The +15V L and -8V TC supplies are used by the Option 020 thermocouple compensated terminal cards to generate hardware compensation voltages for several types of thermocouples.

Drawing excessive current from either supply could cause large compensation errors on Option 020 assemblies. Maximum current allowed from these supplies is: +15V L = 2 mA; -8V TC = 100 μA. The +15V and -8V TC supplies appear on the backplane connector as follows: +15V L at pin 6; -8V TC at pin 5 and +15V L and -8V TC GND at pin 4.

Guard Referenced Power Supplies

WARNING

The GUARD COMMON lines in the 3497A are determined by the voltage of the external circuit which is connected to the instrument. Thus, GUARD could be as much as 170 V peak above ground potential. Do not use the +19V and -19V supplies before reading Guarded Measurements following.

There are two power supplies, the +19V and -19V supplies, which are referenced to GUARD. These supplies have a tolerance of 5% (+18V to +20V and -18V to -20V). Maximum current which can be drawn per assembly from each supply is 20 mA. The +19V and -19V supplies appear on the backplane connector as follows: +19V G at pin P; -19V G at pin 13 and Guard at pins 3, 12, 14, C, N and R.

Guarded Measurements

By using the HCOM (High Common), LCOM (Low Common) and GCOM (Guard) connectors, you can make guarded voltage measurements. A brief discussion of guarded measurements follows. See -hp- Application Note 123, ''Floating Measurements and Guarding'' (-hp- part number 5952-2153) for a full explanation.

Figure 164 shows typical connections for guarded measurements from two input channels. When a channel relay is closed, the voltage appears on the HCOM, LCOM and GCOM lines and is simultaneously passed to the internal DVM, to the HI COM, LO COM and GUARD COM terminals on the rear panel of the 3497A and to other slots.

WARNING

The potentials of HCOM, LCOM and GCOM are determined by the external circuit to which they are connected. Also, GCOM potential appears on the DVM external panel, on the sheet metal inside the 3497A front panel and on the sheet metal around the 3497A card cage.

For this reason, when making voltage measurements, NEVER input voltage simultaneously into the rear panel terminals and the backplane connectors. This can happen since the 3497A will support multiple channel closures in the Latch Mode.

GCOM is the reference for the +19V and -19V Analog Power Supplies. It can also serve as a common mode current if it is properly connected. Common mode voltages are those signals which appear on both the HIGH and LOW voltmeter terminals simultaneously and can cause reading errors if not properly handled. These voltages are shown as Vcm in Figure 164.

GUARDED MEASUREMENTS GUIDELINES

- Always know the potential of GCOM with respect to Earth ground.
- Always connect GCOM so that no common mode current flows through any resistance which determines the input voltage (i.e., the HIGH and LOW DVM input leads).
- Never exceed 170 V peak input between any two input terminals.

Interconnecting Circuitry Using Both Supply References

If your application requires that you use one or more of the Inguard Referenced Power Supplies (+5V Relay, +5V Logic, +15V L or -8V TC) with either of the Guard Referenced Power Supplies (+19V or -19V), the two references must be isolated from each other. The degree of isolation is 170 V minimum. A good way to do this is to use optoisolators as shown in Figure 165. The inputs to the optoisolators should be referenced to the Inguard section and the outputs referenced to GUARD COMMON.

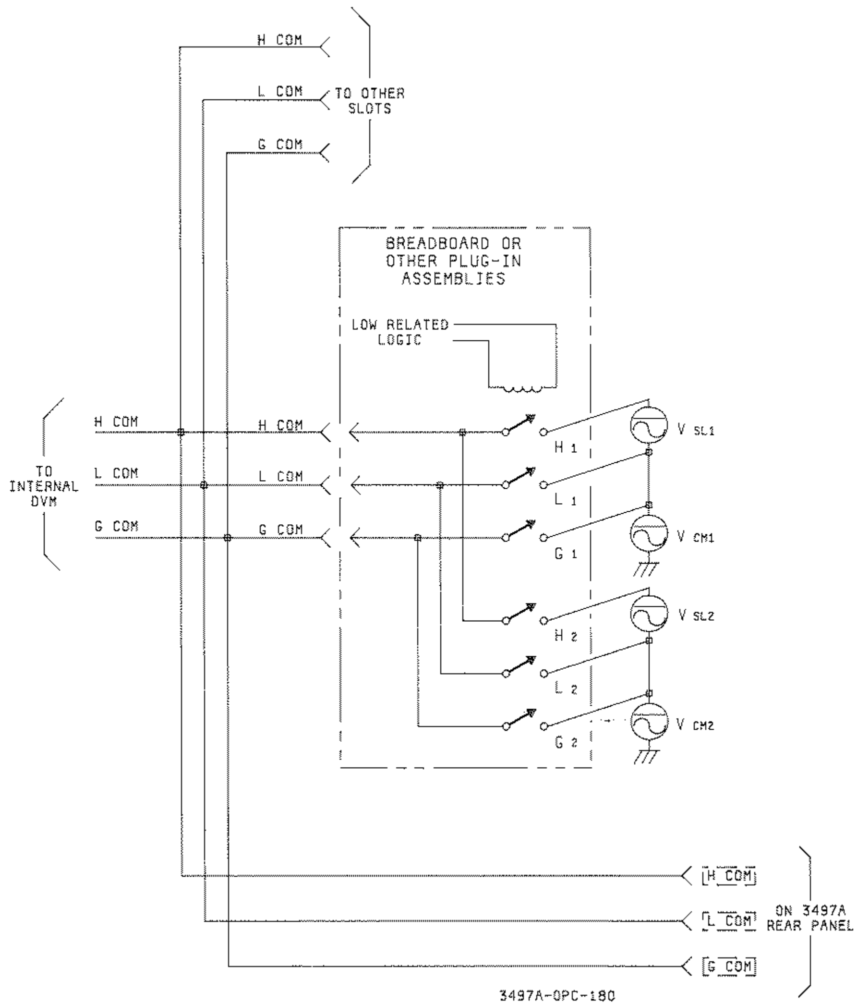


Figure 164. Option 140 - Guarded Measurements

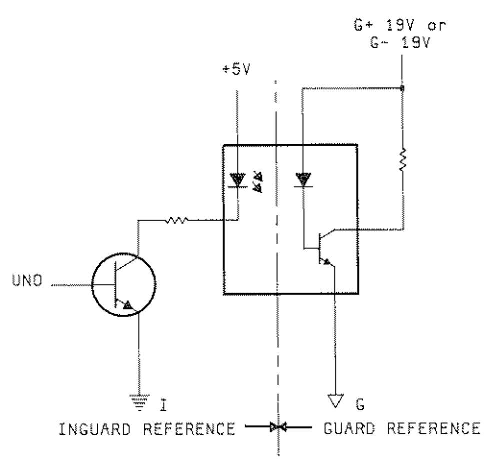


Figure 165. Option 140 - Analog Section Power Supply Isolation

Mounting Components on the Breadboard Card

So that the breadboard card assembly will fit into the 3497A when components are loaded onto the board, the maximum component height/protrusion requirements shown in Figure 166 must be observed. The restrictions shown in Figure 166 assume that the breadboard will be used in a slot with other plug-in assemblies on either side or that the breadboard will be placed in slot 0 or 4 of a 3497A.

Absolute maximum component height allowed is 14 mm (.55 inches). However, if the height of any component exceeds 10 mm (.4 inches), the conductive surface of the component must be insulated. On the circuit side of the breadboard, the lead lengths are limited to 5 mm (.2 inches) or 4 mm (.16 inches) from the adjacent conductive surface. If the card is not adjacent to a conductive surface (i.e., no assemblies in adjacent slots or card is not in either of the end slots), these limitations can be exceeded.

Most wire wrapped components, such as IC sockets, will protrude through the breadboard further than the restrictions allow. When using such components, and the circuit side of the breadboard is adjacent to another card or in the far right slot, make sure to cut the lead lengths to meet the restrictions shown in Figure 166.

Never mount components where they will occupy space along the extreme top and bottom edges of the breadboard. This space is needed to slide the breadboard into the grooves of the slot and is labeled ''NO COMPONENTS ALONG THIS EDGE''. When soldering components on the breadboard, use a soldering iron with a 25 watt (or less) rating and rosin core solder.

Be careful to mount components so they are not across the power supply or ground buses. Also, remember that the analog section has two power supply and two ground buses to accommodate both analog power supply references. The recommended way to connect power supply and ground for a 14-pin IC, where the supply connection is pin 14 and ground is pin 7 is shown in Figure 157. Although Figure 157 shows connections on the digital section, it is applicable for the analog section and/or the third grid as well.

NOTE

If component height is greater than 10mm (.4in.) the conductive surface of components must be insulated. Lead length protrusion is limited to 5mm (.2 in.), or 4mm (.16 in.) from the adjacent conductive surface.

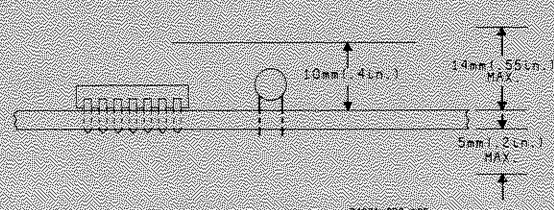


Figure 166. Option 140 · Component Height/Protrusion Requirements

Using Terminal Strips/Cards

The breadboard assembly also contains a third section (grid) which has a terminal strip to allow up to 20 inputs (see Figure 152). If your application requires more than 20 inputs, you can remove the third grid and replace it with one of four manufactured terminal cards:

- 20 Channel Uncompensated Terminal Card (used with Option 010).
- 16 Channel Digital Input Terminal Card (used with Option 050).
- 16 Channel Digital Output Terminal Card (used with Option 110).
- 8 Channel High Voltage Terminal Card (used with Option 115).

The third grid can be removed by one of several methods. A saw, PC board cutter or a paper cutter can be used. If you use a paper cutter, be aware that some paper cutters are not strong enough to cut PC boards. The notches on the board provide a guide to cut off the third grid. When the grid has been removed, approximately 0.64 mm (.025 inches) should remain between the end of the edge connector and the edge connector fingers (see Figure 152).

After the grid has been cut off, remove all rough edges with a file or the edges may not make contact with the terminal card. File the edge connector to look like the edge connector which plugs into the mainframe.

Terminal Card Descriptions

As mentioned, four manufactured terminal cards can be used with the breadboard card assembly when the third grid is removed. The following chart briefly describes these terminal cards. For more information, refer to the appropriate option discussion in this chapter.

TERMINAL CARDS USED WITH THE BREADBOARD CARD

20 CHANNEL UNCOMPENSATED TERMINAL CARD

Used with the 20 Channel Relay Multiplexer (Option 010). Provides straight through connections from the input terminals on the terminal card to the edge connector you have prepared on the breadboard card. Capability to add series/shunt components is provided. -hp- part number is 03497-69542. See Figure 167 for schematic.

16 CHANNEL DIGITAL INPUT TERMINAL CARD

Used with the Digital Input/Interrupt Assembly (Option 050). Provides two-wire connections for each of 16 input channels plus FLAG, GATE and GND. The logic levels are determined by placing jumpers in designated positions to allow portions of resistive networks to attenuate the signal. -hp- part number is 03497-69543. See Figure 168 for schematic.

16 CHANNEL DIGITAL OUTPUT TERMINAL CARD

Used with the Digital Output Assembly (Option 110). Each output channel has three terminals labeled NO (normally open), NC (normally closed) and C (common). Terminals are also provided for GATE+, GATE-, FLAG+ and FLAG-. 16-pin DIP IC sockets (J1,J3,J4 and J6) provide a means of limiting current to the NO,NC contacts to +5V. DIP sockets J2 and J5 can be used to jumper relay common terminal to GND. -hp- part number is 03497-69544. See Figure 169 for schematic.

8 CHANNEL HIGH VOLTAGE TERMINAL CARD

Used with the High Voltage Actuator Assembly (Option 115). This card has provisions for 8 high voltage channels. The terminal strip connections are rated at 252V RMS (AC) at 2 amps or 48V DC at 2 amps. A terminal is provided to ground the terminal card to the 3497A chassis. -hp- part number is 03497-64111. See Figure 170 for schematic.

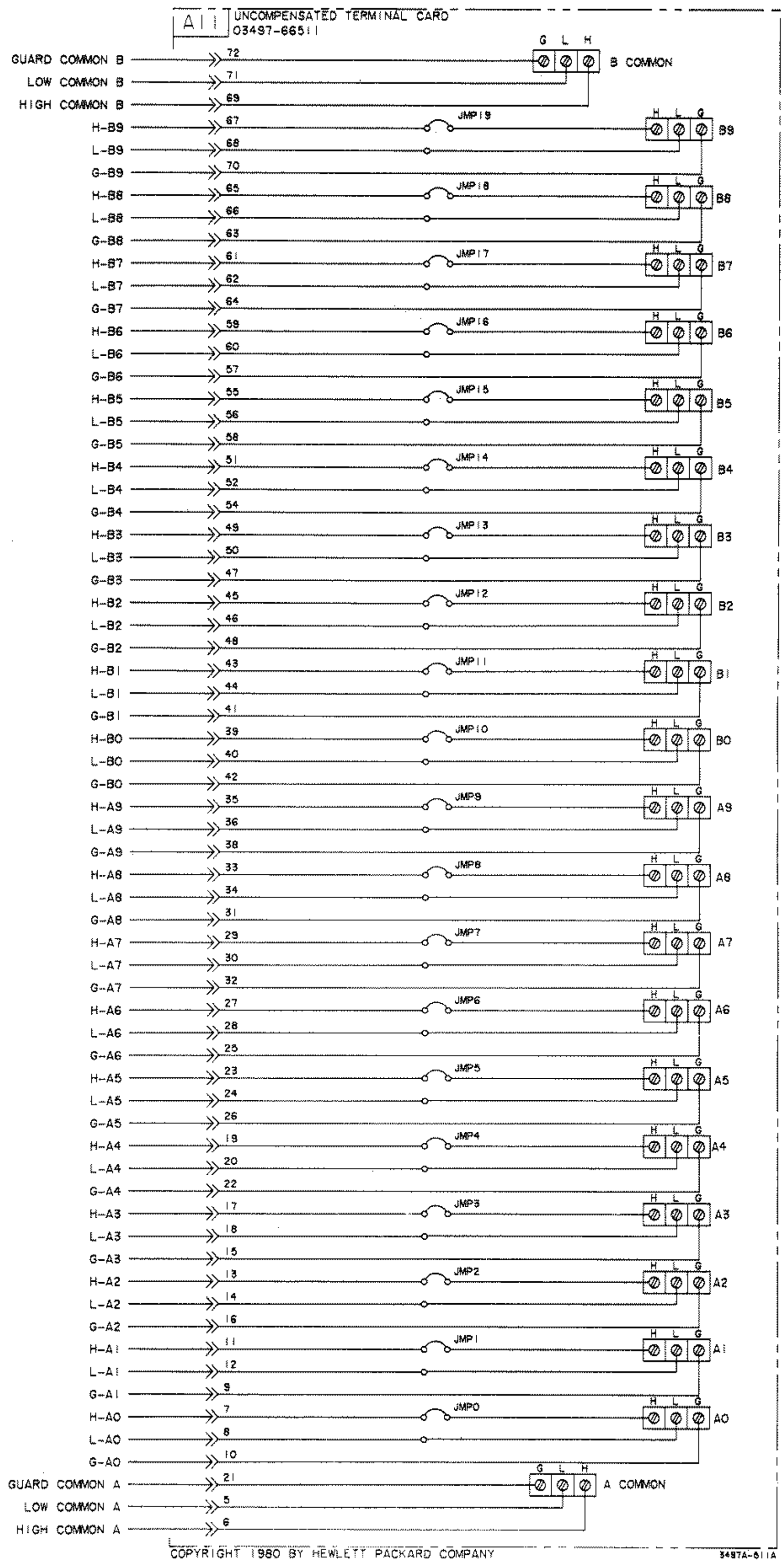


Figure 167. Option 140 - Uncomp Terminal Card (Option 010)

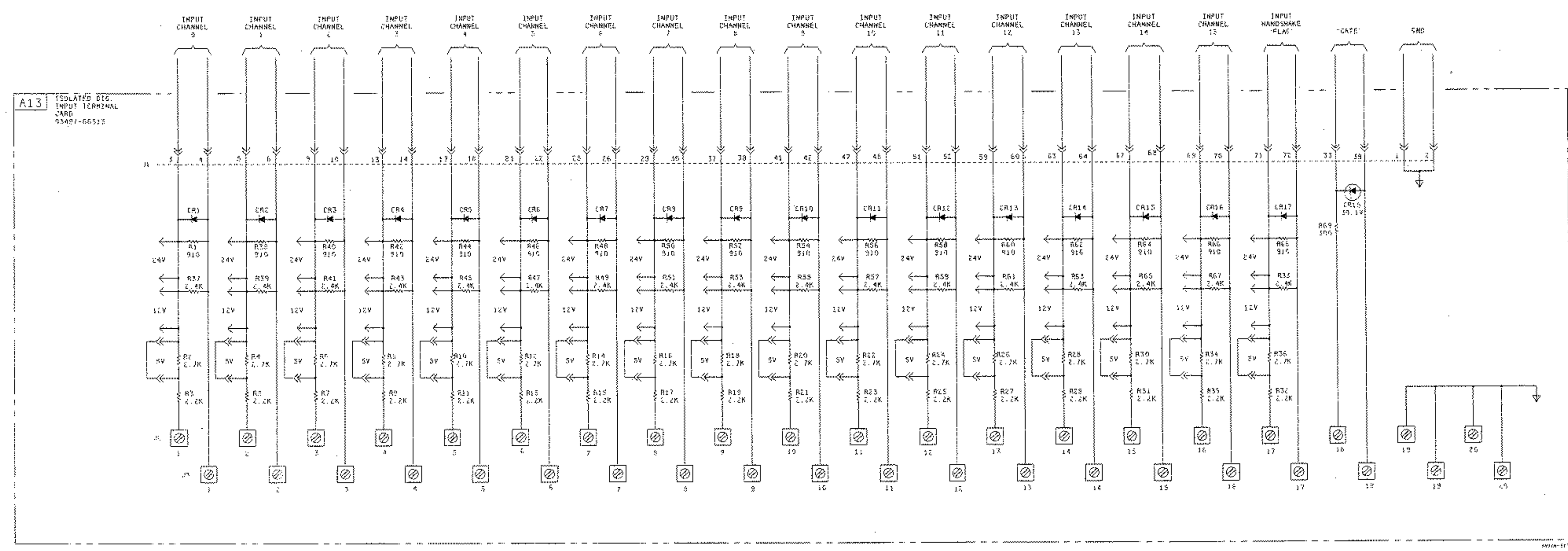


Figure 168. Option 140 - Dig Input Terminal Card (Option 050)

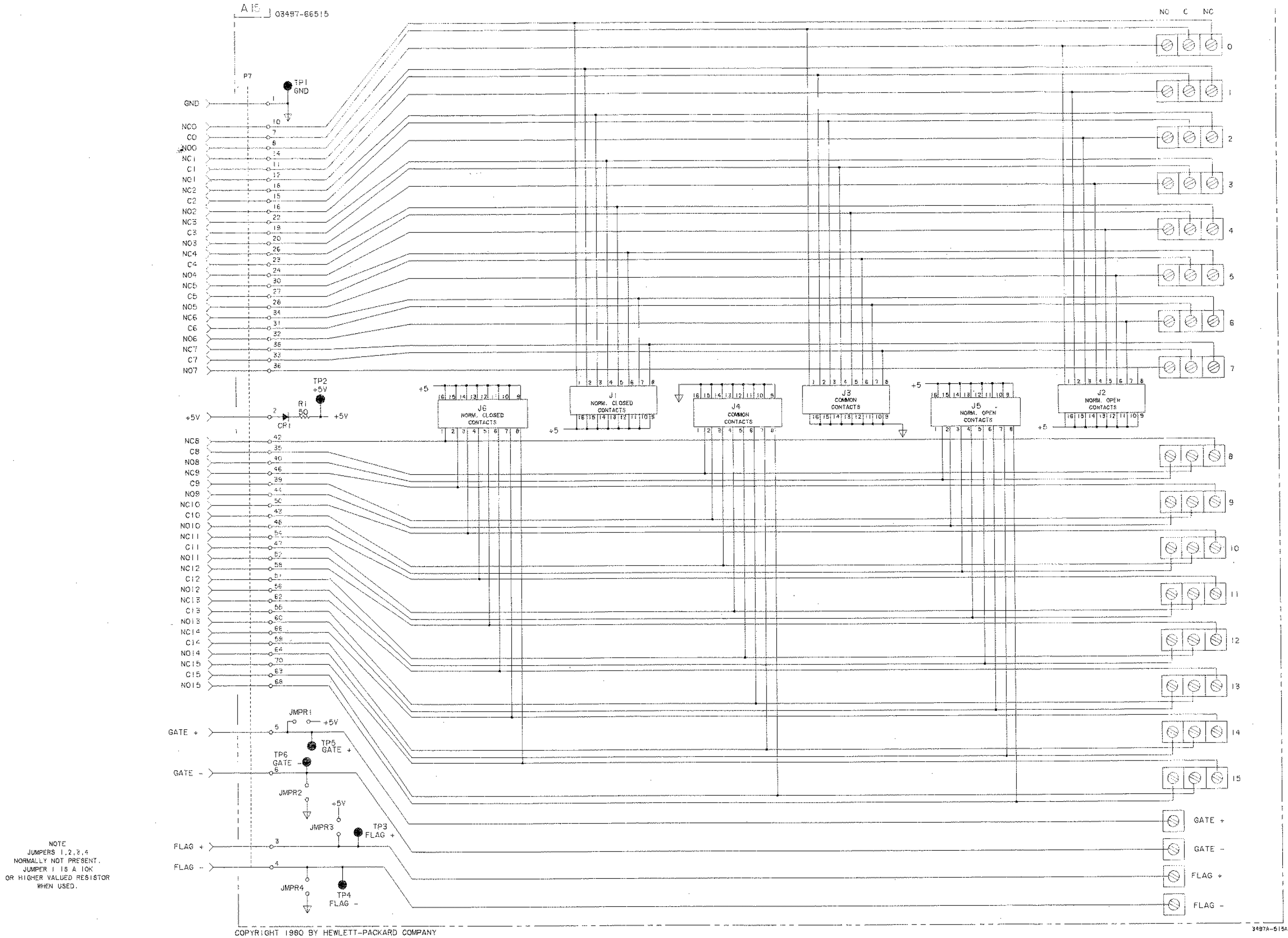


Figure 169. Option 140 - Dig Output Terminal Card (Option 110)

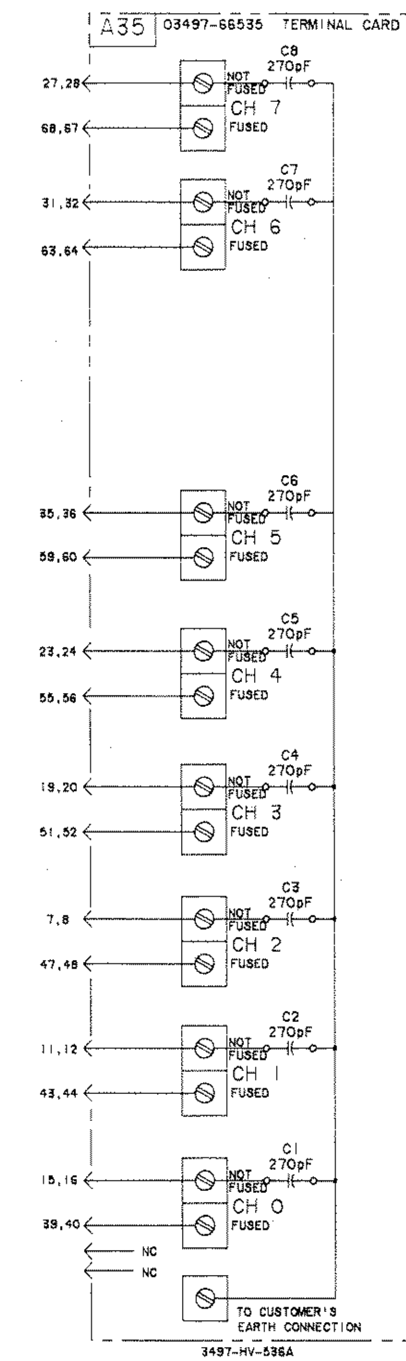
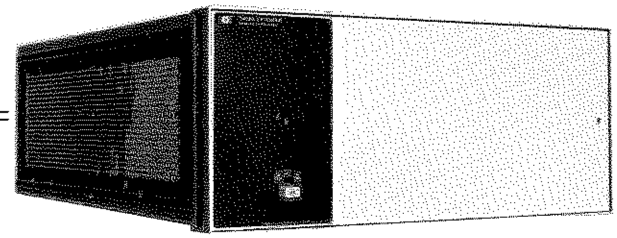


Figure 170. Option 140 - HV Actuator Terminal Card (Option 115)

OPTION 298



3498A Extender

INTRODUCTION

The Model 3498A Extender allows you to add additional plug-in assemblies for expansion of system capability. Each 3498A can hold up to 10 plug-in assemblies. You can add a maximum of thirteen 3498As to each 3497A for a total capability of 135 assemblies (5 in the 3497A and 10 in each 3498A).

The maximum number of analog assemblies (Options 010, 020, 070 and 071) which can be added is 45. The maximum number of digital assemblies (Options 050, 060, 110, 115, 120 or 130) which can be added is 85. Thus, maximum capability is 1000 analog channels or 1360 digital channels. Use of one or more 3498As requires a 3497A for control.

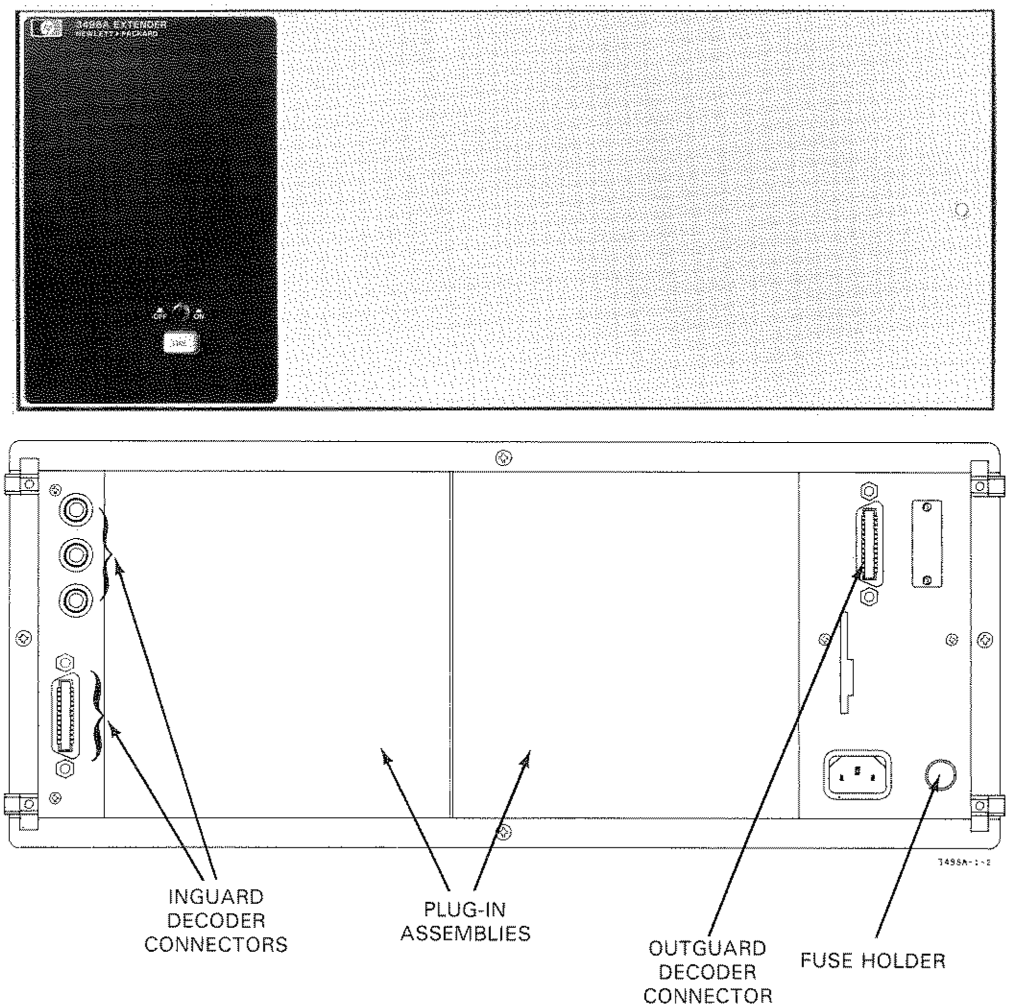
Description

As shown in Figure 171, the 3498A Extender has a blank front panel with only a LINE switch and an indicator light for power-on conditions. The rear view shows that the extender has space for up to 10 plug-in assemblies and interconnections for analog and digital interface cables. The 3498A also includes decoding circuitry to allow the unit to operate with control signals from the 3497A and it contains power supplies for instrument devices using system ground or floating voltages.

Since the 3498A provides only POWER ON SRQ, Option 050 or Option 060 assemblies do not cause interrupt when placed in the 3498A although this capability is available when these assemblies are placed in the 3497A. Also, the DVM (Option 001) cannot be used in the 3498A.

Manual Information

This manual contains configuration and control information for the 3498A. For repair and/or service information, see 3497A Plug-In Assemblies/3498A Extender Service Manual. Instruments manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany the manual. See Appendix B for details.



REAR VIEW SHOWN WITH SAFETY COVER REMOVED

Figure 171. Option 298 · Model 3498A Extender

Specifications

Specifications for the Model 3498A Extender follow. Specifications are performance standards or limits against which the instrument may be tested.

OPTION 298
ADD 3498 EXTENDER

Number of Slots per 3498A: 10

Maximum Number of Added Analog Multiplexer Channels (Options 010, 020): 900 channels (45 assemblies)

Maximum Number of Added Non-analog Acquisition Assemblies (Options 050, 060, 110, 115, 120, 140): 85 assemblies

Maximum Separation From the 3497A:
3498A with analog cards (Options 010, 020, 070, 071): 100 meters
3498A with digital assemblies (all other options): 25 meters (2 meter cables are supplied standard)

Maximum Number of 3498A's per 3497A: 13

Isolation:

	25°C, >85% R.H. 40°C, >60% R.H.	40°C, >95% R.H.
Hi to Lo	$>10^{10}$ Ohms	$>10^{9}$ Ohms
Lo to Guard	$>10^{8}$ Ohms	$>10^{7}$ Ohms
Guard to Chassis	$>10^{8}$ Ohms	$>10^{7}$ Ohms

Operating Considerations

Digital Interrupt is not passed between the 3498A and the parent 3497A. Digital Interrupt is found on the Option 050 Digital Input/Interrupt Assembly and on the Option 060 Counter Assembly.
The DVM assembly cannot be used in the 3498A.
Power and Environmental Information: see 3497A data.

INSTALLING THE 3498A

WARNING

There is no operator installation or configuration for the Model 3498A Extender. Only qualified, service-trained personnel should install or configure the instrument.

Initial Inspection

Whether you ordered the 3498A Extender as Option 298 to the 3497A or as a separate item, the shipping container should contain the items shown in Figure 172. If any item is missing or if there is mechanical damage or defect to the instrument, contact your nearest -hp- Sales/Service office. They will arrange for replacement or repair at -hp- option.

If there is any damage to the shipping carton, keep the carton and notify the carrier as well as -hp-. If you return a 3498A or accessory to -hp-, follow the shipping guidelines in Appendix B.

Line Voltage and Fuse Selection

The 3498A can be operated from any power source which supplies 100V, 120V, 220V or 240VAC (-10% to + 5%), 48-66 Hz, single phase. Power consumption is 150VA. The 3498A requires a 1 hour warm-up time. When you receive the 3498A, check to see that the Line Voltage Selector Switches and fuse size are proper for the power option you specified by doing the following:

CHECKING FUSE AND LINE VOLTAGE SWITCHES

1. Loosen the screw on the right side of the front panel and swing the panel open.

2. Compare the line voltage selector switch positions with those shown in Figure 173. If not correct, set the switches to proper setting.

3. Check the fuse for proper type (1.25A for 100V or 120V operation; 2.5A for 220V or 240V operation). The fuse is located in the fuseholder on the right rear panel of the instrument as shown in Figure 172.

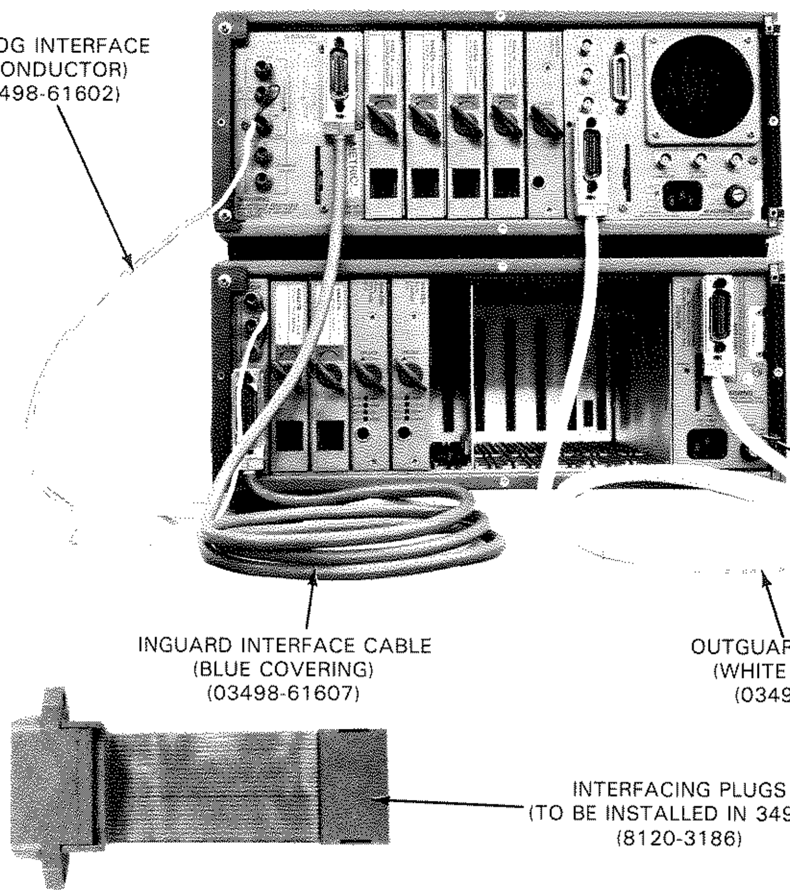


Figure 172. Option 298 - 3498A Extender and Accessories Supplied

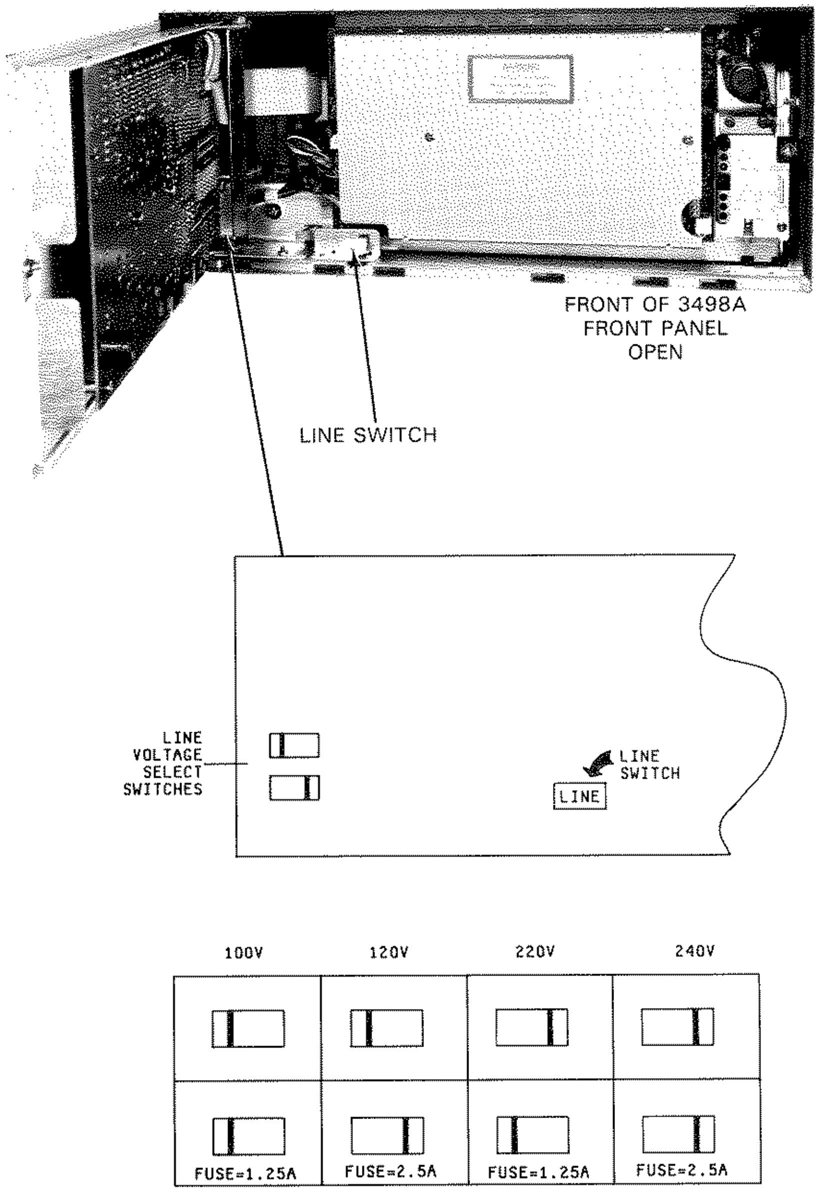


Figure 173. Option 298 - Line Voltage Switch and Fuse Locations

Power Cable and Grounding Requirements

The 3498A is equipped with a three-conductor power cord which, when plugged into an appropriate receptacle, grounds the instrument. The type of power cord shipped with the 3498A depends on the country of destination. See Figure 174 which shows the power cables available to ensure that you have the proper cord for your line voltage.

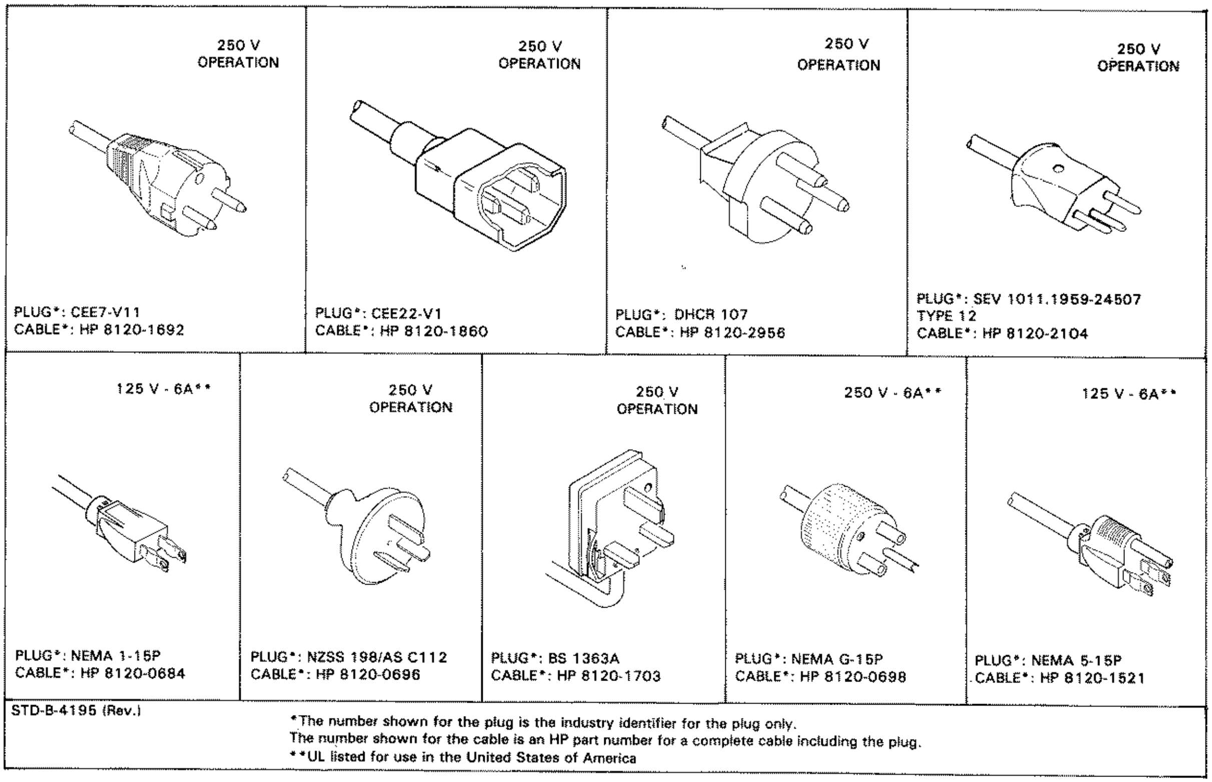


Figure 174. Option 298 - Power Cables for the 3498A

Environmental Considerations

The 3498A can be used either as a bench instrument or can be mounted in a standard 19'' rack. When the 3498A is used as a bench instrument, the plastic feet under the instrument are shaped so that the 3498A may be mounted on top of other -hp- equipment.

