Errata

Title & Document Type:

Manual Part Number:

Revision Date:

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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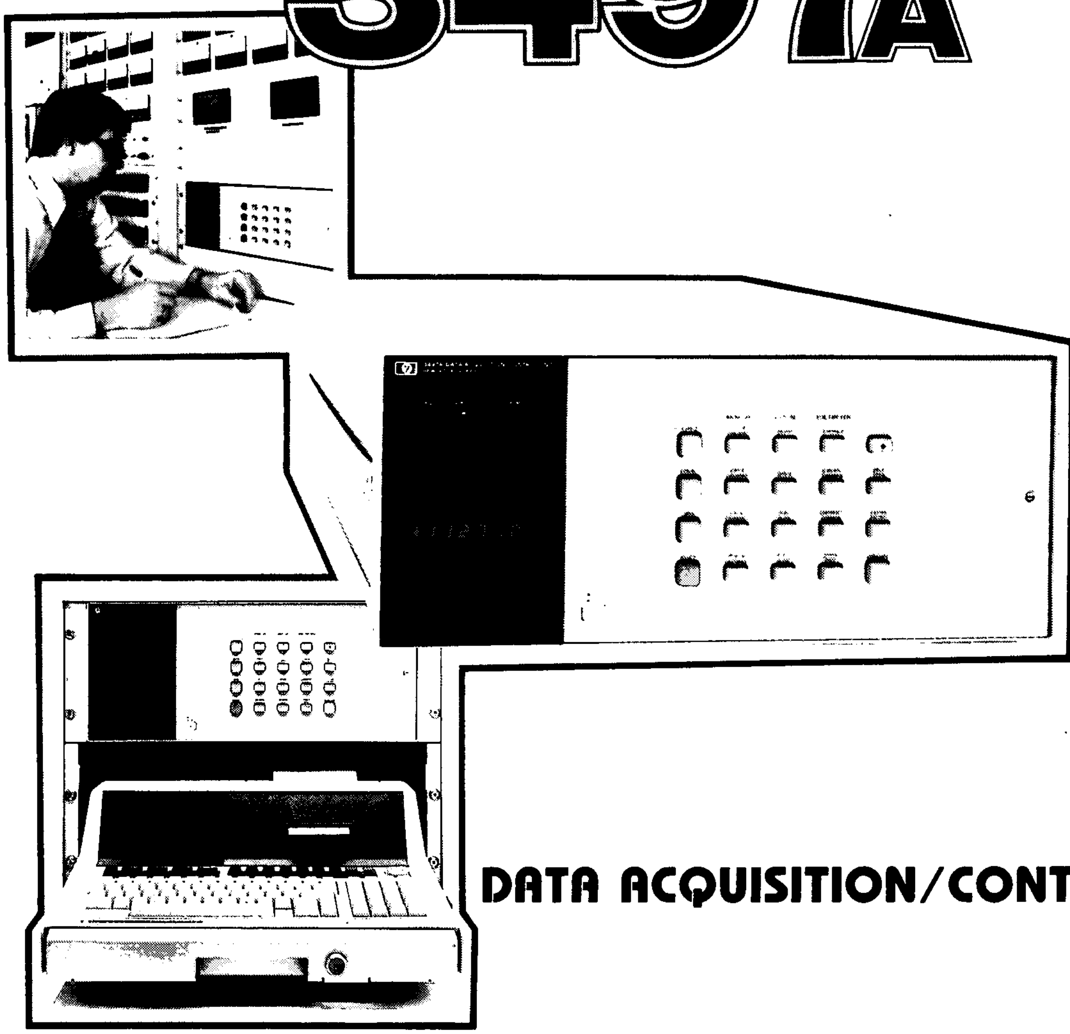
Agilent Technologies

OPERATING, PROGRAMMING AND CONFIGURATION MANUAL

HEWLETT PACKARD

3497A



DATA ACQUISITION/CONTROL UNIT

3497A COMMANDS

D. MARKWALD

ANALOG

Command	Description
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.

VOLTMETER

Command	Description
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 (VS0).
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.

DIGITAL

Command	Description
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

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.

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.

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

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:

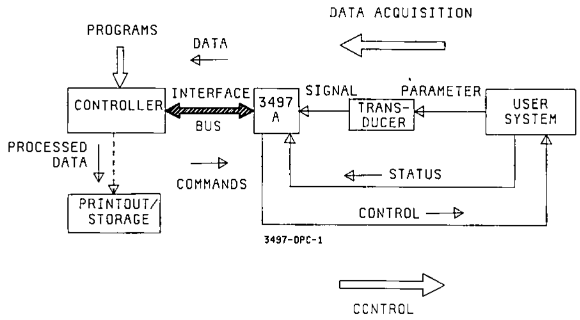
PART I - OPERATING AND PROGRAMMING THE 3497A shows how to send commands to the 3497A by using the front panel or from a controller via either HP-IB or Serial Data interface and shows how to use these commands to program 3497A operation.

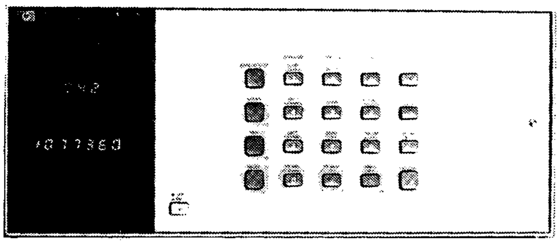
Part II - CONFIGURING THE 3497A shows how to hardware configure the 3497A, all plug-in assemblies (Options 010 through 140) and the 3498A Extender and shows sample ways to connect the 3497A to your system for data acquisition measurements or control applications.

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.



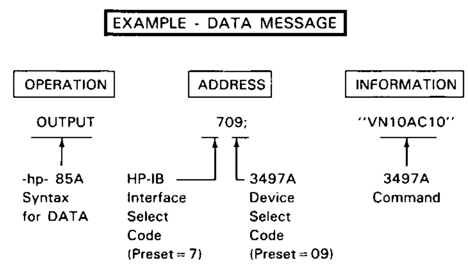


CHAPTER 2
FRONT PANEL OPERATION

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.

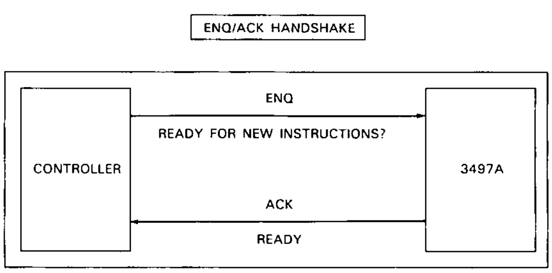
CHAPTER 3
HP-IB PROGRAMMING

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.

DATA FOLLOWING A SELF-TEST COMMAND

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

ANALOG CLOSE

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

Description

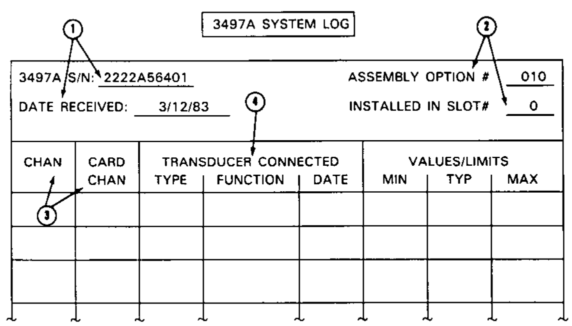
CHAPTER 6
COMMAND DIRECTORY

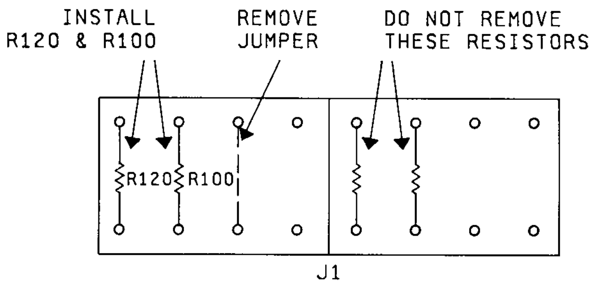
This chapter contains an alphabetical description of the six command groups (ANALOG, COUNTER, DIGITAL, SYSTEM, TIMER and VOLTMETER) used to control the 3497A. The directory also includes a list of the command states at power on. To avoid undesired actions by the 3497A, you should ALWAYS consult this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

CHAPTER 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.



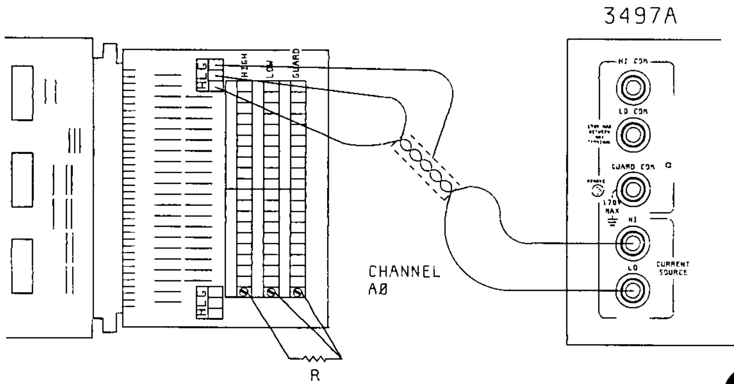


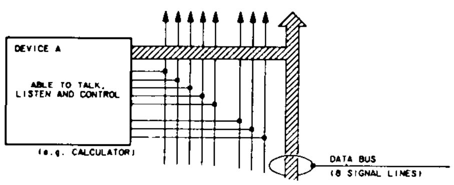
CHAPTER 8
PLUG-IN ASSEMBLY CONFIGURATION

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

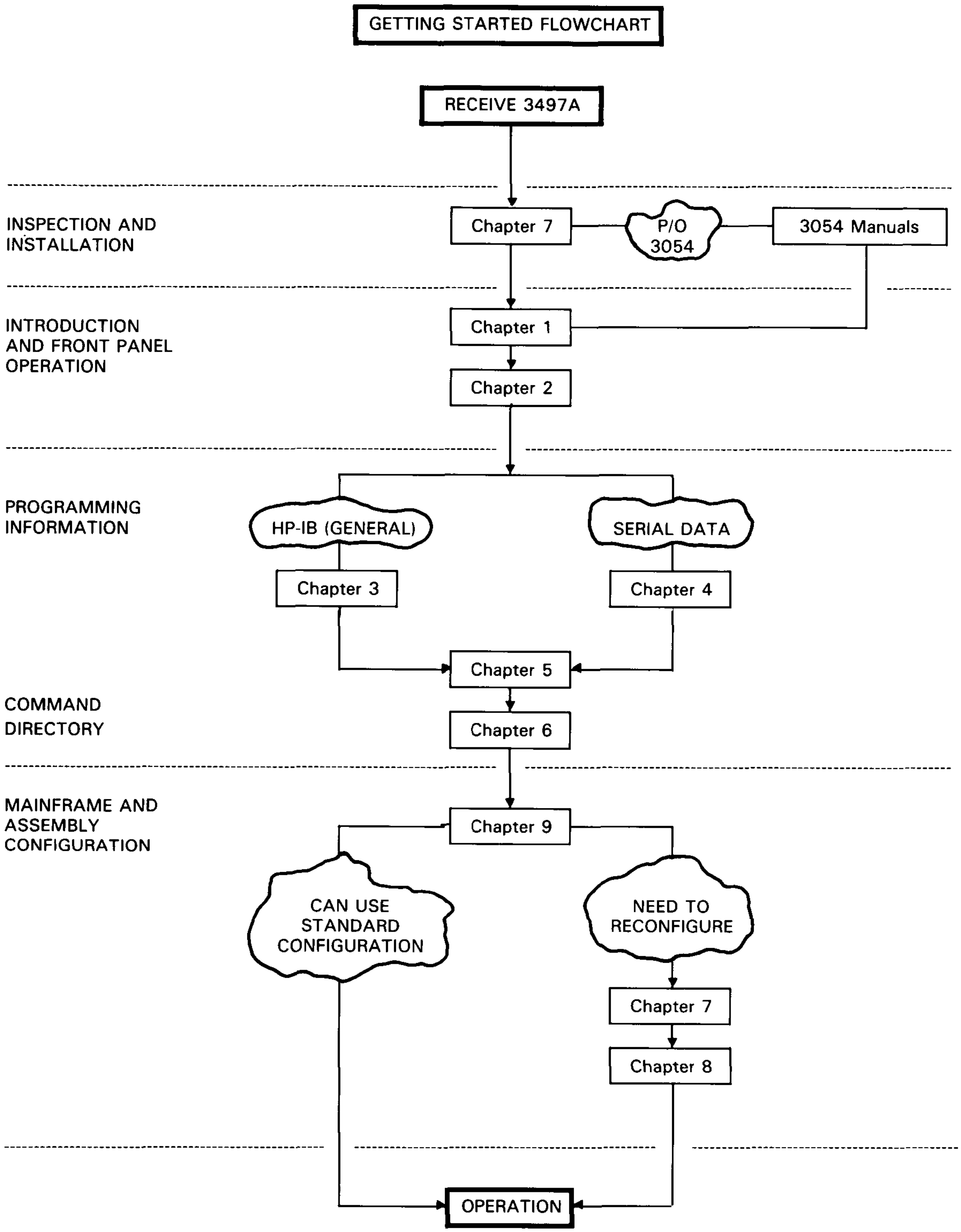
Closed Channel Resistance:
In Series: 100 Ω ± 10% in High, Lo and Guard
Relays Contacts Only: < 1 Ω per contact

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
Chapter 7
P/O 3054
3054 Manuals
INTRODUCTION AND FRONT PANEL OPERATION
Chapter 1
Chapter 2
PROGRAMMING INFORMATION
HP-IB (GENERAL)
SERIAL DATA
Chapter 3
Chapter 4
Chapter 5
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.

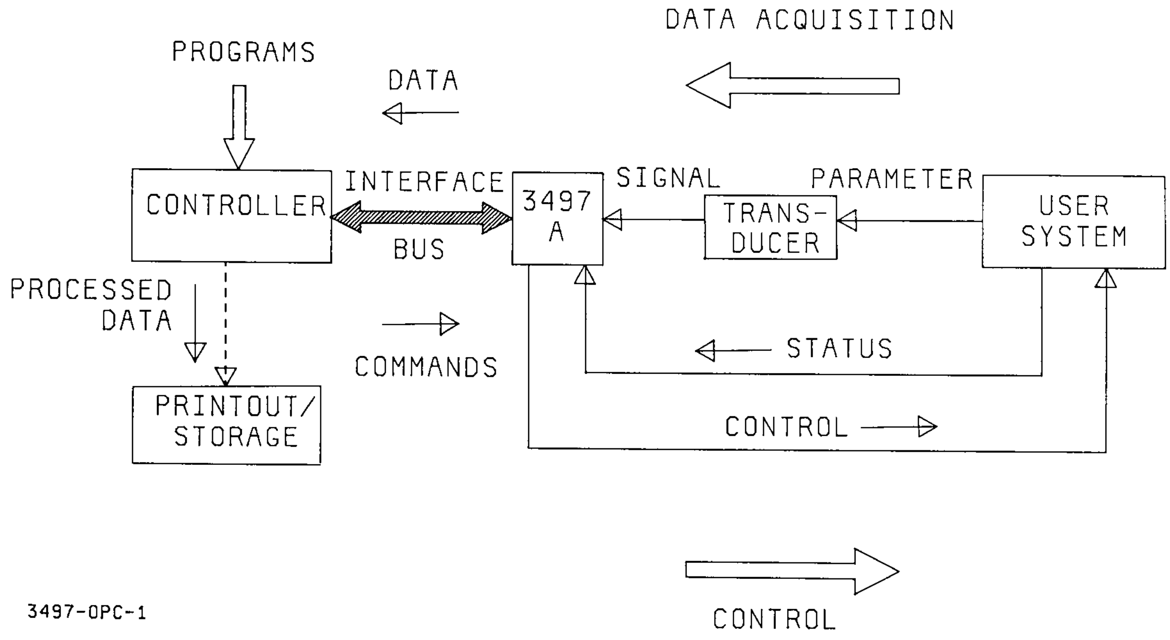


Figure 1. A Data Acquisition/Control System

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.

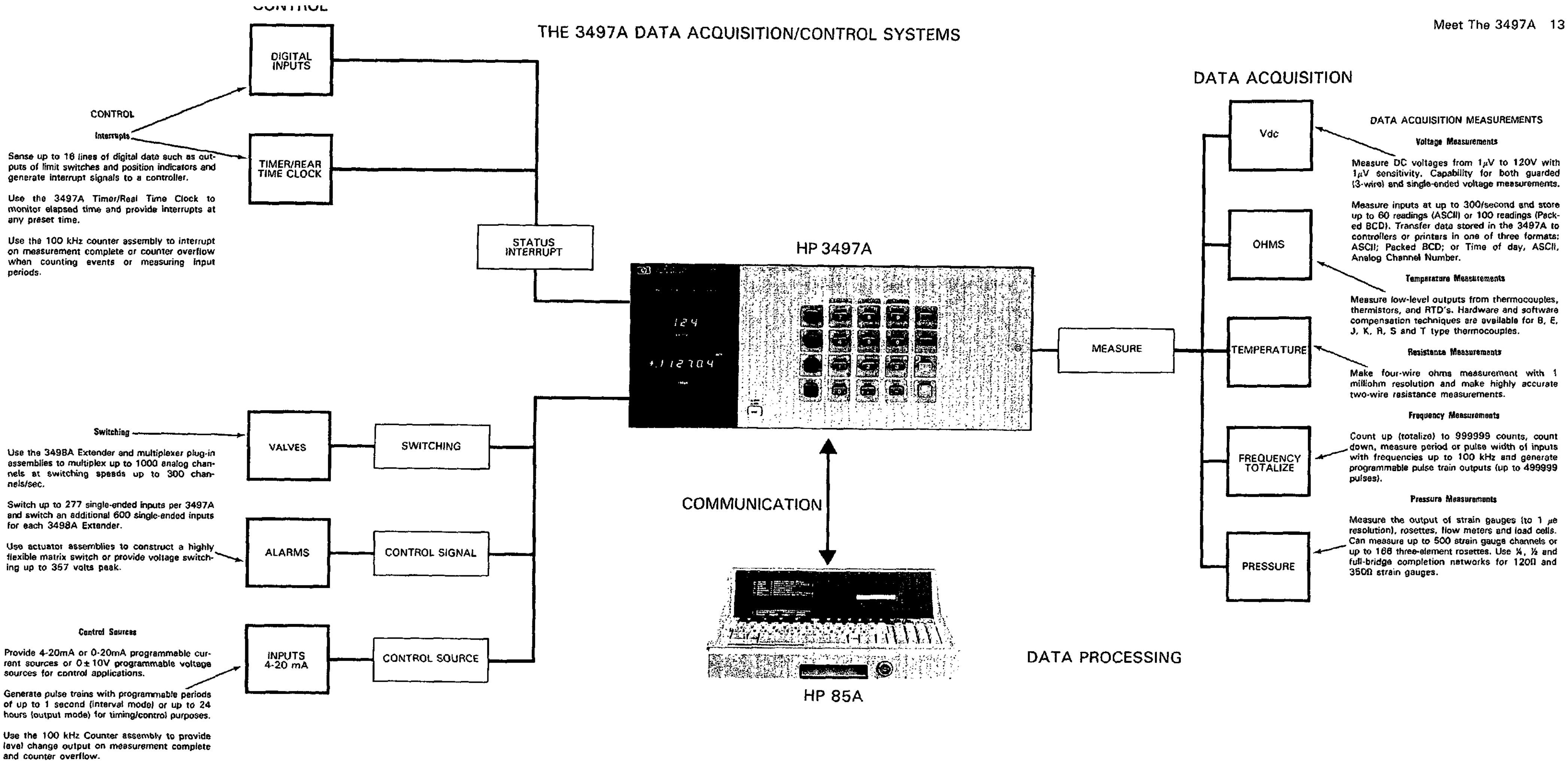


Figure 2. The 3497A in Data Acquisition/Control Systems

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

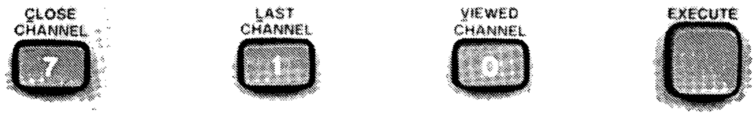
A standard 3497A front panel consists of an alphanumeric keyboard and a display. The keyboard is used to enter command sequences into the 3497A to control its operation. An optional blank front panel (Option 260) has only a power ON/OFF switch and a power ON indicator light. The optional front panel 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:

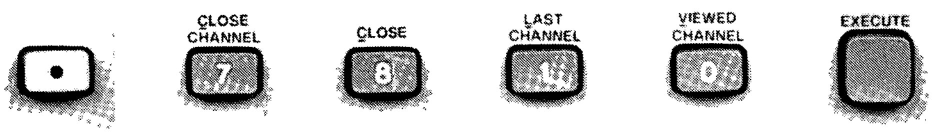


Data Entered:	AC	1	0	Enter AC10 into 3497A

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

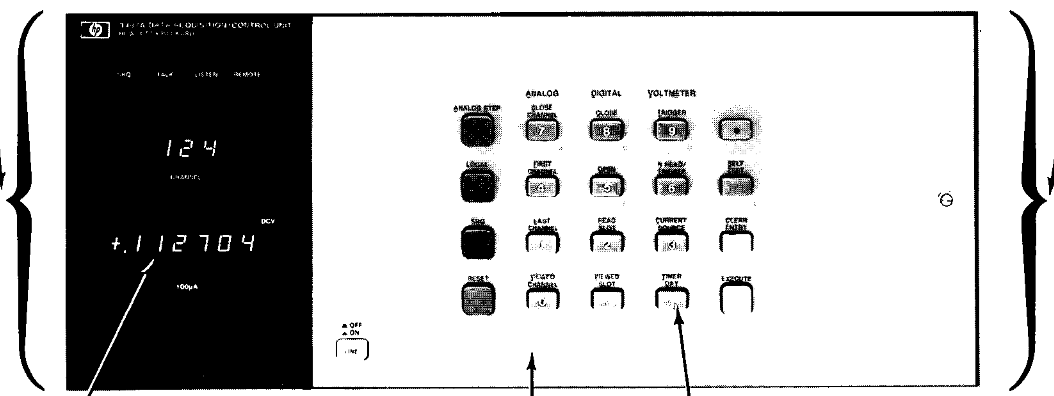
Figure 4 shows rear panel features of a 3497A with HP-IB interface and summarizes their functions. If you have the Serial Data (Option 232) version of the 3497A, the rear panel is identical to the one shown except that a Serial Data connector is used as the communication interface.

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

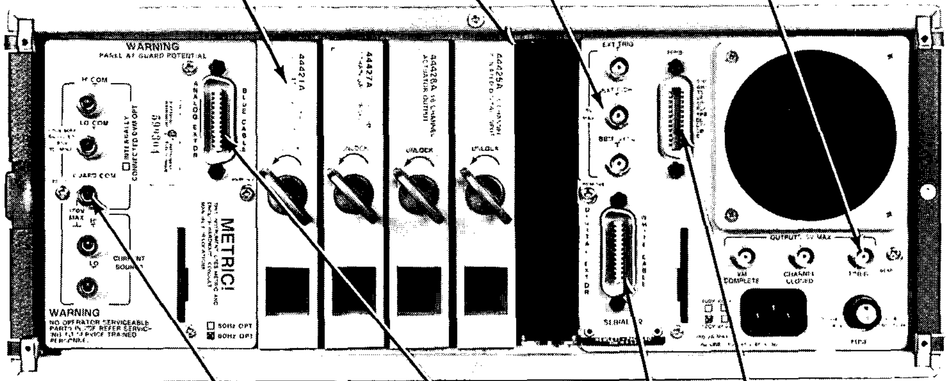
Each 3497A has slots for 5 plug-in assemblies. Slots are numbered from 0 to 4 (left to right).

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.

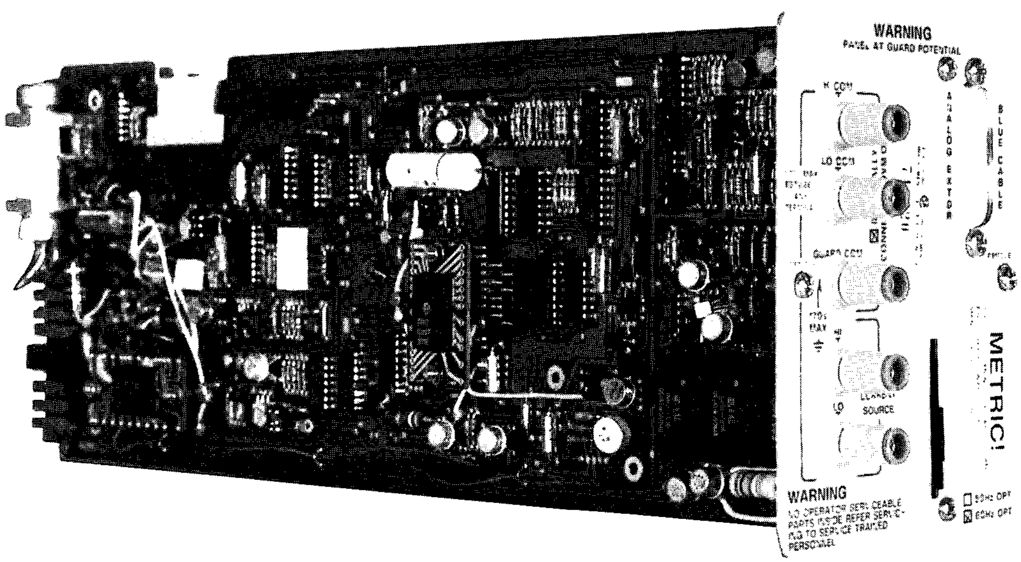
Plug-in assemblies are defined as analog or digital assemblies. Each plug-in assembly is identified by an assembly title and option number (010, 020, etc) or model number (44421A, 44422A, etc.). Descriptions of the plug-in assemblies plus the DVM (Option 001), the RS-232 interface (Option 232) and the 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

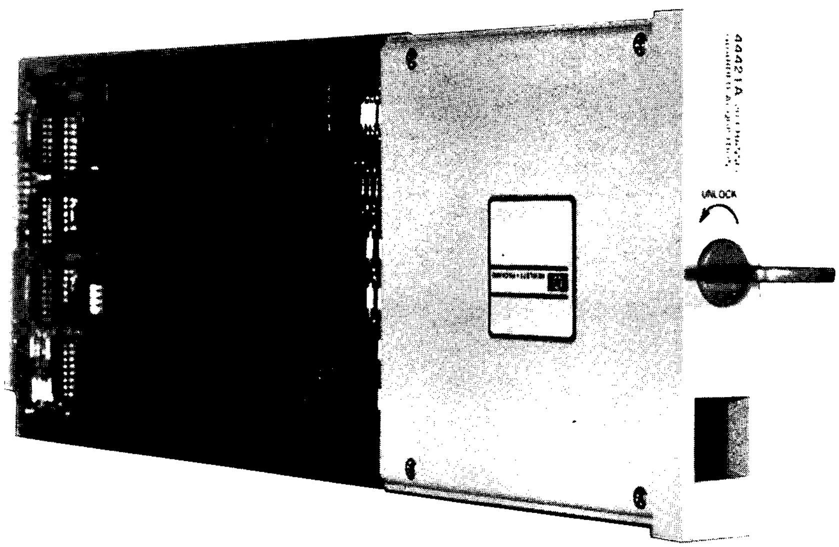
Description

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

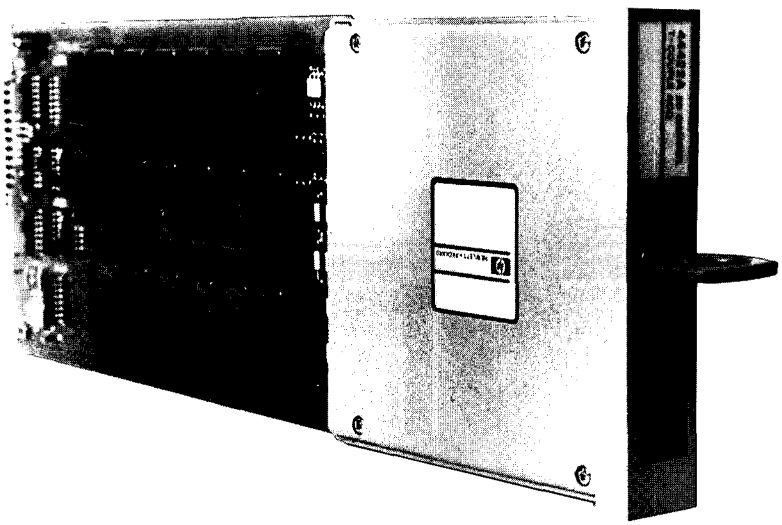
Description

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

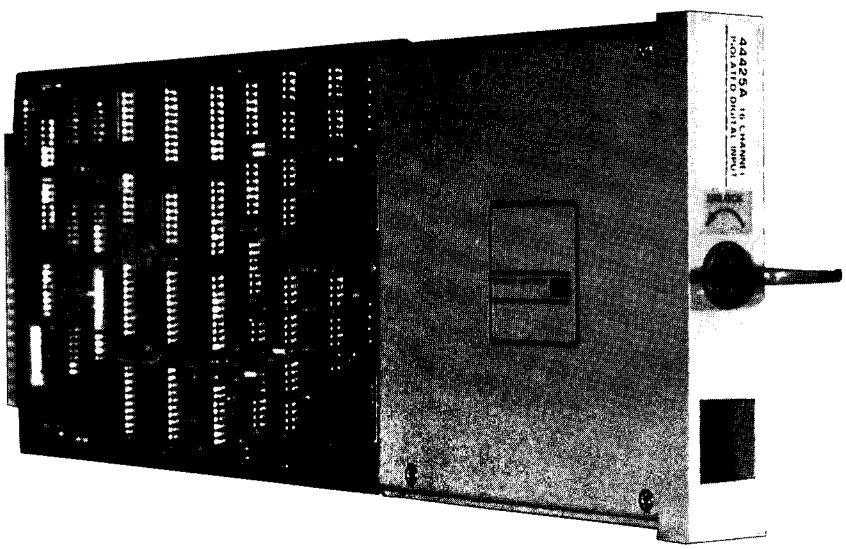
The Option 050 assembly has two functional modes: digital input mode and interrupt mode. In digital input mode, up to 16 digital inputs (ON, OFF; OPEN, CLOSE; etc.) can be input to the assembly. The assembly can also listen to digital data buses.

