Agilent 34970a data logger manual

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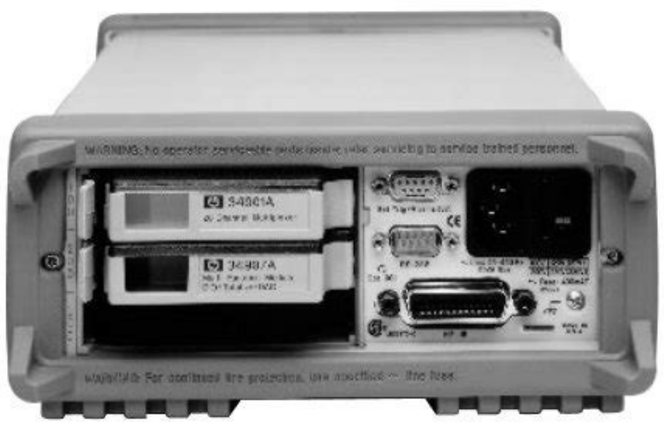

HP 34970A (Back Panel)

Page 1 User’s Guide Part Number 34970-90002 October 1997 For Safety information, Warranties, and Regulatory information, see the pages behind the Index. © Copyright Hewlett-Packard Company 1997 All Rights Reserved. HP 34970A Data Acquisition / Switch Unit... Page 2 The HP 34970A combines precision measurement capability with flexible signal connections for your production and development test systems. Three module slots are built into the rear of the instrument to accept any combination of data acquisition or switching modules. The combination of data logging and data acquisition features makes this instrument a versatile solution for your testing requirements now and in the future. Page 3 The Front Panel at a Glance Denotes a menu key. See the next page for details on menu operation. State Storage / Remote Interface Menus 2 Scan Start / Stop Key 3 Measurement Configuration Menu 4 Scaling Configuration Menu 5 Alarm / Alarm Output Configuration Menu 6 Scan-to-Scan Interval Menu 7 Scan List Single Step / Read Key 8 Advanced Measurement / Utility Menus... Page 4 The Front-Panel Menus at a Glance Several of the front-panel keys guide you through menus to configure various parameters of the instrument (see previous page). The following steps demonstrate the menu structure using the Tip: To review the current configuration of a specific menu, press the menu key several times. A message NO CHANGES is displayed when you exit the menu. Page 5 Display Annunciators SCAN Scan is in progress or enabled. Press and hold Monitor mode is enabled. Press VIEW Scanned readings, alarms, errors, or relay cycles are being viewed. CONFIG Channel configuration is in progress on displayed channel. Measurement is in progress. ADRS Instrument is addressed to listen or talk over the remote interface. Page 6 Advance Input / Channel Closed Output 3 RS-232 Interface Connector Use the Select the HP-IB or RS-232 interface (see chapter 2). Set the HP-IB address (see chapter 2). Set the RS-232 baud rate, parity, and flow control mode (see chapter 2). Page 7 HP BenchLink Data Logger Software at a Glance HP BenchLink Data Logger is a Windows-based application designed to make it easy to use the HP 34970A with your PC for gathering and analyzing measurements. Use the software to set up your test, acquire and archive measurement data, and perform real-time display and analysis of your incoming measurements. Page 8 The Plug-In Modules at a Glance For complete specifications on each plug-in module, refer to the module sections in chapter 9. HP 34901A 20-Channel Armature Multiplexer 20 channels of 300 V switching Two channels for DC or AC current measurements (100 nA to 1A) Page 9 Use this module for those applications that require high-integrity contacts or quality connections of non-multiplexed signals. This module can switch 300 V, 1 A (50 W maximum switch power) to your device under test or to actuate external devices. Screw terminals on the module provide access to the Normally-Open, Normally-Closed, and Common contacts for each of the 20 switches. Page 10 For greater flexibility, you can read digital inputs and the count on the totalizer during a scan. HP 34908A 40-Channel Single-Ended Multiplexer 40 channels of 300 V single-ended (common LO) switching Built-in thermocouple reference junction... Page 11 1-800-452-4844 in the United States, or contact your nearest Hewlett-Packard Sales Office. If your HP 34970A fails within three years of original purchase, we will repair or replace it free of charge. Call 1-800-258-5165 and ask for “Express Exchange.”... Contents Chapter 1 Quick Start To Prepare the Instrument for Use 17 Installing HP BenchLink Data Logger Software 18 To Connect Wiring to a Module 20 To Set the Time and Date 22 To Configure a Channel for Scanning 23... Page 13 Module Overview 163 HP 34901A 20-Channel Multiplexer 164 HP 34902A 16-Channel Multiplexer 166 HP 34903A 20-Channel Actuator 168 HP 34904A 4x8 Matrix Switch 170 HP 34905A/6A Dual 4-Channel RF Multiplexers 172 HP 34907A Multifunction Module 174 HP 34908A 40-Channel Single-Ended Multiplexer 176... Page 14 Alarm System Overview 247 Digital Input Commands 255 Totalizer Commands 256 Digital Output Commands 258 DAC Output Commands 258 Switch Control Commands 259 State Storage Commands 261 System-Related Commands 264 Interface Configuration Commands 269 RS-232 Interface Configuration 270 Modem Communications 274... Page 15 AC Accuracy Specifications 406 AC Measurement and Operating Characteristics 407 Measurement Rates and System Characteristics 408 Module Specifications 409 HP BenchLink Data Logger Software Specifications 412 Product and Module Dimensions 413 To Calculate Total Measurement Error 414 Interpreting Internal DMM Specifications 416... Quick Start... This chapter is divided into the following sections: To Prepare the Instrument for Use, on page 17 Installing HP BenchLink Data Logger Software, on page 18 To Connect Wiring to a Module, on page 20 To Set the Time and Date, on page 22... Page 18 The self-test will begin when you release the key following the beep. If the self-test fails, see the HP 34970A Service Guide for instructions on returning the instrument to Hewlett-Packard for service. Installing HP BenchLink Data Logger Software Installing HP BenchLink Data Logger Software If you ordered the HP 34970A with the internal DMM , then the HP BenchLink Data Logger software is included. The software is shipped on one CD-ROM , but includes a utility to build installation floppy disks. Page 20 You have the option to create an installation on floppy disks from the installation utility. This utility is provided so that you can CD-ROM install HP BenchLink Data Logger on a computer that does not have a drive. CD-ROM Note: You will need a total of five (5) formatted floppy disks to create an installation. Chapter 1 Quick Start To Connect Wiring to a Module To Connect Wiring to a Module 1 Remove the module cover. 3 Route wiring through strain relief. Cable Tie Wrap (optional) 5 Install the module into mainframe. Channel Number: Slot Channel Connect wiring to the screw terminals. Page 22 RTD Types: 0.00385, 0.00391 Thermistor Types: 2.2 k, 5 k, 10 k DC Current / AC Current Valid only on channels 21 and 22 on the HP 34901A. Ranges: 10 mA, 100 mA, 1A DC Voltage / AC Voltage / Frequency... Chapter 1 Quick Start To Set the Time and Date To Set the Time and Date All readings during a scan are automatically time stamped and stored in non-volatile memory. In addition, alarm data is time stamped and stored in a separate non-volatile memory queue. 1 Set the time of day. (102, 110, etc.). Note: You can use or next slot. For this example, assume that you have the HP 34901A multiplexer installed in slot 100 and select channel 103. 2 Select the measurement parameters for the selected channel. Page 25 Chapter 1 Quick Start To Configure a Channel for Scanning Note: Press to sequentially step through the scan list and take a measurement on each channel (readings are not stored in memory). This is an easy way to verify your wiring connections before initiating the scan. Chapter 1 Quick Start To Copy a Channel Configuration To Copy a Channel Configuration After configuring a channel to be included in the scan list, you can copy that same configuration to other channels in the instrument (including digital channels on the multifunction module). This feature makes it easy to configure several channels for the same measurement. To Close a Channel To Close a Channel On the multiplexer and switch modules, you can close and open individual relays on the module. However, note that if you have already configured any multiplexer channels for scanning, you cannot independently close and open individual relays on that module. The instrument is shipped from the factory with a 500 mA fuse installed. This is the correct fuse for all line voltages. See the next page if you need to replace the power-line fuse. To replace the 500 mAT, 250 V fuse, order HP part number 2110-0458. Page 29 Verify that the correct line voltage is selected and the power-line fuse is good. Remove the line-voltage selector from the assembly. Fuse: 500 mAT (for all line voltages) HP Part Number: 2110-0458 Replace the fuse-holder assembly in the rear panel. Chapter 1 Quick Start To Adjust the Carrying Handle To Adjust the Carrying Handle To adjust the position, grasp the handle by the sides and pull outward. Then, rotate the handle to the desired position. Bench-top viewing

positions Carrying position... Instructions and mounting hardware are included with each rack-mounting kit. Any HP System II instrument of the same size can be rack-mounted beside the HP 34970A. Note: Remove the carrying handle, and the front and rear rubber bumpers, before rack-mounting the instrument. Page 32 Chapter 1 Quick Start To Rack Mount the Instrument To rack mount a single instrument, order adapter kit 5063-9240. To rack mount two instruments side-by-side, order lock-link kit 5061-9694 and flange kit 5063-9212. Be sure to use the support rails inside the rack cabinet. To install one or two instruments in a sliding support shelf, order shelf 5063-9255, and slide kit 1494-0015 (for a single instrument, also order filler panel 5002-3999). Front-Panel Overview... Page 34 Front-Panel Overview This chapter introduces you to the front-panel keys and menu operation. This chapter does not give a detailed description of every front-panel key or menu operation. It does, however, give you a good overview of the front-panel menu and many front-panel operations. See chapter 4 “Features and Functions,”... Chapter 2 Front-Panel Overview Front-Panel Menu Reference Front-Panel Menu Reference This section gives an overview of the front-panel menus. The menus are designed to automatically guide you through all parameters required to configure a particular function or operation. The remainder of this chapter shows examples of using the front-panel menus. Page 36 Store up to five instrument states in non-volatile memory. Assign a name to each storage location. Recall stored states, power-down state, factory reset state, or preset state. Configure the remote interface. Select the HP-IB address. Configure the RS-232 interface (baud rate, parity, and flow control). Chapter 2 Front-Panel Overview To Monitor a Single Channel To Monitor a Single Channel You can use the Monitor function to continuously take readings on a single channel, even during a scan. This feature is useful for troubleshooting your system before a test or for watching an important signal. 1 Select the channel to be monitored. Chapter 2 Front-Panel Overview To Set a Scan Interval To Set a Scan Interval You can set the instrument’s internal timer to automatically scan at a specific interval (e.g., start a new scan sweep every 10 seconds) or when an external TTL trigger pulse is received. You can configure the instrument to scan continuously or to stop after sweeping through the scan list a specified number of times. Chapter 2 Front-Panel Overview To Apply Mx+B Scaling to Measurements To Apply Mx+B Scaling to Measurements The scaling function allows you to apply a gain and offset to all readings on a specified multiplexer channel during a scan. In addition to setting the gain (“M”) and offset (“B”) values, you can also specify a custom measurement label for your scaled readings (RPM , PSI , etc.). Chapter 2 Front-Panel Overview To Configure Alarm Limits To Configure Alarm Limits The instrument has four alarms which you can configure to alert you when a reading exceeds specified limits on a channel during a scan. You can assign a high limit, a low limit, or both to any configured channel in the scan list. Page 41 Chapter 2 Front-Panel Overview To Configure Alarm Limits 4 Set the limit value. The alarm limit values are stored in non-volatile memory for the specified channels. The default values for the high and low limits are “0”. The low limit must always be less than or equal to the high limit, even if you are using only one of the limits. To Read a Digital Input Port To Read a Digital Input Port The multifunction module (HP 34907A) has two non-isolated 8-bit input/output ports which you can use for reading digital patterns. You can read the live status of the bits on the port or you can configure a scan to include a digital read. Chapter 2 Front-Panel Overview To Write to a Digital Output Port To Write to a Digital Output Port The multifunction module (HP 34907A) has two non-isolated 8-bit input/output ports which you can use for outputting digital patterns. 1 Select the Digital Output port. To Read the Totalizer Count To Read the Totalizer Count The multifunction module (HP 34907A) has a 26-bit totalizer which can count pulses at a 100 kHz rate. You can manually read the totalizer count or you can configure a scan to read the count. Chapter 2 Front-Panel Overview To Output a DC Voltage To Output a DC Voltage The multifunction module (HP 34907A) has two analog outputs capable of outputting calibrated voltages between 12 volts. 1 Select a DAC Output channel. Select the slot containing the multifunction module and continue turning the knob until DAC is displayed (channel 04 or 05). To Configure the Remote Interface To Configure the Remote Interface The instrument is shipped with both an HP-IB (IEEE -488) interface and an RS -232 interface. Only one interface can be enabled at a time. The HP-IB interface is selected when the instrument is shipped from the factory. Page 47 Chapter 2 Front-Panel Overview To Configure the Remote Interface RS-232 Configuration 1 Select the RS-232 interface. Interface 2 Select the baud rate. Interface Select one of the following: 1200, 2400, 4800, 9600, 19200, 38400, 57600 (factory setting), or 115200 baud. 3 Select the parity and number of data bits. Chapter 2 Front-Panel Overview To Store the Instrument State To Store the Instrument State You can store the instrument state in one of five non-volatile storage locations. A sixth storage location automatically holds the power-down configuration of the instrument. When power is restored, the instrument can automatically return to its state before power-down (a scan in progress before power-down will also be resumed). System Overview... Control Output, starting on page 67 Data Acquisition System Overview You can use the HP 34970A as a stand-alone instrument but there are many applications where you will want to take advantage of the built-in connectivity features. A typical data acquisition system is shown below. Page 51 Data transfers up to 85,000 characters/sec. You can overcome these cable length limitations using special communications hardware. For example, you can use the HP E2050A LAN-to-HP-IB Gateway interface or a serial modem. HP-IB (IEEE-488) Advantages Disadvantages Speed; faster data and Cable length is limited command transfers. Page 52 Data Logging and Monitoring HP BenchLink Data Logger is a Windows to make it easy to use the HP 34970A with your PC for gathering and analyzing measurements. The software is included with the HP 34970A when you order the internal DMM . Use this software to set up your test, acquire and archive measurement data, and perform real-time display and analysis of your incoming measurements. Page 53 Data Acquisition System Overview The HP 34970A Data Acquisition / Switch Unit As shown below, the logic circuitry for the HP 34970A is divided into two sections: earth-referenced and floating. These two sections are isolated from each other in order to maintain measurement accuracy and repeatability (for more information on ground loops, see page 341). Page 54 Chapter 3 System Overview Data Acquisition System Overview Plug-In Modules The HP 34970A offers a complete selection of plug-in modules to give you high-quality measurement, switching, and control capabilities. The plug-in modules communicate with the floating logic via the internal isolated digital bus. Page 55 Chapter 3 System Overview Data Acquisition System Overview System Cabling The plug-in modules have screw-terminal connectors to make it easy to connect your system cabling. The type of cabling that you use to connect your signals, transducers, and sensors to the module is critical to measurement success. Page 56 System Status Alarm Limits The HP 34970A has four alarm outputs which you can configure to alert you when a reading exceeds specified limits on a channel during a scan. You can assign a high limit, a low limit, or both to any configured channel in the scan list. Signal Routing and Switching The