To meet its specifications, the 3498A should be operated within ± 5 °C (± 9 °F) of the calibration (or reference) temperature. The 3498A should be operated within an ambient temperature range of 23 °C ± 5 °C (73 °F ± 9 °F). The instrument may also be operated within an ambient temperature range of 0 °C to 55 °C (+32 °F to 131 °F), but with reduced efficiency.

WARNING

To prevent potential electrical or fire hazard, do not expose the 3498A to rain or moisture.

3498A ENVIRONMENTAL REQUIREMENTS

Warm Up Time	1 Hour
Operating Temperature	0 °C to 55 °C
Non-Operating Temperature	-40 °C to 75 °C
Humidity	To 95% except as noted in Specifications.
Shock	30 G, 11 msec, sine wave on each of six sides.
Vibration	10 Hz to 55 Hz at .010 inch peak to peak excursion.
Operating Power	Switch selection of 110 volts, 120 volts, 220 volts, 240 volts (- 10% to +5%); 48-66 Hz, 150 VA (3497A), 150 VA (3498A).

Bench Installation

When the 3498A is used as a bench instrument, choose a location which provides at least 3 inches (8 cm) of clearance at the rear of the instrument and at least 1 inch (3 cm) on each side. If adequate clearance is not provided, excessive temperatures may be generated inside the 3498A and reduce instrument reliability. Clearances provided by the plastic feet in bench stacking allow adequate air passage across the top and bottom cabinet surfaces.

Rack Mount Installation

Options 907, 908 and 909 (Rack Mounting Kits) enable the 3498A to be mounted in a standard EIA (19'' wide) rack. Installation instructions are included with the Rack Mount Kit ordered. For further information on -hp- rack mounting kits, see -hp- SYSTEM II Rack Mounting Kits & Accessories Manual (-hp- Part Number 5952-0095) which may be ordered from your nearest -hp- Sales and Service Office.

Installing Plug-In Assemblies

To install plug-in assemblies (Options 010 through 140) in the 3498A, select the slot desired for the assembly and insert the assembly as shown in Figure 175, which shows a sample installation for the Relay Multiplexer assembly (Option 010).

WARNING

Do not install or remove plug-in assemblies until you remove the AC power cords from the 3497A/3498A and remove ALL external voltage sources from these instruments.

CAUTION

Most assemblies require clean handling techniques to avoid degraded performance.

NOTE

Some assemblies require that a shield or cover be removed if the assembly is to be installed in slot 14 or 19.

INSTALLATION IN 3498A

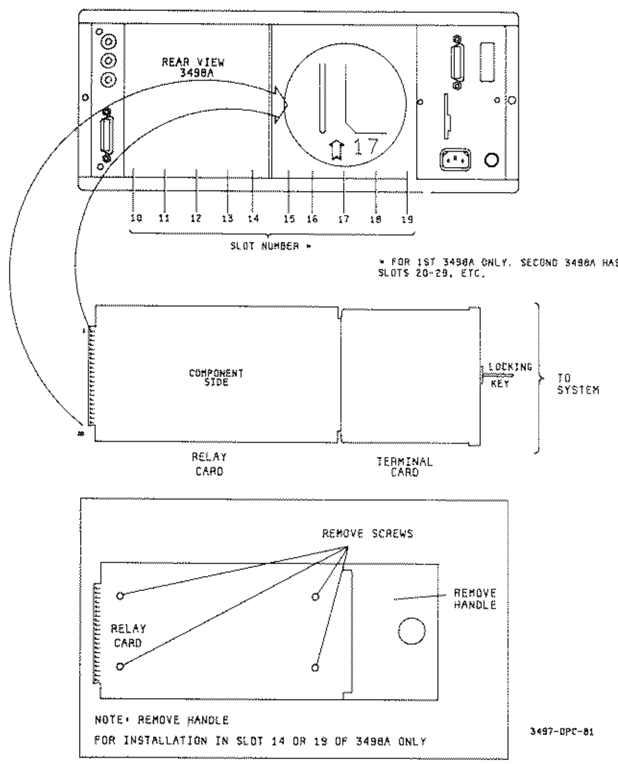


Figure 175. Option 298 - Installing Plug-In Assemblies

Interfacing the 3498A with the 3497A

As noted, you can use up to 13 3498As per 3497A. If you ordered the 3498A as Option 298, you can directly connect the three cables supplied with the 3498A (see Figure 172) to interface the 3498A with the 3497A, as shown in Figure 176.

WARNING

Do not connect two extender cables together as a means of increasing the distance between a 3497A and a 3498A or between 3498As. The exposed metal connector plug housings are at GUARD potential (up to 170V) and thus present a lethal shock hazard.

NOTE

To avoid interference effects between 3497A systems and their installation environment, due regard should be paid to considerations of Electromagnetic Compatibility. Wiring should follow good RF practice, such as ensuring that all interconnections are enclosed by shields connected or bypassed to local earth grounds via low impedance paths.

The 3497A and 3498A outer frames should be interconnected either via heavy metallic braid or by installation in the same rack. Between the 3497A and 3498A(s), the (small white) High-Low-Guard signal cable should be arranged adjacent to the blue extender cable.

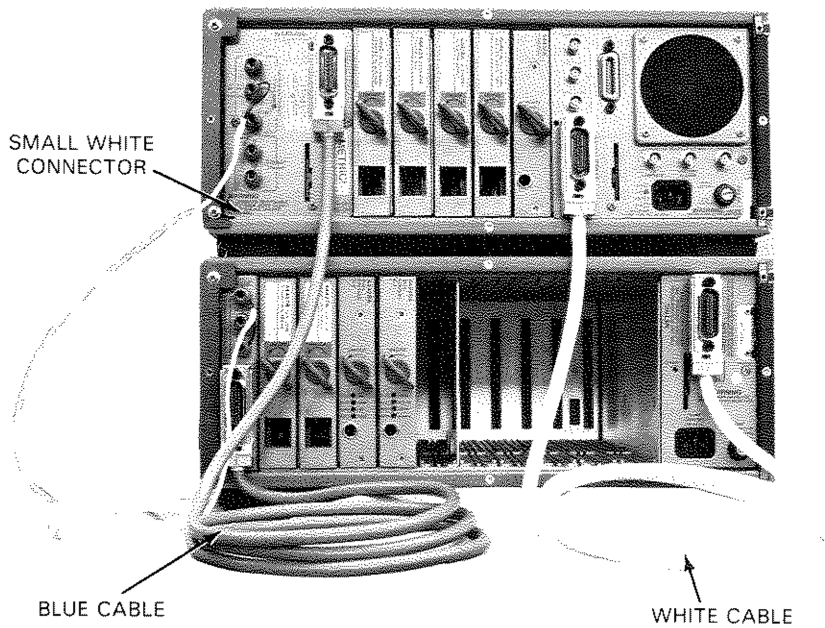
If You Ordered 3498A(s) Separately

If you ordered the 3498A as a separate instrument AND did not order the 3497A with Option 298, you will need to install the two interfacing plugs shipped with the 3498A (see Figure 172) into the 3497A before you can follow the interconnection sequence shown previously.

Figure 177 (a) shows how to install an interface plug on the outguard controller of the 3497A (right side of the 3497A as viewed from the rear of the instrument) and Figure 177 (b) shows how to install the other interface plug on the inguard controller (left side of the instrument).

WARNING

Shown with safety covers removed. Safety covers must be installed on rear of 3497A and 3498A before power is applied.



NOTE

1. *For rack connection, install 3497A and 3498As in same rack.*
2. *Arrange small white connector next to blue cable.*
3. *Interconnect 3497A and 3498A outer frames via heavy metallic braided connector.*

Figure 176. Option 298 · Interconnecting 3498A and 3497A

To install the interface plugs, first verify that all power is removed from the 3497A. Then remove the protective cover, loosen the retaining screw on the outguard controller board and remove the board using the plastic pull ring.

Remove the filler plate from the rear panel of the board and install the connector plug of one of the interface plugs in its place. Then insert the pigtail DIP plug into socket J2 on the outguard controller board. Reinstall the board in the 3497A and replace the protective cover.

To install the other interface plug on the inguard controller, follow the instructions for the outguard controller, except insert the pigtail DIP plug into J7 on the inguard controller.

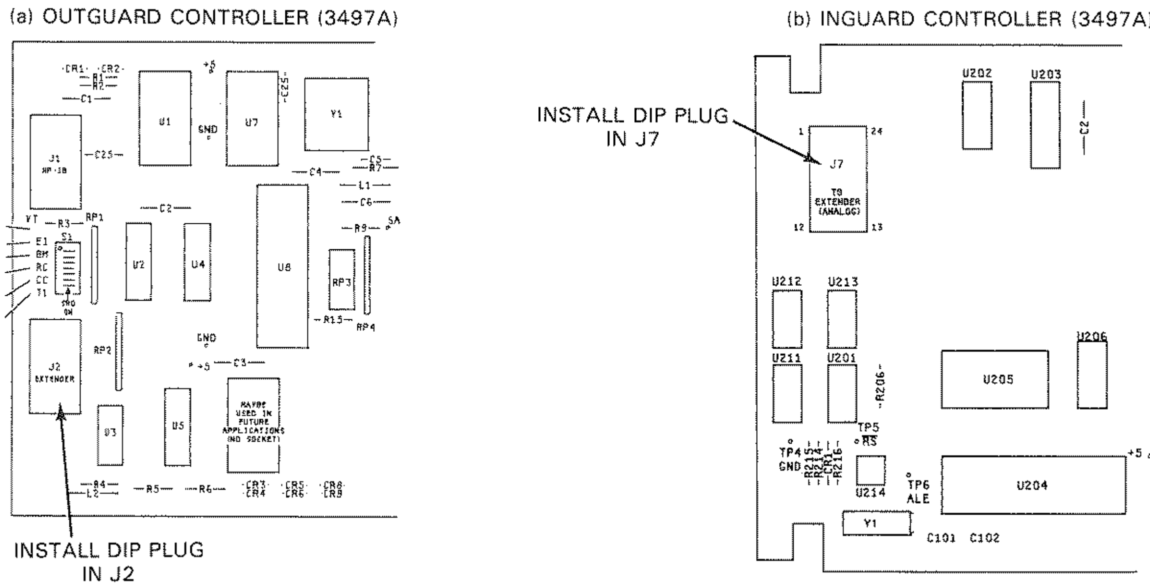


Figure 177. Option 298 - Installing Interface Connector Plugs

Installing Several 3498As

To install more than one 3498A, connections must be made from each successive extender to a previously connected extender, as shown in Figure 178. Note that the 3497A must have only one 3498A connected to it. A 3498A may have either a 3497A or two 3498As connected to it. This is necessary so that the required safety covers can be placed over the rear panels.

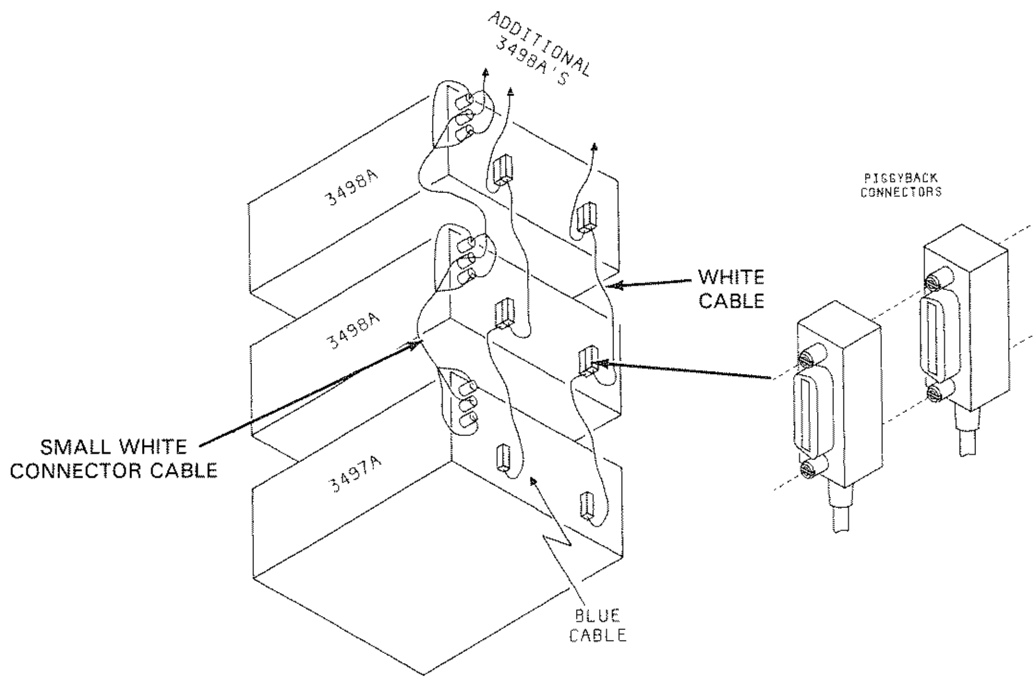


Figure 178. Option 298 - Multiple 3498A Interconnections

CONFIGURING THE ASSEMBLY

In general, it is not necessary to make configuration changes to the 3498A. However, if you use more than one 3498A with your 3497A, you will have to modify the factory set analog addresses and slot numbers. As factory preset, each 3498A is configured for analog addresses 100 through 199 and slot numbers 10 through 19.

A suggested slot and channel number addressing scheme follows. Naturally, you can configure the slot numbers and channel addresses as required for your application. For example, each decade can have any decade address from 0 to 999. Therefore, it is possible for all 20 decades (10 slots) in a 3498A to have the same 10 channel addresses.

SUGGESTED SLOT # AND CHANNEL ADDRESSES

3498A NUMBER	SLOT NUMBER [1]	DECADE A ADDRESSES [2]	DECADE B ADDRESSES [2]
	10	100-109	110-119
	11	120-129	130-139
	12	140-149	150-159
	13	160-169	170-179
	14	180-189	190-199
1			
	15	200-209	210-219
	16	220-229	230-239
	17	240-249	250-259
	18	260-269	270-279
	19	280-289	290-299
2	20-29	300-399	400-499
3	30-39	500-599	600-699
4	40-49	700-799	800-899
5	50-59	900-999	----
6	60-69	----	----
7	70-79	----	----
8	80-89	----	----

[1] The maximum number of slots which can be addressed is 89 (i.e., slots 0-4 in a 3497A plus slots 10-89 in 8 added 3498As). Note that slots 5 through 9 do not exist for digital assemblies.

[2] The maximum number of analog channels is 1000 (0-999). Thus, the maximum number of analog assemblies (Options 010,020,070, 071) which can be used is 50 (i.e., 5 slots in the 3497A and 45 slots in five 3498As added).

Channel and Slot Capacity

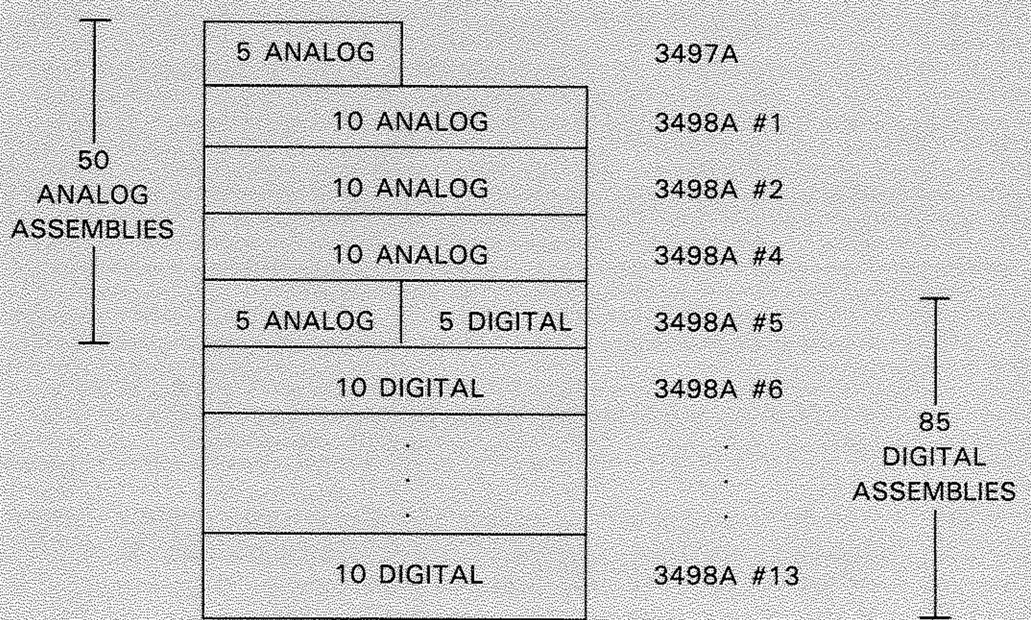
With this suggested addressing scheme, you can input 20 analog channels (0-19) or 16 digital channels (0-15) into each slot. With a 3497A alone, total system capacity is 100 analog channels or 80 digital channels. By using 3498A Extenders, you can expand total system capacity to 1000 analog channels and 1360 digital channels, as shown.

3497A/3498A CHANNEL CAPACITY

ASSEMBLY	3497A ONLY		3497A + 3498As		
	# SLOTS	#CHANNELS	MAX # 3498As	#SLOTS	#CHANNELS
ANALOG	5	100	5	50	1000
DIGITAL	5	80	8	85	1360

EXAMPLE - MAXIMUM SLOT/CHANNEL CAPACITY

For example,to achieve maximum channel capacity, you could configure your system as shown, with analog assemblies in the 3497A and in the first 45 slots of 3498As and digital assemblies in the remaining 85 slots.



Changing Analog Addresses

If you need to change the analog addresses in a 3498A, use the procedures which follow and see Figure 179. Jumpers to modify the analog addresses are located on the Power Supply-Inguard Decoder board which is located behind the front panel of the 3498A.

To gain access to this board, first verify that all power sources are removed from the 3497A/3498A. Then loosen the fastener on the front panel and swing the panel out. Remove the two screws holding the shield over the board and remove the shield. Then locate the CENTURY and DECADE ADDRESS jumpers as shown in Figure 179.

WARNING

The shield covering the Power Supply-Inguard Decoder board is at GUARD potential (up to 170 V) when external voltage sources are applied. Be sure that all power sources are removed from the 3497A/3498A before touching the shield.

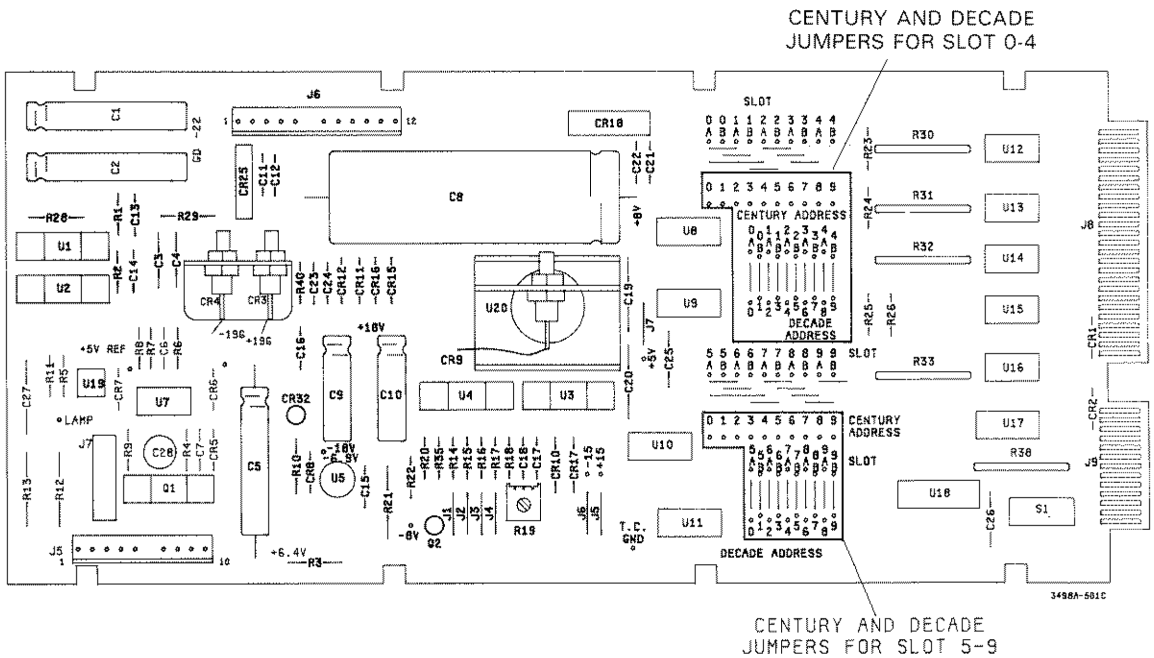


Figure 179. Option 298 · Analog Address Century/Decade Jumpers

As shown in Figure 179, each slot (shown as 0 - 9 in the figure) has CENTURY ADDRESS jumpers and DECADE ADDRESS jumpers. As factory preset, the jumpers are connected so that analog addresses are 100-199 and slot numbers are 10-19. For clarity we'll assume that the slot numbers remain 10-19 and show how to change the analog addresses. See Changing Slot Numbers for procedures to change slot numbers.

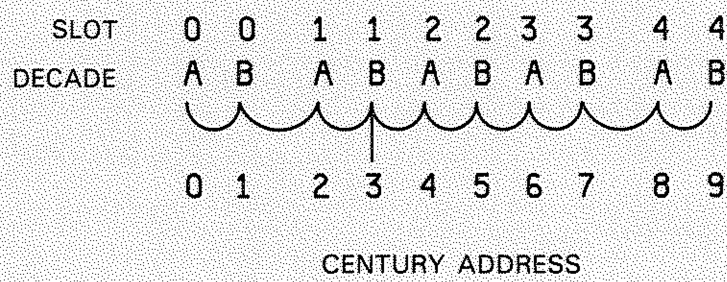
To change the analog addresses, you may need to cut and/or solder jumpers. Some examples follow to illustrate the method. When you have finished modifying the board, replace the shield and secure the front panel.

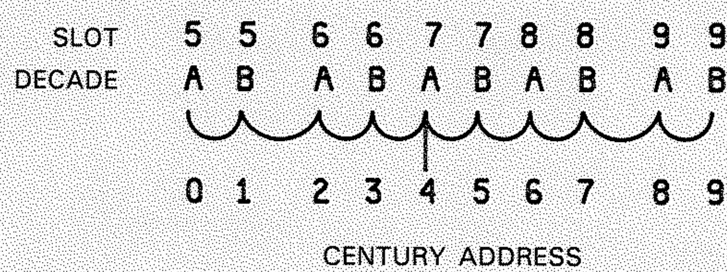
CAUTION

Use clean handling techniques when reconfiguring the board and do not subject the board to electrostatic discharge. After soldering, verify that the circuit board is properly cleaned (i.e., excess solder and flux removed).

EXAMPLE - SET 3498A TO ADDRESSES 300-499

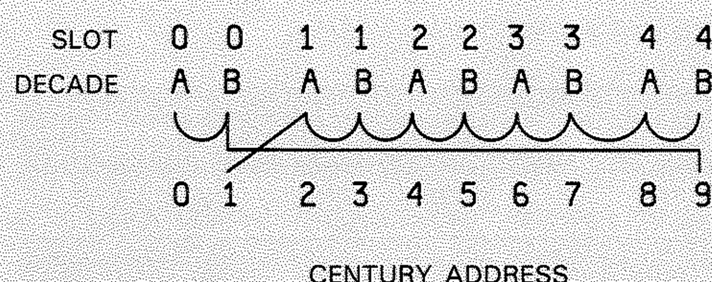
For this example, we'll change only the CENTURY jumpers, as shown below. Since the DECADE address jumpers are not changed, with CENTURY address jumpers for slots 0-4 tied to pin 3, these slots have addresses 300-399 and with CENTURY address jumpers for slots 5-9 tied to pin 4, these slots have addresses 400-499. Since the DECADE address jumpers are not modified, they are not shown.

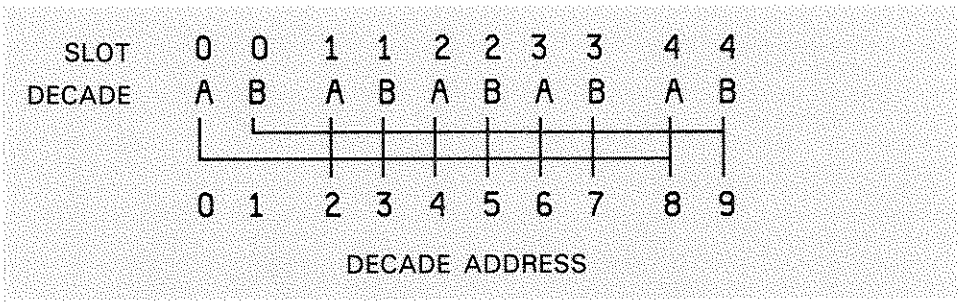




EXAMPLE - SET SLOT 0 TO ADDRESSES 980-999

In this example, we'll set the address of slot 0 (decades A and B) to 980-999 (as factory preset, slot 0 has addresses of 100-119). This will require that the CENTURY jumpers be set for "9" and that the DECADE jumpers be set for "8" for the A decade and or "9" for the B decade, as shown. Since the settings for slots 5 through 9 do not change, they are not shown.





Changing Slot Numbers

As factory configured, each 3498A has slot numbers 10-19. To change the slot numbers for a 3498A, it is necessary to remove the Outguard Decoder circuit board located on the right rear panel of the 3498A (as seen from the rear). To remove this board, first verify that all power has been removed from the 3498A. Then remove the safety cover, loosen the retaining fastener and remove the Outguard Decoder (see Figure 180).

Next, locate the box address selector jumper block (see Figure 180 for location). To change a slot address, simply cut the appropriate jumper(s) according to the following equation, where a jumper in place = a ''1'' in the equation (only the first digit can be modified).

BEGINNING SLOT NUMBER = 10[8 - (A + 2B + 4C)]

For example, to change the beginning address of the slots to 20 (i. e., slots 20-29 are available for this 3498A), cut jumper A. Then, BEGINNING SLOT NUMBER = 10 [8 - (0 + 2 + 4)] = 20.

NOTE

Slot numbers for each 3498A MUST be unique to avoid spurious data which may occur if two 3498As have the same slot numbers.

When the modifications have been made, replace the Outguard Decoder and replace the protective safety cover.

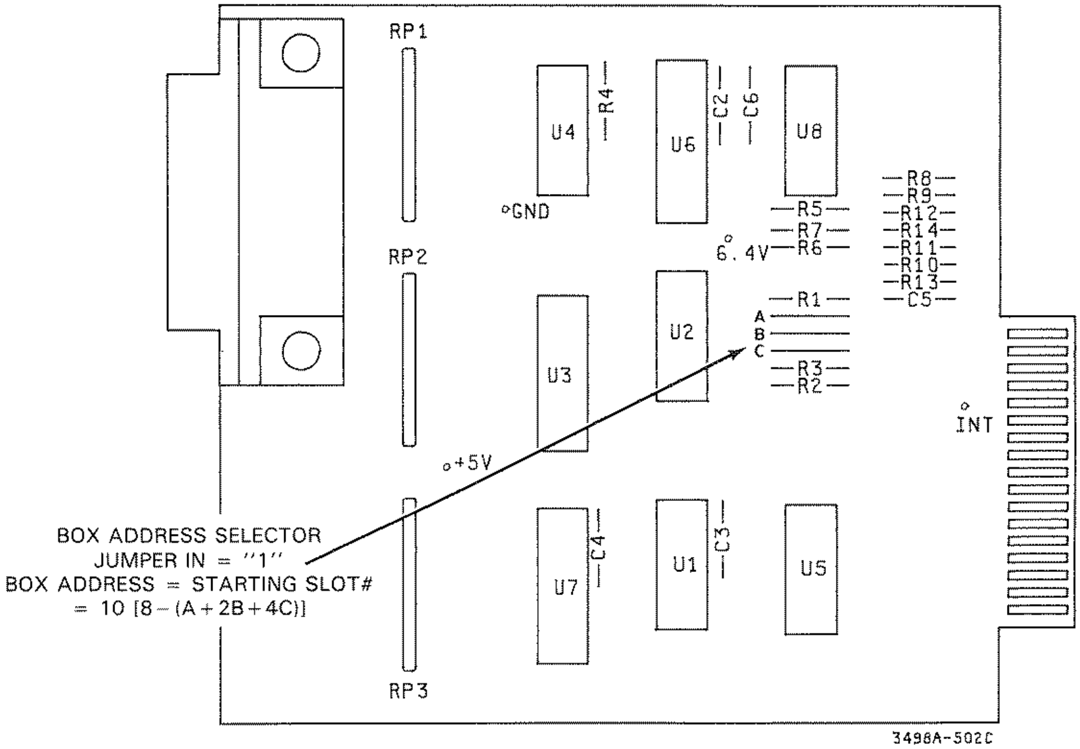


Figure 180. Option 298 · 3498A Outguard Decoder

Power On Interrupts with the 3498A

> **NOTE**
>
> *The following discussion applies only to 3497As with HP-IB capability. For a 3497A with Serial Data (Option 232), POWER ON SRQ is automatically set.*

Although both the digital input/interrupt assembly (Option 050) and the 100 kHz counter (Option 060) can cause a digital interrupt when they are placed in a 3497A, they have no interrupt capability when placed in a 3498A. The only interrupt which can be generated by the 3498A is POWER ON SRQ.

The purpose of the POWER ON SRQ is to provide an indication (when power is returned) that power has been lost to the 3498A. When the 3498A recovers from a low power condition, it sends an interrupt to the 3497A. If the 3497A has previously been enabled for POWER ON SRQ, the 3497A will then send an interrupt to the controller.

Once POWER ON SRQ is enabled, a low power condition in either the 3497A OR the 3498A will cause an interrupt and there is no way to tell if the interrupt resulted from power loss in the 3497A, 3498A or both. If the 3497A is not set for POWER ON SRQ, interrupt is NOT sent to the controller, even if either or both instruments experienced a power failure. Also, note that POWER ON SRQ occurs when power is regained, NOT when it is lost.

To enable the 3497A for POWER ON SRQ, it is necessary to set the POWER ON SRQ switch (position #7) on the 3497A Outguard Controller to the "1" position. To do this, see Figure 181 and use the following sequence.

First verify that all power is removed from the 3497A and 3498As connected. Then, remove the safety cover, loosen the retaining screws holding the outguard controller and remove the outguard controller. Locate the 7-position DIP switch and set switch position #7 to the "1" position (see Figure 181). Replace the outguard controller and the safety cover.

ASCII Code Character		Address Switches					5-bit Decimal Code
Listen	Talk	A5	A4	A3	A2	A1	
SP	@	0	0	0	0	0	00
!	A	0	0	0	0	1	01
"	B	0	0	0	1	0	02
#	C	0	0	0	1	1	03
$	D	0	0	1	0	0	04
%	E	0	0	1	0	1	05
&	F	0	0	1	1	0	06
'	G	0	0	1	1	1	07
(	H	0	1	0	0	0	08
)	I	0	1	0	0	1	09 ← FACTORY SETTING
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
,	L	0	1	1	0	0	12
–	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
Ø	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;	[	1	1	0	1	1	27
<	\	1	1	1	0	0	28
=	]	1	1	1	0	1	29
>	~	1	1	1	1	0	30

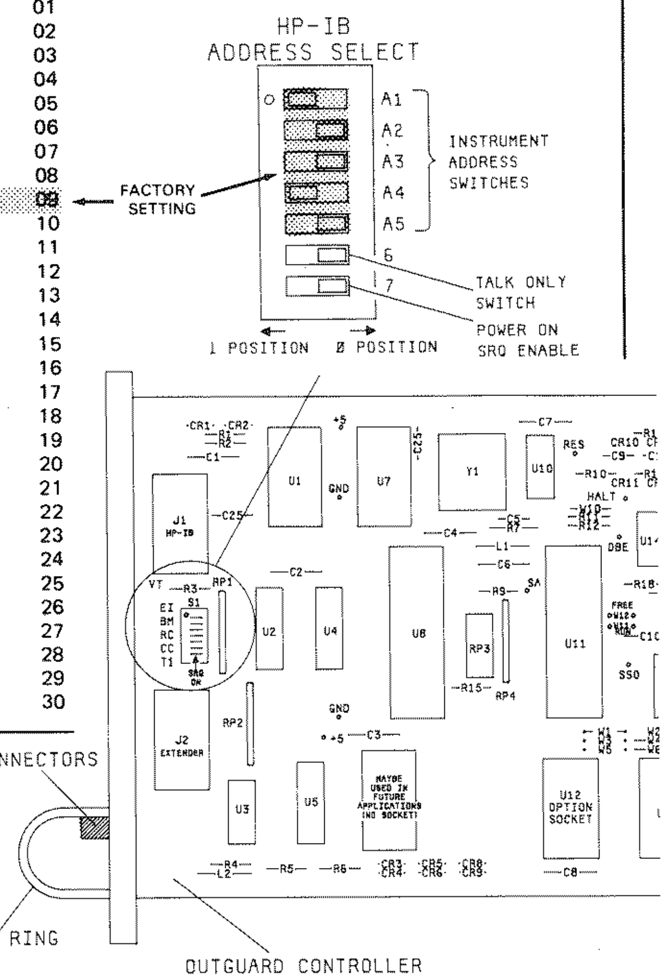


Figure 181. Option 298 - Setting 3497A Power On SRQ

Chapter 9
EXAMPLE 3497A CONFIGURATIONS

INTRODUCTION

As shown in Chapter 1, when the 3497A is used in a Data Acquisition/Control System, the instrument can be used to perform two primary functions: data acquisition measurements and control applications. In this chapter, we'll show some typical ways that the 3497A can be used for data acquisition measurements and control applications.

Chapter 9 consists of 17 example applications divided into eight functional categories: voltage, resistance, thermocouple, frequency and pressure measurements and interrupts, switching and control sources. No attempt is made to define a specific type of user system to be connected to the 3497A. Rather, the emphasis is on the 3497A response to typical user input signals and how to configure and program the 3497A for these signals.

The examples shown apply specifically to the 3497A. If you ordered the 3497A as part of the 3054A/C or 3054DL system, consult the appropriate system manual for a wide variety of examples and programs which use the 3497A as part of the system.

All example configurations have the format shown. Examples are in summary form and assume that you are familiar with the operation and function of the 3497A and the plug-in assemblies used. The sample programs use extended BASIC language and may require conversion if you use a controller which is not compatible with this language.

EXAMPLE CONFIGURATIONS - FORMAT

EXAMPLE TITLE

DESCRIPTION

Describes the purpose and typical applications for the example.

PROCEDURE

Shows a block diagram operation and/or shows specific settings and slot/channel numbers used.

CONFIGURATION

Shows how to connect inputs to the assemblies and/or the 3497A and how to reconfigure the 3497A and assemblies as required.

SAMPLE PROGRAM

A sample program in Extended BASIC for the example.

TYPICAL PRINTOUT

A printout (on the -hp- 85A printer) of typical values (when applicable).

COMMENTS

Precautions and/or conditions for the example.

The following table summarizes the example configurations in this chapter and is divided into the eight categories previously identified. Since the examples are grouped into functional categories, if you want to make voltage measurements, see voltage measurements. If you want to totalize events, see frequency measurements, etc.

VOLTAGE MEASUREMENTS

EXAMPLE NUMBER	TITLE	DESCRIPTION	PAGE
1	GUARDED VOLTAGE MEASUREMENTS	Shows how to use the Option 010 assembly to make sequential DC voltage measurements from 10 electro-mechanical transducers which produce voltages in the millivolt range.	558
2	SINGLE ENDED VOLTAGE MEASUREMENT	Shows how to use the Option 010 assembly to make sequential DC voltage measurements for up to 277 single-ended inputs. This application is useful when you don't require the accuracy of three-wire techniques.	561
3	DATA LOGGING	Shows how to use the time of day function of the 3497A and the Option 010 assembly for data logging of sequentially measured DC voltages.	568
4	FAST SCAN VOLTAGE MEASUREMENT	Shows how to use the internal storage capability of the 3497A and the Option 010 assembly to make up to 60 sequential channel voltage measurements at scan rates up to 125 channels/second.	571

RESISTANCE MEASUREMENTS

5	2-WIRE RESISTANCE MEASUREMENTS	Shows how to use the Option 010 assembly and DVM current source for 2-wire ohms measurements.	576
6	4-WIRE RESISTANCE MEASUREMENTS	Shows how to use the Option 010 assembly and DVM current source for 4-wire ohms measurements. This technique is useful when highly accurate (milliohm range) measurements are required.	579

THERMOCOUPLE MEASUREMENTS

(7)	HARDWARE COMP T-COUPLE MEASUREMENTS	Shows how to use the Option 020 assembly with hardware compensation to determine the temperature of a J-type thermocouple.	582
(8)	SOFTWARE COMP T-COUPLE MEASUREMENTS	Shows how to use the Option 020 assembly with software compensation to determine the temperatures of a mixture of J, K, T and S type thermocouples on the same assembly.	586

FREQUENCY MEASUREMENTS

(9)	COUNT UP/ DOWN MEASUREMENTS	Shows how to use the Option 060 assembly to count up (totalize) from a programmable start point and how to count down to zero from a programmable start point.	592
(10)	PERIOD MEASUREMENTS	Shows how to use the Option 060 assembly to measure the period of an input frequency.	595

PRESSURE MEASUREMENTS

(11)	STRAIN GAUGE MEASUREMENTS	Shows how to use the Option 070 assembly with ¼ bridge configuration to determine the strain of 120 ohm strain gauges.	598

CONTROL APPLICATIONS - INTERRUPTS

⑫	COUNTER INTERRUPTS	Shows how to use the Option 060 assembly to generate an interrupt signal to the controller on counter overflow and/or measurement complete conditions.	602
⑬	EVENT SENSING	Shows how to use the Option 050 assembly to interrupt the controller when an external event, such as closing water valves or the end of motion by a mechanical arm, is sensed by the assembly.	608
⑭	USING THE COUNTER IN THE 3498A	Shows how to use the Option 060 and Option 050 assemblies to detect interrupts measurement complete or overflow when the Option 060 assembly is in the 3498A Extender.	611

CONTROL APPLICATIONS - SWITCHING

⑮	VOLTAGE SWITCHING/ ALARM ACTUATION	Shows how to use the Option 110 assembly to switch power from one user device to another and how to close relays to actuate an alarm.	614
⑯	HIGH VOLTAGE SWITCHING	Shows how to use the Option 115 assembly to sequentially switch power to activate motor starters.	616

CONTROL APPLICATIONS - CONTROL SOURCES

⑰	VOLTAGE AND CURRENT SOURCES	Shows how to use the Option 120 and 130 assemblies to provide a programmable voltage source and a programmable current source for control applications.	620

EXAMPLE 1
GUARDED VOLTAGE MEASUREMENTS

DESCRIPTION

One of the primary functions of the 3497A is to make DC voltage measurements. Usually DC voltage measurements are made using the 20 Channel Relay Multiplexer assembly (Option 010). DC voltage measurements can also be made using the Relay Multiplexer assembly with Thermocouple Compensation (Option 020). This example shows how to make guarded DC voltage measurements from electromechanical transducers which produce positive millivolt level outputs.

PROCEDURE

Figure 182 shows a simplified block diagram configuration and connection diagram using the Option 010 assembly to measure the voltages from sources V1 through V10. For this example, we'll place the assembly in slot 2 and connect the sources (transducers) to the 10 relay inputs in the A Decade. Thus, the channel numbers for the transducers are 40-49.

CONFIGURATION

To configure the Option 010 assembly, see Figure 182. Connect V1 high to A0 HIGH and connect V1 low to A0 LOW on the terminal card connectors. Since we are making guarded (3-wire) measurements, connect one end of the guard lead to the A0 GUARD connector and tie the other end to V1 low, as close to the V1 source as possible. Then repeat the procedure to connect V2 to A1, etc.

When the terminal card is connected, check to see that the T/C jumper on the relay card is set to the NO T/C COMP position. After verifying that all power sources are removed from the 3497A, when the assembly is configured, insert it into slot 2 of the 3497A. Then press the LINE switch on and enter the program shown to measure the channel voltages.