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

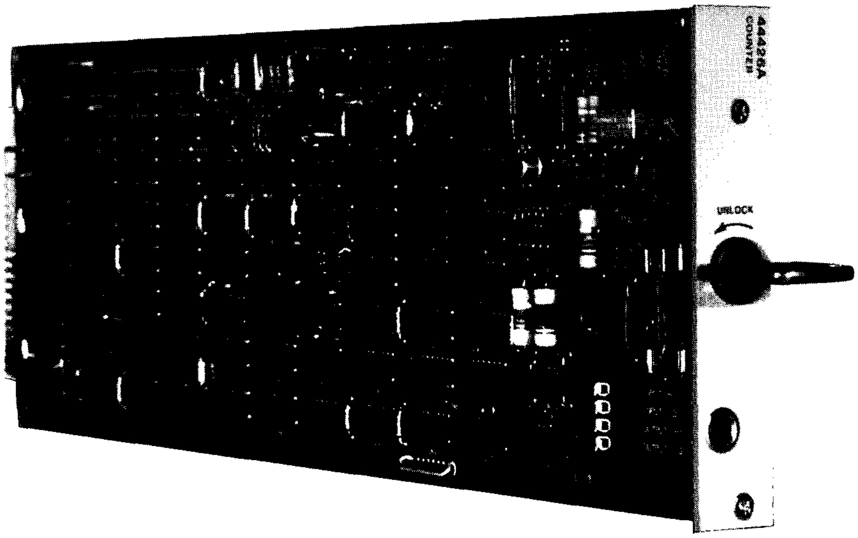
100 kHz Reciprocal Counter Assembly

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

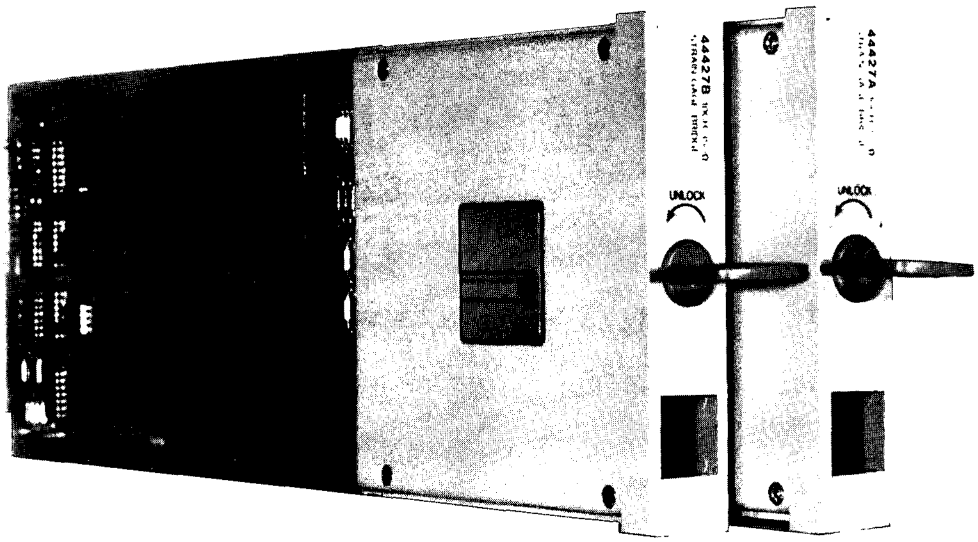
Description

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

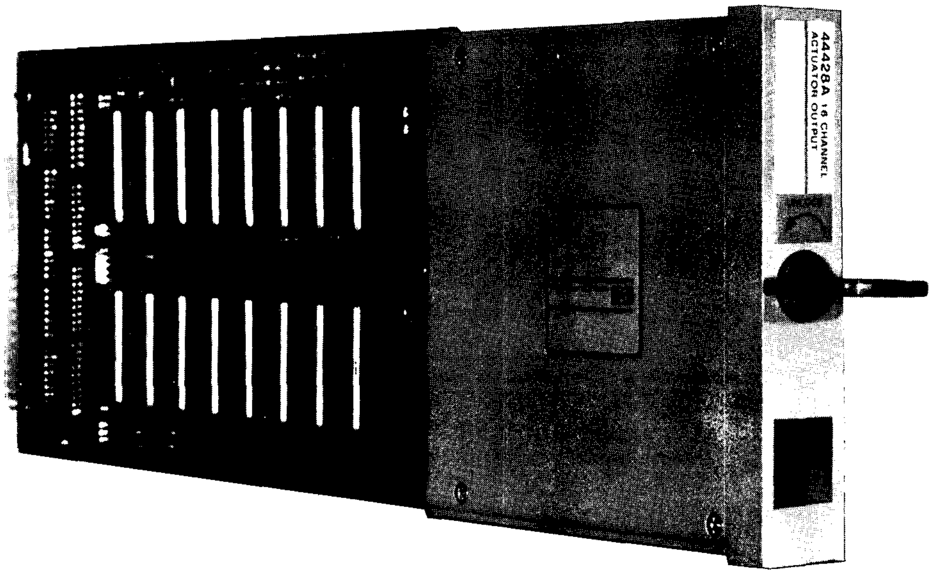
Description

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

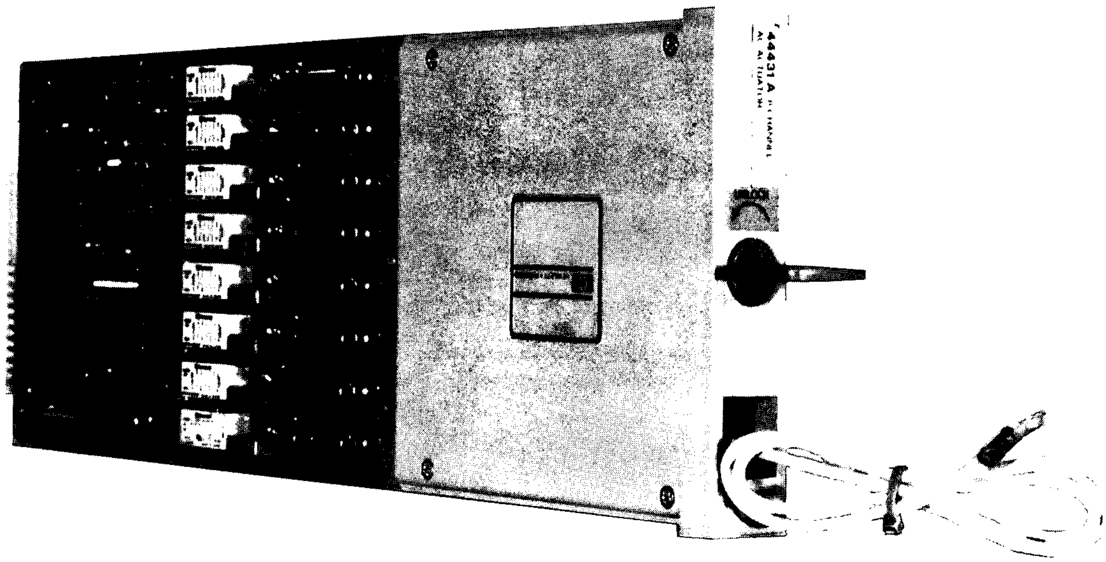
Description

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

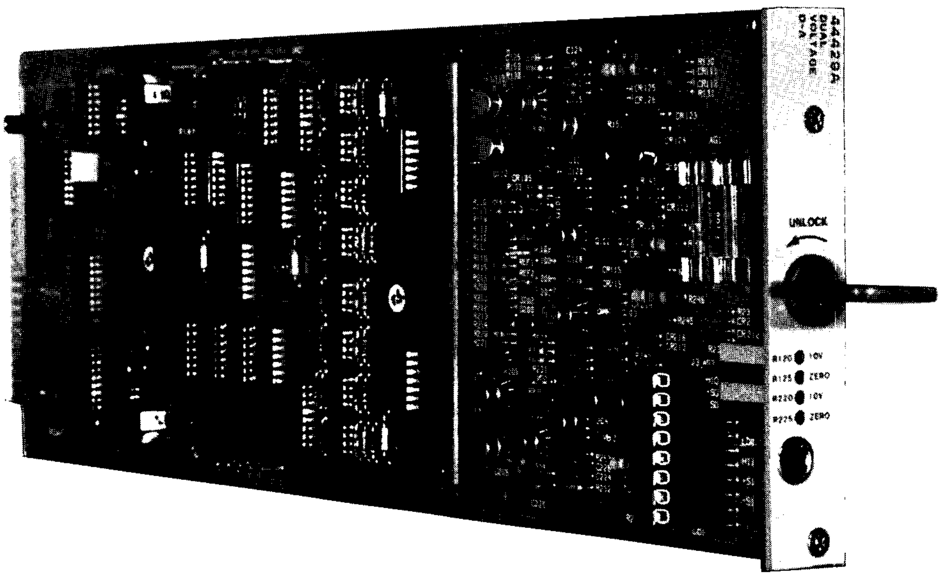
Description

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

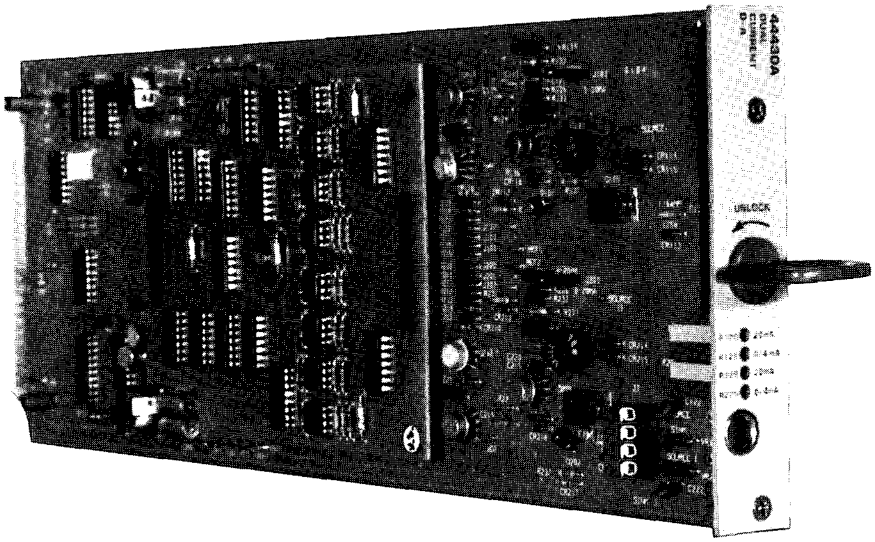
Description

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

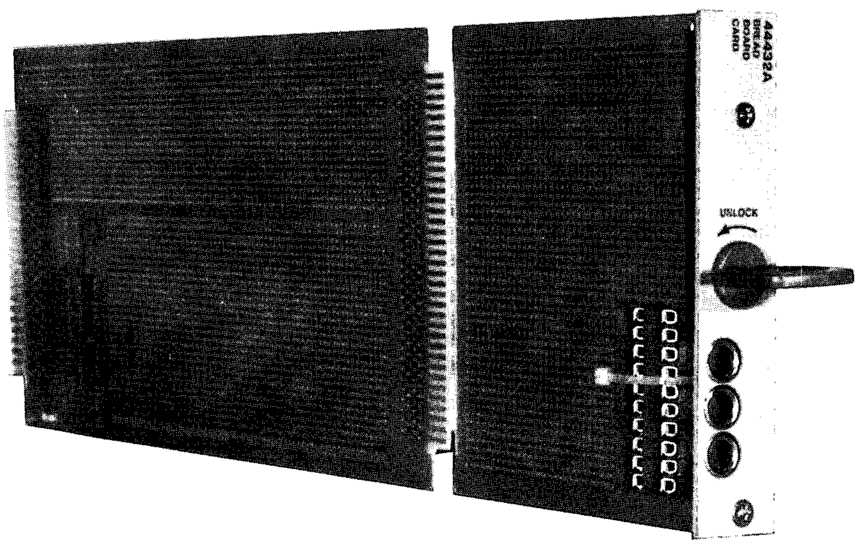
Description

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

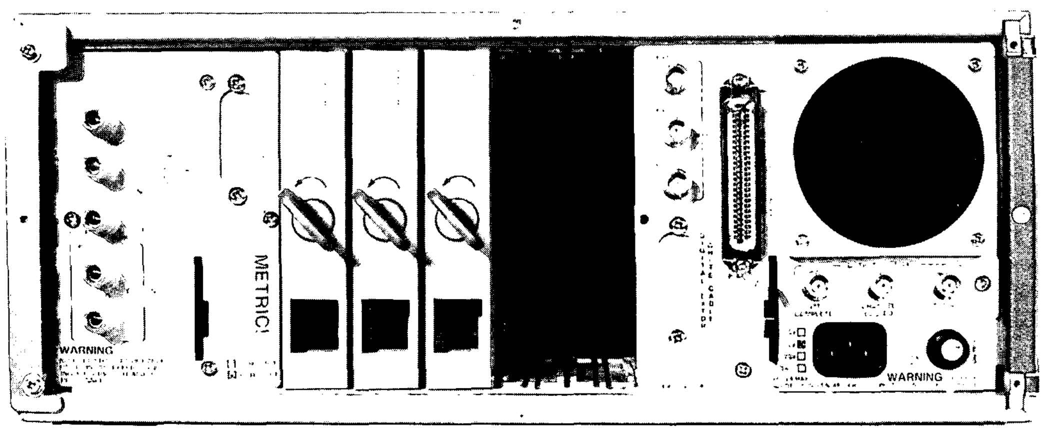
Option 232 to the 3497A deletes the standard HP-IB interface and adds an EIA RS232C (CCITT V.24) compatible serial interface. Option 232 is also compatible with the EIA version of the RS449 serial data interface standard.

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

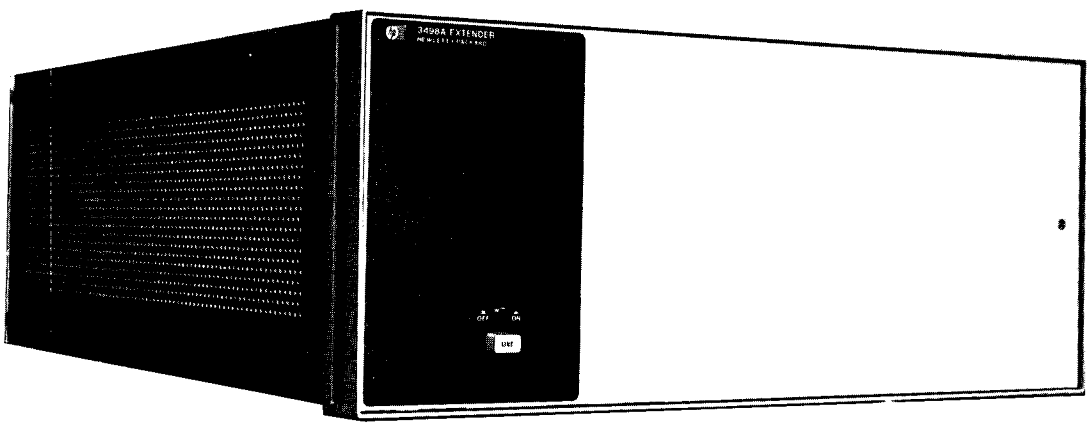
Description

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.

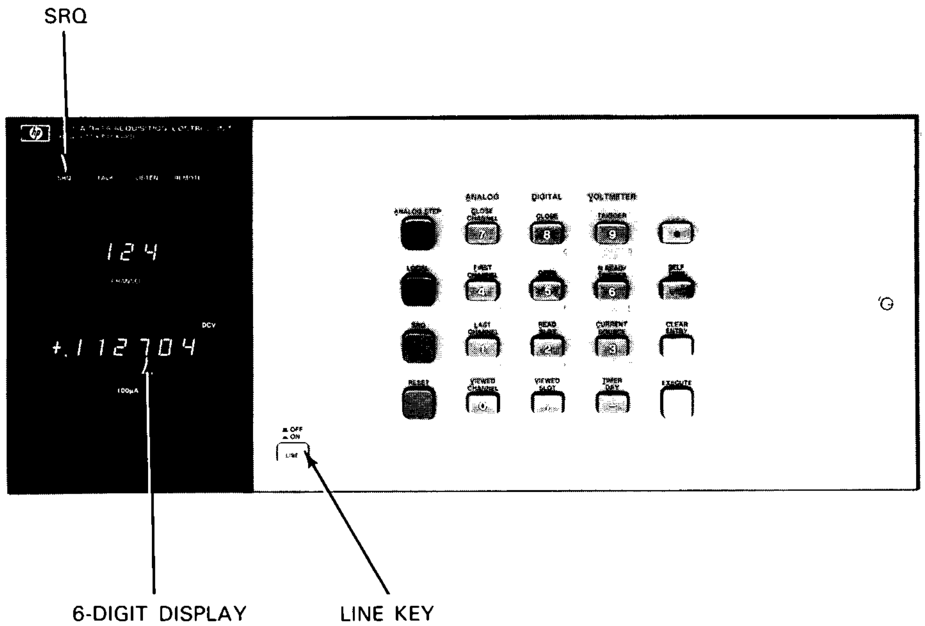
As shipped from the factory, a protective cover is installed over the card cage and DVM terminals. Because of potentially high voltages at the back of the instrument, this cover must be installed whenever the 3497A is connected to an external input. The cover should be removed only by service-trained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

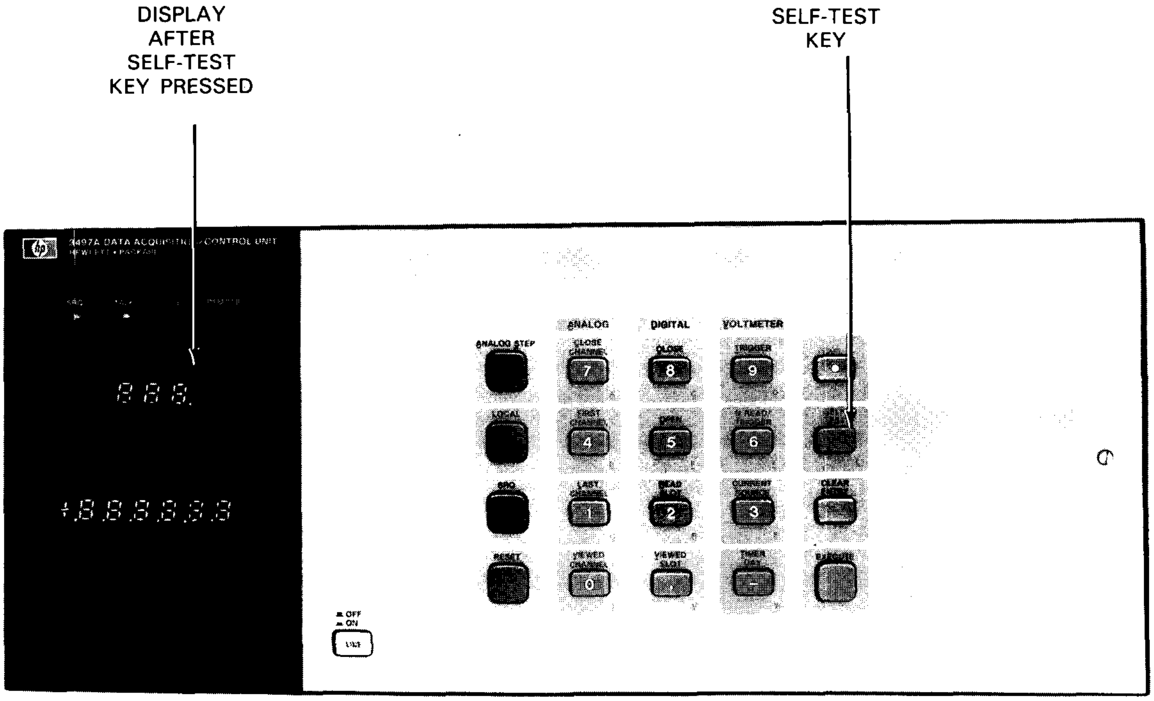


Figure 6. Self-Test Display

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
10 → Analog Channel 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  ─────┘      └───── 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#,...	DIGITAL CLOSE.
slot# = 0 to 89 chan# = 0 to 15	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	DIGITAL INTERRUPT ENABLE.
slot# = 0 to 4 value = 0 to 377 (Octal)	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#	DIGITAL INTERRUPT STATUS.
slot# = 0 to 4	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#	DIGITAL LOAD.
slot# = 0 to 89	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#....	DIGITAL OPEN.
slot# = 0 to 89 chan# = 0 to 15	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#	DIGITAL READ.
slot# = 0 to 89	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#	DIGITAL INTERRUPT SENSE.
slot# = 0 to 4 value = 0 to 377 (Octal)	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#	DIGITAL VIEWED SLOT.
slot# = 0 to 89	Dedicates the front panel display to slot specified. To exit this mode, use DV without slot specifier.

DW slot#,value	DIGITAL WRITE.
slot# = 0 to 89 value = 0 to 177777 (octal)	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	SELF-TEST
ST0 = Self Test OFF ST1 = Self Test ON	ST1 causes 3497A to perform internal self-test. 8E8 returned if self-test passes.

SVn	SYSTEM VIEW.
n = ±999999	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	SYSTEM WRITE.
slot# = 0 to 89 register# = 0 to 7 data = 0 to 377	Use SW to write data to any assembly directly controlled by the main processor (i.e. digital assemblies).

TIMER

TA HH MM SS	TIME ALARM (SET).
Hours = 0 to 24 Minutes = 0 to 59 Seconds = 0 to 59	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	ELAPSED TIME (CONTROL).
TE0 = RESET TE1 = HALT TE2 = START	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	TIME OUTPUT.
n = 0 to 9999	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

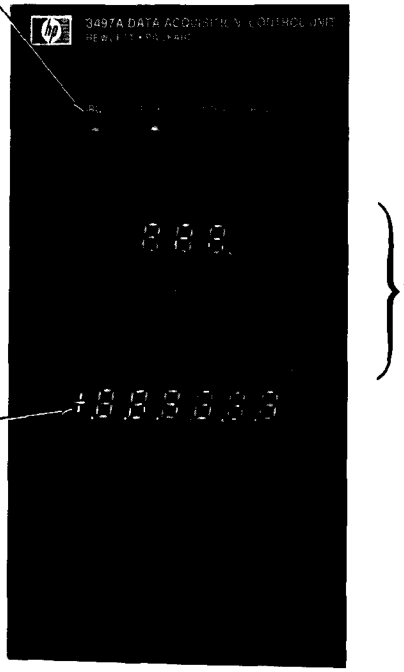
The interface bus status display shows the status of activity on the HP-IB or Serial Data interface bus. There are four LED annunciator lights. For HP-IB operation, each LED is on for the condition shown. For Serial Data (RS232C or RS449/423) operation, the TALK and LISTEN LEDs flash on and off for the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

DISPLAY FOR ANALOG ASSEMBLY	DISPLAY FOR DIGITAL ASSEMBLY
	SLOT
0 2 0	0 2
CHANNEL	CHANNEL
	0

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.

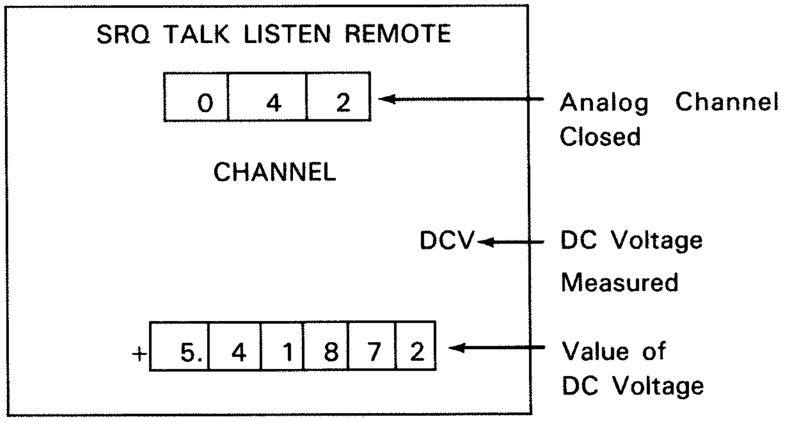
OCT means that the 6-digit display shows the octal value of the true bits in digital channels. ENT shows that the 3497A is ready to accept new inputs or that data is being input from the front panel or from a controller.

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).

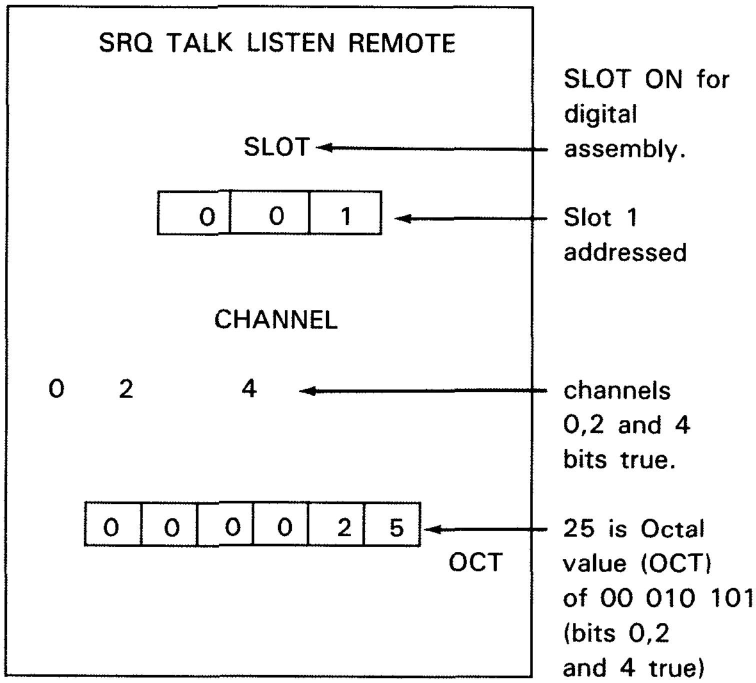
Since the multiplexer is an analog assembly, the SLOT light is OFF, the 3-DIGIT DISPLAY shows the number of the channel measured by the DVM (042 in this case) and the 6-digit display shows the decimal value of the DC voltage measured. The DCV indicator shows that a DC voltage is measured.



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).



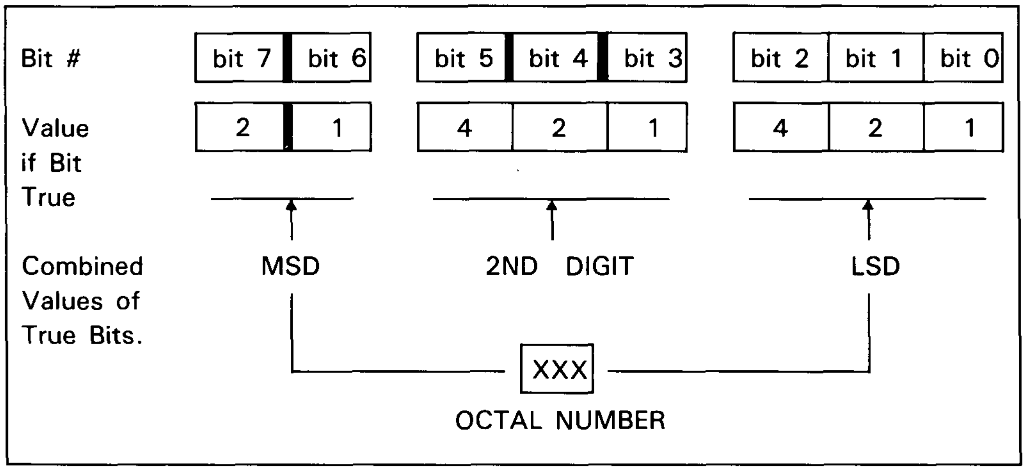
Binary-to-Octal Conversion

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.

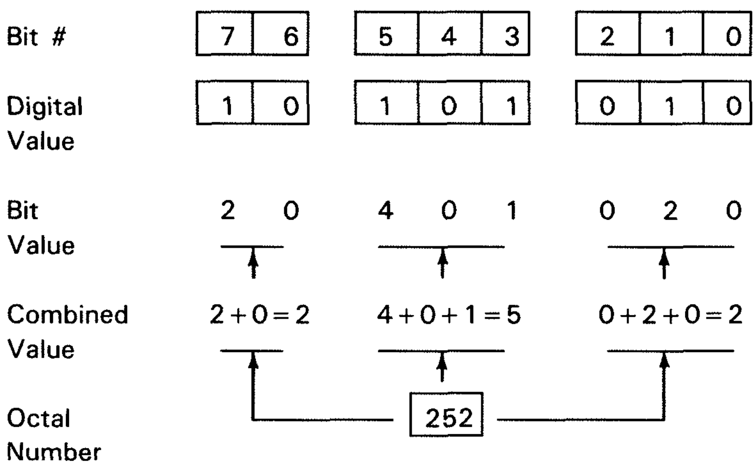
The combined value of bits 6 and 7 which are true forms the MSD of the octal number. The combined value of true bits 3, 4 and 5 forms the second octal digit and the combined value of true bits 0, 1 and 2 forms the LSD of the octal number, as shown.

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.



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.

For example, the ANALOG CLOSE CHANNEL key (numeric 7) has the three modes shown. When the keyboard is in primary mode (SHIFT key not pressed), pressing this key enters AC. Pressing this key a second time then enters the number 7.

However, if the SHIFT key is pressed first, pressing the ANALOG CLOSE CHANNEL key now enters alpha A. Pressing the key again enters another A rather than the number 7 and an invalid command (AA) signal will occur (the 3497A will BEEP at you) and the command sequence will be cancelled.

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 selected analog channel(s). From one to four channels can be closed at a time.
- Sets first channel to be closed in an analog sequence.
- Sets last channel to be closed in an analog sequence.
- Dedicates display to designated analog channel.
- 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 selected channel(s) in slot addressed.
- Open selected channel(s) in slot addressed.
- Read selected slot. Following the command, display shows octal value of true channel bits.
- Dedicates display to selected slot.

VOLTMETER

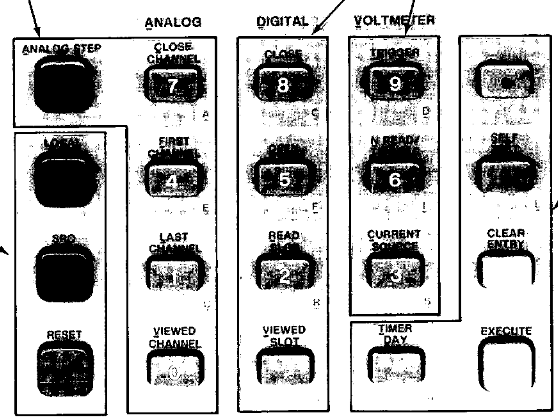
Use these keys to set some functions of the DVM and its current source.

- Set DVM to internal trigger, trigger on external input, software trigger or hold.
- Set number of readings/trigger input.
- 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.

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



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.
- Tests the 3497A internal functions.
- Clears entries if pressed before the EXECUTE key.
- Implements commands entered and prepares 3497A for next command.
- Set Real Time clock to specified time.

POWER ON/OFF SWITCH

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

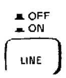
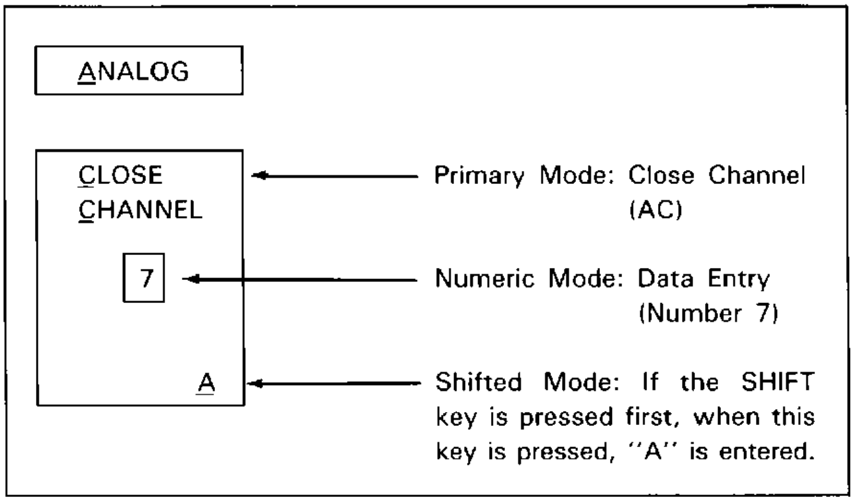


Figure 8. Front Panel Keyboard

ALPHA-NUMERIC KEY MODES



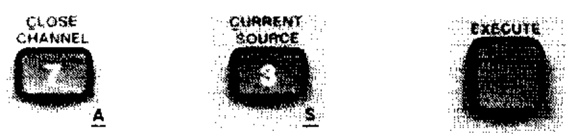
EXAMPLE - CLOSE ANALOG CHANNEL

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.

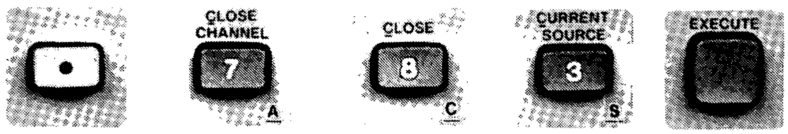
Note that the EXECUTE key also acts as a delimiter. That is, it tells the 3497A that this is the end of this command and sets the 3497A for the next command. If you enter an illegal command, the audible BEEP sounds and the entire (correct) command must be re-entered.

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

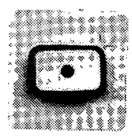
Special Purpose Keys

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.

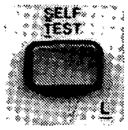
Some typical keystroke sequences are shown to illustrate the function of the keys. In these examples, only the primary mode is shown. However, many of the commands can be entered in shifted mode as well. You may want to practice entering commands by using both methods.

