HP 3852A Data Acquisition/Control Unit

HP 44701A
Integrating Voltmeter Accessory

Configuration and Programming Manual

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GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

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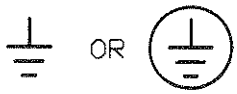
Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

Instruction manual symbol affixed to product. Cautions the user to refer to respective instruction manual procedures to avoid possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.



Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.

Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)

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Introduction

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Chapter 1

Introduction

Manual Contents

This manual shows how to configure and program the HP 44701A Integrating Voltmeter (voltmeter). The manual has four chapters:

- **Chapter 1 - Introduction** contains a manual overview, summarizes voltmeter features, and shows a suggested getting started sequence.
- **Chapter 2 - Defining Your Measurement** gives guidelines to select measurement requirements and voltmeter operating parameters for the measurement.
- **Chapter 3 - Installation and Checkout** shows how to connect user inputs and how to install and check the voltmeter.
- **Chapter 4 - Programming the Voltmeter** shows how to program the voltmeter for multiplexer and rear panel measurements.

Voltmeter Description

The HP 44701A Integrating Voltmeter can be used with an HP 447XXX multiplexer to make AC or DC voltage, AC or DC current (with external shunt resistor), resistance (2-wire ohms and 4-wire ohms), strain, or temperature (RTD, thermistor, and thermocouple) measurements. You can also use the voltmeter with the external (rear) terminals for AC or DC voltage or 4-wire ohms measurements.

The HP 44701A uses offset compensation for most resistance ranges and autozero for all types of measurements. A guard terminal provides added common mode noise rejection and the voltmeter's method of analog to digital conversion (integration) provides normal mode noise rejection. Integration time can be varied from 0.0005 to 16 power line cycles (PLCs) to provide 3½ to 6½ digits of resolution.

Physical Description

Figure 1-1 shows the voltmeter rear panel. The upper three terminals (HI, LO and GUARD) are the input terminals for both voltage and resistance measurements. The lower two terminals (HI and LO CURRENT SOURCE) are the current source terminals for resistance measurements. The lever at the bottom of the panel allows the voltmeter to be released from its slot. To remove the voltmeter from a slot, lift the lever and pull the voltmeter outward.

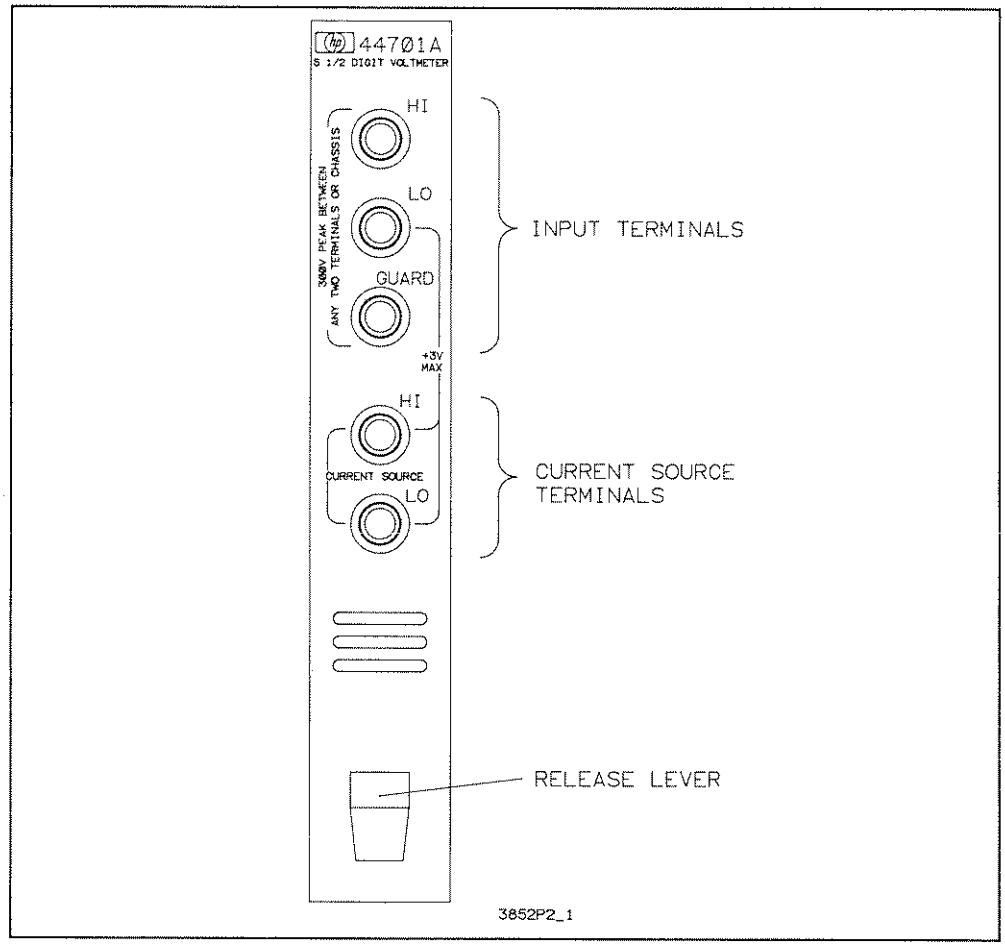

Figure 1-1. HP 44701A Rear Panel

The A/D Converter

The voltmeter measures an analog signal by converting it to a digital value. Once the signal is in digital form it can be displayed, sent over the HP-IB bus, inserted into a mathematical algorithm, etc. Input signals are converted to digital values by the voltmeter A/D (analog to digital) converter.

The A/D converter is responsible for many voltmeter operating characteristics such as normal mode rejection (ability to reject signals at the power line frequency from measurements), measurement speed, resolution, and accuracy. The magnitude of these characteristics are, in turn, determined by the A/D converter integration time.

Integration Time

Integration time is the amount of time that the A/D converter samples the input signal. You specify integration time as a certain number of power line cycles (PLCs) with the NPLC command. The voltmeter then multiplies the specified number of PLCs times the power line period to determine the integration time. With longer integration times, measurement resolution, accuracy, and normal mode rejection increase but measurement speed decreases.

Getting Started

There are three main steps to configure and program the voltmeter for your application:

- Define your measurement
- Configure the voltmeter
- Program the voltmeter

Define Your Measurement

The first step is to define your measurement application and select voltmeter operation for the measurement. Refer to Chapter 2 - Defining Your Measurement for guidelines to define your measurement and select voltmeter operation.

Configure the Voltmeter

The next step is to hardware configure the voltmeter for the measurement. Refer to Chapter 3 - Installation and Checkout to connect user inputs and to install and initially check the voltmeter.

Program the Voltmeter

The third step is to program the voltmeter for the measurement. Refer to Chapter 4 - Programming the Voltmeter to program the voltmeter for multiplexer and rear panel measurements.

Chapter 2
Defining Your Measurement

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Chapter 2

Defining Your Measurement

Introduction

This chapter gives guidelines to define your measurement and to select voltmeter configuration for the measurement. Chapter sections are:

- **Measurements Overview** summarizes the three main parameters of voltmeter measurements: measurement types, voltmeter programming, and data transfers.
- **Defining Measurement Requirements** gives guidelines to define measurement parameters and data/interrupt requirements.
- **Selecting Voltmeter Configuration** gives guidelines to select the voltmeter measurement function, the multiplexer(s) used, and the voltmeter triggering method for your measurement.
- **Configuration Example** shows an example way to characterize a DC voltage measurement and select the voltmeter configuration for the measurement.

Measurements Overview

Figure 2-1 shows three parameters of voltmeter measurements: measurement types, voltmeter programming, and data transfers.

Measurement Types

There are two types of voltmeter measurements: multiplexer measurements and rear panel measurements.

Multiplexer Measurements

AC or DC voltage, AC or DC current (with multiplexer shunt), resistance (2-wire ohms or 4-wire ohms), strain, or temperature (RTD, thermistor, or thermocouple) inputs can be sent to the voltmeter via HP 447XXX multiplexers and the mainframe backplane. These are called multiplexer measurements.

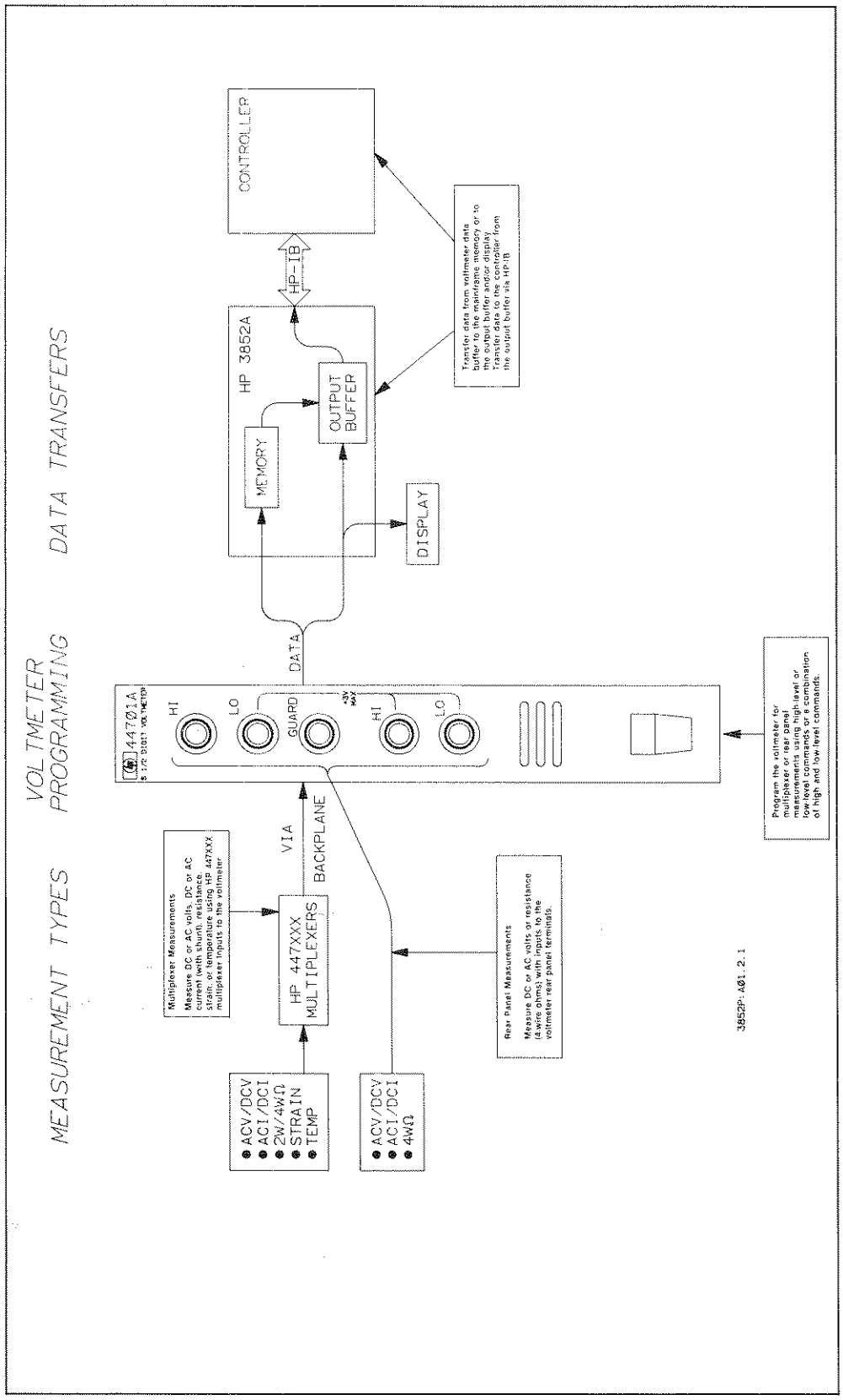


Figure 2-1. Voltmeter Measurements Overview

Rear Panel Measurements

AC and DC volts and 4-wire ohms (only) inputs can be sent directly to the rear panel terminals of the voltmeter. These are called rear panel measurements.

Voltmeter Programming

The voltmeter can be programmed for multiplexer or rear panel measurements using high-level or low-level commands. Refer to the Command Summary in Chapter 4 - Programming the Voltmeter for a list of commands which apply to the HP 44701A voltmeter.

Data Transfers

For any voltmeter measurement, the reading is first stored in the voltmeter data buffer and must be transferred to the mainframe memory or to the output buffer and/or display before the next reading is taken. (Refer to Chapter 6 - Managing Data in the HP 3852A Mainframe Configuration and Programming Manual for details on data storage and transfers.)

Transfer Data to Mainframe Memory

Data stored in the voltmeter data buffer can be transferred to mainframe memory in unconverted (PACKED) format and stored in a PACKED array or can be converted into RL64 or IN16 and stored in a REAL or INTEGER array (or variable) respectively. Data stored in mainframe memory can then be transferred to the output buffer in unconverted or converted format.

Transfer Data to Output Buffer

Data can be transferred directly from voltmeter memory to the output buffer in unconverted (PACKED) format or in any of six converted formats (IASC, LASC, RASC, DASC, RL64, or IN16). For IASC, LASC, RASC, or DASC, data can also be displayed.

Defining Measurement Requirements

Guidelines to help you characterize your measurement follow. The guidelines include a discussion of measurement parameters and data/interrupt requirements. The example numbers used in the discussion are from the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual. Refer to this appendix for complete specifications when characterizing your measurement.

Defining Measurement Parameters

This subsection includes guidelines to select the following measurement parameters:

- Type
- Speed
- Accuracy
- Resolution
- Noise Rejection
- Number of Measurements

Type of Measurement

The first step is to select the type of measurement (AC or DC voltage, AC or DC current, resistance, strain, or temperature) to be made. The voltmeter can measure DC voltages up to ±300 V; AC voltages up to ±200 VAC rms; resistances up to 3 MΩ with 2-wire or 4-wire techniques; strain from strain gages or rosettes; or temperatures (in °C) from thermocouples, thermistors, or RTDs.

Measurement Speed

Measurement speed (maximum reading rate) is a function of the number of power line cycles (PLC) selected and the power line frequency. For example, from the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual, maximum reading rate for DC voltage measurements with a 60 Hz power line frequency varies from 2.7 readings/second with NPLC = 16.0 to 1600 readings/second with NPLC = 0.0005. That is, measurement speed increases as the number of PLCs (and resultant integration time) decreases.

Measurement Accuracy

Measurement accuracy is a function of NPLC and the voltmeter range. For example with NPLC = 0.1 and the 30V range, DC voltage measurement accuracy is ±(0.008% + 700 μV) where 0.008% refers to the % of reading. Thus, for a 10 V reading, maximum error is ±(800 μV + 700 μV) = ± 1.5 mV. For any range, note that measurement accuracy increases as NPLC (and resultant integration time) increases.

Measurement Resolution

Measurement resolution is also a function of NPLC and the voltmeter range. For example, with NPLC = 0.1 and the 3V range, resolution is 10 μV. For any range, note that measurement resolution (the smallest change which can be detected) increases as NPLC increases since the number of digits converted increases.

Noise Rejection

Noise rejection also depends on the NPLC setting. For example, for DC voltage measurements CMR is 120 dB for all NPLC settings; NMR is 0 dB for all settings except NPLC 1 and NPLC 16 (60 dB for NPLC 1 and NPLC 16); and ECMR is 90 dB for all settings except NPLC 1 and NPLC 16 (150 dB for NPLC 1 and NPLC 16).

Number of Measurements

To determine the number of measurements to be made, define the number of sources to be measured and the number of measurements per source. This will determine the number of multiplexers required for your measurement. For example, to measure more than 20 inputs you will need two HP 44705A 20-channel multiplexers or one HP 44706A 60-channel multiplexer, etc. (Refer to Table 2-4 in "Selecting Multiplexer Used" for the maximum number of channels per multiplexer.)

Defining Data/ Interrupt Requirements

When you have defined your measurement parameters, define how to handle the data from the measurement. Two main considerations are:

- Data transfer mode
- Interrupt requirements

Data Transfer Mode

As shown in Figure 2-1, data stored in the voltmeter data buffer can be transferred to the mainframe memory or to the output buffer and/or display. Select the data transfer mode required for your measurement.