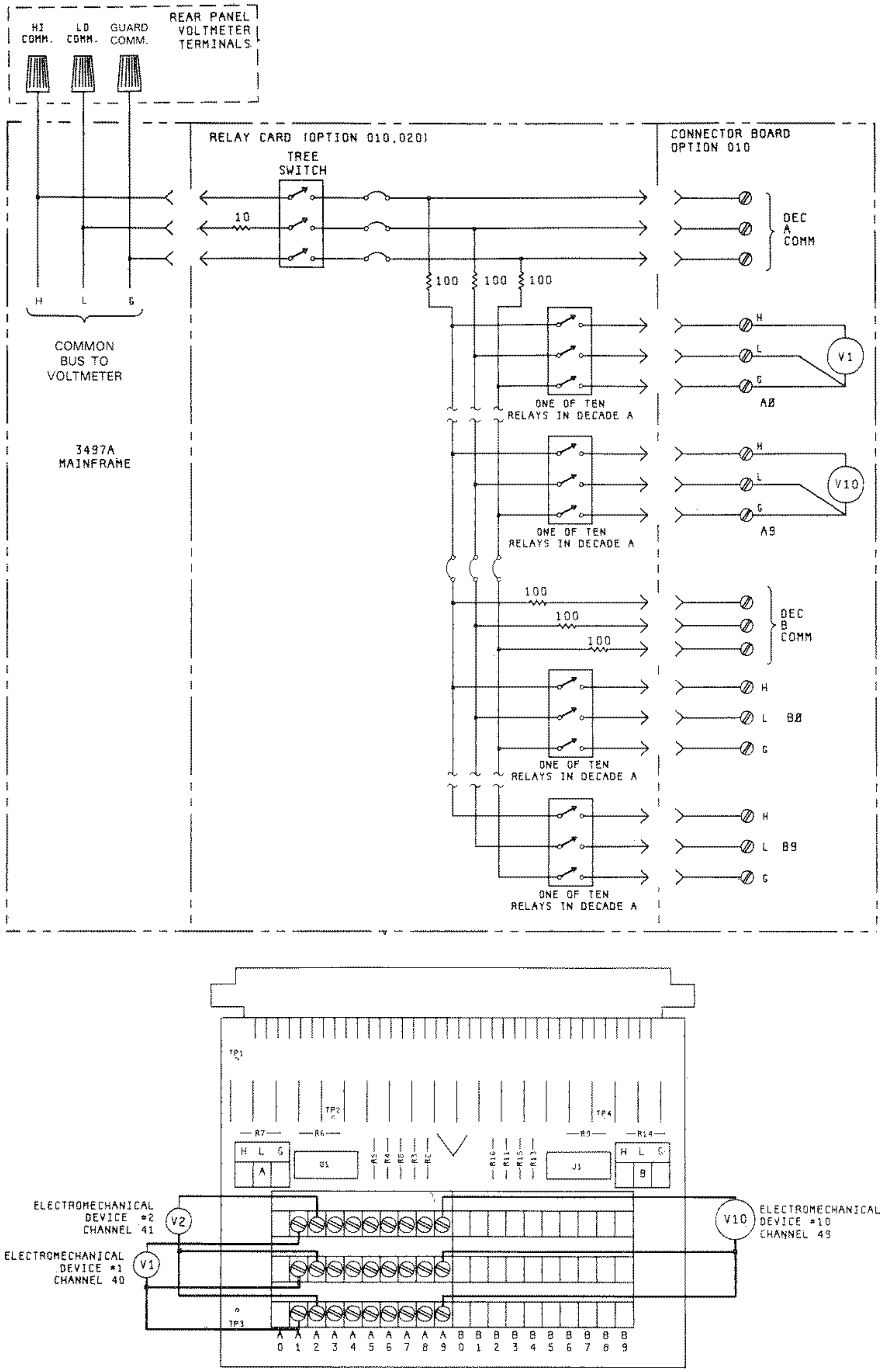


Figure 182. Example 1 - DC Voltage Measurements

SAMPLE PROGRAM

A sample program is shown to sequentially scan channels 40 through 49, by using the AC chan# command, to measure the voltage of sources V1 through V10 and print the results (in millivolts) on an -hp-85 printer. If you want to place the assembly in a slot other than slot 2, modify lines 60 and 90 for the appropriate addresses.

```
SET INITIAL CONDITIONS

 10 PRINT "DC VOLTAGE MEASUREMENTS"
 20 PRINT
 30 PRINT "SOURCE";TAB(13);"MILLIVOLTS"
 40 PRINT
 50 CLEAR 709

MEASURE VOLTAGES ON CHANNELS 40-49

 60 FOR I = 40 TO 49
 70 OUTPUT 709;"AC",I
 80 ENTER 709;A
 90 PRINT TAB (3);I-39;TAB(15);A*1000
100 NEXT I
110 END
```

TYPICAL PRINTOUT

```
DC VOLTAGE MEASUREMENTS

    SOURCE     MILLIVOLTS

       1          398.6
       2          235.54
       .            .
       .            .
      10          612.75
```

COMMENTS

For a detailed explanation of guarded voltage measurements, see -hp- Application Note 123 "Floating Measurements and Guarding" (-hp- part number 5952-2153).

EXAMPLE 2
SINGLE-ENDED MEASUREMENTS

DESCRIPTION

As factory configured, the 3497A is set to measure input voltages using 3-wire (guarded) measurement techniques. If your application doesn't require the accuracy of 3-wire measurements and if the LOW sides of all your voltage sources can be tied together, you can use 20 channnel relay multiplexer assemblies (Option 010) in the 5 slots of a 3497A to measure the inputs of up to 277 single-ended voltage inputs.

One way to do this is to use channels B0, B1 and B2 on a relay multiplexer in slot 4 to form a second level of multiplexing and then use the AC chan#,chan# command to simultaneously close a channel in slot 0, 1, 2 or 3 and the B0, B1 or B2 channel in slot 4 to measure the voltage from a specified input.

PROCEDURE

Figures 183 and 184 show the setup for single-ended measurements used in this example. Figure 183 shows the setup for an assembly in slot 0 and Figure 184 shows the configuration for an assembly in slot 4. Configurations for assemblies in slots 1 through 3 are identical to that in slot 0.

As shown in Figure 183, voltages V1 through V60 are input to relays A0 through B9. The HIGH outputs of each relay are connected to relay B0 of the assembly in slot 4 (channel 90), the LOW outputs to relay B1 (channel 91) and the GUARD outputs to relay B2 (channel 92). Similarly, V61 - V90 are input to slot 1, V91 - V120 are input to slot 2, etc.

As shown in Figure 184, for the assembly in slot 4 ONLY, channels B0, B1 and B2 (channels 90, 91 and 92) are reserved for secondary multiplexing, so only 37 voltages can be input to the slot 4 card. Total channel capacity is thus 60 x 4 = 240 + 37 = 277 single-ended inputs.

To measure a voltage, use the AC chan#,chan# command to simultaneously close the relay connected to the desired input AND relay B0, B1 or B2 of the assembly in slot 4. For example, in Figure 183, V1, V2 and V3 are connected to relay A0 (channel 0). Thus, to measure V1, use AC0,90 to simultaneously close relay A0 in slot 0 and relay B0 in slot 4. To measure V2, use AC0,91 and to measure V3, use AC0,92.

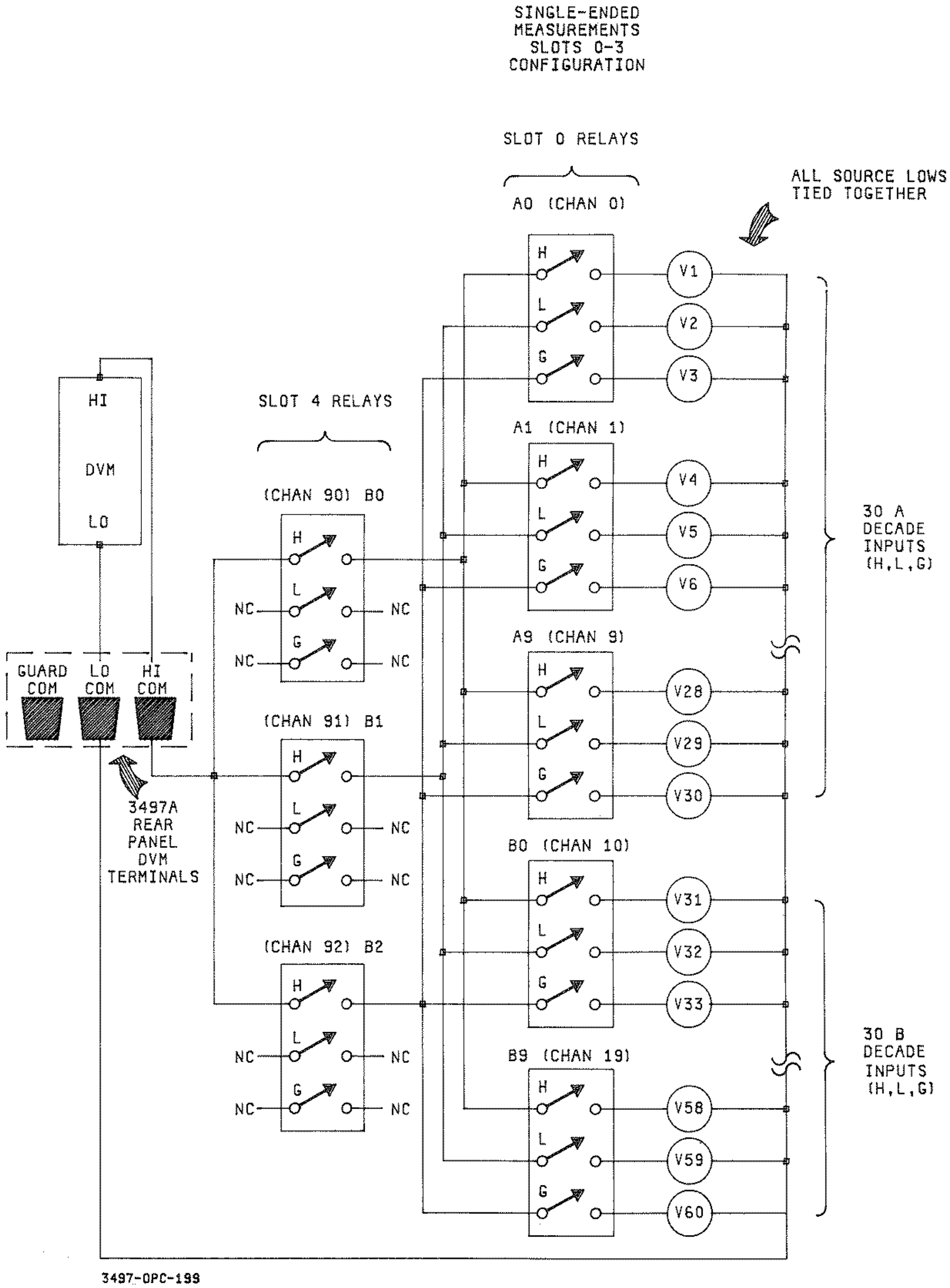


Figure 183. Example 2 - Single-Ended Measurements (Slots 0-3)

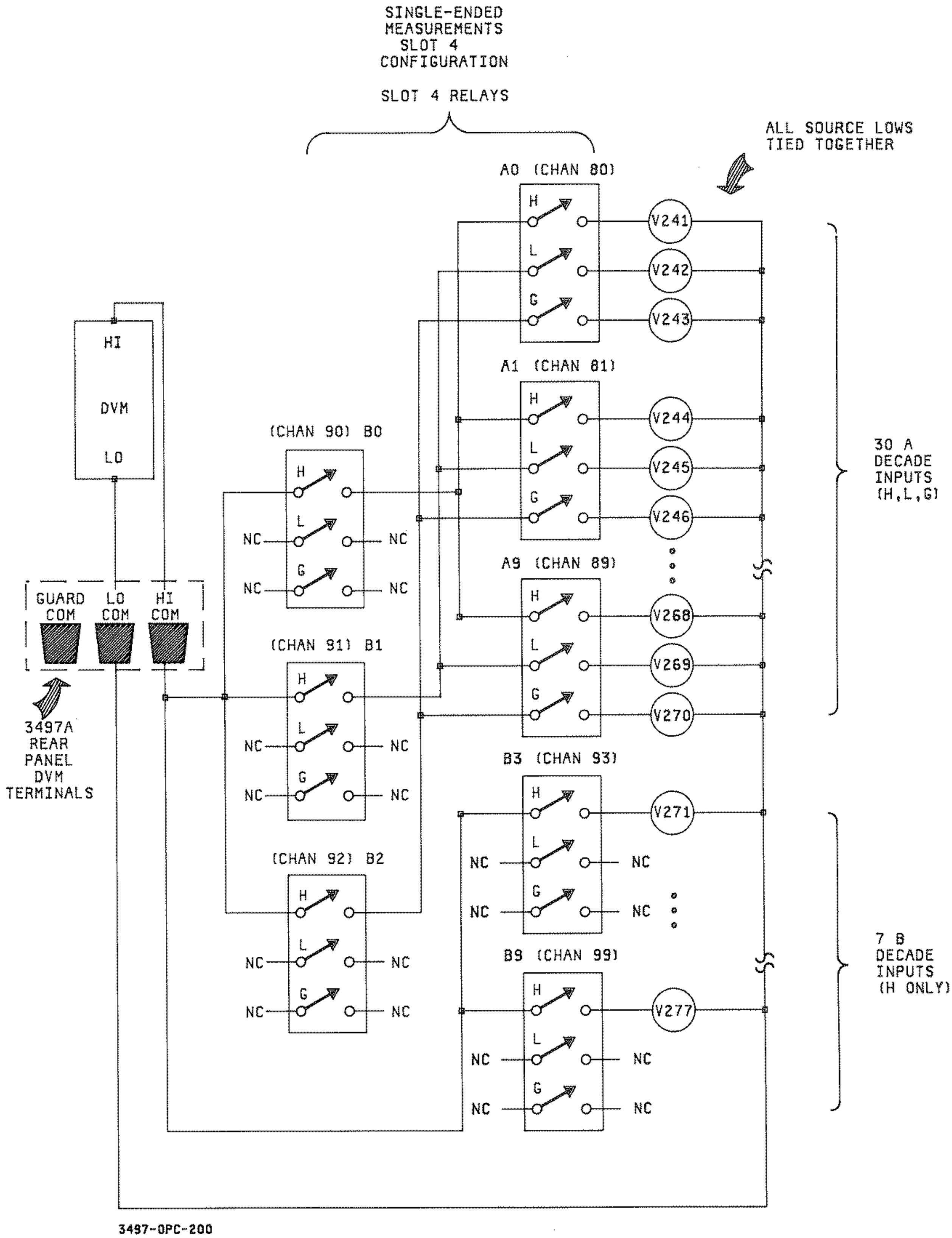


Figure 184. Example 2 - Single-Ended Measurements (Slot 4)

CONFIGURATION

To set up the 3497A for single ended measurements, it is necessary to reconfigure both the 3497A inguard controller and the Option 010 assembly which is to be installed in slot 4 ONLY. It is not necessary to modify the other 4 assemblies.

To configure the 3497A, see Figure 185. Ensure that all voltage sources are removed from the 3497A then remove the protective cover and the inguard controller. Open jumpers JMP1 and JMP2 on the inguard controller board and replace the inguard controller and protective cover.

To configure the Option 010 assembly to be placed in slot 4, see Figure 186. For this assembly ONLY, the seven B Decade inputs (V271 - V277) are connected to the HIGH connectors for relays B3 through B9 respectively, and B0, B1 and B2 are used for secondary multiplexing.

To configure the other four Option 010 assemblies, follow the connection diagram shown for the A Decade in Figure 186 for both the A Decade and B decade inputs.

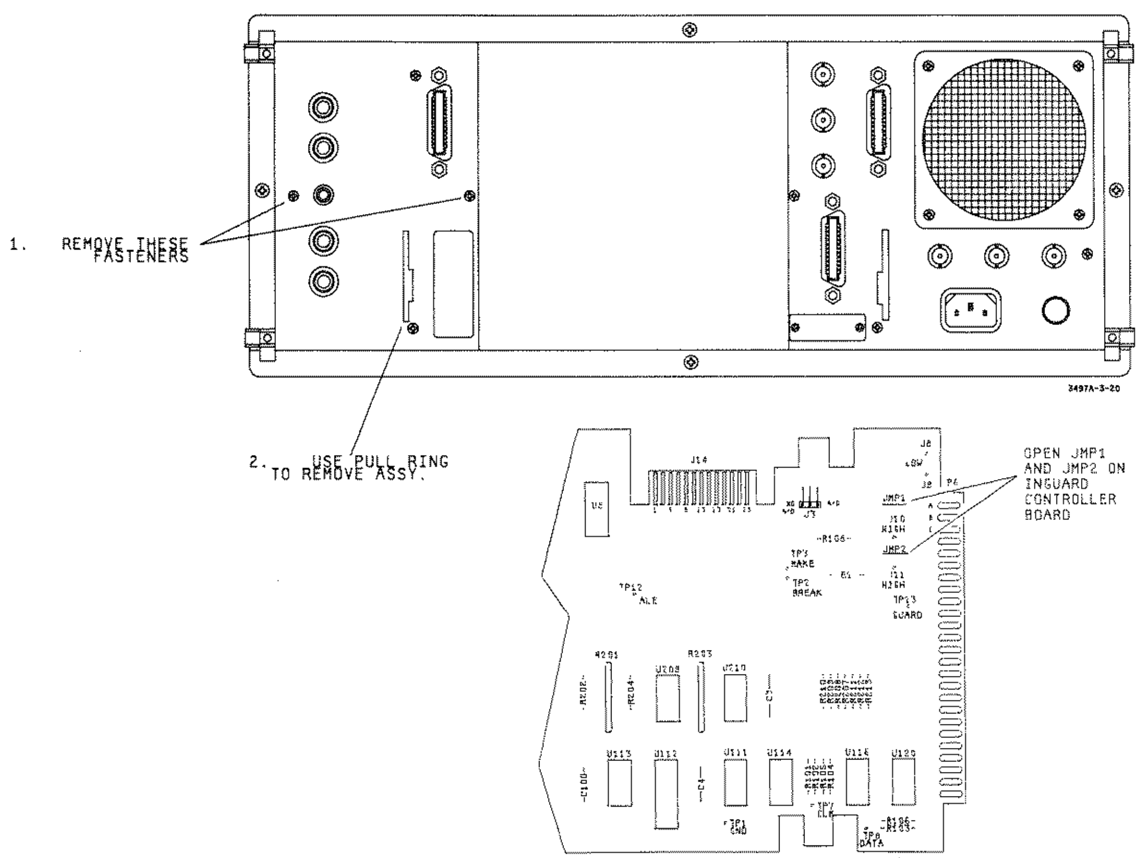


Figure 185. Example 2 · Configuring 3497A for Single-Ended Measurements

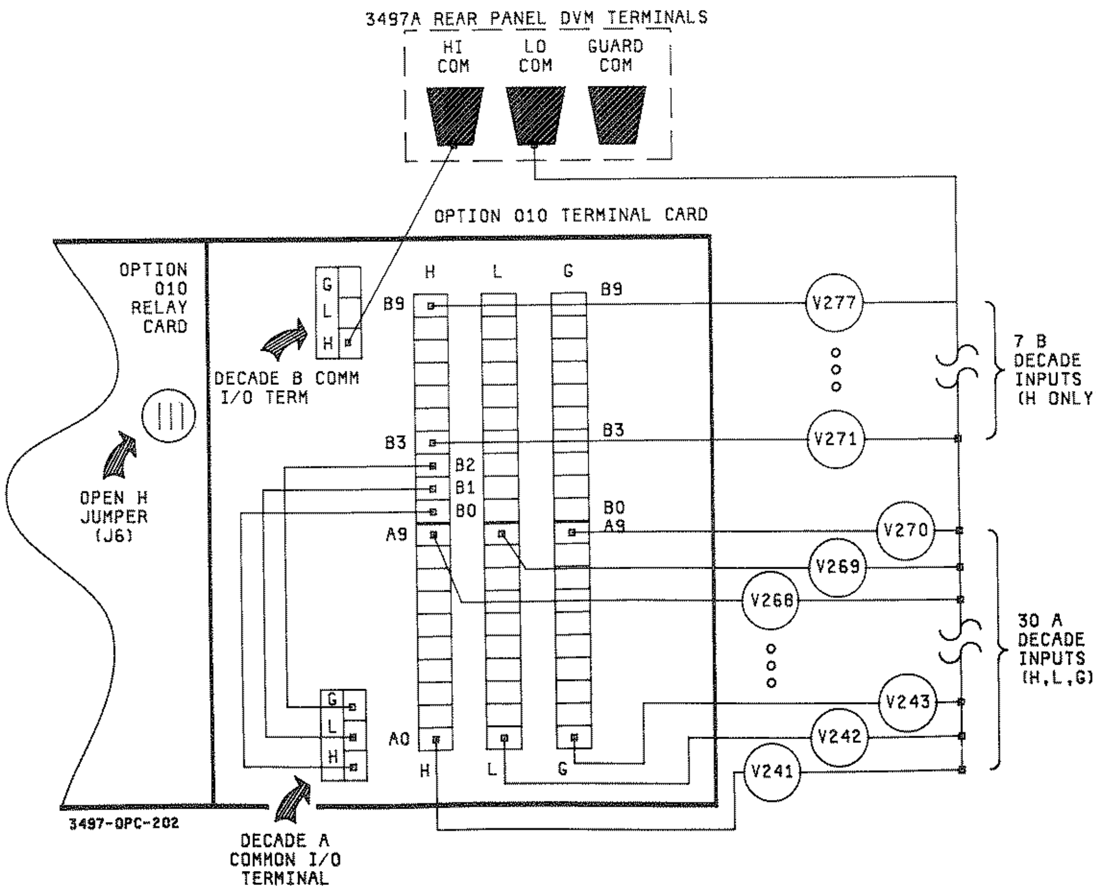


Figure 186. Example 2 · Configuring Option 010 Assembly (Slot 4)

SAMPLE PROGRAM

An example program is shown which sequentially measures the input voltages from 277 sources, assuming that the assembly with secondary multiplexing is in slot 4 and thus the B0 relay has address 90, the B1 relay has address 91 and the B2 relay has address 92.

Although the voltage source designations are arbitrary, for this program V1 is connected to relay A0 HIGH, V2 to relay A0 LOW and V3 to relay A0 GUARD, etc. The assembly with V1 through V60 connected is in slot 0, etc., as shown.

SLOT	DECADE	CHANNELS	SOURCE (V)
0	A B	0-9 10-19	1 - 30 31 - 60
1	A B	20-29 30-39	61 - 90 91 - 120
2	A B	40-49 50-59	121 - 150 151 - 180
3	A B	60-69 70-79	181 - 210 211 - 240
4	A B	80-89 93-99*	241 - 270 271 - 277**

* Channels 90-92 reserved for secondary multiplexing.

** Can only input 7 voltage sources on B decade in slot 4.

The program sequences through V1 through V270 by using an AC chan#,90; AC chan#,91 or AC chan#,92 command. Since secondary multiplexing is not used for inputs V271 through V277, the program sequences through these inputs with an AC chan# (chan# = 93-99) command.

```
SET INITIAL CONDITIONS

 10 J=1
 20 DIM A(90,3)
 30 PRINT "SINGLE ENDED MEASUREMENTS"
 40 PRINT
 50 PRINT "SOURCE";TAB(17);"VOLTS"
 60 PRINT
 70 CLEAR 709

MEASURE VOLTAGES V1 THROUGH V270

 80 FOR I = 0 TO 89
 90 FOR N = 90 TO 92
100 OUTPUT 709; "AC",I;",";N
110 ENTER 709; A(I,N-89)
120 PRINT J;TAB(15);A(I,N-89)
130 J=J+1
140 NEXT N
150 NEXT I

MEASURE VOLTAGES V271 THROUGH V277
```

```
160 FOR K = 93 TO 99
170 OUTPUT 709; ''AC'',K
180 ENTER 709; B
190 PRINT K+178; TAB (15); B
200 NEXT K
210 END
```

TYPICAL PRINTOUT

```
SINGLE ENDED MEASUREMENTS

     SOURCE        VOLTS

          1        1.67853
          2        2.89763
          3        5.99987
          .
          .
        277        0.87654
```

COMMENTS

For the program to work properly, you must have 20 channel relay multiplexer assemblies in slots 0 through 4 and the assembly which is modified for secondary multiplexing (on relays B0, B1 and B2) must be in slot 4. If a voltage source (V1 through V277) is not connected, the number printed out will be of random background voltage.

EXAMPLE 3
DATA LOGGING

DESCRIPTION

In the GUARDED VOLTAGE MEASUREMENTS example (EXAMPLE 1), we showed how to make guarded DC voltage measurements from electro-mechanical transducers which produce positive millivolt output levels. In this example, we'll add the time of day to the printout so that the 3497A can act as a Data Logger for DC voltage measurements.

PROCEDURE

Figure 187 shows a simplified block diagram configuration and connection diagram using the Option 010 assembly to measure the voltages from sources V1 through V10. For this example, we'll place the assembly in slot 2 and connect the sources (transducers) to the 10 relay inputs in the A Decade. Thus, the channel numbers for the transducers are 40-49.

CONFIGURATION

To configure the Option 010 assembly, see Figure 187. Connect V1 high to A0 HIGH and connect V1 low to A0 LOW on the terminal card connectors. Since we are making guarded (3-wire) measurements, connect one end of the guard lead to the A0 GUARD connector and tie the other end to V1 low, as close to the V1 source as possible. Then repeat the procedure to connect V2 to A1, etc.

When the terminal card is connected, check to see that the T/C jumper on the relay card is set to the NO T/C COMP position. When the assembly is configured, after verifying that all power sources are removed from the 3497A, insert the assembly into slot 2 of the 3497A. Then press the LINE key ON and enter the program shown to measure the channel voltages.

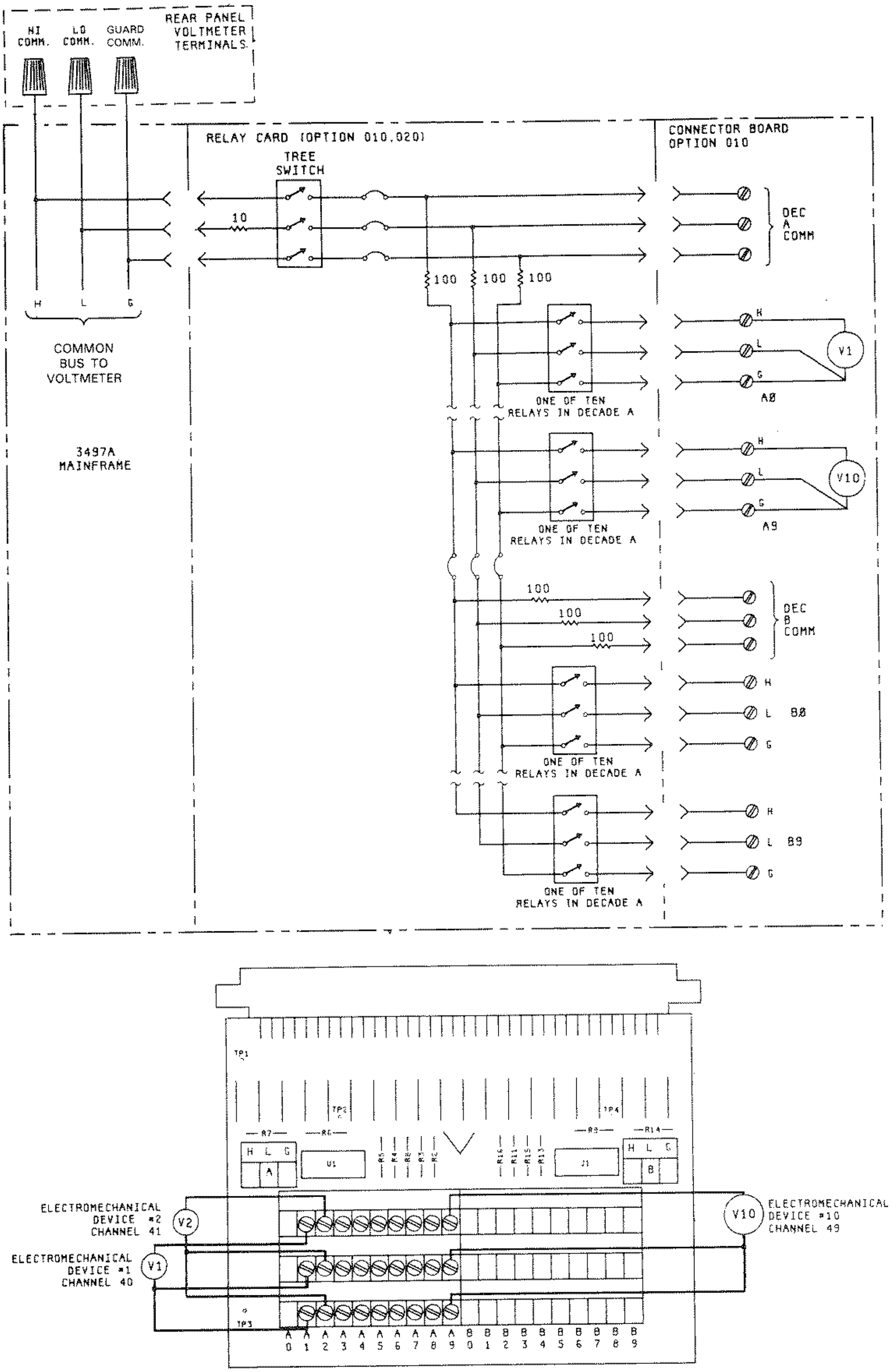


Figure 187. Example 3 - Data Logging - DC Voltages

SAMPLE PROGRAM

A sample program is shown to sequentially scan channels 40 through 49 (by using the AC chan# command), to measure the voltage of sources V1 through V10 and print the time of day and source voltage (in millivolts) for each channel.

If you want to place the Option 010 assembly in a slot other than slot 2, modify line 80 for the appropriate addresses. Also, for this program, the time of day is set for 1:00:00 PM (13:00:00 on the 24-hour clock). For real-time data logging, set line 70 for the appropriate time of day.

```
SET INITIAL CONDITIONS

10 PRINT ''DATA LOGGING - DC VOLTS''
20 PRINT
30 PRINT ''CHAN'';TAB(10);''TIME'';TAB(23);''MILLIVOLTS''
40 PRINT
50 DIM A$[16]
60 CLEAR 709
70 OUTPUT 709; ''VT4VF3TD0715130000''

MEASURE VOLTAGES ON CHANNELS 40-49 AND INPUT TIME

80 FOR I = 40 TO 49
90 OUTPUT 709;''AC'',I
100 ENTER 709;A$,B
110 PRINT I;TAB(7);A$;TAB(23);B*1000
120 NEXT I
130 END
```

TYPICAL PRINTOUT

```
DATA LOGGING - DC VOLTAGE MEASUREMENTS

    CHAN        TIME           MILLIVOLTS

     40     07:15:13:00:00      15.438
     41     07:15:13:00:01      14.999
     .            .                .
     .            .                .
     49     07:15:13:00:08      16.317
```

COMMENTS

For a detailed explanation of guarded voltage measurements, see -hp- Application Note 123 ''Floating Measurements and Guarding'' (-hp- part number 5952-2153). If desired, a wait statement (i. e., 115 WAIT 1000 for a 1 second delay) can be added between 110 and 120.

EXAMPLE 4
FAST SCAN VOLTAGE MEASUREMENTS

DESCRIPTION

A useful application for the 3497A is high-speed voltage measurements on sequential channels. In this example, we'll show how to use the 3497A to scan 60 channels at an approximate 125 channel/second rate and store the measured DC voltages in the -hp- 85 for future printout. With this method, you can take nearly simultaneous measurements of up to 60 channel inputs.

PROCEDURE

For this example, we'll assume that a DC voltage source is connected to each of channels 0-59 (Option 010 assemblies in slots 0, 1 and 2) and that it is required to sequentially scan all 60 channel inputs after the occurrence of a specified system event, such as a switch closure.

To initiate the 60 readings, connect an external input capable of generating a high-to-low TTL pulse to the EXT TRIG port. When the specified event (switch closure) occurs, the TTL pulse to the EXT TRIG port causes the DVM to take and store a reading from each of the 60 channels. After all 60 readings are stored in the 3497A, they are transferred to the controller for printout.

To indicate speed of measurement for different 3497A resolutions, the chart shows the approximate time required to make a measurement with 3½, 4½ and 5½ digit resolution. The times shown are times to make the measurements and do not include transfer time to the controller.

Thus, for example, with 3½ digit resolution about 8 ms is required to measure each channel (a 125 channel/second measurement rate) so less than a half second is required to scan 60 channels (the maximum number of ASCII readings which can be stored).

APPROXIMATE SCAN RATES AND MEASUREMENT TIMES - FAST SCAN

NUMBER DIGITS	TIME TO MEASURE ONE CHANNEL (MS)	SCAN RATE (CHAN/SEC)
3½	8	125
4½	9	111
5½	25	40

CONFIGURATION

Figure 188 shows a simplified block diagram configuration and connection diagram using the Option 010 assembly to measure the voltages from sources V1 through V60. For this example, we'll place the assemblies in slots 0,1 and 2 so the channel numbers are 0-59.

For fast scan, it is necessary to enable the EXT INCR port on the rear panel of the 3497A (by using an AE1 command) and to connect a BNC cable between the VM COMPLETE port and the EXT INCR port (see Figure 189). Then, when the DVM finishes taking a reading, the pulse out of the VM COMPLETE port causes the 3497A to increment to the next channel.

To configure the Option 010 assembly, see Figure 188. Connect V1 high to A0 HIGH and connect V1 low to A0 LOW on the terminal card connectors. Since we are making guarded (3-wire) measurements, connect one end of the guard lead to the A0 GUARD connector and tie the other end to V1 low, as close to the V1 source as possible. Then repeat the procedure to connect V2 to A1, etc.

When the terminal card is connected, check to see that the T/C jumper on the relay card is set to the NO T/C COMP position. When the assembly is configured, after verifying that all power sources are removed from the 3497A, insert the assembly into slot 0 of the 3497A. Repeat the procedure for the next two assemblies and insert them in slots 1 and 2, respectively.

The next step is to connect a BNC connector from the VM COMPLETE port to the EXT INCR port and connect an external trigger source to the EXT TRIG port with a BNC cable as shown in Figure 189. Then, press the LINE switch on and enter the program shown into the -hp- 85.

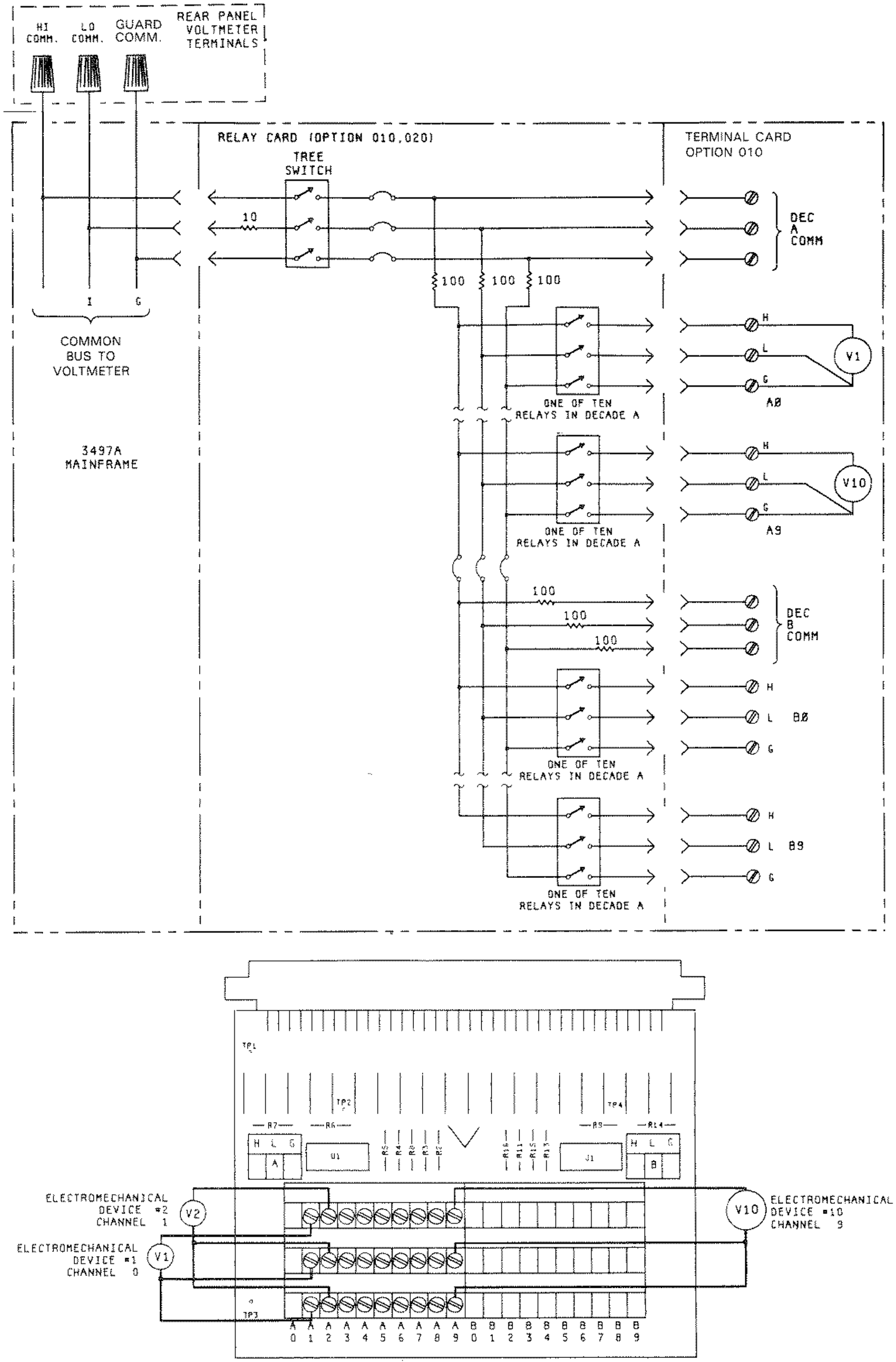


Figure 188. Example 4 - Fast Scan - Option 010 Connections

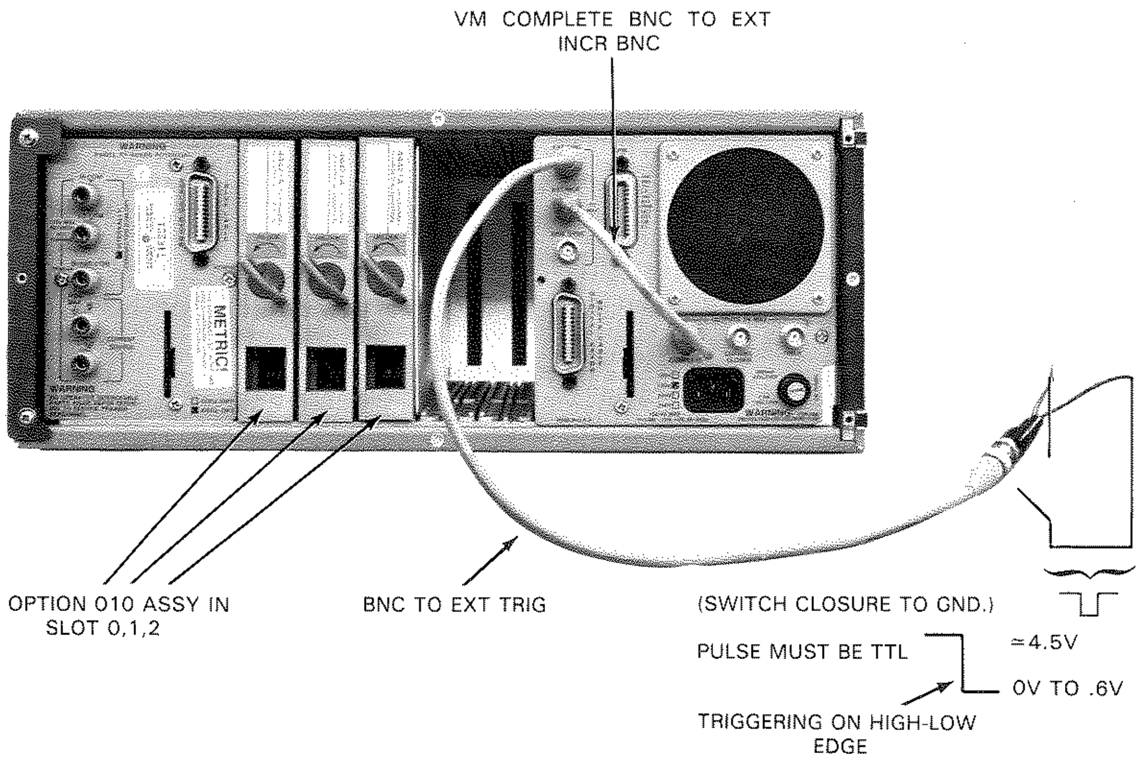


Figure 189. Example 4 · Fast Scan · Rear Panel Connections

SAMPLE PROGRAM

A sample program is shown which sequentially scans channels 0 through 59 to measure the voltage of sources V1 through V60 and print the voltage measured for each channel. If you place the Option 010 assemblies in slots other than 0, 1 and 2, modify line 70 for the appropriate addresses.