switching capabilities of the plug-in modules available with the HP 34970A provide test system flexibility and expandability. You can use the switching plug-in modules to route signals to and from your test system or multiplex signals to the internal DMM or external instruments. Page 58 Chapter 3 System Overview Signal Routing and Switching Multiplexer Switching Multiplexers allow you to connect one of multiple channels to a common channel, one at a time. A simple 4-to-1 multiplexer is shown below. When you combine a multiplexer with a measurement device, like the internal DMM , you create a scanner. Page 59 It is important to make sure that dangerous or unwanted conditions are not created by these connections. Form C (SPDT) Switching The HP 34903A Actuator contains 20 Form C switches (also called single-pole, double-throw). You can use Form C switches to route signals but they are typically used to control external devices. Measurement Input Measurement Input The HP 34970A allows you to combine a DMM (either internal or external) with multiplexer channels to create a scan. During a scan, the instrument connects the DMM to the configured multiplexer channels one at a time and makes a measurement on each channel. Page 61 You can select the resolution and reading speed from 6 digits (22 bits) at 3 readings per second to 4 digits (16 bits) at up to 600 readings per second. The Advanced menu from the HP 34970A front panel allows you to control the integration period for precise rejection of noise signals. Page 62 Chapter 3 System Overview Measurement Input Main Processor The main processor, located in the floating logic section, controls the input signal conditioning, ranging, and the ADC . The main processor accepts commands from, and sends measurement results to, the earth-referenced logic section. The main processor synchronizes measurements during scanning and control operations. Page 63 Chapter 3 System Overview Measurement Input You can configure the event or action that controls the onset of each sweep through the scan list (a sweep is one pass through the scan list): You can set the instrument’s internal timer to automatically scan at a specific interval as shown below. Page 64 Scanning With External Instruments If your application doesn’t require the built-in measurement capabilities of the HP 34970A, you can order it without the internal DMM . In this configuration, you can use the HP 34970A for signal routing or control applications. Page 65 Chapter 3 System Overview Measurement Input The Multifunction Module The multifunction module (HP 34907A) adds two additional measurement input capabilities to the system: digital input and event totalize. The multifunction module also contains a dual voltage output (DAC) which is described in more detail on page 68. Page 66 Chapter 3 System Overview Measurement Input Totalizer The multifunction module has a 26-bit totalizer which can count pulses at a 100 kHz rate. You can manually read the totalizer count or you can configure a scan to read the count. 26 Bits Totalize Gate... Control Output Control Output In addition to signal routing and measurement, you can also use the HP 34970A to provide simple control outputs. For example, you can control external high-power relays using the actuator module or a digital output channel. Page 68 Chapter 3 System Overview Control Output Voltage (DAC) Output The multifunction module has two analog outputs capable of outputting calibrated voltages between 12 volts with 16 bits of resolution. Each DAC (Digital-to-Analog Converter) channel can be used as a programmable voltage source for analog input control of other devices. Page 69 Control Output The Actuator / General-Purpose Switch You can think of the HP 34903A Actuator as a control output because it is often used to control external power devices. The actuator provides 20 independent, isolated Form C (SPDT) switches. Page 70 Features and Functions... Features and Functions You will find that this chapter makes it easy to look up all the details about a particular feature of the HP 34970A. Whether you are operating the instrument from the front panel or over the remote interface, this chapter will be useful. A vertical bar (|) separates multiple parameter choices. Rules for Using a Channel List Many of the SCPI commands for the HP 34970A include a scan_list or ch_list parameter which allow you to specify one or more channels. Scanning is allowed with the following modules: HP 34901A 20-Channel Multiplexer HP 34902A 16-Channel Multiplexer HP 34907A Multifunction Module (digital input and totalizer only) HP 34908A 40-Channel Single-Ended Multiplexer is not allowed with the actuator module, the matrix Automated scanning module, or the RF multiplexer modules. Page 74 Chapter 4 Features and Functions Scanning Each time you start a new scan, the instrument clears all readings (including alarm data) stored in reading memory from the previous scan. Therefore, the contents of memory are always from the most recent scan. While a scan is running, the instrument automatically stores the minimum and maximum readings and calculates the average for each channel. Page 75 DMM and others using an external DMM . Readings are stored in HP 34970A memory only when the internal is used. If the internal DMM is installed and enabled, the instrument will automatically use it for scanning. Page 76 Chapter 4 Features and Functions Scanning Power Failure When shipped from the factory, the instrument is configured to automatically recall the power-down state when power is restored. In this configuration, the instrument will automatically recall the instrument state at power-down and resume a scan in progress. If you do not want the power-down state to be recalled when power is restored, send the MEMory:STATe:RECall:AUTO OFF command (also see the Utility menu);... Page 77 Chapter 4 Features and Functions Scanning Adding Channels to a Scan List Before you can initiate a scan, you must configure the channels to be scanned and set up a scan list (these two operations occur simultaneously from the front panel). The instrument automatically scans the configured channels in ascending order from slot 100 through slot 300. Page 78 Chapter 4 Features and Functions Scanning To Build a Scan List From the Remote Interface: The MEASure?, CONFigure, and ROUTe:SCAN commands contain a scan_list parameter which defines the list of channels in the scan list. Note that each time you send one of these commands, it redefines the scan list. Page 79 Chapter 4 Features and Functions Scanning Scan Interval You can configure the event or action that controls the onset of each sweep through the scan list (a sweep is one pass through the scan list): You can set the instrument’s internal timer to automatically scan at a specific interval. Page 80 Chapter 4 Features and Functions Scanning You can set the scan interval to any value between 0 seconds and 99:59:59 hours (359,999 seconds), with 1 ms resolution. Once you have initiated the scan, the instrument will continue scanning until you stop it or until the scan count is reached. See “Scan Count”... Page 81 Then, send the *TRG (trigger) command to begin each scan sweep. You can also trigger the instrument from the HP-IB interface by sending the IEEE -488 Group Execute Trigger (GET) message. The following statement shows how to send a GET using HP BASIC. Group Execute Trigger TRIGGER 709... Page 82 Chapter 4 Features and Functions Scanning External Scanning In this configuration, the instrument sweeps through the scan list once each time a low-going TTL pulse is received on the rear-panel Ext Trig Input line (pin 6). Ext Trig Input Ext Trig Connector You can specify a scan count which sets the number of external pulses the instrument will accept before terminating the scan. Page 83 Chapter 4 Features and Functions Scanning Scanning on Alarm In this configuration, the instrument sweeps the scan list once each time a reading crossing an alarm limit on a channel. You can also assign alarms to channels on the multifunction module. For example, you can generate an alarm when a specific bit pattern is detected or when a specific count is reached. Page 84 Chapter 4 Features and Functions Scanning Remote Interface Operation: The following program segment configures the instrument to scan when an alarm occurs. TRIG:SOURCE ALARM1 TRIG:COUNT 2 CALC:LIM:UPPER 5,(103) CALC:LIM:UPPER:STATE ON,(OUTPUT:ALARM1:SOURCE (ROUT:MON (103) ROUT:MON:STATE ON INIT Note: To stop a scan, send the ABORt command. Select the alarm configuration Sweep the scan list 2 times Set the upper limit... Page 85 Chapter 4 Features and Functions Scanning Scan Count You can specify the number of times the instrument will sweep through the scan list. When the specified number of sweeps have occurred, the scan stops. Select a scan count between 1 to 50,000 scan sweeps, or continuous. During an Interval Scan (see page 80), the scan count sets the number of times the instrument will sweep through the scan list and therefore determines the overall duration of the scan. Page 86 Chapter 4 Features and Functions Scanning Reading Format During a scan, the instrument automatically adds a time stamp to all readings and stores them in non-volatile memory. Each reading is stored with measurement units, time stamp, channel number, and alarm status information. From the remote interface, you can specify which information you want returned with the readings (from the front panel, all of the information is available for viewing). Page 87 Chapter 4 Features and Functions Scanning Channel Delay You can control the pace of a scan sweep by inserting a delay between multiplexer channels in the scan list (useful for high-impedance or high-capacitance circuits). The delay is inserted between the relay closure and the actual measurement on the channel. Chapter 4 Features and Functions Scanning Automatic Channel Delays If you do not specify a channel delay, the instrument selects a delay for you. The delay is determined by function, range, integration time, and ac filter setting as shown below. DC Voltage, Thermocouple, DC Current (for all ranges): Integration Time Channel Delay... Page 89 Chapter 4 Features and Functions Scanning Front-Panel Operation: CH DELAY AUTO Remote Interface Operation: The following command enables an automatic channel delay on channel 01. ROUT:CHAN:DELAY:AUTO ON,(Selecting a specific channel delay using the ROUTe:CHANnel:DELay command disables the automatic channel delay. Viewing Readings Stored in Memory During a scan, the instrument automatically adds a time stamp to all readings and stores them in non-volatile memory. Page 90 Chapter 4 Features and Functions Scanning Readings acquired during a Monitor are not stored in memory (however, all readings from a scan in progress at the same time are stored in memory). The MEASure? and READ? commands send readings directly to the instrument’s output buffer but readings are not stored in memory. Page 91 Chapter 4 Features and Functions Scanning Remote Interface Operation: The following command retrieves stored readings from memory (the readings are not erased). FETCH? Use the following commands to query the statistics on the readings stored in memory for a specific channel. These commands do not remove the data from memory. Chapter 4 Features and Functions Single-Channel Monitoring Single-Channel Monitoring In the Monitor function, the instrument takes readings as often as it can on a single channel, even during a scan. This feature is useful for trouble- shooting your system before a test or for watching an important signal. Any channel that can be “read”... Page 93 Chapter 4 Features and Functions Single-Channel Monitoring In the Alarm Scan configuration (see “Scanning on Alarm” on page 84), the instrument sweeps the scan list once each time a reading crosses an alarm limit on a channel. In this configuration, you may use the Monitor function to continuously take readings on a selected channel and wait for an alarm on that channel. Scanning With External Instruments If your application doesn’t require the built-in measurement capabilities of the HP 34970A, you can order it without the internal DMM . In this configuration, you can use the system for signal routing or control applications. If you install a multiplexer plug-in module, you can use the system for scanning with an external instrument. Page 95 “timer”. For more information, refer to “Scan Interval” on page 80. You can configure the event or action that notifies the HP 34970A to advance to the next channel in the scan list. Note that the Channel Advance source shares the same sources as the scan interval. Page 96 Chapter 4 Features and Functions Scanning With External Instruments An externally-controlled scan can also include a read of a digital port or a read of the totalizer count on the multifunction module. When the channel advance reaches the first digital channel, the instrument scans through all of the digital channels in that slot and stores the readings in reading memory (only one channel advance signal is required). Chapter 4 Features and Functions General Measurement Configuration General Measurement Configuration This section contains general information to help you configure the instrument for making measurements during a scan. Since these parameters are used by several measurement functions, the discussion is combined into one common section. Refer to the later sections in this chapter for more information on parameters that are specific to a particular measurement function. Page 98 Chapter 4 Features and Functions General Measurement Configuration For frequency and period measurements, the instrument uses one “range” for all inputs between 3 Hz and 300 kHz. The range parameter is required only to specify the resolution. Therefore, it is not necessary to send a new command for each new frequency to be measured. Page 99 Chapter 4 Features and Functions General Measurement Configuration Measurement Resolution Resolution is expressed in terms of number of digits the instrument can measure or display on the front panel. You can set the resolution to 4, 5, or 6 full digits, plus a “ To increase your measurement accuracy and improve noise rejection, select 6 digits. Page 100 Chapter 4 Features and Functions General Measurement Configuration The specified resolution is used for all measurements on the selected channel. If you have applied Mx+B scaling or have assigned alarms to the selected channel, those measurements are also made using the specified resolution. Page 101 Chapter 4 Features and Functions General Measurement Configuration Remote Interface Operation: Specify the resolution in the same units as the measurement function, not in number of digits. For example, if the function is dc volts, specify the resolution in volts. For frequency, specify the resolution in hertz. Page 102 Chapter 4 Features and Functions General Measurement Configuration Custom A/D Integration Time Integration time is the period of time that the instrument’s analog-to- digital (A/D) converter samples the input signal for a measurement. Integration time affects the measurement resolution (for better resolution, use a longer integration time) and measurement speed (for faster measurements, use a shorter integration time). Page 103 Chapter 4 Features and Functions General Measurement Configuration The instrument selects 1 PLC when the measurement function is changed and after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does not change the integration time setting. Front-Panel Operation: First, select the measurement function on the active channel. Page 104 Chapter 4 Features and Functions General Measurement Configuration Autozero When autozero is enabled (default), the instrument internally disconnects the input signal following each measurement, and takes a zero reading. It then subtracts the zero reading from the preceding reading. This prevents offset voltages present on the instrument’s input circuitry from affecting measurement accuracy. Chapter 4 Features and Functions Temperature Measurement Configuration Temperature Measurement Configuration This section contains information to help you configure the instrument for making temperature measurements. For more information on the types of temperature transducers, see “Temperature Measurements” starting on page 345 in chapter 8. The instrument supports direct measurement of thermocouples, RTD s, and thermistors. Page 106 Chapter 4 Features and Functions Temperature Measurement Configuration Thermocouple Measurements To connect a thermocouple to the module’s screw terminals, see page 21. The