Interrupt Requirements

Determine if interrupts are required for your measurement. When enabled, interrupts can be handled in the mainframe or in the controller. Refer to Chapter 8 - Using Interrupts in the HP 3852A Mainframe Configuration and Programming Manual for guidelines on handling interrupts. Refer to Chapter 4 - Programming the Voltmeter for an example interrupt program.

Selecting Voltmeter Configuration

When you have defined your measurement requirements, the next step is to select voltmeter configuration for the measurement. Three voltmeter configuration areas are summarized, as shown. Again, refer to the Specifications Appendix of the HP 3852A Mainframe Configuration and Programming Manual for detailed specifications when selecting voltmeter configuration parameters.

- Voltmeter function
- Multiplexer used
- Triggering method

Selecting Voltmeter Function

As noted, the voltmeter can make AC or DC voltage, AC or DC current (with multiplexer shunt), resistance (2-wire and 4-wire ohms), strain, and temperature (RTD, thermistor, or thermocouple) measurements. Some voltmeter ranges/resolutions and accuracies follow.

DC Voltage Measurements

As shown in Table 2-1, the voltmeter has five DC voltage ranges (30 mV, 300 mV, 3V, 30V, and 300V). The effective range of DC voltage measurements is from about ±10 nV to ±300V.

Table 2-1. DC Voltage Ranges/Resolution

Range	Maximum Display	6½ Digit Resolution	5½ Digit Resolution	4½ Digit Resolution	3½ Digit Resolution
30mV	±30.30000	10 nV	100 nV	1 μV	10 μV
300mV	±303.0000	100 nV	1 μV	10 μV	100 μV
3V	±3.030000	1 μV	10 μV	100 μV	1 mV
30V	±30.30000	10 μV	100 μV	1 mV	10 mV
300V	±300.0000	100 μV	1 mV	10 mV	100 mV

AC Voltage Measurements

The voltmeter has four AC voltage ranges (200 mV, 2V, 20V, and 200V). AC measurements are made with a peak detector calibrated in rms which is intended to measure sine waves. The voltmeter is accurate only when the input voltage is greater than 10% of full scale. Table 2-2 shows AC voltage ranges/resolutions.

Table 2-2. AC Voltage Ranges/Resolution

Range	Maximum Display	3½ Digit Resolution
200mV	± 202.0000	100 μV
2V	± 2.020000	1 mV
20V	± 20.20000	10 mV
200V	± 202.0000	100 mV

Resistance Measurements

The voltmeter can make 2-wire or 4-wire ohms measurements using HP 447XXX multiplexers or can make 4-wire ohms measurements using the rear panel terminals. Six resistance ranges are available, as shown in Table 2-3.

Table 2-3. Resistance Ranges/Resolution

Range	Maximum Display	Resolution 6½ Digit	5½ Digit	4½ Digit	3½ Digit	Current Through Unknown
30Ω	± 30.30000	10 μΩ	100 μΩ	1 mΩ	10 mΩ	1 mA
300Ω	± 303.0000	100 μΩ	1 mΩ	10 mΩ	100 mΩ	1 mA
3kΩ	± 3.030000	1 mΩ	10 mΩ	100 mΩ	1 Ω	100 μA
30kΩ	± 30.30000	10 mΩ	100 mΩ	1 Ω	10 Ω	100 μA
300kΩ	± 303.0000	100 mΩ	1 Ω	10 Ω	100 Ω	10 μA
3MΩ	± 3.030000	1 Ω	10 Ω	100 Ω	1 kΩ	1 μA

Strain Measurements

The voltmeter and the HP 44717A, 44718A, 44719A, or 44720A Strain Gage multiplexers can be used to make strain measurements, including ¼ bridge, ½ bridge, and full-bridge measurements of strain gages or rosettes. Measurement data returned is the equivalent strain (or microstrain) value.

Temperature Measurements

The voltmeter can make temperature measurements of thermocouples, thermistors, or resistance temperature detectors (RTD). The data returned is the equivalent temperature in °C. In addition the reference temperature can be independently measured for thermocouple measurements.

The HP 3852A supports Type B, E, J, K, N14 [N (AWG 14)], N28 [N (AWG 28)], R, S, and T thermocouples, Type 2252, 5K, and 10K thermistors, and Type 85 (α = .00385 Ω/Ω/°C) or Type 92 (α = 0.003916 Ω/Ω/°C) RTDs. Other types of thermocouples can be measured with user-supplied linearization programs.

NOTE

Refer to Hewlett-Packard Application Note 290, "Practical Temperature Measurements", (part number 5952-8801) for guidelines on using thermocouples, thermistors, and RTDs for temperature measurements.

Selecting Multiplexer Used

As shown in Figure 2-1, there are two types of voltmeter measurements: multiplexer measurements and rear panel measurements.

Multiplexer Measurements

The voltmeter can be used with appropriate HP 447XXX multiplexers to make DC or AC voltage, DC or AC current, resistance, strain, or temperature measurements. The type of measurement selected determines the multiplexer(s) to be used. Table 2-4 summarizes multiplexers available for use with the voltmeter and typical measurements for each multiplexer.

Table 2-4. Multiplexer Characteristics

Multiplexer	Ch	Range	Primary Measurement(s)
Relay Multiplexers:			
HP 44705A	20	± 170V	ACV, DCV, ACI, DCI, 2W/4W ohms, RTDs, thermistors
HP 44705H	20	± 354V	ACV, DCV, ACI, DCI, 2W/4W ohms, RTDs, thermistors
HP 44706A	60	± 42V	ACV, DCV, 2W ohms
HP 44708A	20	± 170V	ACV, DCV, ACI, DCI, 2W ohms, thermocouples
HP 44708H	20	± 354V	ACV, DCV, ACI, DCI, 2W ohms, thermocouples
HP 44717A	10	± 42V	120 ohm strain gage, rosettes
HP 44718A	10	± 42V	350 ohm strain gage, rosettes
FET Multiplexers:			
HP 44709A	20	± 10.24V	ACV, DCV, ACI, DCI, 2W/4W ohms, RTDs, thermistors
HP 44710A	20	± 10.24V	ACV, DCV, ACI, DCI, 2W ohms, thermocouples
HP 44719A	10	± 10.24V	120 ohm strain gage, rosettes
HP 44720A	10	± 10.24V	350 ohm strain gage, rosettes
High-Speed FET Multiplexers:			
HP 44711A	24	± 10.24V	ACV, DCV, ACI, DCI, 4W ohms, RTDs, thermistors
HP 44712A	48	± 10.24V	ACV, DCV
HP 44713A	24	± 10.24V	ACV, DCV, ACI, DCI, thermocouples

Rear Panel Measurements

With rear panel measurements, user sources are input directly to the voltmeter rear panel terminals (HI, LO, and GUARD) for DC or AC voltage measurements. You can also use the CURRENT SOURCE (HI and LO) terminals with the voltage terminals for 4-wire ohms measurements.

Selecting Triggering Method

When the voltmeter measurement function and multiplexer(s) have been selected, next select the type of voltmeter triggering required. The voltmeter can be triggered from the mainframe or internally from the voltmeter.

Mainframe Backplane Triggering

The voltmeter can be triggered via the mainframe backplane by using the TRIG SCAN or TRIG SYS command. Refer to Chapter 7 - Triggering and Pacing in the HP 3852A Mainframe Configuration and Programming Manual for a discussion of mainframe triggering.

Voltmeter Internal Triggering

The voltmeter can be internally triggered by a single trigger (TRIG SGL) or triggered as required (TRIG AUTO).

Configuration Example

This section shows an example way to define a measurement and select voltmeter configuration for the measurement. When you have characterized your measurement and selected the voltmeter parameters, refer to Chapter 3 - Installation and Checkout to install the voltmeter and multiplexer(s) used and to initially check the voltmeter.

Example: DC Voltage Measurements

For this example, the application is DC voltage measurements of twenty 5 V inputs. Each input is to be measured 10 times so 200 readings are required. Table 2-6 show typical measurement requirements and voltmeter configuration for this measurement.

Table 2-6. DC Voltage Measurements Selections

Measurement Requirements	
Measurement Parameters	
• Type	DC volts (5V max input)
• Speed	300 readings/second
• Accuracy	1 mV
• Resolution	100 μV
• Noise Rejection	0 dB NMR, 120 dB CMR, 90 dB ECMR
• Number	200 readings
Data/Interrupt Requirements	
• Transfer Mode	To output buffer/display
• Interrupts	Not required
Voltmeter Configuration	
Voltmeter Function	DCV (30V range), NPLC = 0.1
Multiplexer Used	HP 44705A 20-Channel Relay Multiplexer
Triggering Method	Internal triggering
Interrupts	Disabled

For this example, the voltmeter function selected is DCV (30V range), NPLC = 0.1, and internal voltmeter triggering. An HP 44705A 20-Channel Relay Multiplexer will be used since it has the required number of channels and accuracy (refer to Table 2-4). Data destination will be the output buffer (and display) and interrupts will be disabled.

From the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual, NPLC = 0.1 and the 30V range sets the voltmeter for 5½ digits (100 μV of resolution); maximum reading rate of 415 readings/second @ 60Hz (360 readings/second @ 50Hz); (±0.0008% + 700 μV) accuracy; and noise rejections of 0 dB NMR, 120 dB CMR, and 90 dB ECMR.

With these selections, we can now refer to Chapter 3 - Installation and Checkout to configure the voltmeter and then to Chapter 4 - Programming the Voltmeter to program the voltmeter for the measurement. (As required, refer to the HP 44705A Configuration and Programming Manual for additional details.)

Chapter 3
Installation and Checkout

Contents

Chapter 3

Installation and Checkout

Introduction

This chapter shows recommended ways to connect user inputs to the voltmeter and shows how to install and initially check the voltmeter.

Chapter Contents

This chapter has three sections:

- **Introduction** summarizes chapter contents and lists WARNINGS, CAUTIONS, and NOTES which apply to the voltmeter.

- **Connecting User Inputs** shows recommended connections to multiplexers used with the voltmeter and connections to the voltmeter rear panel terminals.

- **Initial Checks** shows how to check the voltmeter ID, how to make the voltmeter self-test, how to check multiplexer wiring connections, and how to determine the mainframe firmware revision.

Warnings, Cautions, and Notes

This section summarizes WARNINGS, CAUTIONS, and NOTES which apply to the HP 44701A voltmeter and associated multiplexers. You should review the WARNINGS and CAUTIONS before handling or configuring any accessory.

WARNING

SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.

WARNING

POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel. Under most conditions of failure, the relays on the relay multiplexers will remain in whatever state the program sets them.

However, for some equipment failures, the relays may not remain in their programmed state. If the relays settle in the closed state, the relay contacts may weld together and the highest voltage present on any one channel may be present on all channels. This condition may cause operator injury if the terminals are touched or equipment damage may result.

WARNING

MAXIMUM VOLTAGE LIMITATIONS. The HP 3852A and the HP 3853A internal analog buses interconnect the multiplexer and voltmeter accessories to form one circuit. To protect against possible personal injury due to equipment failure or programming error, limitations are placed on the potentials that can appear between any two points on the circuit (or between the circuit and chassis).

These limitations are listed for the HP 3852A, HP 3853A, and all plug-in accessories. For any given set of accessories installed in the mainframe or extender, the maximum potential between any two points is determined by the accessory with the LOWEST peak voltage limitation, as follows. (If the analog extender cable is NOT connected between the mainframe and the extenders, each instrument is considered as a separate circuit.)

Instrument/Accessory	*Peak Voltage*
HP 3852A Mainframe	*354 V*
HP 3853A Extender	*354 V*
HP 44701A Integrating Voltmeter	*354 V*
HP 44702A/B High-Speed Voltmeter	*42 V**
HP 44705A/08A/17A/18A 20-Channel Relay Multiplexers	*170 V*
HP 44705H/08H 20-Channel High-Voltage Relay Multiplexers	*354 V*
HP 44706A 60-Channel Relay Multiplexer	*42 V*
HP 44709A/10A/11A/12A/13A FET Multiplexers	*42 V**

* = *42 V maximum on backplane analog bus, but NOT on rear terminals/terminal module.*

Maximum voltage between any of the HP 44701A input terminals (HI, LO, GUARD) or between any two points (terminals or chassis) is ± 354 V peak or ±250 VDC. Maximum voltage between the LO input terminal and the HI or LO CURRENT SOURCE terminal is ±3 V peak AC or DC. Do not exceed these voltages since the HP 44701A and possibly the mainframe or extender will be damaged.

When measuring high voltage levels, be sure TERM EXT is set (selects the HP 44701A rear terminals). If TERM BOTH is set, the voltage will be connected to the mainframe or extender analog bus.

When TERM BOTH is set or in case of equipment failure, any voltage present on the analog backplane will be connected to the HP 44701A rear panel terminals. For safety, always regard the HP 44701A rear panel terminals as being at a high potential.

CAUTION

POSSIBLE EQUIPMENT DAMAGE. When making high-voltage measurements with the HP 44705A/44705H or HP 44708A/44708H, the HP 3852A analog backplane becomes charged to the voltage on the last channel connected to it. Thus, the next channel that is closed may have to absorb all of the stored energy on the backplane.

If the backplane is not discharged after making a high-voltage measurement, the voltage present on the backplane must be added to the voltage being switched on the next channel to determine the total relay contact voltage. See Figure 3-1 for guidelines to maximize relay life and prevent damage to sensitive transducers by high backplane discharge voltages.

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

NOTE

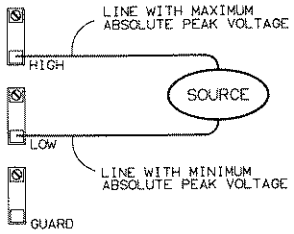
SHIELDED CABLE RECOMMENDED. Shielded, twisted-pair cable is highly recommended for connection to multiplexer inputs terminals or to HP 44701A rear panel terminals to reduce noise and keep measurement error to a minimum.

You can order the appropriate cable from your nearest Hewlett-Packard Sales and Support Office. Order HP part number 03498-61602 which is a 2 metre shielded, twisted-pair cable with crimped and heat-shrunk wires attached to the braided shield at both ends.

NOTE

HP-IB ADDRESS. The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 controllers. Modify slot and channel numbers and program syntax as required.

- **When measuring high-voltages, connect the line which has the highest maximum absolute peak voltage of the source to the HIGH terminal on the terminal module. Connect the line which has the lowest absolute peak voltage of the source to the LOW terminal on the terminal module. Connect the guard line ONLY if high common mode noise rejection is necessary, otherwise, do not connect the guard line.**



OR

- **Discharge the HP 3852A analog backplane to earth ground through 1 MΩ - 10 MΩ resistors connected to HIGH, LOW, and GUARD on an unused channel.**

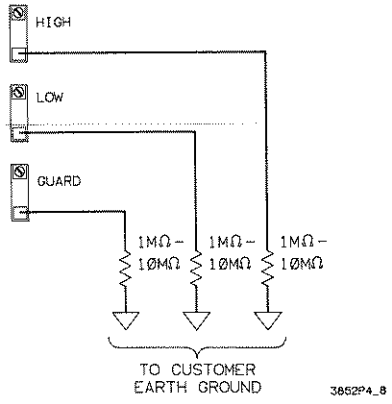


Figure 3-1. Discharging the HP 3852A Backplane

Connecting User Inputs

This section shows recommended ways to connect user inputs to multiplexer terminal modules or to the voltmeter rear panel terminals.

Multiplexer Connections

Always use shielded, twisted-pair cable when connecting user inputs to multiplexers. This is especially important when the transducer used floats above earth ground. With this configuration, the voltmeter can indicate an overload condition even when the transducer outputs a signal which is within the voltmeter range.

This can occur due to bias currents at the voltmeter inputs which cause the voltage with respect to chassis (earth) ground to rise to a level which can cause an overload condition on the input. Good grounding and shielding practices can solve this problem.