The main program is executed until an external trigger is input to the EXT TRIG port at which time the program jumps to line 1000 and the 60 readings stored in the 3497A are transferred to the controller and printed out. Line 90 sets the initial conditions for the 3497A, to await the specified event occurrence (trigger input). The conditions are:

VT4	=	DVM Trigger Hold
VD3	=	3½ Digit Resolution
VA0	=	Voltmeter Autozero OFF
SE1	=	Set 3497A for DATA READY SRQ
AF0	=	First Channel is 0
AF59	=	Last Channel is 59
VN60	=	DVM to take 60 readings/trigger input
VT2	=	DVM to External Trigger
VS1	=	Internal DVM storage (in ASCII format)
AC0	=	Close channel 0
AE1	=	Enable EXT INCR port

SET INITIAL CONDITIONS

```
  10 PRINT "FAST SCAN MEASUREMENTS"
  20 PRINT
  30 PRINT "CHANNEL";TAB(12);"VOLTS"
  40 PRINT
  50 DIM A(60)
  60 CLEAR 709
  70 ON INTR 7 GOSUB 1000
  80 ENABLE INTR 7;8
  90 OUTPUT 709; "VT4VD3VA0SE1AF0AL59VN60VT2VS1AC0AE1"
 100 !Main Program
 110 GOTO 110
 120 END
```

INTERRUPT SUBROUTINE

```
1000 P = SPOLL (709)
1010 IF P <>65 THEN RETURN
1020 OUTPUT 709; "VT4AE0VS"
1030 FOR I = 1 TO 60
1040 ENTER 709 USING "#,K";A(I)
1050 PRINT TAB (3);I-1;TAB(10);A(I)
1060 NEXT I
1070 STATUS 7,1;A
1080 RETURN
```

TYPICAL PRINTOUT (3½ DIGIT RESOLUTION)

```
FAST SCAN MEASUREMENTS

     CHANNEL    VOLTS

        0        3.98
        1        2.35
        .          .
        .          .
       59        2.21
```

COMMENTS

1. The program shown is for 3½ digit resolution which provides the highest reading speed. For 4½ digit or 5½ digit resolution with lower reading speed, change "VD3" in line 90 to "VD4" or "VD5" as required.

2. For a detailed explanation of guarded voltage measurements, see -hp- Application Note 123 "Floating Measurements and Guarding" (-hp- part number 5952-2153).

EXAMPLE 5
2-WIRE RESISTANCE MEASUREMENTS

DESCRIPTION

In the VOLTAGE MEASUREMENTS examples, we showed some ways that the 20 Channel Relay Multiplexer assembly (Option 010) can be used to measure voltages input to the 3497A. The Option 010 assembly can also be combined with the current source in the 3497A internal DVM (Option 001) to make resistance measurements. In this example, we'll show a way to make 2-wire ohms measurements. If your application requires highly accurate measurements, see the 4-WIRE RESISTANCE MEASUREMENTS example (EXAMPLE 6).

PROCEDURE

Figure 190 illustrates the procedure for making 2-wire resistance measurements and shows the connection diagram for the Option 010 assembly. The current source output from the 3497A is connected to the Decade B COMMON connector. Note that measurement errors will occur if the current source is placed on the Decade A COMMON connector because of the 100 ohm series resistors in the voltage sense path.

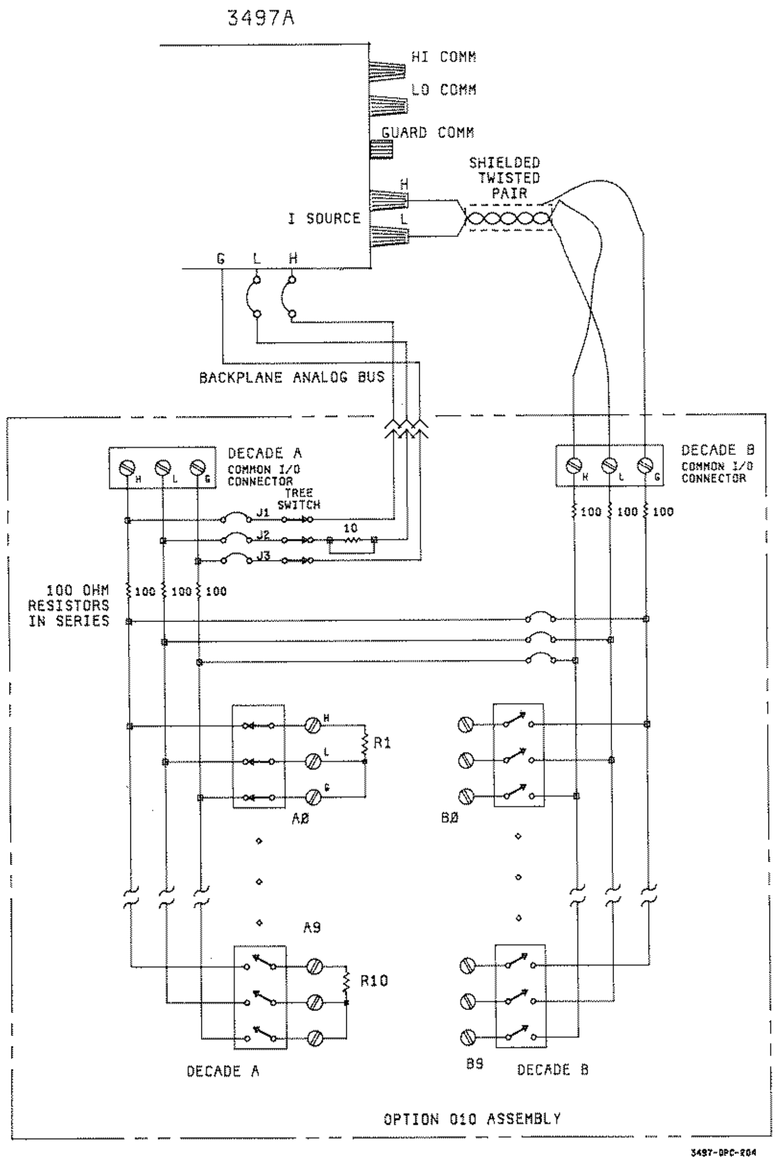
When the current source is set for a specified output (10 μA, 100 μA or 1 mA) and a channel relay is closed, the voltage drop across the channel resistance can be measured and, since I is known, the resistance computed from $R = E/I$.

CONFIGURATION

You can measure the resistance of up to 20 resistors with a single Option 010 assembly or up to 100 resistances per 3497A. See Figure 190 which shows connections for resistors tied to channels A0 and A9.

Note that the current source from the 3497A rear panel CURRENT SOURCE terminals is connected to the B COM connector on the Option 010 terminal card by a shielded twisted pair (for better measurement accuracy).

When the terminal card is configured, check the relay card to insure that the T/C jumper is in the NO T/C COMP position before installing the assembly in the 3497A. To use the program shown, install the assembly in slot 3.



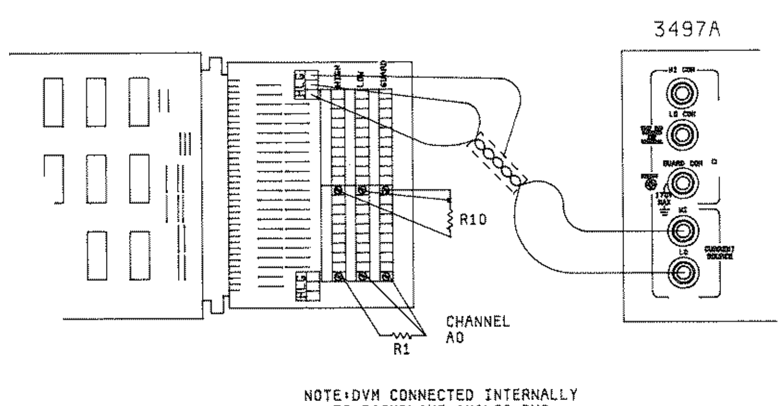


Figure 190. Example 5 - 2-Wire Resistance Measurements

SAMPLE PROGRAM

A sample program is shown to measure the resistances of 10 resistors with R1 connected to channel A0, R2 to channel A1, etc. Since the Option 010 assembly is in slot 3, channel addresses are 60-69. The program sets a 1 mA output from the current source with the VC3 command. Thus, resistances R1 - R10 can be computed from Rx = Vx * 1000, where Vx is the channel voltage measured.

```
SET INITIAL CONDITIONS

 10 PRINT "2-WIRE RESISTANCE MEASUREMENTS"
 20 PRINT
 30 PRINT "RESISTOR";TAB(20);"OHMS"
 40 PRINT
 50 CLEAR 709
 60 OUTPUT 709;"VC3"

MEASURE VOLTAGES ON CHANNELS 60-69 AND COMPUTE RESISTANCE

 70 FOR I = 60 TO 69
 80 OUTPUT 709; "AC",I
 90 ENTER 709;A
100 PRINT TAB(2);I-59;TAB(18);A*1000
110 NEXT I
120 END
```

TYPICAL PRINTOUT

```
2-WIRE RESISTANCE MEASUREMENTS

         RESISTOR    OHMS

            1        463.54
            2        110.78
            .          .
            .          .
            10       100.56
```

COMMENTS

If your application requires using the A Decade COMMON terminal to input current for A Decade (or B Decade) 2-wire resistance measurements, you can short out the 100 ohm series resistors for more accuracy. However, see Chapter 8, Option 010 description before doing this procedure.

EXAMPLE 6
4-WIRE RESISTANCE MEASUREMENTS

DESCRIPTION

The VOLTAGE MEASUREMENTS examples showed some ways that the 20 Channel Relay Multiplexer assembly (Option 010) can be used to measure voltages input to the 3497A. The Option 010 assembly can also be combined with the current source in the 3497A internal DVM (Option 001) to make resistance measurements. In this example, we'll show a way to make 4-wire ohms measurements. If your application does not require highly accurate measurements, see the 2-WIRE RESISTANCE MEASUREMENTS example (EXAMPLE 5).

PROCEDURE

Figure 191 illustrates the procedure for making 4-wire resistance measurements and shows a connection diagram for the Option 010 assembly. The current source output from the 3497A is connected to the Decade B COMMON connector. Jumpers J4, J5 and J6 must be opened since it is necessary to close two channels simultaneously (by using the AC chan#,chan# command).

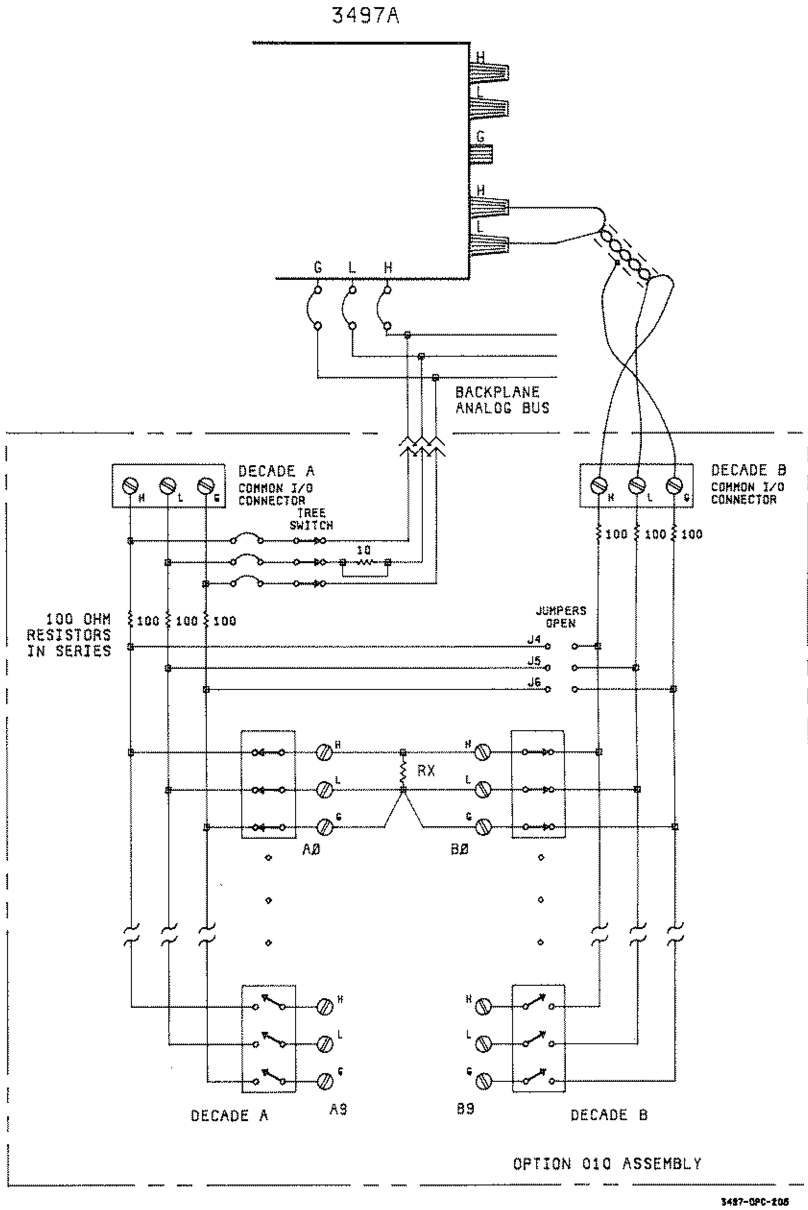
When the current source is set for a specified output (10 μA, 100 μA or 1 mA) and a channel relay is closed, the voltage drop across the channel resistance can be measured and, since the current I is known, the resistance computed from R = E/I.

CONFIGURATION

With 4-wire ohms techniques, you can measure the resistance of up to 10 resistors with a single Option 010 assembly or up to 50 resistances per 3497A. See Figure 191 which shows connections for a resistor tied to channels A0 and B0.

Note that the current source from the 3497A rear panel CURRENT SOURCE terminals is connected to the B COM connector on the Option 010 terminal card by a shielded twisted pair (for better measurement accuracy).

When the terminal card is configured, check the relay card to ensure that the T/C jumper is in the NO T/C COMP position before installing the assembly in the 3497A. To use the program shown, install the assembly in slot 3.



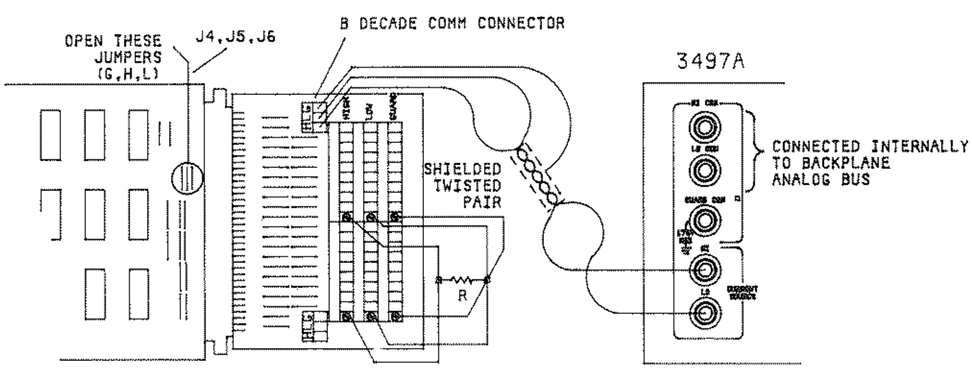


Figure 191. Example 6 - 4-Wire Resistance Measurements

SAMPLE PROGRAM

A sample program is shown to measure the resistances of 10 resistors with R1 connected to channel A0, R2 to channel A1, etc. Since the Option 010 assembly is in slot 3, channel addresses are 60-69. The program sets a 1 mA output from the current source with the VC3 command. Thus, the resistances R1 - R10 can be computed from Rx = Vx * 1000, where Vx is the channel voltage measured.

```
SET INITIAL CONDITIONS

 10 PRINT "4-WIRE RESISTANCE MEASUREMENTS"
 20 PRINT
 30 PRINT "RESISTOR";TAB(20);"OHMS"
 40 PRINT
 50 CLEAR 709
 60 OUTPUT 709;"VC3"

MEASURE VOLTAGES ON CHANNELS 60-69 AND COMPUTE RESISTANCE

 70 FOR I = 60 TO 69
 80 OUTPUT 709; "AC",I;",";I+10
 90 ENTER 709;A
100 PRINT TAB(2);I-59;TAB(18);A*1000
110 NEXT I
120 END
```

TYPICAL PRINTOUT

```
4-WIRE RESISTANCE MEASUREMENTS

         RESISTOR     OHMS

             1        463.54
             2        110.78
             .          .
             .          .
            10        100.56
```

COMMENTS

If your application does not require highly accurate results and you want a lower cost/measurement, you may want to use the 2-wire ohms measurement technique shown in the 2-WIRE RESISTANCE MEASUREMENTS example (EXAMPLE 5).

EXAMPLE 7 HARDWARE COMPENSATED THERMOCOUPLE MEASUREMENTS

DESCRIPTION

The 20-Channel Relay Multiplexer with Thermocouple Compensation assembly (Option 020) can be used to determine the temperature of B,E,J,K,R,S and T type thermocouples. The assembly can be configured for hardware compensation or software compensation. This example shows how the temperatures of up to 20 J-type thermocouples can be determined by using the Option 020 assembly and standard lookup (N.B.S.) voltage-to-temperature tables.

PROCEDURE

Figure 192 shows a simplified block diagram and connection diagram to measure the voltage outputs from up to 20 thermocouples connected to an Option 020 assembly in slot 0. Since hardware compensation is to be used, only ONE type of thermocouple can be used per assembly (i. e., you can't mix J and K types on an assembly, etc.).

For this example, we'll scan the 20 channels and measure the voltage on each channel. Since the assembly is in slot 0, channel numbers are 0 to 19. Then, we can use a standard lookup table to convert the measured voltages to equivalent temperatures in degrees F.

CONFIGURATION

Figure 193 shows how to configure the Option 020 terminal card for hardware compensation of J-type thermocouples. Since the Option 020 assembly is factory configured for software compensation, the jumper shown in Figure 193 must be removed when R120 and R100 are installed.

After configuring the terminal card, check to make sure that the T/C COMP jumper on the relay card is in the T/C COMP position. Then, connect thermocouples as shown in Figure 193. Note the various ways to connect thermocouples, depending on the type.

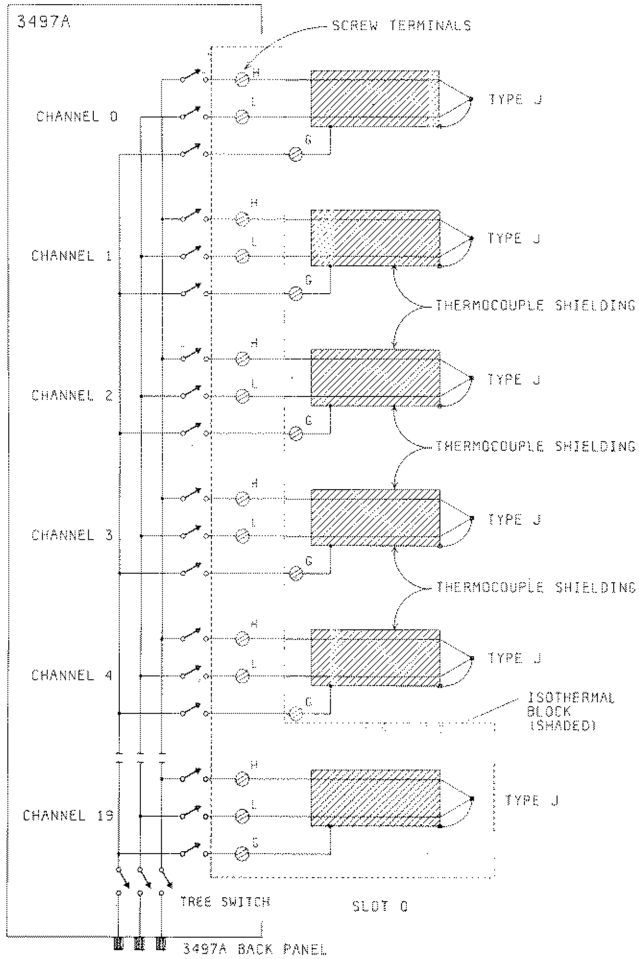


Figure 192. Example 7 - Hardware Compensation J-Type Thermocouples

SAMPLE PROGRAM

The sample program shown measures the voltage from thermocouples T1 - T20, where T1 is connected to A0 (channel 0), T2 to A1 (channel 1), etc. and prints the voltage measureed in absolute millivolts. Note that the values received are valid ONLY for J-type thermocouples.

Since the voltages printed out are already referenced to ice-point, you can directly use them to find the equivalent temperature in a standard lookup table without any need for further conversion. The program does not, however, convert voltage to temperature. See SOFTWARE COMPENSATED TEMPERATURE MEASUREMENTS (EXAMPLE 8) for a way to do this.

SET INITIAL CONDITIONS

```
10 PRINT "J-TYPE THERMOCOUPLE MEASUREMENTS"
20 PRINT
30 PRINT "T-COUPLE";TAB(12);"ABS MV"
40 PRINT
50 CLEAR 709
```

MEASURE 20 THERMOCOUPLE VOLTAGES

```
 60 FOR I = 0 TO 19
 70 OUTPUT 709; "AC",I
 80 ENTER 709; A
 90 PRINT I+1;TAB(10);A*1000
100 NEXT I
110 END
```

TYPICAL PRINTOUT

```
J-TYPE THERMOCOUPLE MEASUREMENTS

          T-COUPLE    ABS MV

              1        2.146
              2        4.635
              .          .
             20        0.734
```

Note: Temperature associated with each ABS MV reading can be directly derived from standard (N.B.S.) conversion tables.

COMMENTS

As noted, the Option 020 assembly can be configured for software compensation of thermocouple measurements so that the manual conversion method shown in this example is not required. See SOFTWARE COMPENSATED THERMOCOUPLE MEASUREMENTS (EXAMPLE 8).

You can also use the Option 020 assembly for thermistor or RTD measurements. For a full discussion of temperature measurements, see -hp- Application Note 290, "Practical Temperature Measurements" (-hp- Part Number 5952-8801).

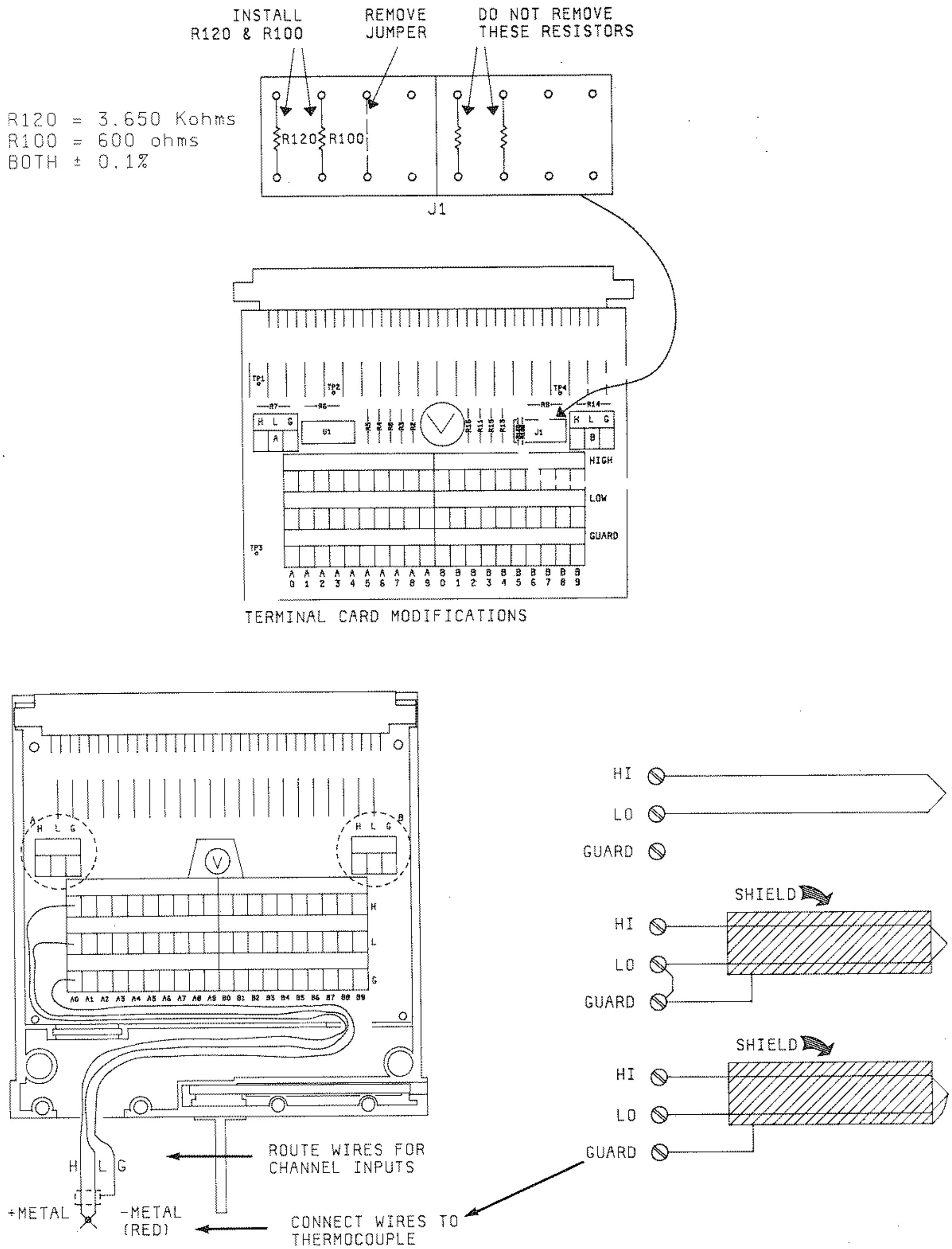


Figure 193. Example 7 - Option 020 Hardware Compensation

EXAMPLE 8
SOFTWARE COMPENSATED THERMOCOUPLE MEASUREMENTS

DESCRIPTION

The 20 Channel Relay Multiplexer assembly with Thermocouple Compensation (Option 020) can be used to determine the temperature of B,E,J,K,R,S and T type thermocouples. The assembly can be configured for hardware compensation or software compensation. This example shows how the temperatures of up to 19 J, K, E, R and/or S-type thermocouples can be directly measured by using the Option 020 assembly.

PROCEDURE

Figure 194 shows a simplified block diagram and connection diagram to measure the voltage outputs from up to 19 thermocouples connected to an Option 020 assembly in slot 0. Since software compensation is to be used, any mixture of thermocouples can be used per assembly (i. e., you can mix J and K types on an assembly, etc.).

For this example, we'll scan the 19 channels and measure the voltage on each channel. Since the assembly is in slot 0, channel numbers are 0 to 19. Between each channel measurement, we'll measure the reference voltage on channel 19 (B9). The procedure is as follows:

1. Measure the temperature transducer voltage from channel 19 (channel B9) and compute the terminal junction's temperature in deg C (2.5V at 25 deg C with 100 mV/deg C.).

2. Convert the terminal junction's temperature to a thermocouple voltage. The converted temperature is dependent on the type of thermocouple being measured.

3. Measure the voltage produced on a channel by the thermocouple.

4. Add the reference voltage of step 2 to the voltage in step 3 for an icepoint reference voltage and then convert this to degrees C and degrees F.

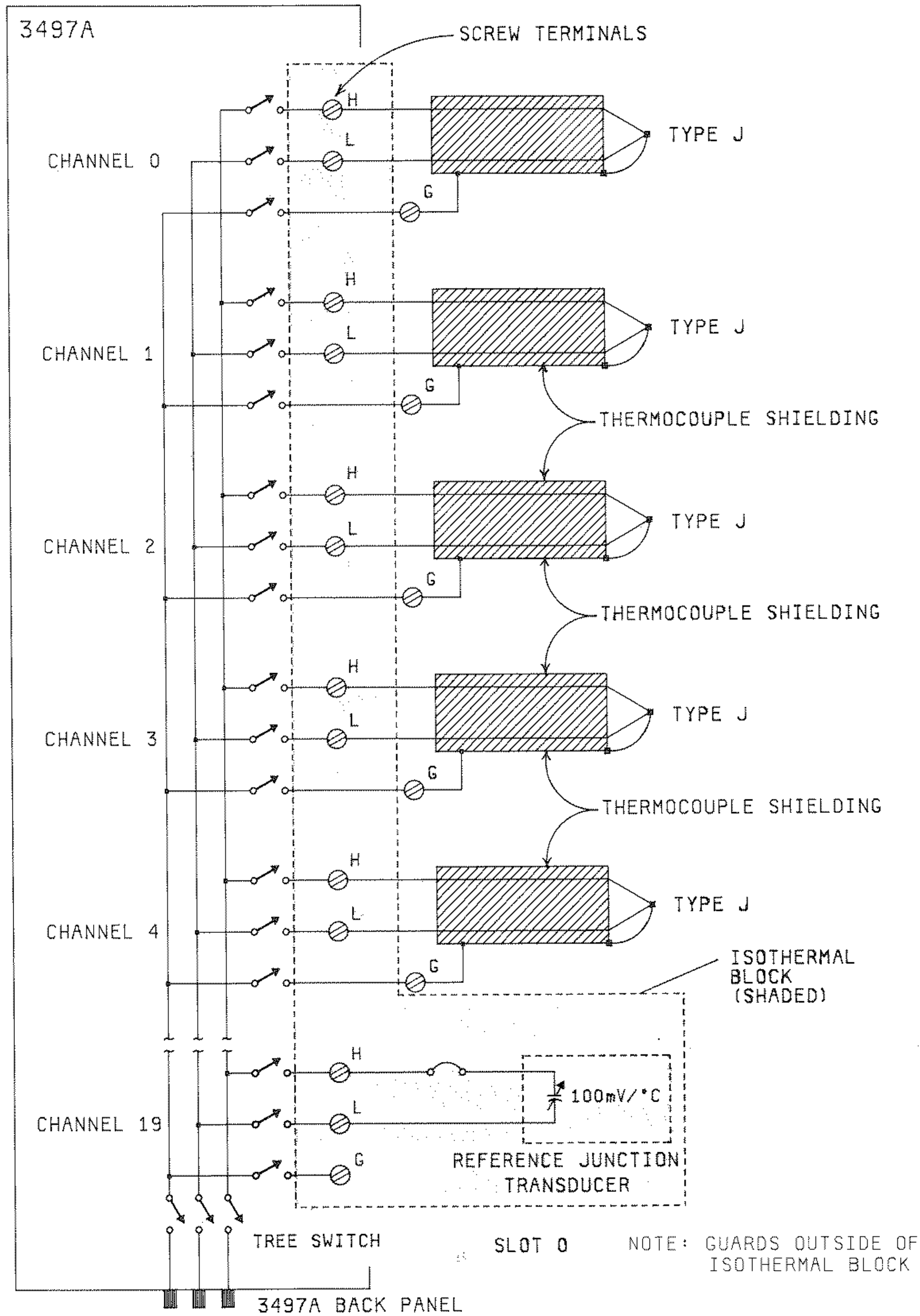


Figure 194. Example 8 · Software Compensation · J-Type Thermocouples

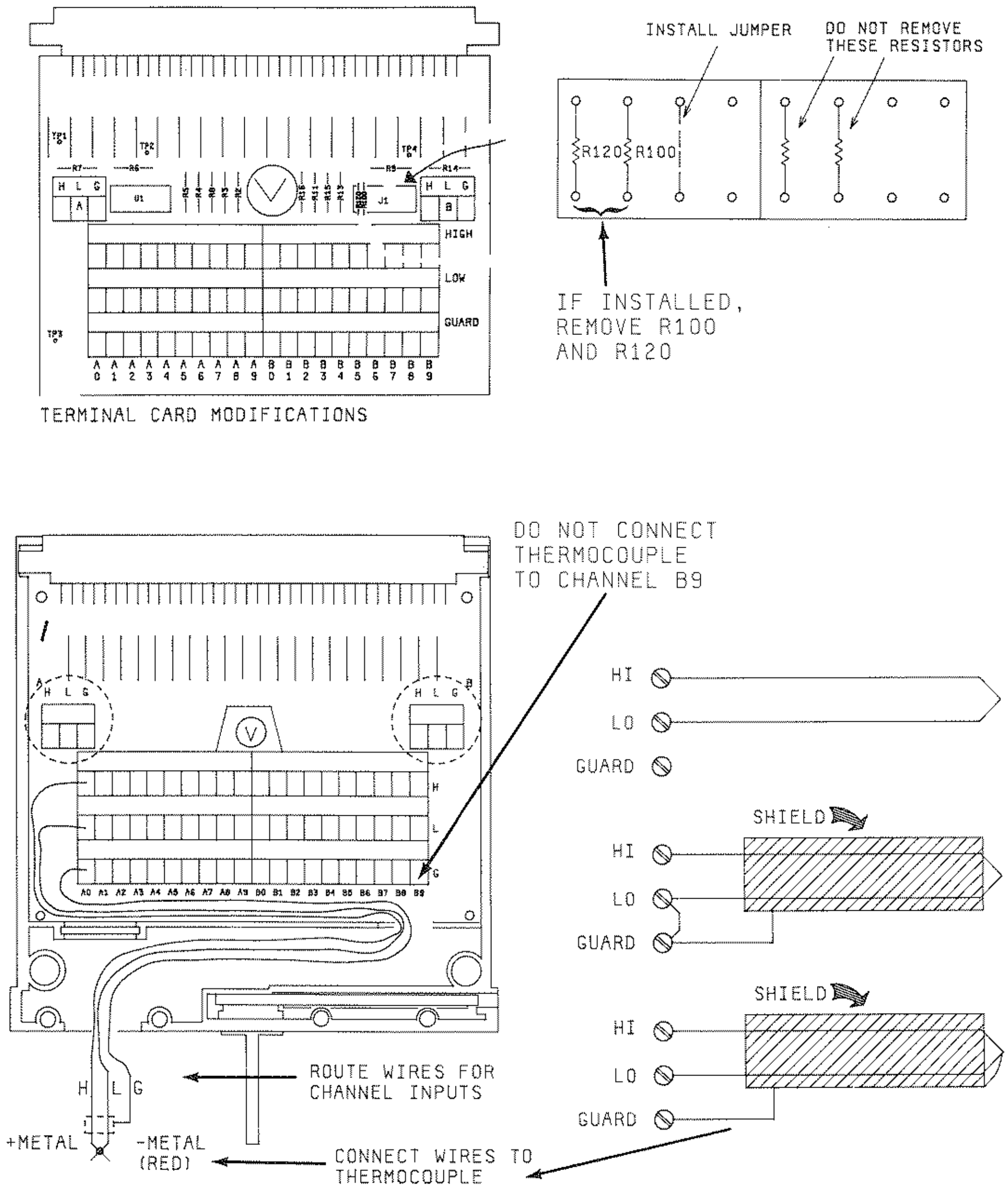


Figure 195. Example 8 - Option 020 Software Compensation

CONFIGURATION

Figure 195 shows how to configure the Option 020 terminal card for software thermocouple compensation. Since the Option 020 assembly is factory-configured for software compensation, the jumper shown must be installed and (if they are installed) R120 and R100 must be removed.

After configuring the terminal card, check to make sure that the T/C COMP jumper on the relay card is in the T/C COMP position. Then, connect thermocouples as shown in Figure 195. Note the various ways to connect thermocouples, depending on the type.

SAMPLE PROGRAM

An example program is shown which computes the temperature in degrees C and degrees F for J-Type thermocouples for an Option 020 assembly placed in slot 0 (channel numbers 0-19). Channel 19 (channel B9) is reserved for measuring the reference voltage so a thermocouple cannot be connected to this channel.

The program first measures the voltage at channel 19, then measures the voltage at channel 0 and adds the two voltages. Next, a 9th-order polynomial is used to convert the resultant voltage to an equivalent temperature in degrees C. Finally, the temperature in deg C is converted to deg F by F = 32 + 1.8C and the results printed out.

On the next loop, the program again measures the reference voltage at channel 19, then measures the voltage at channel 1, adds the two voltages and computes the results as before. A typical printout is shown, assuming that thermocouple #1 is connected to channel 0, #2 to channel 1, etc.

```
SET INITIAL CONDITIONS

10 PRINT ''J-TYPE THERMOCOUPLE MEASUREMENTS''
20 PRINT
30 PRINT ''T-COUPLE'';TAB(12);''DEG C'';TAB(22);''DEG F''
40 PRINT
50 CLEAR 709

POLYNOMIAL CONVERSION COEFFICIENTS

 60 R0 = -.00000075
 70 R1 = .00005053
 80 R2 = .000000023
 90 P0 = -.36
100 P1 = 19750.9
110 P2 = -175117
120 P3 = 18219297
130 P4 = -2831128000
140 P5 = 271508380000
150 P6 = -1.38014121E13
160 P7 = 3.79243843E14
170 P8 = -5.3719255E15
180 P9 = 3.0840254E16

MEASURE AND CONVERT VOLTAGES TO TEMPERATURES

190 FOR I = 0 TO 18
200 OUTPUT 709; ''AC19''
210 ENTER 709; R
220 V1 = R0 + R*(R1 +R*R2)
```

```
230 OUTPUT 709; ''AC'',I
240 ENTER 709;V2
250 V = V1+V2
260 T1=P0+V*(P1+V*(P2+V*(P3+V*(P4+V*(P5+
      V*(P6+V*(P7+V*(P8+V*P9))))))))
270 T2 = 32 + 1.8*T1
280 T3 = INT(T1*100+.5)/100
290 T4 = INT(T2*100+.5)/100
300 PRINT I+1;TAB(11);T3;TAB(21);T4
310 NEXT I
320 END
```

TYPICAL PRINTOUT

```
J-TYPE THERMOCOUPLE MEASUREMENTS

      T-COUPLE    DEG C    DEG F

         1        30.43    86.78
         2        30.66    87.19
         .          .        .
        19        29.89    85.8
```

COMMENTS

This program is valid ONLY for J-type thermocouples since the polynomial conversion coefficients (P0 - P9) and the reference coefficients (R0 - R2) are unique numbers for J-type thermocouples. To use this program to measure the temperatures of E,K,R or S type thermocouples, enter the appropriate coefficients from the following table.

To use a mixture of thermocouples on a single assembly, it is necessary to develop a program which enters the appropriate coefficients for the thermocouple at that channel, which is a rather tedious process. Fortunately, -hp- has already solved this problem and prepackaged programs are available as part of the 3054 A/C Systems. Contact your nearest -hp- Sales and Service Office for details.

TABLE - POLYNOMIAL CONVERSION AND REFERENCE COEFFICIENTS

	THERMOCOUPLE TYPE			
	E	R	K	S
RO	1.23773 E-7	−2.11284 E-7	−8.16774 E-7	−2.01920 E-7
R1	5.866 E-5	5.334 E-6	3.964 E-5	5.442 E-6
R2	4.5 E-8	1.2 E-8	1.6 E-8	1.1 E-8
PO	2.1 E-1	−1.5 E0	−5.1 E-2	−1.4 E0
P1	1.61299 E4	1.72645 E5	2.48503 E4	1.73545 E5
P2	−2.05411 E5	−3.27669 E7	−3.82662 E5	−3.26257 E7
P3	3.049432 E7	7.787787 E9	9.9661057 E7	8.477335 E9
P4	−2.9690242 E9	−1.18982593 E12	−1.0820624 E10	−1.327040 E12
P5	1.4284958 E11	1.01396299 E14	6.0392855 E11	1.2361123 E14
P6	−3.7221944 E12	−5.4842602 E15	−1.9109000 E13	−6.7926749 E15
P7	5.3981272 E13	1.7414495 E17	3.4782347 E14	2.0689294 E17
P8	−4.1055295 E14	−2.9235505 E18	−3.3991028 E15	−2.8874849 E18
P9	1.2777466 E15	1.9280744 E19	1.3828514 E16	8.2663728 E18

EXAMPLE 9
COUNT UP/DOWN MEASUREMENTS

DESCRIPTION

The 100 kHz Reciprocal Counter assembly (Option 060) can be used for two primary functions: counting operations (count up/down) and period/pulse width measurements of input signals. In this example, we'll show how to use the counter assembly to count down a number of input pulses of an oscillator and how to count up (totalize) input pulses from a measurement system.

PROCEDURE

To illustrate the count up procedure, we'll totalize the number of input signals from the circuit in Figure 196 (a) for 5 seconds and print the results. In this circuit, a pulse is input whenever the conveyer belt interrupts the light source. By totalizing the number of counts in 5 seconds, we can (for example) determine if the conveyer belt speed is correct.

