

## Errata

**Title & Document Type:** 8782A Operating Manual

**Manual Part Number:** 08782-90013

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### HP References in this Manual

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

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**HP 8782B  
Vector Signal Generator  
Operating Manual  
1 MHz - 250 MHz**



**HP Part No. 08782-90013  
Printed in U.S.A.**



## Safety Considerations

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

This product is a Safety Class I instrument (provided with a protective earth terminal).

### Before Applying Power

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

### Safety Earth Ground

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

### Warning



**Any interruption of the protective (grounding) conductor (inside or outside the instrument) 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 the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.**

**If this instrument 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 electric shock, do not perform any servicing unless qualified to do so.**

**Adjustments described in the 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 fuseholders.**

**Safety Symbols**



Instruction manual symbol: The product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (see Table of Contents for page references).



Indicates hazardous voltages.



Indicates earth (ground) terminal.

**Warning**



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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.

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**Caution**



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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.

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## CERTIFICATION

*Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, (NIST), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.*

## WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

### LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

### EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

## ASSISTANCE

*Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.*

*For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.*

## HP 8782B

### Herstellerbescheinigung

Hiermit wird bescheinigt, dass dieses Gerät/System in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkenstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/System 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 meets the radio frequency interference requirements of Directive FTZ 1046/1984. The German Bundespost has been notified that this equipment was put into circulation and has been 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 measurements on open setups, the user must ensure that under these operating conditions, the radio frequency interference limits are met at the border of his premises.

## Contents

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<b>1. General Information</b>	
Introduction . . . . .	1-1
Description . . . . .	1-1
Safety Considerations . . . . .	1-3
Instruments Covered By This Manual . . . . .	1-3
Manual Changes Supplement . . . . .	1-4
Accessories Supplied . . . . .	1-4
Specifications . . . . .	1-4
Recommended Test Equipment . . . . .	1-11
<b>2. Installation</b>	
Introduction . . . . .	2-1
Initial Inspection . . . . .	2-1
Operator's Checks . . . . .	2-1
Power Requirements . . . . .	2-2
Line Voltage and Fuse Selection . . . . .	2-2
Selection of Operating Voltage . . . . .	2-3
Power Cables . . . . .	2-3
Hewlett-Packard Interface Bus (HP-IB) . . . . .	2-5
HP-IB Address Selection . . . . .	2-5
Interconnections . . . . .	2-5
Connecting the Generator into an HP-IB System . . . . .	2-5
Connectors . . . . .	2-6
Mating Connectors . . . . .	2-6
HP-IB Interface Connector . . . . .	2-6
Coaxial Connectors . . . . .	2-6
Type N Connectors . . . . .	2-7
Operating Environment . . . . .	2-7
Bench Operation . . . . .	2-7
Rack Mounting . . . . .	2-7
Storage and Shipment . . . . .	2-7
Environment . . . . .	2-7
Packaging . . . . .	2-8
Tagging for Service . . . . .	2-8
Original Packaging . . . . .	2-8
Other Packaging . . . . .	2-8
Operator's Maintenance Procedures . . . . .	2-9

<b>3. Local Operation</b>	
Introduction . . . . .	3-1
Turn-On Instructions . . . . .	3-1
Turn On Procedure . . . . .	3-1
Operator's Maintenance Procedures . . . . .	3-2
Front Panel Overview . . . . .	3-2
Display . . . . .	3-3
Function Selection . . . . .	3-3
Setup and Calibration Keys . . . . .	3-3
Clock Input Keys . . . . .	3-3
Data Input Keys . . . . .	3-3
Invert Data and Clock Input Keys . . . . .	3-3
Modulation Selection Key . . . . .	3-3
Error and Instrument Operation Messages . . . . .	3-3
I and Q Filters . . . . .	3-4
Local or HP-IB Address Display . . . . .	3-4
Set Frequency and Level . . . . .	3-4
Numeric Entry and Units . . . . .	3-4
Special Function . . . . .	3-4
Modulation and RF On/Off Controls . . . . .	3-4
Front Panel Connectors . . . . .	3-4
Data Inputs . . . . .	3-4
Scalar Inputs . . . . .	3-5
Clock Inputs . . . . .	3-5
IQ Vector Inputs . . . . .	3-5
RF Output . . . . .	3-5
Rear Panel Overview . . . . .	3-6
10 MHz IN and OUT . . . . .	3-6
AUX OUT . . . . .	3-6
EXT FILT IN and OUT . . . . .	3-6
COHERENT CARRIER . . . . .	3-7
PRBS . . . . .	3-7
FRAME CLOCK . . . . .	3-7
1 GHz OUTPUT . . . . .	3-7
Display Section . . . . .	3-9
Normal Numeric Operation . . . . .	3-9
Frequency Display . . . . .	3-9
Power Display . . . . .	3-9
Blank Display . . . . .	3-9
Operating Mode Information . . . . .	3-9
Status Annunciators . . . . .	3-9
Other Information . . . . .	3-9
Setup and Calibration Keys . . . . .	3-10
Preset <b>PRESET</b> . . . . .	3-10
Preset State. . . . .	3-10
Calibration <b>CAL</b> . . . . .	3-11
Selecting Self Calibration . . . . .	3-11
When to Calibrate . . . . .	3-11
Calibration Conditions . . . . .	3-11
Filter Calibration . . . . .	3-11
Calibration With Internal Filters . . . . .	3-12

Calibration With External Filters . . . . .	3-12
Method 1 . . . . .	3-12
Method 2 . . . . .	3-13
Method 3 . . . . .	3-13
Save <b>SAVE</b> . . . . .	3-14
Save Setup . . . . .	3-14
Recall <b>RECALL</b> . . . . .	3-14
Recall Setup . . . . .	3-14
Frequency, Levels, and Increments . . . . .	3-15
Set Frequency <b>SET FREQUENCY</b> . . . . .	3-15
Set Level <b>SET LEVEL</b> . . . . .	3-16
Back Space <b>BACK SP</b> . . . . .	3-17
Set Increment <b>SET INCR</b> . . . . .	3-17
Modulation Types . . . . .	3-18
Burst On <b>BURST ON</b> . . . . .	3-18
Scalar On <b>SCALAR ON</b> . . . . .	3-18
PRBS On <b>PRBS ON</b> . . . . .	3-19
RF Output On <b>RF OUTPUT ON</b> . . . . .	3-19
Modulation On <b>MODULATION ON</b> . . . . .	3-19
Modulation <b>MODULATION</b> . . . . .	3-19
Standard Modulation Types . . . . .	3-19
256QAM . . . . .	3-20
64QAM . . . . .	3-21
16QAM . . . . .	3-22
QPSK . . . . .	3-23
BPSK . . . . .	3-24
8PSK . . . . .	3-25
Special PRS Modulations . . . . .	3-25
VECTOR Modulation . . . . .	3-26
Data Keys . . . . .	3-30
General Data Information . . . . .	3-30
Data Terminations . . . . .	3-30
Data Level <b>DATA LEVEL</b> . . . . .	3-30
Serial Input <b>SERIAL INPUT</b> . . . . .	3-30
Serial Or Parallel Data . . . . .	3-30
Emitter Coupled Logic Data <b>ECL DATA</b> . . . . .	3-31
ECL Or Ground Termination . . . . .	3-31
Clock Keys . . . . .	3-31
General Clock Information . . . . .	3-31
Clock Setup Time . . . . .	3-31
Clock Hold Time . . . . .	3-31
Clock Terminations . . . . .	3-31
Clock Level <b>CLOCK LEVEL</b> . . . . .	3-31
External Clock <b>EXT CLK</b> . . . . .	3-32
Parallel Mode External Clocks . . . . .	3-32
Emitter Coupled Logic Clock <b>ECL CLK</b> . . . . .	3-32
ECL Or Ground Termination Clocks . . . . .	3-32
Serial Frame <b>SERIAL FRAME</b> . . . . .	3-33
External Or Internal Frame . . . . .	3-33
Pseudo Random Binary Sequence Clock <b>PRBS CLK</b> . . . . .	3-33
External Or Internal PRBS Clock . . . . .	3-33

External Divide Ratios And Internal Rates . . .	3-33
Invert Data and Clock Inputs . . . . .	3-34
Invert Input <b>(INVERT INPUT)</b> . . . . .	3-34
Inverting Parallel Inputs . . . . .	3-34
Clocks, Frames And Serial Input . . . . .	3-35
Example . . . . .	3-35
I and Q Filters . . . . .	3-36
External Filter <b>(EXT FILT)</b> . . . . .	3-36
Activating External Filters . . . . .	3-36
Local or HP-IB Address . . . . .	3-36
Local <b>(LOCAL)</b> . . . . .	3-36
Local And Displaying HP-IB Address . . . . .	3-36
Messages . . . . .	3-37
Message <b>(MESSAGE)</b> . . . . .	3-37
Message Annunciator Flashing . . . . .	3-37
New Messages . . . . .	3-37
Special Functions . . . . .	3-39
Special Function Key <b>(SPECIAL)</b> . . . . .	3-39
Special Function List . . . . .	3-39
Demo Mode: SPCL 0 DEMO . . . . .	3-39
Lock Step Attenuator: SPCL 1 LOCK STP ATT . . . . .	3-39
Divide Ratio For External PRBS: SPCL 2 PRBS CK DIV . . . . .	3-40
Clock Rate For Internal PRBS: SPCL 3 PRBS CK FREQ . . . . .	3-40
External Filter Correction On/Off: SPCL 4 FILT LOSS . . . . .	3-40
External I-Filter Correction: SPCL 5 I FILT LOSS . . . . .	3-40
External Q-Filter Correction: SPCL 6 Q FILT LOSS . . . . .	3-40
Carrier Leakage On/Off: SPCL 7 CAR LEAK . . . . .	3-40
Carrier Leakage Magnitude: SPCL 8 CAR LEAK MAG . . . . .	3-41
Carrier Leakage Angle: SPCL 9 CAR LEAK ANG . . . . .	3-41
Fade Simulation On/Off: SPCL 10 FADE . . . . .	3-41
Fade Ramp Deviation: SPCL 11 FADE RAMP . . . . .	3-41
Fade Ramp Frequency: SPCL 12 FADE FREQ . . . . .	3-42
Phase Bump: SPCL 13 10 MHZ PHASE . . . . .	3-42
Quadrature Error On/Off: SPCL 14 QUAD ADJUST . . . . .	3-42
Quadrature Error: SPCL 15 SET QUAD ADJ . . . . .	3-42
I/Q Gain Ratio On/Off: SPCL 16 IQ RATIO On/Off . . . . .	3-43
Set I/Q Gain Ratio: SPCL 17 SET IQ RATIO . . . . .	3-43
Special Modulation Formats: SPCL 18 EXTRA MOD . . . . .	3-43
Constellation Rotation On/Off: SPCL 19 CONSTL ROTAT . . . . .	3-44
Constellation Phase Rotation: SPCL 20 CONST ANGLE . . . . .	3-44
Baseband Calibration: SPCL 21 B-BAND CAL . . . . .	3-44
Level Calibration: SPCL 22 LEVEL CAL . . . . .	3-44
Null Calibration: SPCL 23 NULL CAL . . . . .	3-45

HP-IB Address: SPCL 24 HP-IB ADRS . . . . .	3-45
Display On/Off Control: SPCL 100 DISPLAY . . . . .	3-45
Display Software Version: SPCL 110 SW VERSION . . . . .	3-45
Service Voltmeter: SPCL 200 through 300 . . . . .	3-45
Direct Control: SPCL 300 I-BUS CTRL . . . . .	3-46
Game: SPCL 600 GAME . . . . .	3-46
Service Mode On/Off: SPCL 901 SERVICE MODE . . . . .	3-46
Initialize: SPCL 1000 INITIALIZE . . . . .	3-46
<b>4. Remote Operation</b>	
Introduction . . . . .	4-1
Introduction to Programming . . . . .	4-1
Addressing . . . . .	4-2
Interface Select Code (Selects Interface) . . . . .	4-2
Device Address (Selects Instrument) . . . . .	4-2
Command Types . . . . .	4-2
Common Commands . . . . .	4-2
Subsystem Commands . . . . .	4-2
Programming Syntax . . . . .	4-3
Command Header . . . . .	4-3
Query . . . . .	4-4
Program Data . . . . .	4-4
Numeric Data . . . . .	4-4
Special Form Numeric Data . . . . .	4-7
Character Data . . . . .	4-7
Boolean . . . . .	4-7
Standard Notation . . . . .	4-8
Long Form/Short Form . . . . .	4-8
Command Tables . . . . .	4-8
Command Syntax . . . . .	4-8
Status Reporting . . . . .	4-9
Status Byte Register . . . . .	4-9
Enabling Service Request . . . . .	4-11
TMSL Operation Status Group . . . . .	4-11
Standard Event Status Register . . . . .	4-11
Output Queue . . . . .	4-13
TMSL Questionable Data/Signal Register Group . . . . .	4-13
General HP-IB Information . . . . .	4-14
Remote, Local, and Local Lockout . . . . .	4-14
Interface Capabilities . . . . .	4-14
Summary of HP-IB Commands . . . . .	4-15
Common HP-IB Commands . . . . .	4-25
*CAL? (Calibration) . . . . .	4-26
*CLS (Clear Status) . . . . .	4-27
*ESE (Event Status Enable) . . . . .	4-28
*ESR? (Event Status Register Query) . . . . .	4-29
*IDN? (Identification Number) . . . . .	4-30
*IST? (Individual Status) . . . . .	4-31
*LRN? (Learn) . . . . .	4-32
*OPC (Operation Complete) . . . . .	4-33
*PRE (Parallel Poll Register Enable) . . . . .	4-34

