

HP 70138A MMS VECTOR VOLTMETER

Operating Manual

SERIAL NUMBERS

This manual applies directly to HP 70138A Vector Voltmeters with serial numbers prefixed 2914U.

NOTE

Use this manual only with instruments that have a "U" in their serial-number prefix.

First Edition

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SOUTH QUEENSFERRY, WEST LOTHIAN, SCOTLAND EH30 9TG

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SAFETY CONSIDERATIONS

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

The MMS product is a Safety Class 1 instrument provided with a protective earth terminal.

Before Applying Power

Verify that the MMS product is set to match the available line voltage and the correct fuse is installed.

Safety Earth Ground

An uninterruptable safety earth ground must be provided from the main power source to the product wiring terminals, power cord, or supplied power cord set.

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the MMS product) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that protection has been impaired, the MMS product must be made inoperative and secured against any unintended operation.

If the MMS product is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electrical shock, do not perform any servicing unless qualified to do so.

Adjustments described in this manual are performed with power supplied

to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc). Do not use repaired fuses or short circuited fuse holders.

Safety Symbols



Instruction manual symbol: The product will be marked with this symbol when it is necessary for the user to refer to the manual.



Indicates hazardous voltages.



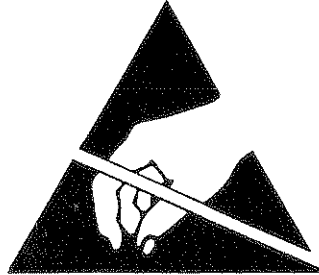
Indicates earth (ground) terminal.

WARNING

The **WARNING** sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a **WARNING** sign until the indicated conditions are fully understood and met.

CAUTION

The **CAUTION** sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a **CAUTION** sign until the indicated conditions are fully understood and met.



ATTENTION Static Sensitive Devices

This instrument was constructed in an ESD (electro-static discharge) protected environment. This is because most of the semi-conductor devices used in this instrument are susceptible to damage by static discharge.

Depending on the magnitude of the charge, device substrates can be punctured or destroyed by contact or mere proximity of a static charge. The results can cause degradation of device performance, early failure, or immediate destruction.

These charges are generated in numerous ways such as simple contact, separation of materials, and normal motions of persons working with static sensitive devices.

When handling or servicing equipment containing static sensitive devices, adequate precautions must be taken to prevent device damage or destruction.

Only those who are thoroughly familiar with industry accepted techniques for handling static sensitive devices should attempt to service circuitry with these devices.

In all instances, measures must be taken to prevent static charge build-up on work surfaces and persons handling the devices.



Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät/System

HP 70138A

in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

Zusatzinformation für Meß- und Testgeräte

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

Manufacturer's declaration

This is to certify that this product HP 70138A meets the radio frequency interference requirements of directive 1046/84. The German Bundespost has been notified that this equipment was put into circulation and was granted the right to check the product type for compliance with these requirements.

Note: If test and measurement equipment is operated with unshielded cables and/or used for measurement on open set-ups, the user must insure that under these operating conditions, the radio frequency interference limits are met at the border of his premises.

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GENERAL INFORMATION

INTRODUCTION

This manual will enable you to operate the HP 70138A Vector Voltmeter, as part of an HP 70000 Modular Measurement System. The information in this manual assumes that the HP 70138A is already installed in an MMS System and is operating correctly. For information on initial installation and the verification procedures, refer to the HP 70138A Installation and Verification Manual.

MANUAL ORGANIZATION

This manual contains the following three chapters:

Section 1, General Information, covers manual organization, front and rear panel features and new user introduction.

Section 2, Functions, covers the softkey trees and softkey descriptions.

Section 3, Measurements, contains basic and advanced measurements, information on remote operation, and the HP-IB command reference.

SAFETY CONSIDERATIONS

Before operating this module, familiarize yourself with any safety markings on the module and the safety instructions in this manual. This module has been manufactured and tested according to international safety standards. The cautions and warnings in this manual must be followed to ensure the safe operation of the module and protection of the personnel. Refer to the summary of safety considerations at the front of this manual.

MODULES COVERED BY MANUAL

The contents of this manual apply to HP 70138A modules with the serial number prefix(es) listed under "Serial Numbers" on the title page.

PRODUCT DESCRIPTION

Overview

The Hewlett-Packard Modular Measurement System (MMS) is a modular, automatic test system built around a mainframe and includes a variety of test instruments.

HP 70001A Mainframe

The HP 70001A MMS mainframe provides the structural environment for plug-in instrument modules along with cooling, power, and digital communication bus interface. It is compatible with 1/8, 2/8, 3/8, and 4/8 width modules and has a maximum capacity of eight one-section (1/8 width) modules. Rack compatibility is provided and benchtop use is facilitated with integral bails and optional handles.

Two digital buses are provided: HP-IB remote operation, and a high-performance bus called the Hewlett-Packard Modular System Interface Bus (HP-MSIB) for inter-module communication. The mainframe has good EMC performance (MIL-STD 461B) and has been designed to withstand the rigors of tough, industrial environments. The mainframe provides a solid, reliable base around which Modular Measurement Systems may be easily configured.

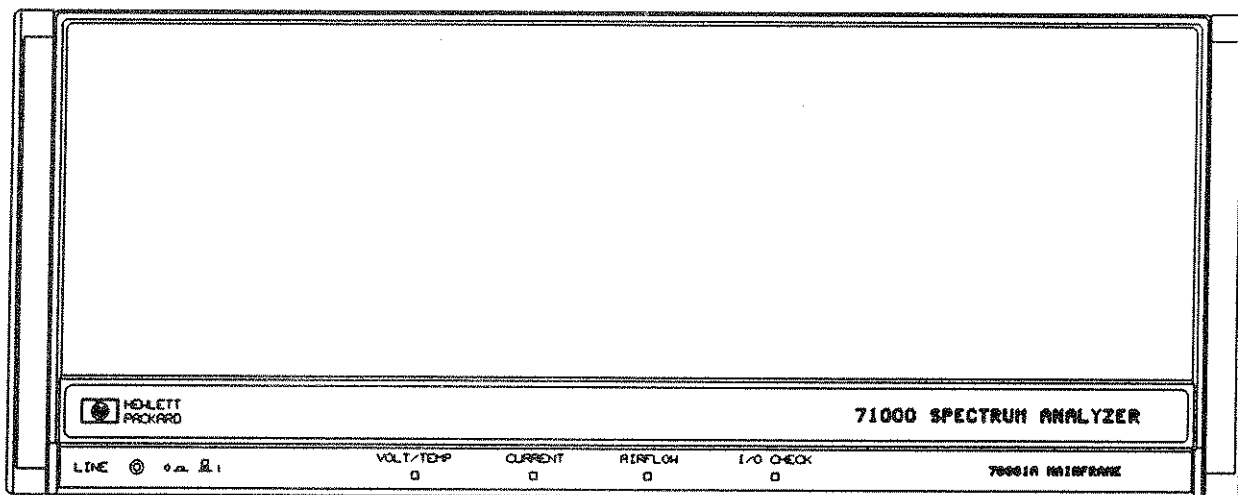


Figure 1-1. HP 70001A Mainframe

HP 70205A Graphics Display

The HP 70205A Graphics Display is a 3/8 width module which provides the human interface and manual control for the HP 70000 Modular Measurement System. The HP 70205A has a 5-inch CRT and can display modular instrument status and measured output and has graphics, trace, text, and marker capability. Controls include 14 user definable menu keys (softkeys), 10 data keys, 10 control keys (three of the keys are referred to as hardkeys in the text) and an analog control knob. Instrument control is accomplished by using the menu keys to establish an interactive front panel for the accessed instrument.

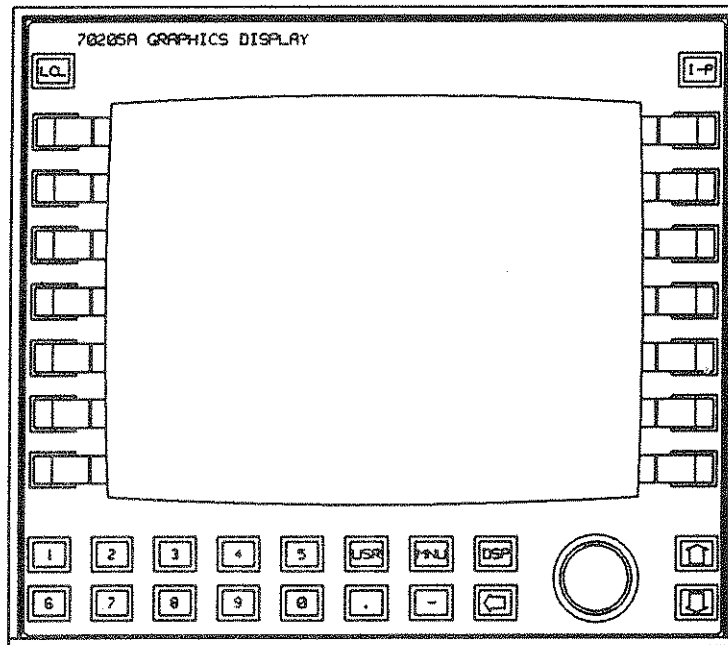


Figure 1-2. HP 70205A Graphics Display

HP 70206A System Graphics Display

The HP 70206A System Graphics Display is a “stand-alone” large-screen display for the HP 70000 Modular Measurement System. The HP 70206A uses a 9-inch raster CRT in a 7-inch, full rack frame and is stack compatible with the HP 70001A Mainframe. The HP 70206A supplies the same display and manual control capability as the HP 70205A Graphic Display. However, the hardkeys on the HP 70206A differ slightly from the hardkeys on the HP 70205A. For example, on the HP 70206A the “display hardkey” is denoted by **[DISPLAY]**, while on the HP 70205A the same hardkey is abbreviated to **[DSP]**. Although the key functions are identical, reference is made to both key labels in this manual.

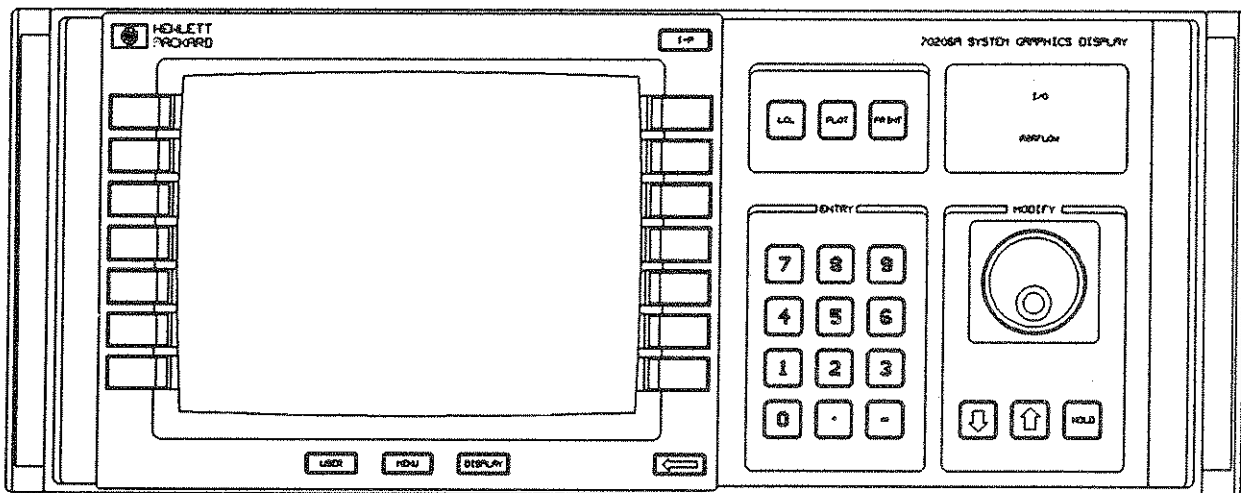


Figure 1-3. HP 70206A System Graphics Display

HP 70138A Vector Voltmeter

The HP 70138A Vector Voltmeter is a dual-channel, autoranging, receiver which measures the voltages of two CW signals and the phase difference between them. The following diagram shows the vector relationship between two signals at the same frequency and the way that one is used as a phase reference in the HP 70138A.

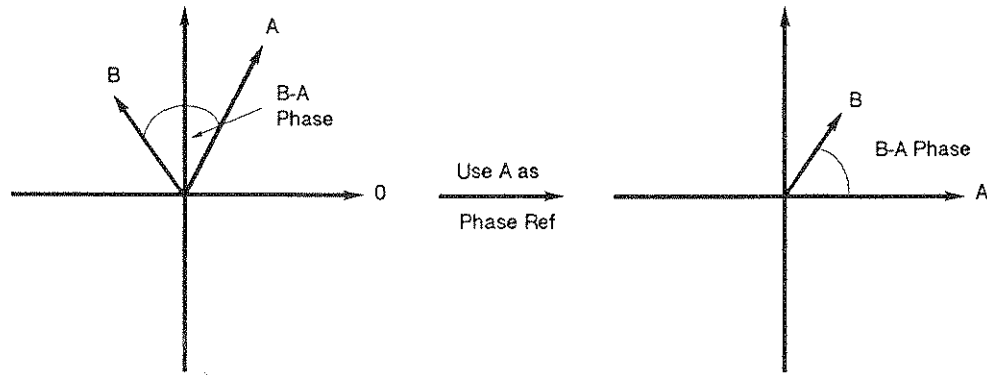


Figure 1-4. Vector Signals

The measurements can be of a single channel or the ratio between the two channels, and results can be displayed as voltage or power (in linear or log units), normalized magnitude and phase angle, or real and imaginary components. In addition the HP 70138A has built-in procedures for simple network analysis. The HP 70138A has two configurations - the first providing two high impedance probe inputs with a frequency range from 100kHz to 1GHz, and the second providing two 50ohm type-N connector inputs with a frequency range of 300kHz to 2GHz. The configuration can be changed by replacing the instrument's input module.

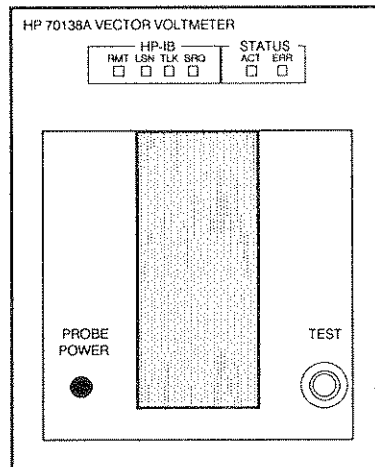


Figure 1-5. HP 70138A Vector Voltmeter

Applications

The HP 70138A is a component of the HP 70000 Modular Measurement System that can be used in any application where CW vector signal information is required - particularly in the design, manufacture or service of RF assemblies. The HP 70138A is a high-sensitivity receiver and can be used with any source, including an HP 70000 MMS system source, a tracking generator, or one that is part of the device to be tested.

Typical measurements include voltage, power, gain or loss, impedance and phase matching. Measurements can be made either from the input to the output of the device, or by probing within the device. Other measurements include transmission and reflection - procedures that include test system calibration against known standards.

Equipment Required

A typical setup includes a source (which may be part of the device to be tested), a reference path and a measurement path. Cables, adapters and other accessories required depend on the application. The following diagram shows an example setup.

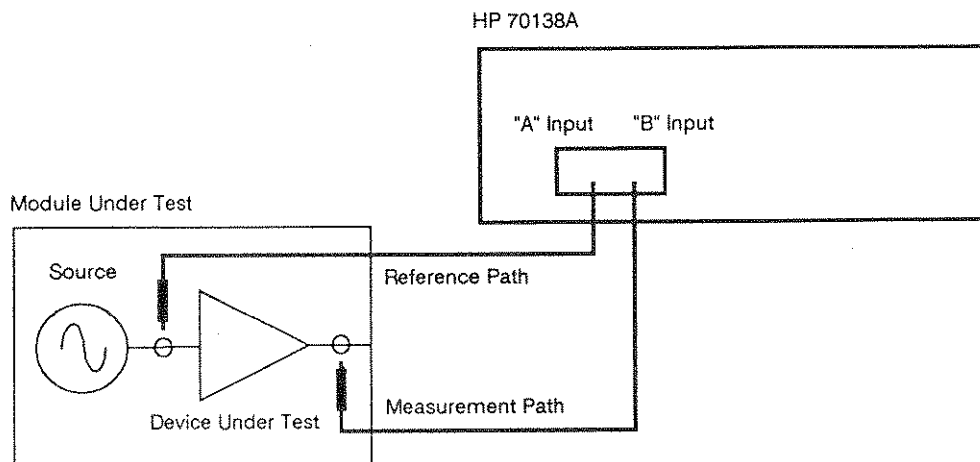


Figure 1-6. Typical Probing Set-up

In order for the source to be suitable for use with the HP 70138A, it has to meet certain specifications. It must produce a stable CW signal at the frequency of interest, with no modulation.

FRONT PANEL FEATURES

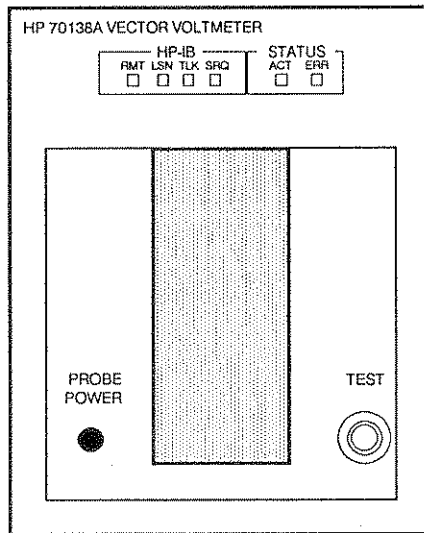


Figure 1-7. Front Panel

The front-panel LEDs indicate the status of the HP 70138A Vector Voltmeter. The front-panel LEDs should turn on and off while the HP 70138A Vector Voltmeter is doing its self-test (for example, at turn-on).

HP-IB Indicators

The following LEDs indicate the HP-IB status of the HP 70138A Vector Voltmeter. They indicate the types of activity that the HP 70138A Vector Voltmeter is engaged in and do not indicate an error condition.

RMT The RMT (remote) LED, when lit, indicates that the HP 70138A is being controlled remotely over the HP-IB. Otherwise, this LED will only be lit during self-test, when it is turned on and off to test the LED.

LSN The LSN (listen) LED, when lit, indicates that the HP 70138A is being controlled remotely over the HP-IB and is in a listen state. Otherwise, this LED will only be lit during self-test, when it is turned on and off to test the LED.