To illustrate count down, we'll preset the counter to 5000 counts, input a 1 kHz signal from an oscillator as shown in Figure 196 (b) and, after a 2 second wait, print the counts remaining. Since the period of a 1kHz signal is 1 msec, after 2 seconds 2000 pulses should have been input to the counter and 3000 counts should be remaining. We can then use the remaining counts to determine actual oscillator frequency.

CONFIGURATION

Figure 196 shows how to configure the Option 060 assembly using Isolated Input mode so that an external pullup is not required.

SAMPLE PROGRAMS

A sample COUNT UP program for an assembly in slot 4 is shown which starts counting up at t=0. After a 5 second delay to allow about 5000 counts to accumulate in the counter, data is transferred to the controller by the CR4,1 command and the actual number of counts printed out.

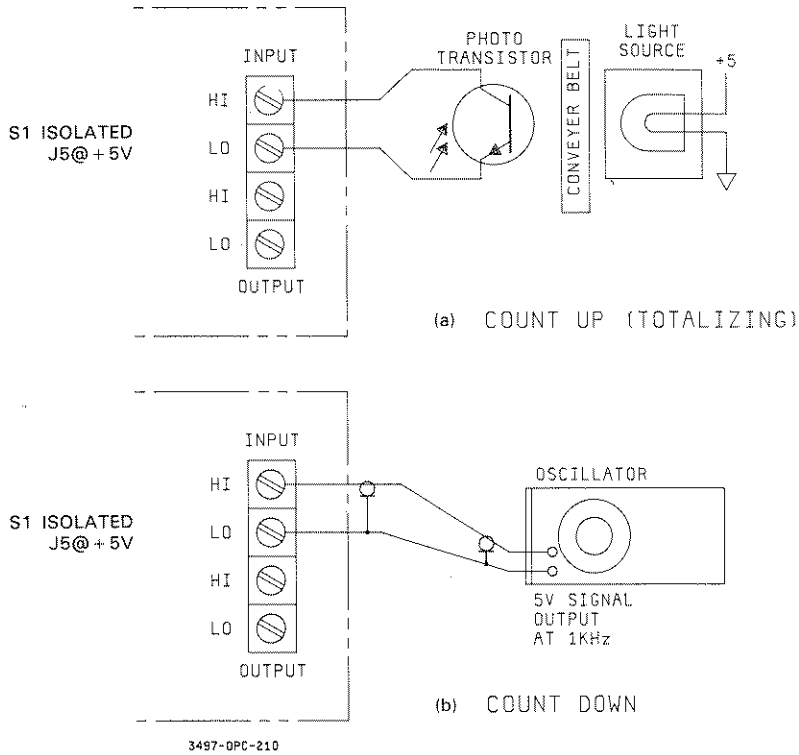


Figure 196. Example 9 - Count Up/Down with Option 060 Assembly

If, for example, we assume that the input pulses from the conveyer belt have a 1 kHz frequency, after 5 seconds 5000 counts should have accumulated in the counter. The printout shows the actual number, so the actual input pulse frequency can be determined.

COUNT UP FROM ZERO

```
10 CLEAR 709
20 OUTPUT 709;''CF4,1''
30 WAIT 5000
40 OUTPUT 709;''CR4,1''
50 ENTER 709;A
60 PRINT ''NUMBER OF COUNTS = '';A
70 END
```

The sample COUNT DOWN program shown presets a counter in slot 3 to 5000 counts and then starts the countdown process. After a 2 second delay to allow 2000 counts to be counted down (for a 1kHz input from the oscillator), the counts remaining is printed out and can be used to determine the actual oscillator input frequency. For example, if counts remaining = 3002, actual oscillator frequency = (5000-3002) =1998 counts/2 sec = 999 Hz.

COUNT DOWN FROM 5000 COUNTS

```
10 CLEAR 709
20 OUTPUT 709;"CS3,5000CF3,2"
30 WAIT 2000
40 OUTPUT 709;"CR3,1"
50 ENTER 709;A
60 PRINT "COUNTS REMAINING = ";A
70 END
```

TYPICAL PRINTOUTS

```
NUMBER OF COUNTS = 5007     (Totalize Mode)
COUNTS REMAINING = 3002     (Count Down Mode)
```

COMMENTS

The Option 060 assembly can also be used to measure input periods and/or pulse widths of inputs with frequencies from 0.0001 Hz to 100 kHz. See PERIOD MEASUREMENTS (EXAMPLE 10).

The Option 060 can also be used to interrupt the 3497A and a user external circuit when measurement complete and/or counter overflow conditions occur. See COUNTER INTERRUPTS (EXAMPLE 12).

EXAMPLE 10
PERIOD MEASUREMENTS

DESCRIPTION

The 100 kHz Reciprocal Counter assembly (Option 060) can be used for two primary functions: counting operations (count up/down) and period/pulse width measurements of input signals. In this example, we'll show how to use the counter assembly to measure the period of a 100 Hz square wave input using a read without wait technique.

PROCEDURE

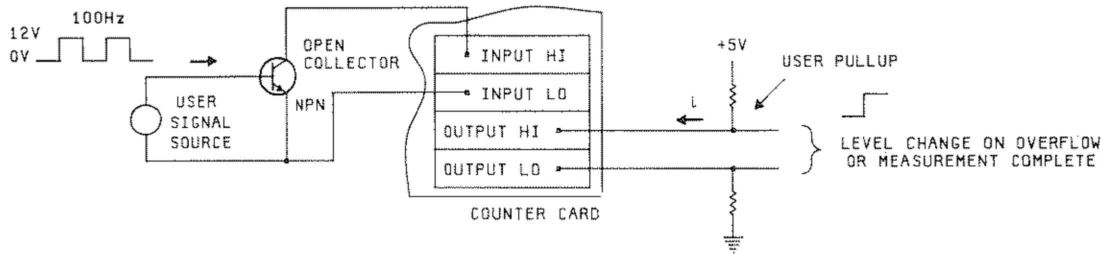
To illustrate period measurements with the Option 060 assembly, we'll input a 100 Hz square wave signal and use an open collector input as shown in Figure 197. We'll average 1000 periods of the input (for greater accuracy) and then show how partial results can be displayed by using the read without wait command.

CONFIGURATION

Figure 197 shows how to configure the Option 060 assembly using an open collector input and a user-supplied pullup on the output. Note that a level change (programmable from high to low or low to high) is always available at the OUTPUT HI terminal of the assembly whenever measurement complete occurs.

PERIOD MODE

CONNECTION DIAGRAM



Circuit	To Select	Set	
Input	Non Isolated Mode Internal Pullup +12V Logic Level	S1 to J3 to J5 to	NON ISOLATED ON 12V
Output	Interrupt Mode Isolated Pullup Positive True Logic	J7 to J1,J2 to J8 to	INTR ISOLATED POS TRUE

Figure 197. Example 10 - Option 060 Connection Diagram (Period Mode)

SAMPLE PROGRAM

When the read without wait (CR slot#,1) command is used, the counter can be read without disturbing data flow into the counter and thus interim answers can be displayed. This is useful when you are making a long measurement and want to know how far the measurement has progressed.

A sample program is shown to average 1000 periods of a 100 Hz input to a counter in slot 4 and read the results without wait. Since the counter requires over 10 seconds to average 1000 periods of the input, the program prints out the current data after 5 seconds to show interim results. In the printout, the minus (-) sign in front of the PARTIAL MEASUREMENT result indicates an incomplete measurement.

```
 10 CLEAR 709
 20 OUTPUT 709;"CF4,3"
 30 WAIT 5000
 40 OUTPUT 709;"CR4,1"
 50 ENTER 709;A
 60 PRINT "PARTIAL MEASUREMENT"
 70 PRINT "PERIOD = ";A;"SEC"
 80 WAIT 6000
 90 OUTPUT 709;"CR4,1"
100 ENTER 709;A
110 PRINT
120 PRINT "COMPLETED MEASUREMENT"
130 PRINT "PERIOD = ";A;"SEC"
140 END
```

TYPICAL PRINTOUT

PARTIAL MEASUREMENT
PERIOD = -.00488705 SEC

COMPLETED MEASUREMENT
PERIOD = .01006823 SEC

COMMENTS

In contrast to the read without wait command, the read with wait command (CR slot#,2) will return results ONLY after the measurement is complete. For count up/down applications, the measurement is always ''complete'', so the CR slot#,1 and CR slot#,2 commands produce the same results.

However, for period (and pulse width) measurements, sending the read with wait command causes the 3497A to wait until all data is accumulated and (if required) averaged and the measurement is complete. Thus, for period measurements, the interim results available with the CR slot#,1 command are not available with CR slot#,2.

The Option 060 assembly can also be used to count up to 999999 counts or count down to zero from a programmable start point). See COUNT UP/DOWN MEASUREMENTS (EXAMPLE 9).

The Option 060 assembly can also be used for interrupts to the 3497A and to a user external circuit when measurement complete and/or counter overflow conditions occur. See COUNTER INTERRUPTS (EXAMPLE 12).

EXAMPLE 11
STRAIN GAUGE MEASUREMENTS

DESCRIPTION

The 120/350 Ohm Strain Gauge/Bridge Completion assemblies (Options 070/071) can be used to measure the strain from 120 ohm or 350 ohms strain gauges. This example shows how to measure the strain from up to ten 120 ohm strain gauges by using an Option 070 assembly configured for ¼ bridge completion on each of the 10 channels.

PROCEDURE

To make strain gauge measurements using the Option 070 (or 071), a four-step procedure is used:

1. Measure the excitation voltage, Vs.

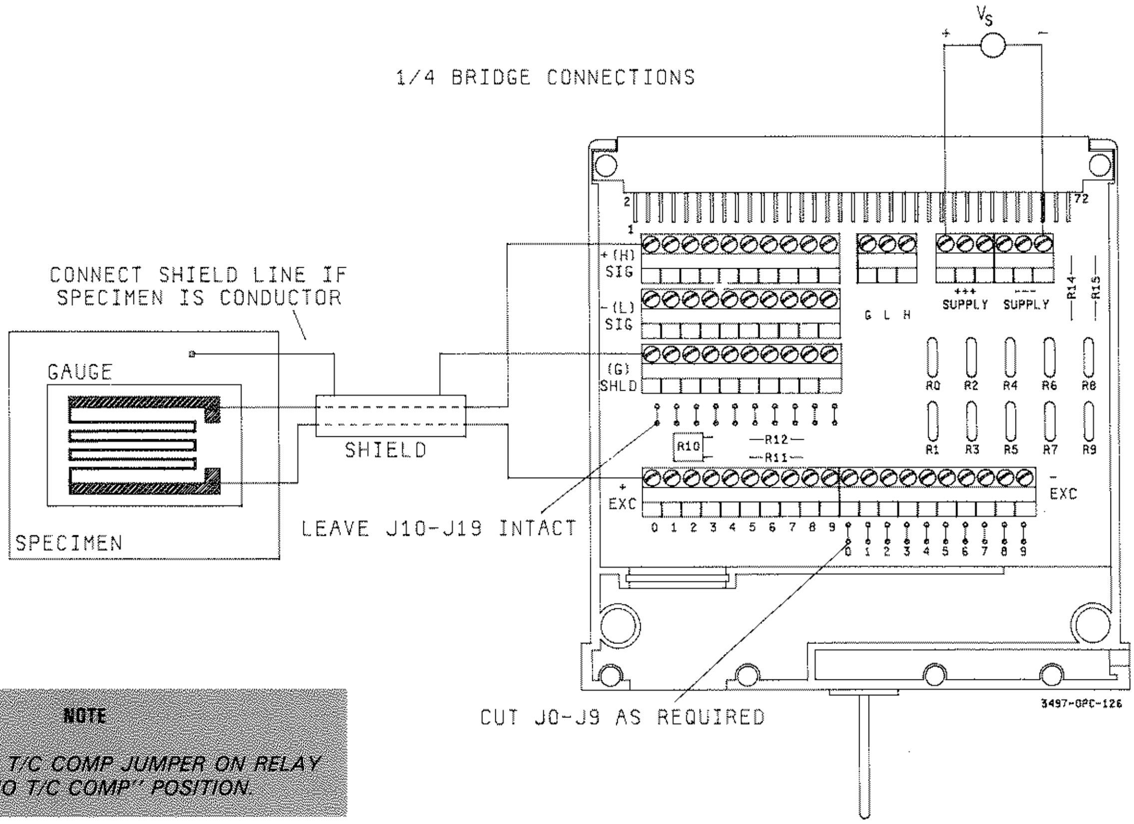
2. Measure bridge output voltage (Voutu) with gauge unstrained.

3. Measure bridge output voltage (Vouts) with gauge strained.

4. Compute strain from ϵ = -4Vr/GF(1 + 2Vr) where GF = Gauge Factor of the strain gauge and Vr = [(Vout/Vs)strained - (Vout/Vs)unstrained].

CONFIGURATION

Figure 198 shows a connection diagram and equivalent circuit for ¼ bridge configuration of a strain gauge connected to channel A0 of a terminal card. To connect up to 10 strain gauges, connect a gauge to A1, A2, .. A9 and cut jumpers J0-J9 for channels used. Note that only one excitation voltage supply (Vs) is required, whether 1, 2, ..., or 10 gauges are connected to the assembly.



NOTE

ENSURE THAT T/C COMP JUMPER ON RELAY CARD IS IN "NO T/C COMP" POSITION.

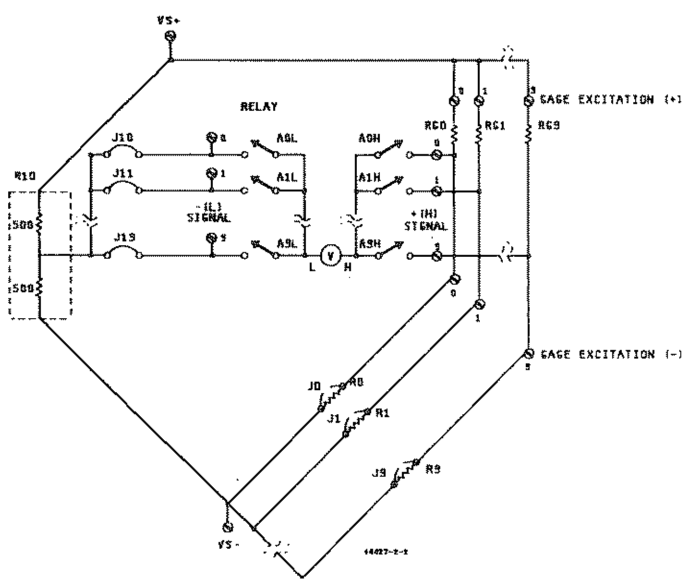


Figure 198. Example 11 · ¼ Bridge Strain Gauge Measurements

SAMPLE PROGRAM

The sample program shown computes the strain for each of 10 gauges connected to an Option 070 assembly in slot 0 (channels 0 through 9), with GF = 2 assumed. The printout shown is in units of microstrain.

Program		Description
10 CLEAR 709 20 PRINT "STRAIN GAUGE MEASUREMENTS" 30 PRINT 40 OUTPUT 709; "AF0AL9AC10" 50 ENTER 709; V	10-50	Sets first channel to 0, last channel to 9 and measures excitation voltage (Vs) on channel 10 (channel B0)
60 FOR I = 0 TO 9 70 OUTPUT 709;"AS" 80 ENTER 709; A(I) 90 U(I) = A(I)/V 100 NEXT I	60-100	Measures unstrained voltage on channels 0 through 9 and computes Vout/Vin unstrained.
110 DISP "ADD STRAIN TO GAUGES. THEN," 120 DISP "WHEN READY PRESS CONT KEY" 130 DISP "TO RESUME PROGRAM" 140 PAUSE	110-140	Program halts to allow strain to be applied to gauges.
150 PRINT "GAUGE";TAB(15); "MICROSTRAIN" 160 PRINT 170 FOR I = 0 TO 9 180 OUTPUT 709;"AS" 190 ENTER 709; B(I) 200 T(I) = B(I)/V	150-200	Measures strained voltages on chans 0 through 9 and computes Vout/Vin when gauges are strained.
210 X(I) = T(I) - U(I) 220 S(I) = -(4*X(I)/(2*(1+2*X(I))) 230 PRINT I+1; TAB(15);S(I)*10**6 240 NEXT I 250 END	210-230	Computes strain and prints results in microstrain.

TYPICAL PRINTOUT

```
STRAIN GAUGE MEASUREMENTS

    GAUGE   MICROSTRAIN

      1          10.75
      2        -134.3
      .            .
      .            .
      10         170.03
```

COMMENTS

Use the Option 070 assembly for 120 ohm strain gauges and the Option 071 assembly for 350 ohm strain gauges. You can also use these assemblies in ½ bridge or full-bridge configuration or with mixed bridge configuration for an assembly.

EXAMPLE 12
COUNTER INTERRUPTS

DESCRIPTION

There are two plug-in assemblies which can be used to generate interrupts to the 3497A when specified system conditions occur: the Digital Input/Interrupt assembly (Option 050) and the 100 kHz Reciprocal Counter assembly (Option 060). In this example, we'll show how the counter assembly can be used to generate an interrupt to the 3497A and, in turn, to the controller for measurement complete and/or counter overflow conditions.

PROCEDURE

The counter can generate an interrupt signal to the 3497A on measurement complete or overflow ONLY if the counter has previously been enabled for interrupts. The 3497A, in turn, can send an interrupt (SRQ or BREAK message) to the controller ONLY if the 3497A has previously been enabled for interrupt.

To enable the 3497A for interrupts from the counter, send ''SE2'' (''SE102'' for Serial Data). To enable the counter to send an interrupt to the 3497A, send ''CE slot#,1'' to enable measurement complete interrupts or send ''CE slot#,2'' to enable overflow interrupts.

After the counter assembly and the 3497A have been enabled for interrupts, you can determine the reason for the interrupt by sending a DI slot# command. The return to the controller following a DI command is either a 1 or a 3, but has four different interpretations, depending on the mode of operation of the counter, since the terms ''Measurement Complete'' and ''Overflow'' have different meanings for different operational modes. See the following chart.

COUNTER ASSEMBLY INTERRUPT CONDITIONS

MEASUREMENT COMPLETE (CE slot#,1 set)	
Return after a DI slot# command = 1	
Count Down (CF slot#,2)	Zero Counts Reached.
Period/Pulse Width (CF slot#,3 thru 6)	Completed Measurement Available.

OVERFLOW (CE slot#,2 set)	
Return after a DI slot# command = 3	
Count Up (CF slot#,1)	>999999 Counts in Counter.
Period/Pulse Width (CF slot#,3 thru 6)	Input period exceeds maximum measurement time for range used.

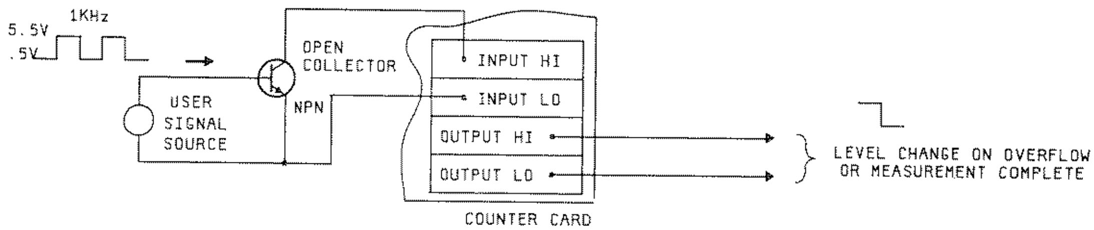
Also, for each mode of operation, a level change output is available at the OUTPUT HI terminal of the counter assembly for Measurement Complete or Overflow, whether or not the counter is enabled for interrupts to the 3497A.

CONFIGURATION

To illustrate interrupt examples, the counter is configured as shown in Figure 199 with an open collector input. Note that the level change output shown is available whenever Measurement Complete or Overflow conditions occur.

INTERRUPT MODE

CONNECTION DIAGRAM



Circuit	To Select	Set
Input	Non Isolated Mode No Internal Pullup +5V Logic Level	S1 to NON ISOLATED J3 to OFF J5 to 5V
Output	Interrupt Mode Non Isolated Pullup Negative True Logic	J7 to INTR J1,J2 to NON ISOLATED J8 to NEG TRUE

Figure 199. Example 12 - Counter Configuration

SAMPLE PROGRAMS

Four sample programs are shown to illustrate interrupts with the counter assembly:

(a) Interrupt on Measurement Complete - Count Down
(b) Interrupt on Measurement Complete - Period/Pulse Width
(c) Interrupt on Overflow - Count Up
(d) Interrupt on Overflow - Period/Pulse Width

For each program, the procedure is the same, so we'll describe the program for the first example, Interrupt on Measurement Complete - Count Down. The counter is assumed to be in slot 4 for all examples.

In this program, line 20 tells the controller to go to an interrupt subroutine (starting at line 1000) ONLY when an interrupt occurs on the remote interface (HP-IB). Line 30 enables the interface for interrupts. Note that the main program continues until an interrupt occurs (in this case, when zero counts are reached in the counter).

In line 40, SE2 enables the 3497A for digital interrupts, CE4,1 enables the counter to interrupt the 3497A when Measurement Complete occurs and CF4,2 sets the counter to the Count Down mode. For this set of conditions, when zero counts are reached, the counter sends an interrupt to the 3497A and the 3497A, in turn, sends an interrupt to the controller.

When the controller receives the interrupt, it goes to line 1000 and does an SPOLL to determine the cause of the interrupt. If digital 66 is returned, interrupt is due to a Digital Interrupt and ''DI4'' is sent to slot 4 to determine whether the counter interrupted due to Measurement Complete or Overflow.

For this example, since the counter was enabled only for Measurement Complete (with the CE4,1 command), the return after a DI4 command is A = 1 (see the chart above) and the program prints SLOT 4 - ZERO COUNTS REACHED.

If the controller does not receive an interrupt, the sample program loops continuously from line 50 to line 980 and back if no Main Program statements are entered. If Main Program statements are entered, the computer can continue with Main Program execution and be interrupted only when zero counts are reached.

The other programs shown are identical to the Count Down Interrupts program except for lines 40 and 1040. Typical printouts for all programs follow the program listings.

(a) INTERRUPT ON MEASUREMENT COMPLETE - COUNT DOWN MODE

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; ''SE2CE4,1CF4,2''
  50 !Main Program
   .
   .
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 IF P <>66 RETURN
1020 OUTPUT 709;''DI4''
1030 ENTER 709;A
1040 IF A = 1 PRINT ''SLOT 4 - ZERO COUNT REACHED''
1050 STATUS 7,1;A
1060 RETURN
```

(b) INTERRUPT ON MEASUREMENT COMPLETE - PERIOD/PULSE WIDTH MODE

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; ''SE2CE4,1CF4,3''
  50 !Main Program
       .    .
       .    .
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 IF P <>66 RETURN
1020 OUTPUT 709;''DI4''
1030 ENTER 709;A
1040 IF A = 1 PRINT ''SLOT 4 - MEASUREMENT COMPLETE''
1050 STATUS 7,1;A
1060 RETURN
```

(c) INTERRUPT ON OVERFLOW - COUNT UP MODE

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; ''SE2CE4,2CF4,1''
  50 !Main Program
       .    .
       .    .
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 IF P <>66 RETURN
1020 OUTPUT 709;''DI4''
1030 ENTER 709;A
1040 IF A = 3 PRINT ''SLOT 4 - OVERFLOW - >999999 COUNTS''
1050 STATUS 7,1;A
1060 RETURN
```

(d) INTERRUPT ON OVERFLOW - PERIOD/PULSE WIDTH MODE

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; "SE2CE4,2CF4,3"
  50 !Main Program
       .   .
       .   .
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 IF P <>66 RETURN
1020 OUTPUT 709;"DI4"
1030 ENTER 709;A
1040 IF A = 3 PRINT "SLOT 4 - OVERFLOW - RANGE EXCEEDED"
1050 STATUS 7,1;A
1060 RETURN
```

TYPICAL PRINTOUTS

Program	Printout
(a)	SLOT 4 - ZERO COUNTS REACHED
(b)	SLOT 4 - MEASUREMENT COMPLETE
(c)	SLOT 4 - OVERFLOW - >999999 COUNTS
(d)	SLOT 4 - OVERFLOW - RANGE EXCEEDED

COMMENTS

Note that the return from a DI slot# command for the counter card is different from the return for an Option 050 (Digital Input/Interrupt) assembly. That is, for an Option 050 assembly, the return shows the true (high) bits in the 16 channels of the assembly, but the counter assembly returns only two values (1 or 3) when an interrupt occurs.

If you send a DI slot# command to a counter card which did not interrupt, a value of 0 is returned.

EXAMPLE 13
EVENT SENSING

DESCRIPTION

An important application for the 3497A is to provide an interrupt to the controller when an event (valve open, mechanical movement completed, etc.) occurs. You can use the Digital Input/Interrupt assembly (Option 050) to sense specified interrupt conditions for up to eight inputs/assembly or up to 40 inputs/3497A.

You can use the first eight channels (CH0-CH7) for interrupt when the assembly is placed in a slot of the 3497A. The Option 050 does not have interrupt capability when placed in the 3498A Extender.

This example shows how to use the interrupt capability of the Option 050 assembly to sense when a mechanical system control (such as a water valve, for example) is activated.

PROCEDURE

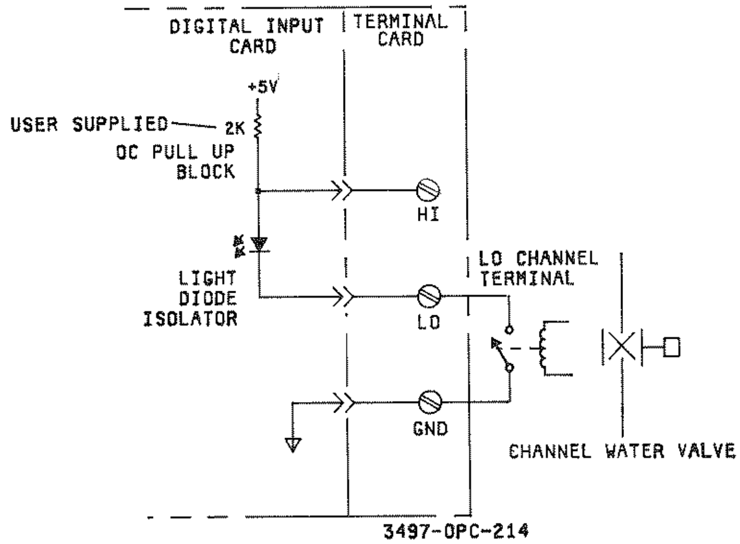
One way to sense when a specified condition occurs is shown in Figure 200. In this figure, a relay coil is connected in parallel with a mechanical system control, such as a water valve. When the valve is open, the relay is closed and sets the channel bit high (a "1" condition).

To enable an interrupt when the valve is open (relay closed), we will enable the channel to send an interrupt to the 3497A by using DE slot#,octal where the octal number represents the channel(s) to be enabled. For example, to enable channels 2 and 5 in slot 4, the command is DE4,44 since octal 44 = 00 100 100.

When interrupt channels have been enabled and an interrupt occurs on one or more of the channels, an interrupt will be sent to the 3497A. If the 3497A has previously been enabled for Digital Interrupt by sending an SE2 command (SE102 for Serial Data), the 3497A will send an interrupt to the controller for further action.

CONFIGURATION

Figure 200 shows a sample connection for relays connected to channels 2 and 5 of the terminal card of an Option 050 assembly and shows the equivalent circuit for each channel. For the contact closure to ground setup shown, note that the LO terminal is connected to one side of the relay and the GND terminal to the other side. Also note that the 2K pull-up resistor to connect the internal power supply on the assembly to the relay is user-supplied.



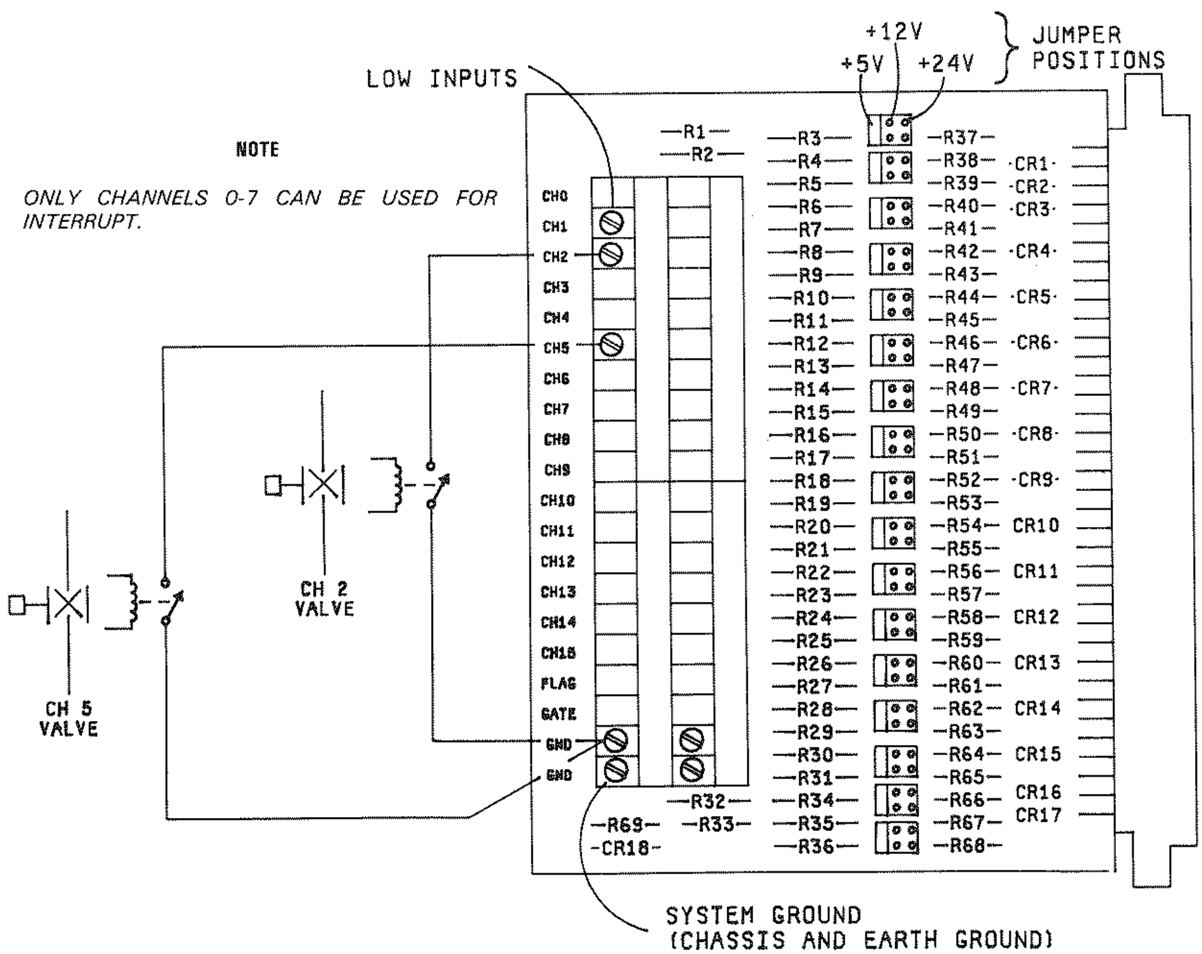


Figure 200. Example 13 - Digital Input Assembly Configuration

SAMPLE PROGRAM

An example program is shown which enables channels 2 and 5 of an assembly in slot 3 to generate an interrupt whenever the channel relay(s) close (i.e., the water valve in that channel opens). When the interrupt occurs, the controller shifts to an interrupt subroutine (starting at line 1000) and does an SPOLL to determine the cause of the interrupt.

If the interrupt comes from the assembly, DIGITAL 66 is returned (Digital Interrupt) and the controller sends DI3 to determine which channel causes interrupt. If OCTAL 4 is returned, channel 2 caused interrupt. If OCTAL 40 is returned, channel 5 caused interrupt. If OCTAL 44 is returned, both channels interrupted simultaneously.

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; ''DE3,44SE2''
  50 !Main Program
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 IF P <> 66 RETURN
1020 OUTPUT 709; ''DI3''
1030 ENTER 709; A
1040 IF A = 0 PRINT ''NO SLOT 3 INTERRUPT''
1050 IF A = 4 PRINT ''VALVE 2 OPEN
1060 IF A = 40 PRINT ''VALVE 5 OPEN''
1070 IF A = 44 PRINT ''VALVES 2 AND 5 OPEN''
1080 STATUS 7,1;A
1090 RETURN
```

TYPICAL PRINTOUT

Valve(s) Open	Printout
2	VALVE 2 OPEN
5	VALVE 5 OPEN
2 & 5	VALVES 2 AND 5 OPEN

COMMENTS

Only channels 0-7 can be used for interrupt and interrupt capability can't be used for an Option 050 assembly in the 3498A. Both the Option 050 assembly AND the 3497A must be enabled for specified system input to cause an interrupt.

EXAMPLE 14
USING THE COUNTER IN THE 3498A

DESCRIPTION

The previous examples on interrupts (COUNTER INTERRUPTS and EVENT SENSING) stated that interrupt capability for the Digital Input/Interrupt assembly (Option 050) or the Counter assembly (Option 060) is not available when either assembly is placed in a slot in the 3498A.

However, you can combine the two assemblies to provide a limited interrupt capability when the counter assembly is placed in the 3498A. This example shows how to enable the counter assembly for measurement complete or overflow interrupts by placing the counter assembly in the 3498A and sending the interrupt signal to an Option 050 assembly in the 3497A.

PROCEDURE

For this example, a counter assembly is placed in slot 12 of a 3498A and a Digital Input/Interrupt assembly in slot 2 of a 3497A, as shown in Figure 201. When an interrupt condition occurs (Measurement Complete or Overflow - see the COUNTER INTERRUPTS example for definitions), the counter sends an interrupt signal to channel 1 of the Digital Input assembly.

Then, as shown in the EVENT SENSING example, if the Digital Input assembly has been enabled for channel 1 interrupts (with a DE 2,2 command) AND the 3497A has been enabled for digital interrupts (with an SE2 or SE102 command), an interrupt signal is sent to the controller for further action.

CONFIGURATION

See Figure 201 for configuration and interconnections of the two plug-in assemblies.

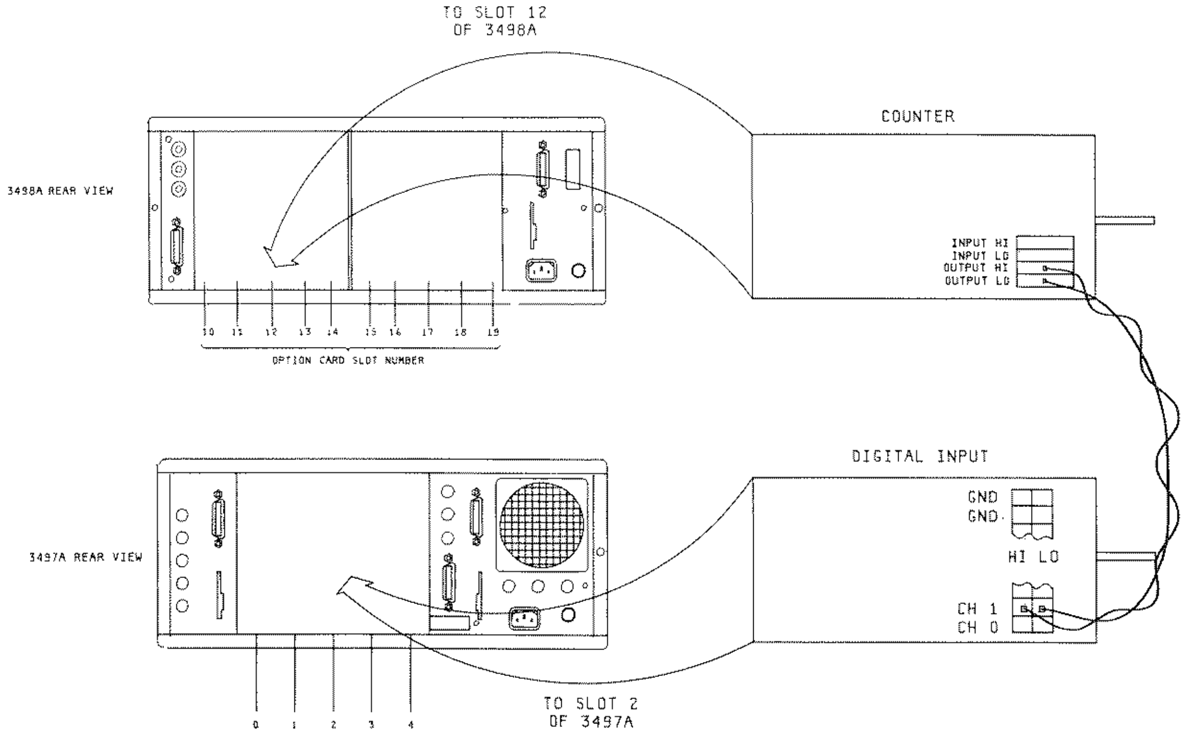


Figure 201. Example 14 - Interrupts With Counter in 3498A

SAMPLE PROGRAM

In the sample program shown, the counter is in slot 12 of a 3498A and the digital input assembly is in slot 2 of a 3497A. Whenever a Measurement Complete or Overflow condition occurs, a level change is output from the OUTPUT HI, OUTPUT LO terminals of the counter which sets channel 1 bit true in the Digital Input assembly.

Since channel 1 of the digital input assembly has been enabled for interrupt by the DE2,2 command and since the 3497A has been enabled for digital interrupt by the SE2 command, when a counter interrupt occurs, the program jumps to an interrupt subroutine (starting at line 1000) and sends a DI2 command to determine the cause of the interrupt.

If the interrupt was due to digital interrupt on channel 1, octal 1 is returned and the program prints ''INTERRUPT ON MEASUREMENT COMPLETE OR OVERFLOW''.