*RCL (Recall) . . . . .	4-35
*RST (Reset) . . . . .	4-36
*SAV (Save) . . . . .	4-37
*SRE (Service Request Enable) . . . . .	4-38
*STB? (Status Byte) . . . . .	4-39
*TST? (Test) . . . . .	4-40
*WAI (Wait) . . . . .	4-41
AM Subsystem . . . . .	4-43
DEPT <sub>H</sub> . . . . .	4-44
FREQUency . . . . .	4-45
SOURce . . . . .	4-46
STATe . . . . .	4-47
Diagnostics Subsystem . . . . .	4-49
BBCal? . . . . .	4-50
LCAL? . . . . .	4-51
NULLcal? . . . . .	4-52
Digital Modulation Subsystem . . . . .	4-53
CLOCK:MODE . . . . .	4-57
CLOCK:SOURce . . . . .	4-58
COUPling:ALL . . . . .	4-59
COUPling:CLOCK . . . . .	4-60
COUPling:DATA . . . . .	4-61
DMODE (Data Mode) . . . . .	4-62
FILTer:CORRection:I . . . . .	4-63
FILTer:CORRection:Q . . . . .	4-65
FILTer:CORRection:STATe . . . . .	4-67
FILTer:SOURce . . . . .	4-68
FORMat . . . . .	4-69
FRAMe:SOURce . . . . .	4-70
IQRatio:MAGNitude . . . . .	4-71
IQRatio:STATe . . . . .	4-73
LEAKage:ANGLE . . . . .	4-74
LEAKage:MAGNitude . . . . .	4-76
LEAKage:STATe . . . . .	4-78
POLarity:ALL (Data Input Polarity) . . . . .	4-79
POLarity:I[n] (I Data Input Polarity) . . . . .	4-80
POLarity:Q[n] (Q Data Input Polarity) . . . . .	4-81
POLarity:ICLock . . . . .	4-82
POLarity:QCLOCK (Q Clock Polarity) . . . . .	4-83
POLarity:SERial:CLOCK . . . . .	4-84
POLarity:SERial:DATA . . . . .	4-85
POLarity:SERial:FRAMe . . . . .	4-86
QUADrature:ANGLE . . . . .	4-87
QUADrature:STATe (Quadrature Angle State) . . . . .	4-89
SOURce . . . . .	4-90
STATe . . . . .	4-91
THReshold:ALL (Data and Clock Threshold) . . . . .	4-92
THReshold:CLOCK . . . . .	4-93
THReshold:DATA . . . . .	4-95
Display Subsystem . . . . .	4-97
STATe (Display State) . . . . .	4-98

Frequency Subsystem . . . . .	4-99
CW . . . . .	4-100
MODE . . . . .	4-102
Output Control Subsystem . . . . .	4-103
IMPedance? . . . . .	4-104
STATe . . . . .	4-105
Phase Subsystem . . . . .	4-107
OUTPut:ADJust (Output Phase Adjust) . . . . .	4-108
OUTPut:STATe (Output Phase State) . . . . .	4-110
RSIGnal:ADJust (10 MHz Adjust) . . . . .	4-111
POWER Subsystem . . . . .	4-115
ATTenuation:AUTO . . . . .	4-116
LEVel:IMMediate:AMPLitude . . . . .	4-117
MODE . . . . .	4-120
UNIT . . . . .	4-121
Pseudo-Random Binary Sequence (PRBS) Subsystem . . . . .	4-123
CLOCK:POLarity . . . . .	4-124
CLOCK:SOURce . . . . .	4-125
DIVide . . . . .	4-126
FREQuency . . . . .	4-127
Pulse Modulation Subsystem . . . . .	4-129
POLarity . . . . .	4-130
STATe . . . . .	4-131
Status Subsystem . . . . .	4-133
Introduction . . . . .	4-133
Condition Register . . . . .	4-133
Transition Filters . . . . .	4-133
Event Register . . . . .	4-133
Event Enable Register . . . . .	4-133
OPERation:CONDition? . . . . .	4-135
OPERation:ENABLe . . . . .	4-136
OPERation:EVENT? . . . . .	4-137
OPERation:NTRansition (Negative Transition) . . . . .	4-138
OPERation:PTRansition (Positive Transition) . . . . .	4-139
QUESTionable:CONDition? . . . . .	4-140
QUESTionable:ENABLe . . . . .	4-141
QUESTionable:EVENT? . . . . .	4-142
QUESTionable:NTRansition (Negative Transition) . . . . .	4-143
QUESTionable:PTRansition (Positive Transition) . . . . .	4-144
System Subsystem . . . . .	4-145
ERRor? . . . . .	4-146
KEY . . . . .	4-148
Vector Modulation Subsystem . . . . .	4-151
QUADrature:ANGLE . . . . .	4-152
QUADrature:STATe (Quadrature Angle State) . . . . .	4-154
STATe . . . . .	4-155

<b>5. Performance Tests</b>	
Introduction . . . . .	5-1
Equipment Required . . . . .	5-1
Performance Test Record . . . . .	5-1
Performance Tests . . . . .	5-2
Calibration Cycle . . . . .	5-2
Operator's Checks . . . . .	5-2
Test Procedures . . . . .	5-2
Frequency Aging Rate, Range, and Resolution . . . . .	5-3
RF Output Level Accuracy, Flatness and Maximum Leveled Power . . . . .	5-7
Residual FM . . . . .	5-12
RF Switch On/Off Ratio . . . . .	5-14
Harmonics . . . . .	5-16
Non-Harmonically Related Spurious Responses . . . . .	5-19
Residual SSB Phase Noise . . . . .	5-22
Pulse (Burst) Modulation . . . . .	5-27
Parallel Clock and Data Rates . . . . .	5-31
Serial Clock and Data Rates . . . . .	5-44
Scalar DC Residual . . . . .	5-50
Scalar Frequency Response . . . . .	5-52
PRBS Clock Rates . . . . .	5-55
Digital Modulation DC Accuracy . . . . .	5-61
Scalar Modulation DC Accuracy . . . . .	5-77
Vector Modulation DC Accuracy . . . . .	5-106
Vector Modulation Frequency Response . . . . .	5-112
<b>A1. HP 8780A Compatibility Commands</b>	
<b>A2. Error Messages</b>	
Introduction . . . . .	A2-1
<b>A3. HP 8782B Block Diagrams</b>	
Introduction . . . . .	A3-1
<b>Index</b>	

## Figures

---

1-1. HP 8782B with Accessories and Options . . . . .	1-2
2-1. Line Voltage and Fuse Selection . . . . .	2-3
2-2. Power Cable and Line (Mains) Plug Part Numbers . . . . .	2-4
2-3. Hewlett-Packard Interface Bus Connection . . . . .	2-5
3-1. Front Panel Features . . . . .	3-2
3-2. Rear Panel Features . . . . .	3-6
3-3. Display Features . . . . .	3-9
3-4. Setup and Calibration Keys . . . . .	3-10
3-5. Frequency, Level and Increment Keys . . . . .	3-15
3-6. Numeric Keys . . . . .	3-16
3-7. Output Switches . . . . .	3-18
3-8. 256QAM Modulation . . . . .	3-20
3-9. 64QAM Modulation . . . . .	3-21
3-10. 16QAM Modulation . . . . .	3-22
3-11. QPSK Modulation . . . . .	3-23
3-12. BPSK Modulation . . . . .	3-24
3-13. 8PSK Constellation . . . . .	3-25
3-14. Arbitrary Vector Modulation . . . . .	3-26
3-15. Modulation Format Constellations . . . . .	3-27
4-1. Status Reporting Structure Overview . . . . .	4-10
5-1. Frequency Test Setup . . . . .	5-4
5-2. RF Level Test Setup . . . . .	5-8
5-3. Residual FM Test Setup . . . . .	5-12
5-4. RF Switch On/Off Ratio Test Setup . . . . .	5-14
5-5. Harmonics Test Setup . . . . .	5-16
5-6. Non-Harmonically Related Spurious Responses Test Setup . . . . .	5-19
5-7. Residual SSB Phase Noise Test Setup . . . . .	5-23
5-8. Pulse (Burst) Modulation Test Setup . . . . .	5-27
5-9. Asynchronous Data Rates Test Setup . . . . .	5-32
5-10. Good 10 MHz Asynchronous Data Rate . . . . .	5-33
5-11. Good 50 MHz Asynchronous Data Rate . . . . .	5-34
5-12. Parallel Clock Data Rate Test Setup . . . . .	5-35
5-13. Good 10 MHz Single Clock Data Rate . . . . .	5-38
5-14. Failed Clock Rate Signal . . . . .	5-39
5-15. Good 100 MHz Single Clock Data Rate . . . . .	5-39
5-16. Good 10 MHz Dual Clock Data Rate . . . . .	5-41
5-17. Failed Dual Clock Data Rate . . . . .	5-42
5-18. Good 100 MHz Single Clock Data Rate . . . . .	5-42
5-19. Serial Clock and Data Rates Test Setup . . . . .	5-44
5-20. Example of a good 40 MHz serial test spectrum . . . . .	5-46
5-21. Example of a good serial test spectrum . . . . .	5-47

5-22. Example of a bad serial test spectrum . . . . .	5-48
5-23. Example of a good serial test oscilloscope trace . .	5-49
5-24. DC Residual Test Setup . . . . .	5-50
5-25. Frequency Response Test Setup . . . . .	5-52
5-26. Good Frequency Response Signal . . . . .	5-54
5-27. PRBS Clock Rates Test Setup . . . . .	5-55
5-28. Good 10 MHz PRBS Clock Frequency Example .	5-57
5-29. Good PRBS External Clock Rates . . . . .	5-59
5-30. Failed PRBS External Clock Rates . . . . .	5-60
5-31. Digital Modulation DC Accuracy Test Setup . . .	5-61
5-32. Scalar Modulation DC Accuracy Test Setup . . .	5-78
5-33. Vector dc Accuracy Test Setup . . . . .	5-107
5-34. Vector Frequency Response Test Setup . . . . .	5-113

## Tables

---

1-2. Recommended Test Equipment . . . . .	1-12
2-1. Fuse Ratings and Part Numbers . . . . .	2-2
2-2. HP-IB Cables Available . . . . .	2-6
3-1. Comparison of External Filter Calibration Techniques	3-12
4-1. HP 8782B Suffixes for Numeric Data . . . . .	4-5
4-2. Standard Event Status Register . . . . .	4-12
4-3. Questionable Data Register . . . . .	4-13
4-4. HP 8782B IEEE 488.2 Common Commands . . . . .	4-15
4-5. AM Subsystem Commands . . . . .	4-16
4-6. Diagnostics Subsystem Commands . . . . .	4-16
4-7. Digital Modulation Subsystem Commands . . . . .	4-17
4-8. Display Subsystem Commands . . . . .	4-19
4-9. Frequency Subsystem Commands . . . . .	4-20
4-10. Output Control Subsystem . . . . .	4-20
4-11. Phase Subsystem Commands . . . . .	4-21
4-12. Power Subsystem Commands . . . . .	4-21
4-13. Pseudo-Random Binary Sequence Commands . . . . .	4-22
4-14. Pulse Modulation Subsystem Commands . . . . .	4-22
4-15. Status Subsystem Commands . . . . .	4-23
4-16. System Subsystem Commands . . . . .	4-23
4-17. Vector Modulation Subsystem Commands . . . . .	4-24
4-18. Diagnostics Subsystem Commands . . . . .	4-49
4-18. Vector Modulation Subsystem Commands . . . . .	4-151
5-1. Level Accuracy Results . . . . .	5-10
5-2. Harmonics Results . . . . .	5-18
5-3. Spurious Responses Results . . . . .	5-20
5-4. Additional Spurious Responses . . . . .	5-21
5-5. Network Analyzer Settings . . . . .	5-62
5-6. 8PSK Results . . . . .	5-64
5-7. 256QAM Results . . . . .	5-66
5-8. 8PSK Magnitude Error Worksheet . . . . .	5-68
5-9. 8PSK Phase Error Worksheet . . . . .	5-69
5-10. 8PSK Corrected Measurement Worksheet . . . . .	5-70
5-11. 256QAM Magnitude Error Worksheet . . . . .	5-71
5-12. 256QAM Phase Error Worksheet . . . . .	5-72
5-13. 256QAM Corrected Measurement Worksheet . . . . .	5-73
5-14. Network Analyzer Settings . . . . .	5-79
5-15. 16QAM Results (Scalar Off) . . . . .	5-81
5-16. 16QAM Results (Scalar = 1.0 V) . . . . .	5-83
5-17. 16QAM Measurement Worksheet (1.0 V) . . . . .	5-84
5-18. 16QAM Results (Scalar = 0.33 V) . . . . .	5-86
5-19. 16QAM Measurement Worksheet (0.33 V) . . . . .	5-87
5-20. 16QAM Results (Scalar = 0.10 V) . . . . .	5-89