TLK The TLK (talk) LED, when lit, indicates that the HP 70138A is being controlled remotely over the HP-IB and is in a talk state. Otherwise, this LED will only be lit during self-test, when it is turned on and off to test the LED.

SRQ The HP 70138A can be set by the user to request service from its HP-IB controller when certain conditions occur (for example, an error condition, or completion of any operation). The SRQ LED will light when these conditions occur. Otherwise, the LED will only be lit during self-test when it is turned on and off to test the LED.

STATUS Indicators

The following LEDs indicate the operational status of the HP 70138A Vector Voltmeter.

ACT The ACT (active) LED is on when the HP 70138A Vector Voltmeter is the instrument being controlled by the display keyboard (over the HP-MSIB). Otherwise, this LED will only be lit during self-test, when it is turned on and off to test the LED.

ERR This is the error LED. If this LED is lit at any time (other than during self-test, when it is turned on and off to test the LED), there is a problem with the HP 70138A Vector Voltmeter. The LED will go out when the error has been reported over the HP-MSIB or HP-IB and the error condition no longer exists. If this LED flashes at about a 1Hz rate, this indicates that the HP 70138A Vector Voltmeter cannot communicate on the HP-MSIB. NOTE: For hardware and internal errors, the ERR LED will remain lit until a power cycle or restart, no matter how many times the error is reported. This is because the source of the error still exists.

PROBE POWER This output provides +12V and -12V supplies, which is sufficient to drive an HP 85024A High Frequency Probe.

TEST This output provides a signal at approximately 1.6MHz and 100mV to allow the user to check that the HP 70138A Vector Voltmeter is operating. The signal is controlled by the [Misc] [TEST ON OFF] function. The LED beside the connector is on when the test output is enabled.

REAR PANEL FEATURES

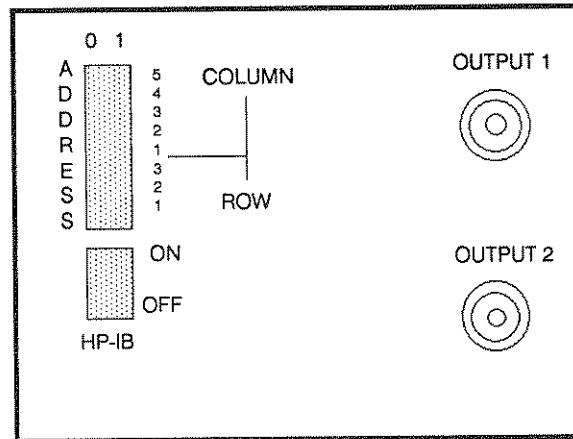


Figure 1-8. Rear Panel

The Rear Panel Outputs provide dc signals which can be fed to external measuring equipment. There are two distinct modes of operation for these outputs.

Normal Mode

This mode provides an analog representation of the digital display values, including internal instrument correction factors. OUTPUT 1 corresponds to DISPLAY 1 and OUTPUT 2 corresponds to DISPLAY2. The update rate is the same as the display update rate (approximately 3 readings per second). The sensitivity is 1mV per displayed digit.

A display value of 123.4mV will produce a d.c. output of 1234mV.

A display value of -135.7 degrees will produce a dc output of -1357mV.

If the MAG RANGE key is used to change the display resolution, the rear panel outputs will change with the display values.

A typical use of this mode might be to drive a chart recorder or similar logging instrument.

Direct Analog Output Mode

This mode provides continuous direct output signals from the internal magnitude and phase detectors through 800Hz low-pass filters. Only limited internal instrument correction factors are applied to the output signals. OUTPUT 1 corresponds to either A or B magnitude (in mV) whichever is selected on the front panel. OUTPUT 2 corresponds to B-A phase. The full scale deflection (FSD) chosen on the front panel always produces an output of 1 volt and this defines the OUTPUT 1 sensitivity.

A display FSD of 1000mV will produce an output of 1000mV for an input of 1000mV.

A display FSD of 31.6mV will produce an output of 1000mV for an input of 31.6mV.

The OUTPUT 2 sensitivity is fixed at 1mV per 0.1 degrees.

A typical use of this mode might be to make narrowband swept measurements on crystals.

HP-MSIB CONNECTOR

This connector is the only means of communication between the HP 70138A Vector Voltmeter and the HP 70001A Mainframe. This interface carries all HP-MSIB and HP-IB signals to and from the module.

HP-IB ON/OFF

With this switch set to OFF, the HP 70138A HP-IB is switched off and it uses only the HP-MSIB for communication. The HP 70138A will not respond over the HP-IB with this switch set to OFF.

ADDRESS SWITCH

The address switches are a group of two-position toggle switches. Each can be set to either 1 or a 0. The factory setting HP-MSIB address for the HP 70138A is row 0, column 8.

NEW USER INTRODUCTION

WARNING

Before the MMS System is switched on, all protective earth terminals, extension cords, autotransformers and devices connected to the system mainframe should be connected to a protective earth grounded socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

For continued protection against fire hazard, replace the line fuse with only a 250V fuse of the same rating. Do not use repaired fuses or short-circuit fuse holders.

CAUTION

Before the MMS System is switched on, it must be set to the same line voltage as the power source or damage to the instrument may result.

OPERATOR'S MAINTENANCE

You can perform an automatic self-test and calibration sequence by pressing [Misc] [CAL]. All other maintenance should be referred to qualified service personnel.

Don't destroy your input probes!

The probes of the HP 85081A Input Module are susceptible to damage from electro-static discharge (ESD). Comply with the following precautions to help avoid damage to your probes.

Anti-static precautions

Never touch the tip of the probe.

Eliminate ESD on the body by wearing a snug-fitting ground strap that is connected to earth ground through a 1M ohm resistor.

Eliminate ESD on the work surface by using a grounded anti-static bench mat. Optional floor mats provide an extra measure of protection especially in areas with floor carpet. Never use this product on a carpeted work surface unless the carpet is of a conductive type specifically designed to eliminate ESD.

Do not introduce ESD into the Device Under Test (DUT) while using the probes. If an unprotected person touches a part of the DUT, a static surge could damage the DUT as well as the probes.

Always refit the protective cover when the probe is not in use.

Mechanical abuse

The tips of the probes are fragile and can break if the probe is dropped.

FUNCTIONS

INTRODUCTION

This section gives you a reminder of the MMS graphics display keys and softkeys. However, the prime function of this section is to describe the HP 70138A Vector Voltmeter softkey functions and their inter-relationships.

GRAPHICS DISPLAYS

Most MMS Systems contain one of two displays: the HP 70205A Graphics Display which plugs into the mainframe, or the HP 70206A System Graphics Display which is a large screen stand-alone display.

Graphics displays serve three purposes:

1. In their “display” function, they show information (such as traces, or results) from the different instruments in the system. In this function, they can display the information from several instruments simultaneously on a single screen and update this information in real-time.
2. In their “control” function, they can control the settings and actions of any one instrument in the system at a time.
3. In their “utility” function, they provide aids such as system level error reporting, system level address analysis, and direct printer and plotter output.

The active instrument being displayed is the element currently selected using the “select instrument” or “assign keyboard” function.

HP 70205A Graphics Display

The HP 70205A has 14 softkeys (7 located on each side of the CRT display). These softkeys are used to control the active instrument. Three hardkeys ([USR], [MNU], and [DSP]), located underneath the CRT, control the softkey menu displayed.

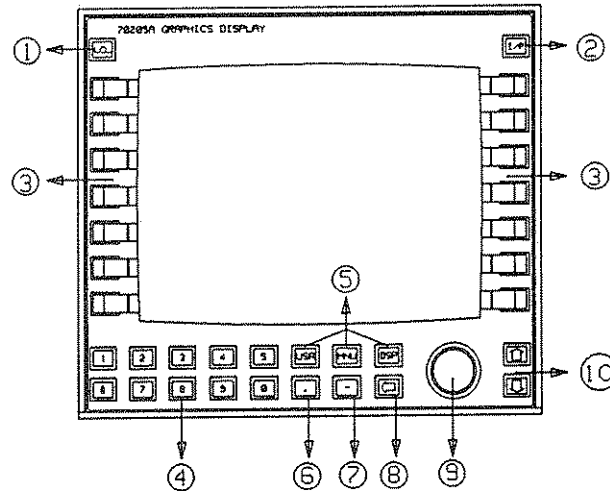


Figure 2-1. HP 70205A Graphics Display

1. [LCL] This is the Local Control key. Pressing this key returns the instrument to local control from remote control, if it is not in local lockout.
2. [I/P] This is the Instrument Preset key. Pressing this key activates the preset conditions of the active instrument.
3. Softkeys. These keys allow access to the instrument functions.
4. Numeric Keypad. Used for entering numeric values.
5. Hardkeys. These three keys ([USR], [MNU], and [DSP]) activate the top-level commands which appear on the screen next to the softkeys.
6. [.] The decimal point is used to enter a decimal point when using the numeric keypad.
7. [-] The minus sign is used for entering negative numbers.
8. [<] The back arrow (back space) key is used to go from a low level of softkeys to the next higher level of softkeys. Continually pressing this key will take you up through the softkey tree to the primary level. Pressing this softkey also deletes digits when numbers are being entered.
9. Display knob. This is used for changing parameter values, selecting alpha characters, and for accessing the diagnostic test.
10. [^], [v] The step keys are used for changing parameters up or down respectively.

HP 70206A System Graphics Display

The HP 70206A has 14 softkeys (7 located on each side of the CRT display). Three hardkeys ([**USER**], [**MENU**], and [**DISPLAY**]) are located underneath the CRT.

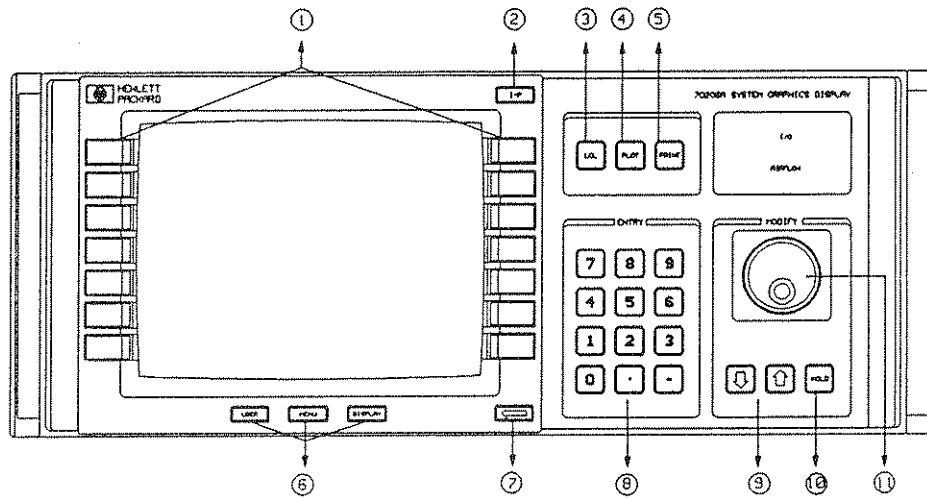


Figure 2-2. HP 70206A System Graphics Display

1. Softkeys. These keys allow access to the instrument functions.
2. [**I/P**] This is the Instrument Preset key. Pressing this key activates the preset conditions of the active instrument.
3. [**LCL**] This is the Local Control key. Pressing this key returns the instrument to local control from remote control, if it is not in local lockout.
4. [**PLOT**] This key causes the HP 70206A to plot (on an external plotter), what is displayed on the screen.
5. [**PRINT**] This key causes the HP 70206A to print (on an external printer), what is displayed on the screen.
6. Hardkeys. These three keys ([**USER**], [**MENU**], and [**DISPLAY**]) activate the top-level commands which appear on the screen next to the softkeys.
7. [**<**] The back arrow (back space) key is used to go from a low level of softkeys to the next higher level of softkeys. Continually pressing this key will take you up through the softkey tree to the primary level. Pressing this softkey also deletes digits when numbers are being entered.
8. Numeric Keypad. Used for entering numeric values.
9. [**^**], [**v**] The step keys are used for changing parameters up or down respectively.
10. [**HOLD**] This key deactivates the function displayed in the active function area and the readout is blanked from the screen.
11. Display knob. This is used for changing parameter values, selecting alpha characters, and for accessing the diagnostic test.

MAINFRAME

HP 70001A Mainframe

The HP 70001A Mainframe is the structure into which the modules are placed. The mainframe provides power, cooling and EMC protection for all of its modules. In addition, the mainframe manages all digital communications between modules. The mainframe has LEDs along the bottom edge of its front panel which indicate its status.

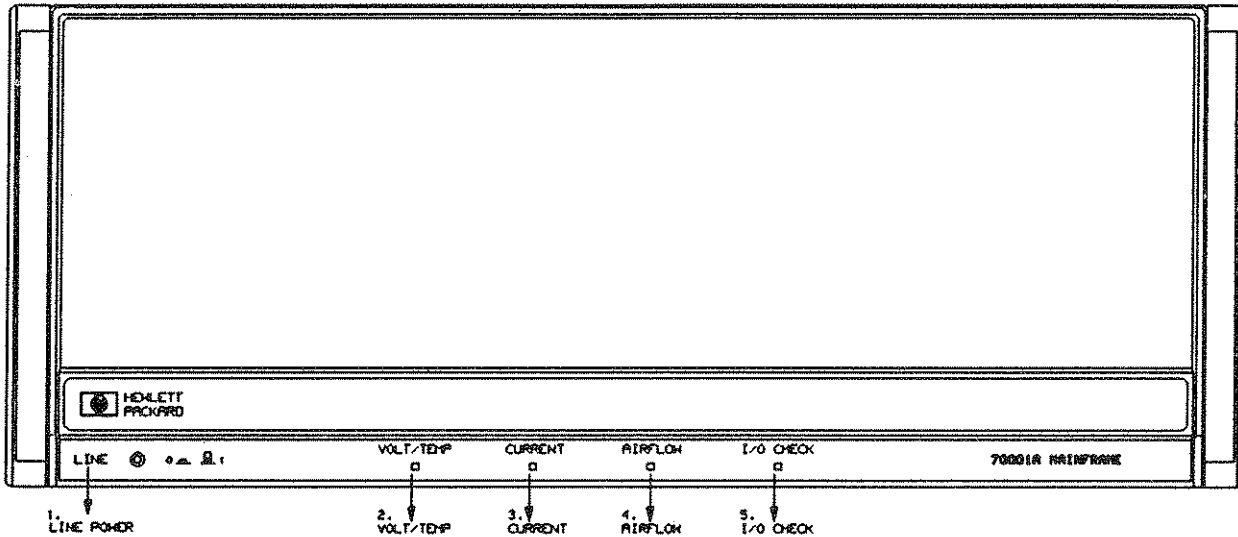


Figure 2-3. HP 70001A Mainframe

1. **LINE** This LED is lit when the power is on.
2. **VOLT/TEMP** This LED is lit if there is a voltage or temperature problem. (When this LED is lit, it indicates a potential system problem, refer to the System Support Manual.)
3. **CURRENT** This LED is lit if there is a power current problem. (When this LED is lit, it indicates a potential system problem, refer to the System Support Manual.)
4. **AIRFLOW** This LED is lit if there is an airflow problem.(Check that the air filter is clean. If this does not appear to be the problem, refer to the System Support Manual.)
5. **I/O CHECK** This LED is lit if there is a communication problem. (When this LED is lit, it indicates a potential system problem, refer to the System Support Manual.)

GRAPHICS DISPLAY MENU KEYS

All of the major functions of MMS instruments are accessed through softkeys. These softkeys are, in turn, accessed through hardkeys on the system display. The three hardkeys which access system level functions are **[USER]** (or **[USR]**), **[MENU]** (or **[MNU]**), and **[DISPLAY]** (or **[DSP]**). The **[USER]** and **[MENU]** keys access the functions of the vector voltmeter.

When the MMS system is powered-up, the **[USER]** set of softkeys for the active instrument appears on the CRT display.

The **[DISPLAY]** (or **[DSP]**) key accesses the entire Display Main Menu, which enables all the display functions of the HP 70205A and HP 70206A Displays. For more information on these menus, refer to either the HP 70205A or HP 70206A documentation.

The **[MENU]** (or **[MNU]**) key accesses the top level softkeys for the active instrument.

Note

The **[I/P]** (instrument preset) key on the display front panel may be used at any time, when the active instrument is not remote, to return the active instrument to a power-on state where all operating parameters are reset.

In addition, the HP 70138A uses the **[MENU]**, **[USER]** and **[<]** keys differently from other MMS modules.

The **[MENU]** key displays the top level menu of the instrument. It does not change any settings and does not preselect any menu.

The **[USER]** key displays the top level menu of the instrument (same as the **[MENU]** key). However, the **[USER]** key does preselect the **[Mag/Ph Measure]** menu. This means that the settings may change in the same way as if the **[Mag/Ph Measure]** softkey had been pressed. The magnitude/phase measurements selected will be displayed on the screen (if the HP 70138A is not in the direct analog mode).

The **[<]** (backspace) key enables you to backtrack to the previous menu. For example, if you press **[Format Functn]**, **[Misc]**, **[Reflect Measure]**, **[Mag/Ph Measure]** and press **[<]** you will highlight each of the keys in the reverse order. This is also true of the sub-menus and the multi-page menus on the right-hand softkeys.

SOFT KEY TREE

To get the Vector Voltmeter to operate, it must be properly configured and installed prior to performing any manual operations. Refer to the Installation and Verification section of this manual for correct installation and configuration instructions for the Vector Voltmeter. Use the following procedure to prepare the Vector Voltmeter for operation.

1. Press the **[DISPLAY]** (or **[DSP]**) key on the display front panel to access the Display Main Menu.
2. Press the **[SELECT INSTR]** softkey until the HP 70138A Vector Voltmeter is selected as the active module.
3. Press the **[MENU]** (or **[MNU]**) key to display the Main Menu of the Vector Voltmeter.