instrument supports the following thermocouple types: B, E, J, K, N, R, S, and T using ITS -90 software conversions. The default is a J-Type thermocouple. Page 107 Chapter 4 Features and Functions Temperature Measurement Configuration Front-Panel Operation: To select the thermocouple function on the active channel, choose the following items. TEMPERATURE , THERMOCOUPLE To select the thermocouple type for the active channel, choose the following item. J TYPE T/C To enable the thermocouple check feature on the active channel (opens are reported as “OPEN T/C”), choose the following item. Page 108 Chapter 4 Features and Functions Temperature Measurement Configuration Remote Interface Operation: You can use the MEASure? or CONFigure command to select the probe type and thermocouple type. For example, the following statement configures channel 301 for a J-type thermocouple measurement. CONF:TEMP TC,J,(301) You can also use the SENSe command to select the probe type and... Page 109 Chapter 4 Features and Functions Temperature Measurement Configuration RTD Measurements To connect an RTD to the module’s screw terminals, see page 21. The instrument supports RTD s with = 0.00391 using ITS -90 software conversions. The default is = 0.00385. The resistance of an RTD is nominal at 0 C and is referred to as R The instrument can measure RTD s with R The default is R... Page 110 Chapter 4 Features and Functions Temperature Measurement Configuration Remote Interface Operation: You can use the MEASure? or CONFigure command to select the probe type and RTD type. For example, the following statement configures channel 301 for 2-wire measurements of an RTD with = 0.00385 or “91”... Page 111 Chapter 4 Features and Functions Temperature Measurement Configuration Thermistor Measurements To connect a thermistor to the module’s screw terminals, see page 21. The instrument supports 2.2 k (44004), 5 k (44007), and 10 k (44006) thermistors. Front-Panel Operation: To select the thermistor function for the active channel, choose the following items. Chapter 4 Features and Functions Voltage Measurement Configuration Voltage Measurement Configuration To connect voltage sources to the module’s screw terminals, see page 21. This section contains information to help you configure the instrument for making voltage measurements. The instrument can measure dc and true RMS ac-coupled voltages on the measurement ranges shown below. Chapter 4 Features and Functions Voltage Measurement Configuration Remote Interface Operation: You can enable or disable the automatic input resistance mode on the specified channels. With AUTO OFF (default), the input resistance is fixed at 10 M for all ranges. With AUTO ON , the input resistance is set to >10 G for the three lowest dc voltage ranges. Chapter 4 Features and Functions Resistance Measurement Configuration Resistance Measurement Configuration To connect resistances to the module’s screw terminals, see page 21. This section contains information to help you configure the instrument for making resistance measurements. Use the 2-wire method for ease of wiring and higher density or the 4-wire method for improved measurement accuracy. To connect a current source to the module’s screw terminals, see page 21. This section contains information to help you configure the instrument for making current measurements on the HP 34901A multiplexer module. This module has two fused channels for direct dc and ac current measurements on the measurement ranges shown below. Page 116 Chapter 4 Features and Functions Current Measurement Configuration Front-Panel Operation: First, select the ac current (or ac voltage) function on the active channel. Then, go to the Advanced menu and select the slow filter (3 Hz), medium filter (20 Hz), or fast filter (200 Hz) for the active channel. Chapter 4 Features and Functions Frequency Measurement Configuration Frequency Measurement Configuration To connect an ac source to the module’s screw terminals, see page 21. Low Frequency Timeout The instrument uses three different timeout ranges for frequency measurements. The instrument selects a slow, medium, or fast timeout based on the input frequency that you specify for the selected channels. Chapter 4 Features and Functions Mx+B Scaling Mx+B Scaling The scaling function allows you to apply a gain and offset to all readings on a specified multiplexer channel during a scan. In addition to setting the gain (“M”) and offset (“B”) values, you can also specify a custom measurement label for your scaled readings (RPM , PSI , etc.). Page 119 4-wire resistance measurement with scaling. For more information, refer to “Strain Gage Measurements” on page 373. Note: HP BenchLink Data Logger software has built-in strain gage measurement capability. Use the following equations to calculate the gain and offset. Page 120 Chapter 4 Features and Functions Mx+B Scaling Front-Panel Operation: The menu automatically guides you through the gain, offset, and measurement label settings. SET GAIN , SET OFFSET , SET LABEL To reset the gain, offset, and measurement label to their defaults, go to the corresponding level in the menu and turn the knob. Chapter 4 Features and Functions Alarm Limits Alarm Limits The instrument has four alarms which you can configure to alert you when a reading exceeds specified limits on a channel during a scan. You can assign a high limit, a low limit, or both to any configured channel in the scan list. Page 122 Chapter 4 Features and Functions Alarm Limits You can assign an alarm to any configured channel and multiple channels can be assigned to the same alarm number. However, you cannot assign alarms on a specific channel to more than one alarm number. Page 123 Chapter 4 Features and Functions Alarm Limits Alarms are logged in the alarm queue only when a reading crosses a limit, not while it remains outside the limit and not when it returns to within limits. Alarm Event No Alarm Four TTL alarm outputs are available on the rear-panel Alarms connector. Page 124 Chapter 4 Features and Functions Alarm Limits For details on configuring alarms on the multifunction module, see “Using Alarms With the Multifunction Module” on page 130. A Factory Reset (*RST command) clears all alarm limits and turns off all alarms. An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does not clear the alarm limits and does not turn off alarms. Page 125 Chapter 4 Features and Functions Alarm Limits Viewing Stored Alarm Data If an alarm occurs on a channel as it is being scanned, then that channel’s alarm status is stored in reading memory as the readings are taken. As alarm events are generated, they are also logged in an alarm queue, which is separate from reading memory. Page 126 Chapter 4 Features and Functions Alarm Limits Remote Interface Operation: The following command reads data from the alarm queue (one alarm event is read and cleared each time this command is executed). SYSTEM:ALARM? The following is an example of an alarm stored in the alarm queue (if no alarm data is in the queue, the command returns “0”... Page 127 Chapter 4 Features and Functions Alarm Limits Using the Alarm Output Lines Four TTL alarm outputs are available on the rear-panel Alarms connector. You can use these hardware outputs to trigger external alarm lights, sirens, or send a TTL pulse to your control system. You can assign an alarm to any configured channel and multiple channels can be assigned to the same alarm number. Page 128 Chapter 4 Features and Functions Alarm Limits You can control the slope of the pulse from the alarm outputs (the selected configuration is used for all four outputs). In the falling edge mode, 0V (TTL low) indicates an alarm. In the rising edge mode, +5V (TTL high) indicates an alarm. Page 129 Chapter 4 Features and Functions Alarm Limits Using Alarms With the Multifunction Module You can configure the instrument to generate an alarm when a specific bit pattern or bit pattern change is detected on a digital input channel or when a specific count is reached on a totalizer channel. These channels do not have to be part of the scan list to generate an alarm. Page 130 Chapter 4 Features and Functions Alarm Limits Remote Interface Operation (Digital Input Channel): To assign the alarm number to report any alarm conditions on the specified digital input channels, use the following command. OUTPut:ALARm[1|2|3|4]:SOURce (To configure alarms on the specified digital input channel, use the following commands (also see the example on the following page). Page 131 Chapter 4 Features and Functions Alarm Limits Example: Configuring an Alarm on a Digital Input Assume that you want to generate an alarm when a binary pattern of “1000” is read on the upper four bits of port 1. Send the following commands to configure the port for an alarm. Digital Input Operations Digital Input Operations The multifunction module (HP 34907A) has two non-isolated 8-bit input/output ports which you can use for reading digital patterns. You can read the live status of the bits on the port or you can configure a scan to include a digital read. Chapter 4 Features and Functions Digital Input Operations Front-Panel Operation: After selecting the port, press the bit pattern (the least significant bit is on the right). The bit pattern read from the port will be displayed until you press another key, turn the knob, or until the display times out. Chapter 4 Features and Functions Totalizer Operations Totalizer Operations The multifunction module has a 26-bit totalizer which can count TTL pulses at a 100 kHz rate. You can manually read the totalizer count or you can configure a scan to read the count. The totalizer channel is numbered “s03”, where s represents the slot number. Page 135 Chapter 4 Features and Functions Totalizer Operations The maximum count is 67,108,863 (2 after reaching the maximum allowed value. You can configure the totalizer to reset its count after it is read without losing any counts (TOTalize:TYPE RRESet command). Then, if the totalizer is included in a scan list, the count will be reset on every scan sweep. Page 136 Chapter 4 Features and Functions Totalizer Operations Remote Interface Operation: To read the count from the specified totalizer channel, send the following command. The count may be returned with time stamp, channel number, and alarm status information depending on the FORMat:READing command setting (see “Reading Format”... Chapter 4 Features and Functions Digital Output Operations Digital Output Operations The multifunction module (HP 34907A) has two non-isolated 8-bit input/output ports which you can use for outputting digital patterns. The digital output channels are numbered “s01” (lower byte) and “s02” (upper byte), where s represents the slot number. Chapter 4 Features and Functions DAC Output Operations DAC Output Operations The multifunction module (HP 34907A) has two low-noise analog outputs capable of outputting calibrated voltages between 12 volts with 16 bits of resolution. Each DAC (Digital-to-Analog Converter) channel can be used as a programmable voltage source for analog input control of other devices. Chapter 4 Features and Functions System-Related Operations System-Related Operations This section gives information on system-related topics such as storing instrument states, reading errors, running a self-test, displaying messages on the front panel, setting the system clock, disabling the internal DMM , reading the firmware revisions, and reading the relay cycle count. Page 140 Chapter 4 Features and Functions System-Related Operations The name can contain up to 12 characters. The first character must be a letter (A-Z), but the remaining 11 characters can be letters, numbers (0-9), or the underscore character (“ _ ”). Blank spaces are not allowed. Page 141 Chapter 4 Features and Functions System-Related Operations Error Conditions When the front-panel ERROR annunciator turns on, one or more command syntax or hardware errors have been detected. A record of up to 10 errors is stored in the instrument’s error queue. See chapter 6 for a complete listing of the errors. Page 142 If the complete self-test is successful, PASS is displayed on the front panel. If the self-test fails, FAIL is displayed and the ERROR annunciator turns on. See the HP 34970A Service Guide for instructions on returning the instrument to Hewlett-Packard for service. Page 143 Chapter 4 Features and Functions System-Related Operations Display Control For security reasons or for a slight increase in scanning rates, you may want to turn off the front-panel display. From the remote interface, you can also display a 13-character message on the front-display. You can only disable the front-panel display by sending a command from the remote interface (you cannot disable the front panel while in local operation). Page 144 Chapter 4 Features and Functions System-Related Operations Real-Time System Clock During a scan, the instrument stores all readings and alarms with the current time and date. The instrument stores the time and date information in non-volatile memory. When shipped from the factory, the instrument is set to the current time and date (U.S. Page 145 Chapter 4 Features and Functions System-Related Operations Firmware Revision Query The instrument has three microprocessors for control of various internal systems. Each plug-in module also has its own on-board microprocessor. You can query the instrument and each module to determine which revision of firmware is installed for each microprocessor. Page 146 The HP 34908A multiplexer contains 40 channels which are switched (HI only) using only 20 relays. Each relay is used to switch HI on two different channels (and only one channel can be closed at a time). Page 147 Chapter 4 Features and Functions System-Related Operations Front-Panel Operation: To read the count on the active channel, choose the following item and then turn the knob. To read the count on the internal DMM relays, turn the knob counterclockwise beyond the lowest numbered channel in the instrument. Page 148 Chapter 4 Features and Functions System-Related Operations SCPI Language Version Query The instrument complies with the rules and conventions of the present version of SCPI (Standard Commands for Programmable Instruments). You can determine the SCPI version with which the instrument is in compliance by sending a command from the remote interface. 