5-21. 16QAM Measurement Worksheet (0.10 V) . . . .	5-90
5-22. 16QAM Magnitude Error Worksheet (Scalar Off) .	5-93
5-23. 16QAM Phase Error Worksheet (Scalar Off) . . .	5-94
5-24. 16QAM Corrected Measurement Worksheet (Scalar Off) . . . . .	5-96
5-25. 16QAM Magnitude and Phase Worksheet (Scalar = 1.0 V) . . . . .	5-97
5-26. 16QAM Corrected Measurement Worksheet (Scalar = 1.0 V) . . . . .	5-98
5-27. 16QAM Magnitude and Phase Worksheet (Scalar = 0.33 V) . . . . .	5-99
5-28. 16QAM Corrected Measurement Worksheet (Scalar = 0.33 V) . . . . .	5-100
5-29. 16QAM Magnitude and Phase Worksheet (Scalar = 0.10 V) . . . . .	5-101
5-30. 16QAM Corrected Measurement Worksheet (Scalar = 0.10 V) . . . . .	5-102
5-31. Performance Test Record . . . . .	5-117

## General Information

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### Introduction

The HP 8782B Vector Signal Generator operating and service information consists of an *Operating Manual* and a *Service Manual*. These two volumes contain all the information required to install, operate, test, adjust and service the HP 8782B. The HP 8782B Vector Signal Generator will be referred to as the "Generator" throughout the documentation. The Operating Manual, which is shipped with each instrument, has five chapters:

- Chapter 1    General Information
- Chapter 2    Installation
- Chapter 3    Local Operation
- Chapter 4    Remote Operation
- Chapter 5    Performance Tests

The Service Manual, which is shipped with the instrument as Option 915 or ordered separately, has four chapters:

- Chapter 1    Adjustments
- Chapter 2    Replaceable Parts
- Chapter 3    Manual Updates
- Chapter 4    Service

Additional copies of the Operating Manual or the Service Manual can be ordered separately through your nearest Hewlett-Packard office. The part numbers are listed on the title page of this manual.

---

### Description

The Generator is a synthesized signal Generator operating from 1 MHz to 250 MHz (typically to 350 MHz). It has a wide variety of precision digital modulation capabilities including BPSK, QPSK, 8PSK, 16QAM, 64QAM, 256QAM, 9PRS, 25PRS, 49PRS, 81PRS and high performance vector modulation (arbitrary I in-phase and Q quadrature components).

An unmodulated coherent carrier is provided for demodulating IF signals. Self-calibration at the touch of a button ensures standardized, calibrated performance.

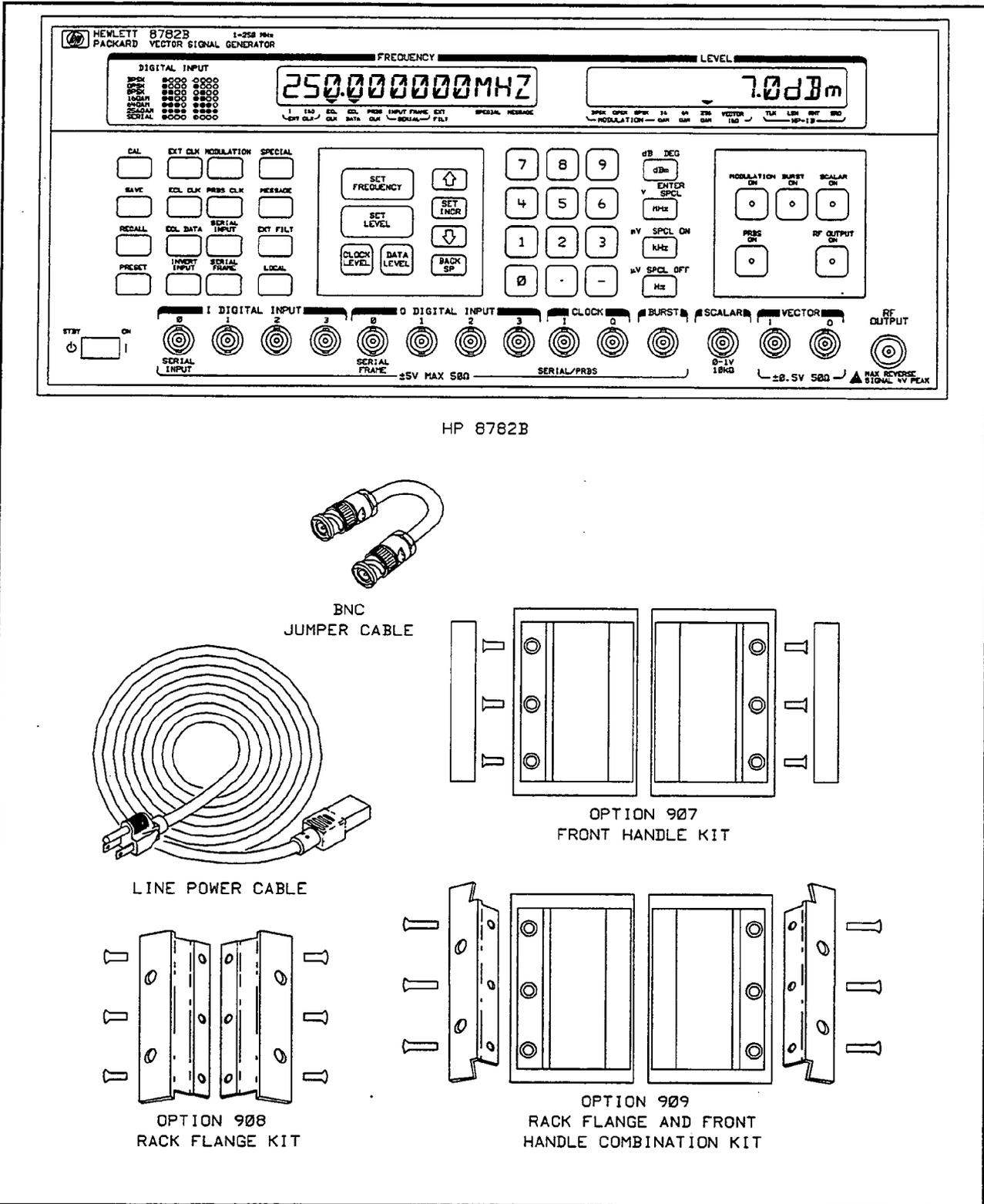


Figure 1-1. HP 8782B with Accessories and Options

The Generator includes an internal digital modulation source of the Pseudo Random Binary Sequence (PRBS) pattern (sequence length  $2^{23} - 1$  with taps at states 18 and 23) to provide the user with a random bit sequence. The generated pattern is one of the recognized PRBS sequences adopted by the International Telegraph and Telephone Consultative Committee (CCITT).

The Generator may be externally modulated either by serial data at clock speeds up to 200 bits per seconds, by parallel data, at clock speeds up to 100 symbols per second, or by two analog signals in vector modulation mode.

A variety of impairments may be selected when using digital modulation to test digital radio performance, such as fading, ability to operate with severe quadrature error, carrier insertion (at an arbitrary angle with respect to the modulation), and constellation rotation. The state accuracy at 256QAM is better than 1%.

---

## Safety Considerations

This product is a Safety Class I instrument, meaning, one that is provided with a protective earth terminal. The Generator and all related documentation should be reviewed for familiarization with safety markings and instructions before operation. Refer to the "Safety Considerations" page found at the beginning of this manual for a summary of the safety information. Safety information for installation, operation, and performance testing, is found in appropriate places throughout this manual.

---

## Instruments Covered By This Manual

Attached to the rear panel of the instrument is a serial number identification label. The serial number is in the form: 0000A00000. The first four digits and the letter are the serial number prefix. The last five digits are the suffix. The prefix is the same for identical instruments; it changes only when a configuration change is made to the instrument. The suffix however, is assigned sequentially and is different for each instrument.

---

## Manual Changes Supplement

In addition to updated information, Manual Changes supplements may also provide corrections to errors in manuals.

Manual Changes supplements may be obtained by contacting your nearest Hewlett-Packard Sales office. To receive the correct documentation for your product, you will need to provide the instrument's name, model number, and serial number.

For information concerning a serial number prefix not listed on the title page, or in the Manual Changes supplement, contact your nearest Hewlett-Packard Sales office.

---

## Accessories Supplied

The accessories supplied with the Generator are shown in figure 1-1.

- One short BNC cable, HP 86071-60003. This cable must be used to connect the 10 MHz TIME BASE OUT to the TIME BASE IN connector, unless an external time base is being used. If an external time base is used the TIME BASE SWITCH must be changed from INT to EXT, and the external time base connected to the 10 MHz TIME BASE IN. See chapter 2, "Interconnections".
- The power line cord is supplied in several different configurations, depending on the destination of the original shipment. Refer to "Power Cables" in chapter 2 of this manual.
- An additional fuse is shipped only with instruments that are factory configured for 100/120 Vac operation. This fuse has a 3.0A rating and is for 220/240 Vac operation.

---

## Specifications

To provide the maximum amount of information about the usefulness and flexibility of this instrument, the following performance specifications and supplemental characteristics are listed. SPECIFICATIONS describe the instrument's warranted performance immediately after calibration. *SUPPLEMENTAL CHARACTERISTICS* are intended to provide information useful in applying the instrument, by giving typical, but non-warranted, performance. *SUPPLEMENTAL CHARACTERISTICS* are in italics and are denoted as "typical" or "nominal".

Table 1-1. Specifications

**Frequency**

<b>Range:</b>	1 MHz to 250 MHz. <i>1 MHz to 350 MHz, typical</i>
<b>Resolution:</b>	1 Hz
<b>Accuracy and Stability:</b>	Same as reference oscillator.
<b>Frequency Switching Time:</b>	<i>Typically &lt;170 ms.</i>

**Internal Reference Oscillator**

<b>Aging Rate:</b>	Less than $1.5 \times 10^{-9}$ /day after 10 day warm-up for internal reference. <i>Typically less than <math>1.5 \times 10^{-9}</math>/day after 24 hour warm-up in normal operating environment.</i>
<b>Temperature Effects:</b>	<i>Typically less than <math>1 \times 10^{-7}</math> per °C</i>
<b>Line Voltage Effects:</b>	<i>Typically less than <math>1 \times 10^{-8}</math> for +5%, -10% change in line voltage.</i>

**RF Output Level**

<b>Level Range:</b>	+7 to -100 dBm, <i>+10 dBm typical</i>
<b>Accuracy:</b>	$\pm 1.5$ dB for levels $\geq -30$ dBm. $\pm 2.0$ dB for levels $< -30$ dBm to $\geq -80$ dBm. $\pm 2.4$ dBm for levels $< -80$ dBm.
<b>Flatness:</b>	$< \pm 1$ dB.
<b>Resolution:</b>	0.1 dB
<b>Residual Output With RF Switch Off:</b>	More than 60 dB below the selected level (for levels $> -40$ dBm).
<b>Output SWR:</b>	<i>Typically &lt; 1.3:1</i>
<b>Output impedance:</b>	<i>50 ohms nominal.</i>

**Coherent Carrier Output**

The coherent carrier provides a reference signal for demodulating the HP 8782B output. It is an unmodulated and unlevelled version of the front panel RF output.

<b>Frequency range:</b>	1 MHz to 250 MHz
<b>Output Level:</b>	<i>Typically +10 dBm from 1 MHz to 150 MHz. Typically +8.5 dBm at frequencies &gt; 150 MHz</i>
<b>Output Impedance:</b>	<i>50 ohm nominal.</i>

**Harmonics:** *Typically  $< -35$  dBc*

**1 GHz Local Oscillator Output (Option 001)**

**Frequency:** 1 GHz

**Accuracy and Stability:** Same as reference oscillator

**Output Level** *Typically 10 dBm*

**Non-Harmonically Related Spurious:**  *$< 60$  dBc for spurious frequencies  $< 2$  GHz, typical*

**Spectral Purity**

**Residual SSB Phase Noise in a 1 Hz BW**

Offset From Carrier	At 140 MHz Carrier (dBc)	1 MHz to 250 MHz (dBc) Typical
1 kHz	-115	-125
10 MHz	-125	-130

**Harmonics:**  $< -30$  dBc

**Non-Harmonic Spurious Signals:**  $< -55$  dBc from 1 MHz to 2 GHz at output levels  $> -40$  dBm

**Residual FM:**  $< 4$  Hz RMS for 300 Hz to 3 kHz bandwidth.

**Digital Modulation**

**Modulation Types:** BPSK, QPSK, 8PSK, 16QAM, 64QAM, 256QAM, 9PRS, 25PRS, 49PRS, 81PRS.

**Clock Modes:** Single, I clock clocks both I and Q channels  
Separate I and Q clocks  
Asynchronous

**Parallel Data Rates:** (Drive signal rise times should be  $< 1.0$   $\mu$ s)  
0 to 100 MHz, clocked.  
0 to 50 MHz, asynchronous.