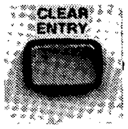
The special purpose keys are used to shift the keyboard to the Alpha mode, self-test the 3497A, clear an undesired entry, execute commands entered and set the real-time clock to a desired time. This key group includes the SHIFT (blue) key, the SELF-TEST key, the CLEAR ENTRY key, the EXECUTE key and the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

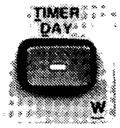
and

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

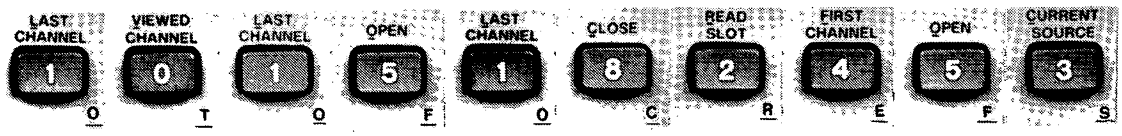
We'll set the clock to Oct 15, 6:24:53 PM. The command to do this is TDn, where n = MM:DD:HH:MM:SS (US format). Press the LINE key on and enter the data as shown.

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

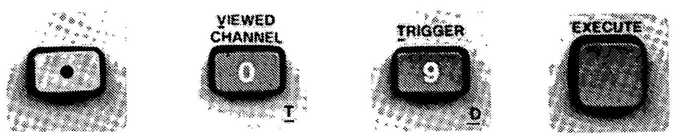


Data Entered	10	15	18	24	53
	10th Month (Oct)	15th day	6PM (24-hr clock)	24 min	53 sec

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

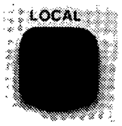


Data Entered	Shifts to Alpha Entries	T	D	Executes TD command to display.

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.

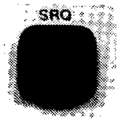
Control Keys

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.

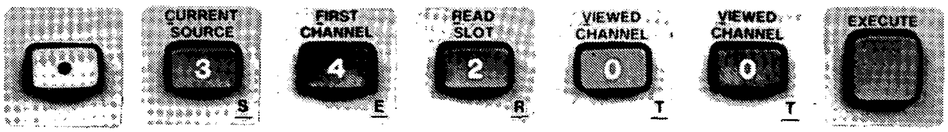
SRQ 

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

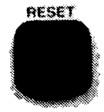
To send an SRQ mesage to a controller by using the front panel SRQ, the first step is to program the 3497A to acknowledge an input from the SRQ key. As described later in Chapter 5, you can do this by entering an SE200 command.

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.

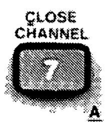
RESET 

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 

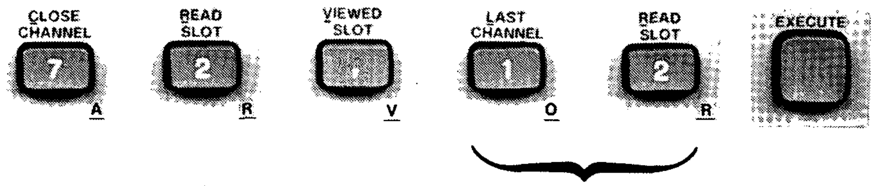
Use the CLOSE CHANNEL key to close from one to four analog assembly channels simultaneously. If more than one channel is to be closed at a time, only one channel/decade can be closed. For example, you can close only one channel at a time in channels 0-9, channels 10-19, etc. up to a maximum of four channels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

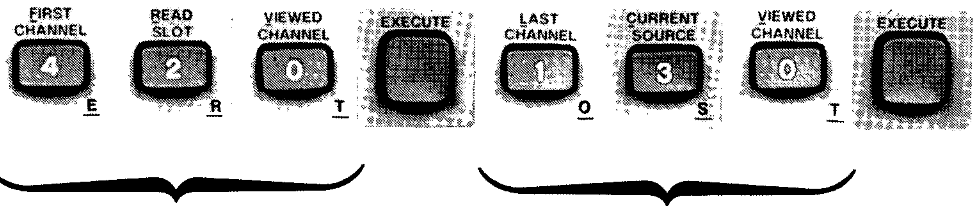
EXAMPLE - STEP ANALOG CHANNELS

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

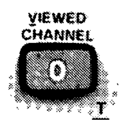
Sets First Channel to 20

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

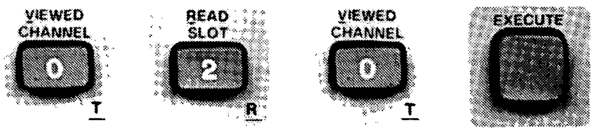
To set channel 20 as the dedicated channel, the command is AV20. To clear a channel from the viewed mode, the command is AV, without a data character.

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:



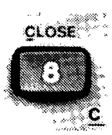
Data Entered: AV 2 0

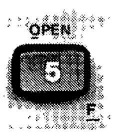
Dedicates channel 20 to Viewed mode.

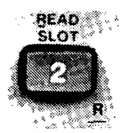
Digital Keys

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).

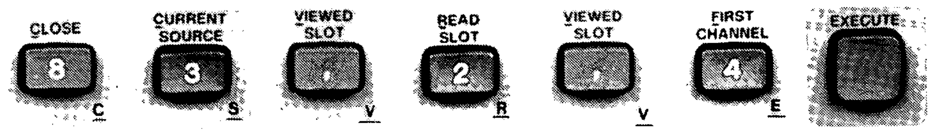
EXAMPLE - CLOSE AND READ DIGITAL CHANNELS

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:

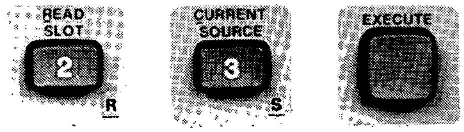


Data Entered:	DC	3	,	2	,	4
	Digital Close	Slot 3 Addressed		Close Chan 2		Close Chan 4

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:

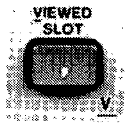
Keystroke Sequence



Data Entered: DR 3

Reads Slot 3 Status

VIEWED SLOT

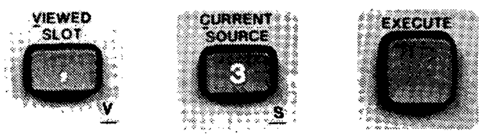


Use the DIGITAL VIEWED SLOT to dedicate the front panel display to a specified slot. The display is updated after a channel is changed (open to closed or closed to open) or when a Digital Read or Digital Load command is sent to that slot. As with VIEWED CHANNEL for analog assemblies, DIGITAL VIEWED SLOT 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

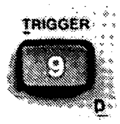
Dedicates Front Panel Display to Slot 3.

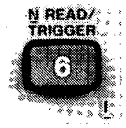
After the EXECUTE key is pressed, the display is as shown. Whenever channels are closed in slot 3, the display will show channels closed and the corresponding octal value.

SLOT
03
VIEWED

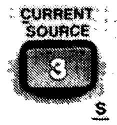
Voltmeter Keys

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.

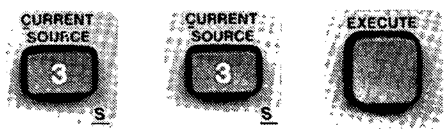
CURRENT
SOURCE 

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.

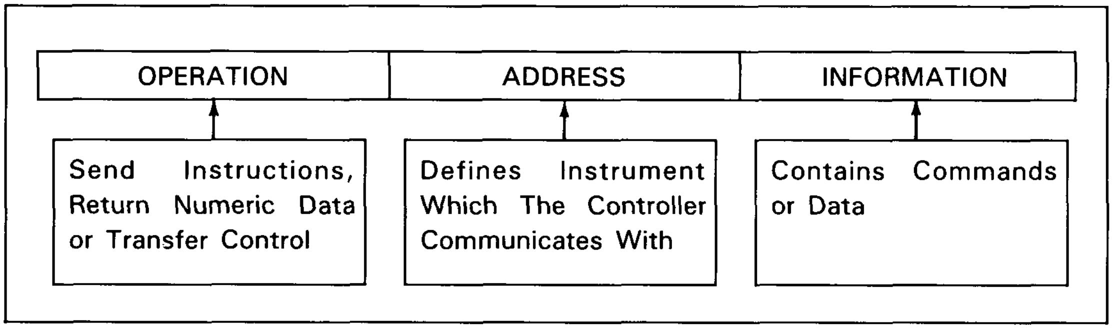
There are 12 HP-IB bus messages (see Appendix A). However, only nine of these are directly applicable to the 3497A. Later on, the 3497A response to these bus messages is summarized. First, let's take a look at the structure of bus messages.

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

7 09

HP-IB Interface Select Code (Preset = 7) → 7

09 ← 3497A Device Select Code (Preset = 09)

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.

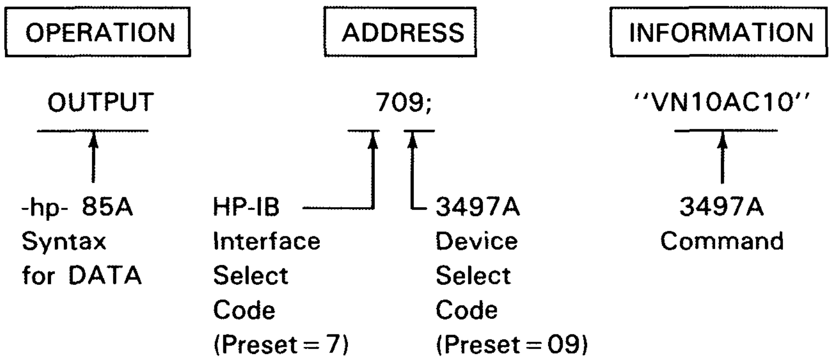
The bus messages must include any delimiters required by the computer language syntax. A delimiter is a character that is used to separate one expression from another or to terminate a list. Delimiters for the 3497A include semicolons, quotation marks, commas and minus (-) signs. The 3497A ignores LF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

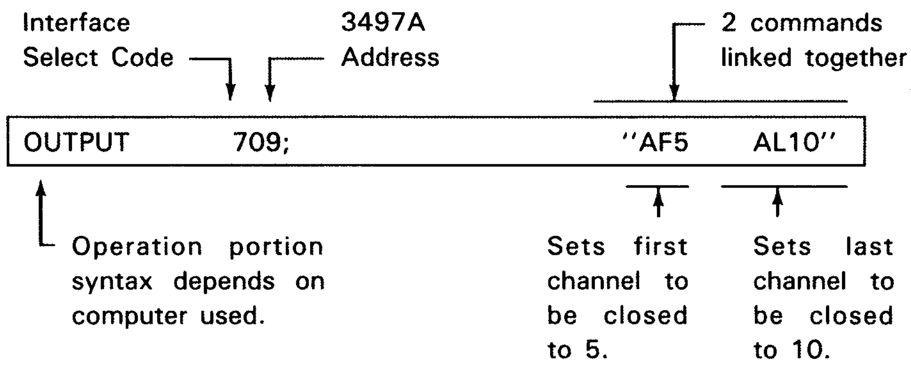
In certain applications, it's convenient to turn the front panel display off for faster reading rates. To do this, enter OUTPUT 709; ''SD0'' into the 85A and press the END LINE key. When this command is executed, the front panel 6-digit display is turned off.

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.

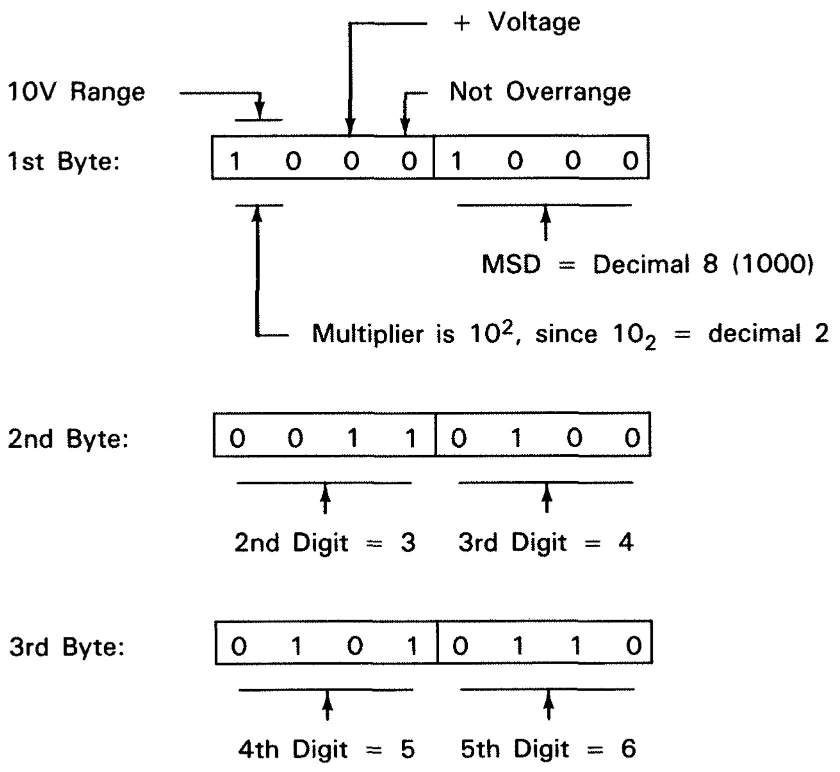
Bit 5 of the first byte is the sign of the measurement. It is 1 for negative voltages and 0 for positive voltages. Bit 4 of the first byte is the overrange indicator and is 1 when the voltage is greater than the range selected. An overload is a voltage which cannot be read and is indicated by 199999.

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	An OUTPUT message causes the 3497A to take action specified by the command(s) in the message.
	ENTER	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

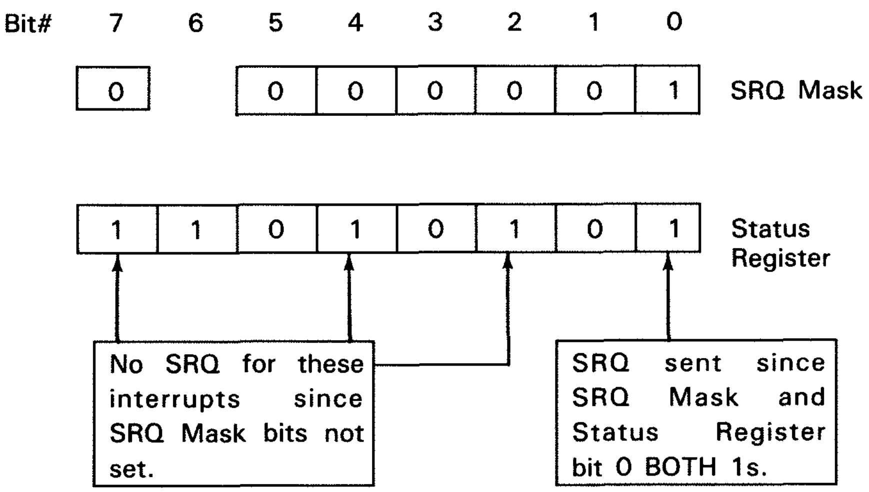
To send SRQ when the 3497A is turned on, set bit 5 of the SRQ Mask by placing the POWER ON SRQ ENABLE switch in the 3497A to the 1 position. Then, at power-on bit 5 of the Status Register is set and SRQ is generated. If the POWER ON SRQ ENABLE switch is in the 0 position, Status Register bit 5 is NOT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

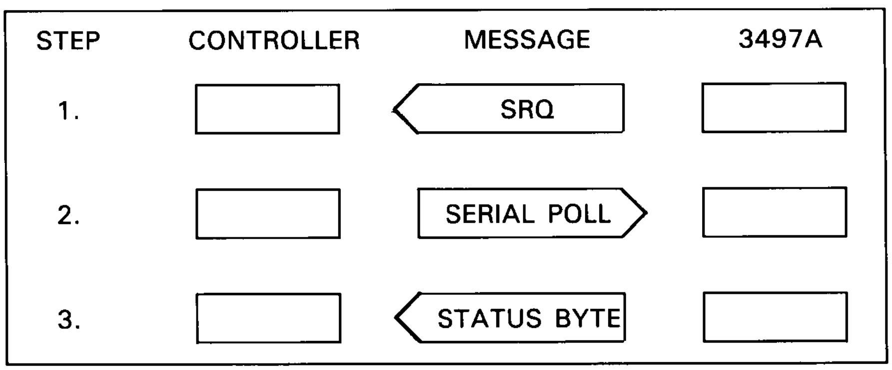
```
P = SPOLL 709      (-hp- 85A)
STATUS 709;P       (-hp- 9845 A/B)
```

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.

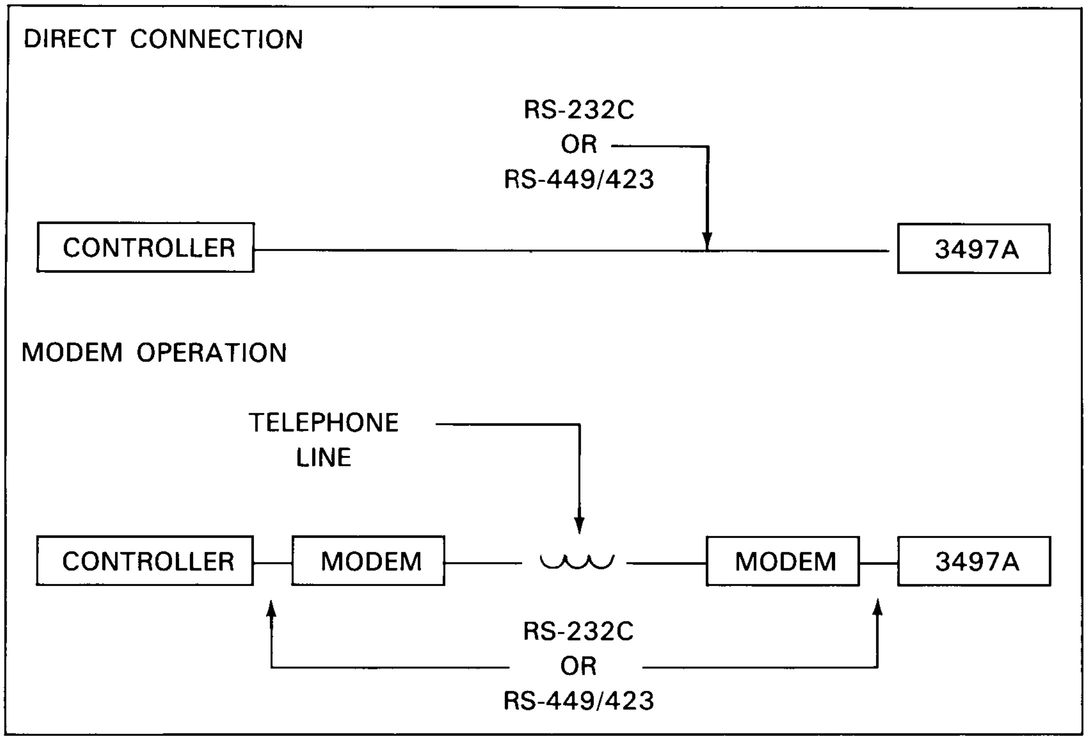
With RS-232 operation, the 3497A can be located a maximum of 50 feet (15.24 meters) from the controller. With RS-449/423 operation, the maximum separation depends on the speed of operation. For example, for data rates up to 1000 bits per second, maximum cable length between the controller and the 3497A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

= 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

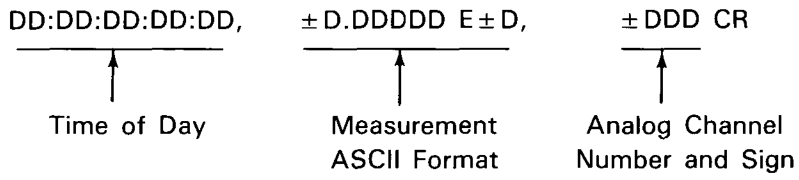
Voltage Measurement:	± D.DDDDD E±D CR
Time of Day:	DD:DD:DD:DD:DD CR
Elapsed Time:	DDDDDDDDDD CR (First 4 Digits are Zeroes)
Digital Read or Digital Load:	OOOOOO CR (0-177777 Octal)
Digital Interrupt:	000OOO CR (Last 3 digits are 0-377 Octal)
Counter Totalize:	DDDDDD CR
Counter Period or Pulse Width:	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.



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.

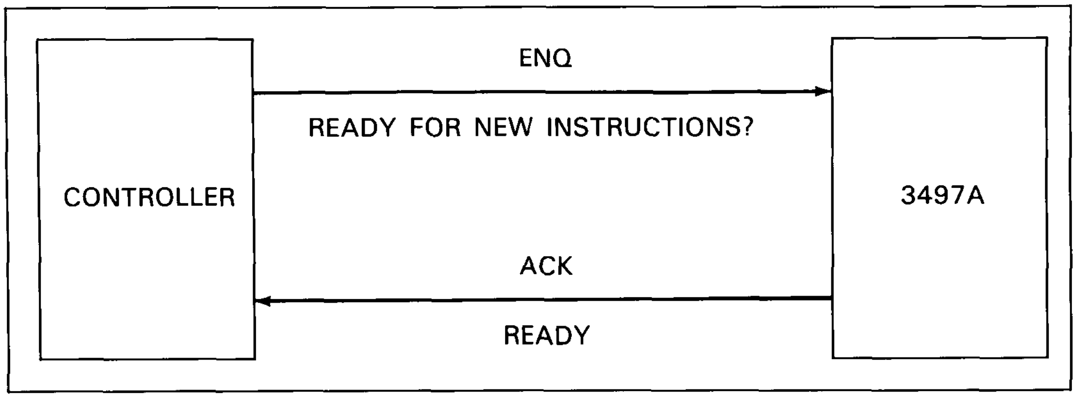
Enquire/Acknowledge (ENQ/ACK)

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
Man SRQ	SRQ	Pon SRQ	Msg Not Exec	Time Intrv	Time Alarm	Dig Intr	I/O Error
← 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	Line	Description
10 RESET 10	10	Clears Serial Interface
20 OUTPUT 10; "TD1015182453"	20	Sets time to Oct 15, 6:24:53 PM.
30 OUTPUT 10; "TD"	30	Reads time of day.
40 ENTER USING "#,K"; A	40	Stores time of day in variable A.
50 PRINT A	50	Prints time of day.
60 END		

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
50 ! Main Program		when break occurs.
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
1020 PRINT A		bits in status register in
1030 STATUS 10,1;B		variable A.
1040 RETURN	1020	Prints octal value.
	1030	Clears the 85A Status/Control register so it can accept next BREAK.
	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	0	14	0	All MODEM lines OFF.
		13	0	All MODEM lines OFF.
		12	0	All MODEM lines OFF.
4th Digit	0	11	0	CTS MODEM line OFF.
		10	0	DSR MODEM line OFF.
		9	0	No system overrun.
3rd Digit	1	8	0	No buffer overflow.
		7	0	No manual SRQ.
		6	1	BREAK due to interrupt.
2nd Digit	0	5	0	No Power-On SRQ.
		4	0	No msg not exec cond.
		3	0	No time interval intr.
(LSD)	4	2	1	Time alarm interrupt.
		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 20 FOR I=1 TO 20 30 OUTPUT 10 ; "AI";I+19	30	Closes channel I and measures volts on channel
50 PRINT I+19,A 60 NEXT I 70 END	40-60	Enters and prints chan 1 voltage

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	**S**ystem **A**larm	Set the 3497A to produce an audible alarm, for applications such as interrupts.	118
SC	**S**ystem **C**lear [Serial Data]	Reset the 3497A from a controller (Serial Data ONLY).	118
SD	**S**ystem **D**isplay	Turn the front panel display ON or OFF.	120
SE	**S**ervice Request **E**nable [HP-IB]	Enable the 3497A for Service Request to interrupt the controller (HP-IB ONLY).	121
SE	**S**ervice Request **E**nable [Serial Data]	Enable the 3497A for Service Request to interrupt the controller (Serial Data ONLY).	126
SI	**S**ystem **I**nitialize	Reset digital assemblies and the DVM to power-on condition.	130
SL	**S**ystem **L**ock [Serial Data]	Disable the keyboard so that commands cannot be entered from the front panel (Serial Data ONLY).	131
SO	**S**ystem **O**utput 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	**S**ystem Single/ Continuous **O**utput [Serial Data]	Set the 3497A to send one reading/command for commands which normally produce continuous output (Serial Data ONLY).	134
SR	**S**ystem **R**ead	Determine the type of assembly in a slot or (for Option 140) read the contents of a specified register.	135
SR	**S**tatus **R**egister Read [Serial Data]	Read the contents of the 3497A status register (Serial Data ONLY).	137
ST	**S**elf **T**est	Set the 3497A to perform an internal self-test.	139
SV	**S**ystem **V**iew	Set the 3497A for front panel display of value sent from the controller.	140
SW	**S**ystem **W**rite	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,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 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
Digit	MSD (Always Zero)	5th digit	5th digit	5th digit	4th digit	4th digit	4th digit

Bit	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
Digit	3rd digit	3rd digit	3rd digit	2nd digit	2nd digit	2nd digit	LSD	LSD	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 controller 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 format). (HP-IB).
20 OUTPUT 10; "TD2405183230"	!Sets the clock for May 24 @6:32:30 PM (Option 231 format). (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$	10	Dimension A as a string variable, since data entered has : entries.
50 END	20-40	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"             !Halts the elapsed time count
20 ENTER USING 10 "#,K";A       process and displays the time (in
30 DISP A                       sec) since the TE2 command was
40 END                          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.

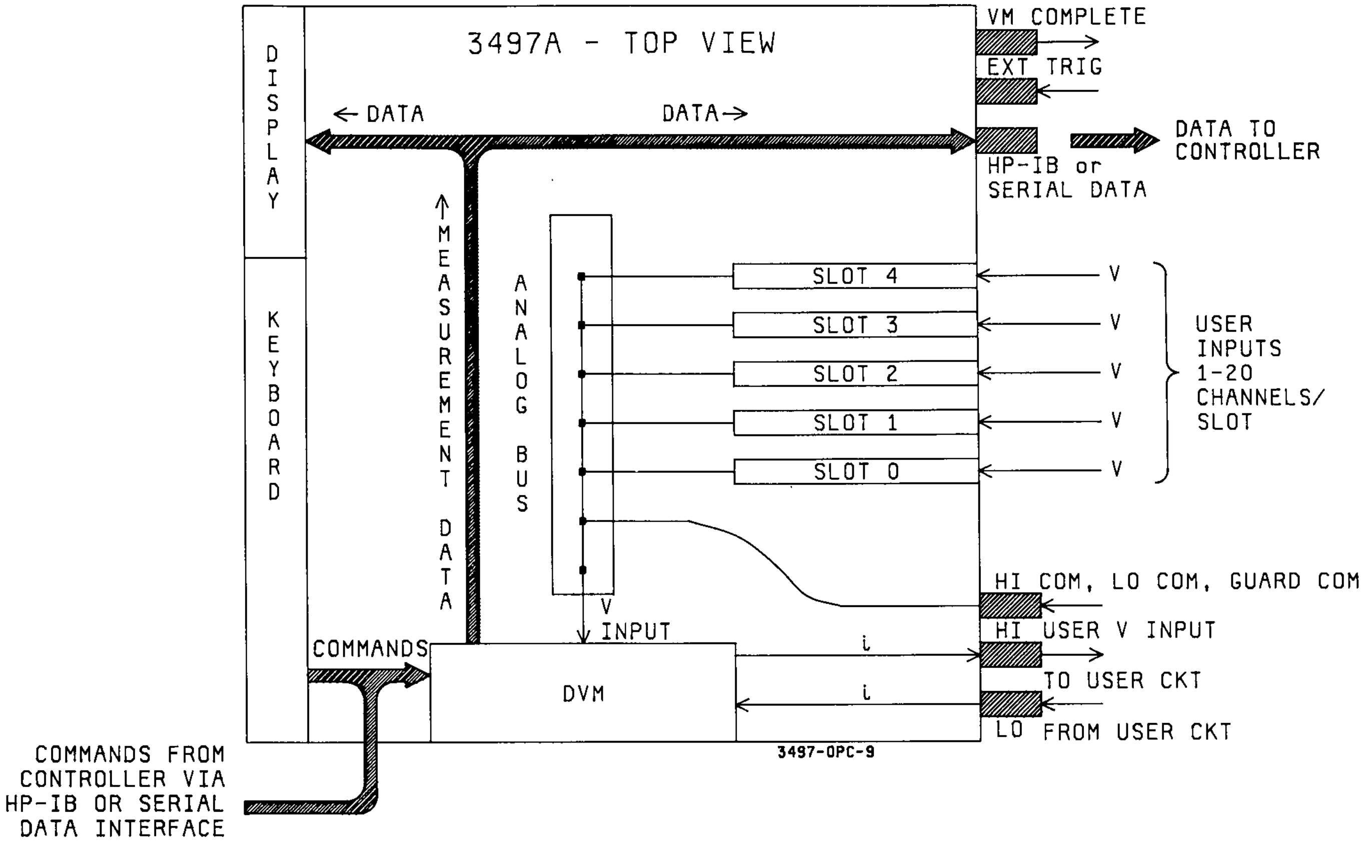


Figure 9. DVM Data Flow Block Diagram

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.

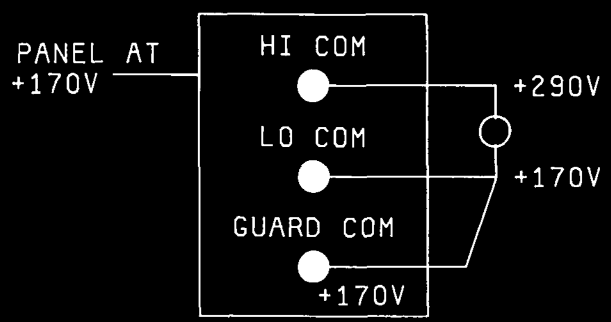
When voltages are input to analog assemblies, sequential channel-to-channel scanning (at speeds up to 300 channels/second) is available. If measurement of a single voltage is required, the voltage may be input from the rear panel connectors. As shown in Figure 9, the DVM uses a three-wire (HIGH, LOW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

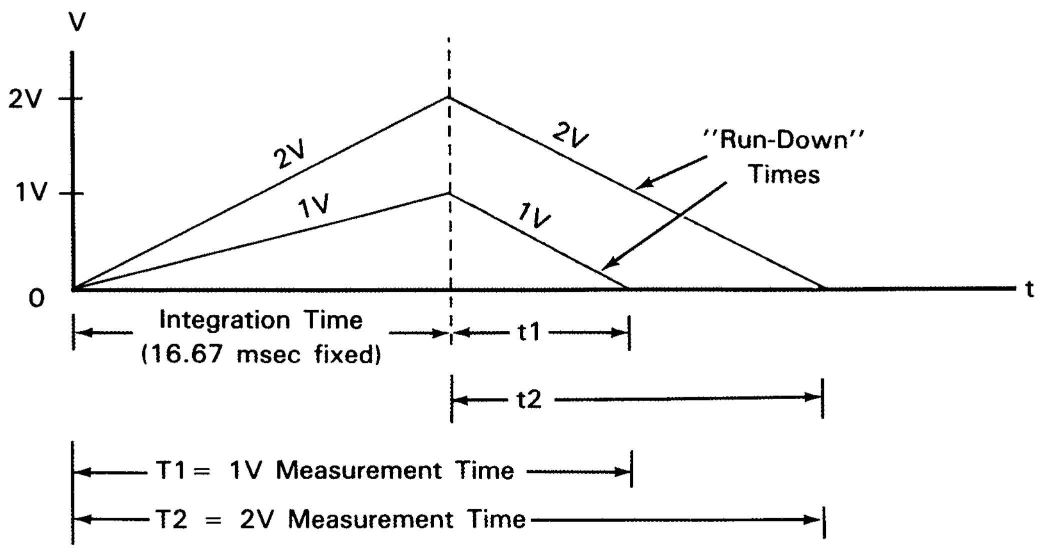
Another important concept for the DVM is integration time. Integration time is the time period, in PLCs, during which the input voltage is sampled by the voltmeter. Note that integration time is NOT the same as measurement time.

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.