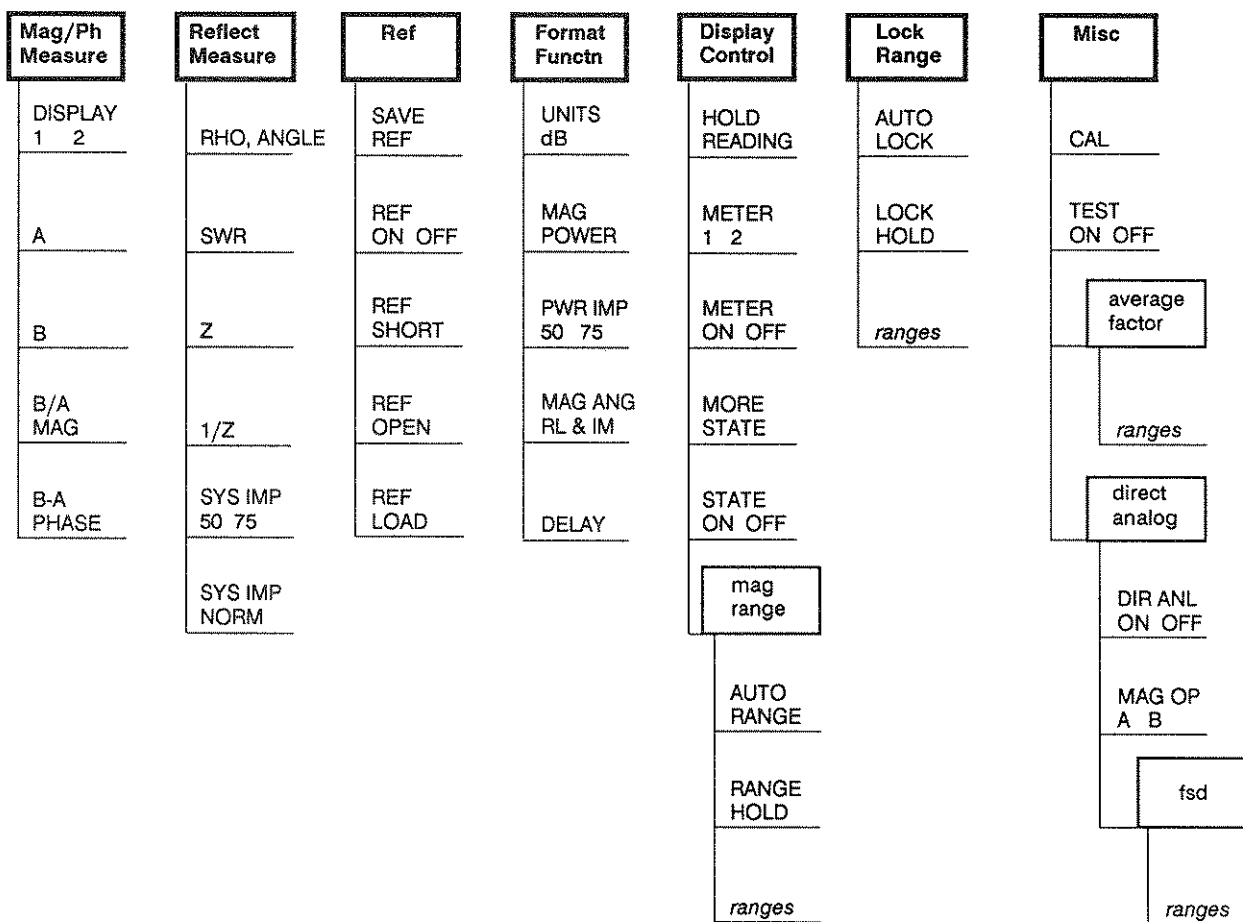


Figure 2-4. Softkey Tree

DISPLAY KEYS

The HP 70138A Vector Voltmeter Main Menu is shown in Figure 2-5. The Main Menu consists of firmkeys and softkeys. The firmkeys are on the left side of the display and the functions associated with these keys does not change when a menu selection is made. The softkeys are on the right side of the display. The functions associated with the softkeys will change depending upon which firmkey or softkey is pressed.

The firmkeys have the following annotation: (for example, [Misc]). The initial letter of the key title is shown in upper-case and the remainder of the title is shown in lower-case.

The softkeys have the following annotations: (for example [RANGE HOLD] or [mag range]). There are two types of softkey - action or navigational.

The action softkeys have all upper-case labels (for example [RANGE HOLD]). These keys have no sub-levels associated with them. Action keys can be of several types: single-key, direct action keys; single-key, two-way toggle action keys; or multi-key, multi-toggle action keys. Underlining of the softkey label (or a portion of the softkey label) denotes which function is currently selected. Action keys are valid depending upon the state of the instrument. If they are valid, pressing them will change the instrument state. If they are not valid, they will be inoperative if pressed.

The navigational softkeys enable you to enter other levels. These softkeys have all lower-case labels (for example [mag range]). These keys have sub-levels associated with them. Sub-menus sometimes consist of more than seven softkeys. In those cases, several pages of softkeys are used. The bottom softkey on such a page will have the annotation [more n of m] where "n" is the current softkey page number and "m" is the maximum softkey page number.

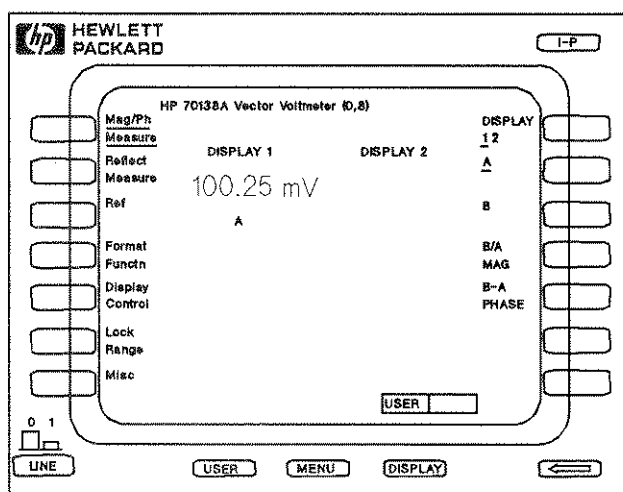


Figure 2-5. Vector Voltmeter Main Menu

When a firmkey is selected, the label for that key will flash in inverse video and the label will be underlined. When a softkey is selected, and its function is performed immediately, the label for that key will flash in inverse video while the function is executing. Because most functions execute so quickly, a minimum length 'flash' has been incorporated to enable you to see what is happening. However, for functions that take longer to execute (for example the calibration function), the length of 'flash' depends on the execution time of that function. If a softkey is selected that requires data to be entered, the label for that softkey will be displayed in inverse video.

FIRMKEY DESCRIPTIONS

The HP 70138A Vector Voltmeter has seven main menus which are displayed on the seven firmkeys on the left side of the display. These menus are:

[Mag/Ph Measure]

Pressing this firmkey sets the instrument into displaying the basic magnitude and phase measurements. It also provides the basic magnitude and phase measurement selection. However, measurements will only be displayed if the instrument is not in direct analog mode. There are five softkeys associated with this firmkey. These softkeys are: [DISPLAY 1 2], [A], [B], [B/A MAG], and [B-A PHASE].

[Reflect Measure]

Pressing this firmkey sets the instrument into displaying the reflection function measurements. It also provides the reflection function measurements and impedance selection. However, measurements will only be displayed if the instrument is not in direct analog mode. There are six softkeys associated with this firmkey. These softkeys are: [RHO, ANGLE], [SWR], [Z], [1/Z], [SYS IMP 50ohm 75ohm], and [SYS IMP NORM].

[Ref]

Pressing this firmkey provides the reference functions. There are five softkeys associated with this firmkey. These softkeys are: [SAVE REF], [REF ON OFF], [REF SHORT], [REF OPEN], and [REF LOAD].

[Format Functn]

Pressing this firmkey provides the functions which change the representation of the measurements. There are five softkeys associated with this firmkey. These softkeys are: [UNITS dB], [MAG POWER], [PWR IMP 50ohm 75ohm], [MAG ANG RL & IM], and [DELAY].

[Display Control]

Pressing this firmkey provides the functions to control the display format. There are 12 softkeys associated with this firmkey. These softkeys are contained in two menus. In the top-level menu, the softkeys are: [HOLD READING], [METER 1 2], [METER ON OFF], [MORE STATE], [STATE ON OFF], and [mag range]. In the second-level menu, the softkeys (accessed through the [mag range] softkey) are: [AUTO RANGE], [RANGE HOLD], [.001], [.01], [.1], and [1].

[Lock Range]

Pressing this firmkey provides the functions associated with lock ranging. There are 20 softkeys associated with this firmkey. These softkeys are contained in three menus. In the top-level menu, the softkeys are: [AUTO LOCK], [LOCK HOLD], [0.1 - 0.2MHz], [0.2 - 0.6MHz], [0.6 - 1.0MHz], [1.0 - 3.0 MHz], and [more 1 of 3]. In the second-level menu, the softkeys (accessed through the [more 1 of 3] softkey), select frequencies in the range 3 to 80MHz. In the third-level menu, the softkeys (accessed through the [more 2 of 3] softkey) select frequencies in the range 80MHz to 2GHz.

[Misc]

This firmkey covers all other functions which do not fit into the previous categories. There are 27 softkeys associated with this firmkey. These softkeys are contained in five menus. In the top-level menu, the softkeys are: [CAL], [TEST ON OFF], [average factor], and [direct analog]. In the second-level menu, the softkeys (accessed through the [average factor] softkey) select averaging factors from 1 to 32. In the third-level menu, the softkeys (accessed through the [average factor], [more 1 of 2] softkeys) select averaging factors of 64 to 1024. In the fourth-level menu, the softkeys (accessed through the [direct analog] softkey) are: [DIR ANL ON OFF], [MAG OP A B], and [fsd]. In the fifth-level menu, the softkeys (accessed through the [direct analog], [fsd] softkeys) select full-scale deflections from 1000mV to 1.00mV.

SOFTKEY DESCRIPTIONS

[Mag/Ph Measure] MENU

[DISPLAY 1 2]

This softkey selects which of the displays, (DISPLAY 1 or DISPLAY 2) shown in the window, will be used to exhibit the results of the measurements selected by the other softkeys. Use this softkey in conjunction with the measurement keys below to define which measurement will be displayed in the selected display.

[A]

Measures the amplitude of the A channel. This softkey is part of a four-way toggle with [B], [B/A MAG] and [B-A PHASE]. Selecting this softkey will deselect the other three. The default display is in mV on Display 1. Power can be displayed by pressing [Format Functn] and [MAG POWER] and selecting either 50ohm or 75ohm impedance with [Format Functn] and [PWR IMP 50ohm 75ohm]. Power will be displayed in Watts or dBm, depending on the setting of [Format Functn] [UNITS dB]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed.

[B]

Measures the amplitude of the B channel. This softkey is part of a four-way toggle with [A], [B/A MAG] and [B-A PHASE]. Selecting this softkey will deselect the other three. The default display is in mV. Power can be displayed by pressing [Format Functn] and [MAG POWER] and selecting either 50ohm or 75ohm impedance with [Format Functn] and [PWR IMP 50ohm 75ohm]. Power will be displayed in Watts or dBm, depending on the setting of [Format Functn] [UNITS dB]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed.

[B/A MAG]

Measures the B/A ratio. This softkey is part of a four-way toggle with [A], [B] and [B-A PHASE]. Selecting this softkey will deselect the other three. The default display is in linear units, changeable to dB using [Format Function], [UNITS dB]. When magnitude ratio and angle are displayed together on displays 1 and 2, the format mat be changed to real and imaginary using [Format Functn] [MAG ANG RL & IM]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed.

[B-A PHASE]

Measures the phase of B with respect to A, in degrees. This softkey is part of a four-way toggle with [A], [B] and [B/A MAG]. Selecting this softkey will deselect the other three. When magnitude ratio and angle are displayed together on displays 1 and 2, the format mat be changed to real and imaginary using [Format Functn] [MAG ANG RL & IM]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed.

[Reflect Measure] MENU

[RHO, ANGLE]

Pressing this softkey displays the reflection coefficient measurement (rho in DISPLAY 1 and angle in DISPLAY 2). The default is to display rho in Units. You can change rho to Return Loss (in dB) by pressing [Format Functn] and [UNITS dB]. This softkey is part of a four-way toggle with [SWR], [Z] and [1/Z]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed. Also, pressing [Format Functn], [MAG ANG RL & IM] will change the format.

[SWR]

Pressing this softkey displays the standing wave ratio measurement. The SWR measurement is shown as a single display. This softkey is part of a four-way toggle with [RHO, ANGLE], [Z] and [1/Z]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed.

[Z]

Pressing this softkey displays the impedance measurement (imaginary is shown in DISPLAY 1 and real is shown in DISPLAY 2 as the default). This softkey is part of a four-way toggle with [RHO, ANGLE], [SWR] and [1/Z]. Choose the impedance (50ohm/75ohm/NORM) to match your measurement needs. The impedance is chosen using the [SYS IMP 50ohm 75ohm] and [SYS IMP NORM] softkeys. This softkey is part of a four-way toggle with [RHO, ANGLE], [SWR] and [1/Z]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed. Also, pressing [Format Functn], [MAG ANG RL & IM] will change the format

[1/Z]

Pressing this softkey displays the admittance measurement. Choose the impedance (50ohm/75ohm/NORM) to match your measurement needs. The impedance is chosen using the [SYS IMP 50ohm 75ohm] and [SYS IMP NORM] softkeys. This softkey is part of a four-way toggle with [RHO, ANGLE], [SWR] and [Z]. NOTE: If this key is already selected, pressing this key again will deselect the function and no measurement will be displayed. Also, pressing [Format Functn], [MAG ANG RL & IM] will change the format.

[SYS IMP 50ohm 75ohm]

This softkey selects which impedance (50ohm or 75ohm) will be selected. An underscore beneath the number indicates which impedance has been selected. This softkey is part of a three-way selection with [SYS IMP NORM].

[SYS IMP NORM]

Pressing this softkey normalizes the measurements to Z0. This softkey is part of a three-way selection with [SYS IMP 50ohm 75ohm].

[Ref] MENU

[SAVE REF]

Pressing this softkey will save the currently measured magnitude and phase results as the reference. Also, it will select the ON state of the [REF ON OFF] softkey.

[REF ON OFF]

Used to make measurements relative to a set of reference values. Pressing [Ref] and [REF ON OFF] will activate (or deactivate) the facility. An underscore (beneath the ON or OFF) defines its state. The state can be toggled on and off without changing the stored reference values. When [REF ON] is active:

displayed phase = measured phase - saved phase

amplitude or magnitude =
$$\frac{\text{measured amp. or mag.}}{\text{saved amp. or mag.}}$$

[REF SHORT]

This softkey is part of a three-way toggle with [REF OPEN] and [REF LOAD]. Pressing this softkey selects a short circuit as the reference impedance for reflection measurements. To initialize the measurement, connect the external equipment and connect this reference impedance to the test port. This would normally be used in conjunction with a bridge or directional coupler.

[REF OPEN]

This softkey is part of a three-way toggle with [REF SHORT] and [REF LOAD]. Pressing this softkey selects an open circuit as the reference impedance for reflection measurements. To initialize the measurement, connect the external equipment and connect this reference impedance to the test port. This would normally be used in conjunction with a bridge or directional coupler.

[REF LOAD]

This softkey is part of a three-way toggle with [REF SHORT] and [REF LOAD]. Pressing this softkey selects a Z0 termination as the reference impedance for reflection measurements. To initialize the measurement, connect the external equipment and connect this reference impedance to the test port. This would normally be used in conjunction with the tee method of reflection measurements.

[Format Functn] MENU

[UNITS dB]

This softkey toggles between linear and logarithmic results.

[MAG POWER]

This softkey toggles between the magnitude and power representation of the A and B magnitudes. Valid only for absolute measurements.

[PWR IMP 50ohm 75ohm]

This softkey selects which impedance (50ohm or 75ohm) will be selected when calculating a power result. An underscore beneath the number indicates which impedance has been selected.

[MAG ANG RL & IM]

This softkey toggles between polar and cartesian representation. It is valid only for vector ratio measurements.

[DELAY]

Pressing this softkey replaces the current measurement display with a psuedo group delay function. As this softkey is a toggle, it can be pressed again to return to the previous measurement display. Also, pressing [Mag/Ph Measure] or [Reflect Measure] deselects delay and selects the appropriate measurement.

[Display Control] MENU

[HOLD READING]

Pressing this softkey ensures that the numeric displays on the CRT are retained when the instrument loses lock, or when the signal drops through a built-in threshold. A display annunciator flashes "HOLD" when the displays are being retained. If only the A voltage/power is displayed, this function is associated with channel A. Otherwise this function is associated with channel B.

[METER 1 2]

If the meter is not currently being displayed, pressing this softkey will turn the meter on and be associated with the last selected reading. If the meter is already on, pressing this softkey will toggle the meter to the other display (for example, DISPLAY 1 to DISPLAY 2). NOTE: This is only valid when both displays are shown on the screen. Also, if there is not enough room on the display (for example, a small window) the meter display has priority and will remove measurement displays from the screen.

[METER ON OFF]

This is a two-way toggle. Pressing this softkey will toggle the meter between being displayed and not being displayed. Pressing this softkey does not affect which display is selected. NOTE: If there is not enough room on the display (for example, a small window) the meter display has priority and will remove measurement displays from the screen.

[MORE STATE]

This is a two function softkey. If the state information display is currently switched off, pressing this softkey will activate the state display. If the state information is currently being displayed, pressing this softkey will activate the next page of information (if there is more information). NOTE: If there is not enough room on the display (for example, a small window) the state display has priority and will remove the meter and measurement displays from the screen.

[STATE ON OFF]

This softkey has a toggle action between switching the state information display off (removing it from the CRT), and switching the state information display on (displaying the last selected page of information). The state information enables the user to view the set-up of the instrument. The information displayed depends on any other information currently being displayed and the size of the display window associated with the HP 70138A. NOTE: If there is not enough room on the display (for example, a small window) the state display has priority and will remove the meter and measurement displays from the screen.

[mag range]

Pressing this softkey displays the magnitude range menu of softkeys.

[Display Control], [mag range] MENU

[AUTO RANGE]

Pressing this softkey selects automatic ranging. This softkey is part of a two-way toggle with [RANGE HOLD]. If any of the measurement range softkeys ([.001], [.01], [.1] and [1]), are pressed the [RANGE HOLD] function will be selected.

[RANGE HOLD]

Pressing this softkey will set the range to the current magnitude range of DISPLAY 1. This softkey is part of a two-way toggle with [AUTO RANGE]. The measurement range softkeys ([.001], [.01], [.1] and [1]), select the particular range for the displays.

[.001], [.01], [.1], [1]

These softkeys comprise a four-way toggle. Selecting a softkey, selects the particular range for the displays.

[Lock Range] MENU

[AUTO LOCK]

Pressing this softkey will select the automatic lock range. This softkey is a two-way toggle with [LOCK HOLD]. If any of the measurement range softkeys ([0.1 - 0.2MHz] to [1 - 2GHz]), are pressed the [LOCK HOLD] function will be selected.

[LOCK HOLD]

Pressing this softkey will select the manual lock range. The range selected will be the current range. This softkey is a two-way toggle with [AUTO LOCK]. When the manual lock range is selected, the lock range will remain fixed until the lock is deactivated or the range is manually changed.