5, “Remote Interface Reference” starting on page 179. HP-IB Address Each device on the HP-IB (IEEE-488) interface must have a unique address. You can set the instrument’s address to any value between 0 and 30. The address is set to “9” when the instrument is shipped from the factory. Factory Reset (*RST command), or after an Instrument Preset (SYSTem:PRESet command). If you select the HP-IB interface, you must select a unique address for the instrument. The HP-IB address is displayed on the front panel when you turn on the instrument. Page 151 Chapter 4 Features and Functions Remote Interface Configuration Baud Rate Selection (RS-232) You can select one of eight baud rates for RS -232 operation. The rate is set to 57,600 baud when the instrument is shipped from the factory. You can set the baud rate from the front panel only. Select one of the following: 1200, 2400, 4800, 9600, 19200, 38400, (factory setting), or 115200 baud. Page 152 Chapter 4 Features and Functions Remote Interface Configuration Flow Control Selection (RS-232) You can select one of several flow control methods to coordinate the transfer of data between the instrument and your computer or modem. The method that you select will be determined by the flow method used by your computer or modem. Page 153 Chapter 4 Features and Functions Remote Interface Configuration Modem: This mode uses the DTR/DSR and RTS/CTS lines to control the flow of data between the instrument and a modem. When the RS-232 interface is selected, the instrument sets the DTR line true. The DSR line is set true when the modem is on-line. This section gives a brief introduction to the calibration features of the instrument and plug-in modules. For a more detailed discussion of the calibration procedures, see chapter 4 in the HP 34970A Service Guide. Calibration Security This feature allows you to enter a security code to prevent accidental or unauthorized calibrations of the instrument. Chapter 4 Features and Functions Calibration Overview To Unsecure for Calibration You can unsecure the instrument either from the front panel or over the remote interface. The instrument is secured when shipped from the factory and the security code is set to “... Page 156 Chapter 4 Features and Functions Calibration Overview To Secure Against Calibration You can secure the instrument either from the front panel or over the remote interface. The instrument is secured when shipped from the factory and the security code is set to “... Page 157 Chapter 4 Features and Functions Calibration Overview Calibration Message The instrument allows you to store one message in calibration memory in the mainframe. For example, you can store such information as the date when the last calibration was performed, the date when the next calibration is due, the instrument’s serial number, or even the name and phone number of the person to contact for a new calibration. Page 158 Chapter 4 Features and Functions Calibration Overview Calibration Count You can query the instrument to determine how many calibrations have been performed. Note that your instrument was calibrated before it left the factory. When you receive your instrument, be sure to read the count to determine its initial value. HI and LO Alarm Limits Alarm Output Alarm Output Configuration Alarm Output State Alarm Output Slope Module Hardware Factory Reset State HP 34901A, 34902A, 34908A HP 34903A, 34904A HP 34905A, 34906A HP 34907A System-Related Operations Factory Reset State Display State... Alarm State HI and LO Alarm Limits Alarm Output Configuration Alarm Output State Alarm Output Slope Module Hardware Preset State HP 34901A, 34902A, 34908A HP 34903A, 34904A HP 34905A, 34906A HP 34907A System-Related Operations Preset State Display State Error Queue... Chapter 4 Features and Functions Multiplexer Module Default Settings Multiplexer Module Default Settings The table below shows the default settings for each measurement function on the multiplexer modules. When you configure a channel for a particular function, these are the default settings. Temperature Measurements Temperature Units Integration Time... HP 34903A 20-Channel Actuator, starting on page 168 HP 34904A 4x8 Matrix Switch, starting on page 170 HP 34905A/6A Dual 4-Channel RF Multiplexers, starting on page 172 HP 34907A Multifunction Module, starting on page 174 HP 34908A 40-Channel Single-Ended Multiplexer, starting on page 176... DMM (external shunts are not required). All 22 channels switch both HI and LO inputs, thus providing fully isolated inputs to the internal DMM or an external instrument. Page 164 Chapter 4 Features and Functions HP 34901A 20-Channel Multiplexer WIRING LOG Name H COM L COM 11 * 12 * 13 * 14 * 15 * 16 * 17 * 18 * 19 * 20 * H COM L COM... HP 34902A 16-Channel Multiplexer This module is divided into two banks of eight channels each. All 16 channels switch both HI and LO inputs, thus providing fully isolated inputs to the internal DMM or an external instrument. When making 4-wire resistance measurements, the instrument automatically pairs channel n with channel n+8 to provide the source and sense connections. Page 166 Chapter 4 Features and Functions HP 34902A 16-Channel Multiplexer WIRING LOG Name H COM L COM 09 * 10 * 11 * 12 * 13 * 14 * 15 * 16 * H COM L COM * 4W Sense Channels are paired to Channel (n-8). Chapter 4 Features and Functions HP 34903A 20-Channel Actuator HP 34903A 20-Channel Actuator This module contains 20 independent, SPDT (Form C) latching relays. Screw terminals on the module provide access to the Normally-Open, Normally-Closed, and Common contacts for each switch. This module does not connect to the internal DMM. Page 168 Chapter 4 Features and Functions HP 34903A 20-Channel Actuator WIRING LOG NO = Normally Open, NC = Normally Closed Refer to the diagrams on page 20 to connect wiring to the module. Maximum Input Voltage: 300 V (CAT I) Maximum Input Current: 1 A... Chapter 4 Features and Functions HP 34904A 4x8 Matrix Switch HP 34904A 4x8 Matrix Switch This module contains 32 two-wire crosspoints organized in a 4-row by 8-column configuration. You can connect any combination of inputs and outputs at the same time. This module does not connect to the internal . Chapter 4 Features and Functions HP 34904A 4x8 Matrix Switch WIRING LOG Name Column Name Example: Channel 32 represents Row 3 and Column 2. Refer to the diagrams on page 20 to connect wiring to the module. Maximum Input Voltage: 300 V (CAT I) Bank Switch NOTES: The HP 34905A is used for 50 applications. The HP 34906A is used for 75 applications. You can close only one channel per bank at a time on these modules; closing one channel in a bank will open the previously closed channel. One channel in each bank is always connected to COM. Page 172 Chapter 4 Features and Functions HP 34905A/6A Dual 4-Channel RF Multiplexers WIRING LOG Name COM1 COM2 Refer to the diagrams on page 20 to connect wiring to the module. Maximum Input Voltage: 42 V Maximum Input Current: 700 mA Maximum Switching Power: 20 W Ten cables are included with the module. Chapter 4 Features and Functions HP 34907A Multifunction Module HP 34907A Multifunction Module This module combines two 8-bit ports of digital input/output, a 100 kHz totalizer, and two 12 analog outputs. For greater flexibility, you can read digital inputs and the totalizer count during a scan. Page 174 Chapter 4 Features and Functions HP 34907A Multifunction Module WIRING LOG 01 (DIO 1) 02 (DIO 2) Threshold Jumper 03 (Totalizer) 04 (DAC 1) 05 (DAC 2) Threshold Jumper Position: Refer to the diagrams on page 20 to connect wiring to the module. HP 34908A 40-Channel Single-Ended Multiplexer The module is divided into two banks of 20 channels each. All of the 40 channels switch HI only, with a common LO for the module. The module has a built-in isothermal block to minimize errors due to thermal gradients when measuring thermocouples. Page 176 Chapter 4 Features and Functions HP 34908A 40-Channel Single-Ended Multiplexer WIRING LOG Name H COM L COM Slot Number: Function Comments... Remote Interface Reference... Totalizer Commands, starting on page 256 Digital Output Commands, on page 258 DAC Output Commands, on page 258 Switch Control Commands, on page 259 State Storage Commands, on page 261 System-Related Commands, starting on page 264 Interface Configuration Commands, on page 269... A vertical bar (|) separates multiple parameter choices. Rules for Using a Channel List Many of the SCPI commands for the HP 34970A include a scan_list or ch_list parameter which allow you to specify one or more channels. Page 180 For example, the following command will generate an error on channel 121 on the HP 34901A module since this channel is for current measurements only. CONFigure:VOLTage:DC (... Chapter 5 Remote Interface Reference SCPI Command Summary Scan Measurement Commands (see page 226 for more information) MEASure TCouple :TEMPerature? { |RTD|FRTD|THERmistor|DEF} type resolution ,{< >|DEF}[,1[,{< range AUTO :VOLTage:DC? [{< >| [,< resolution >|MIN|MAX|DEF}],] (:VOLTage:AC? [{< range >| AUTO [,) :SCAN? :SCAN:SIZE? TRIGger IMMediate :SOURce {BUS| |EXTernal|ALARm1|ALARm2|ALARm3|ALARm4|TIMer} :SOURce? TRIGger :TIMer {< seconds >| |MAX} :TIMer? TRIGger :COUNt {< count >| |MAX|INFinity}... Page 183 Chapter 5 Remote Interface Reference SCPI Command Summary Scan Statistics Commands (see page 233 for more information) CALCulate :AVERage:MINimum? [(< ch_list :AVERage:MINimum:TIME? [(ch_list :AVERage:MAXimum? [(< :AVERage:MAXimum:TIME? [(:AVERage:AVERage? [(< ch_list :AVERage:PTPeak? [(< ch_list >)] ch_list :AVERage:COUNt? [( ) :SCAN? :SCAN:SIZE? TRIGger :SOURce {BUS|IMMediate|EXTernal| :SOURce? TRIGger :TIMer {< seconds >| |MAX} :TIMer? TRIGger :COUNt {< count >|MIN|MAX| INFinity... Page 185 Chapter 5 Remote Interface Reference SCPI Command Summary Temperature Configuration Commands (see page 219 for more information) CONFigure :TEMPerature { TCouple |RTD|FRTD|THERmistor|DEF} ,{< type >|DEF}[,1[,{< resolution ch_list CONFigure? [(< >)] UNIT ch_list :TEMPerature { |F|K}[,(< ch_list :TEMPerature? [(| AUTO |MIN|MAX|DEF} resolution [,< >|MIN|MAX|DEF}],] (ch_list CONFigure? [(< >)] [SENSe:] range VOLTage:DC:RANGe {< >|MIN|MAX}[,(VOLTage:DC:RANGe? [{(| AUTO |MIN|MAX|DEF} resolution [,< >|MIN|MAX|DEF}],] (ch_list CONFigure? [(< >)] [SENSe:] range RESistance:RANGe {< >|MIN|MAX}[,(RESistance:RANGe? [{(| |MIN|MAX|DEF} resolution [,< >|MIN|MAX|DEF}],] (CONFigure? [(| AUTO |MIN|MAX|DEF} resolution [,< >|MIN|MAX|DEF}],] (ch_list CONFigure? [(< >)] [SENSe:] range FREQuency:VOLTage:RANGe {< FREQuency:VOLTage:RANGe? [{(FREQuency:VOLTage:RANGe:AUTO {OFF| FREQuency:VOLTage:RANGe:AUTO? [([SENSe:]... Page 190 Chapter 5 Remote Interface Reference SCPI Command Summary Mx+B Scaling Commands (see page 244 for more information) CALCulate :SCALe:GAIN < gain >[,(< ch_list :SCALe:GAIN? [(< ch_list >)] offset ch_list :SCALe:OFFSet < >[,(< ch_list :SCALe:OFFSet? [(< >)] :SCALe:UNIT [,(< :LIMit:UPPer? [(< ch_list >)] :LIMit:UPPer:STATe {OFF|ON}[,(ch_list :LIMit:UPPer:STATe? [( )] BYTE [SENSe:]DIGital:DATA:{ |WORD}? [(Totalizer Commands... DIO (MSB) Totalizer SOURce voltage ch_list :VOLTage < > ,(< >) ch_list :VOLTage? (< >) Switch Control Commands (see page 259 for more information) ROUTe ch_list :CLOSe (< >) ch_list :CLOSe:EXCLusive (< >) :CLOSe? (| |MAX} :TIMer? TRIGger :COUNt {< count >| |MAX|INFinity} :COUNt? *TRG INITiate READ? State Storage Commands (see page 261 for more information) *SAV {0|1|2|3|4|5}... Page 195 Chapter 5 Remote Interface Reference SCPI Command Summary System-Related Commands (see page 264 for more information) SYSTem :DATE < yyyy > < > ,< > :DATE? ss.sss :TIME < >,< >,< > :TIME? FORMat :READing:TIME:TYPE {ABSolute| :READing:TIME:TYPE? *IDN? SYSTem:CTYPe? {100|200|300} DIAGnostic :POKE:SLOT:DATA {100|200|300}, *SRE? STATus :QUEStionable:CONDition? :QUEStionable[:EVENt]? :QUEStionable:ENABle code :SECure:STATe {OFF| },< :SECure:STATe? CALibration :STRing < quoted_string > :STRing? CALibration value :VALue < > :VALue? Service-Related Commands (see page 294 for more information) INSTrument... Page 198 Chapter 5 Remote Interface Reference SCPI Command Summary IEEE 488.2 Common Commands *CLS *ESR? enable_value *ESE < > *ESE? *IDN? *OPC *OPC? *PSC {0|1} *PSC? *RST *SAV {0|1|2|3|4|5} *RCL {0|1|2|3|4|5} *STB? *SRE < enable_value > *SRE? *TRG *TST? Simplified Programming Overview This section gives an overview of the basic techniques used to program the HP 34970A over the remote interface. This section is only an overview and does not give all of the details you will need to write your own application programs. Page 200 Chapter 5 Remote Interface Reference Simplified Programming Overview Using the MEASure? Command The MEASure? command provides the easiest way to program the instrument for scanning. However, this command does not offer much flexibility. When you execute this command, the instrument uses default values for the requested measurement configuration and immediately performs the scan. Page 201 Chapter 5 Remote Interface Reference Simplified Programming Overview Using the range resolution With the MEASure? and CONFigure commands, you can select the measurement function, range, and resolution all in one command. Use the range parameter to specify a fixed range larger than the expected value of the input signal. Page 202 Chapter 5 Remote Interface Reference Simplified Programming Overview Using the READ? Command The READ? command changes the state of the scan trigger system from the “idle” state to the “wait-for-trigger” state. Scanning will begin when the specified trigger conditions are satisfied following the receipt of the READ? command. Page 203 Chapter 5 Remote Interface Reference Simplified Programming Overview Example: Using MEASure? The following program segment shows how to use the MEASure? command to make a measurement on one channel. This example configures the instrument for dc voltage measurements, internally triggers the instrument to scan one channel, and then sends the reading to the instrument’s output buffer. Page 204 Chapter 5 Remote Interface Reference Simplified Programming Overview Example: Using CONFigure With INITiate and FETCh? The following program segment is similar to the previous example but it uses INITiate to place the instrument in the “wait-for-trigger” state. The INITiate command places the instrument in the “wait-for-trigger” state, scans the specified channel when the Ext Trig terminal is pulsed on the rear panel, and sends the reading to reading memory. Chapter 5 Remote Interface Reference The MEASure? and CONFigure Commands The MEASure? and CONFigure Commands Both the MEASure? and CONFigure commands reset all measurement parameters to their default values. For more information on the default settings for these commands, see the table on page 201. For the range parameter, MIN selects the lowest range for the selected function;... Page 206 Chapter 5 Remote Interface Reference The MEASure? and CONFigure Commands MEASure:TEMPerature? {RTD|FRTD},{85|91|DEF} [,1[,< resolution >|MIN|MAX|DEF}]] ,(Configure the specified channels for 2-wire or 4-wire RTD measurements and immediately sweep through the scan list one time. Use “85” to specify = 0.00385 or “91” to specify also redefines the scan list. Page 207 >|MIN|MAX|DEF}],] (Note: Current measurements are allowed only on channels 21 and 22 on the HP 34901A multiplexer module. Configure the specified channels for dc or ac current measurements and immediately sweep through the scan list one time. Note that this command also redefines the scan list. Page 208 Chapter 5 Remote Interface Reference The MEASure? and CONFigure Commands scan_list MEASure:DIGital:BYTE? (< >) Configure the instrument to read the specified digital input channels on the multifunction module and immediately sweep through the scan list one time. Note that this command also redefines the scan list. The readings are sent directly to the instrument’s output buffer but the readings are not stored in reading memory. Page 209 Chapter 5 Remote Interface Reference The MEASure? and CONFigure Commands CONFigure Command Syntax CONFigure:TEMPerature {TCouple},{B|E|J|K|N|R|S|T|DEF} [,1[,< resolution >|MIN|MAX|DEF}]] ,(Configure the specified channels for thermocouple measurements but do not initiate the scan. Note that this command also redefines the scan list. The default (DEF) transducer type is a J-Type thermocouple. Page 210 >|MIN|MAX|DEF}],] (Note: Current measurements are allowed only on channels 21 and 22 on the HP 34901A multiplexer module. Configure the specified channels for dc or ac current measurements but do not initiate the scan. Note that this command also redefines the scan list. Page 211 Chapter 5 Remote Interface Reference The MEASure? and CONFigure Commands CONFigure:FREQuency CONFigure:PERiod [{< range >|AUTO|MIN|MAX|DEF} resolution scan_list [,< >|MIN|MAX|DEF}],] (< >) Configure the specified channels for frequency or period measurements but do not initiate the scan. Note that this command also redefines the scan list. (34901A) or n+8 (34902A) to provide the source and sense connections. Specify the paired channel in the lower bank (source) as the ch_list channel. Current measurements are allowed only on channels 21 and 22 on the HP 34901A multiplexer module. function [SENSe:]FUNCtion "< >"[,(Select the measurement function on the specified channels. Page 213 Chapter 5 Remote Interface Reference Setting the Function, Range, and Resolution [SENSe:] range VOLTage:DC:RANGe {< >|MIN|MAX}[,(VOLTage:AC:RANGe {< range >|MIN|MAX}[,(RESistance:RANGe {< range >|MIN|MAX}[,(range FRESistance:RANGe {< range CURRent:DC:RANGe {< >|MIN|MAX}[,(range CURRent:AC:RANGe {< >|MIN|MAX}[,(FREQuency:VOLTage:RANGe {< PERiod:VOLTage:RANGe {< range Select the measurement range for the function selected on the specified channels. Page 214 Chapter 5 Remote Interface Reference Setting the Function, Range, and Resolution [SENSe:] VOLTage:DC:RANGe:AUTO? [(VOLTage:AC:RANGe:AUTO? [(RESistance:RANGe:AUTO? [(FRESistance:RANGe:AUTO? [(CURRent:DC:RANGe:AUTO? [(CURRent:AC:RANGe:AUTO? [(FREQuency:VOLTage:RANGe:AUTO? [(PERiod:VOLTage:RANGe:AUTO? [(Query the autorange setting on the specified channels. Returns “0” (OFF) or “1”... Page 215 Chapter 5 Remote Interface Reference Setting the Function, Range, and Resolution [SENSe:] time VOLTage:DC:APERture {< RESistance:APERture {< time FRESistance:APERture {< time CURRent:DC:APERture {< Select the aperture time for the function selected on the specified channels. selects the smallest value accepted for this parameter, which gives the most resolution. Page 216 Chapter 5 Remote Interface Reference Setting the Function, Range, and Resolution [SENSe:] TEMPerature :NPLC {0.02|0.2|1|2|10|20|100|200|MIN|MAX}[,(VOLTage:DC :NPLC {0.02|0.2|1|2|10|20|100|200|MIN|MAX}[,(RESistance :NPLC {0.02|0.2|1|2|10|20|100|200|MIN|MAX}[,(FRESistance :NPLC {0.02|0.2|1|2|10|20|100|200|MIN|MAX}[,(CURRent:DC :NPLC {0.02|0.2|1|2|10|20|100|200|MIN|MAX}[,(Set the integration time in number of power line cycles (PLC s) on the specified channels. Chapter 5 Remote Interface Reference Temperature Configuration Commands Temperature Configuration Commands See also “Temperature Measurement Configuration” in chapter 4 starting on page 106. General Temperature Commands UNIT :TEMPerature {C|F|K}[,(:TEMPerature? [(< ch_list >)] Select the temperature measurement units on the specified channels. The default is “C”. Page 218 Chapter 5 Remote Interface Reference Temperature Configuration Commands Thermocouple Commands [SENSe:]TEMPerature:TRANsducer :TCouple:TYPE {B|E|J|K|N|R|S|T}[,(ch_list :TCouple:TYPE? [(< Select the thermocouple type to use on the specified channels. The default is a J-Type thermocouple. The :TYPE? query returns the thermocouple type currently in use. Returns “ B ”, “ E ”, “ J ”, “ K ”, “ N ”, “ R ”, “... Chapter 5 Remote Interface Reference Temperature Configuration Commands [SENSe:]TEMPerature:TRANsducer :TCouple:CHECk {OFF|ON}[,(:TCouple:CHECk? [(< ch_list Disable or enable the thermocouple check feature to verify that your thermocouples are properly connected to the screw terminals for measurements. If you enable this feature, the instrument measures the channel resistance after each thermocouple measurement to ensure a proper connection. Page 220 Chapter 5 Remote Interface Reference Temperature Configuration Commands RTD Commands [SENSe:]TEMPerature:TRANsducer :RTD:TYPE {85|91}[,(< ch_list :RTD:TYPE? [(< >)] :FRTD:TYPE {85|91}[,(< :FRTD:TYPE? [(< ch_list >)] Select the RTD type for 2-wire or 4-wire measurements on the specified channels. Use “85” to specify = 0.00385 or “91”... Chapter 5 Remote Interface Reference Voltage Configuration Commands Voltage Configuration Commands See also “Voltage Measurement Configuration” in chapter 4 starting on page 113. INPut :IMPedance:AUTO {OFF|ON}[,(:IMPedance:AUTO? [(< ch_list Disable or enable the automatic input resistance mode for dc voltage measurements on the specified channels. Current Configuration Commands See also “Current Measurement Configuration” in chapter 4 starting on page 116. Note: Current measurements are allowed only on channels 21 and 22 on the HP 34901A multiplexer module. [SENSe:] CURRent:AC:BANDwidth {3|20|200|MIN|MAX}[,(CURRent:AC:BANDwidth? [{(Specify the lowest frequency expected in the input signal for ac current measurements on the specified channels. Chapter 5 Remote Interface Reference Frequency Configuration Commands Frequency Configuration Commands See also “Frequency Measurement Configuration” in chapter 4 starting on page 118. [SENSe:] FREQuency:RANGe:LOWer {3|20|200|MIN|MAX}[,(FREQuency:RANGe:LOWer? [{(Specify the lowest frequency expected in the input signal for frequency measurements on the specified channels. The instrument selects a slow, medium (default), or fast measurement timeout based on the frequency you specify. Chapter 5 Remote Interface Reference Scanning Overview Scanning Overview See also “Scanning” in chapter 4 starting on page 74. The instrument allows you to combine a DMM (either internal or external) with multiplexer channels to create a scan. During a scan, the instrument connects the DMM to the configured multiplexer channels one at a time and makes a measurement on each channel. Page 225 DMM and others using an external DMM . Readings are stored in HP 34970A memory only when the internal is used. If the internal DMM is installed and enabled, the instrument will automatically use it for scanning. Page 226 Chapter 5 Remote Interface Reference Scanning Overview Scanning Commands ROUTe scan_list :SCAN (< >) :SCAN? Select the channels to be included in the scan list. To start the scan, use the INITiate or READ? command. To remove all channels from the scan list, send ROUT:SCAN (The :SCAN? query returns a list of channel numbers in the SCPI definite length block format. Page 227 Chapter 5 Remote Interface Reference Scanning Overview TRIGger seconds :TIMer {< >|MIN|MAX} :TIMer? Set the scan-to-scan interval (in seconds) for measurements on the channels in the scan list. This command defines the time from the start of one scan sweep to the start of the next sweep. You can set the interval to any value between 0 seconds and 359,999 seconds (99:59:59 hours), with 1 ms resolution. Page 228 Chapter 5 Remote Interface Reference Scanning Overview ROUTe :CHANnel:DELay:AUTO {OFF|ON}[,(:CHANnel:DELay:AUTO? [(Disable or enable an automatic channel delay on the specified channels. If enabled, the delay is determined by the function, range, integration time, and ac filter setting (see “Automatic Channel Delays,” on page 89). Selecting a specific channel delay (using the ROUT:CHAN:DELay command) disables the automatic channel delay. Page 229 Chapter 5 Remote Interface Reference Scanning Overview Reading Format Commands During a scan, the instrument automatically adds a time stamp to all readings and stores them in non-volatile memory. Each reading is stored with measurement units, time stamp, channel number, and alarm status information. Page 230 Chapter 5 Remote Interface Reference Scanning Overview FORMat :READing:TIME {OFF|ON} :READing:TIME? Disable (default) or enable the inclusion of a time stamp with data produced by READ?, FETCh?, or other queries of scan results. This command operates in conjunction with the other FORMat:READing commands (they are not mutually exclusive). Page 231 Chapter 5 Remote Interface Reference Scanning Overview Scan Statistics Commands While a scan is running, the instrument automatically stores the minimum and maximum readings and calculates the average for each channel. You can read these values at any time, even during a scan. The instrument clears the values when a new scan is started, when the CALC:AVER:CLEAR command (described on the next page) is executed, after a Factory Reset (*RST command), or after an Instrument Preset... Page 232 Chapter 5 Remote Interface Reference Scanning Overview CALCulate:AVERage:AVERage? [(Calculate the mathematical average of all readings taken on each of the specified channels since the start of the scan. Each channel must be a multiplexer channel that has been configured to be part of the scan list. If no data is available for the specified channels, “0”... Page 233 Chapter 5 Remote Interface Reference Scanning Overview Scan Memory Commands You can store up to 50,000 readings in non-volatile memory during a scan. Readings are stored only during a scan and all readings are automatically time stamped. If memory overflows (the MEM annunciator will turn on), a status register bit is set and new readings will overwrite the first readings stored (the most recent readings are always preserved). Page 234 Chapter 5 Remote Interface Reference Scanning Overview SYSTem:TIME:SCAN? Read the time at the start of the scan. This command is not affected by the FORMat:READ:TIME:TYPE command. Returns the time in the form “ 1997,06,02,18,30,00.000 ” (June 1, 1997 at 6:30 PM). FETCh? Transfer readings stored in non-volatile memory to the instrument’s output buffer where you can read them into your computer. Chapter 5 Remote Interface Reference Single-Channel Monitoring Overview Single-Channel Monitoring Overview In the Monitor function, the instrument takes readings as often as it can on a single channel, even during a scan. This feature is useful for trouble- shooting your system before a test or for watching an important signal. Any channel that can be “read”... Page 236 Chapter 5 Remote Interface Reference Single-Channel Monitoring Overview ROUTe channel :MONitor (< >) :MONitor? Select the channel to be monitored. To turn on the monitor function, use the ROUT:MON:STATE ON command (see below). The :SCAN? query returns a list of channel numbers in the SCPI definite length block format. Scanning With an External Instrument If your application doesn’t require the built-in measurement capabilities of the HP 34970A, you can order it without the internal DMM . In this configuration, you can use the system for signal routing or control applications. Page 238 Chapter 5 Remote Interface Reference Scanning With an External Instrument ROUTe scan_list :SCAN (< >) :SCAN? Select the channels to be included in the scan list. To start the scan, use the INITiate or READ? command. To remove all channels from the scan list, send ROUT:SCAN (The :SCAN? query returns a list of channel numbers in the SCPI definite length block format. Page 239 Chapter 5 Remote Interface Reference Scanning With an External Instrument TRIGger seconds :TIMer {< >|MIN|MAX} :TIMer? Set the scan-to-scan interval (in seconds) for measurements on the channels in the scan list. This command defines the time from the start of one scan sweep to the start of the next sweep. You can set the interval to any value between 0 seconds and 359,999 seconds (99:59:59 hours), with 1 ms resolution. Page 240 TRIG:SOUR is reset to IMMediate. A channel advance signal is not required for digital input or totalizer channels included in the scan list. Measurements on these channels are still performed by the HP 34970A and do not require synchronization with the external instrument. ”. Page 241 < ch_list This command is valid only when the internal DMM is disabled or removed from the HP 34970A. Configure the list of channels for 4-wire external scanning without the internal DMM . When enabled, the instrument automatically pairs channel n with channel n+10 (34901A) or n+8 (34902A) to provide the source and sense connections. Chapter 5 Remote Interface Reference Mx+B Scaling Overview Mx+B Scaling Overview See also “Mx+B Scaling” in chapter 4 starting on page 119. The scaling function allows you to apply a gain and offset to all readings on a specified multiplexer channel during a scan. In addition to setting the gain (“M”) and offset (“B”) values, you can also specify a custom measurement label for your scaled readings (RPM , PSI , etc.). Page 243 Chapter 5 Remote Interface Reference Mx+B Scaling Overview Mx+B Scaling Commands CALCulate gain ch_list :SCALe:GAIN < >[,(< ch_list :SCALe:GAIN? [(< >)] Set the gain (“M”) for scaled readings on the specified channels. The maximum gain allowed is 1E+15. The default is M=1. The :GAIN? query returns the gain value on the specified channels. Page 244 Chapter 5 Remote Interface Reference Mx+B Scaling Overview CALCulate:SCALe:OFFSet:NULL (Make an immediate null measurement on the specified channels and store it as the offset (“B”) for subsequent measurements. This allows you to adjust for voltage or resistive offsets through your wiring to the point of the measurement. Chapter 5 Remote Interface Reference Alarm System Overview Alarm System Overview See also “Alarm Limits” in chapter 4 starting on page 122. The instrument has four alarms which you can configure to alert you when a reading exceeds specified limits on a channel during a scan. You can assign a high limit, a low limit, or both to any configured channel in the scan list. Page 246 Chapter 5 Remote Interface Reference Alarm System Overview You can assign an alarm to any configured channel and multiple channels can be assigned to the same alarm number. However, you cannot assign alarms on a specific channel to more than one alarm number. Chapter 5 Remote Interface Reference Alarm System Overview Four TTL alarm outputs are available on the rear-panel Alarms connector. You can use these hardware outputs to trigger external alarm lights, sirens, or send a TTL pulse to your control system. You can also initiate a scan sweep (no external wiring required) when an alarm event is logged on a channel. Page 248 Chapter 5 Remote Interface Reference Alarm System Overview Alarm Limit Commands OUTPut :ALARm[1|2|3|4]:SOURce (:ALARm[1|2|3|4]:SOURce? Assign the alarm number to report any alarm conditions on the specified channels. If not assigned, all alarms on all channels are reported on Alarm 1 by default. The :SOUR? query returns a list of channel numbers in the SCPI definite length block format. Page 249 Chapter 5 Remote Interface Reference Alarm System Overview CALCulate value :LIMit:LOWer < >[,(:LIMit:LOWer? [(< ch_list >)] Set the lower limit for alarms on the specified channels. You can set the value to any number between -120% and +120% of the highest range, for the present function. Page 250 Chapter 5 Remote Interface Reference Alarm System Overview Alarm Output Commands Four TTL alarm outputs are available on the rear-panel Alarms connector. You can use these hardware outputs to trigger external alarm lights, sirens, or send a TTL pulse to your control system. Each alarm output line represents the logical “... Page 251 Chapter 5 Remote Interface Reference Alarm System Overview Digital I/O Alarm Commands See also “Using Alarms With the Multifunction Module” in chapter 4 starting on page 130. CALCulate :COMPare:TYPE {EQUal|NEQual}[,(ch_list :COMPare:TYPE? [(< Select the comparison mode for alarms on the specified DIO channels. Select EQUal to generate an alarm when the data read from the port is equal to CALC:COMP:DATA after being masked by CALC:COMP:MASK . Page 252 Chapter 5 Remote Interface Reference Alarm System Overview CALCulate mask :COMPare:MASK < >[,(:COMPare:MASK? [(< ch_list Specify the mask pattern for comparisons on the specified DIO channels. You must specify the mask parameter as a decimal value between 0 and 255 (binary data is not accepted). Specify 1’s for active bits or 0’s for “don’t care”... Chapter 5 Remote Interface Reference Digital Input Commands Digital Input Commands See also “Digital Input Operations” in chapter 4 starting on page 133. MEASure:DIGital:BYTE? (< Configure the instrument to read the specified digital input channels on the multifunction module and immediately sweep through the scan list one time. Chapter 5 Remote Interface Reference Totalizer

Commands Totalizer Commands See also “Totalizer Operations” in chapter 4 starting on page 135. MEASure:TOTalize? {READ|RRESet} ,(Configure the instrument to read the count on the specified totalizer channels on the multifunction module and immediately sweep through the scan list one time. Page 255 Chapter 5 Remote Interface Reference Totalizer Commands [SENSe:] TOTalize:SLOPe {NEGative|POSitive}[,(TOTalize:SLOPe? [(< ch_list Configure the totalizer to count on the rising edge (default; positive) or falling edge (negative) of the input signal. The totalizer channel is numbered “s03”, where s represents the slot number. The :SLOP? query returns the edge selection. Chapter 5 Remote Interface Reference Digital Output Commands Digital Output Commands SOURce :DIGital:DATA[:{BYTE|WORD}] < :DIGital:DATA[:{BYTE|WORD}]? (Output an 8-bit byte or 16-bit word digital pattern to the specified digital output channels. Note that you cannot configure a port for output operations if that port is already configured to be part of the scan list (digital input). The :CLOS? query returns the state of the specified channels. Returns “1” if the channel is closed or “0” if the channel is open. On the 20-channel multiplexer (HP 34901A), only one of the shunt switches (channels 21 and 22) can be closed at a time; connecting one channel will close the other. Page 258 < ch_list This command is valid only when the internal DMM is disabled or removed from the HP 34970A. Configure the list of channels for 4-wire external scanning without the internal DMM . When enabled, the instrument automatically pairs channel n with channel n+10 (34901A) or n+8 (34902A) to provide the source and sense connections. Chapter 5 Remote Interface Reference State Storage Commands State Storage Commands The instrument has six storage locations in non-volatile memory to store instrument states. The locations are numbered 0 through 5. The instrument uses location “0” to automatically hold the state of the instrument at power down. Page 260 Chapter 5 Remote Interface Reference State Storage Commands MEMory:STATe name :NAME {1|2|3|4|5} [,< :NAME? {1|2|3|4|5} Assign a name to the specified storage location (you cannot assign a name to location “0”). You can name a location from the front panel or over the remote interface but you can only recall a named state from the front panel. Page 261 Chapter 5 Remote Interface Reference State Storage Commands MEMory:STATe :RECall:AUTO {OFF|ON} :RECall:AUTO? Disable or enable (default) the automatic recall of the power-down state from storage location “0” when power is turned on. Select “ ON ” to automatically recall the power-down state when power is turned on. Select “... Chapter 5 Remote Interface Reference System-Related Commands System-Related Commands See also “System-Related Operations” in