**Serial Data Rates:** (Drive signal rise times should be  $< 1.0$   $\mu$ s)  
0 to 200 MHz clock and data lines,

**Modulation Symbol Rate (MHz)**

QPSK	0-100
16QAM	0-50
64QAM	0-30
256QAM	0-25

**Data Input Thresholds (I, Q and Burst) for ECL Terminations:** *Preset to  $-1.3V$ , typical.*

**Data Input Thresholds (I, Q and Burst) for TTL or Grounded Terminations:** *Adjustable typically from  $-2.5V$  to  $+2.5V$*

**Clock Input Thresholds (I or Q Clocks) for ECL Terminations:** *Preset to  $-1.3V$ , typical.*

**Clock Input Thresholds (I or Q Clocks) for Grounded Terminations:** *Adjustable typically from  $-2.5V$  to  $+2.5V$ .*

**Data, Clock and Burst Drive Requirements:** *Typically  $0.3$  to  $3.0V$  peak-to-peak.*

**Data Timing Requirements (With Respect To Selected Clock):**

**Set Up Time:** *Typically  $> 2.5$  ns*

*The data must be valid  $> 2.5$  ns before the clock edge is received.*

**Hold Time:** *Typically  $> 2.5$  ns*

*The data must be valid  $> 2.5$  ns after the clock edge is received.*

**Data, Clock and Burst Input Impedances:** *50 ohms nominal.*

**State DC Accuracy:**  *$\pm 1\%$  of full scale I and Q values, at 70 MHz. Typically  $\pm 2\%$  of full scale I and Q values following calibration at  $25^{\circ}C$  and  $< 5^{\circ}C$  temperature change.*

**Data Skew and Asymmetry:**

Clock Type	Typical P-P Data Skew	Typical P-P Asymmetry
Asynchronous:	$< 1.5$ ns	$< 1.5$ ns
One Clock:	$< 0.75$ ns	$< 1.0$ ns
Two Clocks:	$< 0.75$ ns	$< 1.0$ ns
Burst:	$< 1.5$ ns	$< 1.5$ ns

**Spectrum Filters:** *Internal baseband spectrum limiting filters with a nominal bandwidth of 74 MHz (60 Mbaud) limit aliasing. User supplied baseband filters may be connected at rear panel connectors and switched by front panel control into the baseband signal path in*

place of the internal filters. External filters must have 50 ohms nominal impedance and a maximum passband loss of 3 dB for proper operation. The Generator calibration will properly calibrate for external filter loss provided the external filter passband extends to dc and the maximum passband loss is 3 dB. For ac coupled filters, a loss factor between 0 and 3 dB may be entered manually.

#### Pulse (Burst) Modulation

<b>Burst Rates:</b>	0 to 50 MHz.
<b>Burst dc On/Off Ratio:</b>	50 dB at 70 MHz carrier. <i>Typically 40 dB following calibration at 25 °C and &lt;5 °C temperature drift from 1 to 250 MHz</i>
<b>Burst Rise/Fall Times:</b>	<i>Typically less than 2.2 ns (10% to 90%) using external filter mode, and short 50 ohm BNC cables HP 10502A's in place of filters at the filter terminals.</i>
<b>Minimum Output Pulse Width:</b>	<i>Typically &lt; 8 ns.</i>

#### Simultaneous Modulations

<b>Scalar:</b>	Pulse (Burst) and Scalar modulations available with all digital formats.
----------------	--

#### AM/Scalar Modulation

<b>Sensitivity:</b>	0 to +1V for 0 to full set output power. Output RF voltage varies directly as scalar input control voltage.
<b>Scalar DC Accuracy (at 70 MHz carrier):</b>	<1% of full scale input for 0 to 10 dB of attenuation. <i>Typically 1.5 % of full scale input for 0 to 10 dB attenuation following calibration at 25° C and &lt;5° C temperature drift.</i> <2% for 10 dB to 20 dB of attenuation. <i>Typically &lt;2% at all carrier frequencies.</i>
<b>Scalar DC Residual:</b>	(Residual I and Q Output for 0 Volts Input) <1% of full scale I and Q at 70 MHz carrier. <i>Typically the same at all carrier frequencies.</i>
<b>Scalar Frequency Response:</b>	Dc to 50 kHz (-3 dB) at 70 MHz carrier frequency.
<b>Scalar Input Impedance:</b>	<i>Input impedance 10 kΩ, nominal.</i>

**AM Modulation:** Traditional amplitude modulation (with unmodulated carrier levels 6 dB below the selected output level, and depths from 0% to 99%) is generated when a 0.5V dc offset is added to the scalar input. 0V to 1V applied to the scalar input scales the output from off to full scale.

#### Vector Modulation (Using analog I and Q inputs)

**Vector dc Accuracy:** at 140 MHz: 1.5% of full scale vector inputs.  
*Typically 2% following calibration at 25°C and <5°C temperature change*

**Vector dc Residual:** at 140 MHz: 1% of full scale vector inputs.  
*Typically 1.3% following calibration at 25°C and <5°C temperature change*

**Sensitivity:**  $\pm 0.5V$  into  $50\Omega$  with  $50\Omega$  source impedance for  $\pm 100\%$  of full scale magnitude

**Input Impedance:**  $50\Omega$  nominal

**SWR:**  $<1.5:1$ , dc to 50 MHz, typical

#### PRBS

Internal Pseudo Random Binary Sequence generator with a  $2^{23}-1$  sequence length.

**Internal Clock Rates:** 1.125, 2.5, 5 and 10 MHz.

**External Clock Rates:** Up to 100 MHz.  
*Typical external clock rates: Up to 200 MHz.*

#### Digital Modulation Impairments

##### Constellation Phase

**Rotation:**  
**Range:**  $\pm 30^\circ$ , typical.

**Quadrature Adjustment:**  
**Range:**  $90^\circ \pm 45^\circ$  typical.

**Resolution:**  $0.1^\circ$ , typical

**Accuracy:**  $\pm 0.2^\circ$  80 to  $100^\circ$  typical.

##### I To Q Amplitude

##### Imbalance:

**I-Q Range:**  $\pm 40$  dB  
Where  $Imag \leq 0$  dB (Calibrated full scale)  
or,  
 $Qmag \leq 0$  dB (Calibrated full scale)

**Carrier Leakage:** Typically  $<-10$  dB angle  $\pm 360^\circ$ .

**Vector Modulation Impairments**

**Quadrature Adjustments:** *Typically 80° to 100° ±0.2° accuracy.*

**Filter I and Q Inputs**

Analog signals may be applied directly to the I and Q modulator through the "external filter input" connectors on the rear panel.

**Frequency Response:** *Typically dc to 0.5 dB down at 40 MHz.*

**Sensitivity:** +0.12 ±0.02V with 50 ohm source impedance for + 100% of full scale magnitude.  
-0.12 ±0.02V with 50 ohm source impedance for -100% full scale magnitude.

**Input Impedance:** *50 ohms nominal.*

**SWR:** *Typically <1.5:1*

**Residual DC Offset Voltage:** *Typically <10 mV*

**I TO Q Channel Gain Imbalance:** *Typically <2 dB*

**Internal RF Level Control:** *Nominally 0.1 dB steps*

**Remote Programming**

All functions are HP-IB programmable except the line switch and bus address. The HP 8782B can output over the interface almost all settings, error/malfunction codes and operational status codes.

**Interface Functions:** SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT0, C0, E2.

**General**

**Operating temperature Range:** 0°C to +55°C.

**Operating And Non-operating Environment:** Exceeds MIL-T-28800C Class V requirements for operating and non-operating temperature, humidity, shock and vibration.

**EMI:** Conducted and radiated interference is within the requirements of CE03, CS01, CS02, CS06, RE02, RS01 and RS03 of MIL-STD-461B. It is also within the requirements of VDE 0871/1978, Level B and CISPR publication 11 (1975).

**Recalibration And Warmup Time:** To achieve specified performance the generator should be calibrated after at least 1 hour warm up. For critical tests, calibration just prior to making measurements is

HP 8782B

## General Information

recommended. The generator should be calibrated after any temperature change of more than  $\pm 5^{\circ}\text{C}$  and, for best results, after every 4 hours of operation.

**Power Requirements:** 48 to 66 Hz 100, 120, 220 or 240 Vac (+5%, -10%)  
360 to 440 Hz 100 or 120 Vac (+5%, -10%)  
500 VA max. *360 VA typical.*

**Acoustic Noise Emission** LpA <70 dB(A) per ISO 3744  
*LpA Operation position ... 47 dB*  
*LpA Bystander position ... 44 dB*

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**Recommended Test Equipment**

Equipment required for the performance test procedures is listed in table 1-2, "Recommended Test Equipment." For equipment required for each individual test procedure, refer to the individual test procedure. Except where noted, any equipment that satisfies the critical specifications give in the table may be substituted for the recommended model.

Table 1-2. Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model	Use <sup>1</sup>
Amplifier (Low Noise)	40 dB Gain < 3 dB Noise Figure 50Ω Input and Output Impedance 1 KHz-10 MHz Bandwidth	HP 11729-60014 or HP 8640-60506	P
Attenuator	Attenuation: 10 ±0.6 dB or 20 ±0.6 dB SWR: dc to 8 GHz < 1.2:1	HP 8491A Opt.010 and Opt.020 (Quantity 3)	P
Digital Voltmeter	Range: -25 to +25 Vdc Accuracy: ±0.1% of reading Resolution: 0.001 Vdc	HP 3456A	P
Frequency Counter	Range: 0.9 MHz to 251 MHz Resolution: 0.9 MHz to 251 MHz: 1 Hz Sensitivity: 0.9 MHz to 251 MHz: -10 dBm	HP 5343A	P,T,O
Frequency Standard	Long Term Stability: Better than $1 \times 10^{-10}$ /day Frequency: 10 MHz	HP 5065A	P
Pulse/Function Generator	Frequency Range: 5 kHz to 50 kHz Amplitude: 400 mV pk Flatness: < 1.0 dB over frequency range DC Offset: 0 to 500 mV	HP 8116A	P,O
Mixer	RF and LO Frequency Range: 90 to 190 MHz IF Frequency Range: dc to 50 MHz Double Balanced	Watkins-Johnson <sup>2</sup> M1G or Mini-Circuits <sup>3</sup> ZFM-3	P
Measuring Receiver	Frequency Range: 50 MHz to 250 MHz Measure FM Function Post detection filters 300 Hz high pass 3.0 kHz low pass Response: rms  Measure Level Function Power Range: +7 to -100 dBm	HP 8902A	O,P
Network Analyzer	70 MHz polar display CW sweep mode Real/Imaginary linear marker readout A/B measurement Accuracy: 0.02%	HP 8753A or HP 8753B or HP 8753C	P

Table 1-2. Recommended Test Equipment (continued)

Instrument	Critical Specifications	Recommended Model	Use <sup>1</sup>
Oscilloscope	Bandwidth 500 MHz Two Channel Display Vertical Sensitivity: 10 mV/div Vertical Input: 50 $\Omega$ impedance dc coupled Time base: 1 ns/div External Trigger: from channel 1 or 2	HP 54100A/D or HP 54110D or HP 54111A/D	P
Power Meter	Range: +10 dBm to -25 dBm Accuracy: $\pm 0.13$ dB Relative Measurement Capability	HP 437B or HP 438A	P,O
Power Sensor	Frequency Range: 1 MHz to 250 MHz Input Impedance: 50 $\Omega$ Flatness: $\pm 0.2$ dB SWR: < 1.20 Power Range: -30 to +20 dBm (1 $\mu$ W to 100 mW)	HP 8482A	P,O
Power Supply	Output: +15 Vdc and -15 Vdc Ripple: < 0.01% Noise: < 200 $\mu$ Vrms	HP 6234A or HP 6502C	P
Sensor Module	Frequency: 70 MHz Level: +10 dBm to -100 dBm	HP 11722A or HP 11792A	P,O
Synthesized RF Signal Generator	Frequency: 10 MHz to 250 MHz Level: +10 dBm to -50 dBm in 1 dB steps Resolution: 1 Hz Single Sideband Phase Noise and Spurious Signals: $\geq 6$ dB better than vector signal generator specification	HP 8662A or HP 8663A	P,O
Spectrum Analyzer	Frequency Response: 1 MHz to 2 GHz Flatness: 1 dB in 500 kHz range around 70 MHz Frequency Span per Division: 10 Hz to 200 MHz Amplitude Range: 0 to -80 dB Peak Search Function Delta Marker Measurement Function Noise Sidebands: > 75 dB down 30 kHz from signal at 1 kHz resolution bandwidth	HP 8566B	P,O
Spectrum Analyzer	Center Frequency: 10 Hz to 10 KHz 1 Hz normalized bandwidth measurement capability Sensitivity: 10 dB per division Dynamic Range: 130 dB Residual Phase Noise: 8 dB better than vector signal generator specification	HP 3561A or HP 3582A	P
<sup>1</sup> A = Adjustments, P = Performance Tests, T = Troubleshooting, O = Operator's Checks <sup>2</sup> Watkins-Johnson Co., 3333 Hillview Avenue Palo Alto, California 94304-1204, Tel. (415) 493-4141 <sup>3</sup> Mini-Circuits, Inc., Post Office Box 350166, Brooklyn, New York 11235-0003, Tel. (718) 934-4500			



## Installation

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### Introduction

This chapter provides the information needed for installation of the instrument. Included is information pertinent to initial inspection, power requirements, line voltage selection, power cables, interconnection, environment, instrument mounting, storage, and shipment. Information on setting the HP-IB address is provided.