Figure 3-2 shows typical voltage, 2-wire Ω, and 4-wire Ω connections to an HP 44705A 20-Channel Relay Multiplexer. If you use another multiplexer, refer to the appropriate multiplexer configuration and programming manual for specific details.

Rear Panel Connections

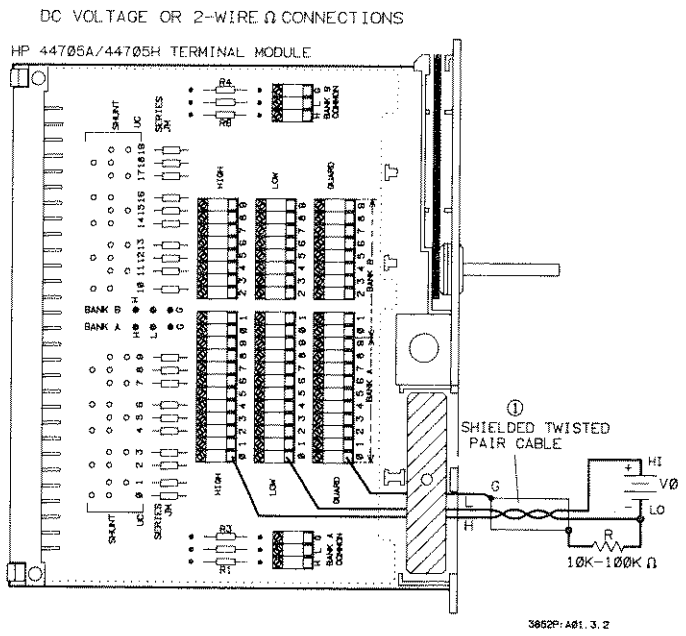
Figure 3-3 shows typical connections to the rear panel terminals for AC and DC voltage and 4-wire ohms measurements (the only measurements which can be made using the rear panel terminals). When connecting user inputs to the voltmeter rear panel terminals (HI, LO, and GUARD for voltage or HI, LO, GUARD and CURRENT SOURCE HI and LO for resistance measurements), use shielded, twisted-pair cables and keep the exposed part of the cable as short as possible.

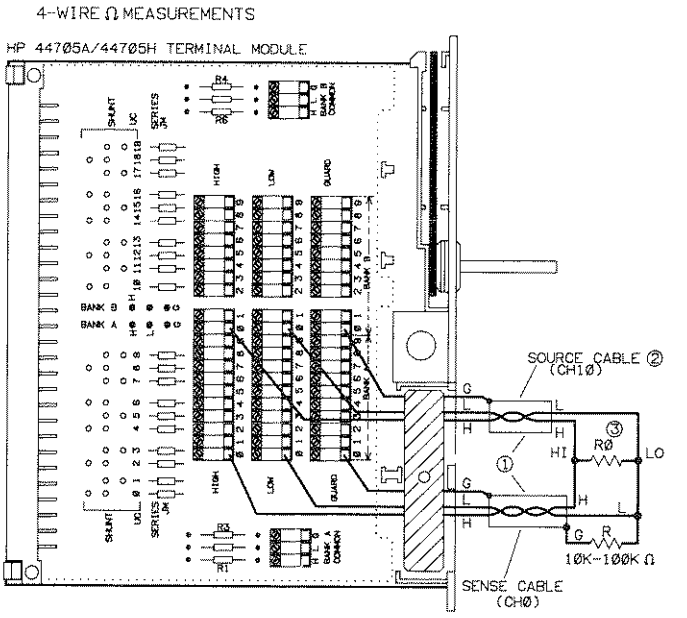
Initial Checks

When the voltmeter and/or multiplexer connections have been made, install the voltmeter in a desired slot as shown in the HP 3852A Mainframe Configuration and Programming Manual. When the voltmeter and multiplexers are installed, the next step is to initially check the voltmeter for proper operation. This section shows how to check the voltmeter ID, how to perform the voltmeter self-test, how to check multiplexer wiring connections, and how to check the mainframe firmware revision number.

Voltmeter ID Check

When the voltmeter has been installed, check the voltmeter identity by entering the ID? *slot* command from the front panel. For example, ID? 400 checks the ID of an accessory in slot 4 of the mainframe. If an HP 44701A is installed in this slot, "44701A" is displayed. If no accessory is installed in the slot addressed, "000000" is displayed.





Notes:

[1] = Shielded cable is highly recommended for measurements with the HP 44701A Voltmeter.

[2] = Do NOT connect Source channel shield lead to R0 LO as this will reduce the effective compliance voltage.

[3] = R0 can be a resistor, and RTD, or a thermistor. The HP 3852A supports Type 85 and 92 RTDs and Type 2252, 5K, and 10K thermistors.

Figure 3-2. HP 44705A Multiplexer Connections

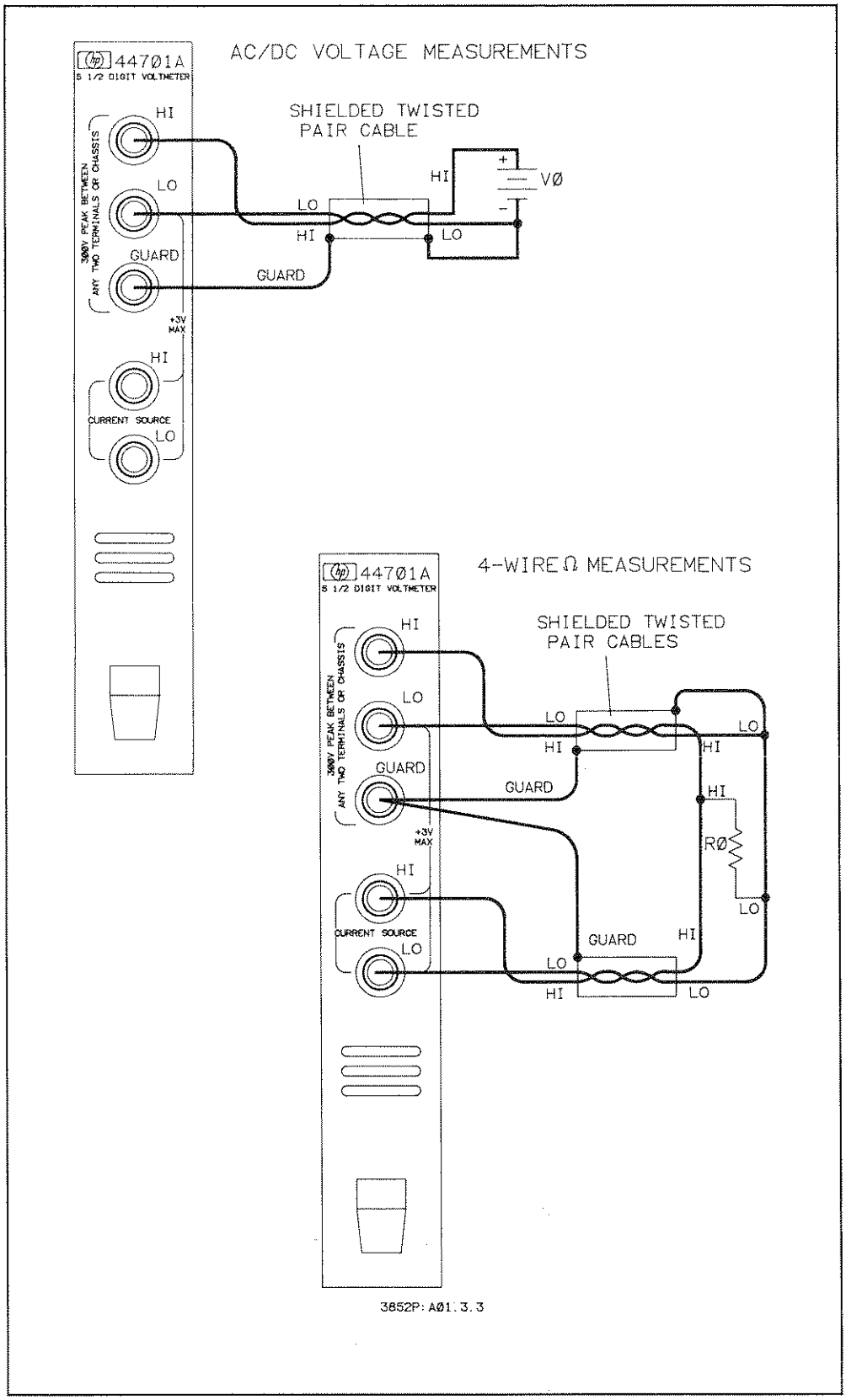


Figure 3-3. HP 44701A Rear Panel Connections

Voltmeter Self-Test

To self-test the voltmeter, enter the TEST *slot* command from the front panel. For example, enter TEST 400 to self-test the accessory in slot 4 of the mainframe. If the voltmeter passes the self-test check, you can be reasonably sure the voltmeter is operating correctly. The self-test checks the voltmeter for proper operation and resets the voltmeter to its power-on state. The HP 44701A voltmeter self-test consists of the following tests:

- Communications check between mainframe/extender and HP 44701A.
- A/D converter test.
- Input amplifier offset test.
- RAM and ROM checksum verification.
- Calibration constants verification.

NOTE

The calibration constants verification does not guarantee that the voltmeter is adequately calibrated. It only verifies that the calibration constants exist. It is possible to calibrate the voltmeter to an inaccurate standard.

Before executing the self-test, ensure that the voltmeter is not busy, since a busy voltmeter will cause a self-test failure when the TEST command is executed. You can set the voltmeter to a non-busy state by entering the RST *slot* command followed by the TEST *slot* command.

If the self-test passes, the HP 3852A displays SELF TEST OK and there is a high confidence level that the voltmeter is operational. If the self-test fails, the HP 3852A displays an error message and you should refer to the HP 3852A Assembly Level Service Manual for details. Following the self-test, the HP 44701A reverts to its power-on state.

Checking Wiring Connections

When the voltmeter passes the self-test, you can check wiring connections to the multiplexers by using the MONMEAS command. (MONMEAS works for DC volts and resistance connections only.)

With MONMEAS, the voltage (or resistance) on a specified channel is continuously monitored and the result sent to the front panel display ONLY. To advance the monitoring to the next channel in the list, press the SADV KEY key on the front panel. An example follows.

Example: Monitoring Multiplexer Inputs (MONMEAS)

This program checks the DC voltage input to channels 200 through 204 of an HP 44705A multiplexer in slot 2 of the mainframe using an HP 44701A voltmeter in slot 6 of the mainframe. (To monitor 2-wire ohms, use CONF OHM in line 30. To monitor 4-wire ohms, use CONF OHMF in line 30).

When MONMEAS is executed, channel 200 is closed. The voltmeter makes repeated measurements on channel 200 and continuously displays the results on the front panel display only.

Pressing the front panel SADV KEY key advances the scan to channel 201. Pressing the SADV KEY key again advances the scan to channel 202, etc. When the scan reaches channel 204, pressing the SADV KEY key once more ends the sequence. (You can also use the CLEAR key to stop the scan.)

```
10 OUTPUT 709;"RST 600"                    !Reset the voltmeter
20 OUTPUT 709;"USE 600"                    !Use voltmeter in mainframe slot 6
30 OUTPUT 709;"CONF DCV"                   !Select DC volts measurements
40 OUTPUT 709;"MONMEAS DCV,200-204"        !Meas/display volts on ch 200-204
50 END
```

A typical return for a 5 V 5% source connected to channel 200 (value in volts) is:

DCV 200	4.999874E+00

Mainframe Firmware Revision

Certain voltmeter commands (such as MEAS and DELAY) have additional capability in mainframe firmware revision 2.2 and greater. To determine if your instrument has this capability, use the following program or enter the IDN? command from the front panel to determine the mainframe firmware revision number.

```
10 DIM Identity$(1:4)[17]
20 OUTPUT 709;"IDN?"
30 ENTER 709;Identity$(*)
40 PRINT USING "K,/";Identity$(*)
50 END
```

For example, a typical return for firmware revision 2.2 is:

```
HEWLETT PACKARD      (Company name)
3852A                (Model number)
0                    (Mainframe serial number unknown)
2.2                  (Firmware revision 2.2)
```

Chapter 4
Programming the Voltmeter

Contents

Chapter 4

Programming the Voltmeter

Introduction

This chapter shows how to program the HP 44701A voltmeter for multiplexer and rear panel measurements. The chapter has five sections:

- **Introduction** lists the chapter contents, shows example program titles, and shows a suggested getting started sequence.

- **Measurements Using CONFMEAS** shows how to make multiplexer measurements using the CONFMEAS command.

- **Measurements Using CONF and MEAS** shows how to make multiplexer measurements using the CONF, MEAS, and low-level commands.

- **Measurements Not Using MEAS** shows how to use CONF and/or low-level commands to make multiplexer and rear panel measurements and to enable interrupts.

- **Command Summary** is an alphabetical summary of commands which apply to the HP 44701A voltmeter.

Program Titles

Table 4-1 lists the titles of the example programs in this chapter, listed by section title.

Table 4-1. Example Program Titles

Title	Description	Command (s)
Measurements Using CONFMEAS		
DC Voltage Measurements	Measure DC Voltages on multiplexer channels.	CONFMEAS
Resistance Measurements	Measure the resistance on a multiplexer channel.	CONFMEAS
Temperature Measurements	Measure the temperature of a thermistor.	CONFMEAS
Reference Temperature Measurement	Measure the isothermal block block temperature.	CONFMEAS
Measurements Using CONF and MEAS		
Setting Voltmeter Operation	Set integration time, number of readings/trigger, delays and range.	NPLC, NRDGS, DELAY, RANGE
Setting Voltmeter triggering	Set voltmeter trigger source.	TRIG, TRG
Setting Scan Triggering	Set scan trigger source and scan advance source.	SADV, STRIG
Measurements Not Using MEAS		
Low-level Multiplexer Measurements	Use CONF and low-level commands for multiplexer measurements.	CLOSE, AZERO, CHREAD
Rear Panel Measurements	Use low-level commands for rear panel measurement.	FUNC, OCOMP, XRDGS
Enabling Interrupts	Use low-level commands to enable a voltmeter interrupt.	ENABLE INTR

Getting Started

As shown in Figure 4-1, you can program the voltmeter or multiplexer or rear panel measurements or you can make field wiring checks.

Multiplexer Measurements

You can make multiplexer measurements in one of three ways: use CONFMEAS; use CONF and MEAS along with low-level commands; or use CONF and/or low-level commands (not using MEAS).

- Measurements Using CONFMEAS:

The easiest way to make multiplexer measurements is to use CONFMEAS which sets the voltmeter to a known condition and makes the measurement with a single command. Therefore, first refer to "Measurements Using CONFMEAS" to see if your measurement can be made with CONFMEAS.