chapter 4 starting on page 140. yyyy SYSTem:DATE < > < > < Set the instrument calendar. The setting is stored in non-volatile memory. When shipped from the factory, instrument is set to the current time and date (U.S Mountain Time). Page 263 Be sure to dimension a string variable with at least 40 characters. SYSTem:CTYPe? {100|200|300} Read the identity of the module in the specified slot. For example, the HP 34903A 20-Channel Actuator returns: HEWLETT-PACKARD,34903A,0,1.0 The last number (1.0 in this example) is the firmware revision number for the module. Page 264 Chapter 5 Remote Interface Reference System-Related Commands DISPlay {OFF|ON} DISPlay? Disable or enable the front-panel display. When disabled, the entire front-panel display goes dark and all display annunciators except are disabled. All keys except ERROR display is disabled. The display is automatically enabled when power is cycled, after a Factory Reset (*RST command), or when you return to local by pressing . Page 265 Chapter 5 Remote Interface Reference System-Related Commands INSTrument :DMM {OFF|ON} :DMM? Disable or enable the internal DMM . When you change the state of the internal DMM , the instrument issues a Factory Reset (*RST command). The :DMM? query returns the state of the internal DMM. Returns “0” (disabled) or “1”... Page 266 *CLS (clear status) command or when power is cycled. The errors are also cleared when you read the queue. See chapter 6 for a complete listing of the HP 34970A error messages. SYSTem:ALARm? Read the alarm data from the alarm queue (one alarm event is read and cleared each time this command is executed). See also “Remote Interface Configuration” in chapter 4 starting on page 150. SYSTem:INTerface {GPIB|RS232} Select the remote interface. Only one interface can be enabled at a time. The HP-IB interface is selected when the instrument is shipped from the factory. SYSTem:LOCal Place the instrument in the local mode for RS -232 operation. Page 268 Chapter 5 Remote Interface Reference RS-232 Interface Configuration RS-232 Interface Configuration See also “Remote Interface Configuration” in chapter 4 on page 150. This section contains information to help you use the instrument over the RS-232 interface. The programming commands for RS-232 are listed on page 269. Page 269 Chapter 5 Remote Interface Reference RS-232 Interface Configuration RS-232 Flow Control Modes You can select one of several flow control methods to coordinate the transfer of data between the instrument and your computer or modem. None: In this mode, data is sent and received over the interface without any flow control used. Chapter 5 Remote Interface Reference RS-232 Interface Configuration RS-232 Data Frame Format A character frame consists of all the transmitted bits that make up a single character. The frame is defined as the bits from the start bit to the last stop bit, inclusively. Page 271 (if you ordered the internal DMM). If you need an additional cable, order the F1047-80002 cable which is part of the HP 34398A Cable Kit. This cable has a 9-pin female connector on each end. The modem adapter is available in the HP 34399A Adapter kit. 7. After turning on the remote modem, you should notice that the AA (auto answer) light is on. When you turn on the HP 34970A, you should notice that the TR (instrument ready) light is on. The SCPI Status System This section describes the structure of the SCPI status system used by the HP 34970A. The status system records various conditions and states of the instrument in five register groups as shown on the following page. Page 274 Chapter 5 Remote Interface Reference The SCPI Status System HP 34970A Status System Questionable Data Register Volt Ovld Curr Ovld Res Ovld Temp Ovld Tot Ovfl Mem Ovfl STAT:QUES:COND? STAT:QUES:EVENt? STAT:QUES:ENABle < value STAT:QUES:ENABle? Output Buffer Standard Event Register Operation Complete... Page 275 Chapter 5 Remote Interface Reference The SCPI Status System The Status Byte Register The Status Byte register group reports conditions from the other register groups. Data in the instrument’s output buffer is immediately reported on the “Message Available” bit (bit 4). Clearing an event register from one of the other register groups will clear the corresponding bits in the Status Byte condition register. Page 276 Chapter 5 Remote Interface Reference The SCPI Status System Using Service Request (SRQ) and Serial Poll You must configure your computer to respond to the IEEE -488 service request (SRQ) interrupt to use this capability. Use the Status Byte enable register (*SRE command) to select which condition bits will assert the IEEE -488 SRQ line. Page 277 Chapter 5 Remote Interface Reference The SCPI Status System Using the Message Available Bit (MAV) You can use the Status Byte “Message Available” bit (bit 4) to determine when data is available to read into your computer. The instrument subsequently clears bit 4 only after all messages have been read from the output buffer. Page 278 Chapter 5 Remote Interface Reference The SCPI Status System The Questionable Data Register The Questionable Data register group provides information about the quality of the instrument’s measurement results. Any or all of these conditions can be reported to the Questionable Data summary bit through the enable register. Page 279 Chapter 5 Remote Interface Reference The SCPI Status System The Questionable Data event register is cleared when: You execute a *CLS (clear status) command. You query the event register using the STATus:QUES:EVENt? command. The Questionable Data enable register is cleared when: You turn on the power (*PSC does not apply). Chapter 5 Remote Interface Reference The SCPI Status System The Standard Event Register The Standard Event register group reports the following types of instrument events: power-on detected, command syntax errors, command execution errors, self-test or calibration errors, query errors, or the *OPC command is executed. Any or all of these conditions can be reported to the Standard Event summary bit through the enable register. Page 281 Chapter 5 Remote Interface Reference The SCPI Status System The Standard event register is cleared when: You execute the *CLS (clear status) command. You query the event register using the *ESR? command. The Standard Event enable register is cleared when: You execute the *ESE 0 command. Page 282 Chapter 5 Remote Interface Reference The SCPI Status System The Alarm Register The Alarm register group is used to report the status of the four instrument alarm limits. Any or all of these alarm conditions can be reported to the Alarm Register summary bit through the enable register. To set the enable register mask, you must write a decimal value to the register using the STATus:ALARm:ENABle command. Page 283 Chapter 5 Remote Interface Reference The SCPI Status System The Standard Operation Register The Standard Operation register group is used to report when the instrument is scanning. Any or all of these conditions can be reported to the Standard Operation summary bit through the enable register. To set the enable register mask, you must write a decimal value to the register using the STATus:OPER:ENABle command. Chapter 5 Remote Interface Reference Status System Commands Status System Commands An application program is included in chapter 7 which shows the use of the Status System Registers. Refer to page 330 for more information. Status Byte Register Commands See the table on page 277 for the register bit definitions. *STB? Query the summary (condition) register in this register group. Page 285 Chapter 5 Remote Interface Reference Status System Commands Questionable Data Register Commands See the table on page 280 for the register bit definitions. STATus:QUEStionable:CONDition? Query the condition register in this register group. This is a read-only register and bits are not cleared when you read the register. A *RST (Factory Reset) will clear all bits in a condition register. Page 286 Chapter 5 Remote Interface Reference Status System Commands Standard Event Register Commands See the table on page 282 for the register bit definitions. *ESR? Query the event register in this register group. This is a read-only register. Once a bit is set, it remains set until cleared by a *CLS (clear status) command. Page 287 Chapter 5 Remote Interface Reference Status System Commands Alarm Register Commands See the table on page 284 for the register bit definitions. STATus:ALARm:CONDition? Query the condition register in this register group (note that this condition register uses only bit 4). This is a read-only register and bits are not cleared when you read the register. Page 288 Chapter 5 Remote Interface Reference Status System Commands Standard Operation Register Commands See the table on page 285 for the register bit definitions. STATus:OPERation:CONDition? Query the condition register in this register group. This is a read-only register and bits are not cleared when you read the register. Note that a *RST (Factory Reset) command may set the “Configuration Change”... Page 289 Chapter 5 Remote Interface Reference Status System Commands num_rdgs DATA:POINts:EVENt:THReshold < > DATA:POINts:EVENt:THReshold? Set a bit in the event register when the specified number of readings have been stored in reading memory during a scan. You can set the memory threshold to any value between 1 reading and 50,000 readings. The default is 1 reading. For an overview of the calibration features of the instrument, refer to “Calibration Overview” in chapter 4 starting on page 155. For a more detailed discussion of the instrument’s calibration procedures, see chapter 4 in the HP 34970A Service Guide. CALibration? Perform a calibration of the instrument using the specified calibration value (CALibration:VALue command). Page 291 > CALibration:VALue? Specify the value of the known calibration signal as outlined in the calibration procedures in the HP 34970A Service Guide. The :VAL? command reads present calibration value. Returns a number in the form “+ 1.00000000E+01 ”. code >... Chapter 5 Remote Interface Reference Service-Related Commands Service-Related Commands INSTrument :DMM {OFF|ON} :DMM? Disable or enable the internal DMM . When you change the state of the internal DMM , the instrument issues a Factory Reset (*RST command). The :DMM? query returns the state of the internal DMM. Returns “0” (disabled) or “1”... Page 293 Chapter 5 Remote Interface Reference Service-Related Commands *RST Reset the instrument to the Factory configuration. See “Factory Reset State” on page 160 in chapter 4 for a complete listing of the instrument’s Factory Reset state. This command is equivalent to selecting from the front-panel Sto/Rcl Menu. Chapter 5 Remote Interface Reference An Introduction to the SCPI Language An Introduction to the SCPI Language SCPI (Standard Commands for Programmable Instruments) is an -based instrument command language designed for test and ASCII measurement instruments. Refer to “Simplified Programming Overview,” starting on page 201, for an introduction to the basic techniques used to program the instrument over the remote interface. Page 295 Chapter 5 Remote Interface Reference An Introduction to the SCPI Language Command Format Used in This Manual The format used to show commands in this manual is shown below: VOLTage:DC:RANGe {< >|MINimum|MAXimum}[,(< >)] range ch_list The command syntax shows most commands (and some parameters) as a mixture of upper- and lower-case letters. Chapter 5 Remote Interface Reference An Introduction to the SCPI Language Command Separators A colon (:) is used to separate a command keyword from a lower-level keyword. You must insert a blank space to separate a parameter from a command keyword. Page 297 Chapter 5 Remote Interface Reference An Introduction to the SCPI Language Querying Parameter Settings You can query the current value of most parameters by adding a question mark (?) to the command. For example, the following command sets the scan count to 10 sweeps: "TRIG:COUN 10"... Page 298 Chapter 5 Remote Interface Reference An Introduction to the SCPI Language SCPI Parameter Types The SCPI language defines several different data formats to be used in program messages and response messages. Numeric Parameters Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. Page 299 Chapter 5 Remote Interface Reference An Introduction to the SCPI Language String Parameters String parameters can contain virtually any set of characters. A string must begin and end with matching quotes; ASCII either with a single quote or with a double quote. You can include the quote delimiter as part of the string by typing it twice without any characters in between. Chapter 5 Remote Interface Reference Using Device Clear Using Device Clear Device Clear is an IEEE-488 low-level bus message which you can use to return the instrument to a responsive state. Different programming languages and IEEE-488 interface cards provide access to this capability through their own unique commands. Error Messages... Error Messages Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. Errors are cleared as you read them. When you have read all errors from the queue, the ERROR annunciator turns off and the errors are cleared. Chapter 6 Error Messages Execution Errors Execution Errors Invalid character -101 An invalid character was found in the command string. You may have used an invalid character such as #, {, $, or % in the command header or within a parameter. Example: CONF:VOLT:DC { -102 Syntax error Invalid syntax was found in the command string. Page 304 Chapter 6 Error Messages Execution Errors -114 Header suffix out of range A header suffix is the number that can be appended to the end of some command headers. This error is generated if an invalid number is used. Example: OUTP:ALARM5:SOURCE Invalid character in number -121 An invalid character was found in the number specified for a parameter. Chapter 6 Error Messages Execution Errors -168 Block data not allowed Data was sent to the instrument in SCPI definite length block format but this command does not accept this format. Example: SOUR:DIG:DATA #128 -178 Expression data not allowed A channel list was received but is not allowed for this command. Example: SYST:CTYPE? (-211 Trigger ignored... Page 306 Chapter 6 Error Messages Execution Errors -230 Data stale A FETCh? or DATA:REMove? command was received but internal reading memory was empty. The readings retrieved may be invalid. -310 System error A firmware defect has been found. This is not a fatal error but you should contact your nearest Hewlett-Packard Service Center if this error is reported. This error is reported at power-on to indicate that a stored state has become unusable. This error is most likely caused by a dead battery (memory is battery-backed). Refer to the HP 34970A Service Guide to replace the internal battery. Page 308 Chapter 6 Error Messages Instrument Errors Settings conflict: calculate limit state forced off If you plan to use scaling on a channel which will also use alarms, be sure to configure the scaling values first. This error is generated if you attempt to assign the alarm limits first and the instrument will turn off alarms and clear the limit values. Chapter 6 Error Messages Instrument Errors Not able to execute while scan initiated While a scan is running, you cannot change any parameters that affect the scan (channel configuration, scan interval, scaling values, alarm limits, issue a Card Reset, or recall a stored state). To stop a scan in progress, send the ABORt command or a bus Device Clear. Page 310 The requested operation is not valid for the specified channel. You may have tried to a configure a channel for current measurements (valid only on channels 21 and 22 on the HP 34901A module). Or you may have tried to configure scaling on a module that does not connect to the internal DMM . Page 311 I/O processor: isolator overrun error Communications: RS-232 framing error Communications: RS-232 overrun error Communications: RS-232 parity error RS-232 only: unable to execute using HP-IB There are three commands which are allowed only with the RS-232 interface: SYSTem:LOCal, SYSTem:REMote, and SYSTem:RWLock. Communications: input buffer overflow... Chapter 6 Error Messages Self-Test Errors Self-Test Errors The following errors indicate failures that may occur during a self-test. Refer to the HP 34970A Service Guide for more information. Self-test: front panel not responding Self-test: RAM read/write Self-test: A/D sync stuck... Calibration Errors Calibration Errors The following errors indicate failures that may occur during a calibration. Refer