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### Initial Inspection

#### Warning



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**To avoid hazardous electrical shock, do not turn on the instrument when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, display).**

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Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in figure 1-1. Procedures for checking electrical performance are given in chapter 5. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged, or the cushioning material shows signs of unusual stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

---

### Operator's Checks

Operator's Checks are procedures designed to verify the proper operation of the instrument's main capabilities. These procedures can be found in the "Performance Tests" portion of this manual (chapter 5).

## Power Requirements

### Warning



To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz. Leakage currents at these line settings may exceed 3.5 mA.

This is a Safety Class I product (that is, it is provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals through the power cable or supplied power cable set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an external autotransformer, make sure the autotransformer's common terminal is connected to neutral (that is, the grounded side of the line (Mains) supply.)

The instrument requires a power source of 100, 120, 220, or 240 Vac, +5% to -10%, 48 to 66 Hz single phase. The Generator has the additional capability of operating with of 360 to 440 Hz. However, operation at line frequencies greater than 66 Hz is limited to a line voltage of 90 to 126 Vac. Power consumption is 500 VA maximum, 360 VA typical.

## Line Voltage and Fuse Selection

### Caution



Before plugging this instrument into the Mains (line) voltage, ensure that the correct operating voltage and fuse have been selected.

Verify that the line voltage selection switches and the fuse are matched to the power source. See figure 2-1, Line Voltage and Fuse Selection. All fuses are non-time delay fuses.

**Table 2-1. Fuse Ratings and Part Numbers**

Line Voltage	Rating	HP Part Number
100/120V	5.0A	HP 2110-0010
220/240V	3.0A	HP 2110-0003

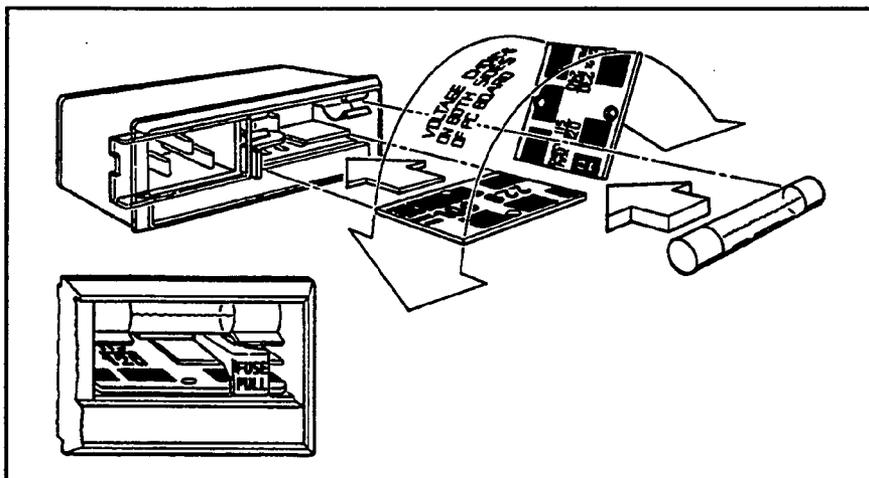


Figure 2-1. Line Voltage and Fuse Selection

### Selection of Operating Voltage

Use the following procedure to select the operating voltage:

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection card. Position the card so the available line (mains) voltage appears at top-left corner. Push the card firmly into the slot.
3. Rotate the FUSE PULL lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

### Warning



To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz. Leakage currents at these line settings may exceed 3.5 mA.

### Power Cables

### Warning



**BEFORE CONNECTING THIS INSTRUMENT**, the protective earth terminals of this instrument must be connected to the protective conductor of the line (Mains) power cable. The line plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two conductor outlet is not sufficient protection.

**Caution**



Failure to ground the instrument chassis, (that is, using a two-pronged adapter on the line [Mains] power cable) will result in increasing the instrument's sensitivity to damage by static discharge.

This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument chassis. The type of power cable plug shipped with each instrument depends on the country of destination. See figure 2-2, "Power Cable and Line (Mains) Plug Part Numbers", for the part numbers of these power cables. Cables are available in different lengths and some with right angle plugs to the instrument. Check with your nearest HP service center for descriptions and part numbers for these cables.

<p>Option 900 BS 1363A PLUG</p> <p>UNITED KINGDOM</p>	<p>Option 901 NZSS 198/AS 3112 PLUG</p> <p>AUSTRALIA/NEW ZEALAND</p>	<p>Option 902 CEE 7 STD SHT VII, DIN 49441, VDE 0620</p> <p>CONTINENTAL EUROPE</p>
<p>Option 903 NEMA 5-15P</p> <p>U. S. /CANADA (NOT INTERCHANGEABLE WITH OPT-918)</p>	<p>Option 905 IEC 320-C14</p> <p>For interconnecting system components and peripherals</p>	<p>Option 906 SEV 1011.1959-24507 TYPE 12 PLUG</p> <p>SWITZERLAND</p>
<p>Option 912 DNCR 107 PLUG</p> <p>DENMARK</p>	<p>Option 917 IEC 83, STD B1 (SABS 164)</p> <p>REPUBLIC OF SOUTH AFRICA and INDIA</p>	<p>Option 918 MITI 41-3692 PLUG</p> <p>JAPAN (NOT INTERCHANGEABLE WITH OPT-903)</p>

Figure 2-2. Power Cable and Line (Mains) Plug Part Numbers

## Hewlett-Packard Interface Bus (HP-IB)

### HP-IB Address Selection

The HP-IB address is selectable from the front panel. When shipped from the factory the address of the instrument is 19. Allowable addresses are 0 through 30, 40, and 50. HP-IB address 40 is listen only mode. HP-IB address 50 is talk only mode. To change the HP-IB address, select special function 24 and key in the address using the numeric keypad. As a terminator press **SET FREQUENCY**.

### Interconnections

Interconnection data for the Hewlett-Packard Interface Bus is provided in figure 2-3, "Hewlett-Packard Interface Bus Connection".

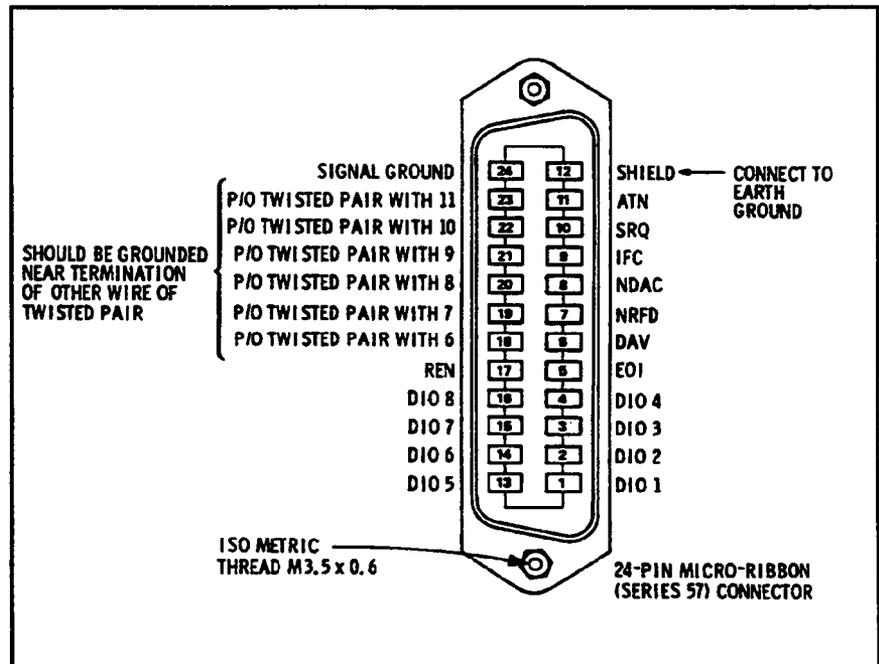


Figure 2-3. Hewlett-Packard Interface Bus Connection

### Connecting the Generator into an HP-IB System

The generator is connected into an HP-IB system using the rear panel HP-IB connector and an appropriate HP-IB cable. Table 2-2 lists the HP-IB cables available.

Table 2-2. HP-IB Cables Available

Part Number	Cable Length
HP 10833A	1m (3.3 ft)
HP 10833B	2m (6.6 ft)
HP 10833C	4m (13.2 ft)
HP 10833D	0.5m (1.6 ft)

Up to 15 HP-IB instruments can be connected in an HP-IB system. (The instrument controller is considered to be an instrument). The cables can be connected in a star or linear configuration or a combination of these two methods. Whichever method you use, you need to observe the following cabling restrictions:

- In a two instrument system that uses just one HP-IB cable, the cable length must not exceed 4 metres (13 feet).
- When more than two instruments are connected in the system, cable length to each instrument must not exceed 2 metres (6.5 feet).
- The total length of cables in the system must not exceed 20 metres (65 feet).

**Note**

It is recommended that no more than three HP-IB cables are connected to any instrument HP-IB connector. Exceeding this number may damage the instrument connector due to the excessive downward force.

---

## Connectors

### Mating Connectors

#### HP-IB Interface Connector

The HP-IB mating connector is shown in figure 2-3, "Hewlett-Packard Interface Bus Connection". Note that the two securing screws are metric.

#### Coaxial Connectors

The majority of connectors on the front and rear panel requires a 50Ω BNC male mating connector that is compatible with the specifications of US MIL-C-39012.

**Type N Connectors**

The RF OUTPUT output on the front panel and on COHERENT CARRIER on the rear panel require 50 $\Omega$  type N male mating connectors. These connectors must be compatible with the specifications of US MIL-C-39012.

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**Operating Environment**

The operating environment is specified to be within the following limitations:

Temperature 0°C TO +55°C  
Humidity <95% relative  
Altitude <4570 meters (15 000 feet)

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**Bench Operation**

The instrument cabinet has plastic feet and fold-away tilt stands for convenience in bench operation. The plastic feet are designed to ensure self-aligning of instruments when stacked. The tilt stands raise the front of the instrument for easier viewing of the front panel.

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**Rack Mounting**

Rack mounting information is provided with the rack mounting kits. If the kits were not ordered with the instrument as options, they may be ordered through the nearest Hewlett-Packard office. Refer to figure 1-1.

---

**Storage and Shipment****Environment**

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Temperature -55°C to +75°C  
Humidity <95% relative  
Altitude <15 300 metres (50 000 feet)

## Packaging

### Tagging for Service

If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument.

To minimize repair time, be as specific as possible when describing the failure. Keep the following two items in mind when describing the failure:

1. Describe what makes you think the instrument is failing. An example might be "Output power level is out of specification at 1 MHz."
2. If the failure only occurs under certain conditions, explain how to duplicate the failure. An example might be "After pressing the LINE switch to ON three times, the instrument will not power up."

### Original Packaging

Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. Mark the container "FRAGILE" to encourage careful handling. In any correspondence, refer to the instrument by model number and full serial number.

### Other Packaging

The following general instructions should be used for repackaging with commercially available materials.

1. Wrap the instrument in heavy paper or antistatic plastic. If shipping to a Hewlett-Packard office or service center, complete one of the blue tags mentioned above and attach it to the instrument.
2. Use a strong shipping container. A double-wall carton made of 2.4 MPa(350 psi) test material is adequate.
3. Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 inches) around all sides of the instrument to provide a firm cushion and prevent movement in the container. Protect the front panel with an appropriate type of cushioning material to prevent damage during shipment.
4. Seal the shipping container securely.
5. Mark the shipping container "FRAGILE" to encourage careful handling.

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## Operator's Maintenance Procedures

### Warning



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**For continued protection against fire hazard, replace the line fuse with a 250V non-time delay fuse of the same rating only. Do not use repaired fuses or short-circuited fuseholders.**

---

Operator's maintenance consists of replacing defective fuses. The primary power fuse is located within the Line Power Module Assembly. Refer to figure 2-1 for instructions on how to change the fuse.