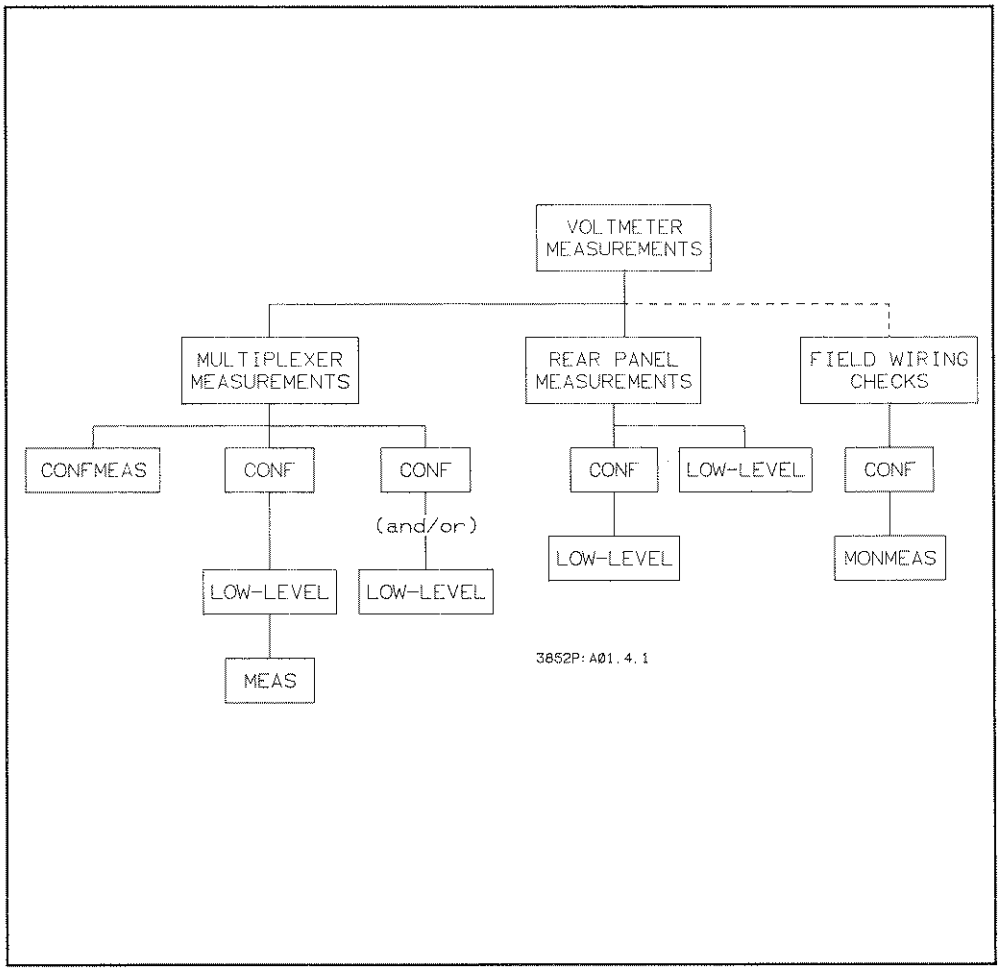


Figure 4-1. Voltmeter Measurements Overview

• Measurements Using CONF and MEAS:

Since CONFMEAS sets the voltmeter to a preset condition, if you need to change operating conditions set by CONFMEAS you can use CONF and MEAS along with low-level commands. Refer to "Measurements Using CONF and MEAS" for details.

• Measurements Not Using MEAS:

Using CONFMEAS or CONF and MEAS along with low-level commands will probably meet most multiplexer melasurement requirements. However, if you need to enable interrupts, make rear panel measurements, or close channels with the CLOSE command. CONFMEAS or MEAS cannot be used. Refer to "Measurements Not Using MEAS" for applications when CONFMEAS or MEAS cannot be used.

Rear Panel Measurements

You can make rear panel measurements using CONF and/or low-level commands. Refer to "Measurements Not Using MEAS" for details.

Field Wiring Checks

Refer to Chapter 3 - Installation and Checkout to check multiplexer field wiring connections using MONMEAS.

Measurements Using CONFMEAS

This section shows how to make multiplexer measurements using the CONFMEAS command. It includes a summary of the CONFMEAS command, describes voltmeter operation with CONFMEAS, shows the preset values for the CONF phase of CONFMEAS, and shows measurement examples using CONFMEAS.

CONFMEAS Command

CONFMEAS can be used with the HP 44701A voltmeter to make AC or DC voltage, AC or DC current (when user-supplied shunt is installed), strain, resistance (2-wire or 4-wire ohms), and temperature (thermocouples, thermistors, or RTDs) measurements. The advantage of using CONFMEAS is that it allows you to quickly and easily configure the voltmeter for a wide variety of measurements with a single command. The CONFMEAS syntax is:

CONFMEAS *function ch_list*[NSCAN *number*] [USE *ch*] [INTO *name*] or [*fmt*]

NOTE

1. The NSCAN number parameter applies only to instruments which have firmware revision 2.2 or greater.

2. For the HP 44717A, 44718A, 44719A, and 44720A strain gage multiplexers, CONFMEAS includes additional optional and/or required parameters. Refer to the HP 44717A, 44718A, 44719A, and 44720A Strain Gage Accessories Configuration and Programming Manual for details.

CONFMEAS configures the voltmeter for a specific measurement function, scans, measures, and transfers data. CONFMEAS can be used only for multiplexer measurements. CONFMEAS does the following:

- Configures the voltmeter to a function appropriate to the specified measurement function (DCV, OHM, etc.) and sets the voltmeter to a known programmed state. The measurement function is specified by the *function* parameter.

- Causes specified multiplexer channel(s) to be scanned and measured and associated data conversion (voltage to temperature in °C or voltage to strain) to be performed (as required) on the results. The channels to be scanned are defined by the *ch_list* parameter. (The optional NSCAN *number* parameter sets the number of times the channels in the *ch_list* will be scanned.)

- As part of thermocouple measurements, measures the isothermal block reference thermistor on the terminal module to provide a reference value for temperature conversions. CONFMEAS can also be used to measure the isothermal block reference temperature only.

- Transfers measurement data to the mainframe memory (when INTO *name* is used) or to the output buffer and display (when INTO *name* is not used).

Table 4-2 shows CONFMEAS *function* parameters and data returns for the *function*. Note that CONFMEAS is actually two commands in one: CONF and MEAS. The configuration phase of CONFMEAS is equivalent to the CONF command, while the measurement phase of CONFMEAS is equivalent to the MEAS command. That is, CONFMEAS is equivalent to a CONF command followed immediately by a MEAS command.

Table 4-2. CONFMEAS Functions/Data Returns

function:	Configure for:	Data Returned:
Voltage		
ACV	AC voltage	AC voltage on chs in ch_list
DCV	DC voltage	DC voltage on chs in ch_list
Resistance		
OHM	2-wire ohms.	Resistance on chs in ch_list
OHMF	4-wire ohms [1].	Resistance on chs in ch_list
Temperature		
TEMPtype	Reference temperature and thermocouple voltage measurements type = B, E, J, K, N14 [N (AWG 14)], N28 [N (AWG 28)], R, S, and T.	Thermocouple temp (°C) on chs in ch_list, compensated to 0°C reference.
REFT	Reference temperature measurement of isothermal block.	Reference temp (°C) of isothermal block in slot addressed.
THMtype	2-wire ohms measurement of thermistor. type = 2252 (2252 Ω thermistor) = 5K (5 kΩ thermistor) = 10K (10 kΩ thermistor)	Thermistor temp (°C) on chs in ch_list.
THMFtype	4-wire ohms measurement of thermistor [1]. type = same as THMtype.	Thermistor temp (°C) on ch in ch_list.
RTDtype	2-wire ohms measurement of RTD. type = 85 (RTDs with α = 0.00385 Ω/Ω/°C) = 92 (RTDs with α = 0.003916 Ω/Ω/°C)	RTD temp (°C) on ch in ch_list.
RTDFtype	4-wire ohms measurement of RTD [1]. type = same as RTDtype.	RTD temp (°C) on ch in ch_list.
Strain [2]		
STRVEX	Bridge excitation voltage (±VS)	Bridge excitation voltage
STRUN	Bridge output which is ref for corresponding strain measurement.	Bridge output voltage
STRQ	¼ bridge strain.	Strain or microstrain [3]
STRFB	Bending full bridge strain.	Strain or microstrain [3]
STRHB	Bending ½ bridge strain.	Strain or microstrain [3]
STRQTEN	Shunt verification (tension shunt) diagnostic (HP 44717A or 44718A only)	Microstrain
STRQCOMP	Shunt verification (compression shunt) diagnostic (HP 44717A or 44718A only).	Microstrain
STRHP	½ bridge Poisson strain.	Strain or microstrain [3]
STRFBP	Bending full bridge Poisson strain.	Strain or microstrain [3]
STRFP	Full bridge Poisson strain.	Strain or microstrain [3]

Notes:

[1] = For 4-wire ohms functions, specify only the Sense channel. CONFMEAS automatically selects the proper Source channel.

[2] = STRVEX, STRUN, DCV, and OHMxx apply to function1. STRQ, STRHB, STRFB, STRQTEN, and STRQCOMP apply to function2. STRHP, STRFBP, and STRFP apply to function3. Refer to the CONFMEAS command in the HP 3852A Command Reference Manual for definition of function1, function2, and function3.

[3] = Depends on Gage factor (GF factor).

CONFMEAS Operation

Figure 4-2 is a simplified version of voltmeter operation for CONFMEAS. When CONFMEAS is executed the voltmeter is configured (1), any required thermocouple or strain references are measured (2), and the scan sequence is started (3).

When the scan sequence is started, the first channel in the channel list is closed and the voltmeter is triggered. After a default delay time t, a measurement (m_1) is made on the first channel in the channel list (4). The default delay time depends on the function, range, and NPLC settings for the voltmeter.

When the first channel is measured, the data is transferred to the mainframe (5), the scan is advanced to the second channel in the channel list (6), and a measurement is taken on the second channel. This sequence repeats for each channel in the channel list. When the last channel is measured, the channel is opened and the scan ends (7).

If the CONFMEAS NSCAN parameter (valid only for firmware revision 2.2 and greater) is not specified, the scan sequence ends at (7). If NSCAN *number* is specified, the scan sequence is repeated *number* times. For example, with NSCAN 3 and 10 channels in the channel list, 30 measurements are taken.

CONFMEAS Presets

As noted, executing CONFMEAS is equivalent to executing a CONF command followed immediately by a MEAS command. To help you decide whether to use CONFMEAS or to use CONF and low-level commands, Table 4-3 shows the values set with the CONF command (presets) which are the same as those set by the CONF phase of CONFMEAS.

If these presets are acceptable for your measurement, refer to the next subsection "Examples: Measurements Using CONFMEAS" for some example programs using CONFMEAS. If not, refer to the next section "Measurements Using CONF and MEAS".

Executing CONF (or the CONF phase of CONFMEAS) is equivalent to setting the twelve low-level commands shown in Table 4-3 in the order shown. CONF does not change the previous settings of any commands not shown in Table 4-3.

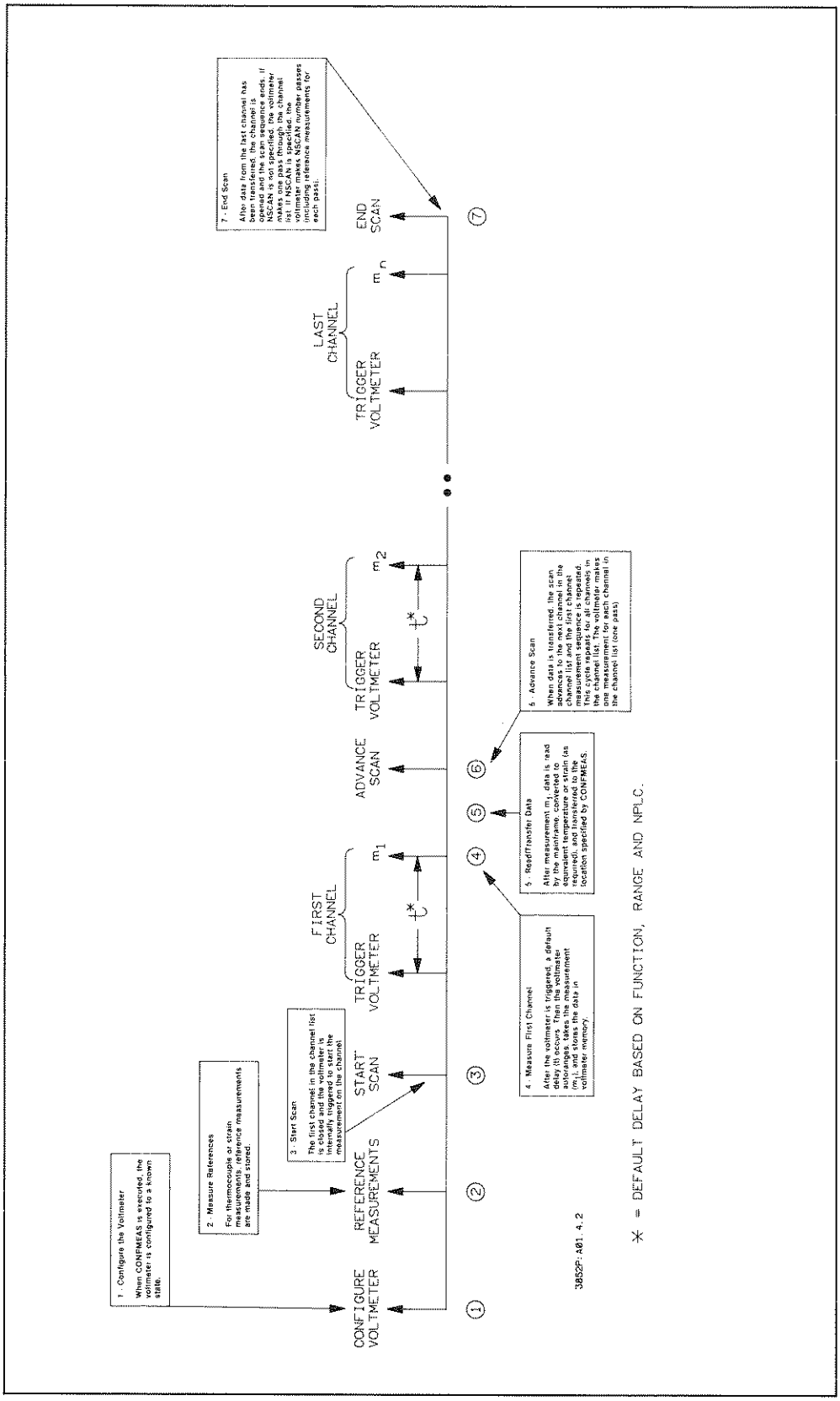


Figure 4-2. CONFMEAS Operation

Table 4-3. CONFMEAS Command Preset Values

Command/Preset(s)	Definition	Notes
STRIG SCAN	Start scan immediately.	
SADV SCAN	Advance scan when NRDGS rdgs available.	
TRIG HOLD	Trigger is disabled (no trigger).	[1]
DELAY t	Built-in delay as set by CONF.	[2]
AZERO ON	Autozero after every reading.	
FUNC DCV, ACV, or OHMF	As appropriate for CONFMEAS function.	[3]
RANGE AUTO	Autorange mode.	[4]
TERM BOTH	Backplane bus/rear panel are both inputs.	
NRDGS 1	One reading/trigger.	
NPLC 1	One power line cycle (PLC) @ 60 Hz.	
OCOMP OFF	Offset compensation disabled.	
DISABLE INTR	Voltmeter interrupts disabled.	

Notes:

[1] = TRIG HOLD is changed to TRIG SCAN by the MEAS phase of CONFMEAS.

[2] = Built-in default delay based on voltmeter function/range/NPLC.

[3] = Function set (ACV, DCV, or OHMF) depends on function parameter of CONFMEAS command.

[4] = For mainframe firmware revisions 2.2 and greater, CONF TEMPtype sets RANGE AUTO. For earlier firmware revisions, the 30 mV range is selected for B, N28 [N (AWG 28)], R, S, and T type thermocouples and the 300 mV range is selected for E, J, K, and N14 [N (AWG 14)] thermocouples.

CAUTION

CONFMEAS sets TERM BOTH which allows inputs to both the rear panel terminals and the mainframe backplane bus (i.e., multiplexers). Thus, any voltage on a closed multiplexer channel also appears on the rear panel terminal. Also, any voltage on the rear panel terminals appears on the multiplexer channel. To avoid damage to the voltmeter or to the system, do not connect any input to the rear panel terminals when making backplane (multiplexer) measurements.

Examples: Measurements Using CONFMEAS

Four program examples using CONFMEAS for multiplexer measurements follow. The first example measures DC voltage, the second measures resistance using 4-wire ohms, the third measures the temperature of a thermistor, and the fourth measures a reference temperature.

The first three examples use an HP 44705A 20-Channel Relay Multiplexer in slot 5 of the mainframe and an HP 44701A voltmeter in slot 6 of the mainframe. See Figure 3-2 in Chapter 3 for typical connections. The fourth example uses an HP 44708A in slot 5 of the mainframe. You should also refer to the appropriate multiplexer configuration and programming manual for additional details.