```
  10 CLEAR 709
  20 ON INTR 7 GOSUB 1000
  30 ENABLE INTR 7;8
  40 OUTPUT 709; ''SE2DE2,2''
  50 !Main Program
      .   .
      .   .
 980 GOTO 50
 990 END
1000 P = SPOLL (709)
1010 IF P<>66 RETURN
1020 OUTPUT 709; ''DI2''
1030 ENTER 709; A
1040 IF A = 1 PRINT ''SLOT 12 - INTERRUPT ON MEASUREMENT
     COMPLETE OR OVERFLOW''
1050 STATUS 7,1;A
1060 RETURN
```

TYPICAL PRINTOUT

After an interrupt occurs, the printout is:

```
SLOT 12 - INTERRUPT ON MEASUREMENT COMPLETE OR OVERFLOW
```

COMMENTS

The setup shown will only provide an indication that a counter interrupt occurred, and not the specific reason (i.e., zero counts reached, measurement complete, etc.) as can be obtained when the counter is in the 3497A (see the COUNTER INTERRUPTS example). However, if you can only place your counter assemblies in a 3498A, this procedure does at least give an interrupt indication.

Note that it is not necessary to enable the counter for interrupts with a CE slot#,1 or CE slot#,2 command as the level change at the OUTPUT HI AND OUTPUT LO terminals is output whenever Measurement Complete or Overflow occurs, regardless of the CE slot#,n command setting.

EXAMPLE 15
VOLTAGE SWITCHING AND ALARM ACTUATION

DESCRIPTION

A primary purpose of the Actuator/Digital Output assembly (Option 110) is voltage switching for applications with 100VA or less. This example shows how to use the Option 110 assembly for three voltage switching applications: alarm actuation; voltage switching and motor reversal.

PROCEDURE

Figure 202 shows a sample connection diagram with inputs connected to channels 0 through 3 of an Option 110 assembly in slot 1. The three applications are:

Alarm Actuation

When channel 0 is open, the NC contact of the relay is connected to common. To sound the alarm, send DC 1,0 which closes channel 0 and connects the NO contact of the relay to common. This completes the circuit and sounds the alarm. To turn off the alarm, send DO1,0 to open channel 0.

Voltage Switching

When channel 1 is open, the NC contact is connected to common and +5V is applied to Device B. To switch power to Device A, send DC1,1 to close channel 1 and connect the NO contact to common.

Motor Reversal

With the relays in the position shown in Figure 202 (both with NC contacts connected to common), the motor will rotate in one direction. By sending DC1,2,3, both relays are closed (NC contacts to common) and the motor will reverse direction of rotation. Note that opening or closing one relay but not the other will stop motor rotation.

CONFIGURATION

See Figure 202 to configure the Option 110 assembly for alarm actuation, voltage switching and motor reversal.

CAUTION

USE CONTACT PROTECTION TO AVOID EXCEEDING THE 100VA CONTACT RATING. INDUCTIVE LOADS, SUCH AS MOTORS, CAUSE HIGH VOLTAGE SPIKES WHEN THE SWITCH IS OPENED.

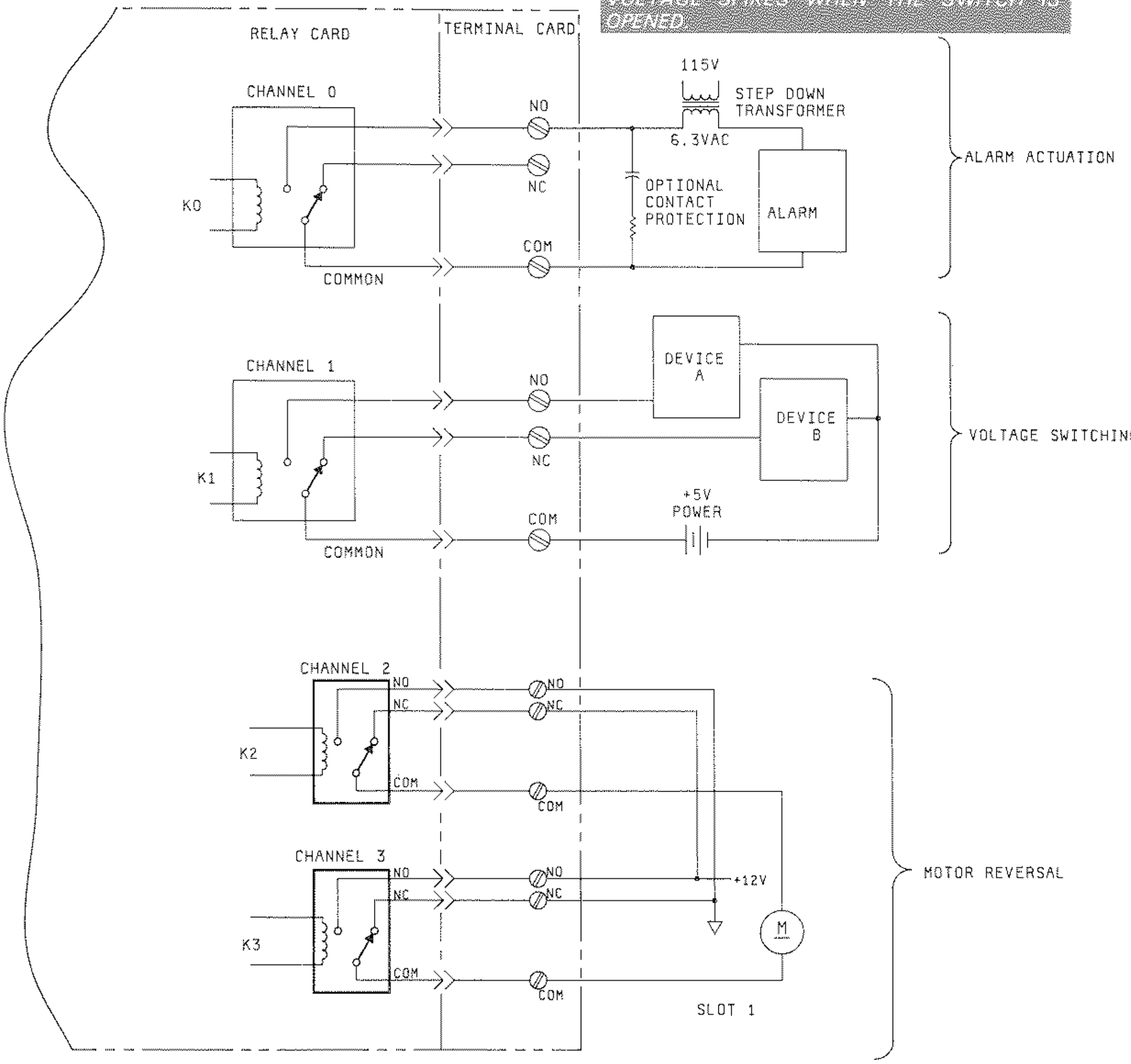


Figure 202. Example 15 - Actuator Assembly Configuration

COMMENTS

You can connect up to 16 inputs to an Option 110 assembly or up to 80 inputs/3497A. If 3498A Extenders are used, you can connect up to 1360 inputs (85 total slots x 16 channels/slot). Remember that slots 5 through 9 do not exist for digital assemblies and should NEVER be addressed in DIGITAL commands.

EXAMPLE 16
HIGH VOLTAGE SWITCHING

DESCRIPTION

A primary application for the High Voltage Actuator assembly (Option 115) is to switch high voltage loads. Since the actuator can handle voltages up to 250V RMS at 2 amps, it is ideally suited for switching line voltages to items such as air solenoids, pilot lights and motor starters. With the Option 115 assembly, you can connect up to eight inputs per assembly or 40 inputs per 3497A. This example shows how to use the high voltage actuator to control (turn on) motor starters.

PROCEDURE

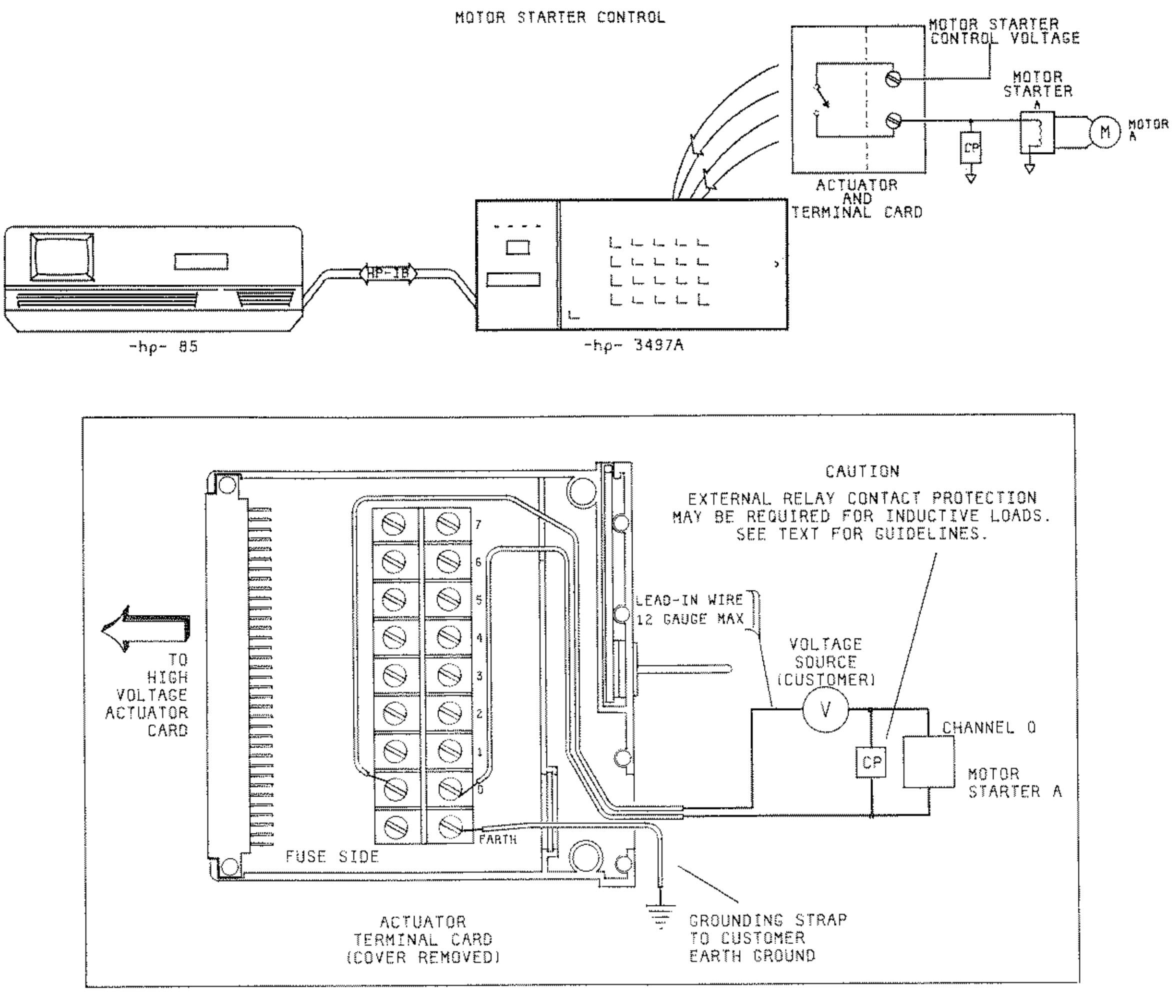
A typical application for the high voltage actuator is to control (turn on) motor starters. Although the actuator can directly switch motors up to ⅔ horsepower, the range of motors it can handle can be greatly increased by using motor starters. The actuator can be used to control the motor starter, essentially supplying the signals to turn the starter on.

For this example, an assembly process requires that three 80 horsepower motors be turned on by using motor starters, according to the following sequence. Motor A is started at time t = 0 (by motor starter A), runs for 5 minutes and is then turned off by an external circuit. At t+5 minutes, motor B is started, runs for 6 minutes and is then shut off. Then, at t+11 minutes, motor C is started, runs for 4 minutes and is stopped, completing the cycle.

MOTOR STARTER	CHANNEL NUMBER	MOTOR RUN TIME (MINUTES)	SEQUENCE NUMBER
A	0	5	1
B	1	6	2
C	2	4	3

CONFIGURATION

Figure 203 shows a simplified block diagram and typical connection diagram. For this example, motor starters are connected to channels 0, 1 and 2 of an assembly in slot 2. Although a specific contact protection network is not shown, you should consult Chapter 8, Option 115 , Contact Protection Guidelines, before running the program shown to ensure that appropriate contact protection is provided.



3497-OPC-203

Figure 203. Example 16 - Motor Starter Configuration

SAMPLE PROGRAM

An example program for the motor starter sequence is shown. In the program, channel 0 relay is closed, supplying voltage to motor starter A which starts motor A. Three seconds later, channel 0 relay is opened to disconnect motor starter A.

After a 5 minute run time, motor A is turned off (by an external system) and channel 1 relay then closes. After a three second delay, channel 1 opens. Following a 6 minute run time for motor B, channel 2 relay is closed for 3 seconds and is then opened. After a 4 minute run time, motor C stops, completing the cycle.

If the optional DR command is used, relay status is displayed on the 3497A front panel. If the relays do not open or close as required, the program prints a ''RELAY FAILED'' message and halts the operation.

SET INITIAL CONDITIONS

```
10 PRINT ''MOTOR STARTER''
20 PRINT
30 PRINT
40 CLEAR 709
50 I = 1
```

CLOSE THEN OPEN CHAN 0, WAIT 5 MIN FOR MOTOR A RUN TIME

```
60 OUTPUT 709; ''DC2,0DR2''
70 ENTER 709;A
80 IF A<>1 THEN 330
90 WAIT 3000
100 OUTPUT 709; ''DO2,0''
110 ENTER 709;B
120 IF B<>0 THEN 340
130 I = 2
140 WAIT 300000
```

CLOSE THEN OPEN CHAN 1, WAIT 6 MIN FOR MOTOR B RUN TIME

```
150 OUTPUT 709; ''DC2,1''
160 ENTER 709;C
170 IF C<>2 THEN 330
180 WAIT 3000
190 OUTPUT 709; ''DO2,1''
200 ENTER 709;D
210 IF D<>0 THEN 340
220 I = 3
230 WAIT 360000
```

CLOSE THEN OPEN CHAN 2, WAIT 4 MIN FOR MOTOR C RUN TIME

```
240 OUTPUT 709; ''DC2,2''
250 ENTER 709;E
260 IF E<>4 THEN 330
270 WAIT 3000
280 OUTPUT 709; ''DO2,2''
290 ENTER 709;F
300 IF F<>0 THEN 340
310 WAIT 240000
```

PRINT FAILURE NOTICE IF RELAY DOES NOT OPEN OR CLOSE

```
320 GOTO 350
330 PRINT ''CHANNEL'';I; ''RELAY DID NOT CLOSE''
340 PRINT ''CHANNEL'';I; ''RELAY DID NOT OPEN''
350 END
```

TYPICAL PRINTOUT

If channel 1 relay did not open, the printout is:

CHANNEL 1 RELAY DID NOT OPEN

COMMENTS

Although motor starters do not have standard control inputs, the high voltage actuator will control common motor starters up to NEMA class 5. This starter, in turn, will handle motors up to 100 horsepower (220V) or 200 horsepower (440-550V).

EXAMPLE 17
VOLTAGE AND CURRENT SOURCES

DESCRIPTION

The Dual Output, 0 to ± 10V Voltage D/A Converter [VDAC](Option 120) provides programmable sources for applications such as programmable test stimulus or to control voltage programmed devices such as power supplies and VCO's. The Dual Output, 0-20 mA/4-20 mA Current D/A Converter [IDAC] (Option 130) provides two 0-20 mA or 4-20 mA programmable current sources.

PROCEDURE

This example shows how to program the Option 120 and 130 assemblies to provide desired voltage and current outputs. In the example, the voltage D/A converter is in slot 2 and the current D/A converter is in slot 3. In addition, the current D/A converter is set for the 0-20 mA range.

Both assemblies are controlled by the AO slot#,chan#,value. To program a desired current or voltage output, the ''value'' part of the command must be specified (i.e., a value of ''40'' outputs 0.0400 volts from a VDAC or 0.080 mA from an IDAC set to the 0-20 mA range).

VDAC Programming

For the VDAC, the value can be programmed from 0 to ± 10238 in units of millivolts. However, the voltage output is in units of 2.5 mV. Thus, for programmed values other than integer multiples of 2.5 mV, the 3497A will round off the value to the nearest integer multiple of 2.5 mV. To program a negative voltage output, the form is AO slot#, chan#, -value (i.e., AO3,1,-40 causes the VDAC to output -0.040 volts on channel 1).

IDAC Programming

The IDAC is programmed in units of 0.01% of the ''span'' where the span is 20 mA for the 0-20 mA range and 16 mA for the 4-20 mA range. However, the output can change only in increments of 0.025% of span. The 3497A will round off the AO command value to the nearest integer multiple of 0.025% of span. If the 4-20 mA range is selected, the minimum output is 4.000 mA.

For example, if the IDAC is configured for the 0 - 20 mA range, the span is 20 mA. Thus, a program value of 5000 (AO slot#,chan#,5000) is 50% of span and gives an output of 10.00 mA. If the IDAC is configured for the 4 - 20 mA range, the span is 16 mA. Thus, a program value of 5000 (AO slot#,chan#,5000) which is 50% of span gives an output of 12 mA (50% of 16 mA = 8 mA + 4 mA minimum).

CONFIGURATION

Figure 204 shows sample connection diagrams for the Option 120 and 130 assemblies, with voltage sensing connections made for the Option 120 assembly. Note that with the Option 130 assembly, conventional current flow is out the SOURCE terminal and into the SINK terminal.

SAMPLE PROGRAM

As mentioned, the voltage D/A converter is in slot 2 and the current D/A converter is in slot 3. To program a desired current or voltage output, the ''value'' part of the command must be specified. For example, a value of ''40'' outputs 0.0400 volts from a VDAC or 0.080 mA from an IDAC set to the 0-20 mA range).

An example program is shown to output 0.320 volts from channel 0 of a VDAC in slot 2 and to output 0.160 mA from channel 1 of an IDAC in slot 3 which is set for the 0-20 mA range.