VDn	Digits	Power Line Cycles	Max Readings/Sec (60 Hz) Autozero ON	Max Readings/Sec (60 Hz) 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 (VS0 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		
70 DISP "INPUT NUMBER OF READINGS (100 OR LESS)" 80 INPUT N 90 OUTPUT 709; "VT4VF2VS2VN";N;"AE1VT3" 100 WAIT 1000	90	VT4 = Trigger Hold VF2 = Packed BCD VS2 = Store in Packed BCD VN = N Reading/Trigger AE1 = Enable EXT INCR port VT3 = Single Trigger
TRANSFER N READINGS TO 85A (IN PACKED BCD FORMAT)		

```
110 OUTPUT 709; "SO1VS"
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	Lines	Description
10 CLEAR 709 20 DIM A$[16] 30 OUTPUT 709;"TD0611130000VF3"	20	A must be string variable since : is transferred
40 PRINT "TIME OF DAY";TAB(17); "VOLTS"; TAB(26); "CHAN" 50 FOR I = 1 TO 10 60 OUTPUT 709; "AI";I 70 ENTER 709; A$,V,C	30	Sets time of day and single triggers DVM
80 PRINT A$; TAB(17);V;TAB(26);C 90 WAIT 1000 100 NEXT I 110 END	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 received 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.

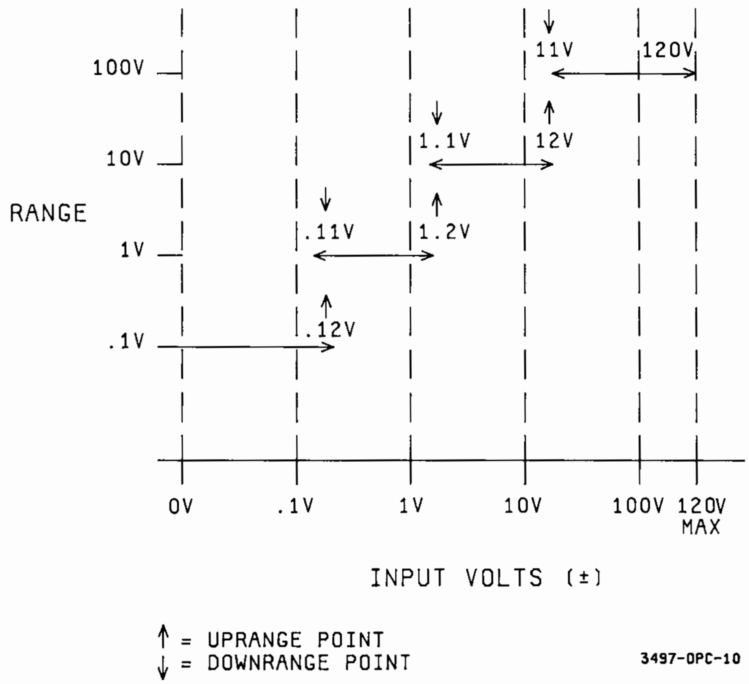


Figure 10. DVM Autorange Hysteresis

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
 |     |     |     |
 |     |     |     └─► Sends single trigger to the DVM.
 |     |     |
 |     |     └─► Sets the DVM to take 5 readings/trigger.
 |     |
 |     └─► Turns on Voltmeter Storage in ASCII mode.
 |
 └─► 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 VSO (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.

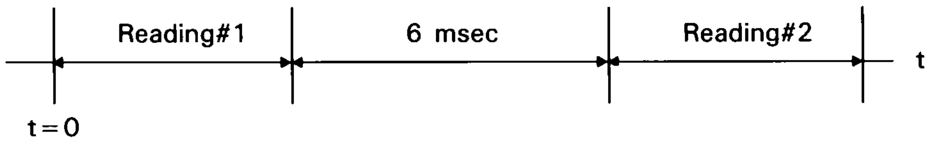
VOLTMETER WAIT (VW)

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

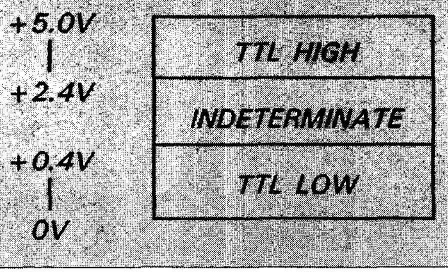
As shown in Figure 11, there are six BNC connectors located on the right rear panel of the 3497A. VM COMPLETE (Voltmeter Complete), CHANNEL CLOSED and TIMER are output ports, EXT TRIG (External Trigger) and EXT INCR (External Increment) are input ports and BBM SYNC (Break-Before-Make Synchronization) 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

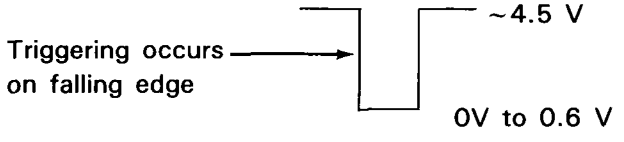
The 3497A requires the following TTL voltage levels for proper operation (+2.4V to +5V = TTL HIGH and 0V to +0.4V = TTL LOW).



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:

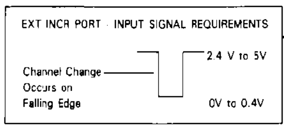
EXT TRIG PORT - INPUT SIGNAL REQUIREMENTS



EXT INCR

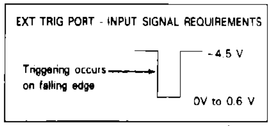
If the port is enabled by an AE1 or AE2 command, a TTL pulse input to the EXT INCR (External Increment) port steps the 3497A from the present analog channel to the next higher (or next lower) analog channel.

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

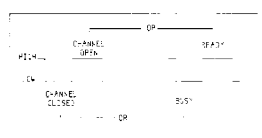
When the DVM is set for external trigger with a VT2 command, a low-going TTL pulse input to the EXT TRIG port causes the DVM to take one or more readings (as set by the VNn command), then set idle and wait for the next trigger input.

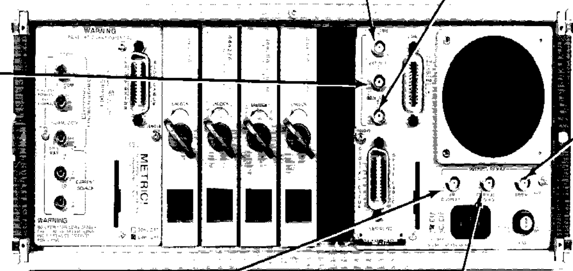


BBM SYNC

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.

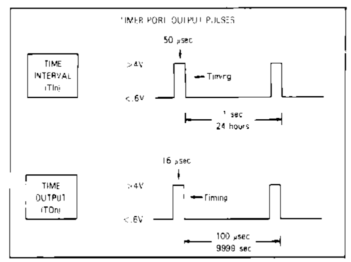
When two or more mainframes are connected together, the signal levels out of the BBM SYNC port are defined as BUSY for LOW (channel closed) or READY for HIGH (channel open) conditions.





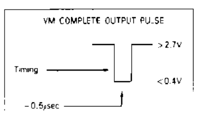
TIMER

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.

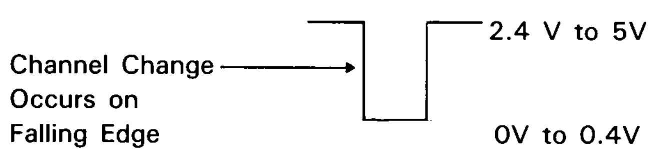
Line 30 halts the program so that an external trigger be input to the EXT TRIG port to start the DVM measurements. After the trigger has been input, you can continue the program by pressing the CONT key on the -hp-85A.

```
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).

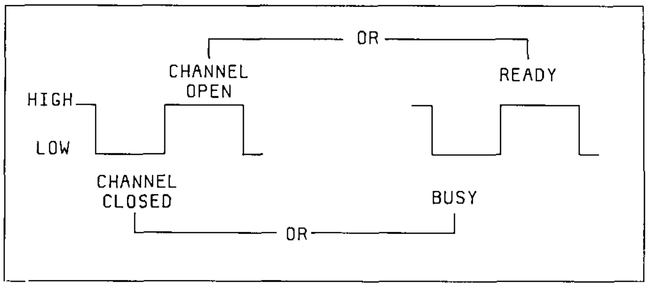
```
 10 PRINT "CHANNEL";TAB(15);"VOLTAGE"
 20 PRINT
 30 DIM A(30)
 40 CLEAR 709
 50 OUTPUT 709; "VT4AF20AL29AE1AC20"
 60 FOR I = 20 TO 29
 70 OUTPUT 709; "SO1VT3"
 80 ENTER 709; A(I)
 90 PRINT I;TAB(17);A(I)
100 WAIT 1000
110 NEXT I
120 END
```

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.

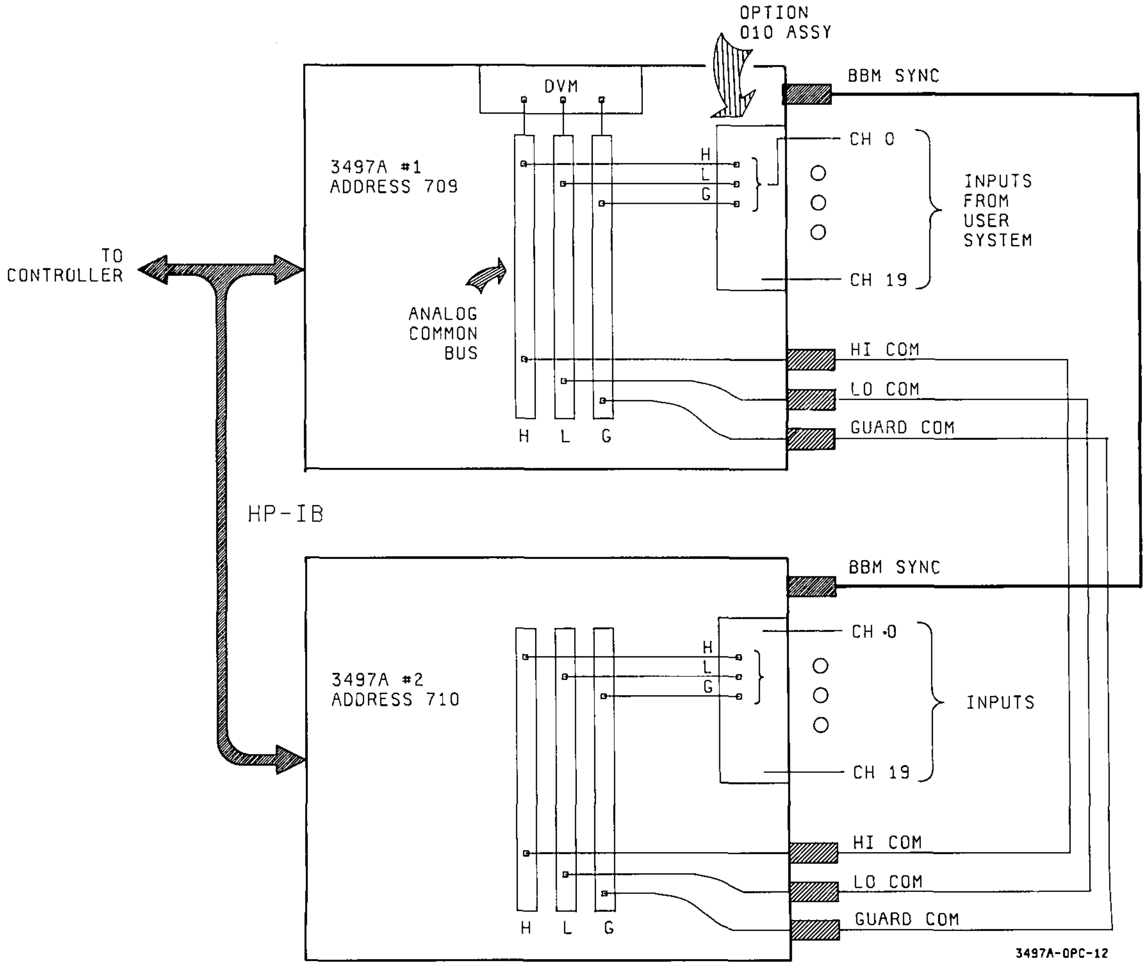
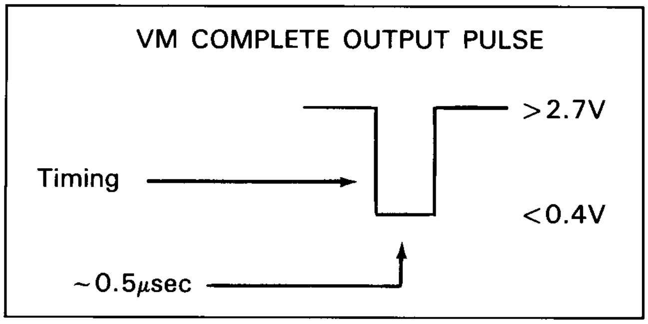


Figure 12. Using the BBM SYNC Port

VM COMPLETE Port

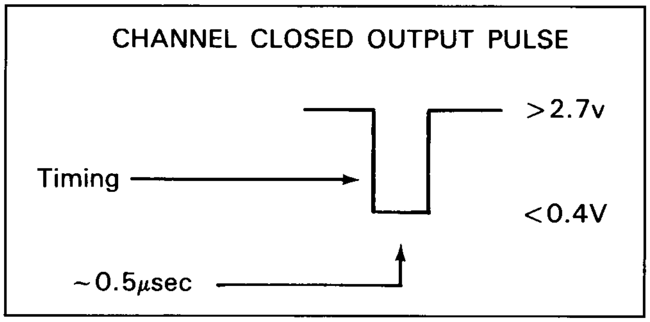
When the voltmeter completes a measurement, a TTL pulse of approximately 0.5 μsec is available at the VM COMPLETE port. The characteristics of the output pulse are shown. Note that the VM COMPLETE port does not have to be enabled by a command. For an example of how this port can be used, see the description 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.



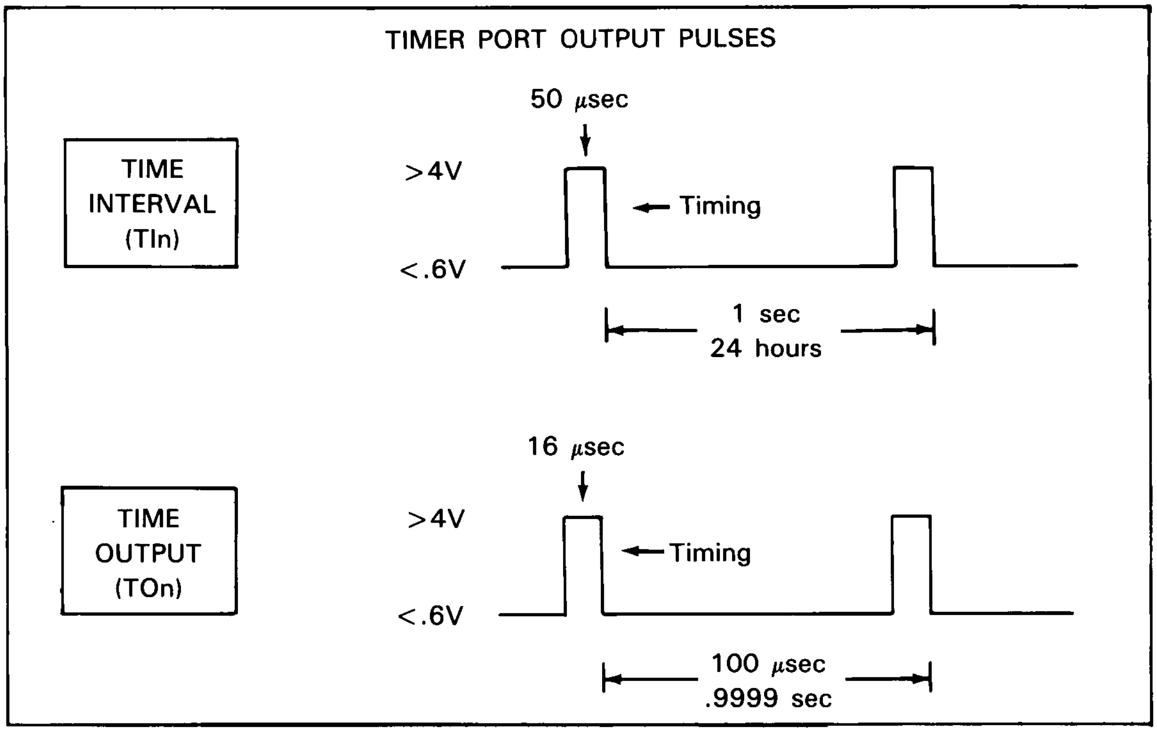
TIMER Port

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

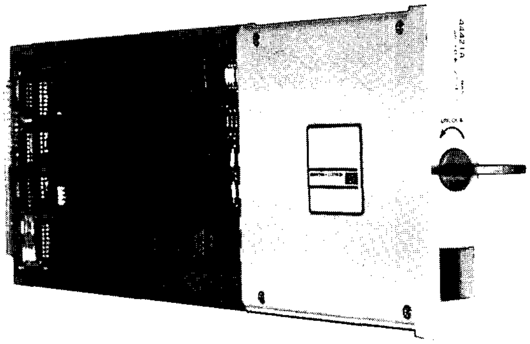
This part of the chapter shows how to use the 3497A commands to control the operation of the plug-in assemblies (Options 010 through 140). Assemblies are presented in order of increasing option number from 010 to 140. Thus, to set up and control the plug-in assemblies you are using in your 3497A or 3498A, 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).

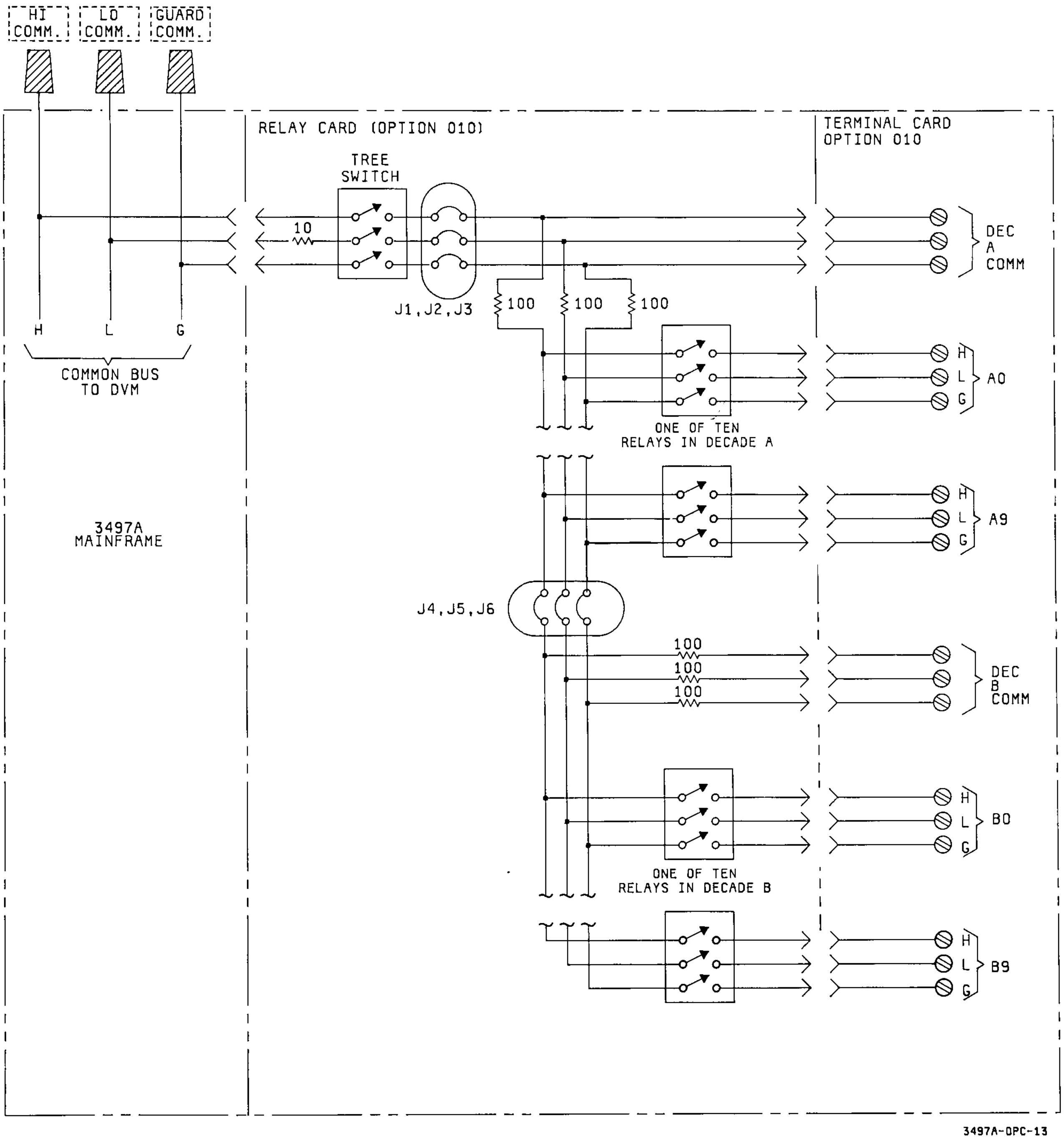


Figure 13. Option 010 - Simplified Operation

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

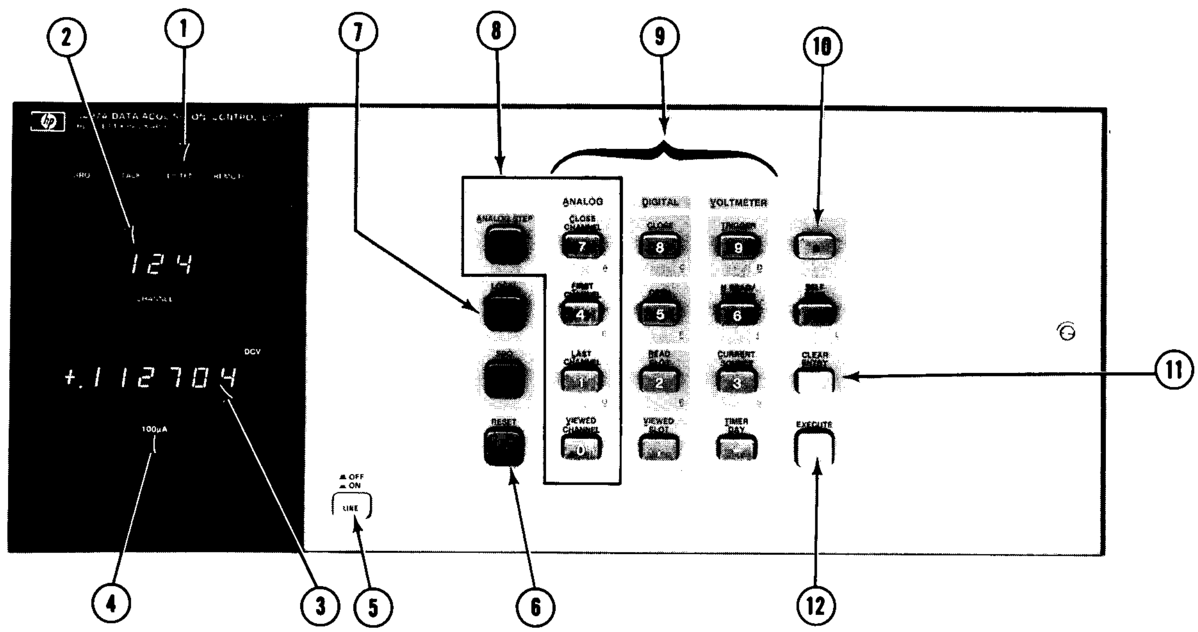
Figure 14 identifies front panel keys used with the relay multiplexer and shows their functions. Since the relay multiplexer is an analog assembly, only the analog display is used. When a channel is closed, the 3-digit display shows the number of the channel closed and the 6-digit display shows the value 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).

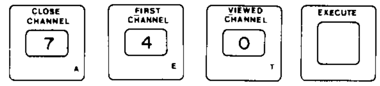
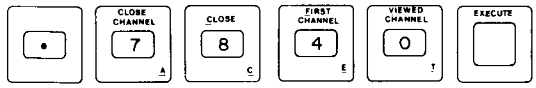
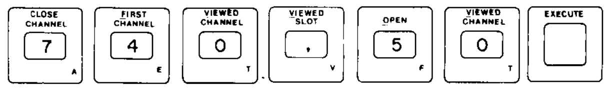
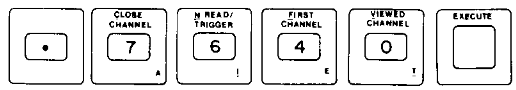
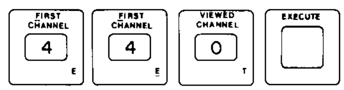
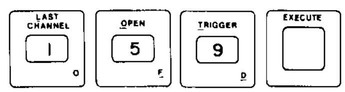
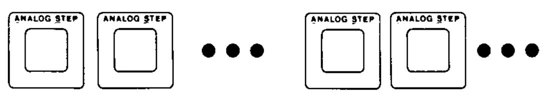
(10) SHIFT: Shifts keyboard (9) to shifted mode (A,C,D, etc). When pressed, light in center of key is ON.

(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

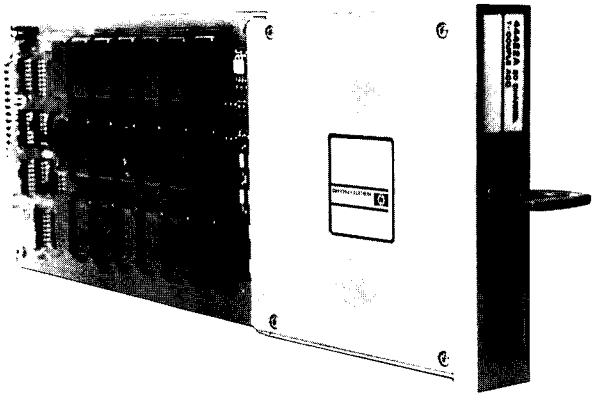
Action(s)	Command(s)	Example Programs
CLOSE CHANNEL 40, INPUT VALUE AT CHANNEL 40.	''AC40''	10 CLEAR 709 20 OUTPUT 709 ; ''AC40'' 30 ENTER 709 ; A 40 PRINT A 50 END
CLOSE CHANNELS 40,50;* INPUT VALUE AT CHANNEL 40, TRIGGER DVM TO TAKE MEASUREMENT.	''AC40,50'' AND ''AI40''	10 CLEAR 709 20 OUTPUT 709 ; ''AC40,50'' 30 OUTPUT 709 ; ''AI40'' 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).

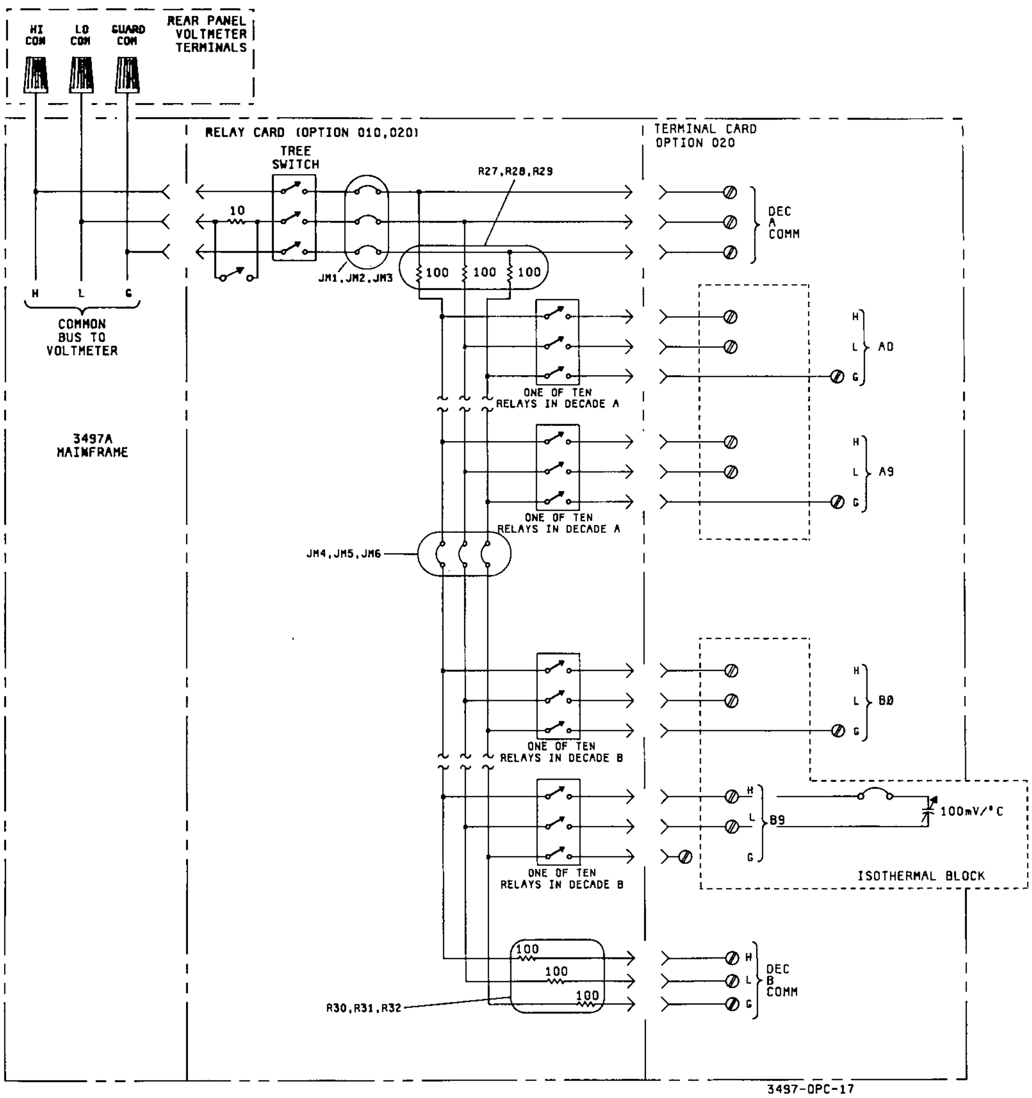


Figure 17. Option 020 - Simplified Schematic

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

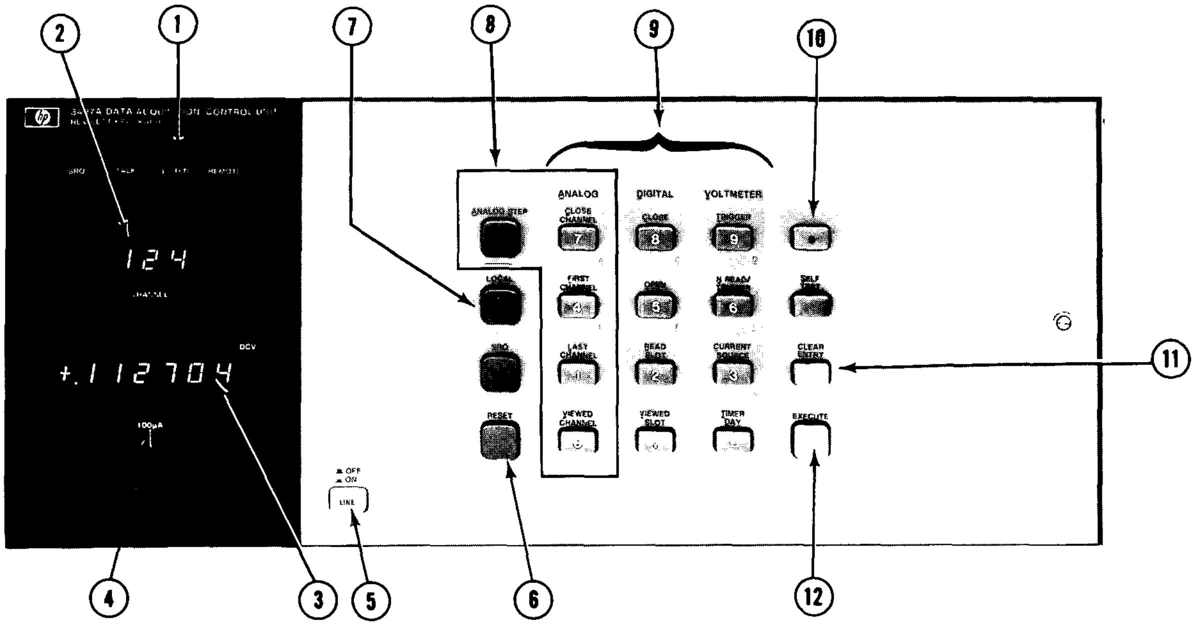
The 20 channel relay multiplexer with thermocouple compensation is controlled with the ANALOG command group. The following chart summarizes the ANALOG commands to control the assembly. For details and sample sequences, see the Command Directory in Chapter 6.