NOTE

The HP 44701A can be used to indirectly measure AC or DC currents by measuring the voltage drop across a resistor mounted on a multiplexer which has current shunt capabilities. Refer to the appropriate multiplexer configuration and programming manual for details.

Example: DC Voltage Measurements (CONFMEAS)

This program uses CONFMEAS to measure DC voltages connected to channels 500 through 509 of an HP 44705A multiplexer. Since NSCAN *number* is not specified, the voltmeter makes a single pass through the channel list.

```
10 DIM Volts(0:9)                          !Dimension controller array
20 OUTPUT 709;"USE 600"                    !Use voltmeter in mainframe slot 6
30 OUTPUT 709;"CONFMEAS DCV,500-509"       !Conf/meas DC volts, ch 500-509
40 ENTER 709;Volts(*)                      !Enter 10 readings
50 PRINT USING "K,/";Volts(*)              !Display 10 readings
60 END
```

For a set of 5 V 5% sources, a typical return (values in volts) is:

```
4.9975 ┐
5.0025 │
   .   │   10 readings
   .   │
4.9875 ┘
```

Example: Resistance Measurements (CONFMEAS)

CONFMEAS can also be used for 2-wire or 4-wire ohms resistance measurements (refer to Table 4-2). This program measures resistance using 4-wire ohms on channel 500 of an HP 44705A multiplexer.

Note that only the Sense channel (channel 500) is specified in the CONFMEAS *ch_list* parameter, since CONFMEAS automatically assigns the correct channel (channel 510 in this case) as the Source channel. Also, note that CONFMEAS OHMF configures the voltmeter for 4-wire ohms measurements and that measurement results are returned in Ω.

```
10 OUTPUT 709;"USE 600"                    !Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONFMEAS OHMF,500"          !Conf/meas resistance on ch 500
30 ENTER 709;A                             !Enter results
40 PRINT A                                 !Display results
50 END
```

A typical return for a 10 kΩ 5% resistor (value in Ω) is:

```
9993.75
```

Example: Temperature Measurements (CONFMEAS)

CONFMEAS can be used for a wide variety of temperature measurements, including RTDs, thermistors, and thermocouples. CONFMEAS can also be used to measure the reference temperature for thermocouple measurements.

The HP 3852A supports 2252Ω, 5 kΩ, and 10 kΩ thermistors; Type 85 and 92 RTDs; and Type B, E, J, K, N14 [N (AWG 14)], N28 [N (AWG 28)], R, S, and T thermocouples. Both 2-wire and 4-wire ohms techniques can be used for RTD or thermistor measurements, but accuracy is reduced for 2-wire ohms measurements (2-wire ohms measurements are NOT recommended for FET multiplexers).

This program uses CONFMEAS to measure the temperature of a 2252 Ω thermistor connected to channel 500 of an HP 44705A multiplexer. See Figure 3-2 for typical thermistor connections to channels 500 and 510 of the multiplexer.

```
10 OUTPUT 709;"USE 600"                    !Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONFMEAS THMF2252,500"      !Conf/meas Type 2252 thermistor
30 ENTER 709;A                             !Enter temperature
40 PRINT A                                 !Display temperature
50 END
```

For a 2252 Ω thermistor at room temperature, a typical return (value in °C) is:

```
24.312
```

Example: Reference Temperature Measurement (CONFMEAS)

As noted, the HP 3852A supports Type B, E, J, K, N14 [N (AWG 14)], N28 [N (AWG 28)], R, S, and T thermocouples. However, if you want to measure other thermocouples, you will need to measure the reference temperature for use in your own linearization program. This program uses CONFMEAS to measure the reference temperature of an HP 44708A multiplexer in slot 5 of the mainframe.

```
10 OUTPUT 709;"USE 600"                    !Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONFMEAS REFT,500"          !Measure reference temperature
30 ENTER 709;A                             !Enter reference temperature
40 PRINT A                                 !Display reference temperature
50 END
```

A typical return at room temperature (value in °C) is:

```
24.312
```

Measurements Using CONF and MEAS

This section shows how to use CONF and MEAS along with some low-level commands for multiplexer measurements. Low-level commands discussed in this section are ARANGE, DELAY, NPLC, NRDGS, RANGE, SADV, STRIG, TRG, and TRIG. (Note that SADV, STRIG, and TRG are mainframe rather than voltmeter commands.) Refer to "Measurements Not Using MEAS" for a discussion of other low-level commands.

Programming Overview

As previously shown, CONFMEAS configures the voltmeter, takes the measurement, and reads the data with a single command. However, CONFMEAS sets the voltmeter to a specific configuration. If your measurement cannot be made with CONFMEAS, you can modify the voltmeter configuration by using the CONF and MEAS commands and low-level commands.

The programming sequence used in this subsection will be to first configure the voltmeter to a known state with the CONF command, modify the CONF settings with one or more low-level commands, and use MEAS to make the measurements and transfer the data. We'll show how to use nine low-level commands to modify the voltmeter settings: ARANGE, DELAY, NPLC, NRDGS, RANGE, SADV, STRIG, TRG, and TRIG.

Refer to "Setting Voltmeter Operation" for the ARANGE, DELAY, NPLC, NRDGS, and RANGE commands. Refer to "Setting Voltmeter Triggering" for the TRG and TRIG commands. Refer to "Setting Scan Triggering" for the SADV and STRIG commands.

NOTE

You can probably make most multiplexer measurements using CONF, MEAS, and one or more low-level commands. However, if you need to make rear panel measurements, use OPEN and CLOSE, or enable interrupts, MEAS cannot be used. In this case, refer to the next section "Measurements Not Using MEAS".

Voltmeter Commands

Table 4-4 summarizes commands for the voltmeter. The table has three parts. The first part shows the four high-level commands (CONF, CONFMEAS, MEAS, and MONMEAS) associated with the voltmeter. The second part shows associated low-level commands for which power-on and default values do not apply. The third part shows low-level voltmeter commands which have a power-on and/or default value.

In Table 4-4, since FUNC has two parameters the command is listed twice, once for each parameter. Also note that the power-on state is the same as the reset (RST or RST *slot*) state. Refer to the HP 3852A Command Reference Manual for details on the commands.

Table 4-4. Voltmeter Commands

High-Level Commands

CONF	Configure the voltmeter.
CONFMEAS	Configure, scan, and measure.
MEAS	Set function, scan, and measure.
MONMEAS	Monitor measurements (wiring checks only).

Low-Level Commands - Data Reads/Queries

CHREAD	Single data read.
ID?	Query accessory ID.
INTR?	Query last interrupt channel serviced.
TEST	Self-test the voltmeter.
USE?	Query USEd channel (voltmeter slot used).
VREAD	Read data from mainframe memory.
XRDGS	Multiple data reads.

Low-Level Commands - Power-On/Default Settings

Command	Description	Power-On	Default	Note
ARANGE [mode]	Autorange mode	ON	ON	
AZERO [mode]	Autozero mode	ON	OFF/ONCE	
CAL	Service cmd	----	----	[1]
DELAY trig_delay	Trigger delay	0 sec	----	
DISABLE event	Disable intr	INTR	----	[2]
FUNC function	Meas function	DCV	----	
FUNC [range]	Meas range	AUTO	AUTO	
NPLC number	Integration time	1 @ 60 Hz	----	[3]
NRDGS number	Rdgs/trigger	1	----	
OCOMP [mode]	Offset comp	OFF	ON	[4]
RANGE [range]	Voltmeter range	AUTO	AUTO	
SADV source	Scan adv source	SCAN	----	[5]
STRIG source	Scan start source	SCAN	----	[5]
TERM terminal	Input terminals	EXT	----	
TRG [source]	System trigger	HOLD	SGL	[6]
TRIG [source]	Trigger source	HOLD	SGL	
USE ch	Voltmeter slot	Low valid slot	----	[7]

Notes:

[1] = Refer to HP 3852A Assembly Level Service Manual.
[2] = Interrupts disabled at power-on.
[3] = 1 based on a 60 Hz line frequency.
[4] = OCOMP valid only for 30 Ω through 30 kΩ ranges.
[5] = Valid for HP 44701A operation only when MEAS is used. STRIG and SADV are mainframe commands.
[6] = TRG is a mainframe command.
[7] = May or may not be the slot the voltmeter is in.

CONF and MEAS Commands

Before showing how to use the low-level commands to modify voltmeter settings, we will briefly discuss the CONF and MEAS commands and show the conditions (called preset values) set by CONF.

The CONF Command

Executing CONF *function* [USE *ch*] is equivalent to setting the twelve low-level commands shown in Table 4-5 in the order shown. CONF does not change the previous settings of any other commands.

Table 4-5. CONF Command Preset Values

Command/Preset(s)	Description	Notes
STRIG SCAN	Start scan immediately.	
SADV SCAN	Advance scan when NRDGS rdgs available	
TRIG HOLD	Trigger is disabled (no trigger).	
DELAY t	Built-in delay as set by CONF	[1]
AZERO ON	Autozero after every reading.	
FUNC DCV, ACV, or OHMF	As appropriate for CONF function.	[2]
RANGE AUTO	Autorange mode set.	[3]
TERM BOTH	Backplane bus/rear panel are both inputs.	
NRDGS 1	One reading/trigger	
NPLC 1	One power line cycle (PLC) @ 60 Hz.	
OCOMP OFF	Offset compensation disabled.	
DISABLE INTR	Voltmeter interrupts disabled.	

[1] = Built-in delay based on voltmeter function/range/NPLC.

[2] = Function set (ACV, DCV, or OHMF) depends on function parameter of CONF command.

[3] = For mainframe firmware revisions 2.2 and greater, CONF TEMPtype sets RANGE AUTO. For earlier firmware revisions, the 30 mV range is selected for B, N28 [N (AWG 28)], R, S, and T type thermocouples and the 300 mV range is selected for E, J, K, and N14 [N (AWG 14)] thermocouples.

The MEAS Command

MEAS *function ch_list* [NSCAN *number*] [USE *ch*] [INTO *name*] or [*fmt*] sets the measurement function appropriate for the *function* parameter, initiates a scan and measurement of the multiplexer channels specified by *ch_list*, and makes the number of passes set by the NSCAN *number* parameter.

NOTE

For MEAS and CONFMEAS, (NSCAN number) x (number of channels in ch_list) x (NRDGS number) must be $\leq$ 67,108,863.

When measurements have been taken, MEAS automatically transfers the readings to the mainframe memory (when INTO *name* is used) or to the output buffer and/or display (when INTO *name* is not used). For temperature or strain measurements, MEAS also causes associated conversions to be performed on the results.

For thermocouple and strain measurements, all reference measurements are first made (automatically) and then all channel measurements are made. A reference measurement is made each time a slot is crossed in the channel list. For example, MEAS TEMPJ,100-223 makes two reference measurements: one for slot 100 and the second for slot 200. However, MEAS TEMPJ,100,200,101,201 makes four reference measurements: slot 100, slot 200, slot 100 again, and slot 200 again.

Executing MEAS disables all interrupts on the channels measured. If MEAS detects that the voltmeter function set is not compatible with the MEAS *function* specified, the voltmeter is reconfigured and autorange is set. MEAS checks and changes (as necessary) the commands shown in Table 4-6.

Table 4-6. Voltmeter Commands Changed by MEAS

Command	Setting
FUNC	Changed to function set by MEAS function
TRIG	TRIG HOLD or TRIG AUTO changed to TRIG SCAN
DISABLE INTR	DISABLE INTR is set.

CONF and MEAS Operation

Since CONF followed immediately by MEAS is equivalent to a CONFMEAS command, voltmeter operation for CONF and MEAS is identical to that for CONFMEAS (see Figure 4-2). However, by using CONF and MEAS along with low-level commands, you can modify voltmeter operation for specific measurement requirements.

Figure 4-3 shows voltmeter operation when CONF and MEAS are used and also shows how some low-level commands can be used to modify voltmeter settings. A summary of voltmeter operation and the related commands shown in Figure 4-3 follows.

When CONF is executed, the voltmeter is configured to a known state and MEAS ensures that the voltmeter is properly set for the specified measurement (1). Then, for strain or temperature measurements, the voltmeter automatically takes and stores the reference measurements (2).

The scan is started by a trigger from the source set by STRIG, the first channel is closed, and the voltmeter makes a single autozero measurement (3). Then, the voltmeter is triggered from the source set by TRIG (4).

After the voltmeter is triggered, the voltmeter takes NRDGS readings on the first channel (5) as set by the NRDGS *number* parameter. DELAY *trig_delay* sets the delay between the trigger and the start of the first measurement (m_1).

For NRDGS >1, DELAY also sets the time between the end of a measurement and the start of the next measurements (from the end of measurement m_1 to the start of measurement m_2, etc). As each measurement is taken, the data is stored in the voltmeter data buffer. Note that the time for each measurement (m_i) depends on the NPLC, OCOMP, and ARANGE settings and if the measurement caused an overload condition.

Stored readings are transferred to the destination specified by MEAS. Each reading from the first channel must be transferred out of voltmeter memory before the voltmeter will take the next measurement (MEAS automatically transfers readings as required).

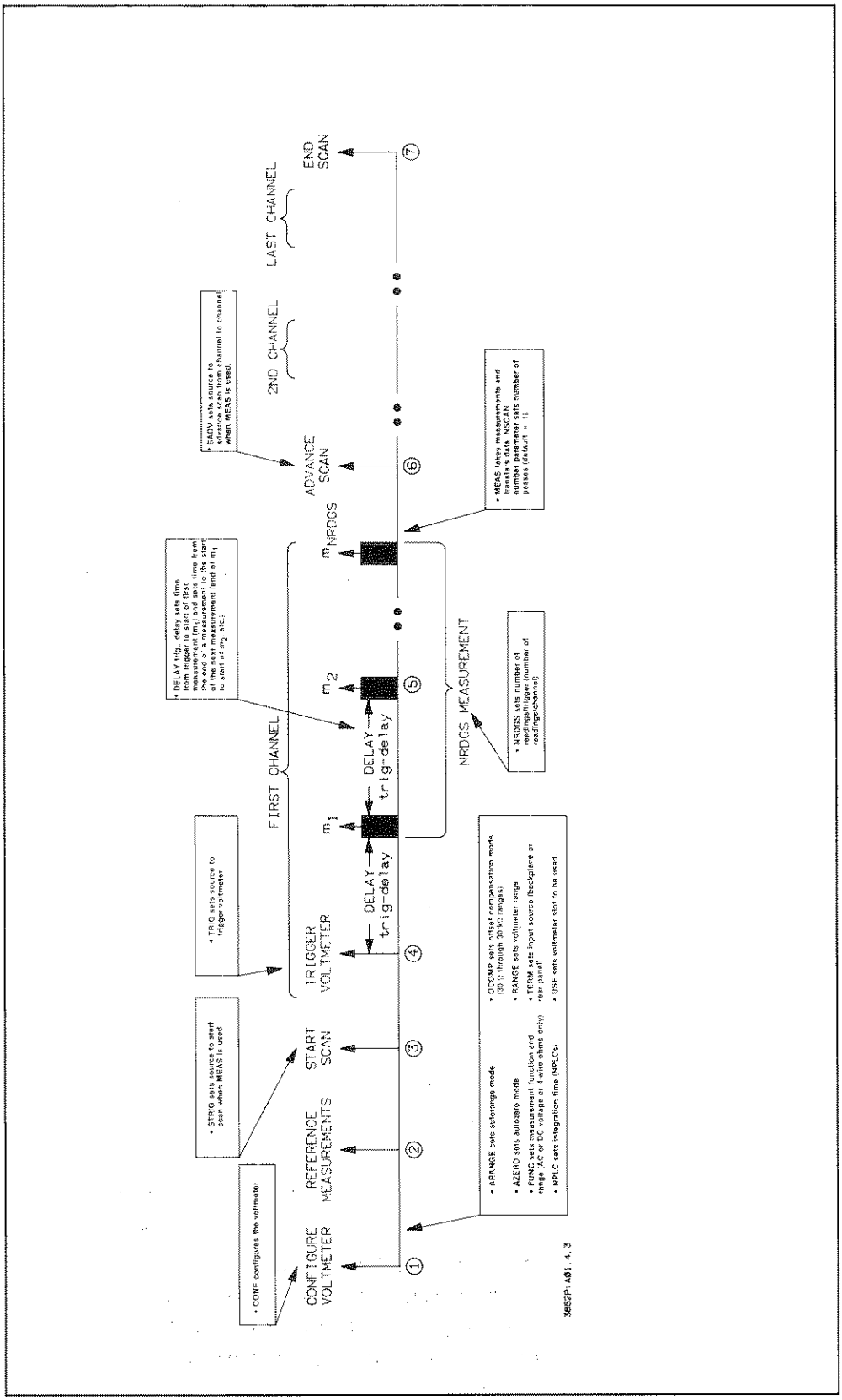


Figure 4-3. CONF and MEAS Operation

After NRDGS readings have been made on channel 1, the scan is advanced to the next channel by a trigger from the source set by SADV (6). (Note that when MEAS is used, STRIG sets the source to start the scan, while SADV sets the source to advance the scan from channel to channel.)