[0.1 - 0.2MHz] to [1 - 2GHz]

These softkeys comprise a 15-way toggle with three menu ranges selected by [more] to go to the next range. Selecting a softkey selects the particular range for the lock range.

[Misc] MENU

[CAL]

Pressing this softkey causes the Vector Voltmeter to perform its power-on self-checks and an internal calibration cycle. If an error number is displayed or if the HP 70138A continues to display a 'TEST' message, refer to the Troubleshooting section of the Service Manual.

[TEST ON OFF]

Pressing this softkey will either enable or disable the front-panel TEST connector signal. The front-panel TEST connector LED will light if the output is enabled and will be extinguished if the output is disabled.

[average factor]

Pressing this softkey presents a selection of 11 possible averaging factors (from [1] to [1024]). Pressing one of the displayed keys will select that number of averages per measurement. The default number of averages per measurement is 32.

[direct analog]

Pressing this softkey selects the range of softkeys dedicated to the direct analog mode.

[Misc], [direct analog] MENU

[DIR ANL ON OFF]

This softkey toggles between either direct analog and normal measurement modes.

[MAG OP A B]

This softkey toggles between sending the A or B magnitudes to the rear panel OUTPUT 1 connector.

[fsd]

Pressing this softkey presents a selection of seven possible full-scale deflection values. Pressing one of the displayed keys will select that full-scale deflection value.

MAKING MEASUREMENTS

BASIC MEASUREMENTS

Introduction

There are two types of Input Module that can be used with the HP 70138A Vector Voltmeter mainframe. These Input Modules are the HP 85081A High Impedance Input Module and the HP 85082A 50 ohm Input Module.

The HP 85081A High Impedance Input Module has a frequency range from 100kHz to 1GHz. This Input Module has high-impedance probes which can be used either alone or with accessories to make in-circuit measurements. The following accessories are available: HP 11570A Accessory Kit (50 ohm accessories), HP 10216A Isolator (probing accessory), HP 11576A 10:1 Divider (probing accessory).

The HP 85082A 50 ohm Input Module has a frequency range from 300kHz to 2GHz. This Input Module has 50 ohm type-N connectors. Using the HP 85082A gives you a higher frequency range than the HP 85081A for measurements in a 50 ohm environment.

Getting acquainted with the Vector Voltmeter

To introduce you to the main functions of the HP 70138A, here are a few simple measurements you can try. You will learn to make single channel voltage and power measurements, and measure the vector ratio between two voltages.

Measurements with probes

For this section, the example measurements described are assumed to be made on a printed circuit board buffer amplifier. It is part of a 50MHz source assembly, and has a gain of approximately 14dB.

Probing at the input of the amplifier (the output of the oscillator) gives a reference signal and probing at the output of the amplifier will give the amplifier gain. The integral source is used as the stimulus, so the amplifier will be tested under normal operating conditions.

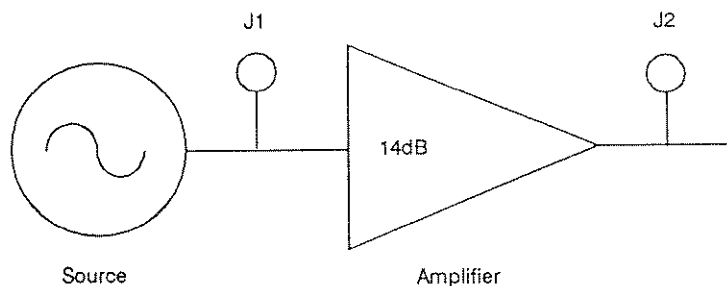


Figure 3-1. Test Assembly With Measurement Points

Since the circuit impedance is 50 ohms, and the measurements are at relatively low frequencies, we can neglect the loading effects of the probe tips on the circuit response. For more sensitive applications, the HP 11576A 10:1 Divider or HP 10216A Isolator accessories can be used with the probes to minimize loading effects and measurement errors.

Measurement details

1. Connect both probes at point "J1" (the amplifier input) in the circuit. Press [I-P] (when HP 70138A window is selected) to return the HP 70138A to a known starting state.
2. Check that the circuit under test is powered up. Press [B/A MAG] [DISPLAY 2], [B-A PHASE] to display vector ratio.
3. Select [Format Functn], [UNITS dB] to measure the amplifier's gain as a log ratio. Press [Ref], [SAVE REF] to store the reference and set the ratio displays to magnitude 0.0dB and phase 0 degrees.
4. Move the B probe to point "J2" (the amplifier output) and measure the gain and phase change. Change the frequency of the oscillator over its operating range and check the frequency response variation. In a circuit with adjustable gain, the HP 70138A [Display Control], [METER ON] display is an aid to tuning. (Use of the meter display is covered in the next example.)

Any unmodulated RF signal in the frequency range 100kHz to 1GHz can be used as a source for these measurements. This includes a source that is part of a larger device under test.

1. PRESET

Before beginning a new measurement, press [I-P] to return the HP 70138A to a known state. The following list shows the preset condition:

Function	
<i>Active Menu</i>	[Mag/Ph Measure]
<i>Power</i>	OFF
<i>Impedance</i>	50 ohms
<i>Format</i>	Mag, Angle
<i>Lock Range</i>	AUTO LOCK
<i>Mag Range</i>	AUTO RANGE
<i>Test Out</i>	OFF
<i>Average Factor</i>	32
<i>Dir Analog</i>	OFF
<i>Reference</i>	OFF

Displays	
<i>Display</i>	DISPLAY 1
<i>Measurement</i>	A
<i>UNITS/dB</i>	UNITS
<i>Meter</i>	DISPLAY 1
<i>METER ON OFF</i>	OFF
<i>HOLD READING</i>	OFF
<i>STATE DISPLAY</i>	OFF

2. UNLOCKED INDICATOR

Check that there is no input to the probes. With no input signal, the display A UNLOCKED will be flashing above DISPLAY 1 (the left display) which should indicate under-range (- - - -).

NOTE: If there are high level radiated signals present, DISPLAY 1 may give a reading. This reading is caused by the unterminated probe acting as an antenna. It will not affect the instrument's ability to make measurements on your circuit.

3. SINGLE-CHANNEL MEASUREMENT - CHANNEL A

The A probe is used as a reference by the HP 70138A, and must be connected for the instrument to function. The signal level should be in the range 300uV to 1V.

Connect the A probe to the source and turn on the output. The flashing display A UNLOCKED should go off and DISPLAY 1 should show the source output voltage.

4. VOLTAGE UNITS

Select [Format Functn], [UNITS dB] to have the HP 70138A compute and display the voltage in dbuV.

5. POWER MEASUREMENT

Press [Format Functn], [MAG POWER] to display power in dBm in a 50ohm system. The conversion of voltage to power uses the value set with the [SYS IMP 50ohm 75ohm] softkey, the default value being 50 ohms.

Press [Format Functn], [MAG POWER] again to return to the voltage measurement mode.

6. SINGLE-CHANNEL MEASUREMENT - B CHANNEL

Most measurements with the HP 70138A will be done using the B probe, leaving the A probe in place as a reference. The B channel is much more sensitive since the A channel already provides the signal to which the instrument is locked.

Press [Mag/Ph Measure], [DISPLAY 1 2] to select Display 2, then [B] to display the B input voltage in Display 2. (The A reading remains in Display 1 unless you turn it off by pressing [Mag/Ph Measure], [DISPLAY 1 2] to select Display 1, then [A]. The A probe must still be connected in order to keep the instrument locked.) Display 2 shows the B channel residual noise level of around 10uV when the probe is not connected.

7. DUAL-CHANNEL MEASUREMENT

The HP 70138A can display the ratio of the signals in its two channels, making it unnecessary to calculate the results of ratio measurements.

Connect the two probes to the source output using a tee, as shown in the following diagram.

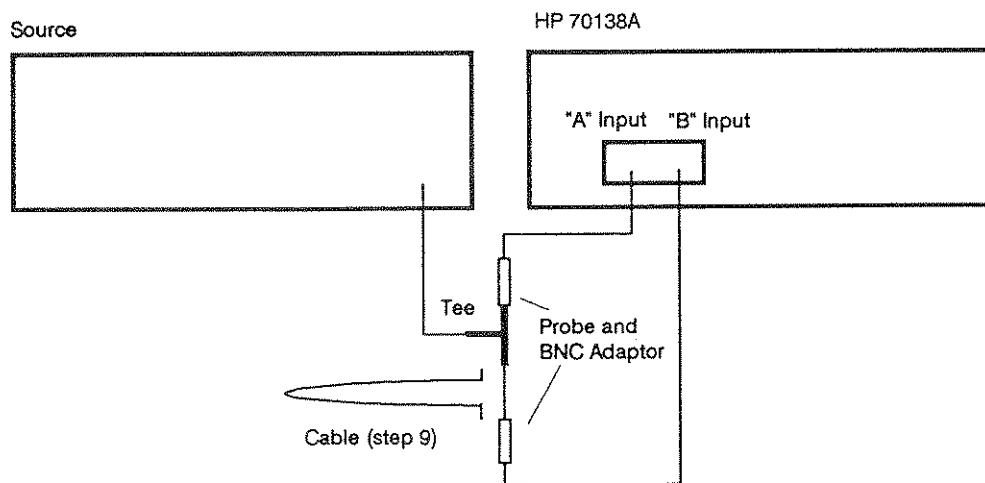


Figure 3-2. Two Probe Connection

Select [Format Functn], [UNITS dB] to display the levels as voltages. (The A and B voltages in Displays 1 and 2 respectively should read approximately the same value.) Press [Mag/Ph Measure], [DISPLAY 1 2] to select Display 1, then [B/A MAG] to show the voltage ratio of B to A in Display 1. The reading should be approximately 1.0. Press [Mag/Ph Measure], [DISPLAY 1 2] to select Display 2, then [B-A PHASE] to display the input phase difference in Display 2. The reading should be approximately 0 deg.

8. SET A REFERENCE

Press [Ref], [SAVE REF] to store the current measurement as a reference and normalize readings to the saved reference value. The displays should now read exactly 1.0 magnitude, and 0.0 deg phase.

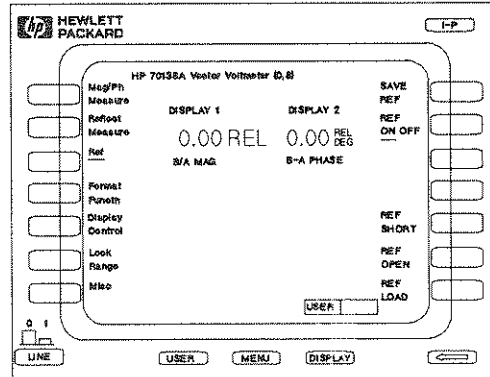


Figure 3-3. Displays

9. RELATIVE MEASUREMENT

Now insert the cable as shown in Figure 3-2. The readings are now of the voltage ratio and phase difference caused by the cable, using the reference set in step 8. Select [Format Functn], [UNITS dB] to read the cable insertion loss in dB. The phase difference can be used to calculate the cable's electrical length.

10. REAL AND IMAGINARY

Instead of magnitude and phase, you can show the measurement results as real and imaginary components. Select [Format Functn], [MAG AND RL & IM] to see results in this form.

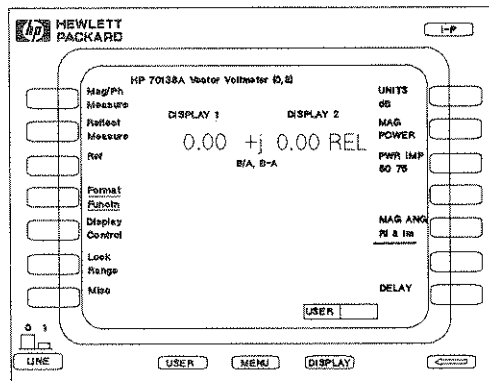


Figure 3-4. Displays

WHAT YOU HAVE ACHIEVED

You have made voltage measurements (A and B) and a vector ratio measurement (B/A MAG, B-A PHASE), and normalized the ratio to a reference.

ADVANCED MEASUREMENTS

This section will cover some simple network analysis measurements using the HP 70138A and a companion source. The source is assumed to be the HP 70300A Tracking Generator, however, any other suitable source may also be used. Transmission and reflection measurements will be covered to show how some of the features of the HP 70138A can be used to make your measurements easier.

The measurement examples will use 50 ohm devices - refer to the following section for details of configuring the HP 70138A for 50 ohm inputs.

Measurements in a 50 ohm system

50 ohm measurements can be made directly when the HP 70138A is fitted with the type-N HP 85028A Input Module, or by using adapters with the probes of the HP 85081A Input Module. The HP 11536A Feedthru Tee is part of the HP 11570A Accessory Kit. The following diagram shows how to connect the probe adapters to make 50 ohm measurements.



Figure 3-5. Probe to 50 ohm Options

In this example, you will measure the 3dB point of a low-pass filter that cuts off at around 50MHz. The circuit includes a source, and a power splitter which is used to obtain a reference signal. The filter is preceded by a 6dB pad to minimize out-of-band reflection problems.

Measurement details

1. Connect the equipment as shown below. Set the source frequency and level as required. On the HP 70138A, press [I-P] to get the instrument to a known state. Now press the [Mag/Ph Measure], [B] softkeys to measure the filter output as a voltage in Display 1.

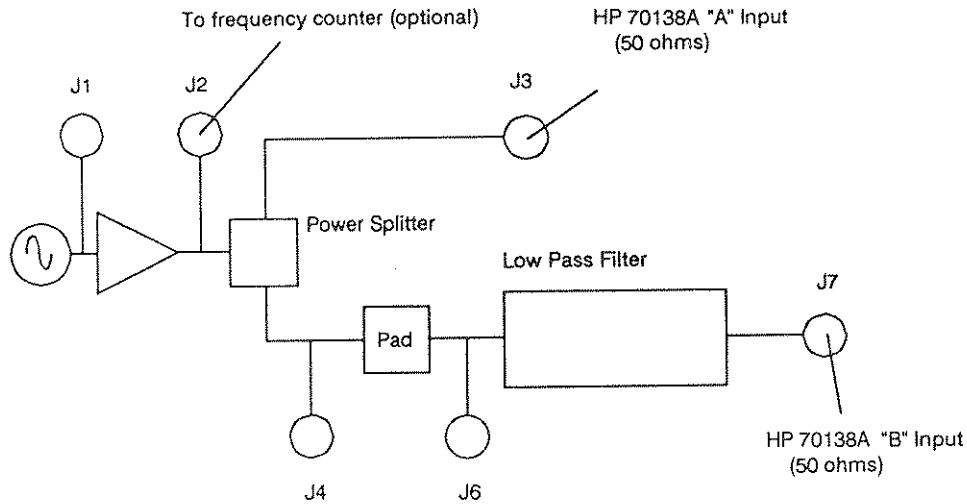


Figure 3-6. Test Setup

2. Press [Display Control], [METER 1 2] to activate the meter on Display 1, then tune the source frequency for a maximum to set the source in the filter passband. Tuning is achieved using the trend indicators (the 'up' and 'down' arrows). An increasing level is highlighted by the 'up' arrow being illuminated. A decreasing level is highlighted by the 'down' arrow being illuminated. A null is indicated by both symbols being extinguished.

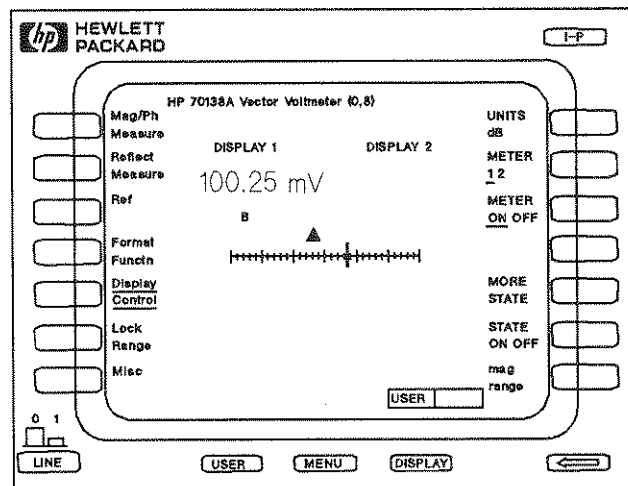


Figure 3-7. Meter Display

3. Press [Mag/Ph Measure], [B/A MAG] to measure the amplitude ratio, and select [Format Functn], [UNITS dB] to display a log ratio.
4. Press [Ref], [SAVE REF] to store the current reading, zero the magnitude reading and refer future measurements to the filter passband.
5. Now increase the source frequency until the display reads -3dB. Note the source frequency. This is the filter 3dB cutoff frequency.

a. Transmission

One good use of a CW receiver such as the HP 70138A is in the measurement of gain as a function of input level. The HP 70138A automatically displays B/A as a ratio, so effects caused by changing input level can be seen directly.

To illustrate this we'll measure the 1dB gain compression point of a 50MHz, 14dB gain amplifier. Since the output at gain compression is specified to be 10dBm, we'll use an HP 8491A 10dB attenuator at the output of the amplifier to minimize measurement errors due to high signal levels.

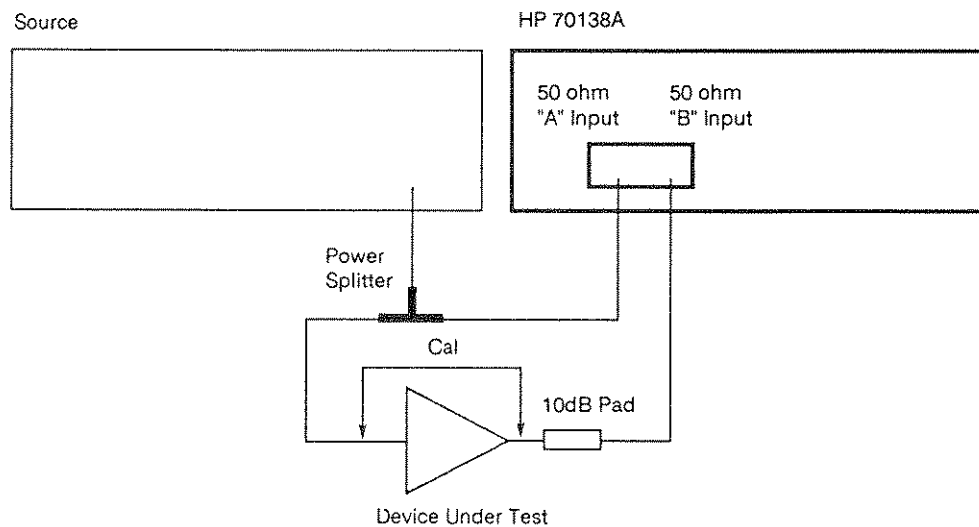


Figure 3-8. Transmission Test Setup

1. Connect the A and B inputs to the power splitter. Set the source output level in the normal operating range of the amplifier. Set the source output frequency to 50MHz. Press [I-P] to return the HP 70138A to a known state.
2. Select [Format Functn], [UNITS dB] to measure log gain. Press [Ref], [SAVE REF] to store the current measurement, zero the display and remove splitter and input effects.
3. Connect the amplifier between the splitter and the B input. Press [Mag/Ph Measure] [B] and measure and note the gain.