to the HP 34970A Service Guide for more information. Cal: security disabled by jumper The calibration security feature has been disabled with a jumper inside the instrument. Page 314 Cal data lost: string data Cal data lost: DCV corrections Cal data lost: DCI corrections Cal data lost: RES corrections Cal data lost: FRES corrections Cal data lost: AC corrections Config data lost: HP-IB address Config data lost: RS-232 DMM relay count data lost... Chapter 6 Error Messages Plug-In Module Errors Plug-In Module Errors Module hardware: unexpected data received Module hardware: missing stop bit Module hardware: data overrun Module hardware: protocol violation Module hardware: early end of data Module hardware: missing end of data Module hardware: module srq signal stuck low Module hardware: not responding Module reported an unknown module type... Application Programs... Windows 95. The examples are written for use over the HP-IB interface and require a VISA (Virtual Instrument Software Architecture) library for use with your HP-IB interface card in your PC . You will want to make sure that you have the file in your c:\windows\system visa32.dll... Example Programs for Excel 7.0 This section contains two example programs written using Excel macros (Visual Basic for Applications) to control the HP 34970A. Using Excel, ® you can send SCPI commands to configure the instrument and then record measurement data on the Excel spreadsheet. Page 319 Excel 7.0 Example: takeReadings Macro ’"" ’ This Excel Macro (Visual Basic) configures the HP 34970A for scanning with the HP 34901A, ’ HP 34902A, or HP 34908A multiplexer modules. When this subroutine is executed, it will ’ take the specified number of readings on the selected channel. You can easily modify the ’... Page 320 ’"" Public Sub SendSCPI(SCPICmd As String) ’ This routine sends a SCPI command string to the HP-IB port. If the command is a ’ query command (contains a question mark), you must read the response with ’getScpi’ Dim commandstr As String Dim actual As Long ’Write the command to the instrument terminated by a line feed... Page 321 Chapter 7 Application Programs Example Programs for Excel 7.0 Sub OpenPort() ’"" ’ Be sure that the HP-IB address has been set in the ’VISAaddr’ variable ’ before calling this routine. ’"" ’ Open the VISA session errorStatus = viOpenDefaultRM(videfaultRM) ’... Page 322 Excel 7.0 Example: ScanChannels Macro ’"" ’ This Excel Macro (Visual Basic) configures the HP 34970A for scanning with the HP 34901A, ’ HP 34902A, or HP 34908A multiplexer modules. When this subroutine is executed, it will ’ scan 5 channels and display the readings on a spreadsheet. You can easily modify the ’... Page 323 = Val(GetSCPI()) Loop Until points >= 1 Or Channel >= numberChannels Next Channel Next columnIndex ClosePort ’ Close communications on HP-IB End Sub ’ Put headings on spreadsheet ’ Put headings on spreadsheet ’ Put time into string variable ’... Page 324 = TimeSerial(Cells(1, 4), Cells(1, 5), Cells(1, 6)) ConvertTime = dateNumber + timeNumber End Function Sub GetErrors() ’ Call this routine to check for instrument errors. The HP-IB address variable ’ ’VISAaddr’ must be set. Dim DataString As String OpenPort SendSCPI "SYSTEM:ERROR?"... The following C programming examples show you how to send and receive formatted I/O. For more information on non-formatted I/O, refer to the HP VISA User’s Guide. The examples in this section show you how to use the SCPI commands for the instrument with the VISA functionality and does not include error trapping. Page 326 * Required: HP 34907A Multifunction Module in slot 200; VISA library * This program uses the VISA library to communicate with the HP 34970A. * The program queries slot 200 and displays the response. It then resets * the instrument and sends the value ’voltage’ to the DAC on channel 205. Page 327 /*** * Required: VISA library. * This program demonstrates the use of the HP 34970A Status Registers * for an alarm and Operation Complete (OPC) and for enabling and receiving * an SRQ interrupt. This program also shows how to configure a scan for * 10 readings on one channel. Page 328 Chapter 7 Application Programs Example Programs for C and C++ /* Stay in loop until the srqFlag goes negative */ index = 1; for (count = 0; count =0); /* A negative srqFlag indicates scan is done */ /* The instrument is done, so close the SRQ handler */ viDisableEvent(DataAcqu,VI_EVENT_SERVICE_REQ,VI_HNDLR);... Tutorial... Page 330 This chapter describes methods that you can use to reduce errors that can affect your measurements. You will also find information to help you better understand how the HP 34970A makes measurements and what you can do to get the best results. This chapter is divided into the... Chapter 8 Tutorial System Cabling and Connections System Cabling and Connections This section describes methods to reduce measurement errors that can be introduced by your system cabling. Many system cabling errors can be reduced or eliminated by selecting the proper cable and grounding scheme for your system. Page 332 20 m 30 m 50 m * Recommended wire size for the screw terminals on HP 34970A plug-in modules. Cable Capacitance – Varies with the insulation type, cable length, and cable shielding. Cables should be kept as short as possible to minimize cable capacitance. Page 333 Chapter 8 Tutorial System Cabling and Connections Grounding Techniques One purpose of grounding is to avoid ground loops and minimize noise. Most systems should have at least three separate ground returns. 1. One ground for signals. You may also want to provide separate signal grounds between high-level signals, low-level signals, and digital signals. Page 334 Chapter 8 Tutorial System Cabling and Connections Shielding Techniques Shielding against noise must address both capacitive (electrical) and inductive (magnetic) coupling. The addition of a grounded shield around the conductor is highly effective against capacitive coupling. In switching networks, this shielding often takes the form of coaxial cables and connectors. Chapter 8 Tutorial System Cabling and Connections Sources of System Cabling Errors Radio Frequency Interference Most voltage-measuring instruments can generate false readings in the presence of large, high-frequency signals. Possible sources of high-frequency signals include nearby radio and television transmitters, computer monitors, and cellular telephones. High-frequency energy can also be coupled to the internal DMM on the system cabling. Page 336 Chapter 8 Tutorial System Cabling and Connections Thermal EMF Errors Thermoelectric voltages are the most common source of error in low-level dc voltage measurements. Thermoelectric voltages are generated when you make circuit connections using dissimilar metals at different temperatures. Each metal-to-metal junction forms a thermocouple, which generates a voltage proportional to the junction temperature difference. Page 337 Chapter 8 Tutorial System Cabling and Connections Noise Caused by Ground Loops When measuring voltages in circuits where the internal DMM and the device-under-test are both referenced to a common earth ground, a ground loop is formed. As shown below, any voltage difference between the two ground reference points (V causes a current to flow through the LO measurement lead. Page 338 Chapter 8 Tutorial System Cabling and Connections Low-Level AC Measurement Errors When measuring ac voltages less than 100 mV, be aware that these measurements are especially susceptible to errors introduced by extraneous noise sources. An exposed test lead will act as an antenna and the internal DMM will measure the signals received. Chapter 8 Tutorial Measurement Fundamentals Measurement Fundamentals This section explains how the HP 34970A makes measurements and discusses the most common sources of error related to these measurements. The Internal DMM The internal DMM provides a universal input front-end for measuring a variety of transducer types without the need for additional external signal conditioning. Page 340 Chapter 8 Tutorial Measurement Fundamentals Rejecting Power-Line Noise Voltages A desirable characteristic of an integrating analog-to-digital (A/D) converter is its ability to reject spurious signals. Integrating techniques reject power-line related noise present with dc signals on the input. This is called normal mode rejection or NMR . Page 341 The mathematical conversion is based on specific properties of the various transducers. The conversion routines used by the HP 34970A are compatible with the International Temperature Scale of 1990 (ITS-90). The mathematical conversion accuracy (not including the transducer accuracy) for each transducer type is shown below. Page 342 = 100 . The resistance of an RTD is nominal at 0 C and is referred to as R The HP 34970A can measure RTD s with R values from 49 to 2.1 k . You can measure RTD s using a 2-wire or 4-wire measurement method. Page 343 Chapter 8 Tutorial Measurement Fundamentals Thermocouple Measurements A thermocouple converts temperature to voltage. When two wires composed of dissimilar metals are joined, a voltage is generated. The voltage is a function of the junction temperature and the types of metals in the thermocouple wire. Since the temperature characteristics of many dissimilar metals are well known, a conversion from the voltage generated to the temperature of the junction can be made. Page 344 Chapter 8 Tutorial Measurement Fundamentals An ice bath is used to create a known reference temperature (0 C). Once the reference temperature and thermocouple type are known, the temperature of the measurement thermocouple can be calculated. Internal DMM Ice Bath The T-type thermocouple is a unique case since one of the conductors (copper) is the same metal as the internal DMM ’s input terminals. Page 345 Chapter 8 Tutorial Measurement Fundamentals To make a more accurate measurement, you should extend the copper test leads of the internal DMM closer to the measurement and hold the connections to the thermocouple at the same temperature. Internal DMM Ice Bath This circuit will give accurate temperature measurements. Page 346 Chapter 8 Tutorial Measurement Fundamentals In some measurement situations, however, it would be nice to remove the need for an ice bath (or any other fixed external reference). To do this, an isothermal block is used to make the connections. An isothermal block is an electrical insulator, but a good heat conductor. Page 347 Chapter 8 Tutorial Measurement Fundamentals Thermocouple Types T/C Type Pos (+) Lead Platinum-30% Rhodium Platinum-60% Rhodium U.S. Gray British Japanese French Iron Constantan U.S. White British Yellow Japanese French Yellow Nickel-Chromium Nickel-Aluminum U.S. Yellow British Brown Japanese French Yellow Copper Constantan U.S. Page 348 A resistance measurement of more than 5 k typically indicates a defective thermocouple. The HP 34970A contains a built-in, automatic thermocouple check feature. If you enable this feature, the instrument measures the channel resistance after each thermocouple measurement to ensure a proper connection. Page 349 Chapter 8 Tutorial Measurement Fundamentals Shunt Impedance The insulation used for thermocouple wire and extension wire can be degraded by high temperatures or corrosive atmospheres. These breakdowns appear as a resistance in parallel with the thermocouple junction. This is especially apparent in systems using a small gauge wire where the series resistance of the wire is high. Page 350 High V 100:1 For input voltages less than 12 Vdc, the Low V switch is closed and applies the input signal directly to the input amplifier. For higher voltages, the High V switch is closed and the signal is attenuated 100:1 before being applied to the input amplifier. Page 351 Chapter 8 Tutorial Measurement Fundamentals Sources of Error in DC Voltage Measurements Common Mode Rejection Ideally, the internal DMM is completely isolated from earth-referenced circuits. However, there is finite resistance and capacitance between the input LO terminal and earth ground. If the input terminals are both driven by an earth-referenced signal (V) then a current will flow through R as shown below. Page 352 Chapter 8 Tutorial Measurement Fundamentals Noise Caused by Injected Current Residual capacitances in the instrument’s power transformer cause small currents to flow from the terminal of the internal DMM to earth ground. The frequency of the “injected current” is the power line frequency or possibly harmonics of the power line frequency. Page 353 Chapter 8 Tutorial Measurement Fundamentals Loading Errors Due to Input Resistance Measurement loading errors occur when the resistance of the device-under-test (DUT) is an appreciable percentage of the instrument’s own input resistance. The diagram below shows this error source. Where: = Ideal DUT voltage = DUT source resistance... Page 354 Chapter 8 Tutorial Measurement Fundamentals Loading Errors Due to Input Bias Current The semiconductor devices used in the input circuits of the internal DMM have slight leakage currents called bias currents. The effect of the input bias current is a loading error at the internal DMM ’s input terminals. The leakage current will approximately double for every 10 temperature rise, thus making the problem much more apparent at higher temperatures. Page 355 Chapter 8 Tutorial Measurement Fundamentals AC Voltage Measurements The main purpose of an ac “front end” is to change an ac voltage input into a dc voltage which can be measured by the ADC . Signal Conditioning for AC Measurements Input signal conditioning for ac voltage measurements includes both attenuation and amplification. Page 356 Chapter 8 Tutorial Measurement Fundamentals True RMS AC Measurements True RMS responding multimeters measure the “heating” potential of an applied voltage. Unlike an “average responding” measurement, a true RMS measurement is used to determine the power dissipated in a resistor. The power is proportional to the square of the measured true RMS voltage, independent of waveshape. Page 357 Chapter 8 Tutorial Measurement Fundamentals Making High-Speed AC Measurements The internal DMM ’s ac voltage and ac current functions implement three low-frequency filters. These filters allow you to trade-off low frequency accuracy for faster scanning speed. The fast filter settles in 0.12 seconds and is useful for measurements above 200 Hz. Page 358 – C.F. Error bandwidth x BW Where: C.F. = Signal crest factor (see the table on page 360) F = Fundamental input signal frequency BW = DMM’s -3 dB bandwidth (1 MHz for the HP 34970A) + Error bandwidth... Page 359 Chapter 8 Tutorial Measurement Fundamentals Example: Calculating Measurement Error Calculate the approximate measurement error for a pulse train input with a crest factor of 3 and a fundamental frequency of 20 kHz. The internal DMM is set to the 1 V range. For this example, use the 90-day accuracy specifications of (0.05% of reading + 0.04% of range), as shown in chapter 9 on page 406. Page 360 Chapter 8 Tutorial Measurement Fundamentals AC Loading Errors In the ac voltage function, the input of the internal DMM appears as a 1 M resistance in parallel with 150 pF of capacitance. The cabling that you use to connect signals to the instrument will also add additional capacitance and loading. Page 361 Chapter 8 Tutorial Measurement Fundamentals Low-Level AC Measurement Errors When measuring ac voltages less than 100 mV, be aware that these measurements are especially susceptible to errors introduced by extraneous noise sources. An exposed test lead will act as an antenna and the internal DMM will measure the signals received. Page 362 Chapter 8 Tutorial Measurement Fundamentals Measurements Below Full Scale You can make the most accurate ac measurements when the internal DMM is at full scale of the selected range. Autoranging occurs at 10% and 120% of full scale. This enables you to measure some inputs at full scale on one range and 10% of full scale on the next higher range. Page 363 Chapter 8 Tutorial Measurement Fundamentals Current Measurements Current measurements are allowed only on the HP 34901A module. An ammeter senses the current flowing through its input connections – approximating a short circuit between its input terminals. An ammeter must be connected in series with the circuit or device being measured such that current flows through both the meter and the test circuit. Page 364 Chapter 8 Tutorial Measurement Fundamentals Sources of Error in DC Current Measurements When you connect the internal DMM in series with a test circuit to measure current, a measurement error is