```
10 CLEAR 709
20 OUTPUT 709; ''AO2,0,320''        !Sets VDAC output to 0.320 V
30 OUTPUT 709; ''AO3,1,80''         !Sets IDAC output to 0.160 mA
40 LOCAL 709                        !Returns control to front panel
50 END
```

COMMENTS

Slots 5 through 9 do not exist for the 3497A or 3498A. Do not attempt to use these slot numbers as spurious voltages may be input or output.

The IDAC is factory set to the 0 to 20 mA range. Reconfiguring the assembly to the 4-20 mA range requires recalibration for output current accuracy.

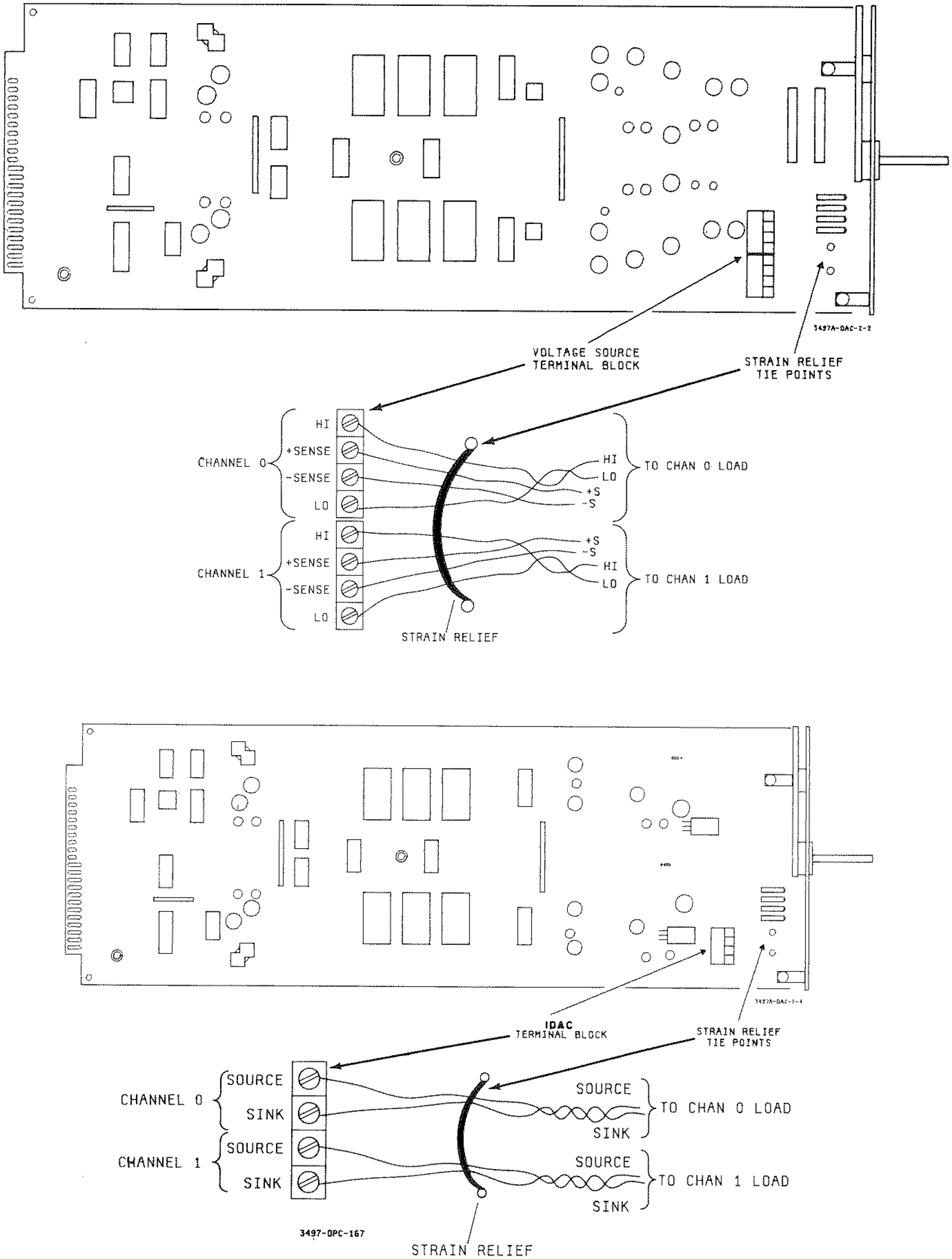


Figure 204. Example 17 - VDAC and IDAC Configurations

Appendix A
INTERFACE CONCEPTS

This appendix introduces concepts for HP-IB and Serial Data (RS232C and RS449/423) interfaces used with the 3497A. It is divided into 3 parts: INTRODUCTION TO THE HP-IB; SERIAL I/O CONCEPTS AND THE 3497A; and INTRODUCTION TO RS232C/RS449.

INTRODUCTION TO THE HP-IB

This part of Appendix A summarizes the major functions of the HP-IB. If you need more information on HP-IB, refer to the HP-IB Abbreviated Description Manual (-hp- part number 5955-2903). A condensed description is also available in the Condensed Description of the Hewlett-Packard Interface Bus Manual (-hp- part number 59401-90030). These manuals are available through your local -hp- Sales and Service Office.

The Hewlett-Packard Interface Bus (HP-IB) is Hewlet-Packard's implementation of IEEE Standard 488-1978, ''Standard Digital Interface for Programmable Instrumentation''. HP-IB is an interface system which uses a party-line bus structure so that up to 15 devices can be placed on a single bus.

One controller can control up to 14 devices on a bus. For example, as shown in Figure A-1, an -hp- 85A Desktop Computer, acting as system controller, can control up to 14 devices over the HP-IB interface bus. Of course, more than one controller can be placed on the bus, if one of the controllers is designated as System Controller.

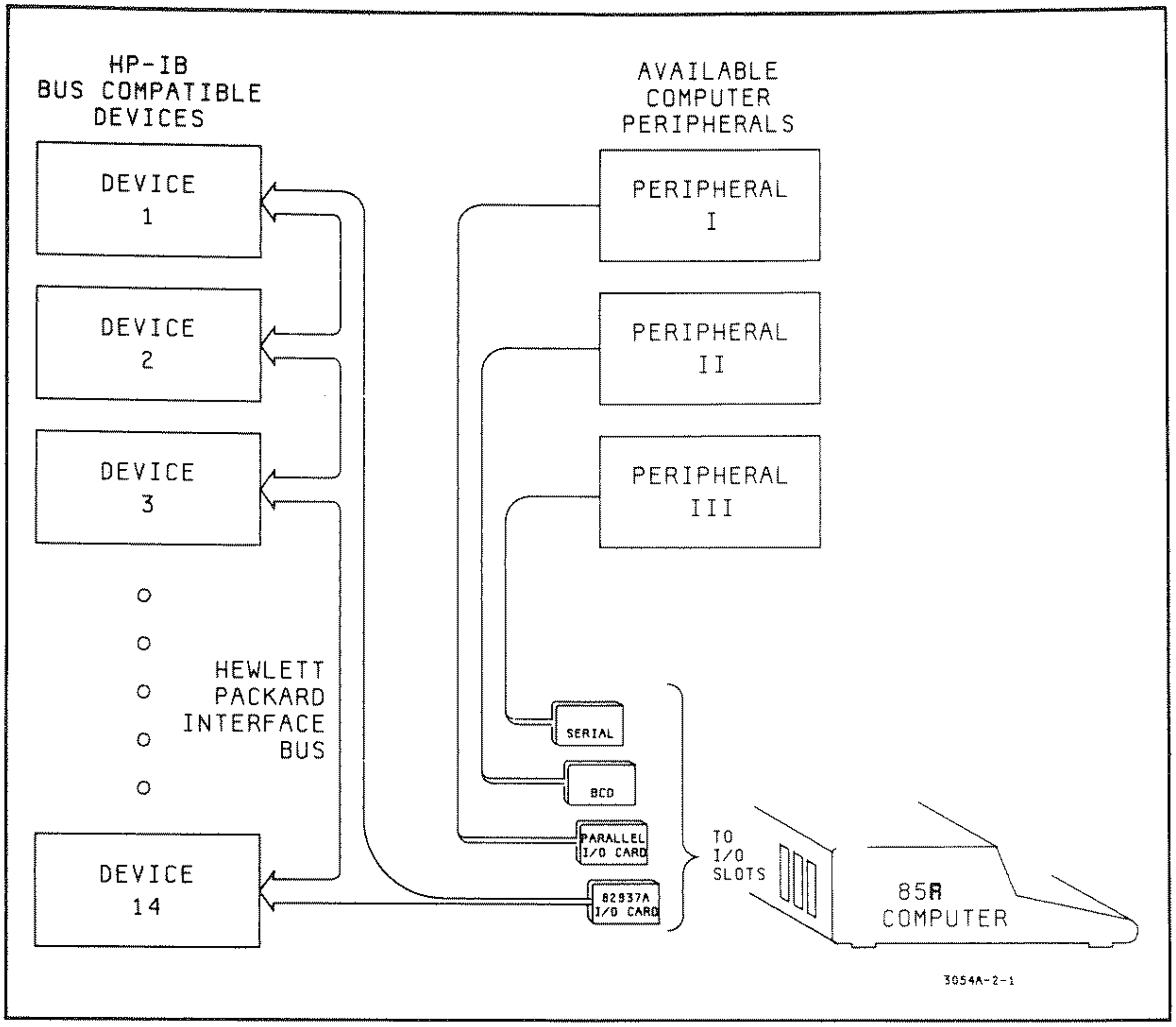


Figure A-1. Typical HP-IB System

HP-IB Bus Structure

As shown in Figure A-2, the HP-IB is a parallel bus of 16 active signal lines, grouped into 3 functional sets, to interconnect up to 15 instruments.

Eight signal lines, called the DATA lines, are used to transmit data in the form of coded messages. These messages are used to program the instrument function, transfer measurement data, coordinate instrument operation and to manage the system. Input and output of messages, in bit parallel-byte serial format, are also transferred in the DATA lines. A 7-bit ASCII code normally represents each piece of data.

The three DATA BYTE TRANSFER CONTROL lines coordinate and control transfer of data by means of an interlocking "handshake" technique which permits asynchronous data transfer at the rate of the slowest active device used in that transfer.

The remaining five GENERAL INTERFACE MANAGEMENT lines are used to manage the devices on the HP-IB. This includes activating all connected devices at once, clearing the interface and others.

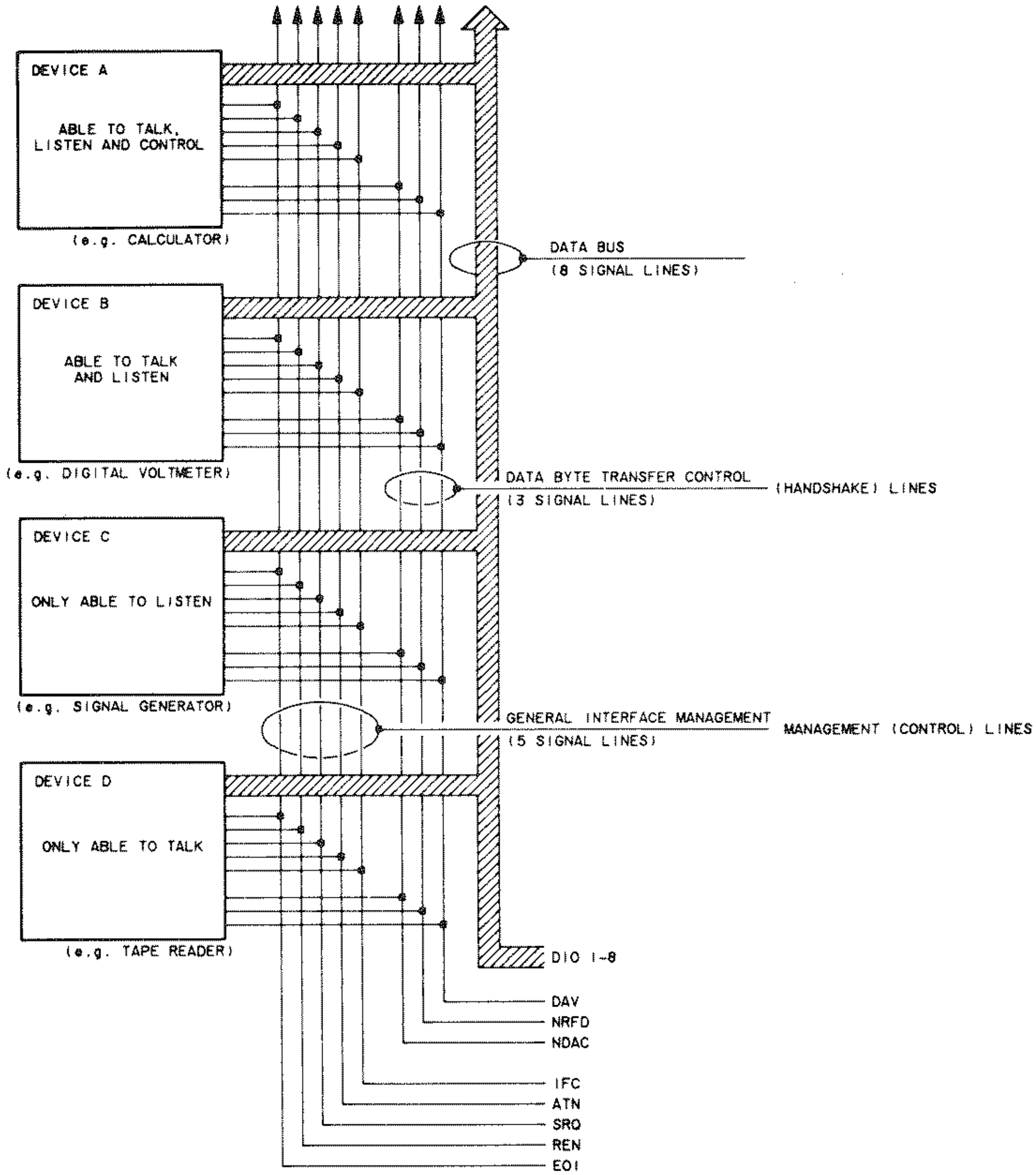


Figure A-2. Structure of the HP-IB

Device Communication Capabilities

Each device on the HP-IB is classified into one of three categories: TALKERS, LISTENERS or CONTROLLERS. The 3497A is classified as a TALKER since it can send data to the controller and a LISTENER since it can receive instructions from the controller.

HP-IB DEVICE CAPABILITIES

LISTENER	A device which is capable of receiving data over the interface bus when addressed. A LISTENER becomes an ACTIVE LISTENER when it is addressed by the controller. There can be up to 14 active listeners simultaneously on the interface. Some examples of listeners are printers, display devices, programmable power supplies, etc.
TALKER	A device which is capable of transmitting data over the interface bus when addressed. A TALKER becomes an ACTIVE TALKER when it is addressed by the controller. There can be only one active talker on the bus at a time. Examples of talkers are tape readers, voltmeters and counters that are outputting data, etc.
CONTROLLER	A device which is capable of specifying talker and listener(s) for an information transfer. There can be two types of controllers, ACTIVE CONTROLLERS and a SYSTEM CONTROLLER. The active controller is the current controlling device. The system controller can take control of the HP-IB even if it is not the active controller. There can only be one active controller on the interface at a time. If there is more than one controller on the HP-IB, only one can be the system controller. A computer with an input/output card is an example of a controller.

HP-IB Messages

Different types of information can be passed over the HP-IB to one or more devices. One type of information is called a BUS MESSAGE. There are 12 bus messages for the HP-IB and each bus message can be divided into three parts: (1) an operation portion (2) the address specified by the controller and (3) the information in the message.

The operation mnemonic portion of a bus message tells what action to take (CLEAR, LOCAL, etc.). Each HP-IB compatible controller has an equivalent syntax (which is controller-dependent) for the operation mnemonic. The address portion of a bus message consists of an interface select code (ISC) and a device selector. The information portion consists of the commands or data.

HP-IB BUS MESSAGES

BUS MESSAGE	DESCRIPTION
ABORT	System controller sends this message to unconditionally assume control of the HP-IB from the active controller. Message terminates all bus communication but does not implement the CLEAR message.
CLEAR	Sets all devices on the interface to pre-defined device dependent states.
DATA	Information (binary bytes) sent from a talker to a listener. The information (data) can be numeric or characters.
LOCAL	Clears the REMOTE message from listening device(s) and returns device(s) to front panel control.
LOCAL LOCKOUT	Prevents manually affecting remote program control.
CLEAR LOCKOUT AND SET LOCAL	Clears LOCAL LOCKOUT and REMOTE messages and reverts all devices to local front panel control.
PASS CONTROL	This message transfers bus management responsibility from one controller to another.
REMOTE	Causes listening device(s) to switch from local front panel control to remote program control when addressed to listen.
REQUIRE SERVICE	A device can send this message at any time to signify that the device needs some type of interaction with the controller. Message cleared by the device's STATUS BYTE message when the device no longer requires service.
STATUS BIT	A byte that represents the operational conditions of a group of devices on the HP-IB. Each device responds on a particular bit of the byte thus identifying a device dependent condition. This bit is typically sent by devices in response to a Parallel Poll operation.
STATUS BYTE	A byte that represents the current status of a single device on the HP- IB. One bit indicates whether the device sent the REQUIRE SERVICE message and the remaining seven bits indicate optional conditions defined by the device. This byte is sent from the talking device in response to a Serial Poll operation performed by the controller.
TRIGGER	Causes listening device(s) to perform a device-dependent action when addressed.

ASCII Table

For convenient reference, an ASCII table showing ASCII character, equivalent binary, octal, hexadecimal and decimal values and (where applicable) HP-IB character follows.

ASCII TABLE

ASCII Char.	EQUIVALENT FORMS				HP-IB
	Binary	Oct	Hex	Dec	
NULL	00000000	000	00	0	
SOH	00000001	001	01	1	GTL
STX	00000010	002	02	2	
ETX	00000011	003	03	3	
EOT	00000100	004	04	4	SDC
ENQ	00000101	005	05	5	PPC
ACK	00000110	006	06	6	
BELL	00000111	007	07	7	
BS	00001000	010	08	8	GET
HT	00001001	011	09	9	TCT
LF	00001010	012	0A	10	
VT	00001011	013	0B	11	
FF	00001100	014	0C	12	
CR	00001101	015	0D	13	
SO	00001110	016	0E	14	
SI	00001111	017	0F	15	
DLE	00010000	020	10	16	
DC1	00010001	021	11	17	LLO
DC2	00010010	022	12	18	
DC3	00010011	023	13	19	
DC4	00010100	024	14	20	DCL
NAK	00010101	025	15	21	PPU
SYNC	00010110	026	16	22	
ETB	00010111	027	17	23	
CAN	00011000	030	18	24	SPE
EM	00011001	031	19	25	SPD
SUB	00011010	032	1A	26	
ESC	00011011	033	1B	27	
FS	00011100	034	1C	28	
GS	00011101	035	1D	29	
RS	00011110	036	1E	30	
US	00011111	037	1F	31	

ASCII Char.	EQUIVALENT FORMS				HP-IB
	Binary	Oct	Hex	Dec	
space	00100000	040	20	32	LA0
!	00100001	041	21	33	LA1
"	00100010	042	22	34	LA2
#	00100011	043	23	35	LA3
$	00100100	044	24	36	LA4
%	00100101	045	25	37	LA5
&	00100110	046	26	38	LA6
'	00100111	047	27	39	LA7
(	00101000	050	28	40	LA8
)	00101001	051	29	41	LA9
*	00101010	052	2A	42	LA10
+	00101011	053	2B	43	LA11
,	00101100	054	2C	44	LA12
-	00101101	055	2D	45	LA13
.	00101110	056	2E	46	LA14
/	00101111	057	2F	47	LA15
0	00110000	060	30	48	LA16
1	00110001	061	31	49	LA17
2	00110010	062	32	50	LA18
3	00110011	063	33	51	LA19
4	00110100	064	34	52	LA20
5	00110101	065	35	53	LA21
6	00110110	066	36	54	LA22
7	00110111	067	37	55	LA23
8	00111000	070	38	56	LA24
9	00111001	071	39	57	LA25
:	00111010	072	3A	58	LA26
;	00111011	073	3B	59	LA27
<	00111100	074	3C	60	LA28
=	00111101	075	3D	61	LA29
>	00111110	076	3E	62	LA30
?	00111111	077	3F	63	UNL

ASCII Char.	EQUIVALENT FORMS				HP-IB
	Binary	Oct	Hex	Dec	
@	01000000	100	40	64	TA0
A	01000001	101	41	65	TA1
B	01000010	102	42	66	TA2
C	01000011	103	43	67	TA3
D	01000100	104	44	68	TA4
E	01000101	105	45	69	TA5
F	01000110	106	46	70	TA6
G	01000111	107	47	71	TA7
H	01001000	110	48	72	TA8
I	01001001	111	49	73	TA9
J	01001010	112	4A	74	TA10
K	01001011	113	4B	75	TA11
L	01001100	114	4C	76	TA12
M	01001101	115	4D	77	TA13
N	01001110	116	4E	78	TA14
O	01001111	117	4F	79	TA15
P	01010000	120	50	80	TA16
Q	01010001	121	51	81	TA17
R	01010010	122	52	82	TA18
S	01010011	123	53	83	TA19
T	01010100	124	54	84	TA20
U	01010101	125	55	85	TA21
V	01010110	126	56	86	TA22
W	01010111	127	57	87	TA23
X	01011000	130	58	88	TA24
Y	01011001	131	59	89	TA25
Z	01011010	132	5A	90	TA26
[	01011011	133	5B	91	TA27
\	01011100	134	5C	92	TA28
]	01011101	135	5D	93	TA29
^	01011110	136	5E	94	TA30
_	01011111	137	5F	95	UNT

ASCII Char.	EQUIVALENT FORMS				HP-IB
	Binary	Oct	Hex	Dec	
`	01100000	140	60	96	SC0
a	01100001	141	61	97	SC1
b	01100010	142	62	98	SC2
c	01100011	143	63	99	SC3
d	01100100	144	64	100	SC4
e	01100101	145	65	101	SC5
f	01100110	146	66	102	SC6
g	01100111	147	67	103	SC7
h	01101000	150	68	104	SC8
i	01101001	151	69	105	SC9
j	01101010	152	6A	106	SC10
k	01101011	153	6B	107	SC11
l	01101100	154	6C	108	SC12
m	01101101	155	6D	109	SC13
n	01101110	156	6E	110	SC14
o	01101111	157	6F	111	SC15
p	01110000	160	70	112	SC16
q	01110001	161	71	113	SC17
r	01110010	162	72	114	SC18
s	01110011	163	73	115	SC19
t	01110100	164	74	116	SC20
u	01110101	165	75	117	SC21
v	01110110	166	76	118	SC22
w	01110111	167	77	119	SC23
x	01111000	170	78	120	SC24
y	01111001	171	79	121	SC25
z	01111010	172	7A	122	SC26
{	01111011	173	7B	123	SC27
|	01111100	174	7C	124	SC28
}	01111101	175	7D	125	SC29
~	01111110	176	7E	126	SC30
DEL	01111111	177	7F	127	SC31

SERIAL I/O CONCEPTS

COMPARING SERIAL I/O TO PARALLEL I/O

What do these two terms mean? Simply stated, serial I/O is the transfer of data, one bit after another in succession, over a line. Parallel I/O, on the other hand, transfers a whole word simultaneously (usually eight or more bits) but requires a separate wire (or line) for each bit. Parallel I/O is usually faster, but not in all cases. Data transfer speeds primarily depend upon the functional capability of the devices.

Parallel I/O has dedicated lines to handshake each word transferred whereas serial I/O doesn't. In fact, serial I/O doesn't necessarily require a handshake at all. If the 3497A handshakes a transfer, it does so with either the ENQ/ACK or DC1 messages. These should not be confused with a hardware handshake. Strictly speaking, these are protocols where message bytes are sent to implement the handshake function.

Perhaps the most important distinction that can be made between serial and parallel I/O transfers, are the respective distances allowed between devices. Since parallel I/O has a separate wire for each bit, there are prohibitive cost and logistic considerations when long distances exist between devices. Serial I/O, however, permits data transfers via telephone lines when the appropriate modems are used. Even in a point to point hookup, serial I/O usually permits greater distances.

STANDARDS AND LINE PROTOCOLS

Confusion often accompanies the distinction between line protocols and standards. Line protocols are disciplines used for orderly information transfers over a communication channel. In other words, they establish the grammar by which devices communicate. Furthermore, some of the synchronous protocols are quite complex in structure.

A standard will usually define a protocol, but not always. RS-232C and RS-449/423 are examples of standards where protocols aren't defined, but they are the exception rather than the rule. A standard, however, will always define the electrical and mechanical requirements devices must adhere to for them to interoperate with other devices.

SYNCHRONOUS VS ASYNCHRONOUS

This manual makes several references to both synchronous and asynchronous operation. Since the 3497A is asynchronous, it will be discussed thoroughly. However, to compare the two, a brief description of synchronous is given first.

Synchronous

Synchronous transmission involves a continuous bit-by-bit serial stream of characters to make up a message block, with no time interval between the characters. The transmitting and receiving station clocks must be precisely synchronized with each other so that each bit time is properly marked. Synchronous operation eliminates the need for start and stop bits to frame characters. Instead, start and stop indicators frame entire message blocks. This type of transmission requires that the transmitting station have the next character ready to transmit in the first bit time following the end of the preceding character. If it isn't ready, it must fill in with some predefined sync character to ensure that the transmitting and receiving stations do not get out of step with each other.

There are a number of synchronous line protocols in use today, such as Binary Synchronous Communications (BSC) and High Level Data Link Control (HDLC) to name only a couple. Some of the synchronous protocols are quite complex.

Asynchronous

Perhaps the first thing that should be noted about this type of operation is that you don't have to be concerned about a complex line protocol. With asynchronous, the character generation is random, thereby making the arrival of an asynchronous character unpredictable. For example, the interval between characters that are typed in from a keyboard will be determined by the operator's skill. This makes it necessary to provide built in character synchronization, which is done with start and stop bits. The asynchronous character structure is shown in Figure A-3.

Characters are transmitted using two voltage levels to represent the two possible states of a binary digit as shown in the following table.

Binary States

Voltage Level	Logic State	Line State	Level Name
+3V to +25V	0	High	Space
−3V to −25V	1	Low	Mark

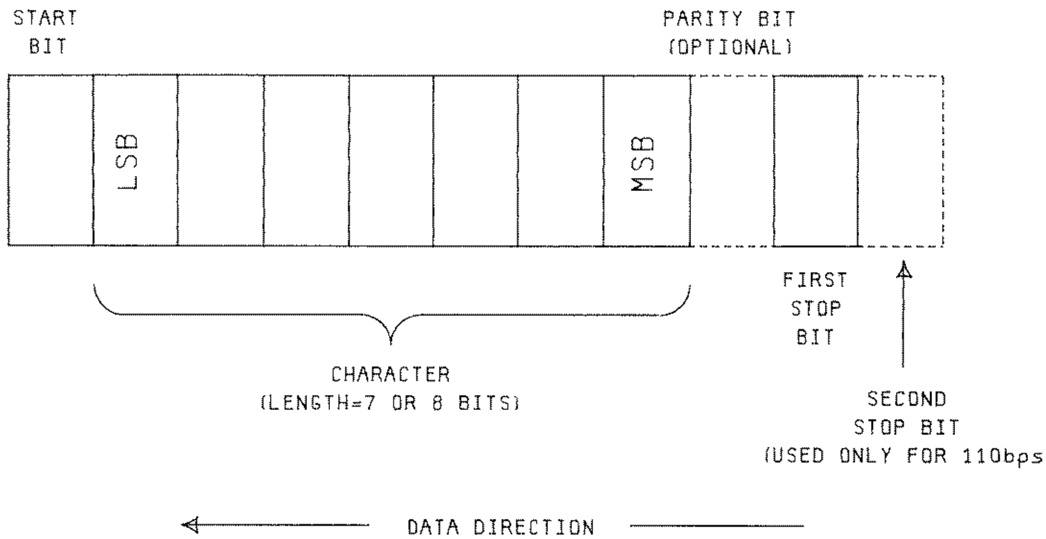


Figure A-3. Asynchronous Character Structure

When data is not being transmitted, the line is idle (low or mark). The transmitting device drives the line high (space) for one bit time when it has a character to send, hence the name start bit. The actual character is then transmitted, followed by a parity bit (optional when the 3497A is configured for 8-bit ASCII). The stop bit(s) is then sent which involves the transmitting device holding the line low (mark) for one or two bit times. The actual character transmission is shown in Figure A-4, which, in this instance, is the 7-bit ASCII representation of the letter "E". A more detailed explanation for each part of the character transmission follows Figure A-4.

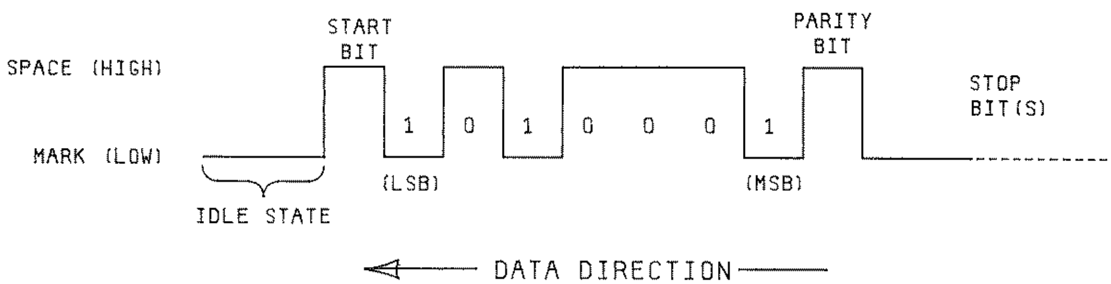


Figure A-4. Asynchronous Character Transmission

Idle State

The line is held at this low voltage level (mark) when no character is being transmitted.

Start Bit

The start bit is inserted at the beginning of the character by the transmitting device. This is done by driving the line high (space) for one bit time. The start bit signals the receiving device that a character is starting so it can turn on its internal clock and input the character.

Character Bits

The 7-bit ASCII representation of the character ''E'' is 1000101. Notice that the character itself is seven bits in length without the start, stop or parity bits. These are the bits you have to consider when you are setting up a character length specification. The 3497A can be configured for 7 or 8 bit ASCII. Also, it is important that the computer has the same character length specification as the 3497A.

Parity Bit

The parity bit provides a means of checking a received character for errors. When used, it is computed and inserted after the character bits by the transmitting device. The receiving device then does a computation on the received character bits to determine what the parity bit should be and compares that with what it received.

Parity can be specified as odd or even. Odd parity simply means that the total number of 1's contained in the character bit pattern, including the parity bit, is an odd number. For even parity, there is an even number of 1's. For example, note that the 7-bit ASCII ''E'' has three 1's, an odd number. In this instance, if odd parity is specified, the parity bit would be a 0 making the total number of 1's an odd number. For even parity, it would be a 1 making the total number of 1's an even number. The following table shows how parity bits are determined.

Parity Specification

Parity Specified	Number of ''1'' Bits In Character	Parity Bit Sent
Odd	Odd	0
Odd	Even	1
Even	Odd	1
Even	Even	0
None	Odd or Even	None

The parity bit is optional when the 3497A is configured for 8-bit ASCII. If parity isn't specified, a parity bit isn't sent and no error checking is performed. Also, the length of time it takes to send an 8-bit ASCII character with a parity bit is reduced by one bit time.

Stop Bit(s)

One stop bit is added following the parity bit for all operating speeds except 110 bps, which uses two stop bits. This involves the transmitting device allowing the line to stay idle (low) for one or two bit times. This gives the receiving device enough time to process the character before the next one is sent.

Bits and Bauds

The term ''bit'' is a contraction of binary digit. Bits are perhaps best represented by the square waves that were previously shown to transmit the ASCII ''E''. ''Baud'' refers to the speed of signal units and is the yardstick for measuring modems in bits per second (bps). If one bit is used as the signal unit, which is quite common, then baud speed and bps are the same. When two bits form the signal unit (double bit or dibit) then the baud rate is half the bps. When three bits form the signal unit (triple bit or tribit) then the baud rate is one third the bps. Most modems handle two state bits making baud and bps the same.

Modems (Data Sets)

The modem name is derived from the modulation and demodulation functions the device performs. Modems, also called data sets, are required when communication is performed over telephone lines. The 3497A can operate with asynchronous full duplex modems, and has been tested to operate with those models listed in Chapter 7.

Modulation is the process of converting the RS-232C or RS-449/423 level digital signals to analog waveforms for transmission over telephone lines. It follows then that demodulation is the process of reconverting the analog signals back to RS-232C or RS-449/423 digital signals. This is illustrated in Figure A-5.

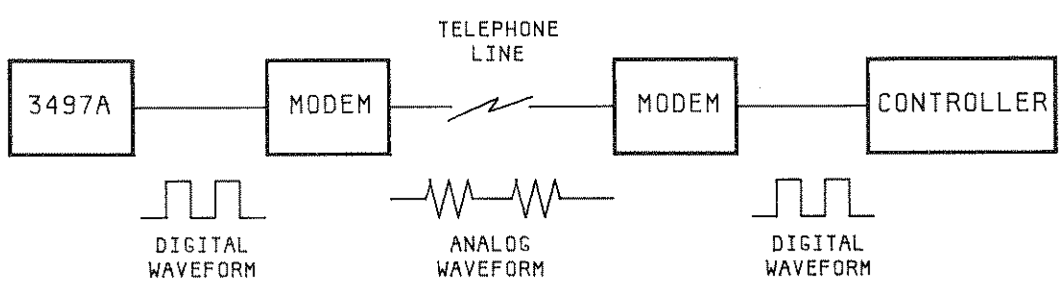


Figure A-5. Modem Functions in a System

An asynchronous modem simply means that it operates at random speeds. That is, the character generation is random and the arrival of a character is unpredictable. This is illustrated in the Figure A-6.

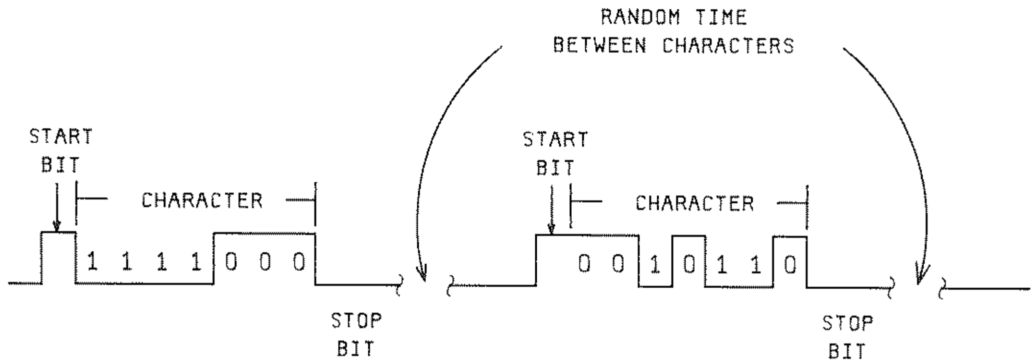


Figure A-6. Asynchronous Bit Flow

A full duplex modem is capable of transmitting and receiving data simultaneously. A half duplex modem can transmit and receive data, but it can't do both at the same time. You may wonder why full duplex operation is required in a data acquisition system since, typically, the 3497A will be instructed to perform some specified task and then transmit the results back to the computer. However, two-way simultaneous transmission is required when the 3497A sends a break. That is, when the 3497A sends a break, it may do so while the computer is still sending commands.

Echo

The 3497A does not support echo, and any computer used in the system should have this feature turned off. Where echo is supported, the receiving device transmits each character it receives back to the transmitting device. The returned character is usually then displayed on a CRT or printed on a printer, permitting a visual check to be made of the character transmission. However, characters echoed back to the 3497A will be interpreted as commands. Since they will not be understood, the 3497A will set the ''Message Not Executed'' Bit in its status register and, if enabled to do so, send a break. Another likely occurrence will be an input buffer overflow.

INTRODUCTION TO RS232C/RS449

RS232C

In 1963 the Electronic Industry Association (EIA) established a standard for the Interface between Data Terminal Equipment (DTE) and Data Communication Equipment (DCE) that use serial binary data interchange. The latest revision of this standard, which has been in effect since 1969 is known as RS232C. This standard covers the following:

- Mechanical characteristics of the interface.
- Electrical characteristics of the interface.
- A number of interchange circuits with descriptions of their functions.
- The relationship of interchange circuits to standard interface types.

The Comite Consultatif International Telephonique et Telegraphique (CCITT) has established standard that correspond to RS232C. While these standards, CCITT V.24 and CCITT V.28, are very similar to RS232C, they are not identical.

Mechanical Characteristics of RS232C Interface

The standard gives definitions to 22 pins and designates three pins as unassigned, but does not specify a 25 pin connector. Although a particular 25 pin connector is not defined, the industry has accepted the connector shown in Figure A-7 as a de facto standard. The male connector is used with Data Terminal Equipment (e.g. desktop computer) and the female connector is used with Data Communications Equipment (the modem).

The length of the cable used by Data Terminal Equipment to connect to Data Communications Equipment should not be longer than 15.24 metres (fifty feet). This is assuming that the load capacitance at the interface point is the worst case value of 2500 picofarads. Longer cables are often used, especially in point-to-point configurations when the user knows that the total load capacitance will not exceed the 2500pF maximum.

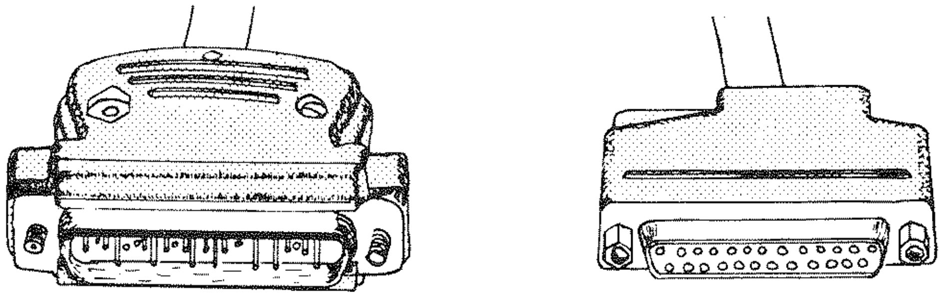


Figure A-7 25 Pin Connector

Electrical Characteristics

A number of electrical parameters and limitations are defined by RS232C for each interchange circuit. They refer to the Equivalent Interchange Circuit shown in Figure A-8.

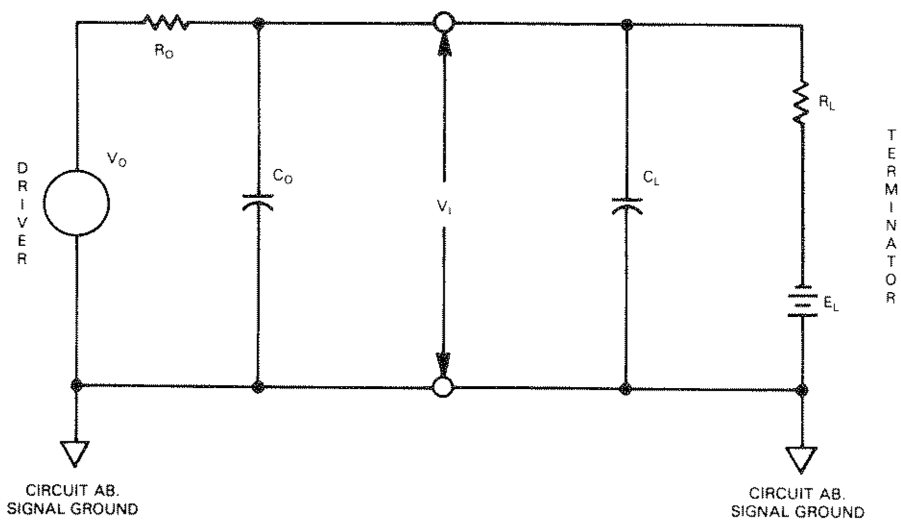


Figure A-8 Interchange Equivalent Circuit

The following electrical characteristics measurements are made at the interface point with reference to signal ground.

- Open circuit voltage from the driver shall not be greater than ±25 volts.
- The open circuit voltage of the terminator shall not exceed ±2 volts.
- The total capacitance of the terminator shall not exceed 2500 picofarads.
- The driver output voltage must be between 5 and 15 volts when the total terminator input resistance is between 3000 Ω and 7000 Ω.
- The output impedance of the driver circuit, when the driver power is off, shall not exceed 300 Ω.
- The rate of change of the driver output voltage (slew rate) shall not exceed 30 volts per microsecond.

In addition, the following rules define the logic state indicated by the voltage levels of the circuit (see Figure A-9).

- A logical "1" (MARK) is indicated when the voltage at the interface point is more negative than −3 volts.
- A logical "0" (SPACE) is indicated when the voltage at the interface point is more positive than +3 volts.
- To indicate a "1" signal condition (MARK), the driver shall assert a voltage between −5 volts and −15 volts.
- To indicate a "0" signal condition (SPACE), the driver shall assert a voltage between +5 volts and +15 volts.

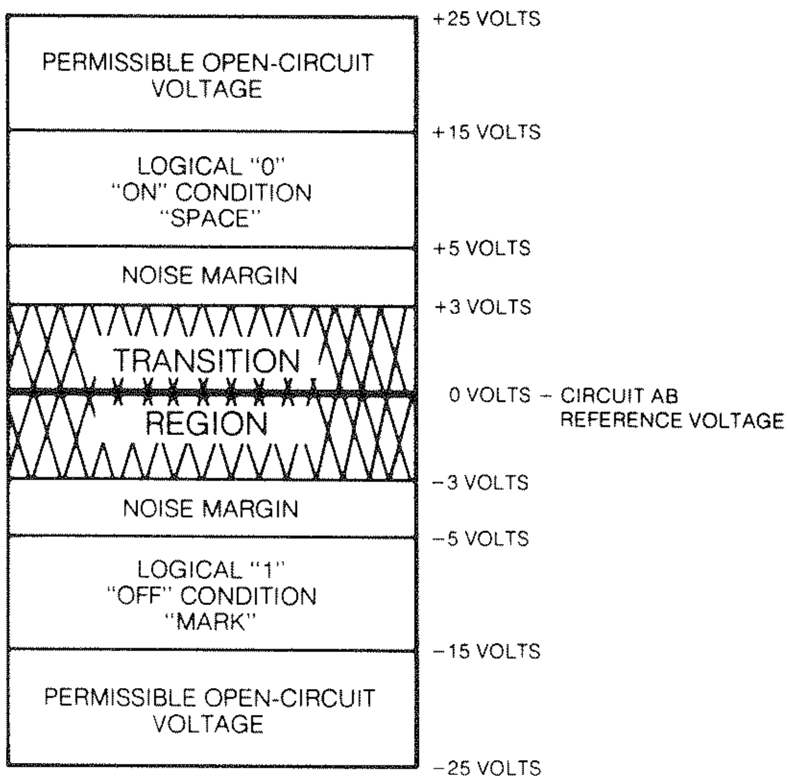


Figure A-9. Circuit Voltage Levels

Note that these standards allow for a 2 volt noise margin between the minimum driver voltage of 5 volts and the maximum undefined voltage of 3 volts. The following specifications govern the transition region.

- All interchange signals entering the transition region shall proceed to the opposite valid signal state. It shall not re-enter the transition region until the next significant change in signal state.
- While in the transition region, the direction of the voltage change must not reverse.

- The time required for a control signal to cross the transition region shall not exceed one millisecond.
- The time required for a data or timing signal to cross the transition region shall not exceed one millisecond or four percent of the nominal signal period, whichever is the lesser.

The following table gives a description and a circuit reference for all of the assigned pins for the industry accepted connector (see Figure A-7).

RS232C Pin Identification

	Circuit Reference		
Pin	RS232C	CCITT	Description
1	AA	101	EARTH or Frame Ground
2	BA	103	Transmitted Data
3	BB	104	Received Data
4	CA	105	Request to Send
5	CB	106	Clear to Send
6	CC	107	Data Set Ready
7	AB	102	Signal Ground
8	CF	109	Received Line Signal Detector
9	+P		Positive DC Test Voltage
10	−P		Negative DC Test Voltage
11			Unassigned
12	SCF	122	Secondary Received Line Detector
13	SCB	121	Secondary Clear to Send
14	SBA	118	Secondary Transmitted Data
15	DB	114	Transmitter Clock
16	SBB	119	Secondary Received Data
17	DD	115	Received Clock
18			Unassigned
19	SCA	120	Secondary Request to Send
20	CD	108/2	Data Terminal Ready
21	CG	110	Signal Quality Detector
22	CE	125	Ring Indicator
23	CH/CI	112,111	Data Rate Selector
24	DA	113	External Transmitter Clock
25			Unassigned

Interchange Circuit Functions

There are four categories of interchange circuits: Ground, Timing, Data, and Control. With the exception of the grounds, they can originate either in the modem (Data Communications Equipment, or DCE) or in the computer (Data Terminal Equipment, or DTE).

Ground Circuits

Circuit AA (CCITT 101)

Protective Ground: Electrically connected to the frame of the equipment and to earth ground as external regulations demand.

Circuit AB (CCITT 102)

Signal Ground: The zero-voltage reference point. Also acts as the common return for unbalanced interchange circuits.

Timing Circuits

The clock generated by the Data Terminal Equipment:

Circuit DA (CCITT 113)

Transmitter Signal Element Timing: Provides timing for the transmitted data on Circuit BA (CCITT 103). A transition from ON to OFF (positive to negative) indicates the approximate center of each signal element.

The clocks generated by Data Communications Equipment:

Circuit DB (CCITT 114)

Transmitter Signal Element Timing: Provides DTE with a timing signal to be used with the transmitted data on Circuit BA (CCITT 103). A transition from OFF to ON (negative to positive) indicates the transition between signal elements.

Circuit DD (CCITT 115)

Receiver Signal Element Timing: Provides timing for the received data on Circuit BB (CCITT 104). The transition from ON to OFF (positive to negative) indicates the approximate center of each signal element.

Data Circuits

There are four Data Circuits, a primary circuit and a secondary circuit in each direction. Each is named in reference to the Data Terminal Equipment. For example, Received Data is driven by the DCE, and Transmitted Data is driven by the DTE.

Data circuits from the Data Terminal Equipment:

Circuit BA (CCITT 103)

Transmitted Data: The primary circuit for data originating at the DTE. Timing for data on this circuit can be provided either by circuit DA or DB.

Circuit SBA (CCITT 118)

Secondary Transmitted Data: The circuit for data originating at the DTE and transmitted via the secondary channel.

Data circuits from the Data Communications Equipment:

Circuit BB (CCITT 104)

Received Data: The circuit for data signals which have been generated by the DCE in response to signals received on the primary data channel. If necessary, timing for data on this circuit can be provided by circuit DD (CCITT 115).

Circuit SBB (CCITT 119)

Secondary Received Data: The circuit for data signals which have been generated by the DCE in response to signals received on the secondary data channel.

Control Circuits

These circuits are used to indicate to the receiving device the status or condition of the driving device.

Control circuits from the Data Terminal Equipment:

Circuit CA (CCITT 105)

Request to Send: Used to indicate to the DCE that data is ready to be sent, and also to control the direction of data transmission on a half duplex channel.

Circuit CD (CCITT 108.2)

Data Terminal Ready: Used to control the switching of the DCE to the communication channel. This means that it allows the modem to enter the data mode in preparation for data transfer, as compared to the standby mode.

Circuit CH (CCITT 111)

Data Signal Rate Selector: Used to select between two data signalling rates when using dual rate synchronous modems. Also used to select between two ranges when using dual range asynchronous modems. Use of this circuit is not compatible with Circuit CI (CCITT 112) which performs a similar function, but is driven by the DCE.

Circuit SCA (CCITT 120)

Secondary Request to Send: Functionally similar to Circuit CA (CCITT 105) except that is requests establishment of the secondary data channel.

Control circuits from the Data Communications Equipment:

Circuit CB (CCITT 106)

Clear to Send: Indicates whether the data set is conditioned to transmit on the data channel or not.

Circuit CC (CCITT 107)

Data Set Ready: Indicates the status of the data set. It indicates only that the DCE is connected to the line, is in the data mode, and is ready to exchange further control signals with the DTE.

Circuit CE (CCITT 125)

Ring Indicator: Indicates that a calling signal is being received on the data channel.

Circuit CF (CCITT 109)

Received Line Signal Detector: Indicates that the signal received on the data channel is within specifications set by the DCE manufacturer and is therefore suitable for demodulation.

Circuit CG (CCITT 110)

Signal Quality Detector: Indicates whether there is a probability of an error in the received data.

Circuit CI (CCITT 112)

Data Signal Rate Selector: Used to select between two data signalling rates in the DTE so that it coincides with the rate used in a dual rate synchronous DCE. Also used to select between two ranges of rates in the DTE so that it coincides with the range of rates used in a dual range asynchronous DCE.

Circuit SCB (CCITT 121)

Secondary Clear to Send: Functionally similar to Circuit CB (CCITT 106) except that it indicates the availability of the secondary channel.

Circuit SCF (CCITT 122)

Secondary Received Line Signal Detector: Functionally similar to Circuit CF (CCITT 109) except that it indicates the suitability of the signal received on the secondary data channel.

RS449

In 1977 EIA adopted the RS449 serial-interface standard. RS449 is a more capable standard than RS232C and when RS449 is implemented with an RS423 electrical subset, it is interoperable with RS232C. The European equivalency for this new standard is CCITT V.10.

RS449 provides additional interchange circuits, reduces crosstalk between interchange circuits, and allows higher signaling rates and greater distances between equipments. RS449 will gradually replace RS232C.

RS449 has a new set of mnemonics that are more descriptive and logical than those for RS232C. Like RS232C, RS449 references the digital side of the modem rather than the analog side. Three RS232C pin designations (pins 1, 9, and 10) are not included in RS449. The following 10 circuit functions were added that have no RS232C equivalent:

LL—local loopback
RL—remote loopback
TM—test mode
SS—select standby
SB—standby indicator
IS—terminal in service
NS—new signal
SF—select frequency
SC—send common
RC—receive common

The following table lists the pin numbers and definitions for the 37-pin primary connector used with RS449. (Both primary and secondary channels are listed) and shows the relationships between RS449 and RS232C.

RS449/232C Relationships

RS449 And RS232C Equivalent Functions				EIA RS232C		
RS449		RS232C		Pin	Circuit	Description
SG	=	AB		1	AA	Protective Ground
IC	=	CE		2	BA	Transmitted Data
TR	=	CD		3	BB	Received Data
DM	=	CC		4	CA	Request to Send
SD	=	BA		5	CB	Clear to Send
RD	=	BB		6	CC	Data Set Ready
TT	=	DA		7	AB	Signal Ground
ST	=	DB		8	CF	Rec Line Sig Det
RT	=	DD		9	—	(Data Set Testing)
RS	=	CA		10	—	(Data Set Testing)
CS	=	CB		11	—	Unassigned (QM-209)
RR	=	CF		12	SCF	Sec Rec Line Sig Det
SQ	=	CG		13	SCB	Sec CTS
SR	=	CH		14	SBA	Sec Tran Data
SI	=	CI		15	DB	Trans Sig Timing (DCE)
				16	SBB	Sec Rec Data (DCT-209)
SSD	=	SBA	Secondary Circuits	17	DD	Rec Sig Timing (DCE)
SRD	=	SBB		18	—	Unassigned (DCR-209)
SRS	=	SCA		19	SCA	Sec RTS
SCS	=	SCB		20	CD	Data Term Rdy
SRR	=	SCF		21	CG	Sig Qual Det
				22	CE	Ring Indicator
SC,RC,IS,NS,SF,LL,RL, TM,SS, and SB have no RS232C equivalents.				23	CH/CI	Data Rate Sel (DTE/DCE)
				24	DA	Trans Sig Timing (DTE)
				25	—	Unassigned (CR-202T)

RS449 Pin Identification

Pin No.	Mnemonic		Function
1		—	Shield
2		SI	Signaling-Rate Indicator
3		—	Spare
4		SD	Send Data
5		ST	Send Timing
6		RD	Receive Data
7		RS	Request to Send
8		RT	Receive Timing
9		CS	Clear to Send
10		LL	Local Loopback
11		DM	Data Mode
12		TR	Terminal Ready
13		RR	Receiver Ready
14		RL	Remote Loopback
15		IC	Incoming Call
16	Dual-Function Pin	SF	Select Frequency
		SR	Signaling-Rate Selector
17		TT	Terminal Timing
18		TM	Test Mode
19		SG	Signal Ground
20		RC	Receive Common
21		—	Spare
22		Same as 4	Secondary
23		Same as 5	Secondary
24		Same as 6	Secondary
25		Same as 7	Secondary
26		Same as 8	Secondary
27		Same as 9	Secondary
28		IS	Terminal in Service
29		Same as 11	Secondary
30		Same as 12	Secondary
31		Same as 13	Secondary
32		SS	Select Standby
33		SQ	Signal Quality
34		NS	New Signal
35		Same as 17	Secondary
36		SB	Standby Indicated
37		SC	Send Common

Appendix B
SPECIFICATIONS AND GENERAL INFORMATION

This appendix provides 3497A/3498A specifications and general information. SPECIFICATIONS shows overall system specifications for the 3497A and the 3498A Extender and for the 3497A options (Options 001 through 140). GENERAL INFORMATION provides warranty information, shows how to obtain repair service, gives shipping guidelines and includes manual information.

SPECIFICATIONS

Specifications for the 3497A/3498A and plug-in assemblies are performance characteristics of the instruments which are certified. These specifications are the performance standards or limits against which the instrument is tested.

Also included are some supplemental characteristics of the 3497A. These should be considered as additional and general information. Because of the many operational capabilities of the 3497A, exercise care when checking the instrument's specifications.

Any changes in specifications due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a MANUAL CHANGE supplement.

SPECIFICATIONS TABLES

SYSTEM ACCURACY SPECIFICATIONS

These system specifications combine individual accuracy specifications to result in a total measurement accuracy specification. For example, the resistance specifications combine the DVM, current source and acquisition assembly error terms.

Voltage Measured Through Acquisition Assembly

3497A Configuration:
DVM: 5½ digit, auto zero on
Relays Switches: Tree Switched

Accuracy: ±(% of reading + number of counts)

90 Days 23°C ± 5°C

Voltmeter Range	Digits Displayed 5½ digits	4½ digits	3½ digits
0.1V	0.007 + 5	0.01 + 2	0.1 + 1
1.0V	0.006 + 1	0.01 + 1	0.1 + 1
10.0V	0.006 + 1	0.01 + 1	0.1 + 1
100.0V	0.006 + 1	0.01 + 1	0.1 + 1

Resistance Measured Through an Acquisition Assembly

3497A Configuration:
DVM: 5½ digit, auto zero on
Current Source: As indicated
Relay Switches: Configured for a 4-terminal resistance measurement

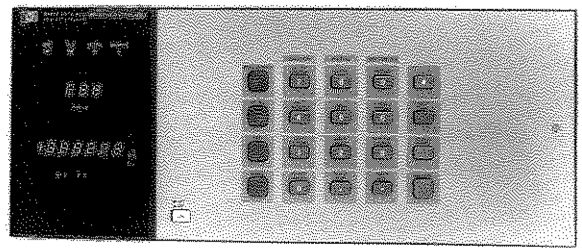
Characteristics

Effective Resistance Range	Effective Resistance Resolution	Current Source Range	Range
100 Ω	1 mΩ	1 mA	.100000
1 kΩ	10 mΩ	100 μA	1.00000
10 kΩ	100 mΩ	100 μA	10.0000
100 kΩ	1 Ω	10 μA	10.0000

Accuracy: ±(% of reading + number of counts)

90 Days 23°C ± 5°C

Range Relays (Opt. 010)	Digits Displayed 5½ digits	4½ digits	3½ digits
100 Ω	.032 + 5	.035 + 2	0.125 + 1
1 kΩ	.032 + 5	.035 + 2	0.125 + 1
10 kΩ	.032 + 5	.035 + 2	0.125 + 1
100 kΩ	.031 + 2	.035 + 2	0.125 + 1



System Noise Rejection