4. Press [Ref], [SAVE REF] to store and use this (nominal) gain as a reference and reset the reading to 0dB.
5. Increase the source output level until the HP 70138A reads -1dB. The amplifier is now operating at its gain compression point.
6. Press [Ref], [REF ON OFF] to remove the reference offset. Press [Mag/Ph Measure], [A] to measure the input voltage (dBuV), and [Format Functn], [MAG POWER] to convert the reading to dBm. Since the splitter is symmetrical, the measured power at the A input will be the same as at the amplifier input to within the tracking specifications of the power splitter.

b. Reflection

The measurement of small reflections in high frequency RF systems requires careful consideration. At low levels, reflections from the device under test can be masked by leakage signals in the measuring equipment, so to make the measurement accurately, you will need to use a high directivity reflection bridge or directional coupler. Use a short circuit as a calibration standard, and measure the return loss of a precision termination.

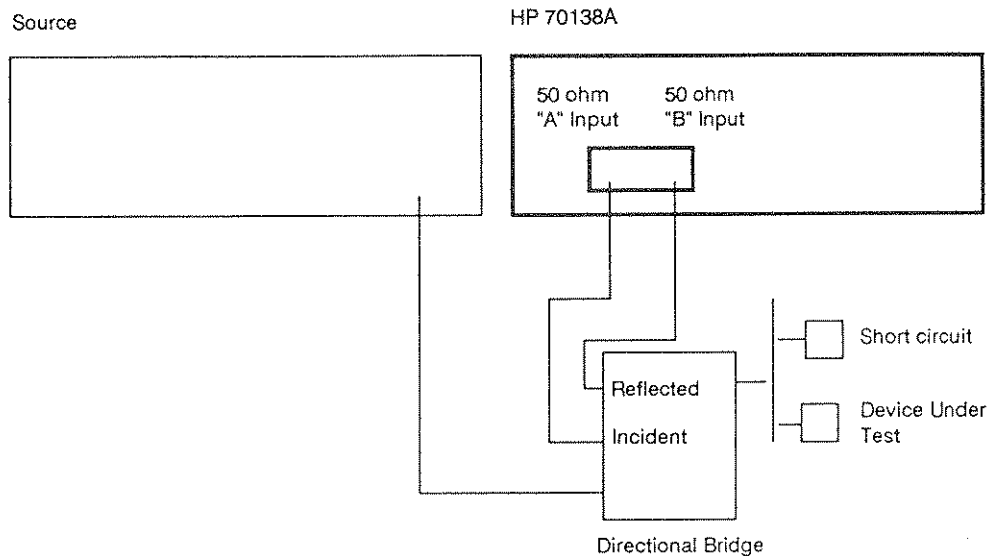


Figure 3-9. Bridge Test Setup

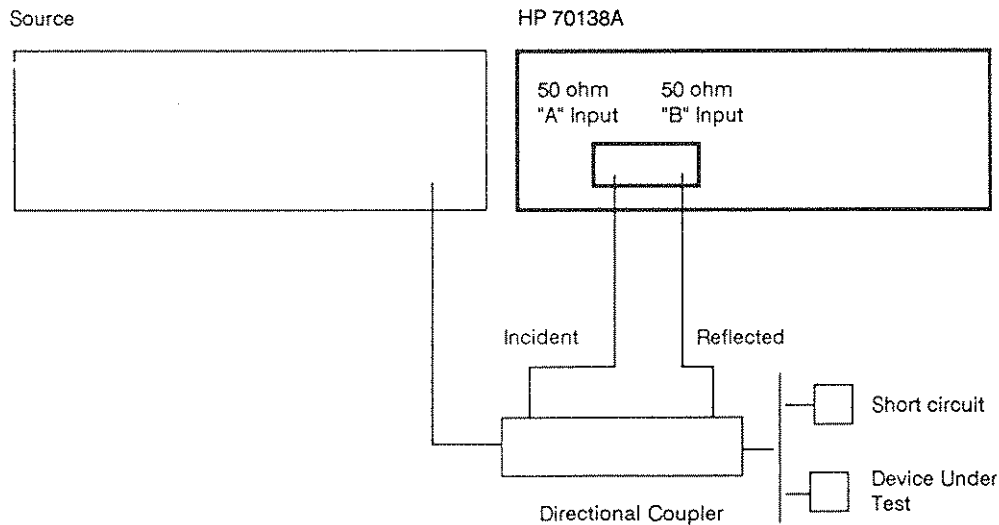


Figure 3-10. Coupler Test Setup

1. Connect the A and B inputs to the bridge or splitter as shown in one of the above diagrams (depending on the equipment you have available). Set the source power to 0dBm and frequency to the test frequency.
2. Connect a short circuit to the test port as the calibration standard. Press [I-P] to return the HP 70138A to a known state. Select [Reflect Measure] to measure reflection coefficient.
3. Select [Ref], [REF SHORT] to use a short circuit as the calibration standard. Select [Format Functn], [UNITS dB] to measure the reflection as return loss in dB. Press [Ref], [SAVE REF] to store the current measurement and display a return loss of 0dB and angle 0 degrees.
4. Remove the calibration standard and connect the termination to be measured. Read the return loss directly.

The HP 70138A has conversions built in to allow you to read results in normalized impedance for use with Smith charts. To make the conversion, select [Reflect Measure], [Z], and [SYS IMP NORM]. There is no need to recalibrate since the new display is computed from the same measurements as before.

c. Other functions

[Display Control], [HOLD READING] - This function is useful when you are probing in a circuit (especially dense circuits where the probe can easily slip onto another track). When the signal disappears, the display is frozen at the last reading.

To initiate this function, configure the equipment for the measurement you want to make. Now press [Display Control], [HOLD READING]. Probe on the circuit. (Use the A probe if "A" only is active or the B probe if both are active.) Lift the probe when you are ready to take a reading. The display(s) will freeze and hold the reading. The HOLD indicator above Display 2 comes on to show that the mode has been activated. To make a new measurement, probe on the circuit. The instrument will automatically re-arm the function.

[Ref], [REF LOAD] - This function allows the use of a simple two resistor tee to enable you to make reflection measurements up to 100MHz. In this case, a termination is used as the calibration standard.

Choose [Ref], [REF LOAD] with the following test setup, then make the measurements in the same way as for other reflection measurements. The Tee method is useful for measuring at frequencies up to approximately 200MHz.

Averaging - When making measurements, the HP 70138A accumulates a number of internal readings and averages them to produce a result which is fed to the display and/or HP-IB. The default is 32 measurements per reading. Higher values may reduce measurement variation, especially with noisy signals, at the cost of a lower measurement rate. Lower values increase the measurement rate and may increase the measurement variation.

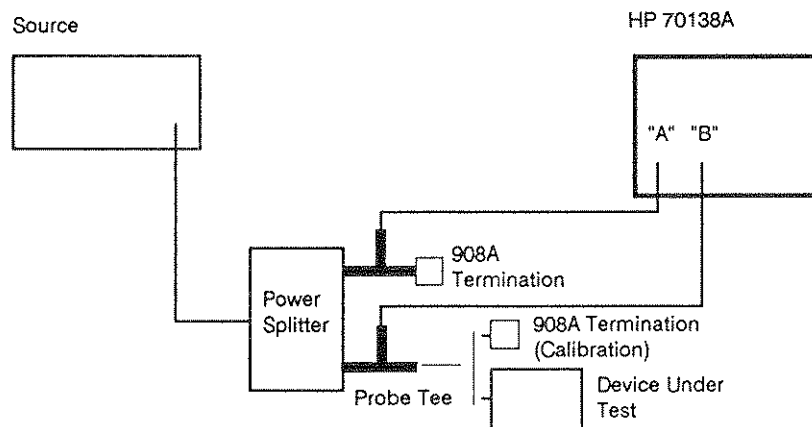


Figure 3-11. Probe Inputs

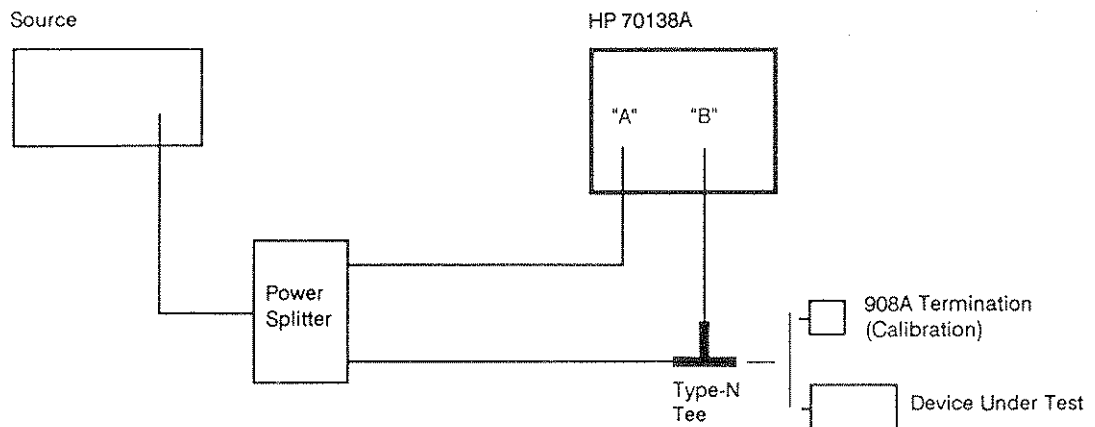


Figure 3-12. 50 ohm Inputs

[Lock Range], [LOCK HOLD] - Using this function provides a faster lock response in automatic systems and when making repetitive measurements near a specification range boundary. This function overrides the automatic selection of frequency lock range. Selecting [LOCK HOLD], or any lock range softkey, turns [AUTO LOCK] off and fixes on the range chosen. Press [AUTO LOCK] to return to normal operation.

[Display Control], [mag range], [AUTO RANGE] - This function overrides the automatic selection of the magnitude display range allowing control of display resolution. Selecting [RANGE HOLD] or one of the range softkeys turns [AUTO RANGE] off and fixes on the range chosen. Press [AUTO RANGE] to return to normal operation. Since the rear panel output is a representation of the display (at 1mV per displayed digit), changing the range also alters the rear panel output range.

[Misc], [CAL] - This function performs power-on self-checks and internal calibration. You should use this function regularly to ensure that the instrument maintains its optimum performance. This function should be used after instrument warm-up (allow a 30 minute warm-up period). In addition, if the instrument is used in a constant environment, this function should be used at least once per day.

[Misc], [TEST ON OFF] - This function turns the TEST output on the HP 70138A front panel on and off. The output is on when the LED beside the TEST output connector is on. This output provides a convenient signal (at approximately 1.6MHz at 100mV), that can be used to check the HP 70138A is operating.

[Misc], [direct analog], [DIR ANL ON OFF] - With the function set to on, the HP 70138A operates as a simple converter. The frequency and amplitude ranges are locked and the rear panel outputs represent the A or B voltage (depending on which is selected using [MAG OP A B]), and the phase difference. No processing is carried out nor are any results displayed. The mode is intended for use in applications such as swept testing of crystal filters.

[Format Functn], [DELAY] - This function enables you to make single-point delay measurements by converting the measured phase difference between the two frequency settings 4kHz apart to a delay measurement. To make a delay measurement, set for transmission. Choose the first frequency on the synthesizer. Select [Format Functn], [DELAY]. Press [Ref], [SAVE REF] to save the measurement and zero the display. Set the synthesizer to the second frequency (+4kHz) and read the delay.

TYPICAL CONFIGURATIONS

Probing measurements with external source

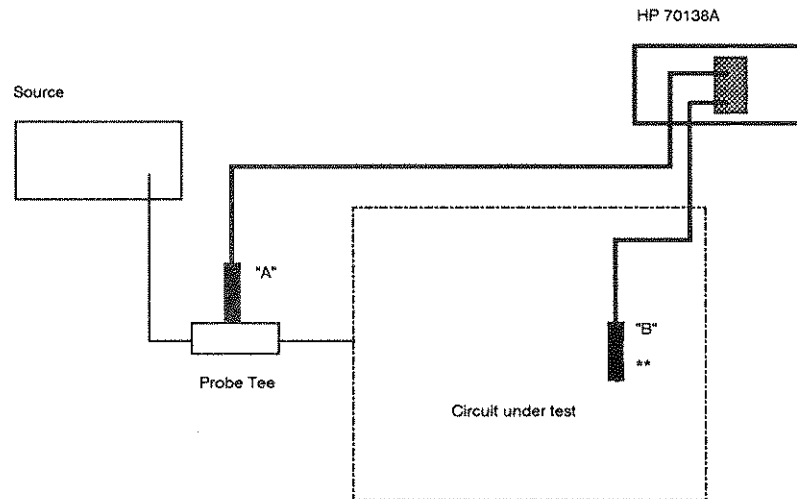


Figure 3-13. Probing Measurements Setup

Equipment:

HP 70300A Tracking Generator

HP 70138A Vector Voltmeter

HP 11536A Probe Tee (Part of HP 11570A Accessory Kit)

HP11851B Cable Kit (1 cable required in this setup)

or

HP11500B RF Cable Adapter from type-N to circuit under test if required

** Probe Accessories (if required)

HP 11576A 10:1 Divider

HP 10216A DC Block

HP 5060-0549 Spanner Top Assembly

Transmission measurements in 50 ohms - Probe inputs

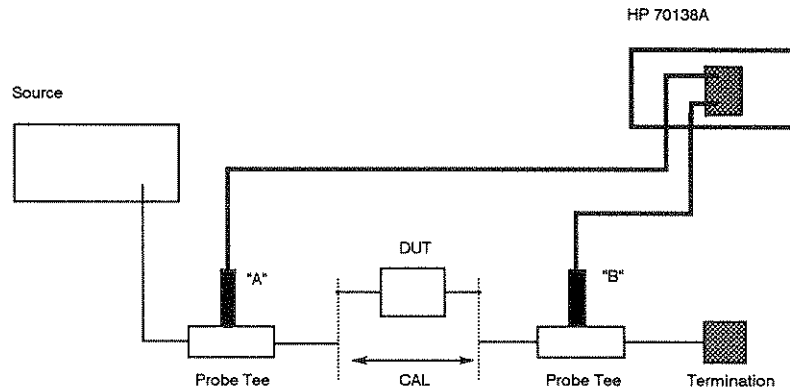


Figure 3-14. Transmission Measurements Setup

Equipment:

HP 70300A Tracking Generator

HP 70138A Vector Voltmeter

HP 11570A Accessory Kit (includes 2 HP 11536A Probe Tee and 1 HP 908A Termination)

HP 11851B Cable Kit (1 cable required in this setup)

or

HP 11500B RF Cable Adapter from type-N to DUT if required

Transmission measurements in 50 ohms - Direct inputs

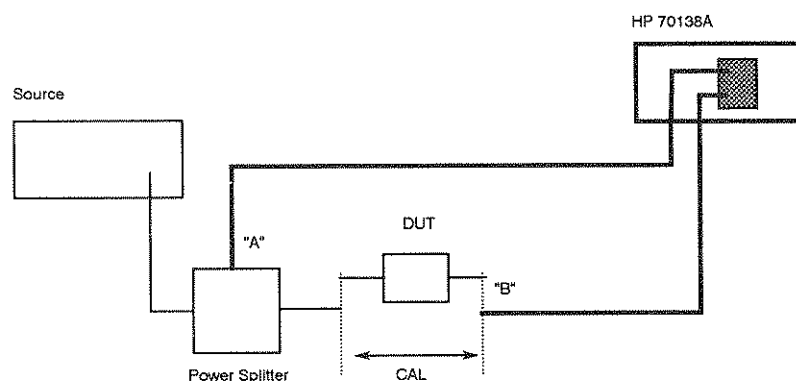


Figure 3-15. Transmission Measurements Setup

Equipment:

HP 70300A Tracking Generator

HP 70138A op 050 Vector Voltmeter with 50 ohm Input Module

HP 11851B Cable Kit (3 cables required in this setup)

HP 11549A Power Splitter (dc to 1GHz)

or

HP 11667A Power Splitter (dc to >2GHz) Adapter from type-N to DUT if required

Reflection measurements in 50 ohms - Probe inputs, dual directional coupler

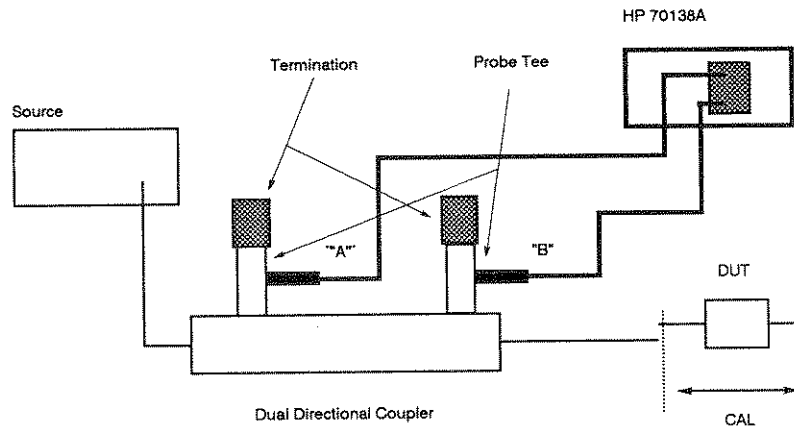


Figure 3-16. Reflection Measurements Setup

Equipment:

HP 70300A Tracking Generator

HP 70138A opt 050 Vector Voltmeter with 50 ohm Input Module

HP 11570A Accessory Kit (includes 2 HP 11536A Probe Tee and 1 HP 908A Termination)

HP 908A Termination (total of 2 required)

HP 77xD Dual Directional Coupler (See "Related Products" section for frequency ranges)

HP 11851B Cable Kit (1 cable required in this setup)

or

HP 11500B RF Cable Adapter from type-N to DUT if required

Calibration Standard (Same as DUT connector)

Reflection measurements in 50 ohms - Direct inputs, reflection bridge

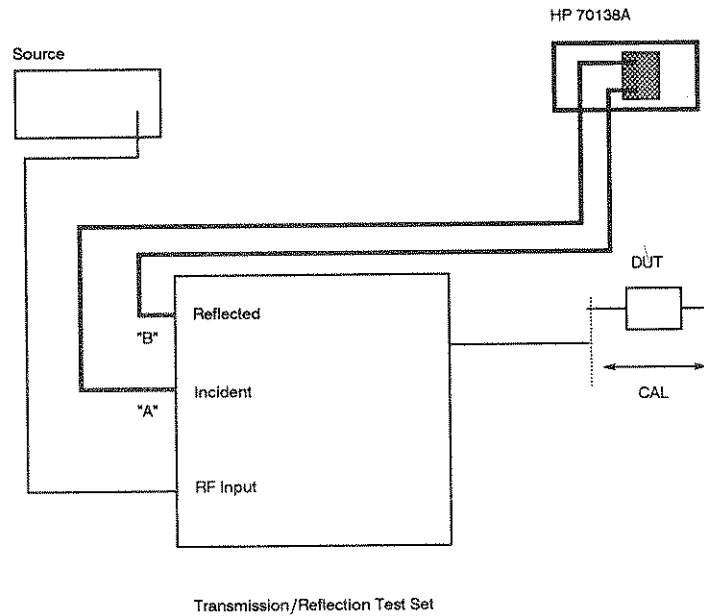


Figure 3-17. Reflection Measurements Setup

Equipment:

- HP 70300A Tracking Generator
- HP 70138A opt 050 Vector Voltmeter with 50 ohm Input Module
- HP 85044A Transmission / Reflection Test Set
- HP 11851B Cable Kit (3 cables required in this setup)
- Adapters from type-N to DUT if required
- Calibration Standard (Same as DUT connector)



REMOTE OPERATION - THE HEWLETT-PACKARD INTERFACE BUS

The HP 70138A Vector Voltmeter is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB) which is Hewlett-Packard's implementation of IEEE Standard 488.1. This section gives details of remote operation, including capabilities, addressing, input and output formats, status and service requests.