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

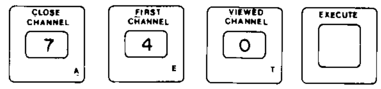
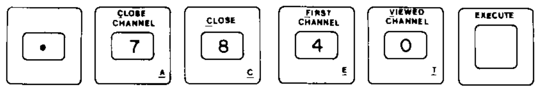
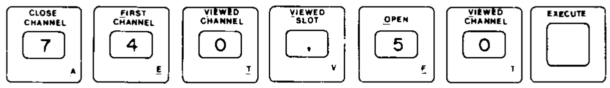
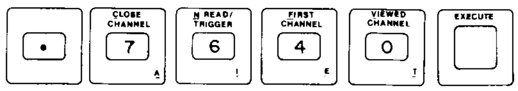
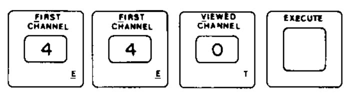
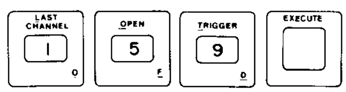
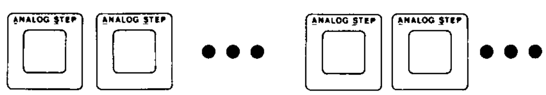
Terminal Card Channel	Address for Assembly in Slot:				
	0	1	2	3	4
A0	0	20	40	60	80
A1	1	21	41	61	81
A2	2	22	42	62	82
.	.	.	.	.	.
.	.	.	.	.	.
A9	9	29	49	69	89
B0	10	30	50	70	90
B1	11	31	51	71	91
.	.	.	.	.	.
.	.	.	.	.	.
B9	19	39	59	79	99

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.

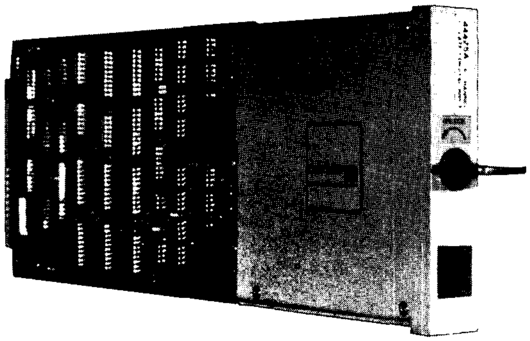
Sample Command Sequences - Remote (HP-IB) Operation

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.

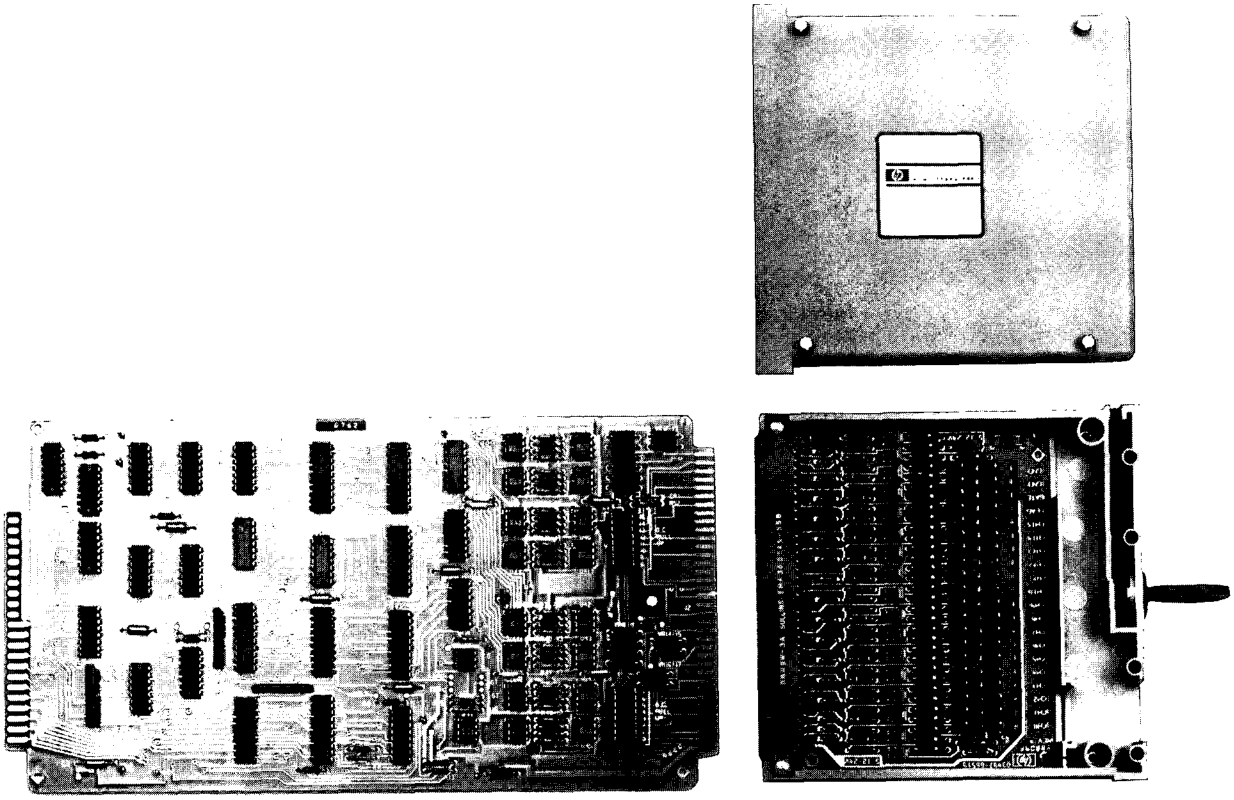
You can use the digital input mode to sense up to 16 lines of digital data such as the outputs of limit switches and position indicators. Use the interrupt mode to interrupt and take corrective action when immediate reaction to a level change is required or when the signal is transient (as in a momentary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

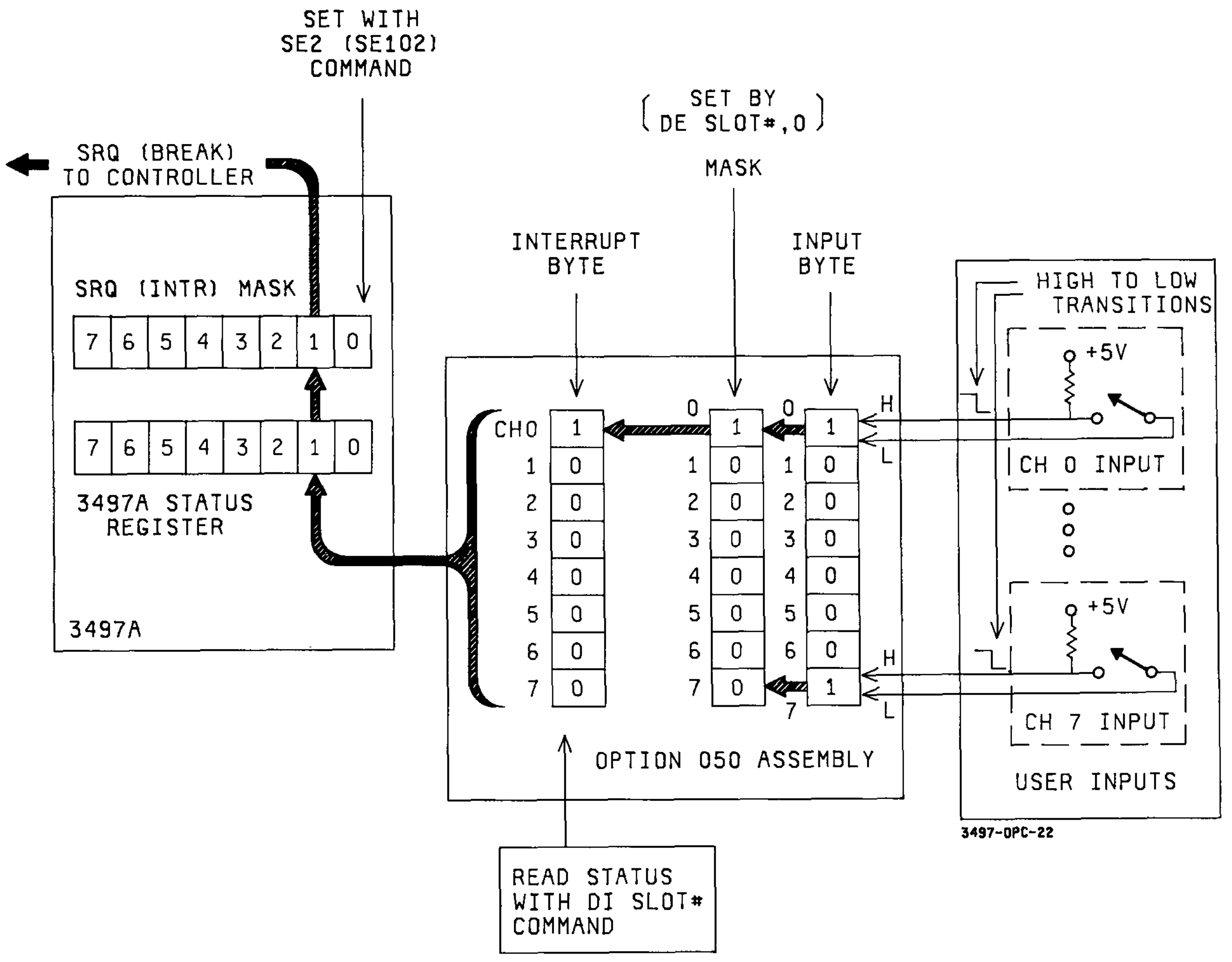


Figure 22. Option 050 - Interrupt Mode

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.

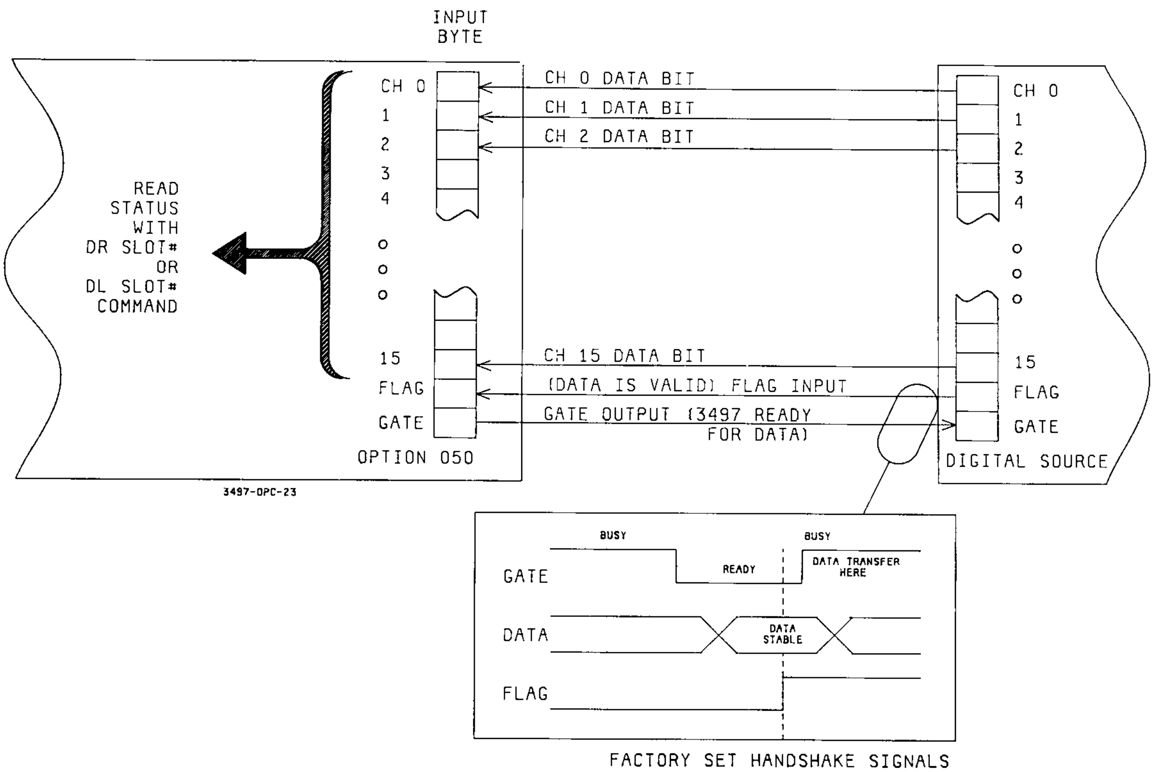


Figure 23. Option 050 - Digital Input Mode

Controlling the Option 050 Assembly

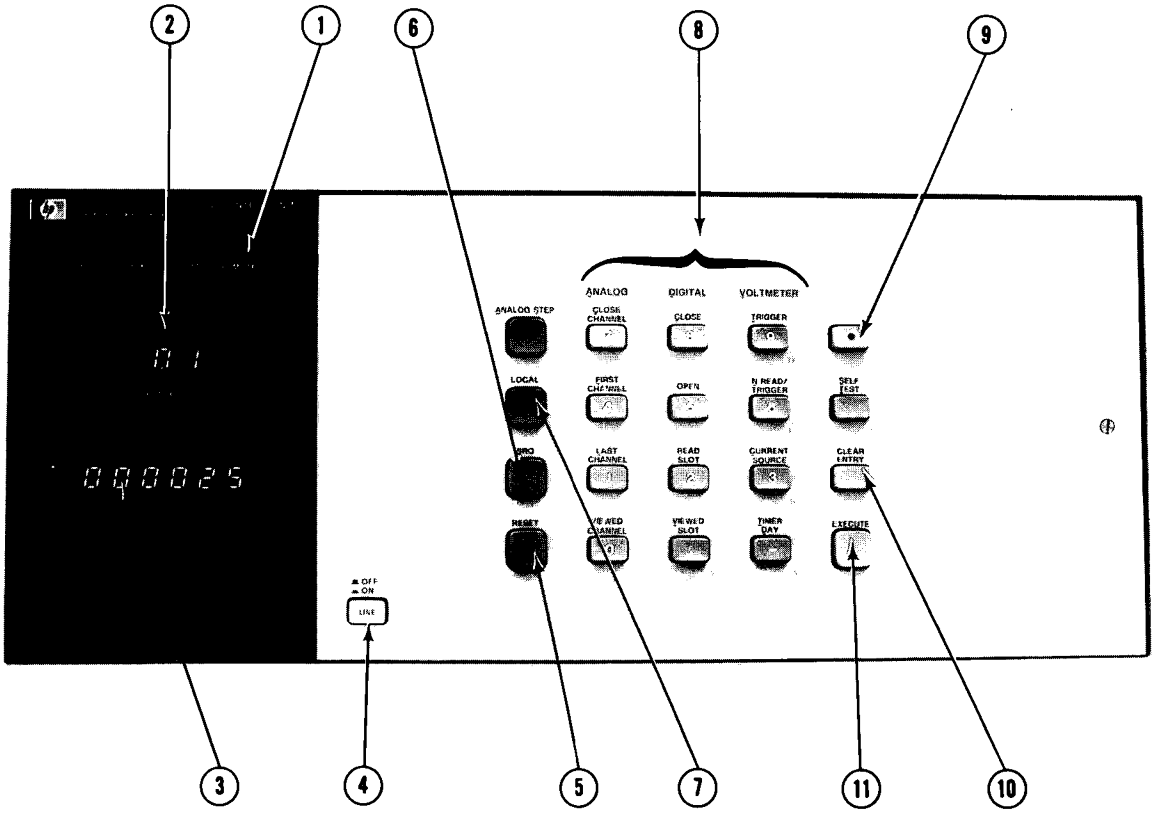
For both interrupt and digital input. the Option 050 assembly is controlled by the DIGITAL command group. The following chart summarizes the DIGITAL commands to which the assembly responds. See the Command Directory in Chapter 6 for details and examples.

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.

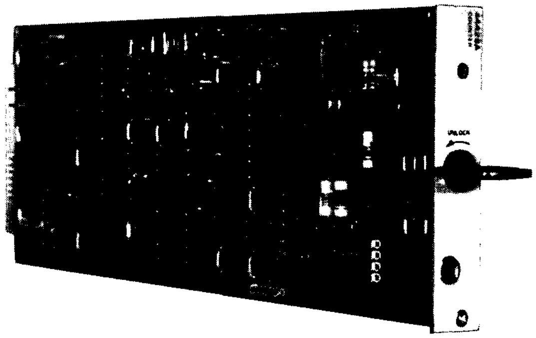
EXAMPLE - READ DIGITAL SLOT

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.

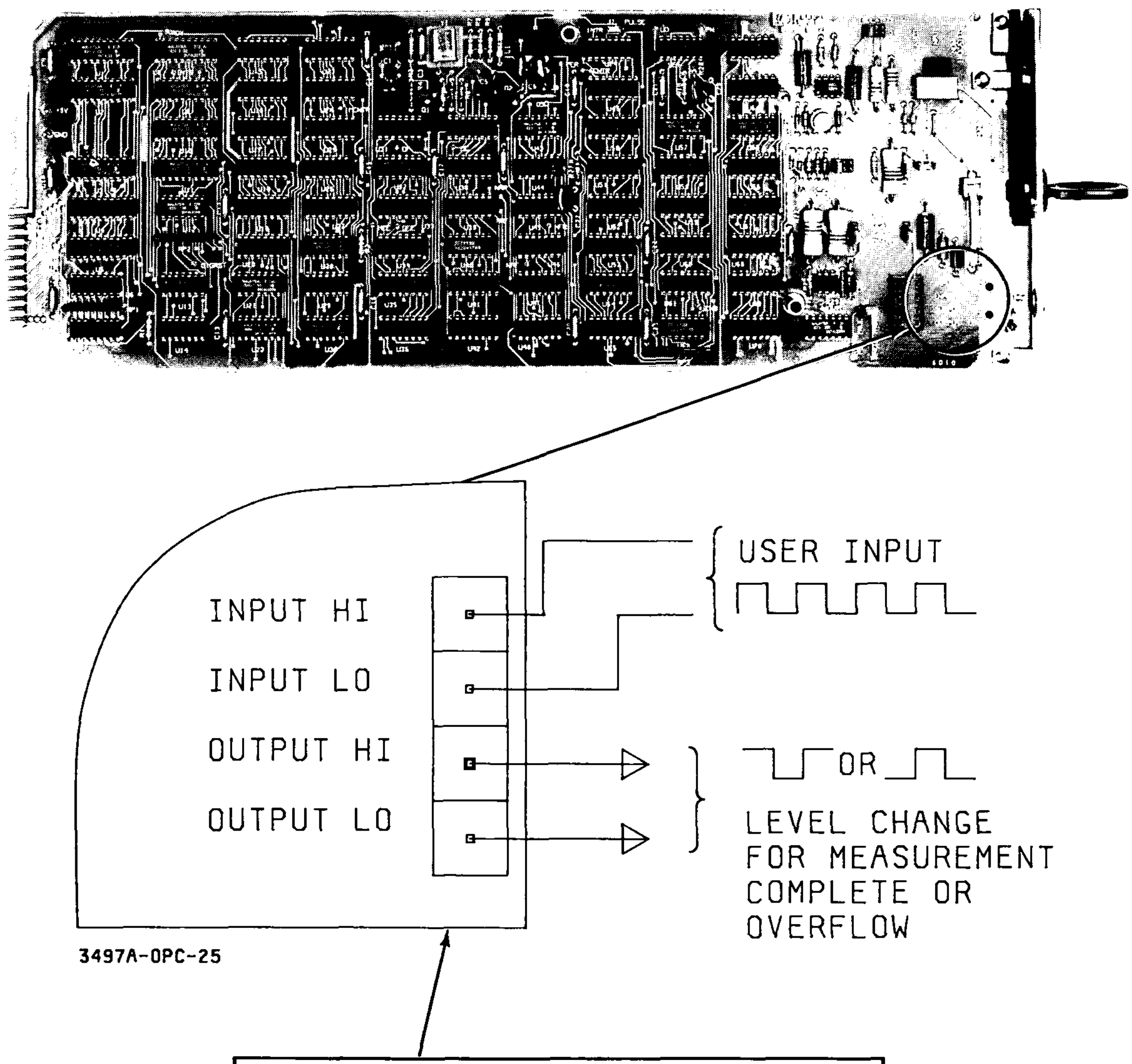
The counter can accept a wide variety of input signals including CMOS, open collector TTL and passive contact closures. The counter is very flexible and can be configured for many measurement configurations. All counter functions, interrupts and trigger modes are fully programmable. The counter can be 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.

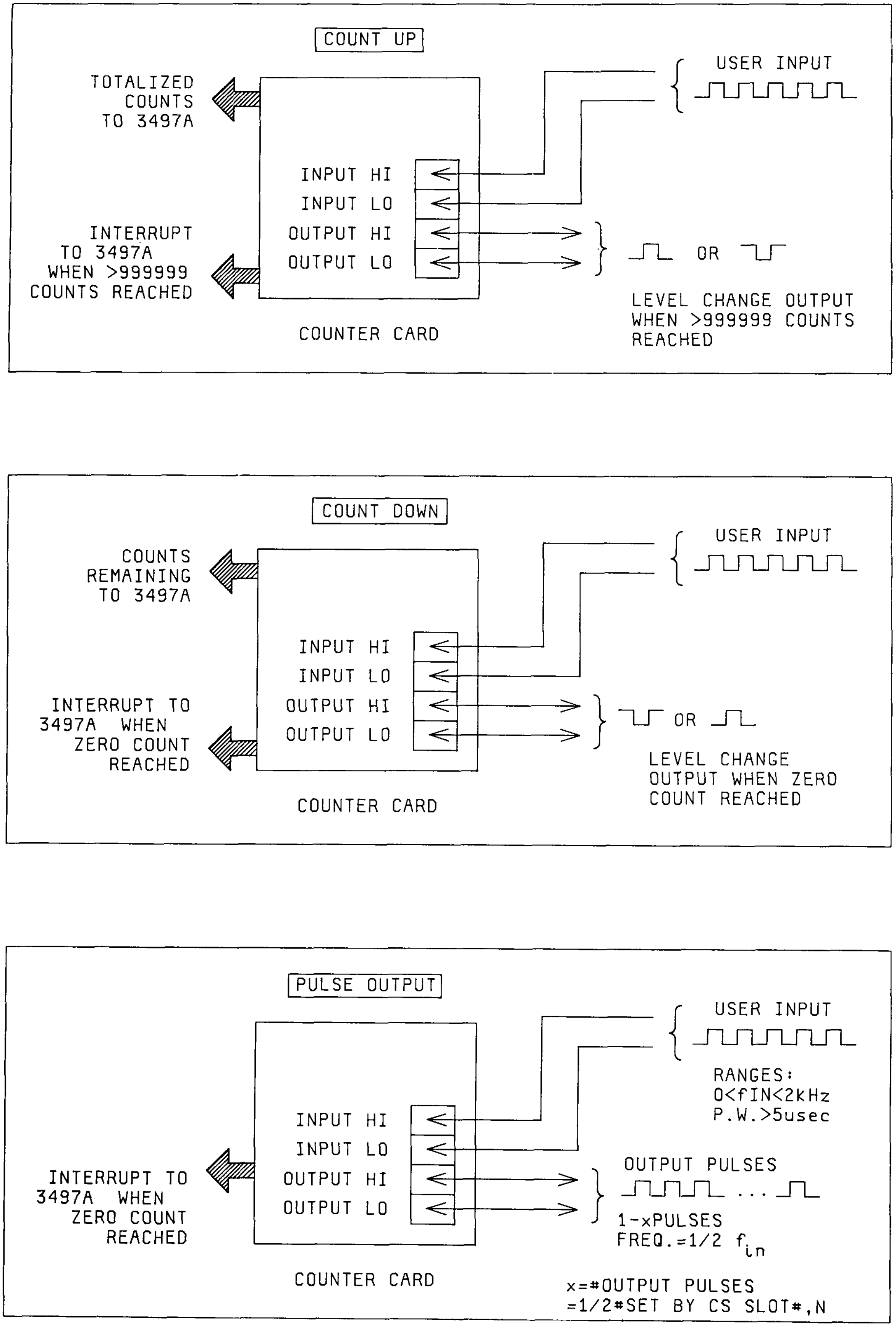
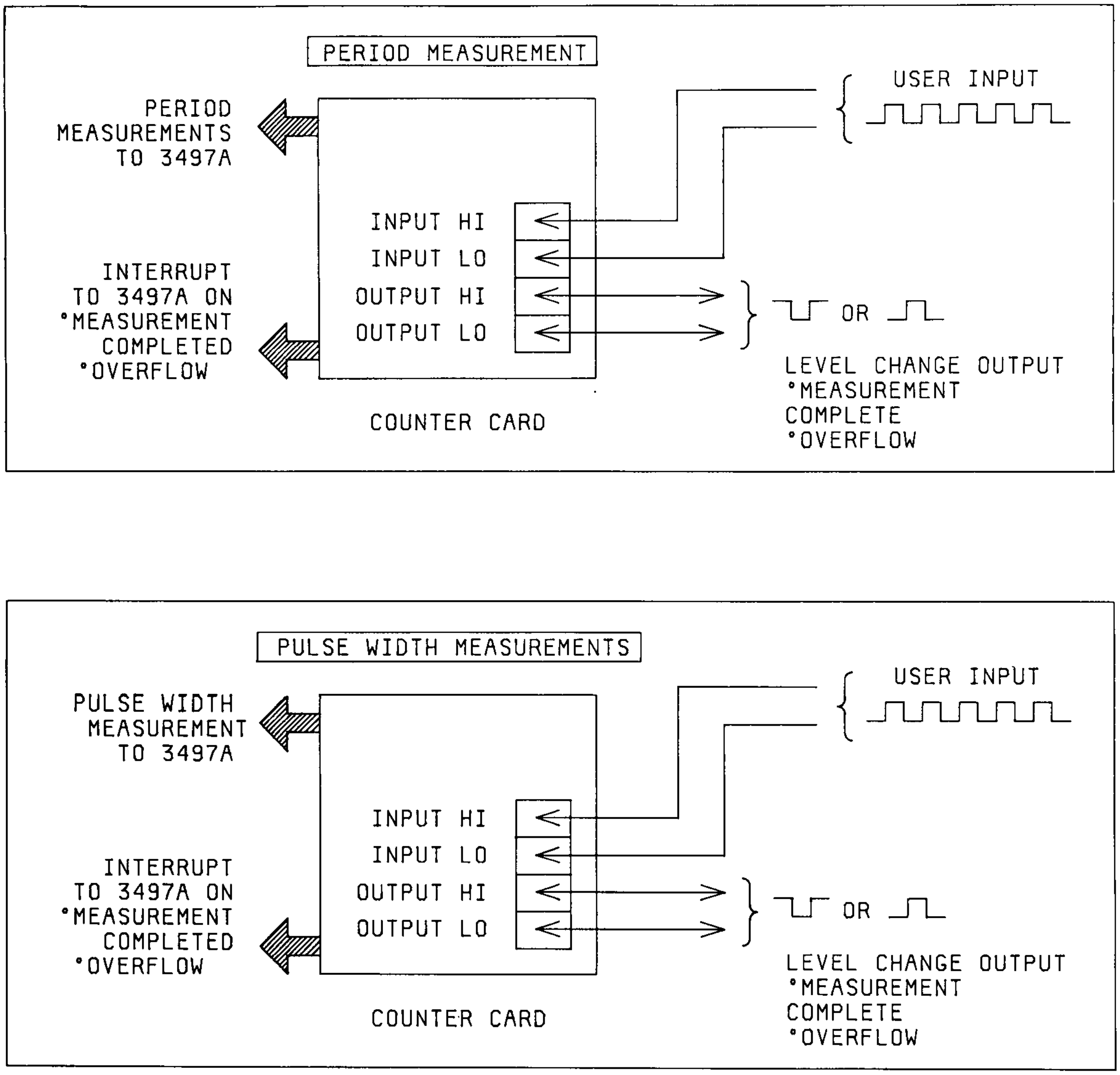


Figure 26. Option 060 - Modes of Operation



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.

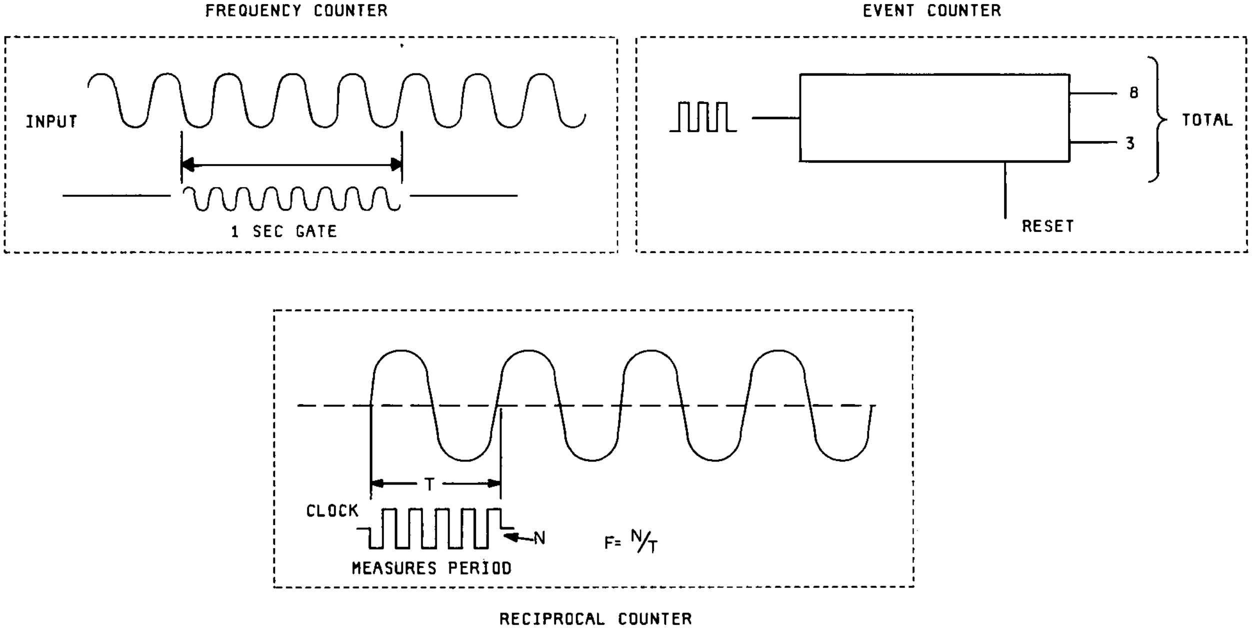


Figure 27. Option 060 · Counter Measurement Techniques

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.

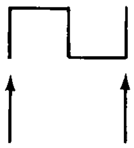
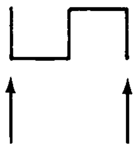
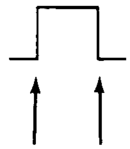
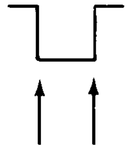
Select Trigger Edges (CT slot#,n) Command

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

CF Slot#, n		CT 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).