## Local Operation

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### Introduction

This chapter describes the functional sections of the Generator front panel. The explanation of each area also explains the interactions of each section and provides a basis for applications and usages.

---

### Turn-On Instructions

#### Warning



Before the Generator is switched on, all protective earth terminals, extension cords, autotransformers and devices connected to it 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. Only 250V non-time-delay fuses with the required rated current should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

---

#### Turn On Procedure

If the Generator is already plugged in, press the LINE switch to ON. If the power cable is not plugged in, follow these instructions.

On the rear panel:

1. Check the line voltage switch for correct voltage selection.
2. Check that the fuse rating is appropriate for the line voltage used. See Table 2-1 and Figure 2-1. Required fuse ratings are printed on the rear panel.
3. Plug in the power cable.
4. On the front panel, press the LINE switch to ON.

When the Generator is turned on it will execute a power up sequence which turns on all the display segments, runs a self check of the microprocessor, and finishes with SELF TEST OK.

#### Note



An internal battery is used to retain data in continuous memory when the Generator is turned off. At turn on, the Generator will be in the exact same state as when the power was turned off, except HP-IB will reset, and number entry will be canceled. This includes the front panel configuration, up to 10 previously stored Generator configurations and the last calibration that was present before the Generator was turned off. For information on erasing these

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(cont'd)



stored generator states, refer to Special Function 1000 in the Special Functions section.

## Operator's Maintenance Procedures

Warning



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

Operator's maintenance consists of replacing defective fuses. The primary power fuse is located within the Line Power Module Assembly. Refer to figure 2-1 for instructions on how to change the fuse.

## Front Panel Overview

The Front panel is shown in detail in Figure 3-1. It is divided roughly into following areas: Display section, Function Selection, Set Frequency and Level, Numerical Entry with Units, and Special Function On/Off controls, Modulation and RF On/Off controls, and front panel connectors.

Individual key functions are described in detail in the following tabbed section Function Keys.

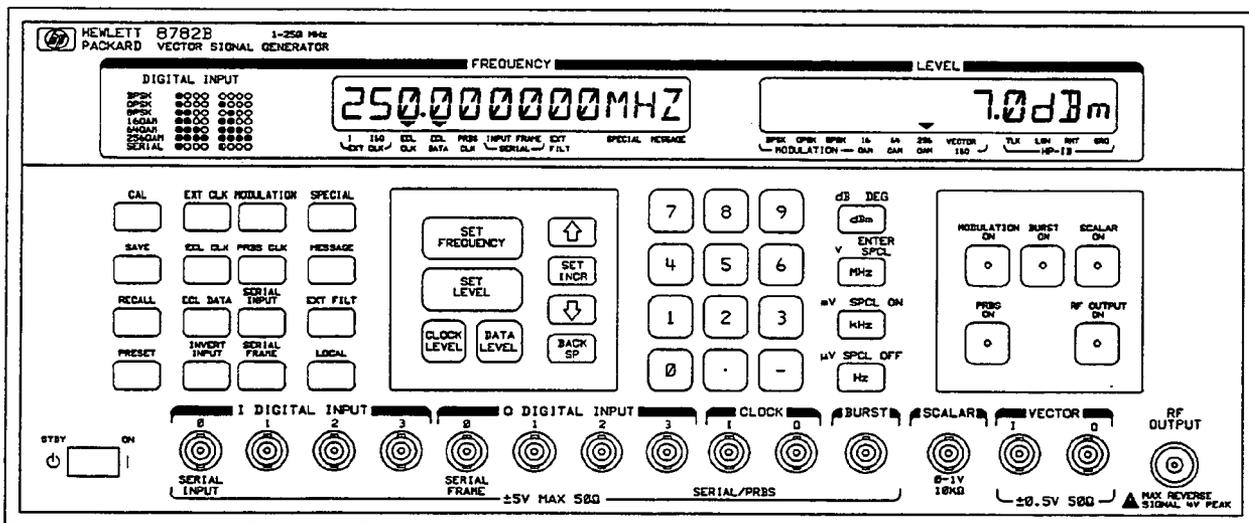


Figure 3-1. Front Panel Features

**Display**

A pair of 12 digit alpha-numeric liquid crystal displays (LCD) normally show frequency and power, but also can indicate other active parameters, information related to special functions, or generator error messages. The displays also can show several annunciators which are associated with the labels next to the bottom edge of the displays. These annunciators indicate the status of several important functions.

**Function Selection**

These are push buttons that allow selection of setup and calibration, clocks, data, invert inputs, modulation type, and special functions.

The function selection section consists of:

**Setup and Calibration Keys**

These include the **PRESET**, **CAL**, **SAVE** and **RECALL** keys.

**Clock Input Keys**

This category of keys includes: **EXT CLK** for parallel mode clocks, **ECL CLK** for emitter coupled logic terminations and thresholds for the clock inputs, **CLOCK LEVEL** for setting clock input thresholds when not in ECL mode, **SERIAL FRAME** for external symbol framing during serial and PRBS modes, and **PRBS CLK** for pseudo random binary sequence external clock. **SERIAL INPUT** also effects the both the clocks and data. See the Data Keys section under Function Keys.

**Data Input Keys**

This category of keys includes: **ECL DATA** for emitter coupled logic terminations and thresholds for the data and burst inputs, **DATA LEVEL** for setting data and burst input thresholds when not in ECL mode, and **SERIAL INPUT** for selecting serial data input. **SERIAL INPUT** affects both clocks and data. See the Data Keys section under Function Keys.

**Invert Data and Clock Input Keys**

Inversion of inputs is performed using the **INVERT INPUT** key. The **▲** and **▼** arrow keys are used to move through a menu of inputs, and the numeric keys are used to control the input polarity.

**Modulation Selection Key**

Most of the standard digital modulations as well as vector modulation are selected with the **MODULATION** key. The PRS formats are selected using special functions.

**Error and Instrument Operation Messages**

If the display's Message annunciator is lit, then pressing the **MESSAGE** key will display the message on the display.

### I and Q Filters

The **EXT FILT** key is used to toggle between external filters or internal filters when using a digital modulation format.

### Local or HP-IB Address Display

The **LOCAL** key returns the Generator from remote HP-IB operation to local operation. Holding the key down will show the HP-IB address of the Generator.

### Set Frequency and Level

These keys select power or frequency as the active parameter. Once power or frequency is selected, numeric keys or the **▲** and **▼** arrow keys may be used to change the value. Terminator keys like **MHz** or **dBm** complete the entry and signal the Generator to change state.

### Numeric Entry and Units

These keys allow change of numeric values for the active parameter. These keys include the digits 0 through 9 and decimal point, **-** to change the sign of a numeric entry, and **BACK SP** (back space) to correct a numeric entry. Also, the **▲** and **▼** arrow keys work with **SET INCR** (set increment) to allow the active parameter to be changed in steps. Most parameters can be incremented. Terminator keys indicate the units of a numeric entry. These include **Hz**, **kHz**, **MHz** for frequency and **dBm**, **V** (Volts), **mV**, and **μV** into a 50 ohm load for RF power. **dB** and **DEG** (degrees) are used for special functions. For unitless entries, the **ENTER SPCL** key is used.

### Special Function

Press the **SPECIAL** key and then the numeric key pad or the **▲** or **▼** keys to select special functions related to Generator operation, special PRS (Partial Response Signal) modulations or different calibrated modulation impairments. When the desired special function shows in the LCD display, the **ENTER SPCL** key is used to select that special function. The **SPCL ON** and **SPCL OFF** keys are used to turn the function off or on.

### Modulation and RF On/Off Controls

**MODULATION ON** and **RF OUTPUT ON** keys toggle the modulation and RF on or off states. An annunciator light in the key is on if the function is enabled.

### Front Panel Connectors

**Data Inputs.** Data inputs are I0 through I3, Q0 through Q3, Serial, and Burst. The external modulation data can be serial or parallel as selected by the **SERIAL INPUT** push button. The correct cables connections are shown by the chart at the left side of the front panel.

HP 8782B

**Local Operation**

**Scalar Inputs.** Scalar input is an analog input with 10 k $\Omega$  impedance.

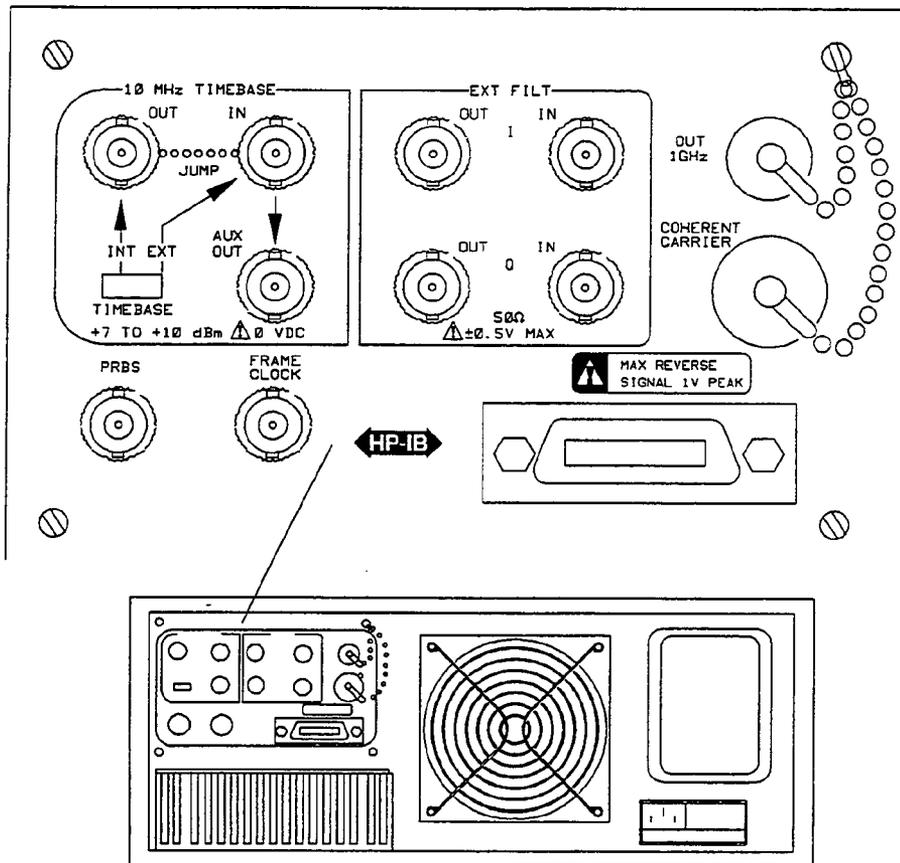
**Clock Inputs.** The clock inputs are for serial frame (shared with the data connectors), serial data clock, parallel data clock (both I and I & Q), and PRBS clock to time the internal PRBS generator.

**IQ Vector Inputs.** IQ Vector Inputs, 50 $\Omega$  BNC. The analog inputs for vector modulation are selected using the **MODULATION** key.

**RF Output.** RF Output is a 50 $\Omega$  Type N (female) connector.

## Rear Panel Overview

The rear panel features are shown in detail in Figure 3-2.



**Figure 3-2. Rear Panel Features**

### 10 MHz IN and OUT

The rear panel has BNC connectors to allow an internal or external 10 MHz time base to be used. Power levels at 10 MHz IN should be +7 dBm to +10 dBm.

### Note



For internal time base, a rear panel jumper cable must be used to connect the 10 MHz time base IN and OUT connectors together, and the INT/EXT Time Base switch must be set to INT.

### AUX OUT

AUX OUT is a buffered version of 10 MHz TIME BASE IN signal.

### EXT FILT IN and OUT

Analog signals may be applied directly to the I and Q modulator through the EXT FILT IN connectors on the rear panel. The EXT

FILT IN and OUT BNC connectors allow external I and Q channel filters be inserted. The external filters can be used to match the desired communications channel characteristics. Internal or external filters can be selected with a front panel push button.

#### **COHERENT CARRIER**

The Coherent Carrier output provides an unmodulated unlevelled version of the front panel RF Output from a type N connector. The coherent carrier can be used as a reference signal for demodulating the HP 8782B output.

#### **PRBS**

The PRBS BNC connector is a data output sample of the PRBS data string. It is an ECL level signal, and should be terminated in 50 ohms to -2 volts.

#### **FRAME CLOCK**

The Frame Clock BNC connector supplies an output sample of the frame clock. When the Generator is in parallel mode, the Frame Clock connector provides a sample of the I channel clock. It is an ECL level signal and should be terminated in 50 ohms to -2 volts.

#### **1 GHz OUTPUT**

Option 001 only. The 1 GHz Output, 50 $\Omega$  BNC connector, provides a CW output which can be used as the LO drive for an external mixer. The 1-250 MHz front panel output can then be mixed with 1 GHz to provide modulated signals in the range 750-999 MHz and 1001-1250 MHz. External filtering can be added if required.