All front panel functions are programmable via HP-IB except menu selection and the state information.

The HP-IB commands used in the Vector Voltmeter conform to the standards set by document IEEE 488.2-1987, "Codes, Formats, Protocols and Common Commands for use with ANSI/IEEE Std 488.1, 22 January 1987". Consult the standards document for details of the commands and structures recommended.

For more information about HP-IB, refer to IEEE Standard 488.1 (or the identical ANSI Standard MC1.1), the Hewlett-Packard Electronic Systems and Instruments catalog, the booklet "Improving Measurements in Engineering and Manufacturing" (HP part number 5952-0058), and "Tutorial Description of the Hewlett-Packard Interface Bus" (HP part number 5952-0156, Nov 87). Anyone who is unfamiliar with the IEEE 488 Standards should read the Tutorial Description as an introduction.

HP-IB Capability

This section gives a general description of HP-IB capabilities as they apply to the Vector Voltmeter. The instrument's command set is summarized in Table 3-1 and command details are given in the Command Reference section.

HP-IB system operation normally relies on three types of bus device behavior, as follows:

- * A LISTENER is capable of receiving data over the bus when addressed to do so. There can be multiple listeners simultaneously active.
- * A TALKER is capable of transmitting data over the bus when addressed to do so. There can be only one active talker at a time.
- * A CONTROLLER specifies the talker and listener(s) for an information transfer, including itself. There can be only one active controller at a time.

Local and Remote Operation

The Vector Voltmeter can operate under either local or remote control. In local mode all front panel controls are operational and control the instrument. In remote mode, all front panel controls are inoperative (except [LCL] when not in Local Lockout), the instrument being controlled by the HP-IB controller. The front panel display reflects the remote programming commands received, unless the display is switched off.

At power-on, the instrument assumes the local state. Under local control all HP-IB instrument commands will be ignored. To gain control over HP-IB the controller must put the instrument into the remote state. This is accomplished by setting the Remote Enable (REN) bus control line true and sending the Vector Voltmeter's HP-IB Listen Address.

In local mode, the Vector Voltmeter's front panel controls are fully operational and it will respond to the Remote message. Whether it is addressed or not, it will also respond to the Clear, Local Lockout and Clear Lockout/Local messages. When addressed to talk, the Vector Voltmeter can issue Data messages and the Status Byte message. Whether addressed, or not, it can issue the Service Request message.

Local Lockout. Local lockout disables the LCL key and allows return-to-local only under program control. Local Lockout is recommended for purely automatic applications.

Remote-to-Local. The instrument switches to local whenever it receives the Local message (GTL) or the Clear Lockout/Local message (REN false). If not in Local Lockout mode, the instrument switches to local when the front panel LCL key is pressed.

Addressing

The Vector Voltmeter's HP-IB address is stored in permanent memory, so that it is remembered through power cycling. The address can be set from the front panel as follows:

- a. Press [DISPLAY], [address map], and highlight the HP 70138A instrument using the rotary knob to display the current address.
- b. Press [SET HP-IB] and enter the new address (in the range 0 to 30) using the number pad and the [ENTER] softkey. The new address becomes effective immediately. The HP 70138A factory preset address is 8. If address 31 is entered, the HP 70138A will set its HP-IB address from its rear panel switch.
- c. Press [MENU] to return to normal operation.

The Vector Voltmeter can be Addressed to Listen, Addressed to Talk, or Unaddressed. It is Addressed by putting either its Listen Address (HP-IB Address + 32) or its Talk Address (HP-IB Address + 64) onto the bus in command mode (ATN true & IFC false). It remains Addressed to Listen until it receives its Talk Address or a Universal Unlisten command. It remains Addressed to Talk until it receives its Listen Address or an Untalk command.

NOTE: HP-IB Address Set Algorithm on Power-up

1. If the rear panel 8-bit switch setting is different from the value it had at power-up, set the non-volatile HP-IB address from the switch.
2. If the non-volatile HP-IB address is greater or equal to 31, set the non-volatile HP-IB address from the switch.
3. If the non-volatile HP-IB address is still greater or equal to 31, set the HP-IB address to 8. Otherwise set the HP-IB address from the non-volatile setting.

Power-on Default Conditions

Several HP-IB parameters are reset at power-on. The parameters and their default conditions are listed below.

- * HP-IB Local Mode
- * Unaddressed
- * Service Request Enable Register cleared
- * Status Reporting Structure cleared
- * Trigger Source Freerun
- * Display State active

Should the Vector Voltmeter fail part of its power-on test sequence the Error code will be placed in the Error Queue. (See also SYSTem:ERRor?)



Data Messages

The Vector Voltmeter communicates on the interface bus primarily with Data messages. Data messages consist of a sequence of bytes sent over the bus data lines, when the bus is in the data mode (ATN false). The Vector Voltmeter receives Data messages when addressed to listen and sends Data messages or the Status Byte message when addressed to talk. All instrument operations available in local mode can be performed in remote mode via Data messages except for menu selection and the state information.

Receiving the Data Message

The Vector Voltmeter responds to Data messages when in remote mode (REN true) and addressed to listen.

Instrument Commands

Instrument commands are sent as data messages. Commands may be linked together using appropriate punctuation, as defined in the IEEE 488.2 standard. Allowable commands for the Vector Voltmeter are described in Table 3-1. Either upper or lower case characters are accepted. Many commands have a query option that returns results or allows the state of the function to be checked remotely. Figure 3-18 shows a typical command.

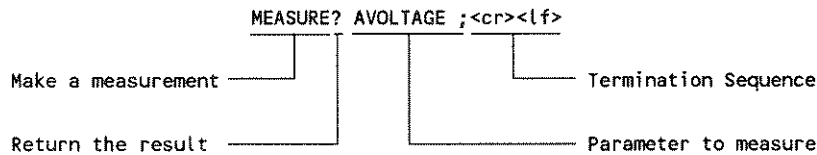


Figure 3-18. A Typical Command

Triggered Measurements

A feature only available via remote programming is selection of free-run or HP-IB triggering. With triggering set to free-run, the Vector Voltmeter measures continuously, outputting data to the display and (if requested) the HP-IB as each measurement cycle is completed.

When the trigger source is set to BUS, the Vector Voltmeter will make triggered measurements. A trigger is initiated by the trigger message, a Group Execute Trigger HP-IB command or a *TRG Instrument command.

In triggered mode, internal settings can be altered, but the instrument is inhibited from measuring and sending results to the front panel or the HP-IB until a trigger is received. When triggered, the instrument completes one cycle of the current measurement and then waits for another trigger. The results of the completed measurement are held, and can be obtained by using the FETCh? or MEASure command. Returning the Vector Voltmeter to local control forces the trigger source to the freerun mode.

Sending the Data Message

The Vector Voltmeter sends Data messages when addressed to talk and has data to output. The output format for the command message is shown in Table 3-1.

Receiving the Remote Message

The Vector Voltmeter switches to remote operation upon receipt of the Remote message. The Remote message has two parts:

- * The Remote Enable bus control line (REN) set true, and
- * A Device Listen Address received once (while REN is true).

When the Vector Voltmeter switches to remote, the front panel RMT annunciator turns on.

Receiving the Local Message

The Local message is the means by which the controller sends the Go To Local (GTL) bus command. If addressed to listen, the Vector Voltmeter returns to front panel control when it receives the Local message. If the instrument is in local lockout when the Local message is received, front panel control is returned, but lockout is not cleared. Unless it receives the Clear Lockout/Local message, the Vector Voltmeter will return to local lockout the next time it goes to remote. The following settings are changed by the transition from remote to local:

- * Trigger State is set to freerun.
- * Display State on.

When the Vector Voltmeter goes to local mode, the front panel RMT annunciator turns off. However, when the Vector Voltmeter is being addressed to talk or listen (whether in local or remote), its front panel LSN or TLK annunciator remains lit.

Receiving the Local Lockout Message

The Local Lockout message is the means by which the controller sends the Local Lockout (LLO) bus command. If in remote mode, the Vector Voltmeter responds to the Local Lockout message by disabling the front panel [LCL] key. The local lockout mode prevents loss of system control due to accidentally pressing front panel keys. When in local lockout mode, the Vector Voltmeter can be returned to local only by the controller (using Local or Clear Lockout/Local messages) or by setting the MMS System LINE switch to OFF and ON.

Receiving the Clear Lockout/Set Local Message

The Clear Lockout/Local message is the means by which the controller sets the Remote Enable (REN) bus control line false. The Vector Voltmeter returns to local mode (full front panel control) when it receives the Clear Lockout/Set Local message. When the Vector Voltmeter goes to local mode, the front panel R annunciator turns off.

Receiving the Pass Control Message

The Vector Voltmeter does not respond to the Pass Control message since it cannot act as a controller.



Receiving the Abort Message

The Abort message is the means by which the controller sets the Interface Clear (IFC) bus control line true. When the Abort message is received, the Vector Voltmeter becomes unaddressed and stops talking and listening.

Sending the Status Bit Message

The Vector Voltmeter has no Parallel Poll capability, and makes no response to the status bit message.

Other Messages

Other messages sent by the Vector Voltmeter are responses to the query option of some commands and status information. In general, the query options return the recommended form of the corresponding command. This is either a number (where the command sets a range or sends data, or sets the function ON or OFF), or a string (where the command itself is a string). Status functions return a number to be decoded to determine conditions which have set status bits.

HP-IB Command Set Summary

Table 3-1. Command and status message summary

Description	Query (1)	Command Header (2)	Parameter (3)
Averaging Value	y	AVERAge:COUNT	<nrf>
Calibration	y	*CAL?	
Capability	y	CAP?	
Clear Status	n	*CLS	
Configure Measurement Correction	n	SENSE CORRection	<meas> (4)
A Value	y	:DATA :A	<nrf>
B Value	y	:B	<nrf>
Phase Value	y	:PHASe	<nrf>
Normalize Impedance	y	:IMPedance	ON OFF 1 0
Termination	y	:TERMination	Z0 SHORT OPEN
Perform Normalization	n	:PERForm	
Normalization State	y	:STATE	ON OFF 1 0
Direct Analog Output	y	DANalog	ON OFF 1 0
Display State	y	DISPlay:STATe	ON OFF 1 0
Fetch Results	y	FETCh?	
Continuous readings	y	:CONTinuous?	
Format	y	FORMat	LINear LOGarithmic POLar RECTangular CARTesian
Frequency		FREQuency	
Band	y	:BAND	<nrf>
Auto Ranging	y	:AUTO	ON OFF 1 0
Identification	y	*IDN?	
Input		INPut	
Impedance	y	:IMPedance	<nrf>
Module Type	y	:POD?	
Measure	y	MEASure?	<meas> {, <meas> } (4)
Output Test Signal	y	OUTPut	ON OFF 1 0
Operation Complete	y	*OPC	
Reset	n	*RST	
Self Test	y	*TST?	
Service Request Enable	y	*SRE	<nrf> (5)
Standard Event Enable	y	*ESE	<nrf>
Standard Event Register	y	*ESR?	(6)
Status Byte Request	y	*STB?	
Status Control		STATus	
Operation Status		:OPERation	
Condition Register	y	:CONDition?	(7)
Positive Transition Filter	y	:PTRansition	<nrf> (7)
Negative Transition Filter	y	:NTRansition	<nrf> (7)
Event Register	y	:EVENT?	
Enable Mask	y	:ENABle	<nrf> (7)
System		SYSTem	
Error Register	y	:ERRor?	NUMeric STRing
Key	y	:KEY	<nrf>
Format	y	:FORMat	ASCIi FP64
Trigger	n	*TRG	
Trigger Setup		TRIGger	
Source	y	:SOURce	BUS FREErun
Wait-to-continue	n	*WAI	



NOTES

(1) Commands which allow a query option are indicated by “y”. Commands where the query is mandatory are also shown with the query question mark in the Command Header column.

(2) Letters in CAPITALS are required. The remainder of the command can be added if desired for legibility.

(3) <nrf> indicates Numeric Representation Flexible, which is a forgiving real format described in IEEE 488.2.

(4) <meas> indicates AVOLTage|BVOLTage|APOWer|BPOWer|BA|PHASe|TRANsmission|
DELay|SWR|RHO|Y|Z|CORE

(5) Status Byte bit usage is as follows.

- bit 4 Message Available
- bit 5 Standard Event Summary Bit
- bit 6 Request Service / Master Summary Status (MSS)
- bit 7 Operation Status Register Summary Bit

Other bits are unused.

(6) Standard Event Status Register bit usage is as follows.

- | | |
|--------------------------|-----------------------|
| bit 0 Operation Complete | bit 4 Execution Error |
| bit 2 Query Error | bit 5 Command Error |
| bit 3 Device Error | |

Other bits are unused.

(7) Operation Status Register bit usage is as follows.

- | | |
|--------------------------|------------------------|
| bit 0 Calibrating | bit 3 Measuring |
| bit 2 Ranging (Unlocked) | bit 4 Awaiting Trigger |

Other bits are unused.

NOTE: Bits 0, 2, 3 and 4 will normally be in a 0 state, except when a function is active (for example, making a measurement) when they will be in a 1 state.

Command Reference

Commands which have no parallel in local operation are described fully in this section, and are indicated by the <=HP-IB=> logo in the header. Commands which operate instrument functions available from the front panel are described only briefly here, because full functional descriptions are given in the section describing local operation.

Averaging Value **AVERAge:COUNT** <nrf>

When making measurements, the Vector Voltmeter accumulates a number of internal readings and averages them to produce a result which is fed to the display and/or HP-IB. The default is 32 measurements per reading. Higher values may reduce measurement variation, especially with noisy signals, at the cost of a lower measurement rate. Lower values increase the measurement rate and may increase measurement variation.

Range 0 to 10. Default 5. The number of internal readings made is two, raised to the power of AVERAge:COUNT.

The query option returns the current setting.

Calibration *CAL?

Performs an internal device calibration. A value of 1 will be returned if the calibration fails. A value of 0 indicates successful calibration.

Capability <=HPIB=> CAPability?

Returns the instrument's HP-IB capability string as follows:

SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E2

Clear Status <=HPIB=> *CLS

Clears the contents of the status register and associated status data structures. This command should be used as part of remote instrument preset.

Configure Measurement **SENSE** <meas>

This command is used to configure the measurement that the Vector Voltmeter will make, and the results it will return in response to a measurement query. Default is AVOLtage.

Options for <meas> are listed in the Measure section.



Correction

CORRection

A Value <=HPIB=>	:DATA	
B Value <=HPIB=>	:A	<nrf>
Phase Value <=HPIB=>	:B	<nrf>
Normalize Impedance	:PHASe	<nrf>
Termination	:IMPedance	ON OFF 1 0
Perform Normalization	:TERMination	SHORT OPEN ZO
Normalization State	:PERForm	
	:STATe	ON OFF 1 0

The correction commands define the normalization values and state. Correction values can be sent to the Vector Voltmeter, impedance measurements can be normalized, current measurements can be saved as a reference and the normalization function can be switched on and off.

The default state is all correction off.

CORR:DATA allows data to be sent to the Vector Voltmeter for use as a reference value. :A :B and :PHASe are used to define the destination of the reference value. The ability to use specific data as reference values is a function available only from HP-IB.

The query options return the current value.

CORR:IMPedance sets the impedance normalization function. ON (1) sets the Vector Voltmeter to normalize impedance measurements. OFF (0) implies that impedance measurements are calculated from the current value of Input Impedance. The default is OFF.

The query option returns 1 or 0.

CORR:TERMination sets the termination standard for reflection measurements. The default is SHORT.

The query option returns the current setting as an ASCII string.

CORR:PERForm sets the :A :B and :PHASe references to be the current measurement values.

CORR:STATe defines if the CORRECTION function is in use. It sets the normalization function to ON (1) or OFF (0). The default is OFF.

The query option returns 1 or 0.

Direct Analog Output

DANalog

ON|OFF|1|0

Sets the Vector Voltmeter to operate as a simple converter. The frequency and amplitude ranges are locked and the rear panel outputs represent the A or B voltage (depending on which is selected on the front panel) and the phase difference. No processing is carried out, nor are any results available over HP-IB. The mode is intended for use in applications such as narrowband swept testing of crystal filters.

The default is OFF.

The query option returns 1 or 0.



FREQ:BAND selects the frequency band explicitly. The command forces BAND:AUTO to OFF. Bands are as follows:

Band Number	Frequency band (MHz)	Band Number	Frequency Band (MHz)
1	0.1 to 0.2	9	25 to 50
2	0.2 to 0.6	10	50 to 80
3	0.6 to 1	11	80 to 150
4	1 to 3	12	150 to 250
5	3 to 5	13	250 to 500
6	5 to 8	14	500 to 1000
7	8 to 15	15	1000 to 2000
8	15 to 25		

The default setting is automatic band selection.