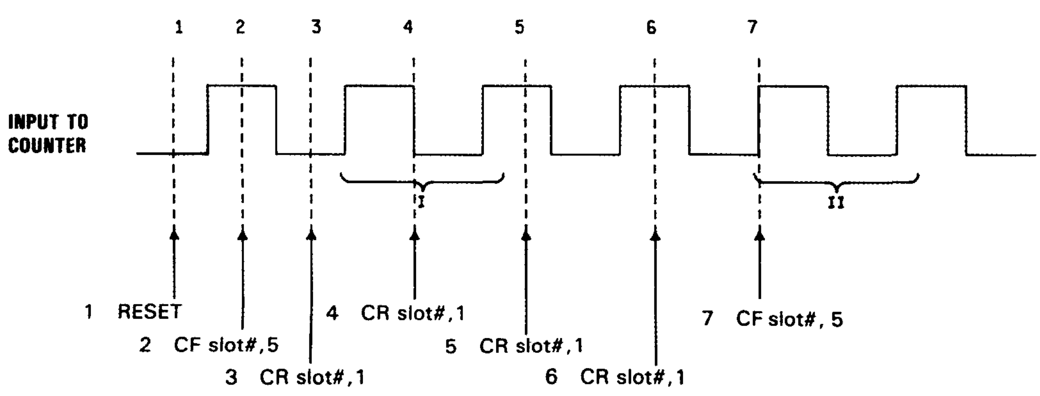
DATA AVAILABLE AFTER A COUNTER READ COMMAND

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)

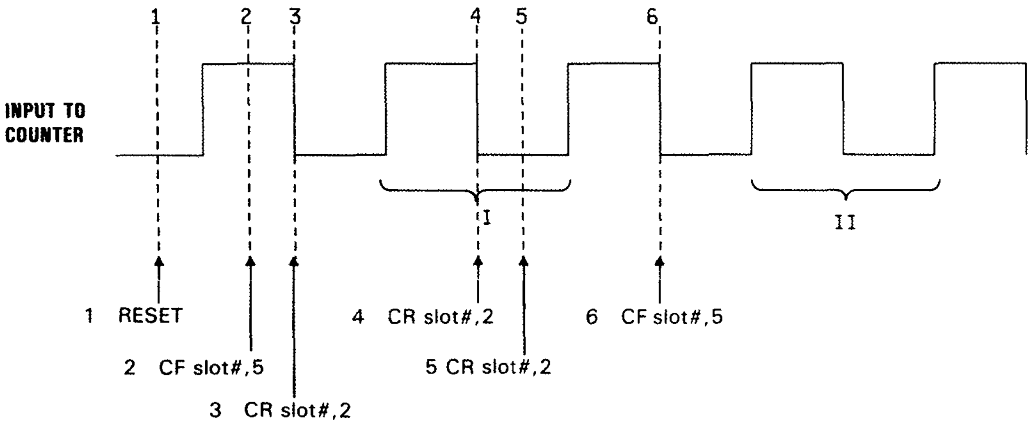
With the read with wait command, results are returned only after the measurement is completed. For period or pulse width measurements, all data is accumulated and averaged (if required) and the 3497A waits for the completed measurement before outputting data to the interface.

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''.

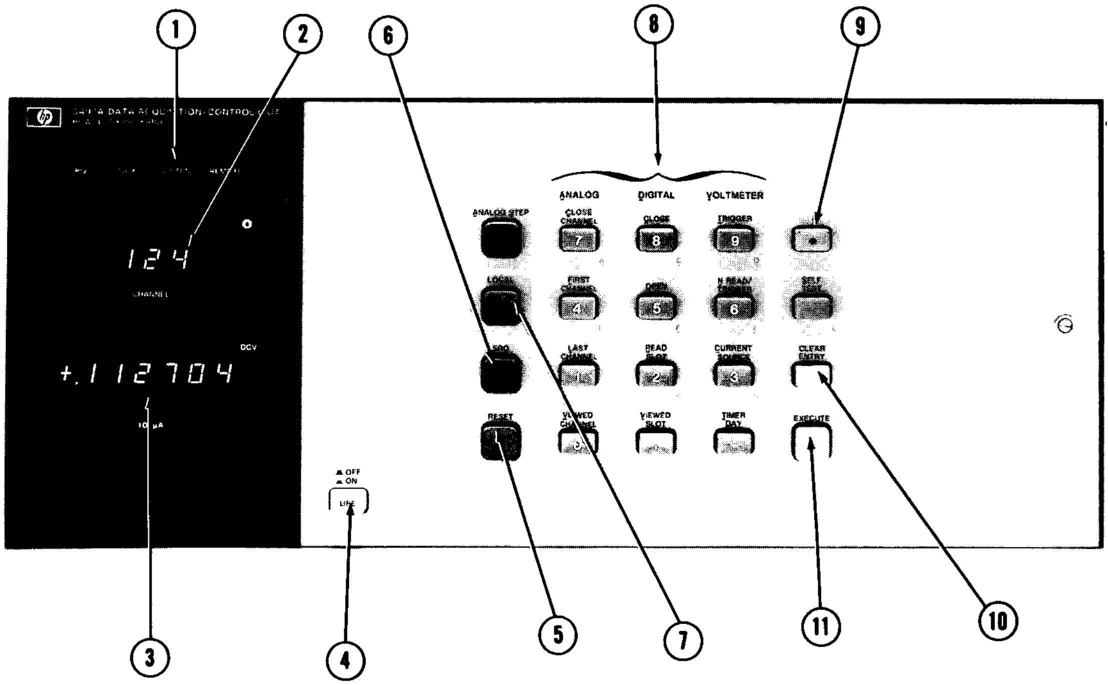
EXAMPLE - SETTING COUNTER FOR INTERRUPT ON COUNT UP OVERFLOW

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.

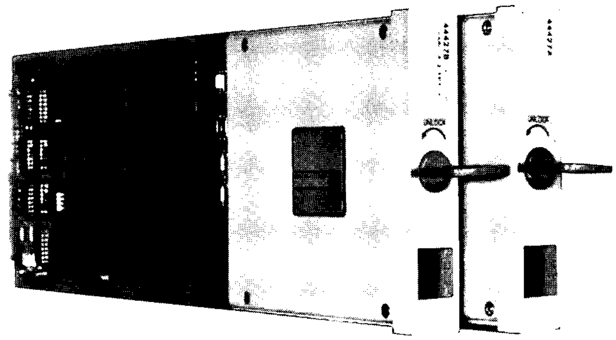
Except for counter internal trigger (CR slot#,3), all counter commands have the same interpretation for HP-IB and Serial Data. Unless indicated, all programs apply to both HP-IB and Serial Data operation.

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.

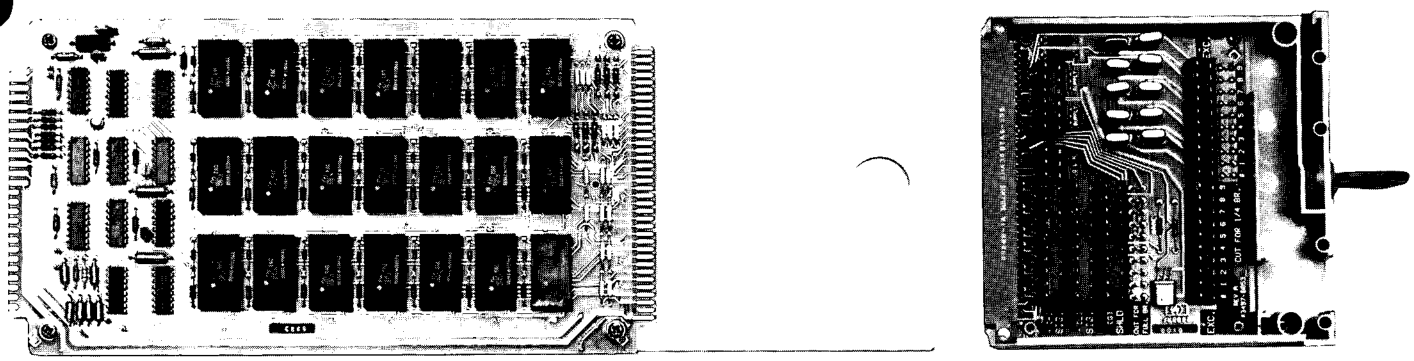
The assemblies require an external (user-supplied) power supply for bridge excitation and a DVM (such as the internal 3497A DVM, -hp- 3456A voltmeter or equivalent DVM). Initial voltmeter readings for bridge excitation and bridge unbalance are used to solve bridge equations, thereby eliminating the need 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.

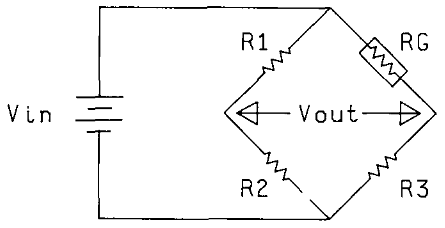
Strain

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.

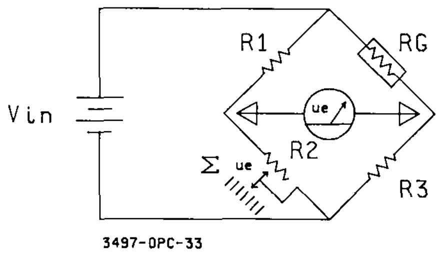
$$GF = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\epsilon} \qquad (1)$$

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.



WHEATSTONE BRIDGE CIRCUIT



BRIDGE CIRCUIT WITH PROVISION FOR BALANCING THE BRIDGE

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 $\mu\epsilon$ ($\epsilon \times 10^6$). 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.

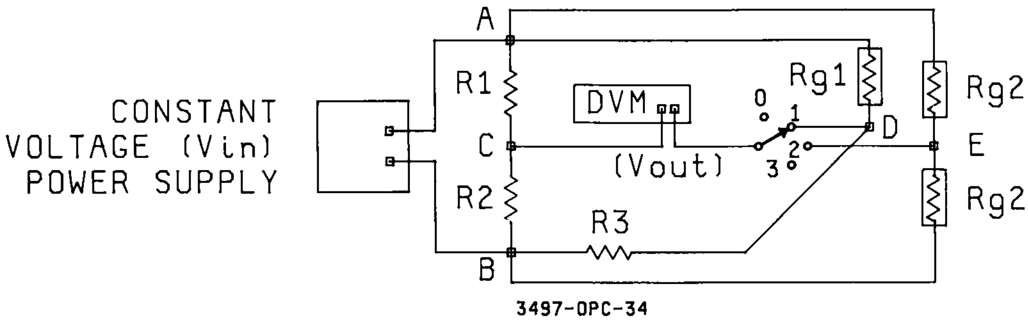


Figure 34. Options 070/071 - Bridge Circuits for Assemblies

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.

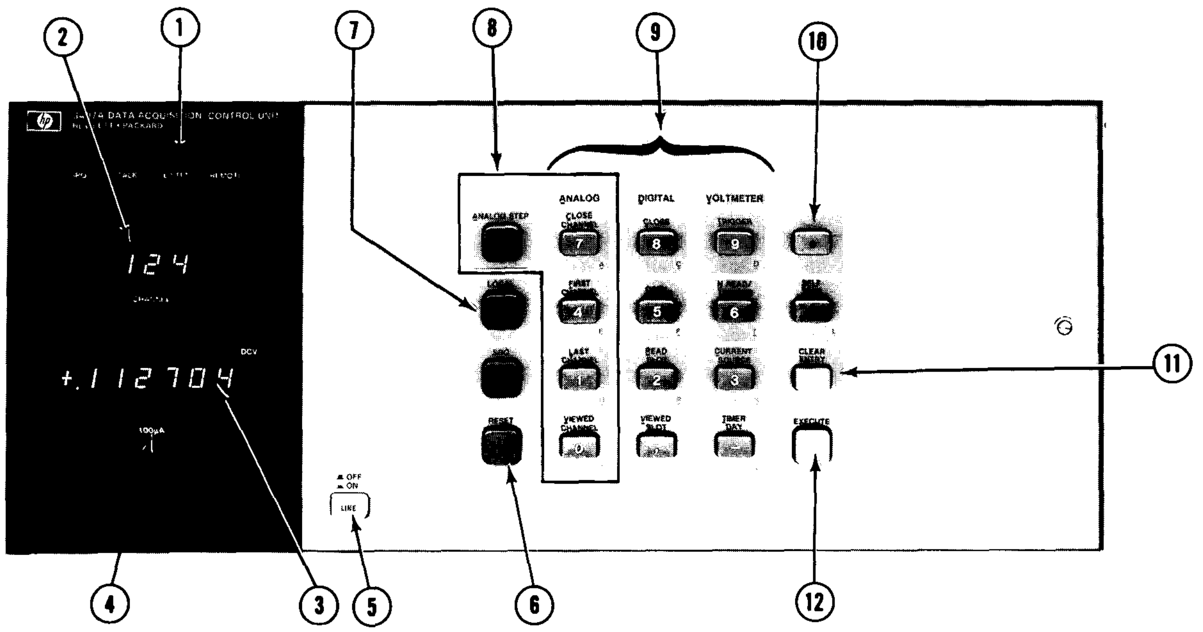
If you want to measure the voltage on a sequence of channels, use the AF, AL and AS commands. For example, to scan channels 0 through 9, set AF0 and AL9. Then sending AS repeatedly will cause relay closure on channel 0,1,...,9,0,.. Note that if AF < AL the sequence is increasing from AF through AL and 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

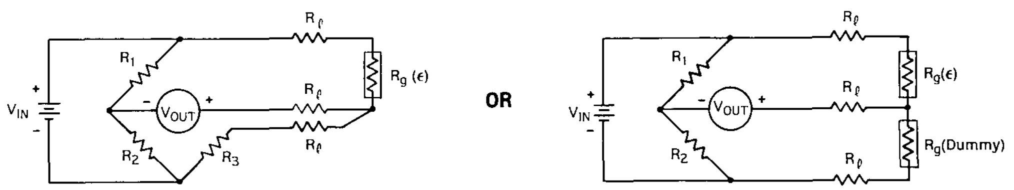
Material	Poisson's Ratio, ν	Modulus of Elasticity, E psi x 10^6	Elastic Strength (a) Tension (psi)
ABS (unfilled)	–	0.2-0.4	4500-7500
Aluminum (2024-T4)	0.32	10.6	48000
Aluminum (7075-T6)	0.32	10.4	72000
Red Brass, soft	0.33	15	15000
Iron-Gray Cast	–	13-14	–
Polycarbonate	0.285	0.3-0.38	8000-9500
Steel-1018	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 (−)

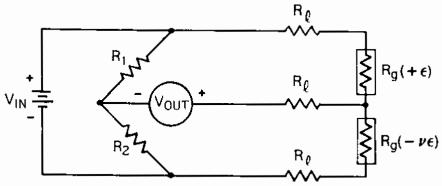
Quarter Bridge Configurations:



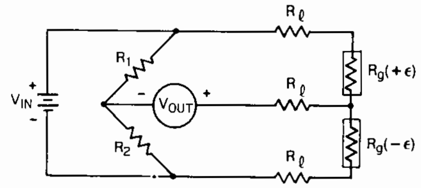
$$\epsilon = \frac{-4V_r}{GF(1+2V_r)} \cdot \left(1 + \frac{R_\ell}{R_g}\right)$$

Figure 36. Options 070/071 · Strain Gauge/Rosette Equations

Half Bridge Configurations:

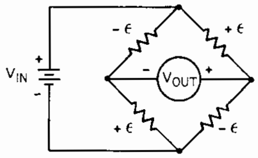


$$\epsilon = \frac{-4V_r}{GF[(1+\nu)-2V_r(\nu-1)]} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

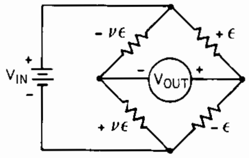


$$\epsilon = \frac{-2V_r}{GF} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

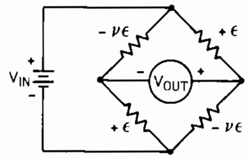
Full Bridge Configurations:



$$\epsilon = \frac{-V_r}{GF}$$



$$\epsilon = \frac{-2V_r}{GF(\nu+1)}$$



$$\epsilon = \frac{-2V_r}{GF[(\nu+1)-V_r(\nu-1)]}$$

Equations

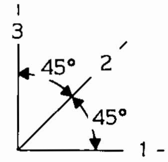
BIAXIAL STRESS STATE EQUATIONS

$$\epsilon_x = \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \epsilon_z = -\nu\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \sigma_y = \frac{E}{1-\nu^2}(\epsilon_y + \nu\,\epsilon_x)$$

$$\epsilon_y = \frac{\sigma_y}{E} - \nu\frac{\sigma_x}{E} \qquad \sigma_x = \frac{E}{1-\nu^2}(\epsilon_x + \nu\,\epsilon_y) \qquad \sigma_z = 0$$

ROSETTE EQUATIONS

Rectangular Rosette:

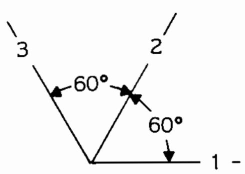


$$\epsilon_{p,q} = \left[\frac{1}{2}\ \epsilon_1 + \epsilon_3 \pm \sqrt{(\epsilon_1-\epsilon_3)^2 + (2\epsilon_2-\epsilon_1-\epsilon_3)^2}\right]$$

$$\sigma_{p,q} = \left[\frac{E}{2}\ \frac{\epsilon_1+\epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\ \sqrt{(\epsilon_1-\epsilon_3)^2 + (2\epsilon_2-\epsilon_1-\epsilon_3)^2}\right]$$

$$\theta_{p,q} = \frac{1}{2}\ TAN^{-1}\frac{2\epsilon_2-\epsilon_1-\epsilon_3}{\epsilon_1-\epsilon_3}$$

Delta Rosette:



$$\epsilon_{p,q} = \left[\frac{1}{3}\ \epsilon_1 + \epsilon_2 + \epsilon_3 \pm \sqrt{2[(\epsilon_1-\epsilon_2)^2 + (\epsilon_2-\epsilon_3)^2 + (\epsilon_3-\epsilon_1)^2]}\right]$$

$$\sigma_{p,q} = \left[\frac{E}{3}\ \frac{\epsilon_1+\epsilon_2+\epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{2[(\epsilon_1-\epsilon_2)^2 + (\epsilon_2-\epsilon_3)^2 + (\epsilon_3-\epsilon_1)^2]}\right]$$

$$\theta_{p,q} = \frac{1}{2}\ TAN^{-1}\frac{\sqrt{3}(\epsilon_2-\epsilon_3)}{2\epsilon_1-\epsilon_2-\epsilon_3}$$