Display Section

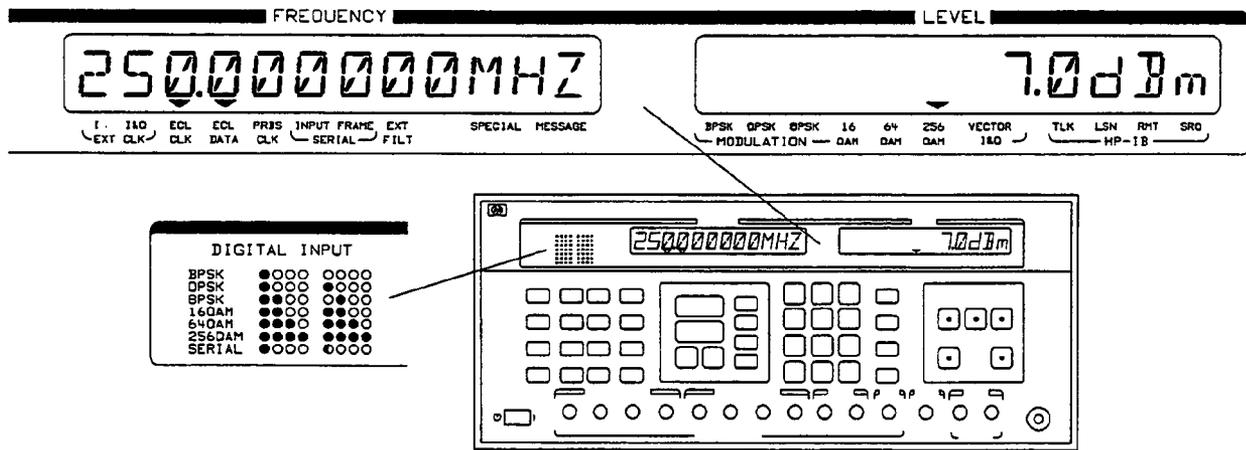


Figure 3-3. Display Features

Normal Numeric Operation

Frequency Display

The frequency is displayed in units of Hz, kHz or MHz to a resolution of 1 Hz.

Power Display

The power can be shown in dBm with a resolution of 0.1 dB. Voltage is shown in volts, millivolts, microvolts, or nanovolts (into 50 Ω) with a resolution to four places.

Blank Display

The frequency, power, and all other status indicators can be blanked with Special Function 100.

Operating Mode Information

Status Annunciators

Below the display windows are status indicator labels which correspond to an annunciator arrow on the display above. The indicated function is active if the annunciator is on.

Other Information

The display also can show information relating to other functions such as the status of the inverted inputs, the special PRS type modulations that are selected or voltmeter readings for service.

## Setup and Calibration Keys

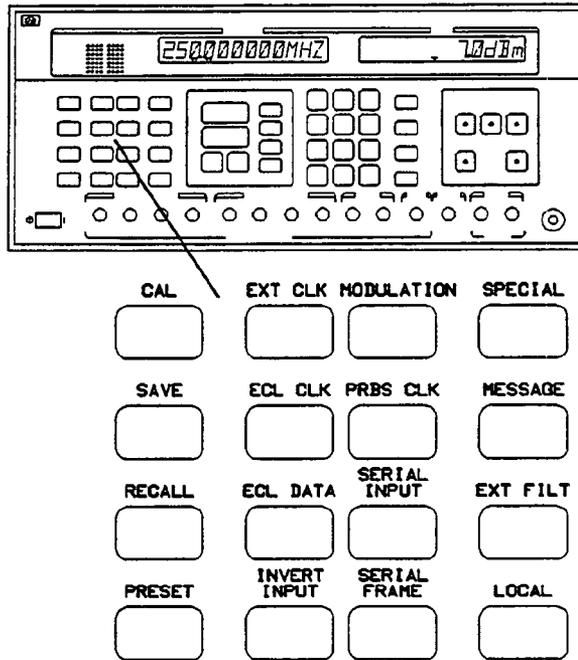


Figure 3-4. Setup and Calibration Keys

### Preset **PRESET**

#### Preset State.

Press **PRESET** (Figure 3-4) to set the Generator to the following states: (various other states are set also but not mentioned here. See the parameter in question if you would like to know its preset state.)

- Modulation off
- 70 MHz
- Amplitude -100 dBm
- RF output: ON
- No specials
- No inverts
- Clocks: NONE
- Parallel input
- Serial framing: internal
- ECL levels and terminations for clock, data and burst
- No external filter
- PRBS: OFF
- PRBS clock: internal

- Mod format: QPSK
- Burst: OFF
- Scalar: OFF
- Vector Modulation: OFF

HP-IB: “\*RST”

## Calibration **CAL**

### Selecting Self Calibration

This key is used to start the self calibration of the Generator. While the Generator is calibrating various messages will be displayed indicating what part of the Generator is being calibrated. Pressing any key during calibration causes the calibration to be aborted; the Generator is returned to the state prior to the calibration, but the key will not be executed. For example, pressing the **CAL** key again will simply abort the calibration process.

All instrument specifications should be met regardless of the frequency at which calibration is performed. However, for best results, select the desired frequency before performing calibration.

### When to Calibrate

To achieve specified performance, the Generator should be calibrated after at least 1 hour warm up. For critical tests, calibration just prior to making the measurements is recommended. The Generator should be calibrated after any temperature change of more than  $\pm 5^{\circ}\text{C}$  and, for best results, after every 4 hours of operation.

### Calibration Conditions

Data, clock, burst and scalar inputs are disabled during calibration as is the RF output of the Generator. The annunciator in the **RF OUTPUT ON** key will be off during calibration indicating there is no output; however, the coherent carrier signal is active during calibration.

### Filter Calibration

The Generator will attempt to calibrate either external or internal filters depending on which filter path is selected when calibration is started. If the Generator is in internal filter mode (the Preset state), then only the internal filter path will be calibrated. If the Generator is in external filter mode when calibration is started, then the Generator will attempt to calibrate the external filter path. In general, the Generator's calibration factors will be different for internal and external filters. If vector modulation is being used, then the filter path is not used and so the filter selection has no effect on the vector accuracy result.

### Calibration With Internal Filters

An internal filter calibration is initiated by setting the Generator to internal filter mode, then pressing **(CAL)**. Internal lowpass filters with a nominal corner frequency of 74 MHz limit aliasing for applications where spectral shaping is not critical. The internal filters also provide a path for calibration in the event of an unsuccessful external filter calibration.

### Calibration With External Filters

Calibration of the external filter path is slightly more complicated than calibration of the internal filter path. The Generator characterizes the external filter path by applying dc calibration levels. If external filters are not connected, have excessive insertion loss, or are not dc-coupled, then the dc levels cannot be measured. In these cases, alternative methods of calibration must be used.

There are three possible methods of calibrating the external filter path. The filter characteristics and the desired accuracy determine which of the three techniques to use.

**Table 3-1. Comparison of External Filter Calibration Techniques**

Calibration Method	Accuracy	DC Coupled Filters Required	Filter Loss	Filters Must Be Replaced By Jumpers During Calibration
1	Best	Yes	Measured Automatically	No
2	Very Good	No	Supplied by User	Yes
3	Good	No	Supplied by User	No

#### Method 1. External Filters Pass DC Calibration Signals.

If the external filters are installed and pass the dc calibration levels with low enough attenuation, then the Generator can automatically calibrate I and Q channel gain, and carrier null. This gives the most accurate results.

To perform calibration using this method, first select external filters using the **(EXT FILT)** key, then press the **(CAL)** key to begin calibration.

The Generator is specified to work with external filters having a loss of 0 to 3 dB. Filters with more loss may still allow calibration, but the Generator performance may be degraded. Filter loss affects maximum output power, digital and scalar dc accuracy, and signal to noise ratio.

#### Note



If the Generator is unable to calibrate the external filter path as in method 1, then the Generator will perform the first steps of method 3. While method 3 is simpler than method 2, method 3 is less accurate.

**Method 2. Calibration With Filters Replaced By Cables.**

If the external filters will not pass the dc calibration levels, then automatic measurement of I and Q channel gain is not possible. By substituting coax cables for the filters, the Generator alone can be calibrated.

Temporarily replace the external filters with short, low loss cables (Such as HP 10502A). Next, select external filters using the **EXT FILT** key, and then press the **CAL** key to begin calibration. This will automatically calibrate the I and Q channel gain for the Generator only.

Accurately measure the filter insertion loss, and then enter the loss values using special functions 5, and 6. Enable filter correction using special function 4. In order to maintain 1% accuracy, the filter loss must be known to about 0.01 dB. Now the I and Q channel gain for both the Generator and the filters is calibrated.

Next, re-install the external filters. Since carrier null depends on filter output impedance, select special function 23 to automatically calibrate the carrier null.

**Method 3. Calibration Based On Internal Filters.**

If the external filters will not pass the dc calibration levels, then automatic measurement of I and Q channel gain is not possible. However, the I and Q channel gain of the internal filter path is approximately the same as the I and Q channel gain of the external filter path (not including the loss of the external filters). An internal filter path calibration can substitute for an external filter path calibration with a slight degradation of accuracy.

Select external filters using the **EXT FILT** key, and then press the **CAL** key to begin calibration. Since the external filters will not pass the dc calibration signals, the Generator will switch to the internal filter path, calibrate, then return to the external filter path and perform a carrier null calibration. A warning message will indicate that a complete external filter calibration was not possible; only the carrier null and the *Generator* I and Q channel gain have been calibrated.

Accurately measure the filter insertion loss, and then enter the loss values using special functions 5, and 6. Enable filter correction using special function 4.

**HP-IB:**

- “\*CAL?”
- “DM:FILT:SOUR”
- “DM:FILT:CORR”
- “DIAG:NULL?”

**Save** **SAVE****Save Setup**

This key (Figure 3-4) is used to save the current state of the Generator in one of ten register locations. The valid locations are 0 through 9. When this key is pressed the display will show:

SAVE SETUP ENTER 0-9

The user should then press a numeric key to save the Generator state.

HP-IB: “\*SAV”

**Recall** **RECALL****Recall Setup**

This key (Figure 3-4) is used to recall the state of the Generator that was saved with the use of the SAVE key. Valid locations to recall are 0 through 9. When this key is pressed the display will show:

RECALL SETUP ENTER 0-9

The user should then press a numeric key to recall the Generator state.

HP-IB: “\*RCL”

## Frequency, Levels, and Increments

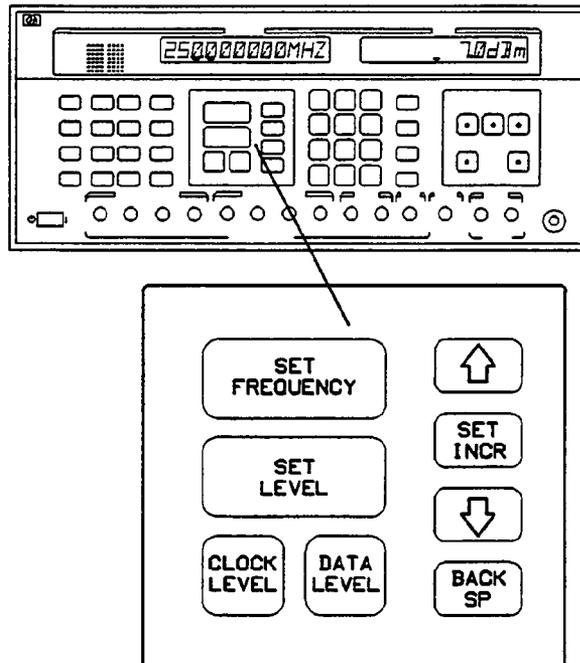


Figure 3-5. Frequency, Level and Increment Keys

### Set Frequency

SET FREQUENCY

This key (Figure 3-5) is used to enable frequency entry. Numeric values are entered on the numbered keys to the right (Figure 3-6). Units of Hz, kHz, and MHz are selected to complete the frequency setting.

Specified values for frequency are 1 to 250 MHz. Typically the Generator works well to 350 MHz, although spurious performance, maximum power, and RF amplitude and group delay flatness will be degraded. The frequency will be displayed in the left display. Frequency entries greater than 375 MHz are not accepted and will generate an error message. The Generator will switch to the correct frequency in 170 ms or less.