The scan advances through each of the channels in the channel list and the first channel measurement sequence is repeated for each channel. When the data from the last channel has been read, the last channel is opened and the first pass ends (7).

If MEAS NSCAN *number* is not specified, the voltmeter makes one pass through the channel list and the scan sequence ends. Otherwise, the voltmeter makes the number of passes set by NSCAN *number*. For example, with NSCAN 3; 10 channels in the channel list; and 10 readings/trigger, the voltmeter makes 300 measurements. Note that a separate trigger (from STRIG *source*) is required to start each pass.

Setting Voltmeter Operation

This subsection shows how to use the NPLC, NRDGS, DELAY, RANGE, and ARANGE commands to set voltmeter operation for multiplexer measurements.

Setting Integration Time (NPLC)

The HP 44701A samples the input signal for a period of time (integration time) based on the power line frequency as specified with the NPLC *number* command, where *number* is the number of power line cycles (PLC).

You specify integration time as a number of power line cycles (PLCs) with the NPLC command. The voltmeter then multiplies the specified number of PLCs by the power line period to determine the integration time. For example, the period of a 50 Hz power line is 1/50 = 20 msec. If NPLC *number* = 0.1 (0.1 PLCs), integration time = 20 msec x 0.1 = 2 msec.

Integration time controls measurement speed, accuracy, maximum digits of resolution, and the amount of normal mode rejection (ability to reject the line frequency from the measurement). Power-on integration time is 1 PLC at a line frequency of 60Hz.

NOTE

At power-on, the voltmeter bases its integration time on a line frequency of 60 Hz regardless of actual power line frequency. For 50 Hz or 400 Hz line frequency, you must execute the NPLC or CONF command before making measurements to select the proper line frequency reference for the A/D converter.

With longer integration times, measurement resolution, accuracy, and normal mode rejection increases but measurement speed decreases. Table 4-7 shows the relationship between the number of PLCs, maximum number of converted digits, maximum reading rate, and normal mode rejection. Note that only integral numbers of PLCs (1 and 16) provide normal mode rejection. Also, for AC voltage measurements, reading rate is 1.5 readings/sec regardless of integration time.

Table 4-7. NPLC vs. Measurement Values

Power Line Cycles	Integration Time 60 Hz	Integration Time 50 Hz	Number of Converted Digits	Reading Rate [1] 60 Hz	Reading Rate [1] 50 Hz	Normal [2] Mode Rejection
0.0005	10 μs	10 μs	3 ½	1600	1600	0 dB
0.005	100 μs	100 μs	4 ½	1350	1350	0 dB
0.1	1.67 ms	2.0 ms	5 ½	415	360	0 dB
1	16.7 ms	20.0 ms	6 ½	57	48	60 dB
16	267 ms	320 ms	6 ½	2.7	2.3	60 dB

[1] = Maximum reading rate (readings/sec) with autorange and autozero off. For AC voltage measurements, reading rate is 1.5 readings/sec regardless of integration time.

[2] = Normal Mode rejection @ 50 or 60 Hz ±0.09%.

Setting Number Readings/Trigger (NRDGS)

The voltmeter can be programmed to make from 1 to 65535 measurements for each channel in the channel list as set with NRDGS *number* [USE *ch*]. For power-on, reset (RST), or when CONF is sent the number of readings is set at 1 for each channel in the channel list (NRDGS 1 is set).

As shown in Figure 4-3, since the voltmeter makes NRDGS *number* readings on each channel in the channel list, the total number of readings taken is the number of channels in the channel list times the number of readings per trigger.

For example, with NRDGS 10 and 10 channels in the channel list, the voltmeter makes 100 readings. Note however, that each reading must be read from the voltmeter buffer before the voltmeter will take the next measurement. (MEAS automatically transfers the readings as required.)

NOTE

For MEAS NSCAN, (NSCAN number) x (number of channels in ch_list) x (NRDGS number) must be ≤ 67,108,863.

Setting Measurement Delays (DELAY)

DELAY *trig_delay* sets the delay interval between measurement cycles. As shown in Figure 4-3, for NRDGS 1 (one reading/trigger) the delay is inserted between the trigger and the start of the first measurement (m_1). For NRDGS >1, the delay is between the trigger and start of the first measurement and between the end of a meaurement and the start of the next measurement (from the end of measurement m_1 to the start of measurement m_2, etc.).

NOTE

Measurement (m_i) time depends on several factors, such as the NPLC, OCOMP, and ARANGE settings and if the reading causes an overload. Thus, the DELAY trig_delay time is the minimum delay between measurements.

The range of DELAY *trig_delay* is 0 to 4294.967295 seconds. For mainframe firmware revisions 2.2 and greater, *trig_delay* = AUTO can be used which restores default values used at power-on or following a reset (RST or RST *slot*).

For example, DELAY 0.1 sets a 0.1 second delay from the trigger to the start of the first measurement (for NRDGS = 1) or sets a 0.1 second delay from the trigger to the start of the first measurement and sets a 0.1 second interval between the end of a measurement an the start of the next measurement (for NRDGS > 1). Thus, for ten readings/trigger (NRDGS 10), total measurement time for each channel in the channel list is at least 1 second.

The voltmeter automatically selects a default delay time (settling time) for each measurement function, range, and resolution. The default delay time is automatically updated whenever the function or range changes. However, when a delay time is specified, the value does not change until another delay time is specified; until the voltmeter is reset or power is cycled; or until CONF is executed.

The default delay time for AC voltage measurements is 1.5 seconds regardless of range or resolution. Table 4-8 shows default delay times for DC voltage and 4-wire ohms measurements.

Table 4-8. Default Delay Times

Function	Range	Default Delay Times (μsec) NPLC 0.0005	0.005	0.1, 1, and 16
DCV	30mV	380	496	600
	300mV	200	260	320
	3V	200	260	320
	30V	36	46	57
	300V	11	14	17
OHMF	30 Ω	320	390	460
	300 Ω	200	240	290
	3 kΩ	200	240	290
	30 kΩ	200	240	290
	300 kΩ	720	880	1000
	3 MΩ	7200	8800	10000

NOTE

1. You can specify a shorter delay time than the default value. However, the resulting settling time may not produce accurate measurements. Also, because of hardware constraints, specified delay times between 1 μsec and 58 μsec produce an actual delay time of 30 μsec.

2. With OCOMP ON, a delay occurs before the measurement with the current source on and after the measurement with the current source off.

Setting Voltmeter Range (RANGE)

At power-on, after a reset (RST), or when CONF is executed, the voltmeter is set for autorange mode. RANGE [*range*] [USE *ch*] can be used to set the voltmeter range or to set autorange. To determine the specific voltmeter range, you must specify the maximum expected signal amplitude or the maximum expected resistance. The voltmeter then automatically selects the correct range. Autorange is selected by entering the word AUTO or the number 0 for the RANGE [*range*] parameter.

NOTE

The HP 44701A indicates an overload condition (input greater than the present range can measure) by sending 1.E+38 to the output buffer and display instead of a reading.

Table 4-9 shows the voltmeter range selected by the RANGE [*range*] parameter for DC and AC voltages and 4-wire ohms ranges (the only valid functions for RANGE). In Table 4-9, any value between the ranges shown selects the range shown. For example, if the voltmeter is configured for DC voltage, any value of RANGE *range* >0.3 through 3 sets the voltmeter to the 3V range.

Table 4-9. RANGE [range] Parameter Values

DC Voltage		AC Voltage		4-Wire Ohms	
range	sets	range	sets	range	sets
0 or AUTO	Autorange	0 or AUTO	Autorange	0 or AUTO	Autorange
>0 - .03	30 mV	>0 - .2	200 mV	>0 - 30	30 Ω
>.03 - .3	300 mV	>.2 - 2	2 V	> 30 - 300	300 Ω
>.3 - 3	3 V	>2 - 20	20 V	>300 - 3E3	3 kΩ
>3 - 30	30 V	>20 - 200	200 V	>3E3 - 3E4	30 kΩ
>30 - 300	300 V			>3E4 - 3E5	300 kΩ
				>3E5 - 3E6	3 MΩ

Setting Autorange Mode (ARANGE)

The ARANGE (autorange) command enables or disables the autorange mode. When autorange is enabled (ARANGE ON), the HP 44701A samples the input prior to each measurement and automatically selects the correct range. With autorange disabled (ARANGE OFF), the range used for previous measurements is used for the subsequent measurements. Power-on and default *mode* is ARANGE ON.

NOTE

With autorange enabled (ARANGE ON), the voltmeter samples the input before each measurement which may affect measurement speed.

Example: Setting Voltmeter Operation

The following example shows a way to change voltmeter operating parameters using NPLC, NRDGS, DELAY, and RANGE for DC voltage measurements on channels 500 through 504 of an HP 44705A multiplexer. See Figure 3-2 for typical connections to the multiplexer.

Example: Setting Voltmeter Operation (NPLC/NRDGS/DELAY/RANGE)

This program uses the NPLC, NRDGS, DELAY, and RANGE command to modify the settings made with CONF (refer to Table 4-5). NRDGS 5 changes the number of readings/trigger to 5; DELAY 0.1 sets 0.1 sec delay from the trigger to the first measurement and sets 0.1 sec between the end of a measurement and the start of the next; and RANGE 5 sets the voltmeter to the 30V range for each channel measured (refer to Table 4-9). The program assumes the maximum expected voltage for channels 500 through 504 is 5 volts.

Since NPLC 0.1 (line 50) sets 0.1 PLC @ 60 Hz and RANGE 5 (line 80) sets the 30V range, the voltmeter is configured for 5 1/2 digits (100 μV of resolution), maximum reading rate of 415 readings/second (@ 60 Hz), 0.0008% + 700 μV accuracy, and noise rejection of 0 dB NMR, 120 dB CMR, and 90 dB ECMR. (Refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual).

```
10 DIM Volts(0:24)                          !Dimension controller array
20 OUTPUT 709;"RST 600"                     !Reset voltmeter
30 OUTPUT 709;"USE 600"                     !Use voltmeter in mainframe slot 6
40 OUTPUT 709;"CONF DCV"                    !Set DC volts
50 OUTPUT 709;"NPLC 0.1"                    !Set 0.1 PLC integration time
60 OUTPUT 709;"NRDGS 5"                     !Set 5 readings/trigger
70 OUTPUT 709;"DELAY 0.1"                   !Set 0.1 sec delay
80 OUTPUT 709;"RANGE 5"                     !Set 30V range
90 OUTPUT 709;"MEAS DCV,500-504"            !Measure channels 500-504
100 ENTER 709;Volts(*)                      !Enter 25 readings
110 PRINT USING "K,/";Volts(*)              !Display 25 readings
120 END
```

For a set of 5 V 5% sources, a typical return (values in volts) is:

```
4.997 ┐
5.003 │
  .   │  25 readings
  .   │
5.001 ┘
```

Setting Voltmeter Triggering

When CONFMEAS (or CONF followed by MEAS) is used, the voltmeter is automatically triggered as required by a trigger from the mainframe. However, you can use the TRIG and TRG commands to trigger the voltmeter from one of several sources. This subsection describes the TRIG and TRG command parameters and shows an example use of these commands.

Setting Trigger Source/Mode (TRIG)

TRIG [*source*] [USE *ch*] sets the source or mode to trigger the voltmeter, as shown in Figure 4-4 and Table 4-10. Power-on *source* is HOLD (no trigger) and default *source* is TRIG SGL (single trigger). CONF (or the CONF phase of CONFMEAS) sets TRIG HOLD, while MEAS (or the MEAS phase of CONFMEAS) changes TRIG HOLD or TRIG AUTO to TRIG SCAN.

Table 4-10. Trigger (TRIG) Sources/Modes

source/mode	Definition
AUTO	Voltmeter internal triggering.
HOLD	No triggering. Triggering is held off.
SCAN	Trigger when multiplexer channel is closed.
SGL	Single trigger when TRIG SGL is executed.
SYS	System trigger pulse (used with TRG command).

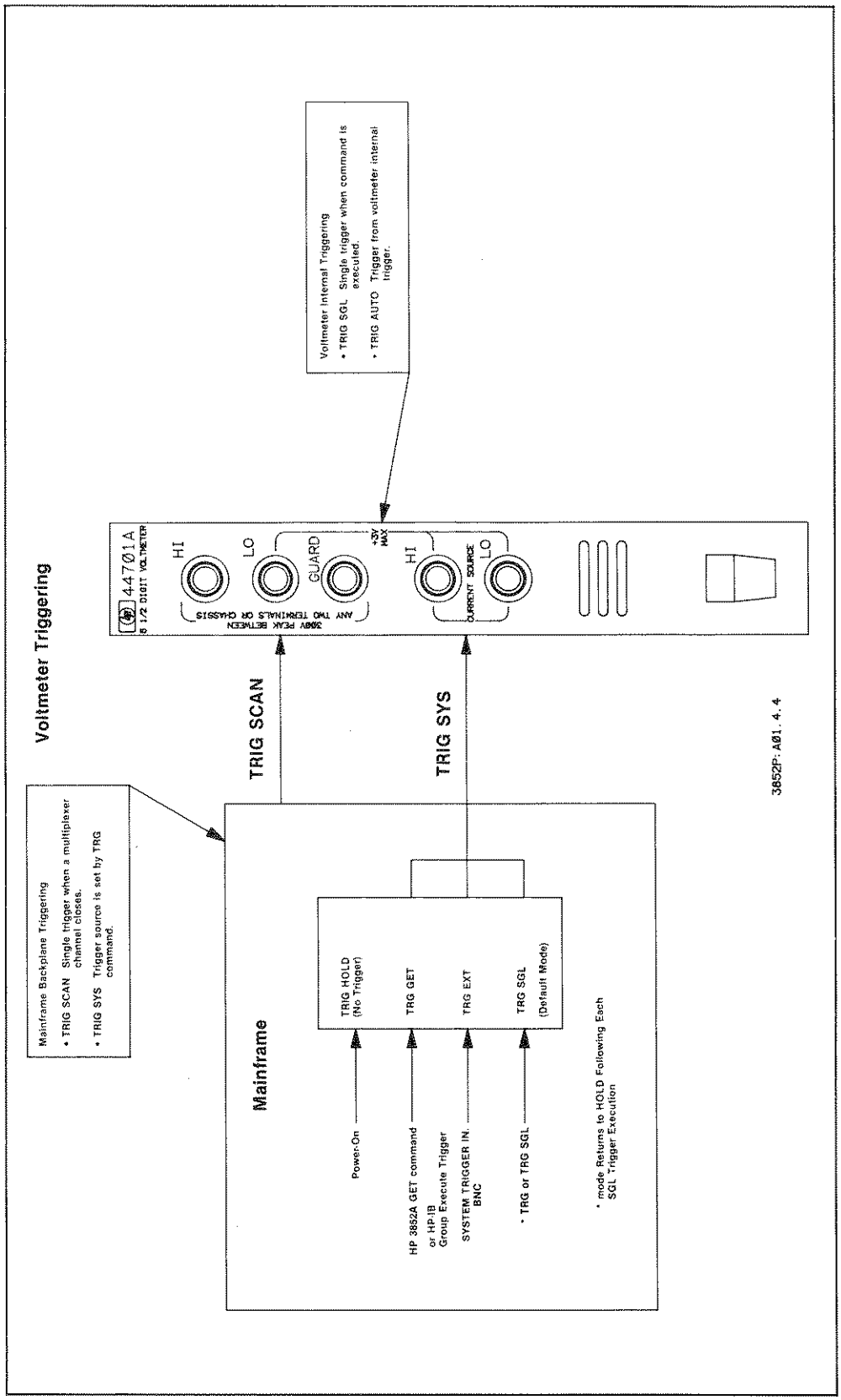


Figure 4-4. Voltmeter Triggering

Mainframe Backplane Triggering (TRIG SCAN, TRIG SYS)

TRIG SCAN and TRIG SYS set mainframe backplane triggering. With TRIG SCAN, the voltmeter is single triggered when a multiplexer channel is closed. TRIG SCAN is set by MEAS or the MEAS phase of CONFMEAS. TRIG SYS is used with the TRG command (refer to the TRG command discussion).