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

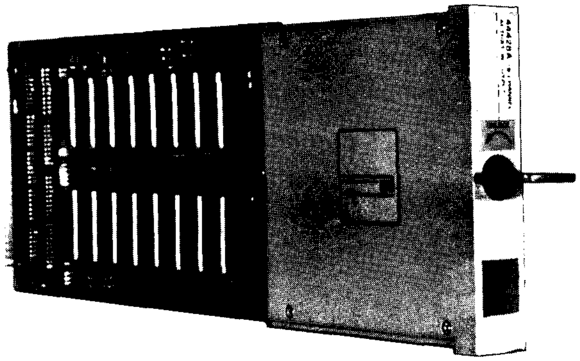
```
 10 CLEAR 709
 20 PRINT "STRAIN GAUGE MEASUREMENTS"
 30 PRINT
 40 OUTPUT 709; "AF0AL9AC10"
 50 ENTER 709; V

 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.

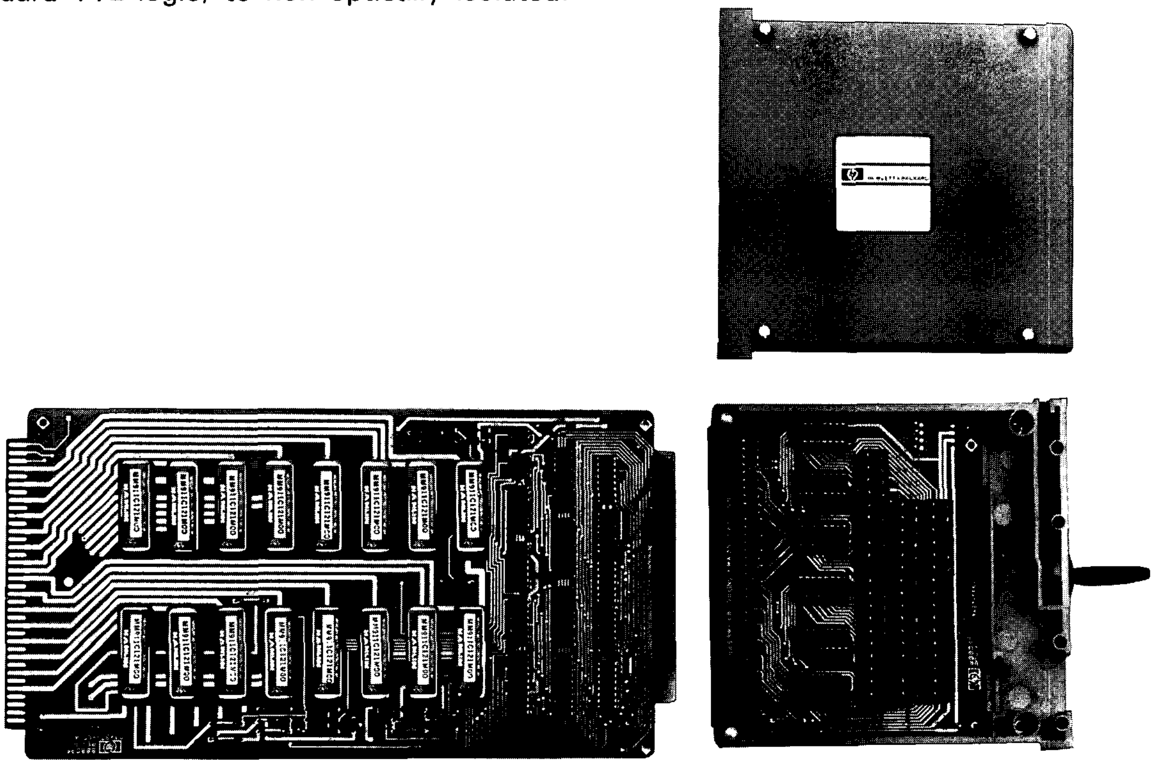
The assembly can be also configured as a 4 x 4 point matrix scanner and additional assemblies can be added to construct larger matrices. Since the Option 110 assembly can switch one amp at 100 volts, it can be used to switch test fixture power or to actuate alarm bells. In addition, the assembly can 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.

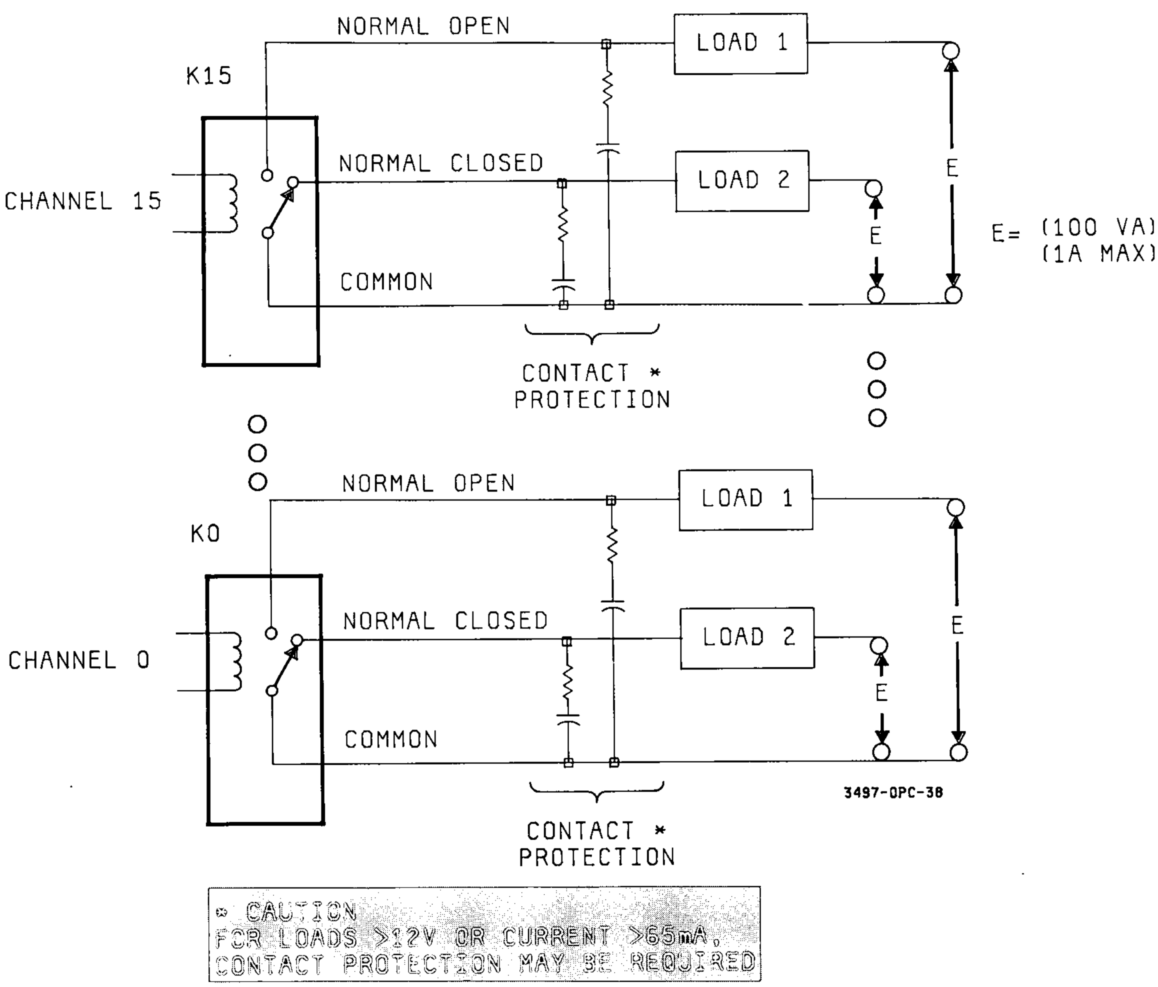
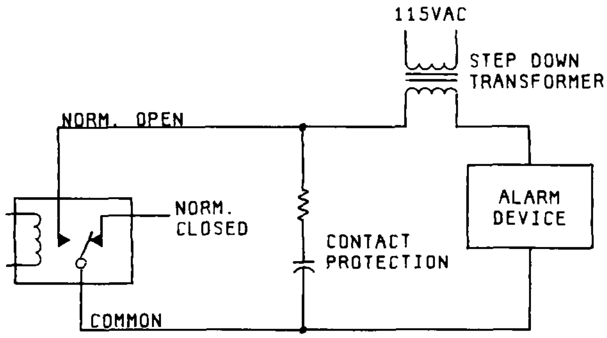


Figure 38. Option 110 · Actuator (Switching) Mode

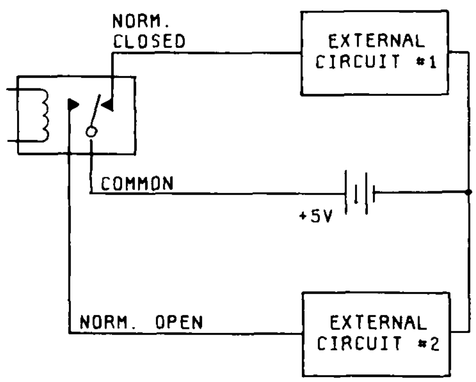
The assembly can be used in many applications, as long as the load circuits are fused for 1A or less and less than 100 VA. To indicate some of the ways that the assembly can be used in the actuator mode, Figure 39 shows a relay actuated alarm circuit, voltage switching and matrix switching.

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.

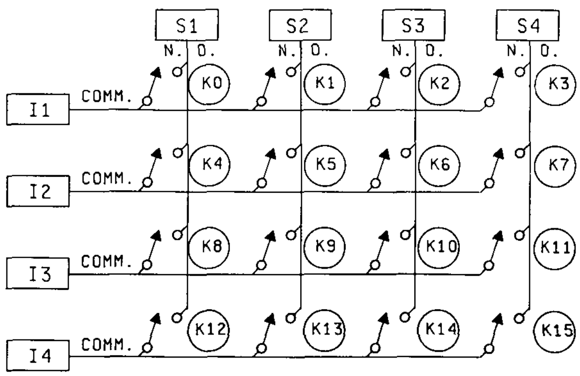
As a specialized application of the actuator mode, the assembly can be configured as a 4 x 4 matrix switch. For example, as shown in Figure 39, signal sources S1 through S4 can be connected to measuring instruments I1 through I4 by closing relays K0 through K15 as required (i. e., to connect source S3 to instrument I2, close relay K6, etc.).



RELAY ACTUATED ALARM CIRCUIT



VOLTAGE SWITCHING



MARTRIX SWITCHING 3497-OPC-39

Figure 39. Option 110 - Actuator Mode Examples

Digital Output Mode

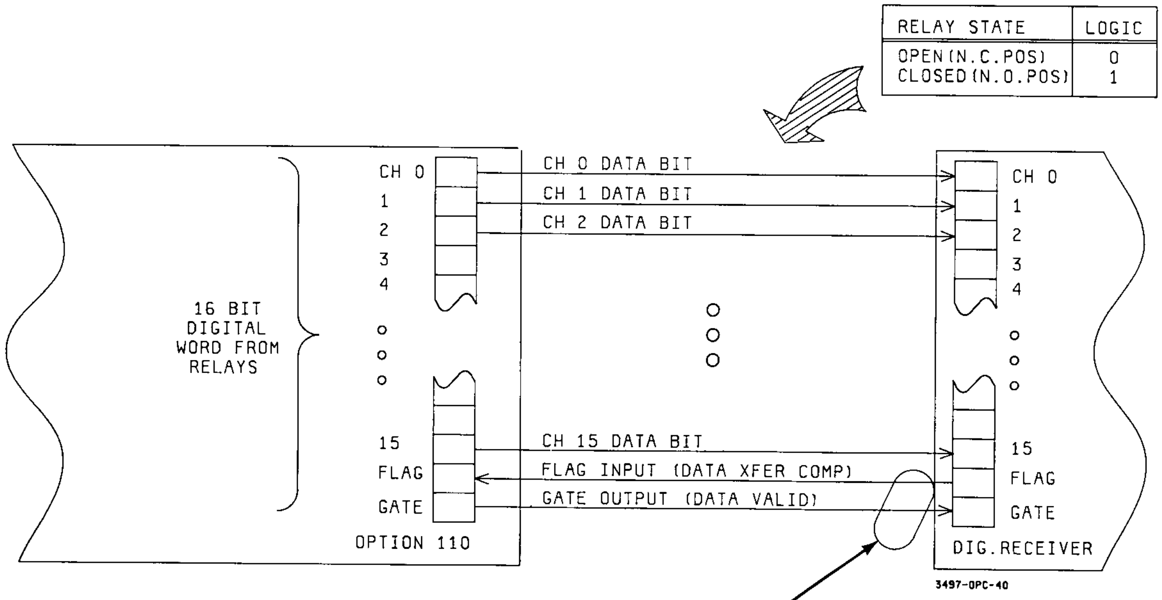
The Option 110 assembly can also be used in digital output mode to communicate with a 16-bit digital receiver at a typical maximum read rate of 400 Hz. As shown in Figure 40, a 16-bit wide digital word is input to the relays (channels 0 through 15) and the word is transferred to a digital receiver. As 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.

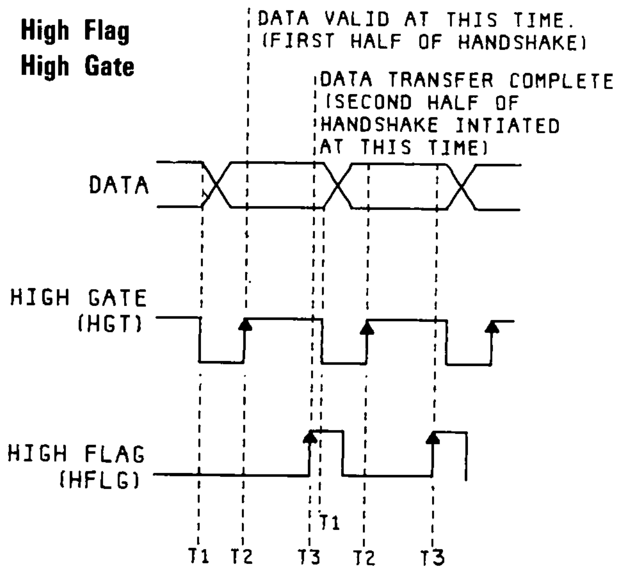
When handshaking is enabled, the handshake sequence for either High Gate, High Flag or Low Gate, Low Flag operation is as shown in Figure 40. When a 16-bit wide word is entered into the assembly and settling time has occurred, the assembly sends a Gate output to the receiver to signal Data Valid condition. 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

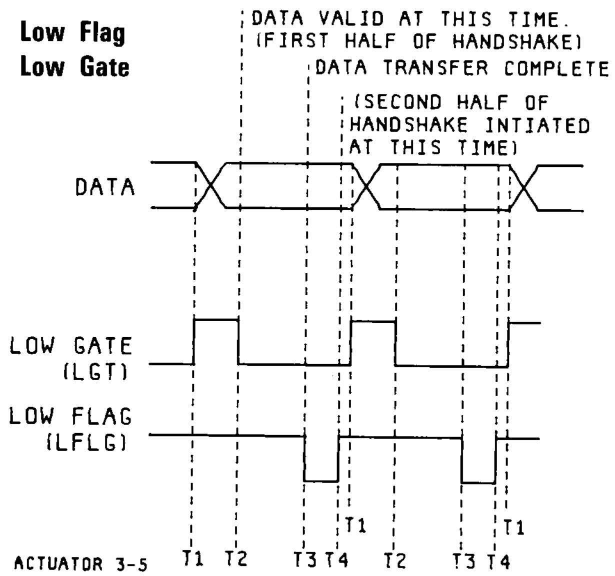
As noted, the actuator/digital output assembly has two modes of operation: actuator (switching) and digital output. For both modes, the assembly is controlled by DIGITAL commands. The following chart shows the DIGITAL commands used to control the assembly. See the Command Directory in Chapter 6 for details and examples.



Handshake Timing Diagrams



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



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

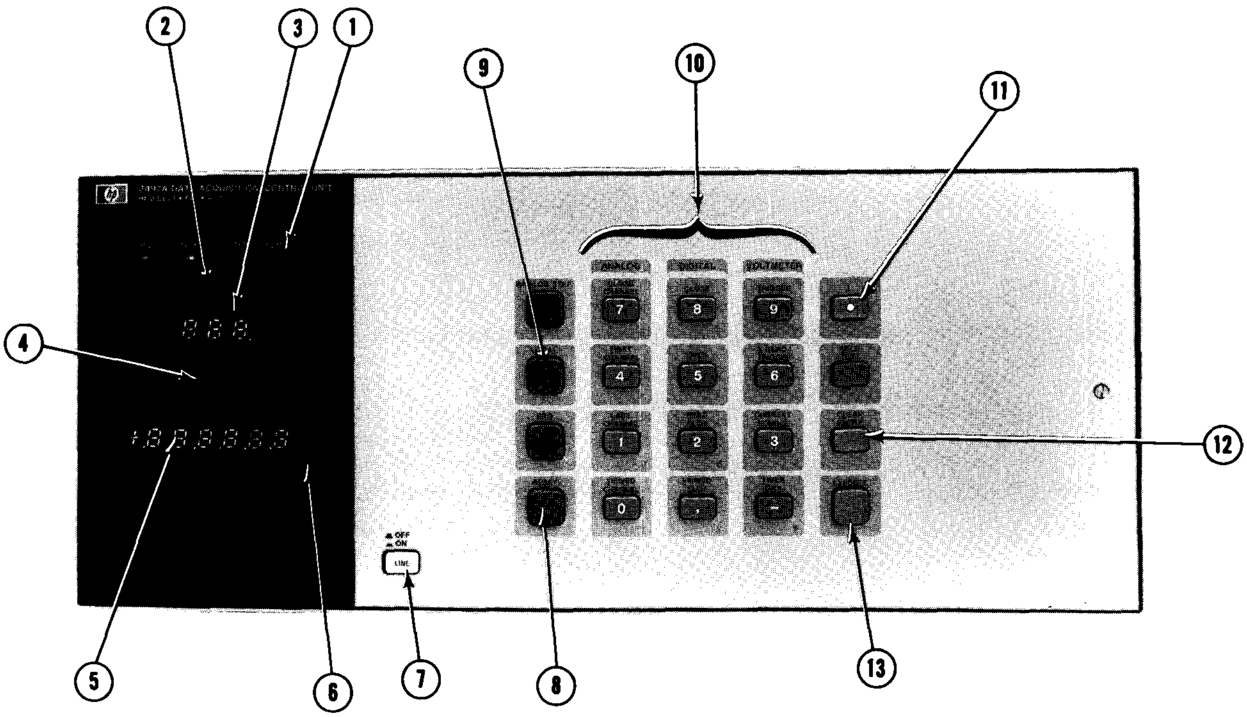
Figure 40. Option 110 - Digital Output Mode

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.

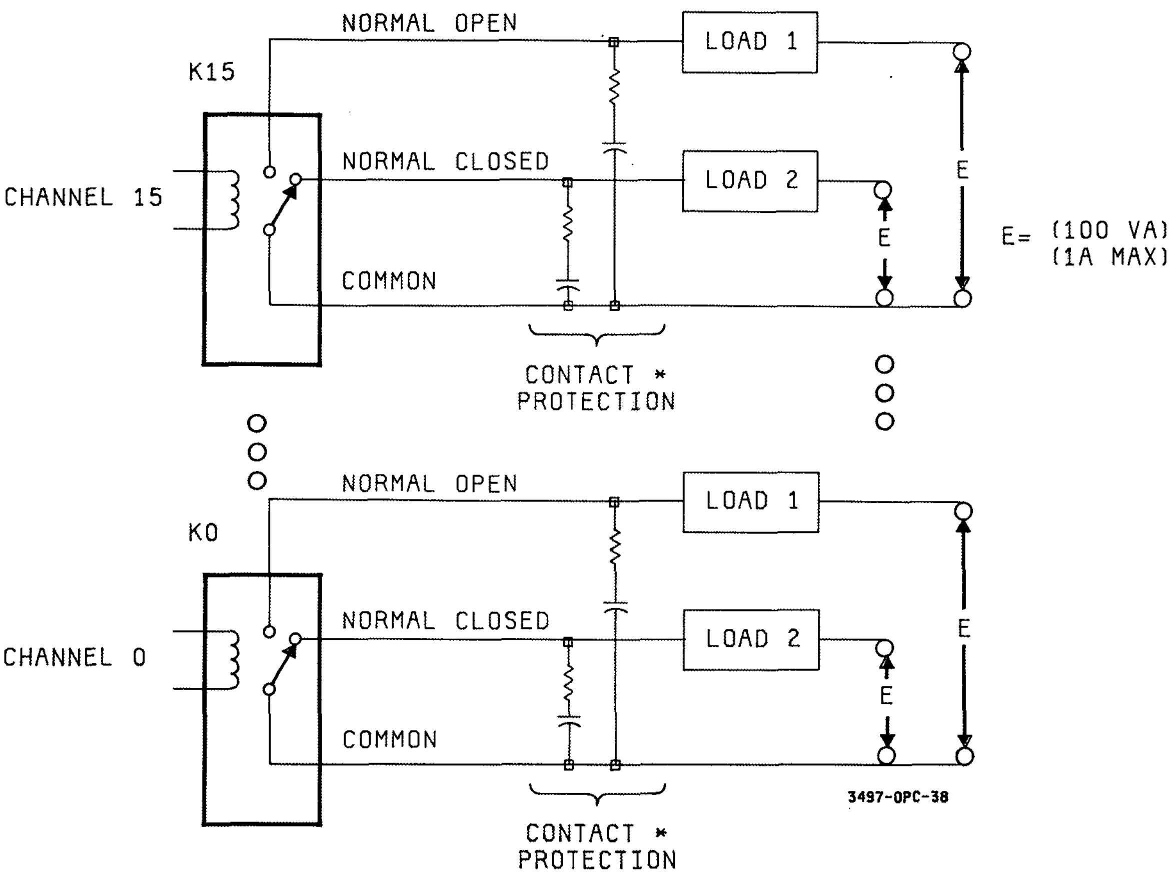
chan#	15	14 13 12	11 10 9	8 7 6	5 4 3	2 1 0
chan state	1	0 0 0	0 1 0	0 1 0	1 0 0	0 0 0
octal value	1	0	2	2	4	0

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.



* CAUTION
FOR LOADS >12V OR CURRENT >65mA,
CONTACT PROTECTION MAY BE REQUIRED

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.

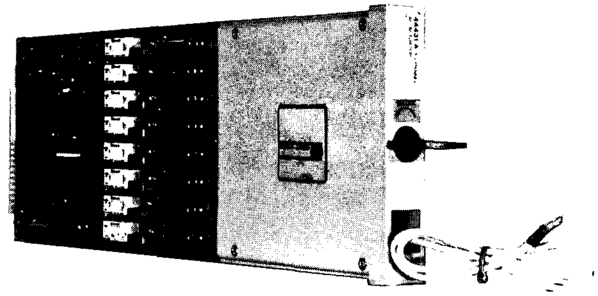
EXAMPLE - READ DIGITAL SLOT

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.

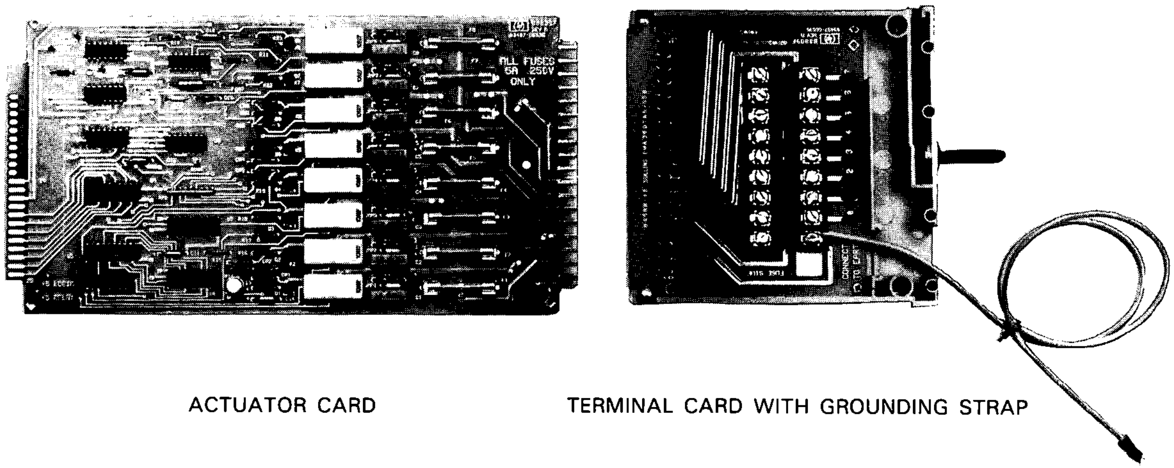
Description

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, $C = 0.047\ \mu F$). 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.

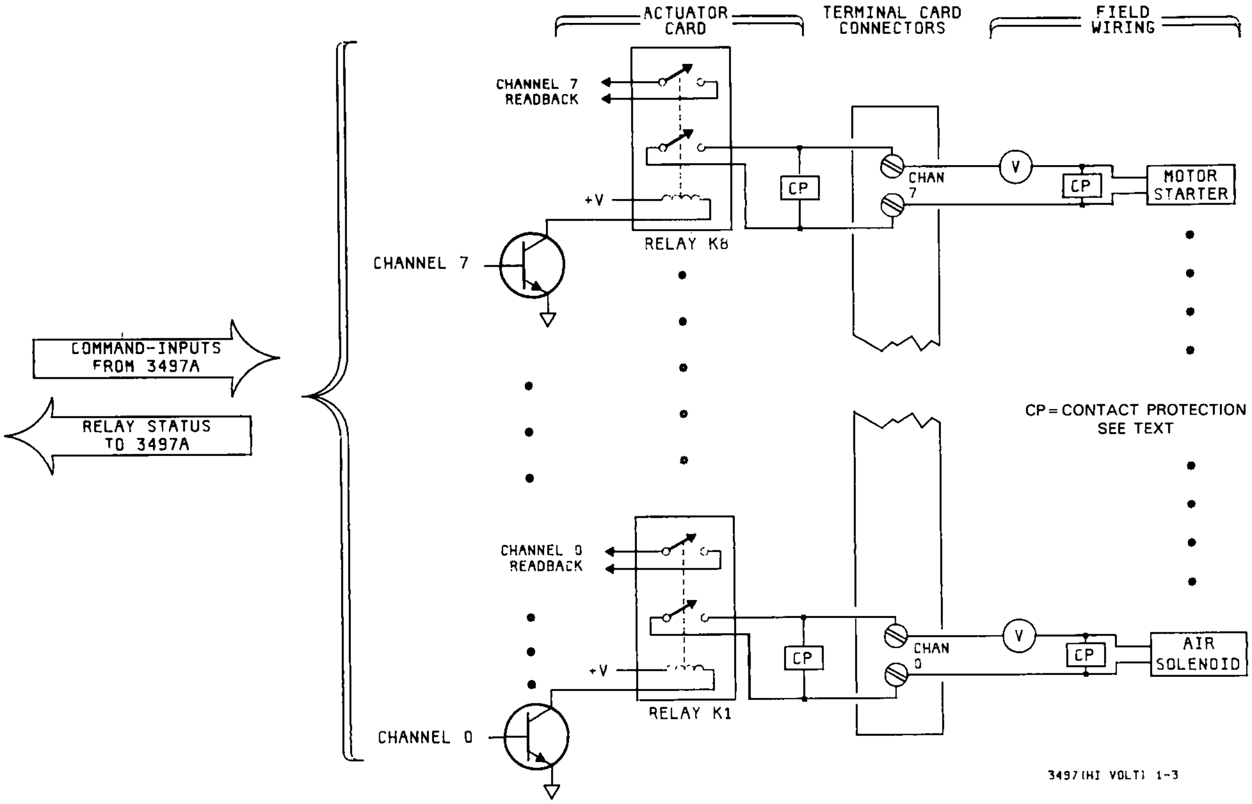


Figure 44. Option 115 - Actuator Typical Applications

Controlling the High Voltage Actuator Assembly

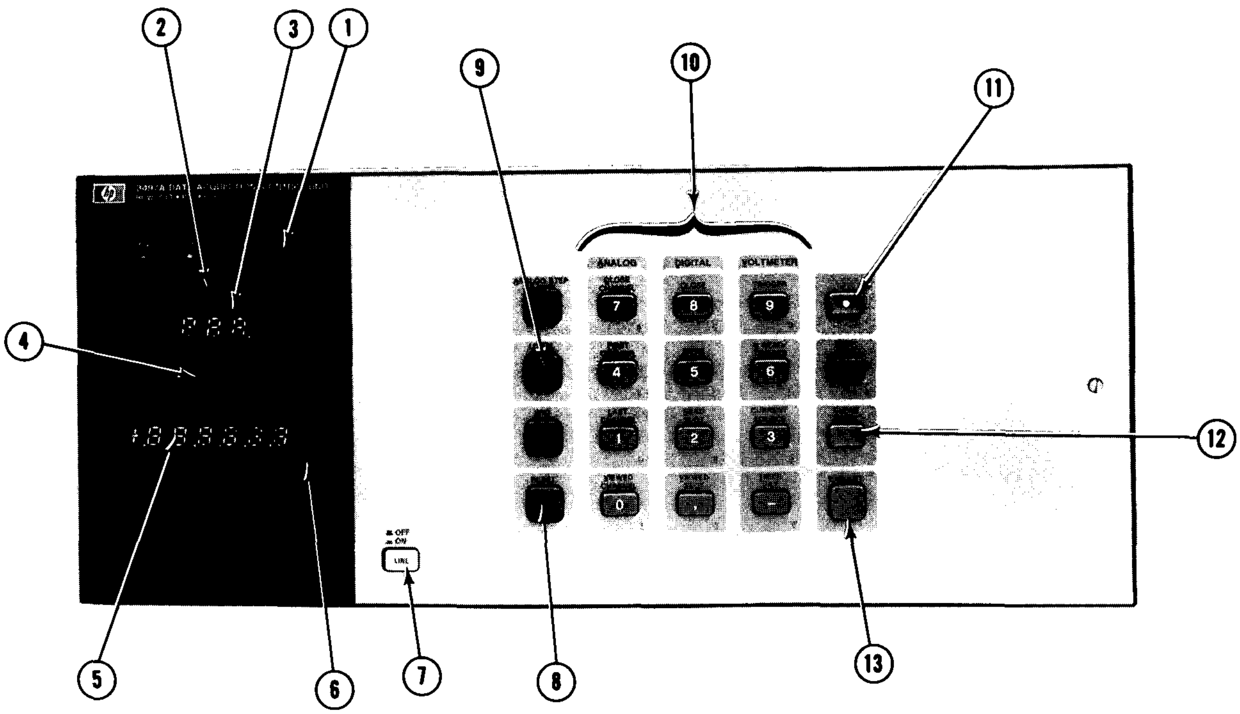
The high voltage actuator assembly is controlled by DIGITAL commands, as shown in the following chart. See the Command Directory in Chapter 6 for details and examples.

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).

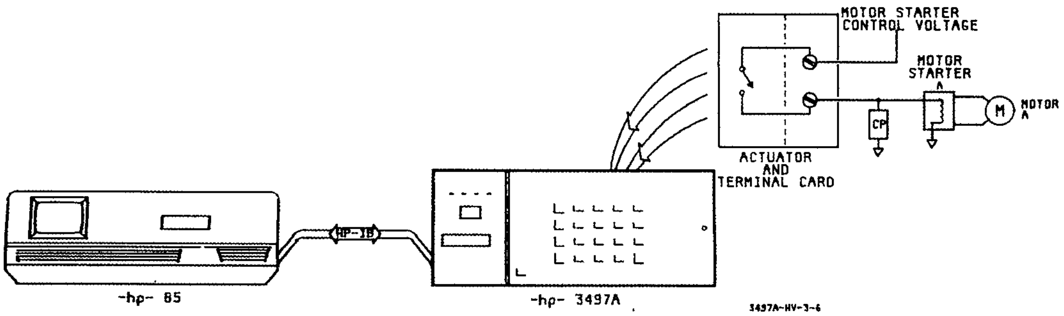
As an example use of the high voltage actuator to control motor starters, let's say that an assembly process requires that three 80 horsepower motors be turned on by using motor starters, according to the following sequence. For this example, we'll assume that each motor is stopped by an external control 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.

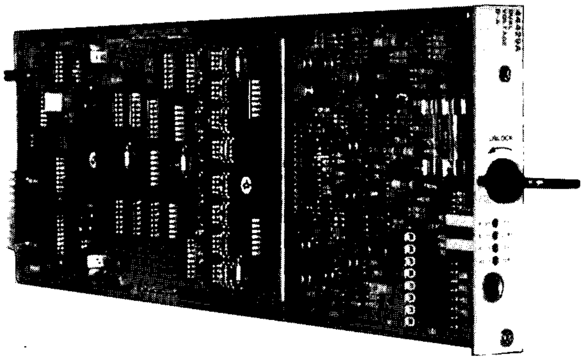


Program

```
 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).

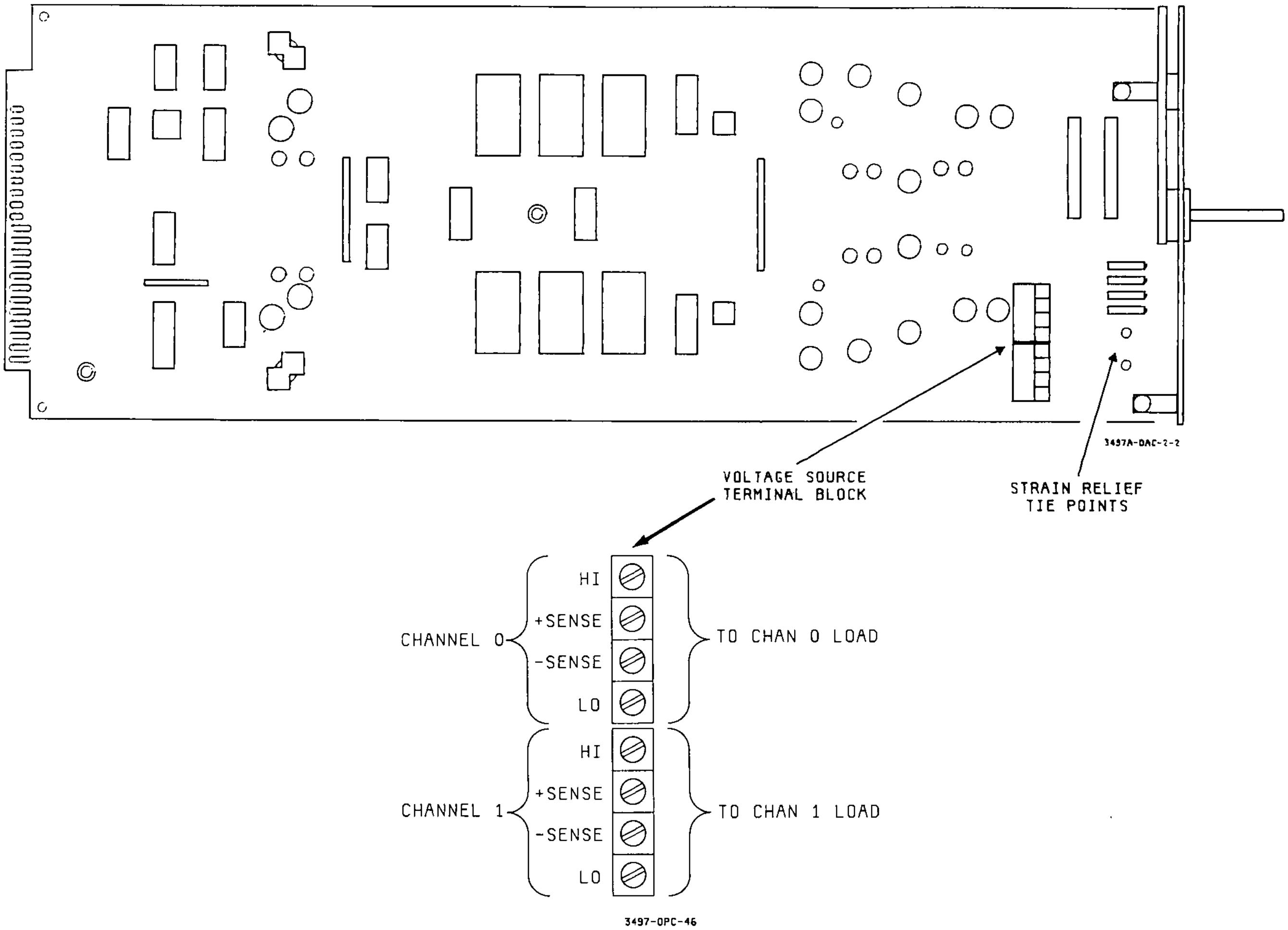


Figure 46. Option 120 - Dual Output, 0 to ± 10 V Voltage D/A Converter (VDAC)

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.

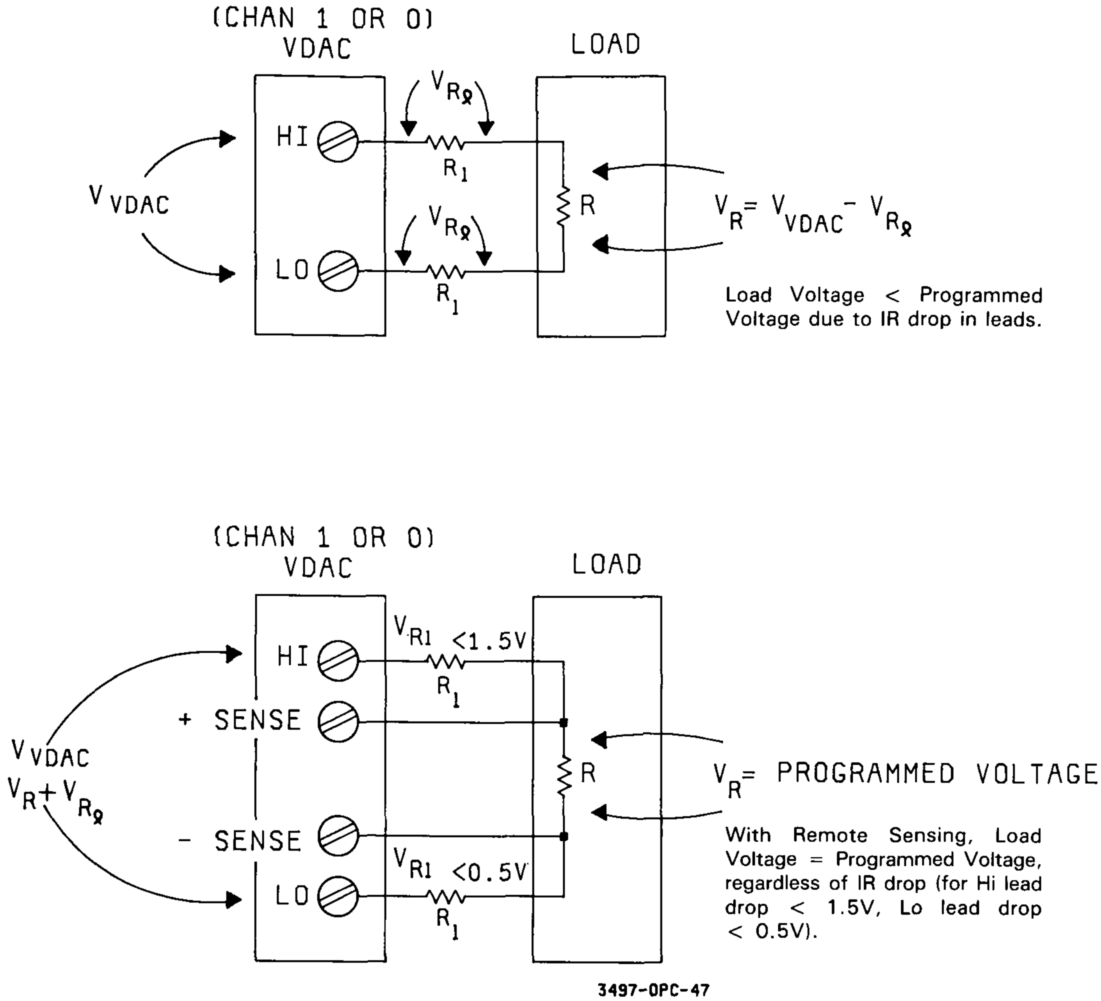


Figure 47. Option 120 - VDAC Remote Sensing

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 slot# = 0 to 4 and 10 to 89 chan# = 0 or 1 value = 0 to ± 10238	ANALOG OUTPUT 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

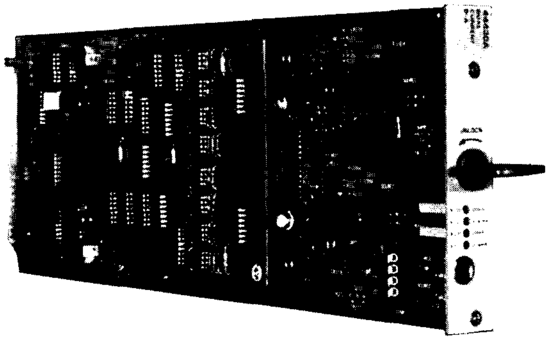
EXAMPLE - SET VDAC FOR VOLTAGE OUTPUT

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.

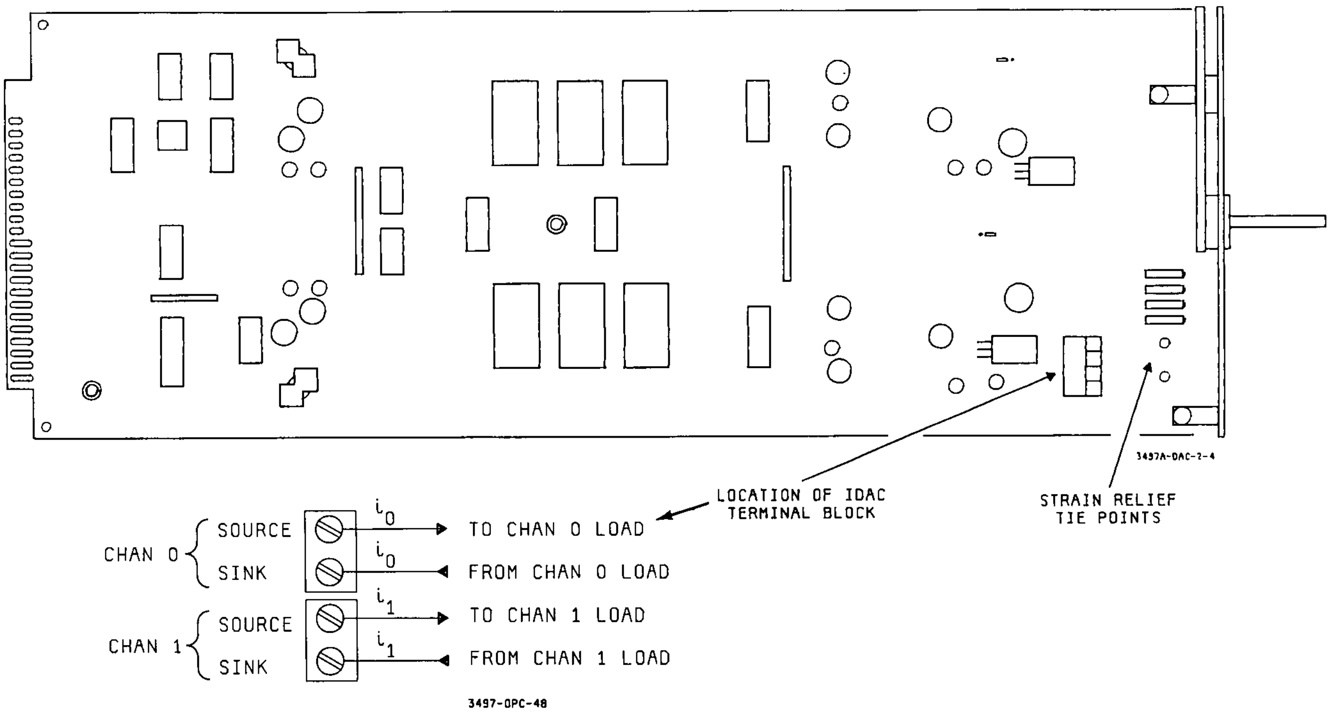


Figure 48. Option 130 - Dual Output, 0-20 mA/4-20 mA Current D/A Converter (IDAC)

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.

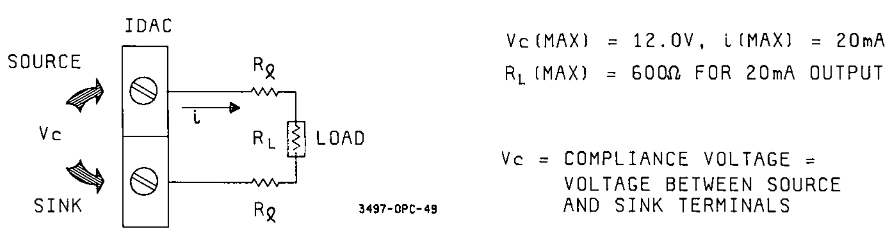


Figure 49. Option 130 - IDAC Compliance Voltage

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

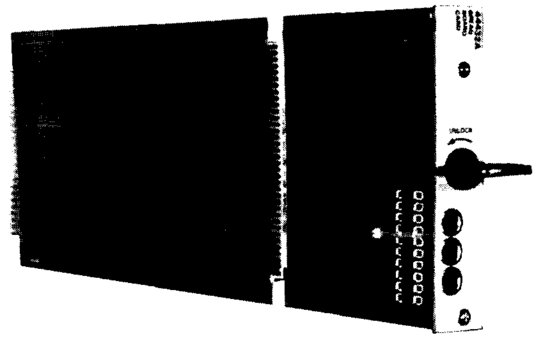
If the IDAC is configured for the 0 - 20 mA range, the span is 20 mA. Thus, a program value of 5000 [AO slot#,chan#,5000] is 50% of span and gives an output of 10.00 mA. So, send AO3,0,5000 to output 10.00 mA from channel 0 of an IDAC in slot 3 when the IDAC is in the 0-20 mA range.

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.