The query option returns the current band.

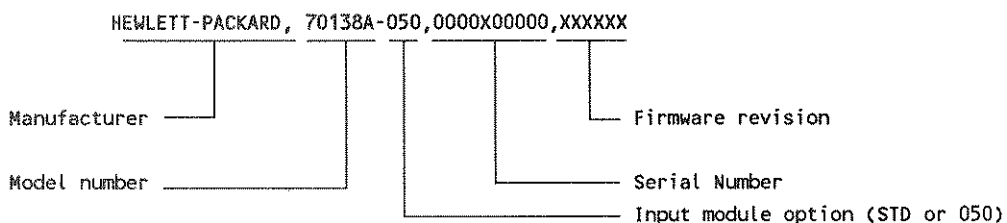
FREQ:BAND:AUTO selects explicit or automatic frequency band selection. When turned OFF the Vector Voltmeter remains in the current band.

The default is ON, but is forced to OFF when the FREQ:BAND command is received.

The query option returns 1 or 0.

Identification <=HPIB=> *IDN?

The identification command returns a string which describes the Vector Voltmeter and Input Module. The string contains four fields, separated by commas, as shown below.



Input

INPut

: IMPedance

<nrf>

: POD?

Input impedance sets the impedance of the measurement system, used in power and impedance measurements. Allowed values are 50 or 75 (Ohms).

The query option returns the current setting.

INPut: POD? returns either 50 or HI and this defines which input module is installed.

Measure **MEASure?** **<meas>(, <meas>)**

This command is used to configure and make a Vector Voltmeter measurement (or measurements) and return the result(s). Default is AVOLTage.

Options for <meas> are listed below

AVOLTage	Channel A Voltage, using current setting of FORMat (LOG LIN).
BVOLTage	Channel B Voltage, using current setting of FORMat (LOG LIN).
APOWer	Channel A Power, using current settings of INPut:IMPedance and FORMat (LOG LIN).
BPOWer	Channel B Power, using current settings of INPut:IMPedance and FORMat (LOG LIN).
BA	B/A Magnitude Ratio, using current setting of FORMat (LOG LIN).
PHASe	B-A Phase.
TRANsmission	B/A Magnitude Ratio and B-A Phase, computed from the same measurement, using current settings of FORMat (LOG LIN and POL RECT).
DELay	Delay
SWR	Standing Wave Ratio
RHO	Reflection Coefficient, using current settings FORMat (LOG LIN and POL RECT).
Y	Admittance (1/Z), using current settings of INPut:IMPedance and FORMat (POL RECT).
Z	Impedance, using current settings of INPut:IMPedance and FORMat (POL RECT).
CORE	All basic measurements - AVOLTage, BVOLTage and PHASe. Equivalent to MEAS? AVOL,BVOL,PHASe.

All the above measurements are also dependant on whether CORRection:STATE is ON or OFF.

Output **OUTPut** **ON | OFF | 1 | 0**

Controls the front panel Test output signal.

The default is OFF.

The query option returns 1 or 0.

Operation Complete <=HPIB=> *OPC

This command causes the Operation Complete bit in the Standard Event Status Register to be set when the Vector Voltmeter has completed all pending operations.

The Standard Event Status Register can be monitored to find when the bit is set using the *ESR? command, or the Vector Voltmeter can be set to request service when the bit is set true.

The query option returns "1" when all pending operations have been completed.

Reset ***RST**

The reset function sets the Vector Voltmeter to a front panel state the same as using the PRESET key. It has no effect on the status registers or results waiting to be read.



Self Test

*TST?

This command initiates an instrument self check and causes a result to be output. The result will be zero (0) if the test is completed without errors. A one (1) indicates an error has occurred. Full details of the error codes appear in the Troubleshooting section of this Manual.

Service Request Enable <=HP-IB=>

*SRE

<nrf>

Sets the service request conditions.

Status Byte bit usage is as follows.

- bit 4 Message Available
- bit 5 Standard Event Status Register summary bit
- bit 7 Operation Status Register summary bit

Other bits are unused.

The query option returns the currently selected conditions. There is more detail contained in the Service Requests section later in this manual.

Standard Event Status Enable <=HP-IB=>

*ESE

<nrf>

Sets the Standard Event Register mask conditions. Range 0 through 255, using encoding as in Table 3-1.

The query option returns the currently selected conditions. Range 0 through 255, using encoding as in Table 3-1.

Standard Event Status Register <=HP-IB=> *ESR?

Returns and Clears the current value of the Standard Event Status Register.

Status Byte Query <=HP-IB=>

*STB?

Returns the current value of the Status Byte, with Master Summary Status (MSS) as bit 6. The Byte consists of bits which summarize each Status Reporting Structure. Bits are cleared by clearing the related structure.

Status Control/Operation Status <=HPIB=>

	STATUS	
	:OPERation	
Condition Register	:CONDition?	
Positive Transition Filter	:PTRansition	<nrf>
Negative Transition Filter	:NTRansition	<nrf>
Event Register	:EVENT?	
Enable Mask	:ENABLE	<nrf>

The status command controls the setup and operation of the condition and event registers. The registers are set by positive or negative transitions of the appropriate condition, enabled by transition filters.

EVENT? and CONDition? return the current values of the corresponding registers.

ENABLE selects which events latched using the Positive TRansition and Negative TRansition filters, are reported in the Status Byte summary bit 7.

The query option of ENABLE returns 0 through 255, using encoding as in Table 3-1.

The query options of PTRansition and NTRansition return the current transition masks.

System

SYSTem

Error Register	:ERRor?	NUMeric STRing
<=HPIB=> Key	:KEY	<nrf>
<=HPIB=> Format	:FORMat	ASCii FP64

The system command covers miscellaneous housekeeping and global activities in the Vector Voltmeter.

SYSTem:ERRor ? returns an error code describing any error that occurs. Errors are returned as either numeric responses or as a string describing the error. By default a string is returned. Full details of the error codes appear in the Troubleshooting section of this Manual.

SYSTem:KEY allows direct programming of the Vector Voltmeter by simulating key presses. Each key is simulated by sending its keycode given in Table 3-2.

The query option returns 0. (Note: this is an <nrf> zero not an ASCII zero.)



Table 3-2. Keycodes

Keycode	Description
1	A
2	B
3	REFL MEAS
4	FORMAT
5	POWER MEAS
6	B/A MAG
7	B-A PHASE
8	REF SELECT
9	REF
10	SYSTEM IMPD
11	METER SELECT
12	LOCK RANGE
13	STEP UP
14	STEP DOWN
15	MAG RANGE
16	HOLD VALUE
17	DISPLAY
18	SHIFT
19	LCL
20	PRESET

NOTE: These names refer to the HP 8508A Vector Voltmeter front panel keys. The HP 70138A and the HP 8085A are fully HP-IB compatible. For a detailed explanation of the HP 8508A keys refer either to the HP 8508A manual, or to Appendix A at the rear of this manual.

SYSTem:FORMat sets the HP-IB output format for measurement results. Two formats are available (ASCIi and FP64) and they are described in the later section on HP-IB Response Formats.

Trigger <=HPIB=> *TRG

The trigger command performs the same function as the Group Execute Trigger command defined by IEEE 488.1, that is it initiates a new measurement when the TRIGger:SOURce is BUS.

Trigger Setup <=HPIB=> TRIGger
Source :SOURce BUS | FREErUN

The trigger setup function allows the trigger mode to be selected. In freerun, the Vector Voltmeter makes measurements as quickly as possible. When the trigger source is set to BUS, the Vector Voltmeter waits to receive a trigger before initiating the next measurement.

Wait-to-continue <=HPIB=> *WAI

This command causes the Vector Voltmeter to complete all current actions before accepting any more commands. It can be used to synchronize the instrument's operation with other equipment.

Service Requests

HP-IB devices may request service from the controller by asserting the SRQ bus control line. The controller usually responds to this signal by asking each device on the bus in turn for its Status Byte. If bit 6 is set, it indicates that the device requires service and the controller looks at the remaining bits in the Status Byte for further information.

The interpretation of these bits depends on whether the device complies only with IEEE488.1 or, like the Vector Voltmeter, with IEEE488.1 and IEEE488.2. Bit 6 has two distinct functions. Within IEEE488.1 it is the Request Service (RQS) bit and within IEEE488.2 is the Master Summary Status (MSS) bit. IEEE488.2 also defines bit 5 as the Event Summary Bit (ESB) and bit 4 as the Message Available Bit (MAV).

When dealing with service requests, a key operational difference emerges between instruments which comply only with IEEE488.1 and those which meet IEEE488.2 as well. If the Status Byte of a IEEE488.1 instrument is read (by a Serial Poll Enable bus command), the RQS bit is cleared as a consequence of the read operation. A Serial Poll of an IEEE488.2 instrument produces the same effect. IEEE488.2 provides a further command, *STB?, to read the Status Byte. If this command is used, the state of the MSS bit is returned and the bit is not cleared when read.

These differences arise because IEEE488.2 defines a status reporting structure which extends the specifications of the original standard. In IEEE488.2, the Status Byte summarizes the underlying status data structures and the concept of enabling service requests is defined.

Enabling Service Requests

The service request enabling operation is shown in Figure 3-19. The user can set bits in the Service Request Enable Register (SRER). These bits correspond to bits in the Status Byte. If a bit is set in the SRER, it enables the instrument's ability to generate an SRQ when the corresponding event occurs. For example, setting bit 4 in the SRER will produce a service request when the MAV bit is set.

If a bit is set in the Status Byte, but not enabled in the SRER it cannot cause bit 6 to be set and consequently will not initiate an SRQ, although it will be read when the Status Byte is read.

Refer to Figure 3-19 for an example of SRQ enabling and handling.



```
10  ! HP 70138A Example HP-IB SRQ Enable & Handling Program
20  !
30  ! This program continually sends an illegal command to the HP 70138A,
35  ! and deals with the returned SRQ. It also reports the HP 70138A
37  ! going out of lock, when the A channel signal is removed.
40  !
50  Addr=708 ! Vector Voltmeter Address
60  ON INTR 7 CALL Intr7 ! Set up SRQ interrupt handler call
70  !
80  CLEAR Addr ! Clear interface
90  OUTPUT Addr;''*RST'' ! Reset Vector Voltmeter
100 !
110 OUTPUT Addr;''*ESE 36'' ! Enable SRQ on Query or Command Error
140 !
150 OUTPUT Addr;''STATUS:OPER:PTR 4'' ! Enable SRQ when HP 70138A becomes
180 OUTPUT Addr;''STATUS:OPER:ENAB 4'' ! Unlocked
200 !
210 OUTPUT Addr;''*SRE 160'' ! Generate SRQ on above conditions
230 !
240 ENABLE INTR 7;2 ! Enable SRQ interrupts in BASIC
250 REPEAT
260     OUTPUT Addr;''SYST:KET 1'' ! An incorrect Command to generate an SRQ
270     WAIT .5
280 UNTIL 1=0 ! Repeat Forever
290 END
300 !
310 !
320 SUB Intr7
330     DIM Err_message$(100)
340     Addr=708
350     OUTPUT Addr;''*STB?''
360     ENTER Addr;Stat ! Read Status Byte
370     IF BIT(Stat,5) THEN
380         OUTPUT Addr;''*ESR?'' ! Read & Clear Standard Event Register
390         ENTER Addr;Std_event
400         IF BIT(Std_event,5) THEN PRINT ``Command Error''
410         IF BIT(Std_event,2) THEN PRINT ``Query Error''
420         OUTPUT Addr;''SYST:ERR?''
430         ENTER Addr;Err_message$
440         PRINT Err_message$
450     END IF
460     IF BIT(Stat,7) THEN
470         PRINT ``HP 70138A UNLOCKED''
480         REPEAT
490             OUTPUT Addr;''STATUS:OPER:COND?''
500             ENTER Addr;Condition
510             UNTIL BIT(Condition,2)=0 ! Wait for lockup again
520             PRINT ``HP 70138A LOCKED''
530             OUTPUT Addr;''*CLS'' ! Clear ALL Status Structures
540         END IF
550     !
560     ENABLE INTR 7 ! re-enable SRQ
570 SUBEND
```

Figure 3-19. SRQ Enabling and Handling

Sending the Service Request Message

The Vector Voltmeter sends the Service Request message in either local or remote mode. When it is sending the message, the front panel SRQ annunciator lights. The message is cleared when a serial poll is executed by the controller or when a *CLS (Clear Status) instrument command is received.

Sending the Status Byte Message

The Vector Voltmeter sends the Status Byte message after receiving a Serial Poll Enable (SPE) bus command and when addressed to talk. It complies with IEEE488.2, so bits 4 and 5 are defined as MAV and ESB, respectively. The Vector Voltmeter also makes use of bit 7 as the Operation Status Register Summary Bit but all other bits are unused. The bit pattern of the Status Byte is shown in Figure 3-20.

Once the Vector Voltmeter receives the SPE bus command, it is no longer able to alter the Status Byte. If a bit has been enabled and that condition occurs after bit 6 has been set, the bit is stored in a buffer and is read the next time the Vector Voltmeter receives the SPE bus command.

The Status Byte and any Service Request message pending will be cleared if a *CLS (Clear Status) instrument command is received by the Vector Voltmeter.

Status Reporting

The IEEE 488.2 Standard describes a status reporting structure so that controllers know how to ask a device such as the Vector Voltmeter for its status. Figure 3-20 shows an overview of the status reporting structure.

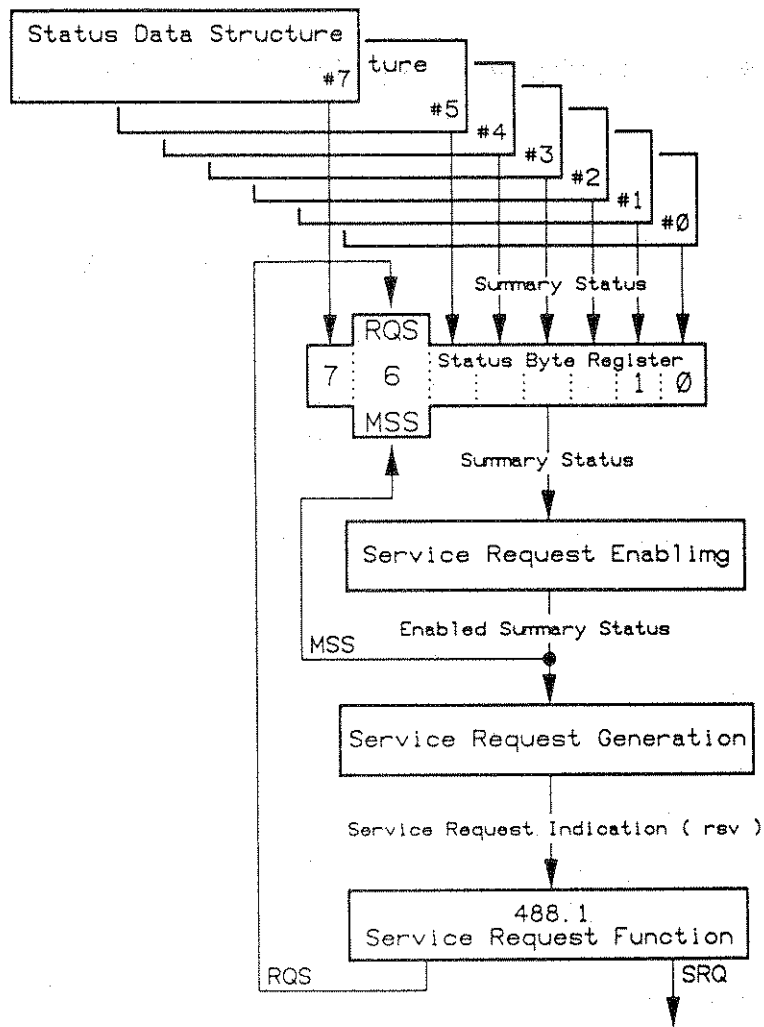


Figure 3-20. IEEE488.2 Status Reporting Structure Overview

Status Data Structures

IEEE488.2 allows the Status Byte to contain up to seven single bit summary messages from data structures, but the Vector Voltmeter only makes use of bits 4, 5 and 7 as described earlier in Sending the Status Byte Message. The status data structures are queues or event registers and the summary bits are used as follows:

- * Bit 4 (MAV) reports the status of the Output Queue.
- * Bit 5 (ESB) reports the status of the Standard Event Status Register.
- * Bit 7 reports the status of the Operation Status Register.

Figure 3-21 shows the Standard Status Model for IEEE488.2 instruments. Two of the Vector Voltmeter's data structures are not shown, but are described later. The Operation Status data structure is similar to the Standard Event Status data structure and the Error Queue is summarized in the error bits of the Standard Event Status Register.

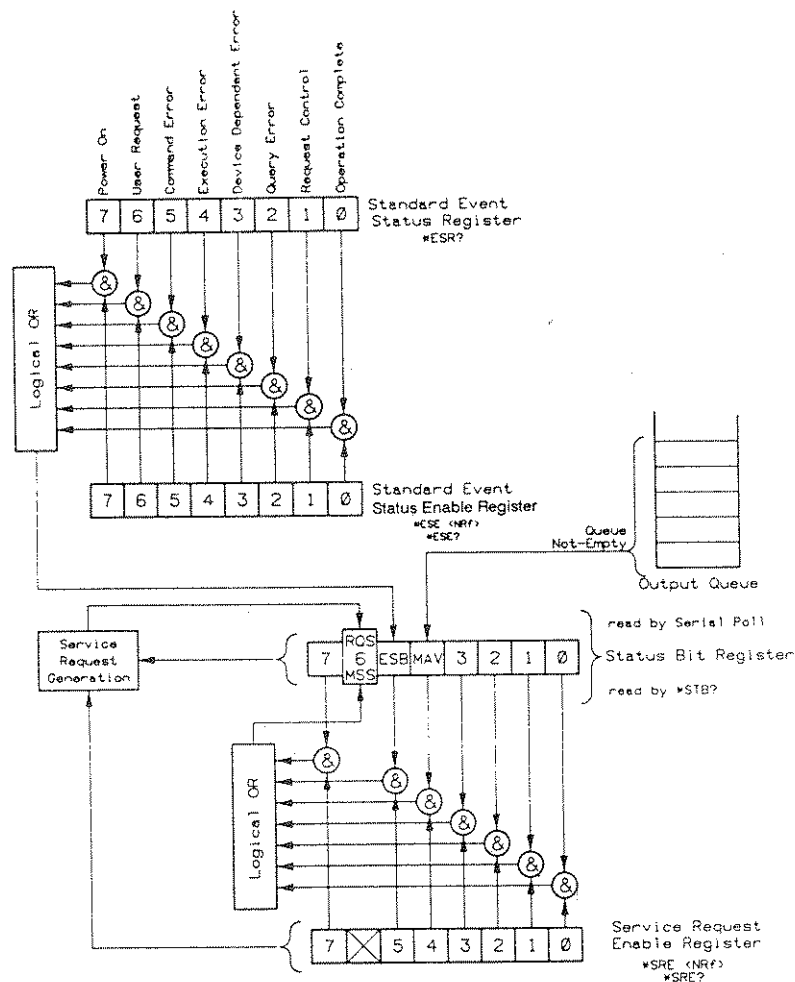


Figure 3-21. Standard Status Model



Queues

Queues permit a device to report status or other information in a sequential manner. Each queue has a summary message bit which indicates that the queue contains some information. This bit will be TRUE when the queue contains any information, otherwise it will be FALSE. Reading a queue will remove a piece of information from it, and a queue is considered empty when it no longer contains any information. Queues can be cleared by reading all the information in them.