Normal Mode Rejection (NMR): (50 or 60 Hz + .09%)

DVM Digits Displayed	Rejection
5½	60 dB
4½	0 dB
3½	0 dB

NMR is a function of the 3497A DVM configuration only and is not affected by the number of channels in the system.

Effective Common Mode Rejection (ECMR): The ECMR of a 3497A based system is a combination of the ECMR of the 3497A DVM and the effects of adding multiplexer assemblies and 3498A extenders.

ECMR: 1(kΩ imbalance in low lead, using tree switching, ac at 50 or 60 Hz, 25°C, <85% R.H.)

Voltmeter Configuration

Number of Acquisition Channels (Options 10,20)		5½ digits	4½ digits	3½ digits
0	AC	150 dB	90 dB	90 dB
	DC	120 dB	120 dB	120 dB
<100	AC	150 dB	90 dB	90 dB
	DC	104 dB	104 dB	104 dB
<400	AC	140 dB	80 dB	80 dB
	DC	92 dB	92 dB	92 dB
<1000	AC	130 dB	70 dB	70 dB
	DC	85 dB	85 dB	85 dB

Measurement Speeds

For the 3497A DVM and the relay multiplexer. Speeds are given for measurements on random channels (using software channel selection) and sequential channels (using external hardware increment). Speeds include I/O times to the indicated computers.

	Number of Digits Selected	Computer 85	9826*	1000L	1000E,F
Sequential Channels using external increment	5½ digits	39(33)**	39	39(25)	30(25)
	4½ digits	97(88)	103	108(79)	88(79)
	3½ digits	112(107)	123	127(99)	107(99)
Random Channels using software	5½ digits	13(15)	27	21(16)	22(16)
	4½ digits	14(21)	51	31(28)	35(30)
	3½ digits	14(23)	55	33(29)	35(32)

*9826 speeds for BASIC operating system
**50 Hz speeds in ( )

TIMER/REAL TIME CLOCK

Clock Format

Month:Day:Hours:Minutes:Seconds (Option 230)
Day:Month:Hours:Minutes:Seconds (Option 231)

	Maximum Time	Resolution	Accuracy	Output
Real Time Mode	1 year	1 second	±(.005% of time + .1s)	Display and HP-IB
Elapsed Time Mode	10^6 seconds	1 second	±(.005% of time + .1s)	Display and HP-IB
Time Alarm Mode	24 hours	1 second	±(.005% of time + .1s)	HP-IB SRQ
Time Interval Mode	24 hours	1 second	±(.005% of time + .1s)	50 μS TTL Pulse + HP-IB SRQ
Time Output Mode	1 second	100 μS	±(.02% of time)	16 μS TTL Pulse
Power Failure Protection: Battery back-up for >24 hours for time and elapsed time only				

3497A MAINFRAME AUXILIARY INPUTS/OUTPUTS

Ext Trig. Input: TTL Compatible
Minimum pulse width: 50 n seconds

Ext Incr. Input: TTL Compatible
Minimum pulse width: 50 μ seconds

BBM Sync: TTL Compatible
This terminal serves as a break before make synchronizing signal to the 3497A and other equipment. The terminal is both an input and output with a low level indicating a channel is closed. The 3497A will not close any additional channels until the line is sensed high and the line will float high when all channels are open.

VM Complete Output: TTL Compatible
Pulse width = 500 n seconds

Channel Closed Output: TTL Compatible
Pulse width = 500 n seconds

Timer Interval Output: TTL Compatible
Output port for the time interval and time output functions.

Physical Parameters

Size (3497A or 3498A): 190.5 mm (7½ in.) high
428.6 mm (16 7/8 in.) wide
520.7 mm (20½ in.) deep
An additional two inches in depth should be allowed for wiring.

Net Weight:

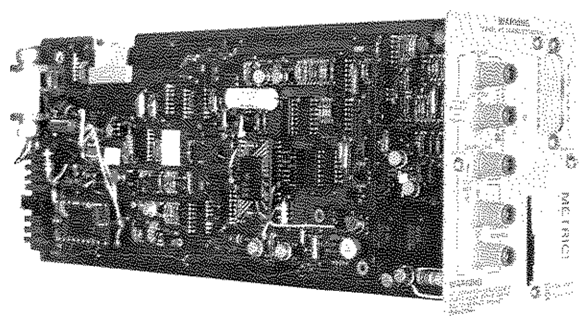
	3497A	3498A
Maximum (with assemblies in all slots)	20.4 kg (45 lbs.)	20.4 kg (45 lbs.)

Shipping Weight:

	3497A	3498A
Maximum (with assemblies in all slots)	26.3 kg (58 lbs.)	26.3 kg (58 lbs.)

Environmental (3497A or 3498A):
Warm Up time: 1 hour
Operating Temperature 0°C to 55°C
Non-operating Temperature: -40°C to 75°C
Humidity: to 95% at 40°C except as noted
Shock: 30 G, 11 Millisec. sine wave on each of six sides
Vibration: 10 Z to 55 Hz at .010 inch peak to peak excursion
Operating Power: switch selection of 110 volts, 120 volts, 220 volts, 240 volts, ±10%, 48-66 Hz, 150 VA 3497A, 150 VA 3498A

OPTION 001
5½ DIGIT DVM AND CURRENT SOURCE



Voltmeter Ranges/Resolution

Range	Maximum Display	5½ Digit Resolution	4½ Digit Resolution	3½ Digit Resolution	Max. Input Voltage
.10V	±.119999	1 μV	10 μV	100 μV	
1.0V	±1.19999	10 μV	100 μV	1 mV	120V peak
10.0V	±11.9999	100 μV	1 mV	10 mV	
100.0V	±119.999	1 mV	10 mV	100 mV	

Voltmeter Measurement Accuracy
± (% of reading + Number of Counts)
(Auto Zero On)

24 Hours: 23°C ± 1°C

	Digits Displayed		
Range	5½ Digits	4½ Digits	3½ Digits
.10V	.003 + 3	.01 + 1	.1 + 1
1.00V	.002 + 1	.01 + 1	.1 + 1
10.00V	.002 + 1	.01 + 1	.1 + 1
100.00V	.002 + 1	.01 + 1	.1 + 1

90 Days: 23°C ± 5°C

	Digits Displayed		
Range	5½ Digits	4½ Digits	3½ Digits
.10V	.007 + 3	.01 + 1	.1 + 1
1.00V	.006 + 1	.01 + 1	.1 + 1
10.00V	.006 + 1	.01 + 1	.1 + 1
100.00V	.006 + 1	.01 + 1	.1 + 1

1 Year: 23°C ± 5°C

	Digits Displayed		
Range	5½ Digits	4½ Digits	3½ Digits
.1V	0.015 + 3	0.02 + 1	0.1 + 1
1.0V	0.015 + 1	0.02 + 1	0.1 + 1
10.0V	0.015 + 1	0.02 + 1	0.1 + 1
100.0V	0.015 + 1	0.02 + 1	0.1 + 1

Auto Zero Off[1]: Additional Error if Auto Zero is turned off in a thermally stable environment (temperature deviations less than ± 1°C, up to 24 hours)

Range	Additional Error
.10V	10 counts
1.00V	1 count
10.0V	1 count
100.00V	1 count

Temperature Coefficient[1]: ±(% Reading + Number of Counts)/°C; 0-18°C, 28-55°C

Range	
.10V	.00025 + .15
1.00V	.00020 + .02
10.00V	.00020 + .01
100.00V	.00025 + .03

[1]Valid for 5½ digit operation. Multiply counts by .1 for 4½ digit operation. Multiply counts by .01 for 3½ digit operation.

Noise Rejection

NMR = NORMAL MODE REJECTION (50 or 60 Hz. ± .09%)
ECMR = EFFECTIVE COMMON MODE REJECTION (1 kΩ unbalance, low lead)

Rejection	Digits Displayed (Integration Period in Cycles[1]) 5½ Digits (1 cycle)	4½ Digits (.1 cycle)	3½ Digits (.01 cycle)
AC NMR (dB) (50 or 60 Hz)	60	0	0
AC ECMR (dB) (50 or 60 Hz)	150	90	90
DC ECMR (dB)	120	120	120

[1]Integration Period in line cycles
1 cycle = 16.7 ms for 60 Hz operation
1 cycle = 20 ms for 50 Hz operation

Input Impedance

Hi to Low (in parallel with 120 pF at 1 MHz)	25°C, <85% R.H. 40°C, <60% R.H.	40°C, <95% R.H.
.1V to 10V Range	$>10^{10}\Omega$	$>10^{9}\Omega$
100V Range	10MΩ ± .5%	10MΩ ± .5%

Maximum Input Voltage

High to Low: 120 V peak
Low to Guard: 170 V peak
Guard to Chassis: 170 V peak

Current Source

Range	Accuracy 24 Hours 23°C±1°C	90 Days 23°C±5°C	1 Year 23°C±5°C	Temperature Coefficient (per °C; 0°C−18°C; 28°C−55°C)
10 μA	1.25 nA	2.5 nA	3.2 nA	.25 nA
100 μA	12.5 nA	25.0 nA	32.0 nA	2.5 nA
1 mA	125 nA	250 nA	320 nA	25.0 nA

Compliance: > + 15 volts
Isolation Voltage: 170 volts peak
Output Resistance: $>10^{10}\Omega$

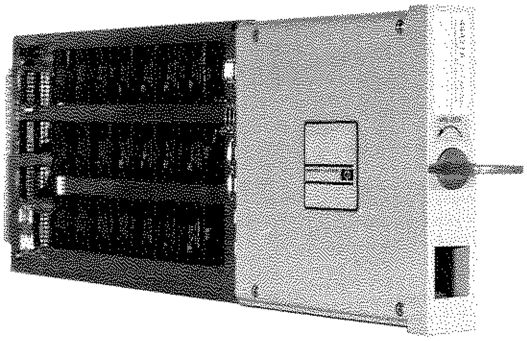
General Information

Maximum Reading Rate: (readings/second)

Auto Zero	60 Hz Operation Digits Displayed 5½	4½	3½	50 Hz Operation Digits Displayed 5½	4½	3½
ON	25	100	150	20	83	125
OFF	50	200	300	40	166	250

Delay: 0 to 99.9999 sec. in 100 μsec. steps
Buffer size: Packed Format: 100 Readings
ASCII Format: 60 Readings
Number of readings per Trigger: 1 to 999

OPTION 010
20 CHANNEL RELAY MULTIPLEXER ASSEMBLY



Input Characteristics

Maximum Input Voltage: <170V peak between any two input terminals

Maximum Current: 50 mA per channel non-inductive

Maximum Power: 1 VA per channel

Thermal Offset: Direct Switched: < 1μV Differential
Tree Switched: <2 μV Differential

Closed Channel Resistasnce:
In Series: 100 Ω ± 10% in High, Lo and Guard Relays
Contacts Only: <1 Ω per contact

Open Channel Isolation:

			25°C, <85% R.H. 40°C, <60% R.H.	40°C, >95% R.H.
Hi to Lo	Option 010		$>10^{10}\Omega$	$>10^{9}\Omega$
	Option 020	Open	$<10^{10}\Omega$	$>10^{9}\Omega$
		Closed	$>10^{8}\Omega$	$>10^{7}\Omega$
Lo to Guard			$<10^{8}\Omega$	$>10^{7}\Omega$
Guard to Chassis			$>10^{10}\Omega$	$>10^{9}\Omega$

Operating Characteristics

Maximum Switch Rate: Random Channels;
Using Hardware Increments: 475/second

Rated Switch Life at 1 VA: 10^7 operations

All Relays are Break Before Make

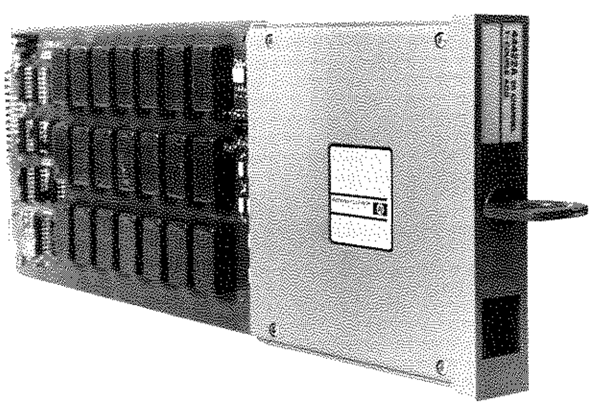
AC Performance

High to Low Capacitance: Channel Open: < 10 pF/per channel
Channel Closed: <220 pF/per channel

Interchannel Capacitance: < 10 pF

	100 kHz	1 MHz
Frequency Response (1 MΩ Termination, 10 kHz Reference)	± .3 dB	±.5 dB
Cross Talk		
Channel to Common		
50 Ohm Termination	−70 dB	−50 dB
1M Ohm Termination	−50 dB	−40 dB
Channel to Channel		
50 Ohm Termination	−60 dB	−40 dB
1M Ohm Termination	−40 dB	−30 dB

OPTION 020
RELAY MULTIPLEXER ASSEMBLY WITH THERMOCOUPLE COMPENSATION



Reference Junction Compensation Comparison

	Compensation Type: Software	Compensation Type: Hardware
Compatible Thermocouples	Any Mixture	One of the Following Types: B,E,J,K,R,S,T
Measurement Channels Available per Assembly	19	20
Reference Junction Compensation Accuracy (23°C ± 5°C)	.1°C	

Valid for thermocouple compensation only. The total accuracy of 3497A based temperature measurement systems including compensation accuracy, 3497A scanner offsets. DVM accuracy and software accuracy is shown below.

Temperature Coefficient (0°C → 18°C, 28°C → 55°C)	.009°C/°C	
Stability	.075°C/1000 Hours	
Temperature Difference Across Isothermal Block:	< .2°C	
Software Compensation Output: (Channel B9)	100mV/0C 2.5V@25°C	
Additional In Series Resistance: (Hardware Compensasation only).		10Ω

Temperature Measurement Accuracy

For a 3497A based temperature measurement system. Includes all errors introduced by the 3497A and the HP 3054A/C Data Acquisition/Control System Software.

Input Characteristics

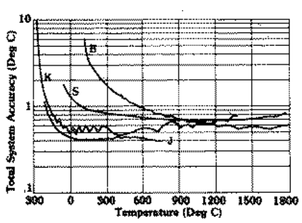
Maximum Input Voltage: < 170 V peak between any two input terminals

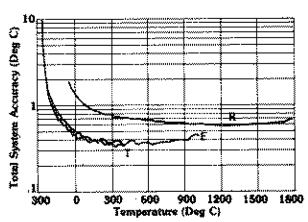
Maximum Current: 50 mA per channel non-inductive

Maximum Power: 1 VA per channel

Thermal Offset: Direct Switched: < 1 μV Differential
Tree Switched: < 2 μV Differential

Closed Channel Resistance:
In Series: 100 Ω ± 10% in High, Lo and Guard
Relays Contacts Only: < 1 Ω per contact





Open Channel Isolation:

			25°C, <85% R.H. 40°C, <60% R.H.	40°C, >95% R.H.
Hi to Lo	Option 010		>10^{10}Ω	>10^{9}Ω
	Option 020	Open	<10^{10}Ω	>10^{9}Ω
		Closed	>10^{8} Ω	>10^{7}Ω
Lo to Guard			<10^{8} Ω	>10^{7}Ω
Guard to Chassis			>10^{10}Ω	>10^{9}Ω

Operating Characteristics

Maximum Switch Rate: Random Channels;
Using Hardware Increments: 475/second

Rated Switch Life at 1 VA: 10^7 operations

All Relays are Break Before Make

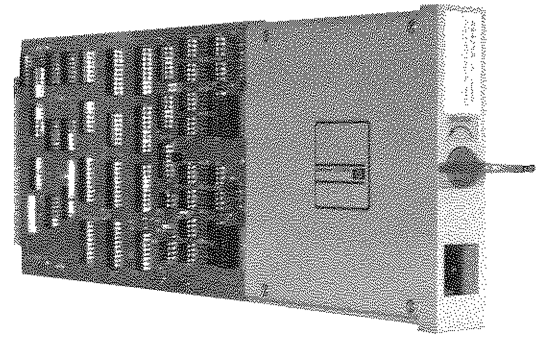
AC Performance

High to Low Capacitance: Channel Open: < 10 pF/per channel
Channel Closed: <220 pF/per channel

Interchannel Capacitance: < 10 pF

	100 kHz	1 MHz
Frequency Response (1 MΩ Termination, 10 kHz Reference)	± .3 dB	±.5 dB
Cross Talk		
Channel to Common		
50 Ohm Termination	−70 dB	−50 dB
1M Ohm Termination	−50 dB	−40 dB
Channel to Channel		
50 Ohm Termination	−60 dB	−40 dB
1M Ohm Termination	−40 dB	−30 dB

OPTION 050
16 CHANNEL ISOLATED DIGITAL INPUT/INTERRUPT ASSEMBLY



Input Signal Characteristics

Input Level	V_{LO}(max.)	V_{HI}(min.)	Max. Input Voltage	Min. Input Current
5V	0.8V	2.4V	30V	400 μA
12V	3.0V	7.0V	42V	1 mA
24V	6.0V	13.0V	42V	2 mA

(5 volt level is standard, 12 and 24 volt levels are jumper selectable. Other voltage levels can be accepted using customer supplied resistors).

Maximum Isolation Voltage: < 170V peak between any input terminal and ground.

Digital Input Mode (Bits 0-15)

Logic Polarity: Positive True
(Negative True is jumper selectable)

Handshaking: Gate and Flag Lines are optically isolated. Gate output is open collector. Flag input is identical to input lines. Polarity of gate/flag is jumper selectable. The assembly may be configured to operate with no handshaking.

Interrupt Mode (Bits 0-7)

Minimum Pulse Width: 100 microseconds

Triggering: Each interrupt line is individually programmable for positive or negative edge triggering.

Masking: Each interupt line may be enabled or disabled using a programmable mask.

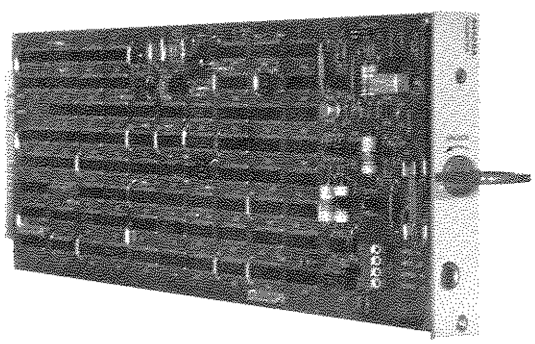
Multiple Interrupts: Multiple interrupts are latched and are dealt with at a computer dependent rate.

Interrupt Timing: The Option 050 assembly will respond to an interrupt within 1 millisecond of a programmed interrupt condition change.

Five Volt Supply: Source up to 20 mA per assembly.

Operating Consideration: Digital Interrupt (SRQ) is not available in the 3498A Extender.

OPTION 060
100 kHz RECIPROCAL COUNTER ASSEMBLY



Input Signal Characteristics:

Input Levels:

Input Level Range	V(Lo) (maximum) Isolated	V(Lo) (maximum) Non-iso	V(Hi) (minimum) Isolated	V(Hi) (minimum) Non-iso	Max Input Voltage
5V	1.0V	1.0V	4.2V	4.2V	±12.0V
12V	1.8V	2.7V	10.3V	8.0V	±21.0V
24V	2.6V	6.0V	18.4V	16.5V	±32.0V

Input Circuit: Switch selection of optically isolated or non-isolated input. Non-isolated input has 19.5 kΩ minimum input impedance. Non-isolated mode is standard.

Minimum Current:
Isolated: (all ranges) 8 mA
Non-isolated: 5V range: 30 μA
12V range: 250 μA
24V range: 750 μA

Input Fuse: 125 mA

Maximum Isolation Voltage: 170 V peak between any terminal and ground. Frequency ≤ 60 Hz.

Period Mode:

Input Signal Characteristics:
Maximum Input Frequency: 100 kHz
Minimum On Time: 5 μs
Minimum Off Time: 5 μs

Range Charactristics:

Range	Least Significant Digit (LSD) HP-IB	Least Significant Digit (LSD) Display	Periods Averaged
9999.999 s	1 ms	10 ms	1
99.99999 s	10 μs	100 μs	1
0.9999999 s	100 ns	1 μs	100
.09999999 s	10 ns	1 μs	1000

Accuracy: ±(.01% of reading + 2 LSDs + Trigger Error)

Trigger Error: Maximum Transition Time for input voltage to go from V(Lo) to V(Hi) or V(Hi) to V(Lo)

Pulse Width:

Input Signal Characteristics:
Minimum Start to Stop Time (Pulse Width): 18 μs
Minimum Stop to Start Time: 18 μs

Range Characteristics:

Range	Least Significant Digit (LSD) HP-IB	Least Significant Digit (LSD) Display	Periods Averaged
9999.999 s	1 ms	10 ms	1
99.99999 s	10 μs	100 μs	1
0.9999999 s	1 μs	1 μs	100
.099999 s	1 μs	1 μs	1000

Accuracy: ±(.01% of reading + Trigger Error + 2 LSDs or 18 μs, whichever is greater)

Trigger Error: Maximum Transition Time for input voltage to go from V(Lo) to V(Hi) + V(Hi) to V(Lo)

Totalize/Down Count Mode:

Input Signal Characteristics:
Maximum Input Frequency: 100 kHz
Minimum Pulse Width: 5 μs

Range: 0 to 999,999

Preset Value Range: 0 to 999,999

General Information

Level Change Output: Level change occurs on measurement complete, overflow and zero count (down count mode only).
Output Circuit: Open Collector
Isolated mode is standard; non-isolated is jumper selectable. Interrupt mode is standard; square wave output is jumper selectable. Negative true logic is standard; positive true is jumper selectable.
Maximum Current: 1.6 mA
Maximum Voltage: 12 volts
Maximum Low Level Voltage: .65 V at 1.6 mA

Square Wave Output Operation: The output line can be configured to act as a square wave output with a frequency equal to ½ of the counter input signal. When used in the count down function with the counter input connected to the 3497A Timer output (or other external source), the counter output line can be used to output a programmable number of square wave pulses. This feature may be useful in driving devices controlled by square wave pulse trains like stepper motor controllers.
Maximum Input Frequency: 2 kHz
Maximum Output Frequency: 1 kHz (½ of input frequency)
Output Range: 0-499,999 pulses programmable

+ 5 Volt Supply: Jumper selectable to sense contact closures and open collector outputs on the non-isolated input. May also be used to supply open collector level change output. Connected through supplied pull up resistors.

Operating consideration: Digital Interrupt (SRQ) is not available in the 3498A Extender.

OPTION 070/071
120/350 OHM, STRAIN GAUGE/BRIDGE COMPLETION ASSEMBLIES

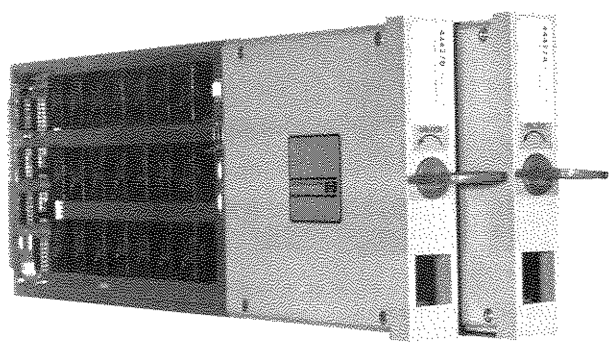
No Manual Adjustments
The assembly is used with an external supply and either the 3497A voltmeter or an external 3456A voltmeter. The initial voltmeter readings for bridge excitation and bridge unbalance are used by the system computer to solve the bridge equation, eliminating the need for any span and offset adjustments. To compute strain, this assembly must be used in conjunction with a system computer.

Bridge Excitation
The excitation voltage V_S is always applied, never switched, so there are no errors due to the dynamic heating and cooling of the gauge. Since the excitation voltage is measured on each strain gauge/bridge card, the strain accuracy is independent of long-term supply voltage changes. An inexpensive power supply, such as the HP 6214A, is adequate to achieve the accuracy specification shown. It also has enough current capability to provide power for up to 50 channels (5 cards).

Excitation Supply Requirements:
(½ bridge configuration)
V_S max: ±5.4 volts DC
I_S: 250 mA per 10 channels (120 ohm gauges)
80 mA per 10 channels (350 ohm gauges)

General Information:

Isolation Voltage: ≥ 170 V peak between any terminal and chassis



Sensitivity vs. Supply Voltage

Bridge Type	V_S = 100 mV	V_S = 1 volt	V_S = 5 volts
Full	0.5 με	0.05 με	0.01 με
½	1 με	0.1 με	0.02 με
¼	2 με	0.2 με	0.04 με

(GF = 2, System Voltmeter = 3456A. For 3497A Voltmeter, multiply numbers by 10).

Accuracy
These specifications include all system-related errors: bridge resistor tolerance and drift, thermal offsets of bridge scanner and voltmeter, voltmeter accuracy, injected currents, self-heating of bridge resistors and system noise. The only exceptions are lead wire mismatch and the accuracy of the gauge itself. Specifications are valid for either the 3497A or the 3456A voltmeter with integration time set to one power line cycle.

Accuracy at V_S = 5 volts

Bridge Type	24 Hr. ± 1°C	90 Day 23 ± 5°C	≤90 Days 23 ± 5°C	Temperature Coefficient (0-18,28-55°C)
Full	1 $\mu\epsilon$	1 $\mu\epsilon$	0.04 $\mu\epsilon$/Mo.	0.025 $\mu\epsilon$/°C
½	4 $\mu\epsilon$	5 $\mu\epsilon$	0.4 $\mu\epsilon$/Mo.	0.3 $\mu\epsilon$/°C
¼	7 $\mu\epsilon$	25 $\mu\epsilon$	1.8 $\mu\epsilon$/Mo.	1.8 $\mu\epsilon$/°C

Accuracy At V_S = 1 Volt

Full	3 $\mu\epsilon$	3.5 $\mu\epsilon$	0.04 $\mu\epsilon$/Mo.	0.1 $\mu\epsilon$/°C
½	5 $\mu\epsilon$	10 $\mu\epsilon$	0.9 $\mu\epsilon$/Mo.	0.4 $\mu\epsilon$/°C
¼	10 $\mu\epsilon$	35 $\mu\epsilon$	6.8 $\mu\epsilon$/Mo.	1.8 $\mu\epsilon$/°C

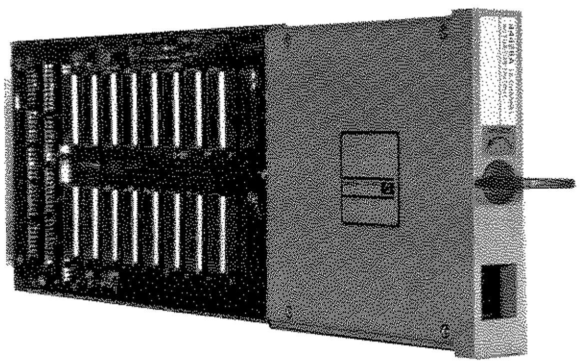
Accuracy At V_S = 100 mV

Full	20 $\mu\epsilon$	35 $\mu\epsilon$	0.04 $\mu\epsilon$/MO.	0.8 $\mu\epsilon$/°C
½	40 $\mu\epsilon$	75 $\mu\epsilon$	0.9 $\mu\epsilon$/Mo.	1.7 $\mu\epsilon$/°C
¼	80 $\mu\epsilon$	150 $\mu\epsilon$	6.8 $\mu\epsilon$/Mo.	3.5 $\mu\epsilon$/°C

All Specifications Are ±
These figures assume a gauge factor of 2.

Maximum self-heating offset due to change in the number of gauges on one assembly: 0.3 $\mu\epsilon$ per gauge (V_S = + 5, R_g = 120 Ω, ¼ bridge)

Maximum self-heating offset due to .1 V change in supply voltage: 0.38 $\mu\epsilon$ (V_S = + 5, R_g = 120 Ω, ¼ bridge).



AC Performance

Contact Capacitance: < 15 pF

Interchannel Capacitance: < 30 pF

Frequency Response

(10 kHz Reference)	f<100 kHz	f<1 MHz
50 Ohm Termination	±.3 dB	±.5 dB
1M Ohm Termination	±.3 dB	±.5 dB

Cross Talk

1M Ohm Termination	<30 dB	<30 dB

OPTION 110
ACTUATOR/DIGITAL OUTPUT ASSEMBLY

Input Characteristics

Contact Ratings: Voltage: ±100 V peak
Current: 1 ampere/channel
Power: 100 volt amperes/channel

CAUTION: For use only in circuits fused at 1 ampere or less and less than 100 VA.

Thermal Offset: < 20 μV

Contact Resistance: < 400 milliohms

Isolation: > 10^6 Ω common to open

Isolation Voltage: 170V peak any terminal to chassis

General Information

Single Channel Closure Rate: > 27/second (Using 9835A)

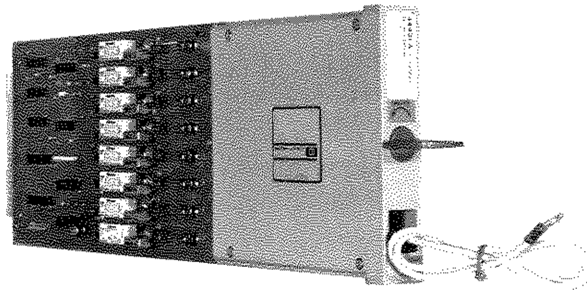
Switch Life: > 10^{10} with contact protection

+ 5V Supply: Source up to 50 mA per assembly

Operating Considerations: Should not be used in a position greater than 30° above horizontal

Handshake Lines: Optically isolated, TTL compatible, open collector output

OPTION 115
8 CHANNEL HIGH VOLTAGE ACTUATOR ASSEMBLY



Maximum Contact Ratings:

Voltage AC 252 VRMS DC 48 VDC
Current AC 2 amps RMS DC 2 ADC
Power AC 500 VA per chan. DC 60 VA per chan.
Peak Surge Current: 10 Amps RMS
Thermal Offset: $<20\mu V$
Series Resistance: <500 mΩ

Isolation Impedance: $>10^6$ ohms, input to output with no protection network

Isolation Voltage: >400 V peak input to output
>1500 VRMS to chassis

Minimum Input: 100 μA, 100 mV DC (for contact cleansing)

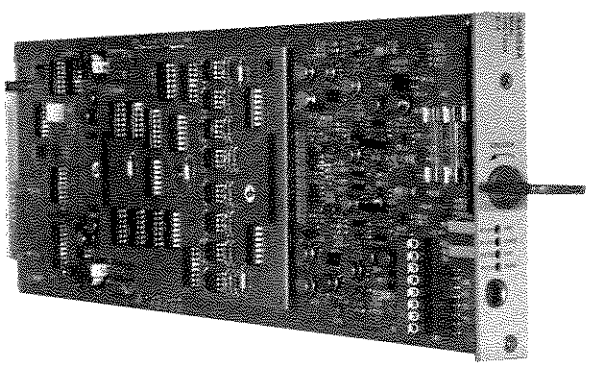
Relay Lifetime: > 10^8 at minimum load, > 10^5 at full load

Switching Speed: Any combination of channels can be closed simultaneously. Programming and execution of a single or multiple channel closure or open requires 40 ms. Repetitive changes of the same Option 115 assembly are limited to one every 1.5 seconds. Changes of the same assembly up to 25 a second can be jumper enabled but will result in decreased lifetime at full load.

Maximum Leakage Current:
(at 250 VRMS and 60 Hz)
1 mA RMS with no protection network
6 mA RMS with protection network

Protection Network: R = 47 Ohms ± 20%.
C = .047 μF ± 10%

OPTION 120
DUAL OUTPUT, 0 TO ± 10V VOLTAGE D/A CONVERTER



Output: 13 bits including polarity

Least Significant Bits: 2.5 mV

Output Range: -10.2375 V to +10.2375 V

Accuracy: (Using remote sense)
24 Hours,
23°C ± 1°C: ± .024% of programmed value ± 2.8 mV
90 Days,
23°C ± 5°C: ± .070% of programmed value ± 4.0 mV

Temperature Coefficient: (0-18°C, 28-50°C) ± .0045% of programmed value/°C ± 100 μV/°C

Ripple and Noise: 2.5 mV rms, 20 Hz to 250 kHz into 1 kΩ

Load Regulation: 600 μV(0-15 mA)

Maximum Output Current: 15 mA (output within specifications)

Short Circuit Current: (maximum) 50 mA

Maximum Voltage Drop in Source Leads Using Remote Sense:
Low Lead: .5 V
High Lead: 1.5 V

Monotonicity: Over operating range (Monotonicity guarantees that the output will never change in a direction different than that programmed)

Settling and Programming Time: (Using 9835A Computer, 3497A DVM in Trigger Hold, R(L) = 1 kΩ, C(L) = 1000 pF)
To within ± 1.0 mV of final value: 100 ms

Isolation: > 170 V peak between any terminal and chassis

Protection: Can withstand indefinite open or short circuit

OPTION 130
DUAL OUTPUT, 0-10 mA/4-20 mA CURRENT D/A CONVERTER

Analog Output: 12 bits

Least Significant Bit: 5 μA (0-20 mA range)
4 μA (4-20 mA range)

Output Current Range: 0 to 20.475 mA or 4 to 20.380 mA (each source jumper selectable)

Accuracy:
24 Hours,
23°C ± 1°C: ± .03% of programmed value ± 6.5 μA
90 Days,
23°C ± 5°C: ± 0.07% of programmed value ± 10.0 μA

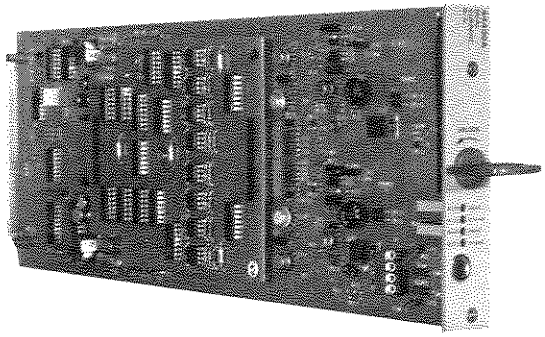
Temperature Coefficient (0-18°C, 28-50°C):
± .0075%/°C of programmed value ± 650 nA/°C

Ripple and Noise: 5 μA rms, 20 Hz to 250 kHz into 100 ohms

Compliance Voltage: 12.0 volts

Load Regulation: ± 2.0 μA (2.0 V to 12.0 V)

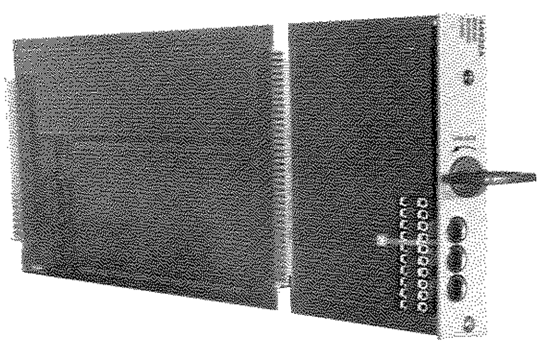
Monotonicity: Over operating range (Monotonicity guarantees that the output will never change in a direction different than that programmed)



Settling and Programming Time: (Using 9835A Computer, 3497A DVM in Trigger Hold, R(L) = 100 Ω)
To within ± 3.0 μA of final vlaue: 100 ms

Isolation Voltage: > 170 V peak between any terminal and chassis

Protection: Can withstand indefinite open or short circuit



General Communication Rate: Instructions can be sent to the 3497A breadboard card and data read from the 3497A breadboard card at a rate of 20 individual operations per second using the HP 85, and 90 operations per second using the HP 9826 computer.

OPTION 140
BREADBOARD CARD

Component Area: (consisting of plated thru .1168 cm. (.046") inside diameter holes spaced .254 cm. (.100") apart

368 cm.^{2} 57.13 in.^{2}

Maximum Component Height: 1.4 cm. (.55 in.)

Maximum Component Lead Length: .51 cm. (.2 in.)

Maximum Power Dissipation: (total per assembly from all supplies): 2 watts

Power Supply Rating: S: (supplied by the 3497A, maximum per card, up to 5 cards per 3497A cardcage)

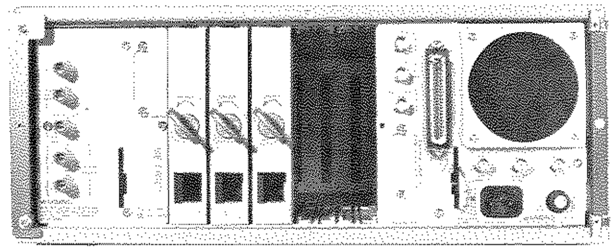
Digital Supplies (Nonisolated): + 5 V @ 400 mA max.

Analog Supplies (Isolated):

		Maximum Current
Low Related Supplies	+ 5 V	50 mA
	+ 15 V	2 mA
	− 8 V	100 μA
Guard Related Supplies	+ 19 V	20 mA
	− 19 V	20 mA

To avoid design difficulty and possible damage to the 3497A, analog (isolated) and digital (nonisolated) supplies should not be interconnected.

OPTION 232
RS232/423 (CCITT V.24/V.10) INTERFACE



Specifications

These specifications are particular to the 3497A Option 232 operating at 60 Hz line frequency. For 50 Hz operation, multiply rates by 5/6.

BPS Rate Vs. Distance

RS232C (V.24) recommends a maximum cable length of 50 feet or less than 2500 pF of total load capacitance.

The distance specifications for RS423 (V.10) are:

BPS	110	300	600	1200
Distance	1200 m	1200m	1200 m	900 m
	4000 ft	4000 ft	4000 ft	3000 ft

BPS	2400	4800	9600	19200
Distance	600 m	300 m	120 m	60 m
	3000 ft	1000 ft	400 ft	200 ft

Maximum Reading Rate For 85 Readings

Packed mode, display off, reading storage on, single trigger burst, fixed channel:

#Digits	Auto Zero On	Auto Zero Off
3½	205	300
4½	125	205
5½	26	50

BPS Vs. Reading Rate

Readings transferred directly into the computer.

Packed mode, display off, internal trigger, fixed range

	BPS			
Auto Zero Off	300	1200	9600	19200
3½	10	38	190	210
4½	10	38	130	175
5½	10	30	45	45

Auto Zero On	300	1200	9600	19200
3½	10	38	140	160
4½	10	38	100	110
5½	10	20	25	25

ASCII mode, display off, internal trigger:

Auto Zero Off	300	1200	9600	19200
3½	3	10	65	100
4½	3	10	60	86
5½	3	10	30	38

Auto Zero On	300	1200	9600	19200
3½	3	10	60	90
4½	3	10	50	70
5½	3	8	20	22

Minimum analog switching time for sequential scanning:
280 channels/s (ch/s)

Minimum analog switching time for random scanning 10 channels or less:
120 channels/s (ch/s)

> **10 Channels:**

BPS	300	1200	9600	19200
Switching Rate ch/s	7	26	83	95

Minimum analog switching and reading time for sequential scanning:

BPS	300	1200	9600	19200
Switching Rate ch/s	10	40	120	130

Minimum analog switching and reading time for random scanning 10 channels or less:

BPS	300	1200	9600	19200
Switching Rate ch/s	5	18	60	65

> **10 Channels:**

BPS	300	1200	9600	19200
Switching Rate ch/s	7	13	25	27

Interrupt response: The length of time for BREAK to be sent to the computer after an interrupt occurs: 150 ms. Includes HP 85A response time.

D to A output response vs. BPS: The length of time required to respond to a change in the output of the D to A card after the commands for change are received by the 3497A

BPS	300	1200	9600	19200
Switching Rate ms	500	175	100	100

Handshakes: ENQuire/ACKnowledge and DC1

Error Checking: Even, odd, or no parity. On detection of a parity error, the status register sets a bit for parity error.

Accessories Supplied: Supplied standard with Option 232 is a 13222-60001 5 meter, 50 pin connector to male RS232C connector, adapter cable.

Output Data Format

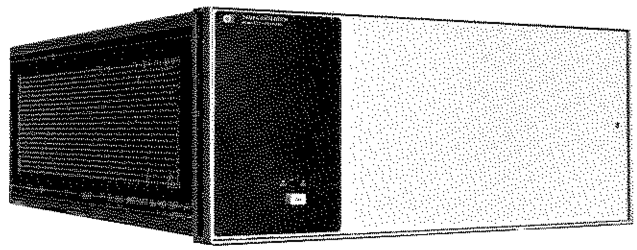
The 3497 has the ability to send data in ASCII or packed BCD. The output format for ASCII is:

Measured Data	$\pm$D.DDDDDE$\pm$DC$_R$
Time of Day	DD:DD:DD:DD:DDC$_R$
Elapsed Time	DDDDDDDDDDDC$_R$ 1st 4 DIGITS ARE ZEROS
Digital Read/Load	OOOOOOC$_R$ 0-177777*
Digital Interrupt	OOOOOOC$_R$ 0-377
Counter Totalize	DDDDDDC$_R$
Counter Period	D.DDDDDDE+DC$_R$ (sec)
Analog Channel	$\pm$DDDC$_R$ "-" is no channel closed
System Read	OOOOOOC$_R$ 0-377
Status Read	OOOOOOC$_R$ 0-377

*D = Decimal Digit
*O = Octal Digit

The packed BCD is used only for voltage measurements.

OPTION 298
ADD 3498 EXTENDER



Number of Slots per 3498A: 10

Maximum Number of Added Analog Multiplexer Channels (Options 010, 020): 900 channels (45 assemblies)

Maximum Number of Added Non-analog Acquisition Assemblies (Options 050, 060, 110, 115, 120, 140): 85 assemblies

Maximum Separation From the 3497A:
3498A with analog cards (Options 010, 020, 070, 071): 100 meters
3498A with digital assemblies (all other options): 25 meters (2 meter cables are supplied standard)

Maximum Number of 3498A's per 3497A: 13

Isolation:

	25°C, >85% R.H. 40°C, >60% R.H.	40°C, >95% R.H.
Hi to Lo	$>10^{10}$ Ohms	$>10^{9}$ Ohms
Lo to Guard	$>10^{8}$ Ohms	$>10^{7}$ Ohms
Guard to Chassis	$>10^{8}$ Ohms	$>10^{7}$ Ohms

Operating Considerations

Digital Interrupt is not passed between the 3498A and the parent 3497A. Digital Interrupt is found on the Option 050 Digital Input/Interrupt Assembly and on the Option 060 Counter Assembly.
The DVM assembly cannot be used in the 3498A.
Power and Environmental Information: see 3497A data.

WARRANTY INFORMATION

The warranty statement for the -hp- Model 3497A, -hp- Model 3498A and for all plug-in assemblies to the 3497A/3498A, EXCEPT for Option 140 (-hp- Model 44432A, Breadboard Card assembly) is in Figure B-1. The warranty statement for the Option 140 assembly ONLY is in Figure B-2.

HOW TO OBTAIN REPAIR SERVICE

You may have your 3497A repaired at your local -hp- service center at any time, whether it is under warranty or not. There is, however, a charge for repairs after the one year warranty period. Contact your local Sales and Service Office for shipping instructions prior to returning the instrument. A list of Sales and Service Offices is located in the back of this manual.

3497A SERIAL NUMBERS

Each 3497A and 3498A has a serial number printed on a plate on the rear panel. The serial number has the form XXXXAYYYYY where the XXXX is the serial prefix, A is the country of origin (A = USA) and YYYYY is the serial suffix.

We recommend that owners keep a separate record of this number. Should your instrument be lost or stolen, the complete serial number is often necessary for tracing and recovery, as well as for insurance claims.

GENERAL SHIPPING INSTRUCTIONS

If you need to ship your 3497A or a plug-in assembly back to -hp- , be sure the instrument is packaged in a protective package (use the original shipping container and cushioning material, if possible) to avoid transit damage. Such damage is not covered by the warranty.

Hewlett-Packard suggests that you always insure shipments. Attach a tag to the instrument identifying the owner and indicating the service or repair needed. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number.

WARRANTY FOR 3497A/3498A AND PLUG-IN ASSEMBLIES
(EXCEPT OPTION 140 - BREADBOARD CARD ASSEMBLY)

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

10/1/79

Figure B-1. Warranty for 3497A/3498A

WARRANTY FOR OPTION 140 - BREADBOARD CARD ASSEMBLY

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from the date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

The design and implementation of any circuit used on this product is solely the responsibility of the Buyer. Hewlett-Packard Company does not warrant the Buyer's circuitry or malfunctions of the 3497A, 3498A, or plug-in options that result from the Buyer's circuitry. In addition, -hp- does not warrant any damage that occurs as a result of the Buyer's circuit, including but not limited to the following:

1. Analog and digital sections are interconnected.
2. 3497A/98A power supply limitations are exceeded.
3. Component height/protrusion restrictions are violated.
4. Guard and internal 3497A DVM voltage specifications are violated.
5. Maximum input voltage on the digital lines is exceeded.
6. The trace current specifications listed in this manual are exceeded.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

Figure B-2. Warranty for Option 140

MANUAL INFORMATION

This 3497A Operating, Programming and Configuration Manual applies to all 3497A Data Acquisition/Control Units with serial number prefixes 2222A and above and to 3498A Extenders with serial number prefixes 2223A and above.

It also applies to all plug-in assemblies (Options 010 through 140), except for -hp-Model 44426A 100 kHz Counter, Revision A. For information on Revision A Counters, see -hp- Model 44426A, 100 kHz Reciprocal Counter Assembly Operating and Service Manual (-hp- part number 44426-90000).

Instruments manufactured after the publication date of this manual may have changes incorporated. In this case, a yellow MANUAL CHANGES sheet will accompany the manual. MANUAL CHANGES may also contain information to correct manual errors.

To keep this manual as accurate as possible, we suggest that you periodically request the current MANUAL CHANGES supplement which is identified by the print date and part number on the title page of this manual. Complimentary copies are available from your nearest -hp- Sales and Service office.

One copy of this manual is supplied with each 3497A ordered. Additional copies may be ordered from your nearest -hp- Sales and Service office. The part number is listed on the title page of this manual.

You may also order 100 x 150 mm (4 x 6 inch) microfilm transparencies of this manual. The microfiche part number is listed on the manual title page below the manual part number. Each microfiche contains up to 96 photo-duplicates of the manual pages and includes the latest MANUAL CHANGES supplements.

ORDERING AND CONFIGURATION GUIDE

The 3497A has a wide variety of optional configurations. The Ordering and Configuration Guide (see Figure B-3) is provided for your convenience. If you want to order any of the configurations shown, contact your nearest -hp- Sales and Service Office for assistance.

3497A ORDERING AND CONFIGURATION GUIDE

3497A Option Number	Description
STANDARD	Data Acquisition/Control Unit with Front Panel Keyboard and Display. Real Time clock and HP-IB Interface. Each 3497A can hold one DVM assembly (Option 001 and up to 5 plug-in assemblies. Each 3498A (Option 298) can hold 10 additional plug-ins. For plug-ins in excess of cardcage capacity, order as 444XXX field installation kits. REQUIRED ON EVERY ORDER: • A Clock Format (Option 230 or 231) • A Power Line Frequency and Voltage (Options 315 through 346) • Suboptions for Option 020 (if ordered)
001	5½ Digit DVM and Current Source • 1 μV Sensitivity • Fully Programmable • 300 Readings/Second in 3½ Digit Mode To field install Option 001, order 44420A kit
PLUG-IN ASSEMBLIES	
010	20 Channel Relay Multiplexer Assembly To field install Option 010, order 44421A kit
020	Relay Multiplexer Assembly with Thermocouple Compensation Must specifiy one of the following no charge sub-options for each of the assemblies ordered: A20 software compensation B20 hardware compensation for type B thermocouples E20 hardware compensation for type E thermocouples J20 hardware compensation for type J thermocouples K20 hardware compensation for type K thermocouples R20 hardware compensation for type R thermocouples S20 hardware compensation for type S thermocouples T20 hardware compensation for type T thermocouples To field install Option 020, order 44422A kit
050	16 channel Isolated Digital Input/Interrupt Assembly To field install Option 050, order 44425A kit
060	100 kHz, Reciprocal Counter Assembly To field install Option 060, order 44426A kit
070	120 Ohm Strain Gauge/Bridge Completion Assembly To field install Option 070, order 44427A kit
071	350 Ohm Strain Gauge/Bridge Completion Assembly To field install Option 071, order 44427B kit
110	16 Channel Actuator/Digital Output Assembly To field install Option 110, order 44428A kit
115	8 Channel High Voltage Actuator Assembly To field install Option 115, order 44431A kit
120	Dual Output 0 to ± 10 Volt D/A Converter Assembly To field install Option 120, order 44429A kit
130	Dual Output 0-20 mA or 4-20 mA D/A Converter Assembly To field install Option 130, order 44430A kit
140	Breadboard Card To field install Option 140, order 44432A kit

Figure B-3. 3497A Ordering and Configuration Guide

3497A Option Number	Description
CONFIGURATION OPTIONS	
230	Clock Format (Month:Day:Hours:Min:Sec)
231	Clock Format (Day:Month:Hours:Min:Sec)
232	Delete HP-IB Interface Add RS232C (CCITT V.24)/RS423 (CCITT V.10) Interface Includes 13222-60001 Cable
260	Delete Keyboard and Display on the 3497A
298	Add 3498A Extender and Connecting Cables
POWER AND FREQUENCY OPTIONS	
315	100 Volts, 50 Hz
316	100 Volts, 60 Hz
325	120 Volts, 50 Hz
326	120 Volts, 60 Hz
335	220 Volts, 50 Hz
336	220 Volts, 60 Hz
345	240 Volts, 50 Hz
346	240 Volts, 60 Hz
RACK MOUNTING/DOCUMENTATION OPTIONS	
907	Front Handle Kit (Part Number 5061-0090)
908	Rack Flange Kit (Part Number 5061-0078)
909	Rack Flange and Front Handle Kit (Part Number 5061-0084)
910	Extra Set of 3497A/3498A Documentation

ACCESSORIES

Extender Board for Servicing:	03497-67913
Verification Connector and Software for Options 010, 020, 050, 070, 071, 110, 115	
85A Computer:	03497-67912
9825A Computer:	03497-67911
9835A Computer:	03497-67909
9845A Computer:	03497-67910
Connector Only:	03497-67908
Extra Terminal Assemblies for 20 Channel Multiplexer:	03497-69542
Relay Multiplexer with Thermocouple Compensation:	03497-69540
Digital Input/Interrupt:	03497-69543
120 Ohm Strain Gauge:	03497-64109
340 Ohm Strain Gauge:	03497-64110
16 Channel Actuator:	03497-69544
8 Channel Actuator:	03497-64111
Kit to Convert Thermocouple Compensation:	03497-69541
30 cm (12 in.) BNC to BNC Cable	11170A
60 cm (24 in.) BNC to BNC Cable	11170B
120 cm (48 in.) BNC to BNC Cable	11170C
1 meter (39.37 in.) HP-IB Cable	10631A
2 meter (78.74 in.) HP-IB Cable	10631B
4 meter (157.48 in.) HP-IB Cable	10631C

Figure B-3. 3497A Ordering and Configuration Guide (Cont'd)

3497A SYSTEM LOG

For your convenience in logging system inputs to your 3497A/3498A, a 3497A SYSTEM LOG form is shown in Figure B-4.

3497A SYSTEM LOG

3497A S/N: ____________ ASSEMBLY OPTION ______

DATE RECEIVED: ____________ INSTALLED IN SLOT# ______

CHAN	CARD	TRANSDUCER CONNECTED			VALUES/LIMITS		
	CHAN	TYPE	FUNCTION	DATE	MIN	TYP	MAX

Figure B-4. 3497A SYSTEM LOG Form

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