Voltmeter Internal Triggering (TRIG AUTO, TRIG SGL)

You can use TRIG AUTO or TRIG SGL to internally trigger the voltmeter. With TRIG AUTO, the voltmeter generates internal triggers as required during the measurement scan. Use TRIG SGL for a single internal trigger which occurs when TRIG SGL is executed.

Setting System Trigger Source (TRG)

As shown in Figure 4-4, the TRG command has four modes: TRG HOLD, GET, EXT, and SGL. (Note that TRIG SYS must be set for the voltmeter to respond to any trigger from the TRG source.) For TRG GET, the trigger source is either the HP 3852A GET command or the HP-IB Group Execute Trigger. For TRG EXT, the source is an input to the SYSTEM TRIGGER IN BNC. For TRG or TRG SGL, the source is an internal (mainframe) trigger generated when the command executes.

NOTE

When triggering the HP 44701A from an external source, it is possible for successive trigger(s) to occur before the voltmeter completes the present measurement. In this case, no error is generated and the first of the successive triggers is stored. When the measurement completes, the stored trigger initiates another measurement.

Example: Setting Voltmeter Triggering

This program sets the SYSTEM TRIGGER IN BNC as the voltmeter trigger source and measures the voltage on channels 500-504 of an HP 44705A multiplexer in slot 5 of the mainframe. See Figure 3-2 for a typical connection diagram.

With this setting, a low-going pulse into the SYSTEM TRIGGER IN BNC triggers the voltmeter. Note that TRIG SYS must be set for the system trigger to actually trigger the voltmeter. Also note that five trigger pulses into the SYSTEM TRIGGER IN BNC are required to make the pass through the channel list.

Example: Setting Voltmeter Triggering (TRIG/TRG)

In this program, the voltmeter is triggered by a low-going pulse input to the SYSTEM TRIGGER IN BNC. (Five triggers are required - one for each channel).

```
10 DIM Volts(0:4)                        !Dimension controller array
20 OUTPUT 709;"RST 600"                  !Reset the voltmeter
30 OUTPUT 709;"USE 600"                  !Use voltmeter in mainframe slot 6
40 OUTPUT 709;"CONF DCV"                 !Configure for DC volts
50 OUTPUT 709;"TRG EXT"                  !Select SYSTEM TRIGGER IN BNC as source
60 OUTPUT 709;"TRIG SYS"                 !Select system triggering
70 OUTPUT 709;"MEAS DCV,500-504"         !Measure ch 500-504
80 ENTER 709;Volts(*)                    !Enter 5 readings
90 PRINT USING "K,/";Volts(*)            !Display 5 readings
100 END
```

For a set of 5 V 5% sources, a typical return (values in volts) is:

```
4.996
5.001
4.99
4.986
5.002
```

Setting Scan Triggering

When MEAS is used, you can use the STRIG and SADV commands to set the source to start and advance the scan, respectively. Note that STRIG and SADV act to open and/or close multiplexer channels and are NOT voltmeter commands.

Setting Scan Trigger Source (STRIG)

When MEAS is used, STRIG *source* sets the trigger source which directs the mainframe to close the first channel in the channel list. The source set by STRIG starts the scan sequence but the source set by SADV advances the scan sequence.

Note that STRIG is a mainframe command and is NOT a voltmeter command. Also, for NSCAN *number* parameter >1, a separate trigger from STRIG *source* is required for each of the NSCAN passes through the channel list. Refer to Table 4-11 for STRIG *source* parameter descriptions. Power-on and reset *source* is STRIG SCAN.

Table 4-11. Mainframe Scan Trigger (STRIG) Sources

CHADV	Rear panel CHANNEL ADVANCE BNC pulse starts scan.
KEY	Front panel SADV KEY key (scan advance key) starts scan.
PACER	Pulse output from PACER OUT BNC starts scan.
SCAN	Close first channel automatically at beginning of scan.

Setting Scan Advance Source (SADV)

When MEAS is used, SADV *source* sets the trigger source to advance the scan sequence from channel to channel. Note that the source set by STRIG starts the scan sequence but the source selected by SADV advances the channel advance. Also note that SADV is a mainframe command and is NOT a voltmeter command. Refer to Table 4-12 for SADV *source* parameter descriptions. Power-on and reset *source* is SADV SCAN.

Table 4-12. Scan Advance (SADV) Sources

CHADV	Advance scan when the number of readings set by CONF, CONFMEAS, or NRDGS have been taken and readings transferred and an input to the CHANNEL ADVANCE BNC port occurs.
KEY	Advance scan when the number of readings set by CONF, CONFMEAS, or NRDGS have been taken and readings transferred and the front panel SADV KEY key is pressed.
PACER	Advance scan when the number of readings set by CONF, CONFMEAS, or NRDGS have been taken and the readings transferred and a pacer pulse occurs.
SCAN	Advance scan automatically as soon as number of readings set by CONF, CONFMEAS, or NRDGS have been taken and readings transferred. (CONF and CONFMEAS set one reading/trigger.)

Example: Setting Scan Triggering

This example uses the system pacer and the STRIG and SADV commands to control scan start and scan advance for DC voltage measurements on channels 500 through 504 of an HP 44705A multiplexer. See Figure 3-2 for typical connections to the multiplexer.

Example: Setting Scan Triggering (STRIG/SADV)

This program scans channels 500 through 504 and makes three passes through the channel list (15 measurements total). To start the scan, press the front panel SADV KEY key. After a 1 second delay, the voltmeter measures channels 500 through 504 and halts. Press the SADV KEY key again to start the second pass and press the key a third time to start the third pass.

In the program, PACER 0.1 (line 70) sets the system pacer to continuously output pulses at 0.1 second intervals and PDELAY 1 (line 80) delays the first pulse 1 second after PTRIG SGL (line 90) activates the system pacer.

Note that although MEAS NSCAN 3 (line 100) sets three passes through the channel list, the SADV KEY key must be pressed to start the scan for EACH pass (of 5 readings).

```
10 DIM Volts(0:14)                              !Dimension controller array
20 OUTPUT 709;"RST 600"                         !Reset the voltmeter
30 OUTPUT 709;"USE 600"                         !Use voltmeter in mainframe slot 6
40 OUTPUT 709;"CONF DCV"                        !Set DC volts, set SADV SCAN
50 OUTPUT 709;"STRIG KEY"                       !Start when SADV KEY key pressed
60 OUTPUT 709;"SADV PACER"                      !Set pacer pulses as ch adv source
70 OUTPUT 709;"PACER 0.1"                       !Set pacer pulses 0.1 sec apart
80 OUTPUT 709;"PDELAY 1"                        !Delay 1st pacer pulse 1 sec
90 OUTPUT 709;"PTRIG SGL"                       !Send pacer trigger pulse
100 OUTPUT 709;"MEAS DCV,500-504,NSCAN 3"       !Meas ch 500-504; make 3 passes
110 ENTER 709;Volts(*)                          !Enter 15 readings
120 PRINT USING "K,/";Volts(*)                  !Display 15 readings
130 END
```

For a set of 5 V 5% sources, a typical return (values in volts) is:

```
4.9975 ┐
4.9925 │
   .   │  15 readings
   .   │
5.005  ┘
```

Measurements Not Using MEAS

All previous examples in this chapter have used MEAS (or the MEAS phase of CONFMEAS) to make the measurement and transfer the data. However, for some applications MEAS cannot be used. This section shows some ways to use low-level commands when MEAS is not used. Three measurement areas are discussed: low-level multiplexer measurements, rear panel measurements, and enabling interrupts.

Low-Level Multiplexer Measurements

As noted, when MEAS is not used, STRIG and SADV are not valid to start or advance the scan, respectively, and CLOSE and OPEN must be used to close and open multiplexer channels. Also, when MEAS is not used, CHREAD or XRDGS must be used to read the data from voltmeter memory. This subsection shows how to use the AZERO, CHREAD, CLOSE, and OPEN commands to make low-level multiplexer measurements.

Controlling Multiplexer Channels (CLOSE/OPEN)

When MEAS is not used, you can use the CLOSE *ch_list* command to close channels in the channel list and use the OPEN *ch_list* command to open the channels in the channel list. Note that CLOSE and OPEN do NOT automatically set the tree switches or isolation relays, so these channels must also be specified. Refer to the appropriate multiplexer configuration and programming manual for channel definitions.

CAUTION

The CLOSE command does not close channels in a break-before-make fashion. Therefore, the command **can** *and* **will** *cause damage to the multiplexer accessory (relay or FET) and external system if it is used to force one channel open by closing another. This applies to channels in the same bank, in separate banks tied together by the tree relays, and to the relays themselves.*

Before a channel is closed with the CLOSE command, use the OPEN command to open the channel that is currently closed. This prevents any two channels from being closed at the same time and reduces the risk of damaging your equipment.

NOTE

CLOSE is a low-level command intended for individual switch control in special signal-routing applications. It is not the easiest way to do routine measurements since the tree switches and isolation relays are not automatically configured as with the high-level commands.

Setting Autozero Mode (AZERO)

The autozero function ensures that internal voltmeter offset errors are nulled from measurement readings. The autozero mode is set with the AZERO [*mode*] parameter. With AZERO ON, the HP 44701A internally disconnects the input signal and makes a zero reading following every measurement. It then subtracts the zero reading from the preceding measurement.

With AZERO OFF or ONCE, the HP 44701A takes one zero reading and subtracts it from all subsequent measurements. The voltmeter also takes a new zero reading whenever the function or range changes. Power-on *mode* is AZERO ON and the default *mode* is OFF/ONCE. AZERO ON cannot be set for AC voltage measurements. Autozero has no effect on resistance measurements.

When the HP 44701A makes a zero reading with AZERO OFF or ONCE, it actually averages 16 zero readings made using the present integration time setting to ensure the zero reading has maximum line frequency rejection. Depending on integration time (set by NPLC), this zero reading may take 500 msec or longer. With AZERO ON, the HP 44701A makes a single zero reading after each measurement (not the average of 16 readings).

In most cases, AZERO ON requires more time per reading than AZERO OFF or ONCE. However, if you are making a series of measurements where the range or function will be changing, you may get faster readings using AZERO ON rather than AZERO OFF or ONCE.

Transferring Readings (CHREAD)

When MEAS is not used, readings stored in voltmeter memory can be transfered to the mainframe memory or the the output buffer and/or display one at a time with CHREAD *ch* [INTO *name*] or [*fmt*]. CHREAD with INTO *name* transfers data to mainframe memory into a variable or array previously defined with a DIM, REAL, INTEGER, or PACKED command. (Use VREAD to transfer data stored in mainframe memory to the output buffer and/or display.)

Use CHREAD *ch* [*fmt*] to transfer one reading from the voltmeter memory to the output buffer and/or display in the format specified by *fmt*. If neither INTO *name* or *fmt* is used, data is returned in default format to where the command originated.

To transfer a reading, data must be stored in the voltmeter memory and data must be available. If a reading is not available when CHREAD is executed, CHREAD waits until the reading is available and the mainframe remains busy.

NOTE

1. When CONFMEAS or MEAS is used, CHREAD is not required (and will not work) since these commands automatically transfer the data to the mainframe memory or output buffer and/or display as part of the command sequence.

2. Any programming command except ENABLE INTR or DISABLE INTR clears the voltmeter memory data buffer. This guarantees that any data returned by CHREAD (or XRDGS) reflects the current programmed state.

Example: Low-Level Multiplexer Measurements

This example shows how to use CLOSE and OPEN to control multiplexer channels and how to use CHREAD to transfer the data from channel measurements for an HP 44705A multiplexer. (See Figure 3-2 for typical connections to the multiplexer.) In addition, AZERO OFF is used so that only a single autozero measurement is made.

Example: Low-Level Multiplexer Measurements (CLOSE/AZERO/CHREAD)

This program measures the voltage on channels 500 and 501 of an HP 44705A multiplexer. Channel 500 is closed with CLOSE, the voltmeter is triggered with TRIG SGL, and data transferred to the controller. Then, channel 500 is opened with OPEN and the sequence repeated for channel 501. AZERO OFF (line 40) sets the voltmeter to autozero once.

```
10 OUTPUT 709;"RST 600"                 !Reset voltmeter
20 OUTPUT 709;"USE 600"                 !Use voltmeter in mainframe slot 6
30 OUTPUT 709;"CONF DCV"                !Select DC volts
40 OUTPUT 709;"AZERO OFF"               !Autozero once
50 OUTPUT 709;"CLOSE 500,591"           !Close ch 500, sense bus
60 OUTPUT 709;"TRIG SGL"                !Trigger the voltmeter
70 OUTPUT 709;"CHREAD 600"              !Read ch 500
80 ENTER 709;A                          !Enter ch 500 reading
90 PRINT A                              !Display ch 500 reading
100 OUTPUT 709;"OPEN 500"               !Open ch 500
110 OUTPUT 709;"CLOSE 501"              !Close ch 501
120 OUTPUT 709;"TRIG SGL"               !Trigger the voltmeter
130 OUTPUT 709;"CHREAD 600"             !Read ch 501
140 ENTER 709;B                         !Enter ch 501 reading
150 PRINT B                             !Display ch 501 reading
160 OUTPUT 709;"OPEN 501"               !Open ch 501
170 END
```

If 5 V 5% sources are connected, a typical return (values in volts) is:

```
5.01
4.99
```

Rear Panel Measurements

This subsection shows how to use CONF and low-level commands to make rear panel measurements (only AC and DC volts and 4-wire ohms are allowed for rear panel measurements).

Setting Input Terminals (TERM)

The TERM *terminal* parameter sets the input source to the voltmeter. TERM EXT (set at power-on) selects the rear panel terminals while TERM BOTH selects both the analog backplane bus and the rear panel terminals as inputs. Note that CONF sets TERM BOTH (refer to Table 4-5). Also note that there is no way to select the analog backplane bus only.

NOTE

After using a voltmeter for multiplexer measurements, the voltmeter input terminals remain connected to the analog backplane bus. If another voltmeter is used to make measurements in the same mainframe or extender, the input terminals of both voltmeters are connected in parallel which lowers the effective input impedance of both. In addition, ohms measurements will be in error since there will be two current sources. To prevent this, disconnect the unused voltmeter input terminals from the backplane bus by using TERM EXT or by resetting the voltmeter.

Setting Measurement Function (FUNC)

FUNC *function* [*range*] [USE *ch*] selects a measurement function and a measurement range, where *function* selects the measurement function and *range* selects a measurement range or the autorange mode. Only ACV, DCV, or OHMF can be used for FUNC *function*.

To select the FUNC measurement range, you must specify the expected maximum signal amplitude or maximum resistance. The voltmeter then selects the correct range. To set autorange, use the word AUTO or the number 0 for *range*. Values for the FUNC [*range*] parameter are the same as for the RANGE [*range*] parameter shown in Table 4-9.

Setting Offset Compensation (OCOMP)

OCOMP [*mode*] controls the offset compensation function on the 30 Ω through 30 kΩ ranges for both 2-wire and 4-wire ohms measurements. Offset compensation allows the HP 44701A to correct for small *external* offset voltages on these ranges. (Offset compensation is not done for the 300 kΩ and 3 MΩ ranges.)