introduced. The error is caused by the DMM ’s series burden voltage. A voltage is developed across the wiring resistance and current shunt resistance of the internal as shown below. Page 365 Chapter 8 Tutorial Measurement Fundamentals Resistance Measurements An ohmmeter measures the dc resistance of a device or circuit connected to its input. Resistance measurements are performed by supplying a known dc current to an unknown resistance and measuring the dc voltage drop. unknown test The internal DMM offers two methods for measuring resistance:... Page 366 Chapter 8 Tutorial Measurement Fundamentals The 4-wire ohms method is used in systems where lead resistances can become quite large and variable and in automated test applications where cable lengths can be quite long. The 4-wire ohms method has the obvious disadvantage of requiring twice as many switches and twice as many wires as the 2-wire method. Page 367 “Offset Compensation” on page 115 for more information. Offset compensation can be used for 2-wire or 4-wire ohms measurements (but not for RTD or thermistor measurements). The HP 34970A disables offset compensation when the measurement function is changed or after a Factory Reset (*RST command). Page 368 Chapter 8 Tutorial Measurement Fundamentals Sources of Error in Resistance Measurements External Voltages Any voltages present in the system cabling or connections will affect a resistance measurement. The effects of some of these voltages can be overcome by using offset compensation (as described on the previous page). Page 369 Although the instrument does not directly support strain measurements, you can measure a strain gage using a 4-wire resistance measurement with scaling. However, HP BenchLink Data Logger software has built-in strain gage measurement capability. When a force is applied to a body, the body deforms. The deformation per unit length is called strain ( ). Page 370 For more information on strain gages, refer to “Practical Strain Gage Measurements” (HP Application Note 290-1). This application note is also available on the HP Website in the Test and Measurement section (www.hp.com). Strain Sensors The metal foil resistance strain gage is by far the most widely used strain measurement sensor. Page 371 2.0 m Using the Mx+B scaling function with the equations shown below will allow you to display results directly in strain on the HP 34970A front-panel display. You can use a custom measurement label to display readings in “uE” (micro-strain) directly. The instrument will automatically add the micro (“u”) prefix based upon actual calculated values. Page 372 Chapter 8 Tutorial Measurement Fundamentals Frequency and Period Measurements The internal DMM uses a reciprocal counting technique to measure frequency and period. This method generates constant measurement resolution for any input frequency. The internal DMM ’s ac voltage measurement section performs input signal conditioning for frequency and period measurements. Page 373 Chapter 8 Tutorial Measurement Fundamentals Sources of Error in Frequency and Period Measurements The internal DMM ’s ac voltage measurement section performs input signal conditioning. All frequency counters are susceptible to errors when measuring low-voltage, low-frequency signals. The effects of both internal noise and external noise pickup are critical when measuring “slow”... 2. The instrument first closes the channel 1 relay, makes the voltage measurement, and then opens the relay before moving on to channel 2 (called break-before-make switching). Other low-level switching modules available with the HP 34970A include the following: HP 34903A 20-Channel Actuator... Page 375 Low-Level Signal Multiplexing and Switching One-Wire (Single-Ended) Multiplexers On the HP 34908A multiplexer, all of the 40 channels switch the HI input only, with a common LO for the module. The module also provides a thermocouple reference junction for making thermocouple measurements (for more information on the purpose of an isothermal block, see page 350). Page 376 Chapter 8 Tutorial Low-Level Signal Multiplexing and Switching Four-Wire Multiplexers You can make 4-wire ohms measurements using the HP 34901A and HP 34902A multiplexers. For a 4-wire ohms measurement, the channels are divided into two independent banks by opening the bank relay. Page 377 Signal Routing and Multiplexing When used stand-alone for signal routing (not scanning or connected to the internal DMM), multiple channels on the HP 34901A and HP 34902A multiplexers can be closed at the same time. You must be careful that this does not create a hazardous condition (for example, connecting two power sources together). Page 378 Low-Level Signal Multiplexing and Switching Sources of Error in Multiplexing and Switching Noise can be coupled inside a switch by the drive circuitry, by switch thermal EMF s, or by coupling among signal paths. Noise can also be generated outside the network and conducted or coupled into the switch. Page 379 Chapter 8 Tutorial Low-Level Signal Multiplexing and Switching The HP 34901A and HP 34902A multiplexers have an additional relay, called a bank switch or tree switch, which helps reduce channel-to- channel noise (C). The multiplexer channels are divided into two banks. Chapter 8 Tutorial Actuators and General-Purpose Switching Actuators and General-Purpose Switching The HP 34903A Actuator provides 20 independent, isolated SPDT (single-pole, double-throw) or Form C switches. This module offers simple on-off switching which you can use to control power devices or for custom switching applications. Page 381 A breadboard area is provided on the HP 34903A to implement custom circuitry such as simple filters, snubbers, and voltage dividers. The breadboard area provides the space necessary to insert your own components but there are no circuit board traces here. Page 382 Chapter 8 Tutorial Actuators and General-Purpose Switching The maximum value for R is usually made equal to the load resistance R Therefore, the limits on R can be stated as: < R < R Note that the actual value of the current (I by the equation: Where V is the peak value of the source voltage and R of the load. Page 383 Chapter 8 Tutorial Actuators and General-Purpose Switching Using Attenuators Provisions have been made on the HP 34903A circuit board for installing simple attenuators or filter networks. An attenuator is composed of two resistors that act as a voltage divider. A typical attenuator circuit is shown below. Chapter 8 Tutorial Matrix Switching Matrix Switching A matrix switch connects multiple inputs to multiple outputs and therefore offers more switching flexibility than a multiplexer. Use a matrix for switching low-frequency (less than 10 MHz) signals only. A matrix is arranged in rows and columns. For example, a simple 3x3 matrix could be used to connect three sources to three test points as shown below. Page 385 Combining Matrices You can combine two or more matrix switches to provide more complex switching. For example, the HP 34904A provides a 4-row by 8-column matrix. You can combine two of these modules as either a 4-row by 16-column matrix or an 8-row by 8-column matrix. An 8x8 matrix is shown below. Test 3 4 x 1 Multiplexer On the HP 34905A (50) and HP 34906A (75) RF multiplexers, you can close only one channel per bank at a time; closing one channel in a bank will open the previously closed channel. These modules respond only to the CLOSE command (OPEN does not apply). Page 387 Be sure that all leads and signal paths are properly terminated. Unterminated sections of line can appear as near shorts at RF frequencies. Note that the HP 34905A and HP 34906A do not automatically terminate open channels. Insertion Loss (50... Multifunction Module Multifunction Module Digital Input The HP 34907A module has two non-isolated 8-bit input/output ports which you can use for reading digital patterns. You can read the live status of the bits on the port or you can configure a scan to include a digital read. Page 389 Chapter 8 Tutorial Multifunction Module Digital Output The HP 34907A module has two non-isolated 8-bit input/output ports which you can use for outputting digital patterns. You can combine the two ports to output a 16-bit word. A simplified diagram of a single output bit is shown below. Page 390 Driving External Switches You can use two digital output channels to control an external switch. For example, you can drive the HP 865X series of microwave switches using an external power supply and two digital output channels. The HP 865A switch provides an internal protection diode. The state of the 2-to-1 multiplexer is changed by setting the appropriate output bit low (0). Page 391 Chapter 8 Tutorial Multifunction Module Totalizer The HP 34907A module has a 26-bit totalizer which can count pulses at a 100 kHz rate. You can manually read the totalizer count or you can configure a scan to read the count. Contact bounce on external switches can create false counts. All mechanical switches bounce when they open and close. Use an external capacitor to filter the contact bounce. +5 V Switch Closed Limit Switch ” terminal enables counting Noise cause by bounce creates a false count Totalizer... Page 393 Chapter 8 Tutorial Multifunction Module Voltage (DAC) Output The HP 34907A module has two analog outputs capable of outputting calibrated voltages between 12 volts with 16 bits of resolution. Each DAC (Digital-to-Analog Converter) channel can be used as a programmable voltage source for analog input to other devices. Page 394 Chapter 8 Tutorial Multifunction Module DAC Errors The output of a DAC varies with temperature. If possible, you should operate the instrument at a stable temperature and as close as possible to the calibration temperature of the DAC for greater accuracy. The output of a DAC also exhibits two other types of errors: differential error and integral error. Relay Life and Preventative Maintenance Relay Life and Preventative Maintenance The HP 34970A Relay Maintenance System automatically counts the cycles on each relay in the instrument and stores the total count in non-volatile memory on each switch module. Use this feature to track relay failures and predict system maintenance requirements. Page 396 For most applications, a relay with contact resistance greater than 1 should be replaced. The graph below shows the typical contact resistance characteristics of the relays used on the HP 34970A switching modules. Typical Relay Lifetime Full Load... Page 397 This strategy decreases the risk of failure during actual use at the expense of replacing some relays that may have useful life remaining. Note: In both cases described above, you can use the HP 34970A Relay Maintenance System to track and even predict relay failures. AC Measurement and Operating Characteristics, on page 407 Measurement Rates and System Characteristics, on page 408 Module Specifications: HP 34901A, 34902A, 34908A, 34903A, 34904A, on page 409 HP 34905A, 34906A, on page 410 Typical AC Performance Graphs, on page 411... 500 nA 100.0000 M 500 nA || 10 M DC Current 10.00000 mA < 0.1 V burden 100.0000 mA < 0.6 V HP 34901A Only 1.000000 A < 2 V Temperature Best Range Accuracy Type Thermocouple 1100 C to 1820 C... 300 V on all ranges DC Current Shunt Resistance: 5 for 10 mA, 100 mA; 0.1 for 1A. Input Protection: 1.5A 250 V fuse on HP 34901A module Thermocouple Conversion: ITS-90 software compensation Reference Junction Type: Internal, Fixed, or External Open T/C Check: Selectable per channel. 40 Hz – 300 kHz True RMS 10.00000 mA 3 Hz – 5 Hz AC Current 5 Hz – 10 Hz HP 34901A Only 1.000000 A 10 Hz – 5 kHz 100.0000 mA 3 Hz – 5 Hz 5 Hz – 10 Hz 10 Hz –... (measures the ac component only) Shunt Resistance: 5 for 10 mA; 0.1 for 100 mA, 1A Input Protection: 1.5A 250 V fuse on HP 34901A module Measurement Noise Rejection AC CMRR: 70 dB Measurement Considerations (Frequency and Period) All frequency counters are susceptible to error when measuring low-voltage, low-frequency signals. 34902A Scanning Temperature 34902A Scanning ACV 34902A Scanning DCV/Ohms, alternate channels 34901A/34908A Scanning DCV INTO and OUT of Memory to HP-IB or RS-232 (INIT, FETCh) 34902A Scanning DCV 34902A Scanning DCV with Time stamp OUT of Memory to HP-IB Readings... Chapter 9 Specifications Module Specifications Module Specifications HP 34901A, 34902A, 34908A, 34903A, 34904A General Number of Channels Connects to Internal DMM Scanning Speed Open/Close Speed Maximum Input Voltage (dc, ac rms) Current (dc, ac rms) Power (W, VA) Isolation (ch-ch, ch-earth) Chapter 9 Specifications Module Specifications Module Specifications HP 34905A, 34906A RF Multiplexer General 34905A Number of Channels Dual 1x4 Open/Close Speed Maximum Input Voltage (dc, ac rms) Current (dc, ac rms) Power (W, VA) DC Characteristics Offset Voltage Initial Closed Channel R... Chapter 9 Specifications Typical AC Performance Graphs Typical AC Performance Graphs HP 34905A, 34906A Insertion Loss (50 VSWR (50 Crosstalk (50 Insertion Loss (75 Direct to Module Using provided adapter cables VSWR (75 Crosstalk (75... Computer Interfaces HP-IB: HP 82335B, 82340A/B/C, 82341A/B/C/D National Instruments AT-GPIB/TNT, PCI-GPIB LAN-to-HP-IB: HP E2050A (Windows 95 and NT only) RS-232 (Serial Port): PC COM 1 to 4 Performance Scan and Save to Disk: 100 ch/s, 2 strip charts displayed [1] Software provided on CD-ROM; includes utility to create... Chapter 9 Specifications Product and Module Dimensions Product and Module Dimensions 103.6 mm 254.4 mm 374.0 mm 88.5 mm 212.6 mm 348.3 mm Module 315.6 91.9 All dimensions are shown in millimeters. Chapter 9 Specifications To Calculate Total Measurement Error To Calculate Total Measurement Error Each specification includes correction factors which account for errors present due to operational limitations of the internal DMM . This section explains these errors and shows how to apply them to your measurements. Refer to “Interpreting Internal DMM Specifications,”... Page 410 Chapter 9 Specifications To Calculate Total Measurement Error Understanding the “ % of range ” Error The range error compensates for inaccuracies that result from the function and range you select. The range error contributes a constant error, expressed as a percent of range, independent of the input signal level. Chapter 9 Specifications Interpreting Internal DMM Specifications Interpreting Internal DMM Specifications This section is provided to give you a better understanding of the terminology used and will help you interpret the internal DMM ’s specifications. Number of Digits and Overrange The “number of digits”... Page 412 This means that you can achieve greater actual measurement precision for a specific accuracy specification number. The HP 34970A is designed and tested to meet performance better than mean 3 sigma of the published accuracy specifications. Page 413 Chapter 9 Specifications Interpreting Internal DMM Specifications 24-Hour Accuracy The 24-hour accuracy specification indicates the internal DMM ’s relative accuracy over its full measurement range for short time intervals and within a stable environment. Short-term accuracy is usually specified for a 24-hour period and for a 1 °C temperature range. 90-Day and 1-Year Accuracy These long-term accuracy specifications are valid for a 23 °C 5 °C... Chapter 9 Specifications Configuring for Highest Accuracy Measurements Configuring for Highest Accuracy Measurements The measurement configurations shown below assume that the internal is in its Factory Reset state. It is also assumed that manual ranging is enabled to ensure proper full scale range selection. DC Voltage, DC Current, and Resistance Measurements: Set the resolution to 6 digits (you can use the 6 digits slow mode for further noise reduction). Index If you have questions relating to the operation of the HP 34970A, call 1-800-452-4844 in the United States, or contact your nearest Hewlett-Packard Sales Office. ac voltage measurements Warnings HP 34901A, 165 HP 34902A, 167 HP 34903A, 169 HP 34904A, 171 HP 34908A, 176 “... Page 416 42, 133 CALC:AVER:MAX? command, 233 bits, vs. integration time, 103, 203 CALC:AVER:MIN:TIME? command, 233 block diagram CALC:AVER:MIN? command, 233 HP 34970A, 53 CALC:AVER:PTPeak? command, 234 internal DMM, 60 CALC:COMP:DATA command, 253 BNC cable kits CALC:COMP:MASK command, 254... Page 417 (Mx+B) RS-232, 5 debounce (totalizer), 396 cycles protection, 385 resistance, 399 RTD, 345 DAC output (HP 34907A) thermistor, 345 thermocouple, 345 continuous, 38, 86 data acquisition overview, 50 default value, 38, 86 data bits (RS-232) settings, 38, 86... 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