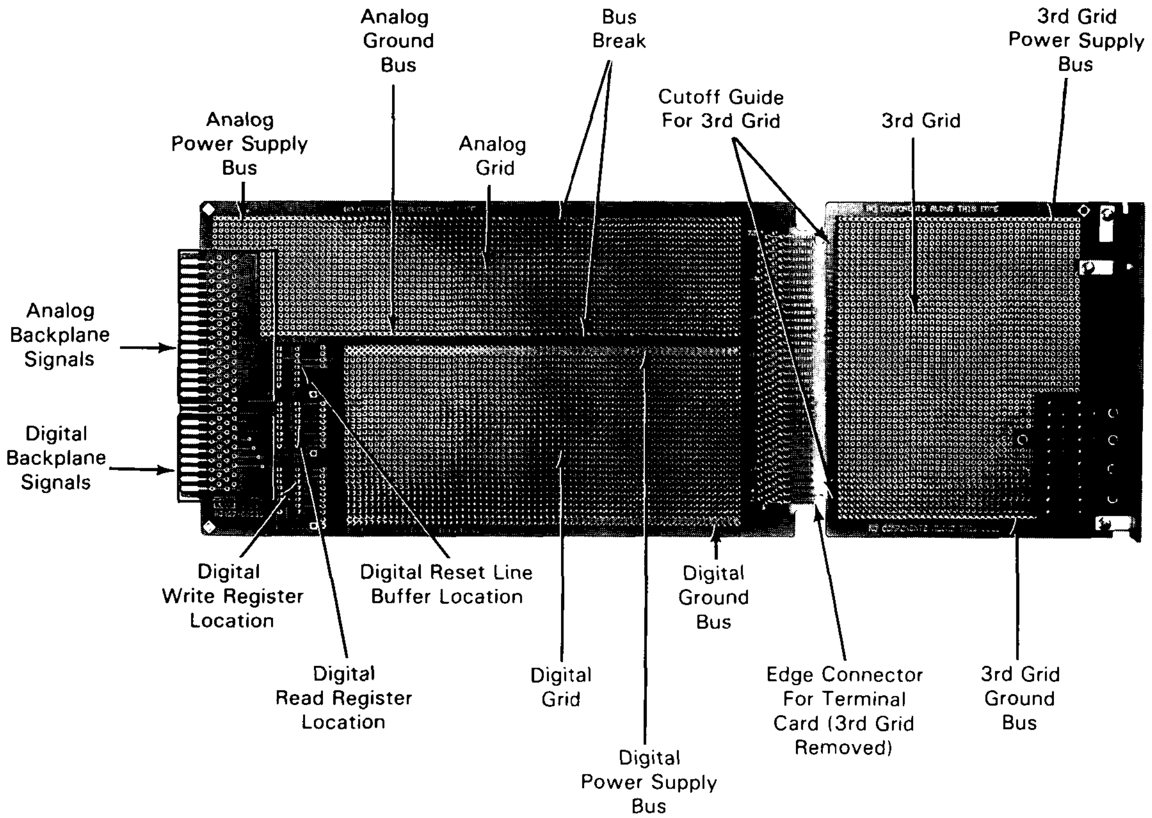


Figure 50. Option 140 · Breadboard Card Assembly

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.

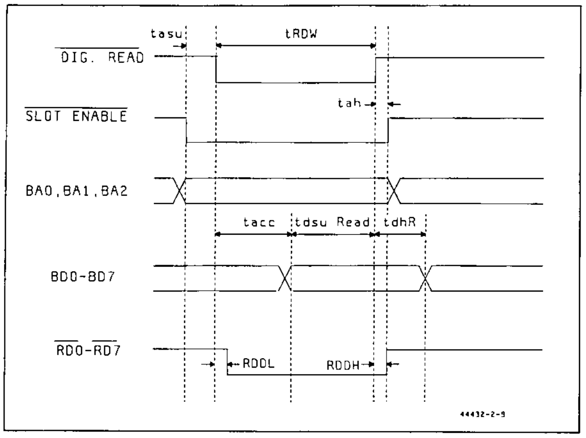
When using the SW and SR commands, the read and write cycle timing diagrams are important. See Figure 51 for these timing cycles. The SRn,r and SWn,r are the read and write commands used to specify slot address and register number. For example, to read the contents of register 6 from an assembly in slot 1, send "SR1,6".

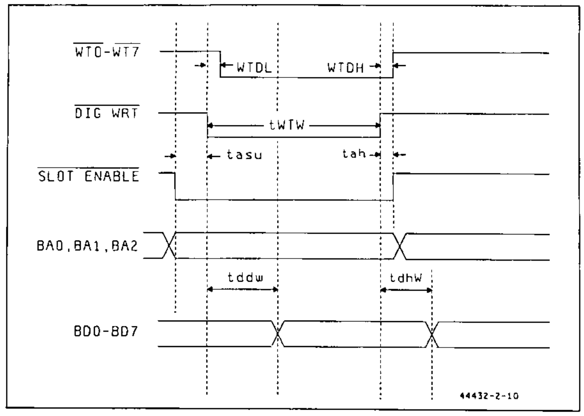
When a card is addressed, the SLOT ENABLE line goes true. The register number is specified by the address lines. For example, to specify register 6, the address lines would be:

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 RDDH WTDL RDDL		17 17 25 25	26 26 38 38	nS nS nS nS
Write Pulse Width	tRDW tWTW	450 450	500 500		nS 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 Low Level Output Current High Level Output Voltage Low Level Output Voltage	IOH IOL VOH VOL	 2.4 	 3.0 0.3	40 .8 0.5	µA mA V V
Power Supply Current	Icc			400	mA*
High Level Input Voltage Low Level Input Voltage High Level Input Current Low Level Input Current	VIH VIL IIH IIL	2.7 	3.5 .4 	 .5 20 -0.2	V V µA 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

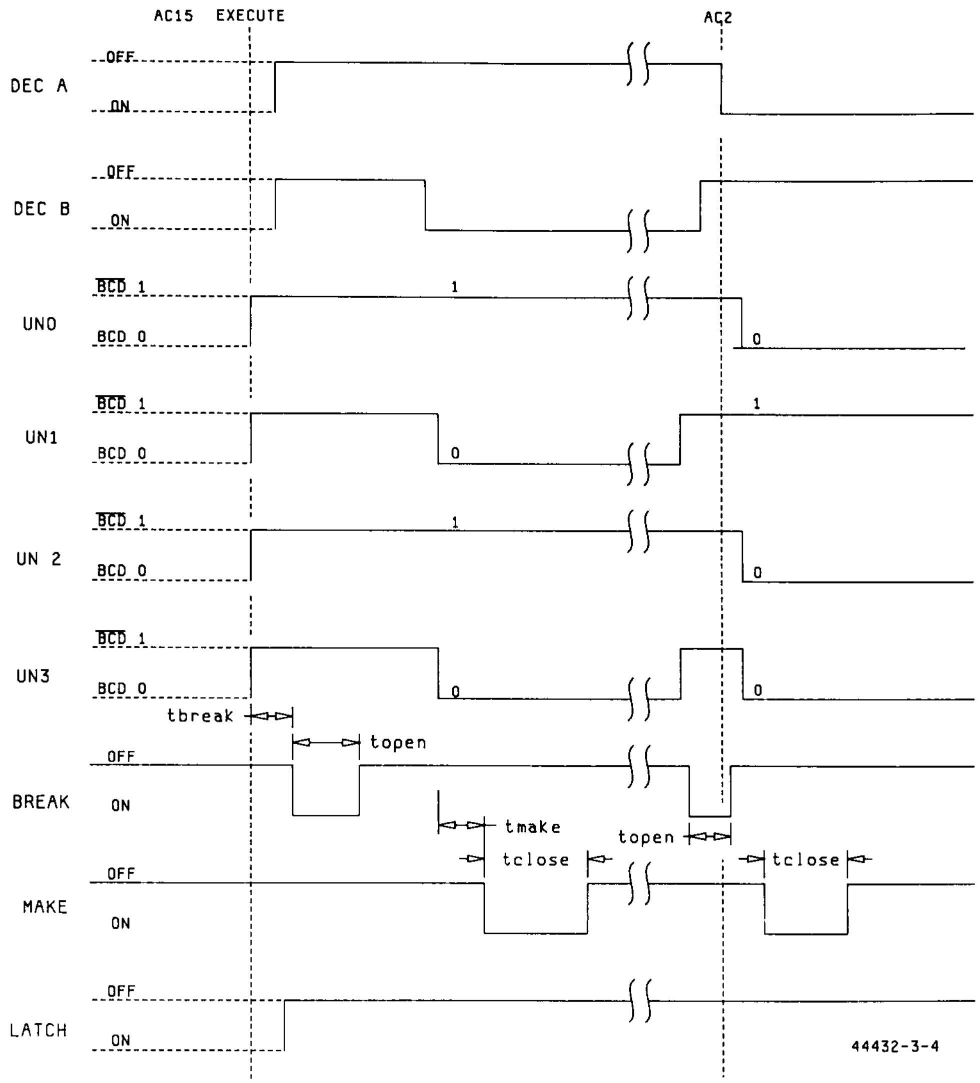
To enter the Latch mode, the LATCH line goes low. In this mode, multiple channel closures (up to 4 with one channel closed per decade) are permitted. For example, AC2,12,22,32 is a valid command, since it selects channels in four different decades, but AC2,3,4,5 is not.

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.

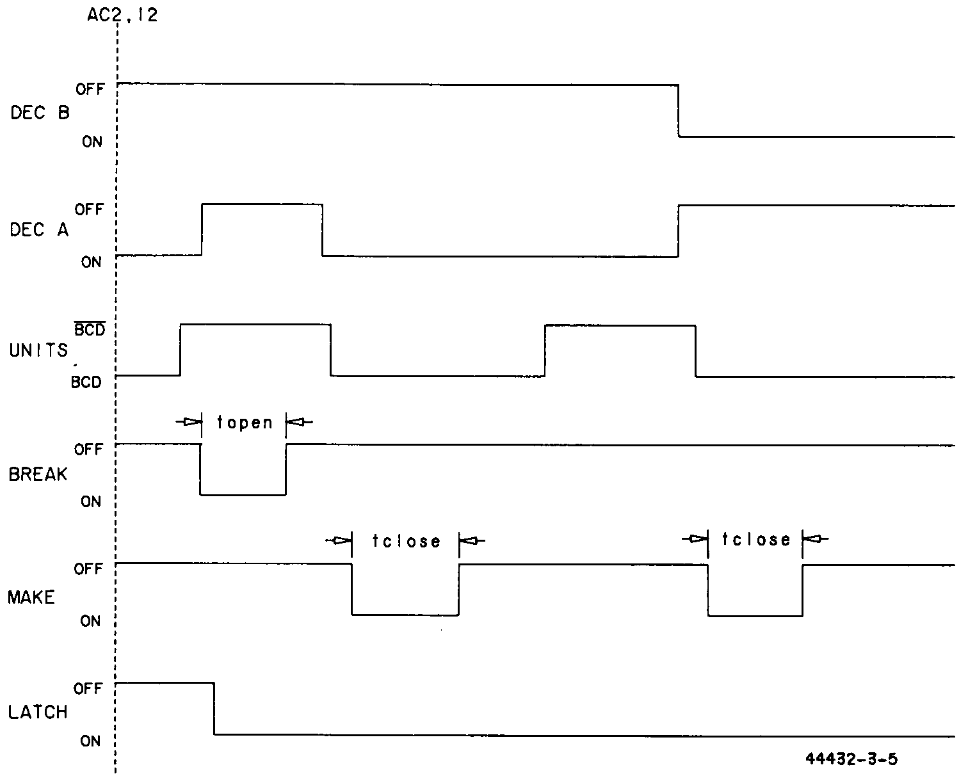


topen = time required to open a channel, if closed
tclose = time required to close a channel
tbreak, tmake = ≤ 10 μS

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.

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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).

A N A L O G

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.

ANALOG

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.

COUNTER

COUNTER FUNCTION

CF slot#,n	n =	0 = Counter Stop
		1 = Count Up
		2 = Count Down
slot# = 0 to 89		3 = Average 1000 Periods/P.W.
n = 0 to 6		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 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.

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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

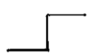
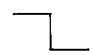
1. For HP-IB, Digital Read returns the same information as Digital Load command, except that readings are continuously updated for Digital Read.
2. For Serial Data, with SO0 in effect, Digital Read returns continuously updated readings. With SO1 in effect, one reading is returned per DR command.
3. The 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).

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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 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.

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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

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.

S Y S T E M

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.

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 SOO 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 SDO 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.

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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

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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.

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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" 20 ENTER USING "#,K";A 30 DISP A 40 END	!Halts elapsed time count process and displays time (in sec) since elapsed timer started. (Serial Data)

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" 70 ENTER 709; A 80 DISP 90 END	!Reads and displays number of seconds elapsed on the timer since the TE2 command was received. (HP-IB)
10 OUTPUT 10; "TE2" . . 90 END	!See HP-IB example. (Serial Data)

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 SE110 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 COMMANDS

VOLTMETER

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 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 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 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.

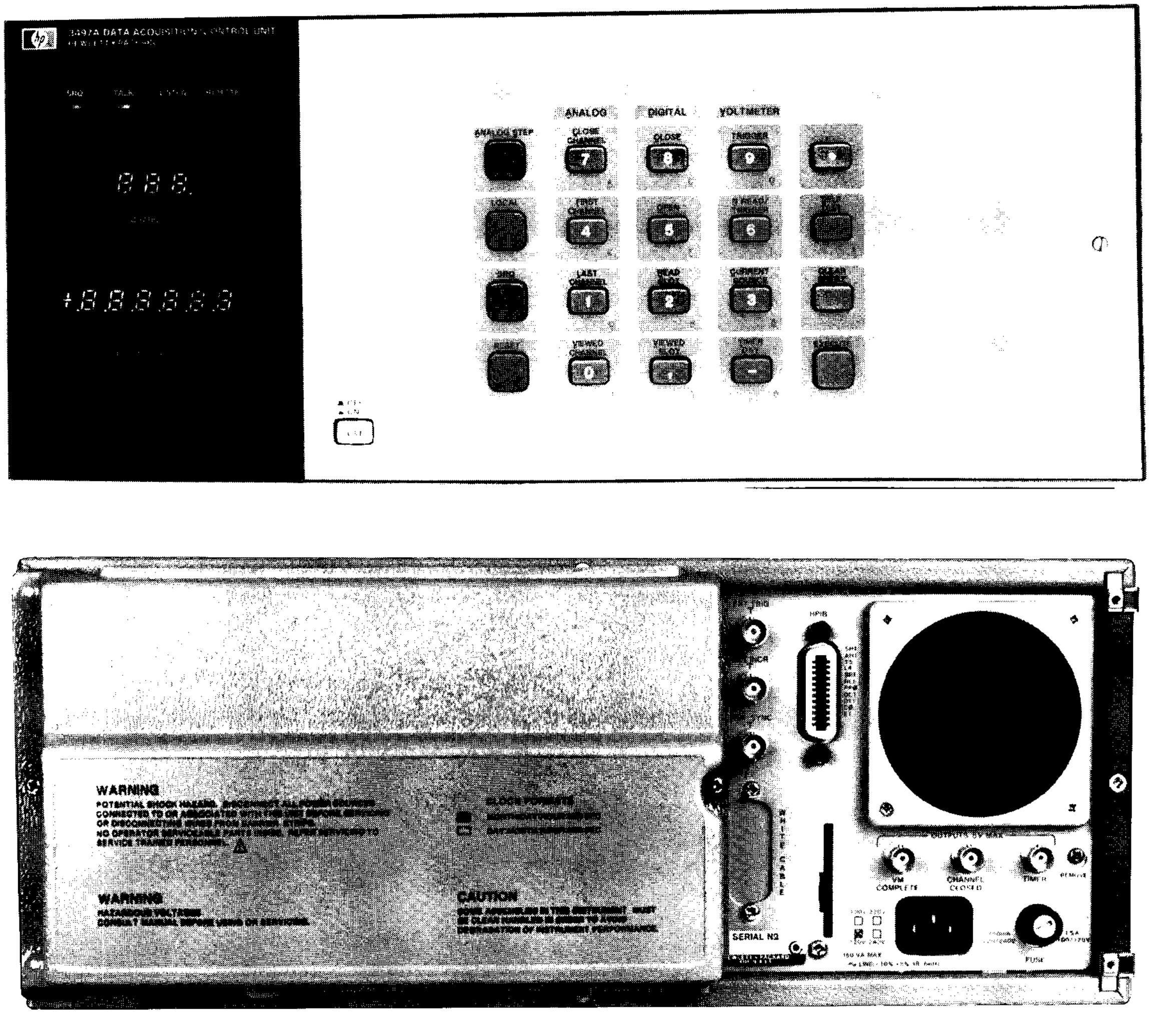

Figure 54. 3497A Front and Rear Views

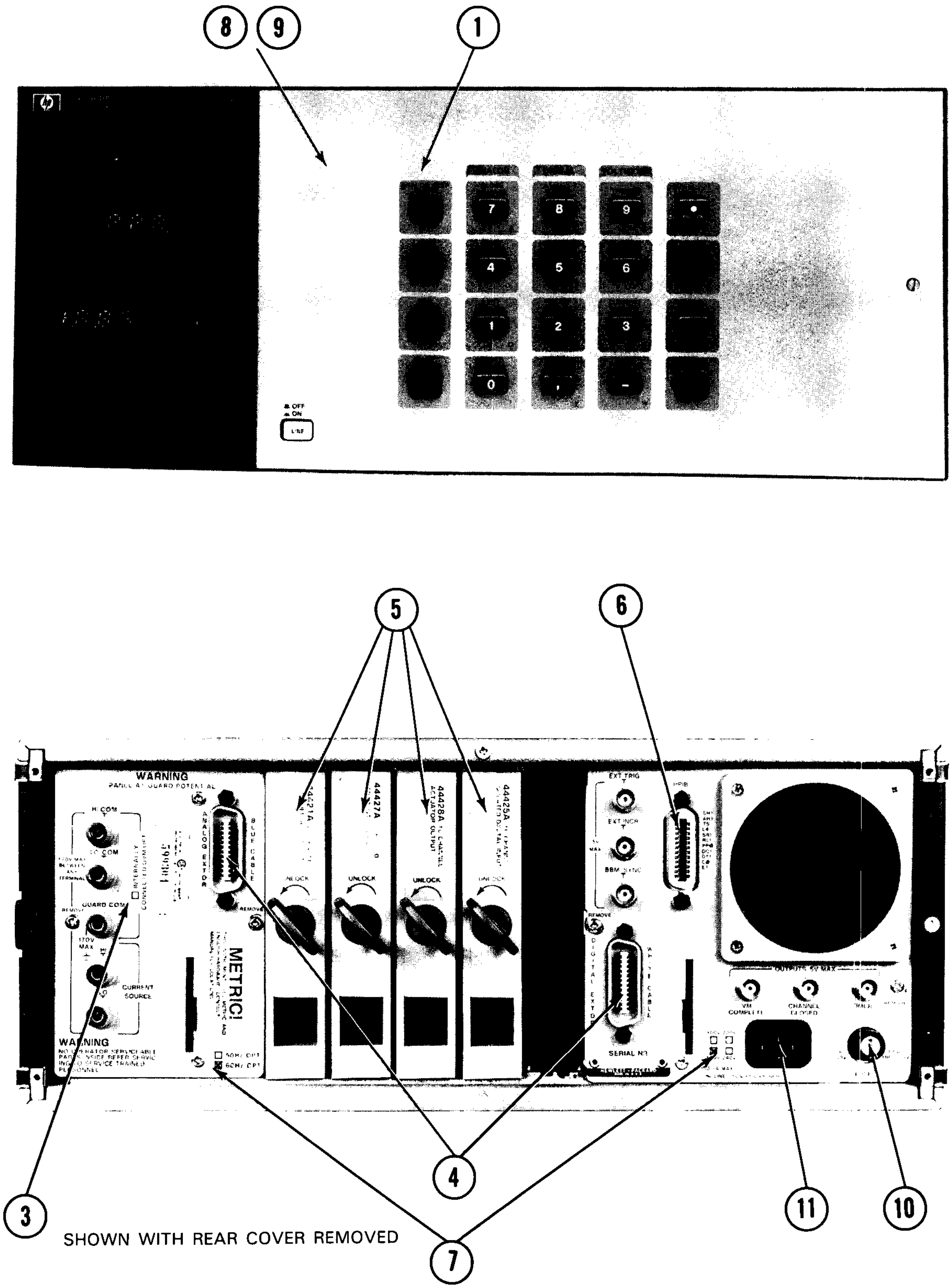

Figure 55. Standard (HP-IB) 3497A - Front and Rear Panels

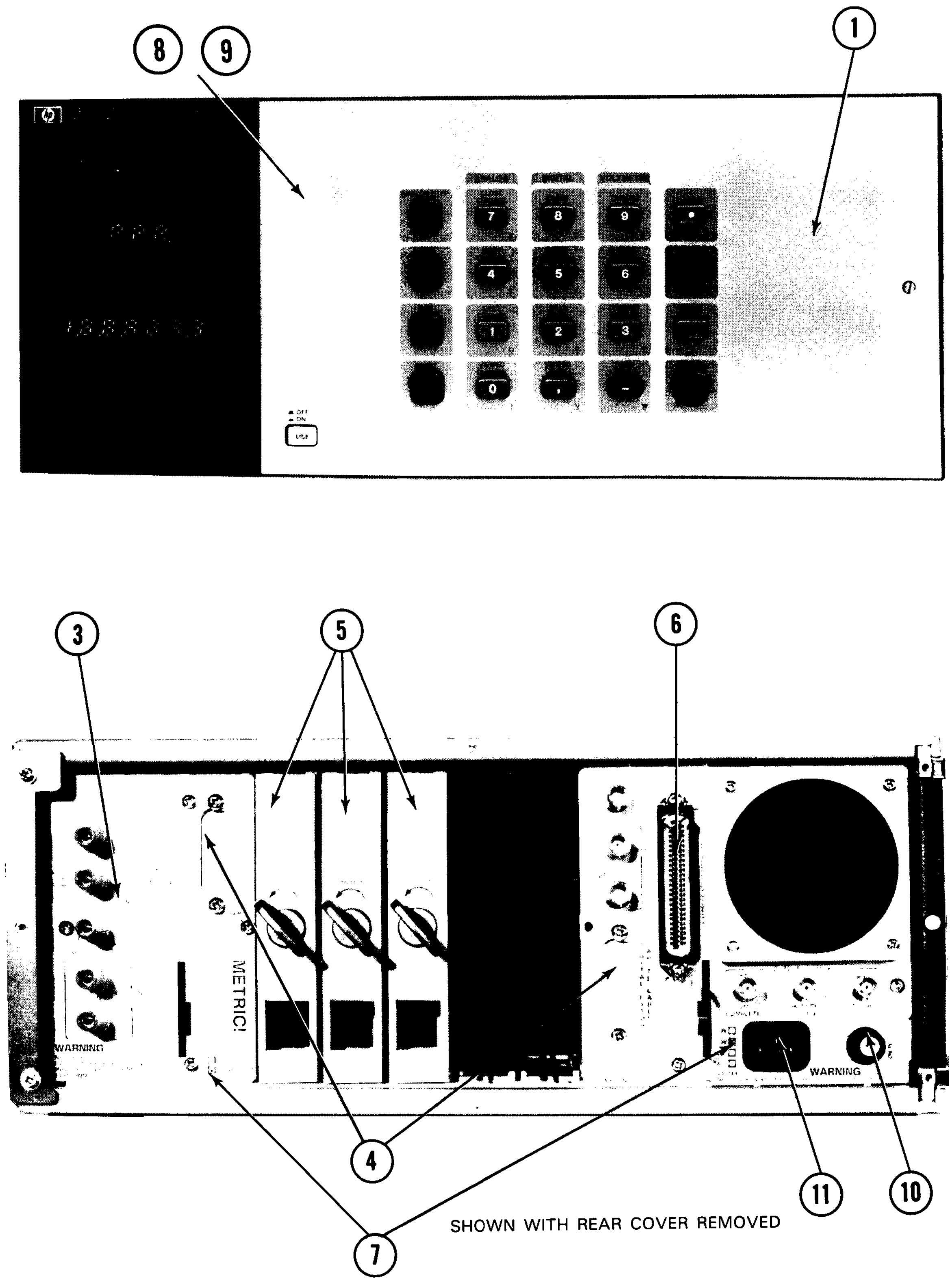

Figure 56. 3497A with Option 232 - Front and Rear Panels

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 apppropriate 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.
[illegible]	[illegible]
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

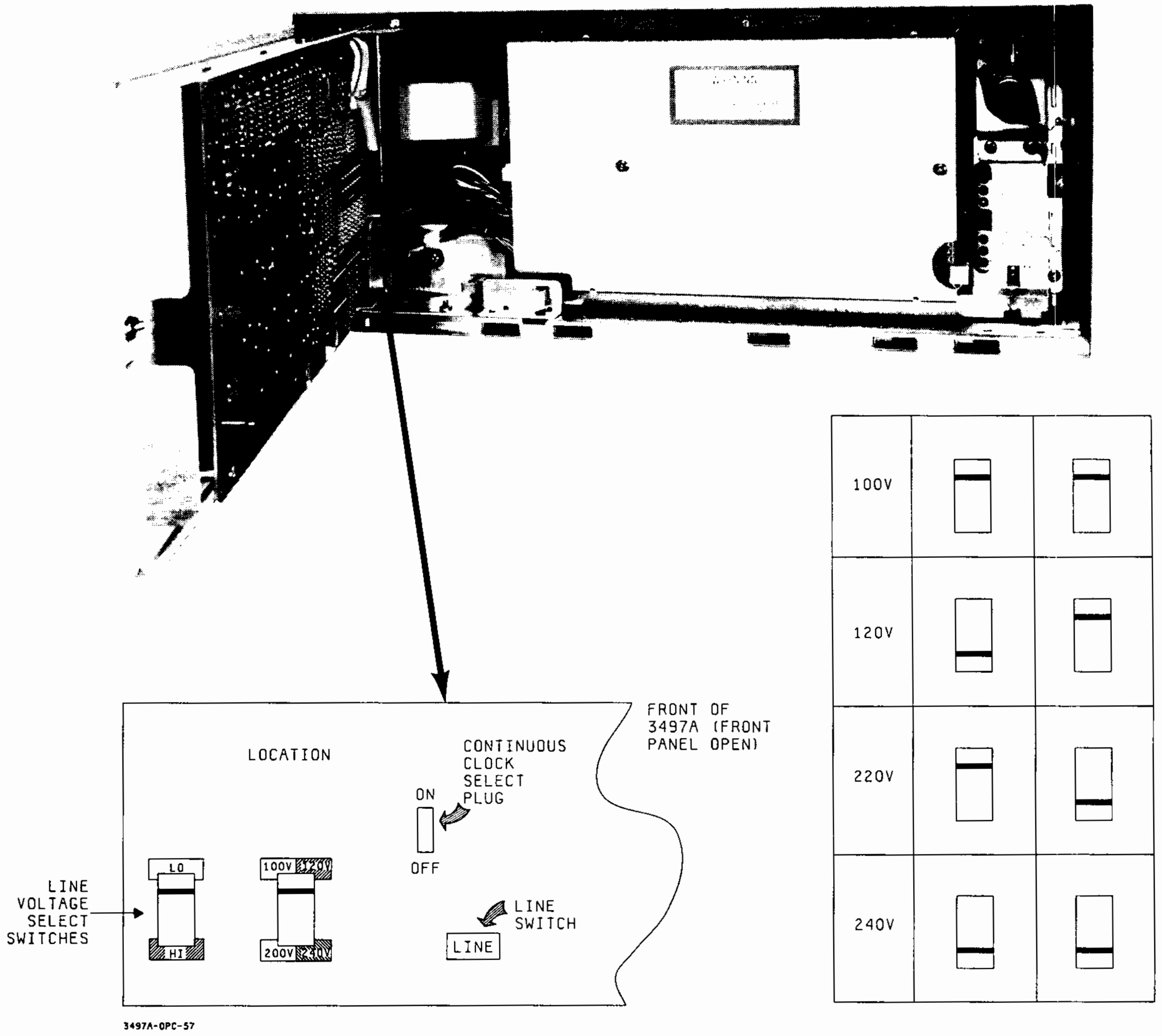

Figure 57. Line Voltage Selector Switches and Continuous Clock Select Plug

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).

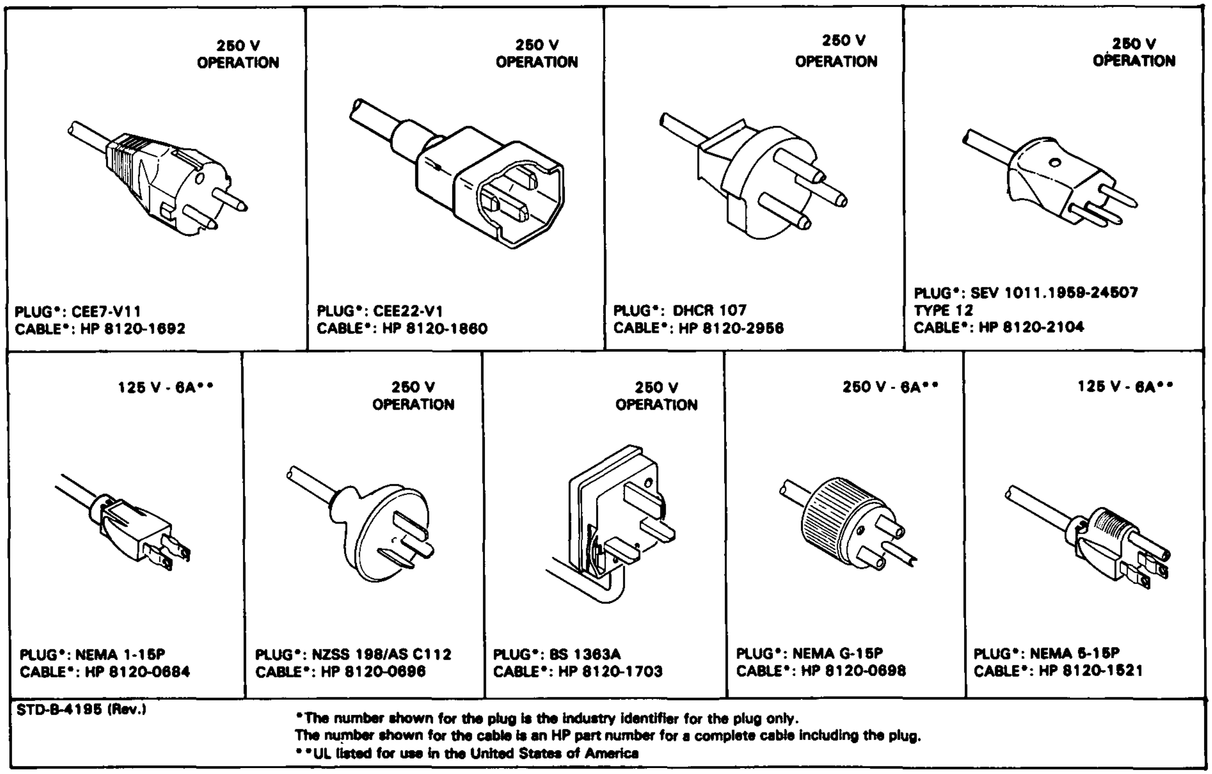

Figure 58. AC Power Cords for the 3497A/3498A

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.

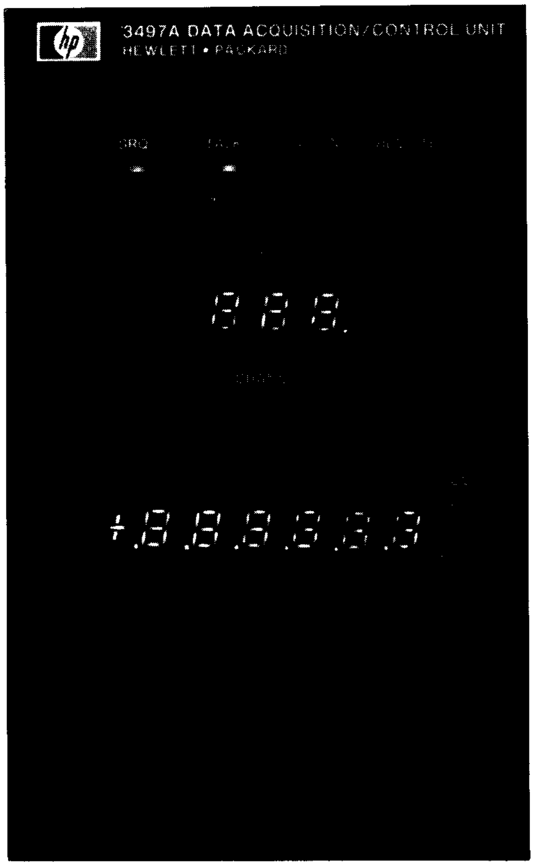

Figure 59. Self-Test Display

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.