With offset compensation enabled (OCOMP ON), the voltmeter sources current and measures the total induced and offset voltage. Then, the voltmeter turns off the current source, measures the offset voltage, and subtracts the offset from the combined voltage to determine induced voltage. The voltmeter then uses this induced voltage value to calculate the unknown resistance (resistance = voltage/current). Table 4-13 shows maximum combined (induced plus offset) voltages for each range.

NOTE

With offset compensation enabled (OCOMP ON), the voltmeter measures the external offset voltage after each resistance measurement which may increase the time per reading. Also, with OCOMP ON, autozero is not done on the 30 Ω through 30 kΩ ranges.

Table 4-13. Maximum Combined Voltages by Range

Resistance Range	Maximum Combined Voltage
30 Ω	30 mV
300 Ω	300 mV
3 kΩ	300 mV
30 kΩ	3 V

Transferring Multiple Readings (XRDGS)

When CONFMEAS or MEAS is not used, you can use XRDGS *ch* [*number*] [INTO *name*] or [*fmt*] to transfer readings to the mainframe memory or to the output buffer and/or display. XRDGS with INTO *name* transfers data to the mainframe memory, while XRDGS without INTO *name* transfers data to the output buffer and/or display. (Use VREAD to read data from mainframe memory to the output buffer and/or display.)

XRDGS *ch* [*number*] [*fmt*] transfers multiple readings to the output buffer and/or display in the format specified by *fmt*, where *number* is the number of readings to be transferred (default = 1). The range of *number* is 1 to 2147483647.

If *number* is specified, XRDGS transfers readings as they become available until the specified number of readings have been transferred. If *number* is not specified, the voltmeter returns one reading each time XRDGS is executed. That is, if *number* is not specified, XRDGS is the same as CHREAD.

For example, XRDGS 600,100 transfers 100 readings from a voltmeter in slot 6 of the mainframe to the output buffer and/or display (one at a time) as the readings become available. However, XRDGS 600 (*number* not specified) will transfer only one reading.

Recall that the voltmeter data buffer can store only one reading. Thus, for multiple readings, when a measurement is made the reading is transferred by XRDGS before another measurement is made. When readings are to be transferred over HP-IB, the mainframe allows the voltmeter to make measurements until the output buffer is full (about 68 readings for default format).

When the output buffer is full, the voltmeter must wait until sufficient data is removed from the buffer before it can take another reading. This means that the controller must remove data from the output buffer at a rate high enough to prevent the buffer from filling. (See the following NOTE on Potential Mainframe/Controller Deadlock.)

NOTE

1. When CONFMEAS or MEAS is used, XRDGS is not required (and will not work) to transfer data from voltmeter memory to mainframe memory or output buffer and/or display, since these commands automatically do this as part of the command sequence.

2. Any programming command except ENABLE INTR or DISABLE INTR clears the voltmeter memory data buffer. This guarantees that any data returned by XRDGS (or CHREAD) reflects the current programmed state.

3. Potential Mainframe/Controller Deadlock. With INBUF OFF, the controller and the HP 3852A may deadlock if multiple commands are sent in a single command line and a command generates enough data to fill the output buffer (XRDGS can fill the output buffer).

The best way to avoid potential deadlock is to send a single command per command line and read the results as soon as possible after the data-generating command is sent. Refer to Chapter 5 - HP-IB Communication in the HP 3852A Mainframe Configuration and Programming Manual for details on potential deadlock.

Example: Rear Panel Measurements

The following program makes five 4-wire ohms measurements of a resistance connected to the voltmeter rear panel terminals. (See Figure 3-3 for typical connections.) Offset compensation is used. For the program, maximum expected resistance to be measured is 1 kΩ.

Example: Rear Panel Measurements (FUNC/OCOMP/XRDGS)

In this program, FUNC OHMF,1000 sets the voltmeter for 4-wire ohms measurements on the 3 kΩ range. (TERM EXT is set by the RST command). Since the *number* parameter is specified, XRDGS transfers the 5 readings (one at a time) to the output buffer and display.

```
10 DIM Ohms(0:4)                    !Dimension controller array
20 OUTPUT 709;"RST 600"             !Reset the voltmeter
30 OUTPUT 709;"USE 600"             !Use voltmeter in mainframe slot 6
40 OUTPUT 709;"FUNC OHMF,1000"      !Set 4-wire ohms, 3 kohm range
50 OUTPUT 709;"OCOMP ON"            !Enable offset compensation
60 OUTPUT 709;"NRDGS 5"             !Take 5 readings
70 OUTPUT 709;"TRIG SGL"            !Trigger the voltmeter
80 OUTPUT 709;"XRDGS 600,5"         !Transfer 5 readings to output buffer
90 ENTER 709;Ohms(*)                !Enter 5 readings
100 PRINT USING "K,/";Ohms(*)       !Display 5 readings
110 END
```

A typical return for a 1 kΩ 5% resistor (values in Ω) follows.

```
9999.7
9998.6
9998.3
9999
9999.9
```

Enabling Interrupts

This subsection shows how to enable the voltmeter to interrupt and shows an example way to handle the interrupt in an HP Series 200/300 controller.

Setting Interrupts (ENABLE INTR)

At power-on or when MEAS or CONFMEAS is used, voltmeter interrupts are disabled. However, you can enable interrupts by using the ENABLE INTR command. When enabled, the voltmeter generates an interrupt when a reading is avalable.

NOTE

1. Voltmeter interrupts are always **serviced** *by the mainframe, but can be handled by the mainframe or by the controller. Use DISABLE INTR to disable the voltmeter from interrupting.*

2. Use the INTR? command to query the status of interrupts. INTR? returns the address of the last channel whose interrupt was serviced. If no interrupt has been **serviced** *since power-on or following a system reset, −1 is returned.*

Handle Interrupt in Mainframe (ENABLE INTR)

To service and handle a voltmeter interrupt in the mainframe, use ON INTR CALL *name* where *name* is the name of the servicing subroutine. When ON INTR CALL *name* is executed (as a result of the interrupt), the interrupt is disabled. Table 4-14 shows a typical sequence of commands to service and handle a voltmeter interrupt in the mainframe.

Table 4-14. Mainframe Interrupt Handling Commands

command	Description
SUB name	Set up servicing subroutine name in mainframe.
sub comands	Define subroutine servicing action.
SUBEND	End subroutine.
USE ch	Set which voltmeter is to interrupt.
ON INTR CALL name	Call servicing subroutine name on interrupt.
ENABLE INTR SYS	Enable mainframe to recognize voltmeter interrupt.
ENABLE INTR	Enable voltmeter to interrupt.

Handle Interrupt in Controller (ENABLE INTR)

Interrupts can also be serviced in the mainframe but handled by the controller. Table 4-15 shows a typical set of commands to service a voltmeter interrupt in the mainframe and handle the interrupt in an HP Series 200/300 or equivalent controller.

Table 4-15. Controller Interrupt Handling Commands

command	Description
Controller Commands	
ON INTR 7 GOSUB Name*	Call servicing subroutine name on interrupt.
ENABLE INTR 7;2	Enable interface
Name: !	Start controller subroutine
subroutine commands*	Define subroutine actions
SPOLL(709)	Serial Poll - clears SRQ bit
STOP	End controller subroutine
HP 3852A Commands	
USE ch	Set which voltmeter is to interrupt.
RQS INTR (or RQS 512)	Enable RQS Mask Register INTR bit.
RQS ON	Set RQS Mode ON.
ENABLE INTR SYS	Enable mainframe to recognize voltmeter interrupt.
ENABLE INTR	Enable voltmeter to interrupt on data available.
STA?	Clear Status Register FPS,LCL,INTR,LMT,ALRM bits.
CLROUT	Clear output buffer.
configuration commands	Set voltmeter configuration for measurement.

* = HP 200/300 Series controller and/or HP 3852A commands.

Example: Enabling Interrupts

This program enables a voltmeter in slot 6 of the mainframe to interrupt when a trigger is input to the SYSTEM TRIGGER IN BNC. When the interrupt occurs, the HP-IB SRQ line is set TRUE and the interrupt is sent to the controller. The interrrupt is handled in controller subroutine Results.

Example: Enabling Interrupts (ENABLE INTR)

When the interrupt occurs (trigger to the SYSTEM TRIGGER IN BNC), this program measures the DC voltage on channel 500 of an HP 44705A multiplexer. (See Figure 3-2 for typical connections.) The STA? command reads the Status Register and clears the FPS, LCL, INTR, LMT, and ALRM bits and CLROUT clears the output buffer. The SPOLL command clears the Status Register service request bit (SRQ bit).

```
10 ON INTR 7 GOSUB Results          !Call sub Results on interrupt
20 ENABLE INTR 7;2                  !Enable controller intr on SRQ
30 OUTPUT 709;"RST 600"             !Reset the voltmeter
40 OUTPUT 709;"USE 600"             !Use voltmeter in mainframe slot 6
50 OUTPUT 709;"RQS ON"              !Set RQS mode ON
60 OUTPUT 709;"RQS INTR"            !Enable RQS Mask Reg INTR bit
70 OUTPUT 709;"STA?"                !Clear FPS,LCL,INTR,LMT,ALRM bits
80 OUTPUT 709;"CLROUT"              !Clear output buffer
90 OUTPUT 709;"CONF DCV"            !Configure for DC volts
100 OUTPUT 709;"CLOSE 500,591"      !Close ch 500, sense bus
110 OUTPUT 709;"TRG EXT"            !Set EXTERNAL TRIGGER IN as source
120 OUTPUT 709;"ENABLE INTR"        !Enable voltmeter intr capability
130 OUTPUT 709;"ENABLE INTR SYS"    !Enable mainframe intr capability
140 OUTPUT 709;"TRIG SYS"           !Set system triggering
150 GOTO 150                        !Loop until interrupt occurs
160 Results: !                      !Start controller subroutine
170 OUTPUT 709;"TIME"               !Query time of day
180 ENTER 709;T                     !Enter time of day
190 PRINT "Ch 500 Intr @ ";TIME$(T) !Print interrupt time/message
200 OUTPUT 709;"CHREAD 600"         !Read ch 500 voltage
210 ENTER 709;B                     !Enter ch 500 voltage
220 PRINT "Ch 500 Voltage = ";B     !Display ch 500 voltage
230 A=SPOLL (709)                   !Read/clear SRQ bit
240 OUTPUT 709;"OPEN 500"           !Open ch 500
250 STOP                            !End controller subroutine
260 END
```

When a trigger pulse is input to the SYSTEM TRIGGER IN BNC, the interrupt occurs and a typical return (value in volts) is:

```
Ch 500 Intr @ 02:46:50
Ch 500 Voltage = 3.075
```

Command Summary

Table 4-16 summarizes commands which apply to the HP 44701A voltmeter divided by high-level and low-level commands. High-Level commands (CONF, CONFMEAS, MEAS and MONMEAS) perform a series of operations and (when scanning) provide additional measurement functions such as temperature or strain conversions. Low-level commands perform only simple operations such as changing ranges or transferring readings.

Table 4-16. Command Summary

High-Level Commands

CONF *function* [**USE** *ch*]

Configure the voltmeter measurement function (DCV, OHMF, etc.) and preset values for other functions (autozero, range, etc.).

CONFMEAS *function ch_list* [**NSCAN** *number*][**USE** *ch*] [**INTO** *name*] or [*fmt*]

Configure the voltmeter function, scan, and measure. CONFMEAS is equivalent to CONF followed immediately by MEAS. CONFMEAS can only be used for multiplexer measurements. NSCAN *number* is valid only for mainframe firmware revision 2.2 and greater.

MEAS *function ch_list* [**NSCAN** *number*] [**USE** *ch*] [**INTO** *name*] or [*fmt*]

Set the voltmeter measurement function and initiate a scan and measurement of multiplexer channels specified by *ch_list*. NSCAN *number* is valid only for mainframe firmware revision 2.2 and greater.

MONMEAS *function ch_list* [**USE** *ch*]

Select voltmeter measurement function, scan, measure, and display. MONMEAS selects the voltmeter function, then causes the voltmeter to measure the first channel in the channel list and display the results on the display. The measurement sequence is advanced to the next channel in the list when the front panel SADV KEY key is pressed.

Low-Level Commands

ARANGE [*mode*] [**USE** *ch*]

Sets the autorange mode. With ARANGE ON (power-on and default), the voltmeter samples the input and selects the appropriate range before each measurement. With ARANGE OFF (autorange disabled), the range used for previous measurements is used for subsequent measurements.

AZERO [*mode*] [**USE** *ch*]

Autozero control mode. AZERO ON (autozero always) and AZERO OFF are used only for DC voltage measurements. AZERO ON cannot be used for AC voltage measurements.

CAL

Service-related command. Refer to the HP 3852A Assembly Level Service Manual.

CHREAD *ch* [**INTO** *name*] or [*fmt*]

Transfer readings stored in the voltmeter data buffer to the mainframe memory or to the output buffer and/or display. The voltmeter must have been triggered and data must be available before CHREAD will return a reading.

Table 4-16. Command Summary (Cont'd)

DELAY *trig_delay* **[USE** *ch***]**

For one reading/trigger, sets the delay between the voltmeter trigger and the measurement. For multiple readings/trigger sets the time between the voltmeter trigger and the first measurement and sets the time between successive measurements.

DISABLE INTR [USE *ch***]**

Prevents the voltmeter from generating an interrupt.

ENABLE INTR [USE *ch***]**

Enables the voltmeter to generate an interrupt when data is available. The interrupt can be serviced and handled by the mainframe or serviced by the mainframe and handled by the controller.

FUNC *function* [*range*] **[USE** *ch***]**

Sets the measurement function and range. The *function* parameter can be set only for AC or DC voltage or 4-wire ohms measurements. The *range* parameter can be set to one of several ranges or to autorange (AUTO).

ID? [*slot*]

Returns the identity of the accessory in the slot addressed by *slot*. An HP 44701A returns 44701A.

INTR? [INTO *name*] or [*fmt*]

Returns the address of the last channel whose interrupt was serviced. If no interrupt has been serviced since power-on or following a system reset, -1 is returned.

NPLC *number* **[USE** *ch***]**

Sets number of power line cycles (PLC) (integration time) during which the HP 44701A samples the input signal. Integration time = (#PLC) x (power line period).

NRDGS *number* **[USE** *ch***]**

Sets the number of readings/trigger for each channel in the channel list. The range of *number* is 1 to 65535.

Table 4-16. Command Summary (Cont'd)

OCOMP [*mode*] [**USE** *ch*]

Enables or disables the HP 44701A offset compensation function on the 30 Ω through 30 kΩ ranges for both 2-wire and 4-wire ohms measurements. Offset compensation is not done on the 300 kΩ or 3 MΩ ranges.

RANGE [*range*] [**USE** *ch*]

Sets the voltmeter measurement range or enables the autorange mode.

SADV *source*

When MEAS is used, sets the source to advance the scan sequence as defined by *source*. Valid *source* are CHADV, KEY, PACER, and SCAN.

STRIG *source*

When MEAS is used, sets the source to start the scan sequence as defined by *source*. Valid *source* are CHADV, KEY, PACER, and SCAN.

TERM *terminal* [**USE** *ch*]

Selects the voltmeter input terminals. TERM BOTH selects the mainframe backplane bus and rear panel terminals as inputs. TERM EXT selects the rear panel terminals only.

TRG [*source*]

System trigger source. Power-on *source* = HOLD. Default *source* = SGL.

TRIG [*source*] [**USE** *ch*]

Source or mode for the voltmeter trigger. Power-on *source* is HOLD (no trigger) and the default *source* is SGL (single trigger from source).

USE *ch*

Specifies the slot to be used for voltmeter commands.

USE? [**INTO** *name*] or [*fmt*]

Returns the current USEd channel (or slot) address last set by the USE command or parameter.

XRDGS *ch* [*number*] [**INTO** *name*] or [*fmt*]

Transfers a specified number of readings from the voltmeter data buffer to the mainframe memory or to the output buffer and/or display.