The Output Queue

There are two queues in the status reporting structure of the Vector Voltmeter.

The Output Queue is a “first-in, first-out” (FIFO) queue. It stores output messages until they are read from the instrument. The availability of data is summarized in the MAV bit of the Status Byte. The Output Queue is read by addressing the instrument to talk and then handshaking the bytes. It can be cleared by the Reset Command, the Device Clear Command (IEEE488.1) or by power on.

The Vector Voltmeter also has an Error Queue, which operates as a FIFO and stores error messages until they are read from the Vector Voltmeter. The Error Queue is summarized in the error bits (bits 2 to 5, inclusive) of the Standard Event Status Register. It is read by the SYSTem:ERRor ? command and can be cleared by using the Clear Status command (*CLS). When the Error Queue is empty, the string “0, NO ERROR” is returned.

Event Registers

Event Registers capture changes which occur within a device. Each bit in an event register corresponds to some device condition. Bits become TRUE when some pre-defined device condition transition occurs. The event register bits are latched so that once they become TRUE they cannot be cleared except by the user. There are two means of clearing an event register. Reading a register will clear it and the Clear Status command (*CLS) will clear all event registers.

The Vector Voltmeter uses two kinds of transition filter for setting these event bits TRUE:

1. Positive Transition. The event becomes TRUE when its condition makes a FALSE to TRUE transition.
2. Negative Transition. The event becomes TRUE when its condition makes a TRUE to FALSE transition.

See Figure 3-22 for a detailed representation of the register model for the status data structure.

Device Status Continuously Monitored

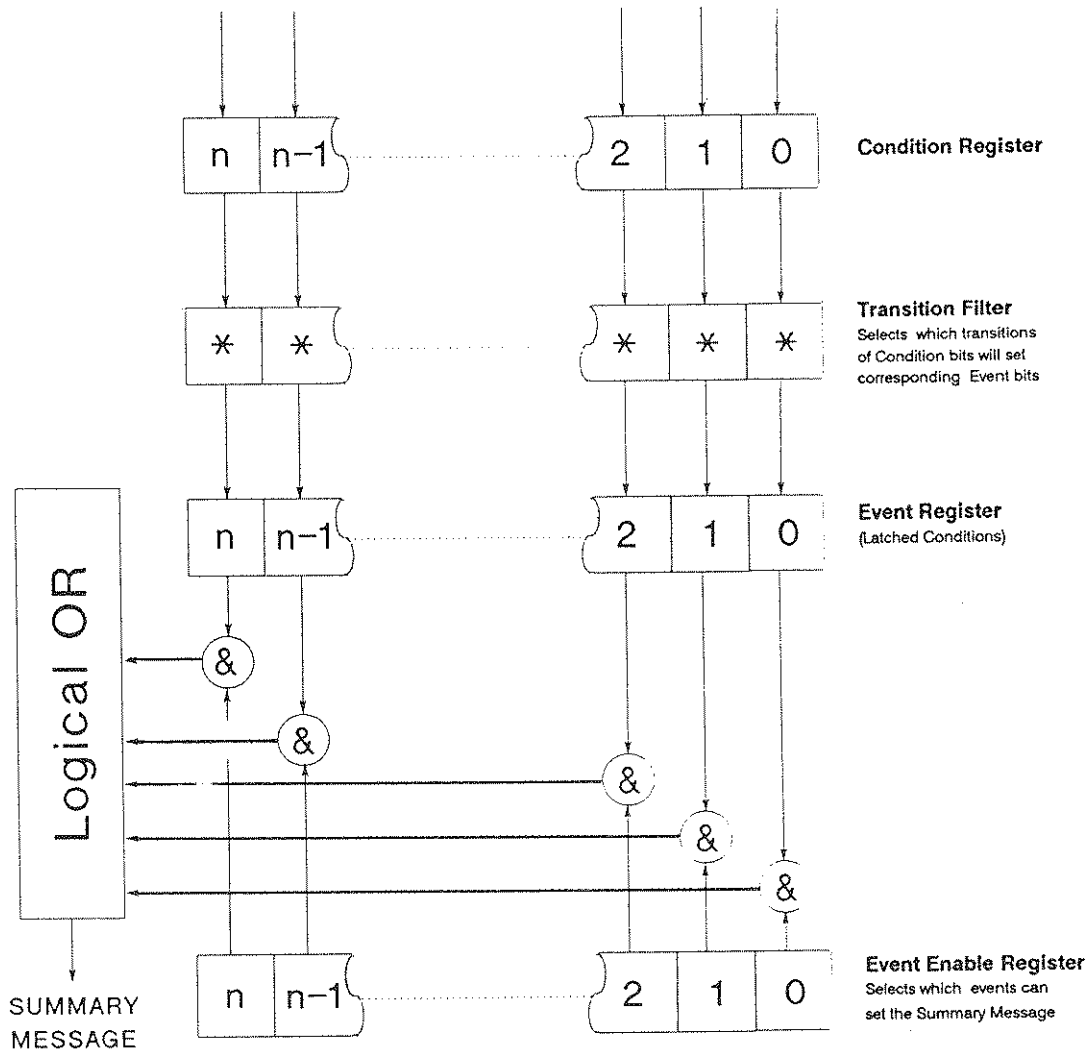


Figure 3-22. Register Model for the Status Data Structure.

The instrument also provides a Standard Event Status Enable Register and an Operation Status Enable Register and provides further commands to read them. These registers work in the same way as the Service Request Enable Register described earlier in Sending the Status Byte Message.



Standard Event Status Register (SESR)

Figure 3-19 shows the operation of the Standard Event Status Register. This is a specific application of the event registers discussed previously and its bit definitions are as follows:

Bit 5 - Command Error (CME)

This bit indicates that the device has detected a command error. The following events cause a command error.

1. An IEEE 488.2 syntax error. This means that the device received a message which did not follow the syntax defined by the IEEE488.2 standard. For example, it received data which violated the device listening format.
2. A semantic error occurred. For example, the device received an incorrectly spelled command. Another example would be that the device received an optional IEEE488.2 command which it does not implement.
3. The device received a Group Execute Trigger (GET) inside a program message.

Bit 4 - Execution Error (EXE)

This bit indicates that the device detected an error while trying to execute a command. It indicates that:

1. A <PROGRAM DATA> element received in a command was outside the legal range for the device, or inconsistent with the operation of the device.
2. The device could not execute a valid command due to some device condition.

Bit 3 - Device-dependent Error (DDE)

A device-dependent error is any device operation which did not execute properly due to some internal condition such as over range. It indicates that the error was not a command, query, or an execution error.

Bit 2 - Query Error (QYE)

This bit indicates:

1. An attempt to read data from the Output Queue when no data was present.
2. That data in the Output Queue was lost. An example of this would be queue overflow.

Bit 0 - Operation Complete (OPC)

This bit indicates that the device has completed any pending operations and is ready to accept new commands. This bit is generated only in response to the Operation Complete (*OPC) command.

SESR Operation

The SESR operates in the same manner as the Event Registers described earlier. It can only be cleared by:

1. a Clear Status command (*CLS).
2. reading it (*ESR?).
3. a power-on transition.

The associated Standard Event Status Enable Register is written with the Enable Status (*ESE) command and read with the Enable Status (*ESE?) query.

Register Bit Coding

The Status Byte, SESR, Operation Status Register and Transition Filters are set using a value which determines the conditions to be enabled. The weights of each of the bits to be enabled are summed to obtain the value required. Table 3-3 shows the weighting of each bit for each of the registers.

Table 3-3. Register Bit Coding

Bit	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1

HP-IB Response Formats

Results returned by the Vector Voltmeter from measurement queries take the ASCII form:

`<+> | <->D.DDDE<+> | <->DD<term>`

That is a leading sign, a four digit mantissa between 1.000 and 9.999, an exponent designator “E” or “e”, an exponent sign, a two digit exponent between 00 and 99 and a terminator.

The value is always in fundamental units (volts, ohms, watts, dB etc.). The terminator <term> depends on the data requested, as follows:

<term> is a comma (,) where another data item follows as part of the same result.

<term> is a semicolon (;) where the data item completes a result and another result follows.

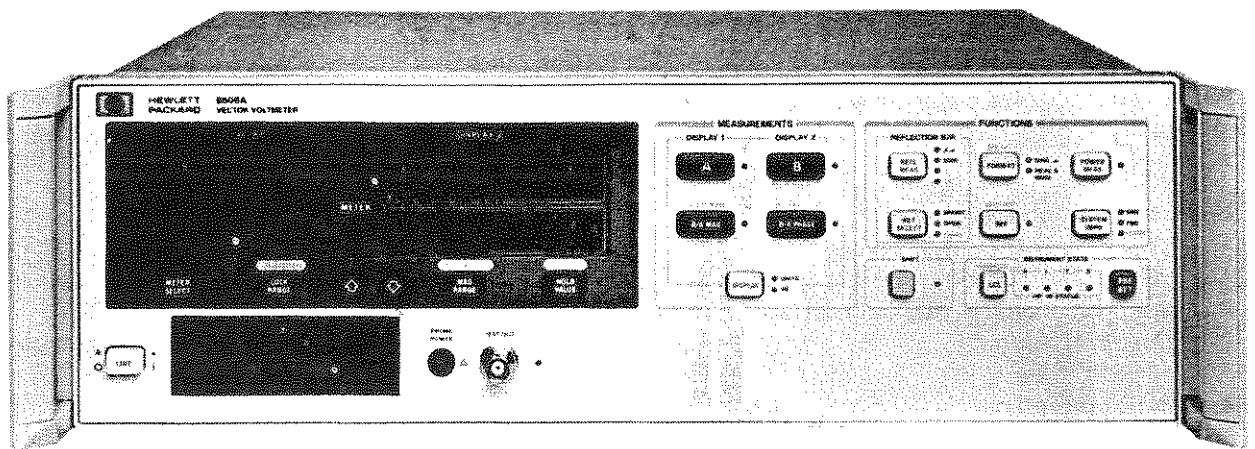
<term> is linefeed <lf> with EOI set true where the data item is the last or only part of a result.

Using the SYSTem:FORMat command results can also be coded as 64 bit Floating Point numbers, in IEEE488.2 Definite Length Arbitrary Block Response Data format. This will be of the form ASCII characters ‘#’ ‘1’ ‘8’ followed by eight data bytes in IEEE 754-1985 double precision format.



APPENDIX

HP 8508A FRONT PANEL FEATURES



Appendix A-1. Front Panel

MEASUREMENT KEYS

Introduction

The following four keys operate similarly. One press lights the LED and the measurement result is shown in the appropriate display window. A second press turns off the LED and the measurement result. Any single measurement is available and any combination can be chosen by selecting the required measurements. Note that A, B/A mag and B, B-A phase combinations can be selected using shifted functions (that is, pressing [SHIFT] and the appropriate key). If a new measurement is selected which uses the same display as an existing measurement, the existing measurement will be turned off (for example, selecting Phase when B is displayed will turn B off).

A

Measures the amplitude of A. Default is mV on Display 1, changeable to dBuV by toggling the [DISPLAY] key to dB. Power can be displayed by pressing the [POWER MEAS] key and selecting either 50 or 75 ohms with the [SYSTEM IMPD] key. Units available are uW and dBm.

B

Operates in the same way as A but the value appears on Display 2, units are controlled by the [DISPLAY] key.

B/A mag

Measures the B/A ratio. Default is linear units on Display 1, changeable to dB using the [DISPLAY] key.

B-A phase

Measures the phase of B with respect to A, in degrees.

A, B/A mag

Places the A measurement in Display 1 and the B/A measurement in Display 2.

B, B-A phase

Places the B measurement in Display 1 and the B-A phase in Display 2.

DISPLAY

Defines the scale associated with the display(s), depending on what measurement is displayed. Units selects the linear scale and dB selects the log scale.

Example 1 - Amplitude of A has a units scale in mV and a dB scale in dbuV.

Example 2 - Power in A has a units scale in uW and a dB scale in dBm.

FUNCTION KEYS

REF

Works in A amplitude, B amplitude B/A magnitude and Phase to make measurements relative to a set of reference values. [SAVE REF] stores the current A, B and Phase values, and turns [REF] on. When [REF] is turned on:

displayed phase = measured phase - saved phase and displayed

$$\text{amplitude or magnitude} = \frac{\text{measured amp. or mag.}}{\text{saved amp. or mag.}}$$

REFL MEAS

Uses measurements of B/A ratio and B-A phase to make simple reflection measurements - using an external device. The [SHORT] and [OPEN] reference impedances are used with a bridge or directional coupler and [LOAD] is used when making measurements with a Tee. Note that [LOAD] is selected as a shifted function.

To initialize the measurement, connect the external equipment and connect the appropriate reference impedance to the test port. Press [SAVE REF]. The REF LED is automatically turned on. The A, B and phase values are then retained and used as a correction for any level and/or phase changes occurring between the A channel (incident) signal and the B channel (reflected) signal.

To make a corrected measurement, connect the DUT to the test port. It is also possible to make an uncorrected measurement by turning REF off.

When making Z or 1/Z measurements, absolute values can be displayed by choosing the appropriate [SYSTEM IMPD] of 50 or 75 ohms. If values normalized to Z0 are required, choose [NORM].

POWER MEAS

Works with A and B amplitude only to convert the measured voltage to an equivalent power using the value selected by the [SYSTEM IMPD] key.

FORMAT

The default display configuration for magnitude and phase related measurements is magnitude in Display 1 and phase in Display 2. An alternative real and imaginary format is available when displaying the following: B/A and Phase (together), rho and phase angle, Z and 1/Z.

DELAY

Uses the B-A phase to make simple delay measurements. The delay is calculated assuming a 4kHz change between the two frequencies. The delay is shown in Display 1 with Display 2 showing "dely" (for delay). The delay can be zeroed by pressing [SAVE REF].

INSTRUMENT STATE

PRESET

This key forces the instrument into a defined measurement state, as follows: A is displayed in mV with no other functions engaged and all ranging is automatic.

LOCAL

Returns the instrument to front panel control unless local lockout has been asserted over the HP-IB.

ADDRESS

Used to show the current HP-IB address of the instrument. It is changed by using the [STEP] keys. The display reverts to measurement display when another key is pressed.

DISPLAY AREA KEYS

MAG RANGE

When [MNL] is selected, the display resolution is controllable using the [STEP] keys, which move the position of the decimal point. When A and B are displayed together, both displays show the same resolution.

DIR ANLG OUT

When this mode is engaged, the raw phase and magnitude detector outputs are fed directly to the rear panel so that external measurements can be made when a CW or swept(*) source is used. Internal gain ranging is forced into manual operation with the display showing XXX mV full-scale deflection, adjustable by use of the [STEP] keys. The [LOCK RANGE] is also forced into manual mode. The only valid measurement selection is A or B.

(*) The HP 8508A will lose lock if the sweep rate exceeds approximately 15MHz/second or if the frequency reaches a lock range boundary.

LOCK RANGE

When [MNL] is selected, the instrument is prevented from signal searching outside the current frequency range.

RANGE

Display the current lock range, the range can then be changed by using the [STEP] keys. The display reverts to measurement display when another key is pressed.

HOLD VALUE

This retains the displayed values when the signal voltage crosses a fixed threshold or if the instrument loses lock. If both displays are active, the function is associated with the B signal level. If only the A voltage is displayed (Channel B is unused), the function is associated with the A channel. When the function is engaged, the LED beside the key flashes to show that a reading is being held.

METER SELECT

This key is used to associate the METER with either Display 1 or Display 2, or to turn it off. If phase is being displayed in Display 2, a HI or LO annunciator lights to show the meter range.

Table A-1. Keycodes

Keypress	Function
[SHIFT] [B/A MAG]	A, B/A MAG
[SHIFT] [B-A PHASE]	B, B-A PHASE
[SHIFT] [REF SELECT]	LOAD
[SHIFT] [FORMAT]	DELAY
[SHIFT] [REF]	SAVE REF
[SHIFT] [LCL]	ADDRESS
[SHIFT] [LOCK RANGE]	VIEW RANGE
[SHIFT] [MAG RANGE]	DIR ANLG OUT
[SHIFT] [HOLD VALUE]	CAL TEST

Product Line Sales/Support Key

- Key Product Line
A Analytical
CM Components
C Computer Systems
E Electronic Instruments & Measurement Systems
M Medical Products
P Personal Computation Products
 * Sales only for specific product line
 ** Support only for specific product line

IMPORTANT: These symbols designate general product line capability. They do not insure sales or support availability for all products within a line, at all locations. Contact your local sales office for information regarding locations where HP support is available for specific products.

HEADQUARTERS OFFICES

If there is no sales office listed for your area, contact one of these headquarters offices.

NORTH/CENTRAL AFRICA

Hewlett-Packard S.A.
 7, rue du Bois-du-Lan
 CH-1217 MEYRIN 1, Switzerland
 Tel: (022) 83 12 12
 Telex: 27835 hmea
 Cable: HEWPACKSA Geneva

ASIA

Hewlett-Packard Asia Ltd.
 47/F, 26 Harbour Rd.,
 Wanchai, HONG KONG
 G.P.O. Box 863, Hong Kong
 Tel: 5-8330833
 Telex: 76793 HPA HX
 Cable: HPASIAL TD

CANADA

Hewlett-Packard (Canada) Ltd.
 6877 Goreway Drive
 MISSISSAUGA, Ontario L4V 1M8
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