Preset value: 70 MHz, 1 MHz increment

HP-IB: "FREQ: CW"

## Function Keys

HP 8782B

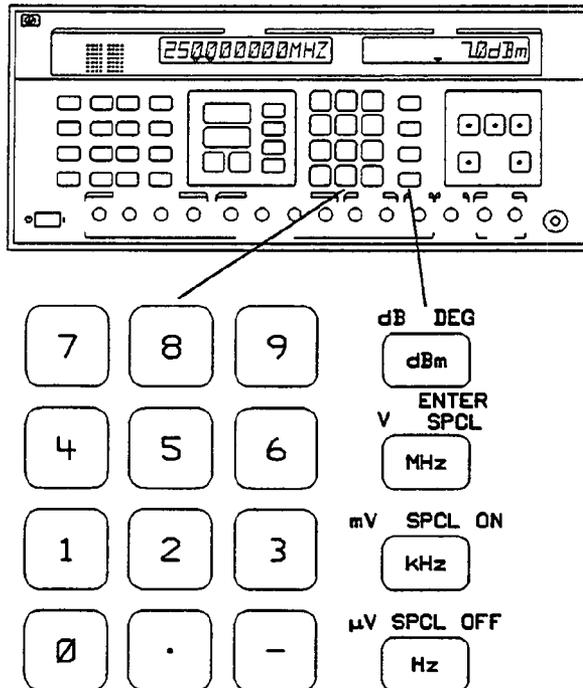
Set Level **SET LEVEL**

Figure 3-6. Numeric Keys

This key (Figure 3-5) is used to set the power levels from  $-100$  to  $+7$  dBm. Numeric values are entered on the numbered keys to the right (Figure 3-6). The units of dBm, V, mV, or  $\mu$ V are selected to complete the power level setting.

**Note**

The internal step attenuator changes automatically in 10 dB steps. To keep the step attenuator range locked, see Special Function 1.

Preset value:  $-100$  dBm

HP-IB: "POW:IMM:AMPL"

HP 8782B

Function Keys

**Back Space** **BACK SP**

Press **BACK SP** to correct a number entry. Once the unit is selected (dBm, MHz, V, etc.) the back space key is inoperative.

**Set Increment** **SET INCR**

The increment key can be used for almost any setting that requires a numeric value. Press the function key you wish to incrementally increase or decrease. Press **SET INCR** then the desired increment on the number key pad. In the case of Frequency, set the unit of increment (MHz, kHz, Hz) to complete the setting. Press the **▲** or the **▼** to implement the actual change.

## Modulation Types

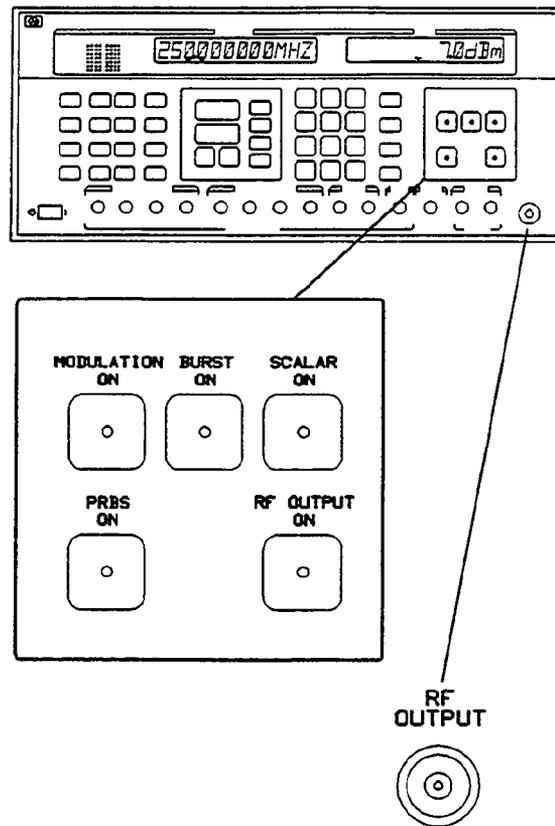


Figure 3-7. Output Switches

### Burst On **BURST ON**

Burst (pulse) is available on all digital modulations including CW. It is asynchronous with all other inputs. It is considered a data input, therefore its threshold and termination are the same as other data inputs. Refer to ECL Data and Data Level in this section.

HP-IB: "PULM:STAT"

### Scalar On **SCALAR ON**

The Scalar input can control the RF output level. An input of 0 to +1V corresponds to 0 to full set output level. RF voltage varies directly with scalar voltage. Input impedance is 10 k $\Omega$ , nominal. Scalar can be used for traditional AM by adding a +0.5V offset.

HP-IB: "AM:STAT"

### Note



Burst and Scalar are not available with VECTOR modulation.

**PRBS On** **PRBS ON**

PRBS can be used as the internal data source for all digital modulations except PRS and 8PSK. The generated pattern is one of the recognized PRBS sequences adopted by the CCITT (Consultative Committee of International Telegraph and Telephone). Sequence length is  $2^{23}-1$  with taps at states 18 and 23. To output PRBS modulation, **PRBS ON**, **MODULATION ON**, and the **RF OUTPUT ON** keys must be lit at the same time.

PRBS can clock internally or externally. (See PRBS clock in this section and Special Functions 2 and 3.) When the PRBS key is lit, ECL output of the data stream is available from the rear panel. (See Rear Panel Overview.) External serial framing is available by selecting **SERIAL FRAME**.

When PRBS and 8PSK are selected together, the Generator creates a low frequency sequence intended to calibrate the HP 8981A. When PRBS and BPSK are selected together the BPSK symbol rate is half the requested symbol rate.

HP-IB: "DM:SOUR"

**RF Output On**  
**RF OUTPUT ON**

Press **RF OUTPUT ON** to toggle the front panel RF output and the rear panel coherent carrier output on and off. When the key is lit both outputs are enabled.

HP-IB: "OUTP:STAT"

**Modulation On**  
**MODULATION ON**

When the **MODULATION ON** key is lit, the selected modulation is enabled. These modulations are BPSK through VECTOR and 9PRS through 81PRS. See Modulation below to select BPSK through 256QAM. See Special Function 18 to select 9PRS through 81PRS.

HP-IB: "DM:STAT" HP-IB: "VM:STAT"

**Modulation** **MODULATION****Standard Modulation Types**

This key (Figure 3-4) is used to select a digital modulation format or vector modulation. The annunciators on the right hand LCD indicate the modulation format that is currently selected: BPSK, QPSK, 8PSK, 16QAM, 64QAM, 256QAM and VECTOR. Each time this key is pressed the next modulation format in the sequence is selected.

Preset value: QPSK

See Figure 3-15 for a mapping of the available modulations.

HP-IB: "DM:FORM"

HP-IB: "VM:STAT"

**256QAM**

Two hundred fifty-six State Quadrature Amplitude Modulation maps eight bits of data into two hundred fifty six possible I-Q vector states. The following figure illustrates the state mapping and serial input timing.

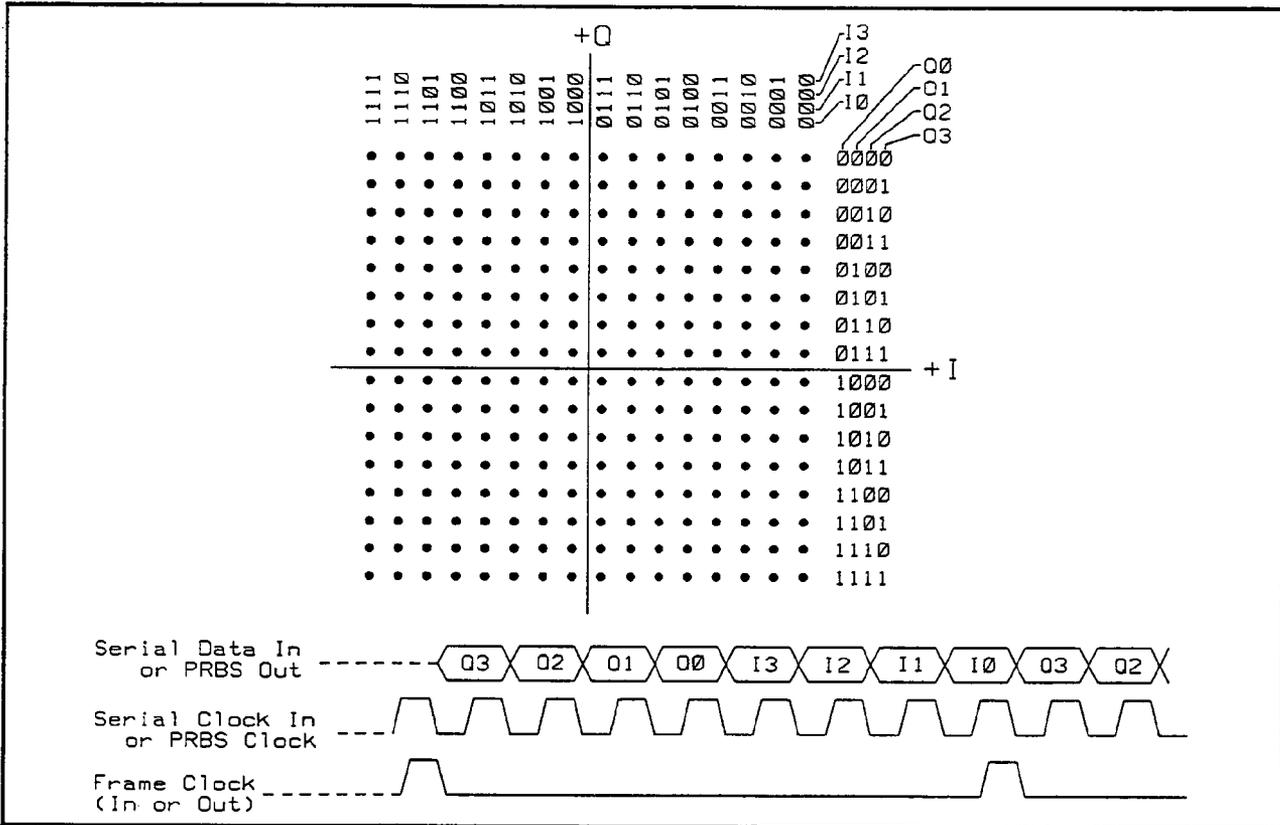
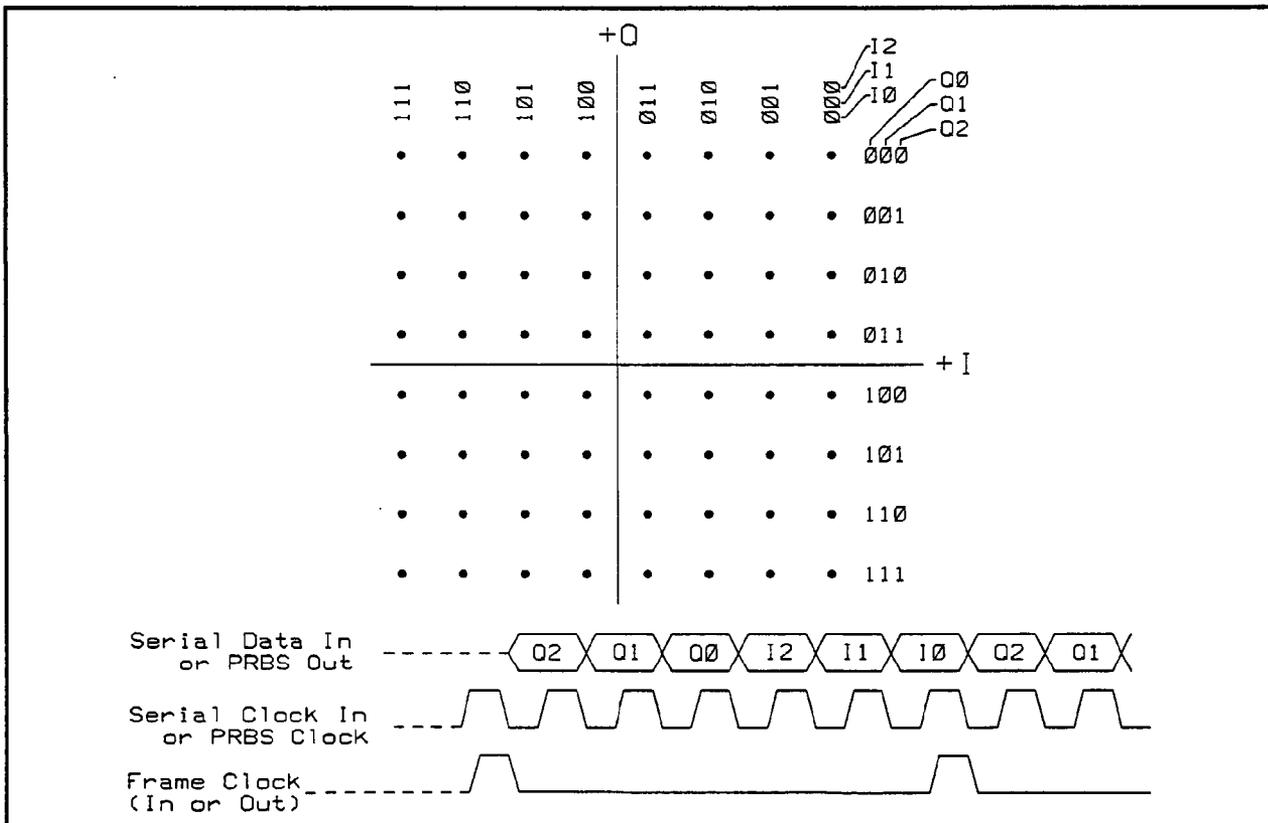


Figure 3-8. 256QAM Modulation

**64QAM**

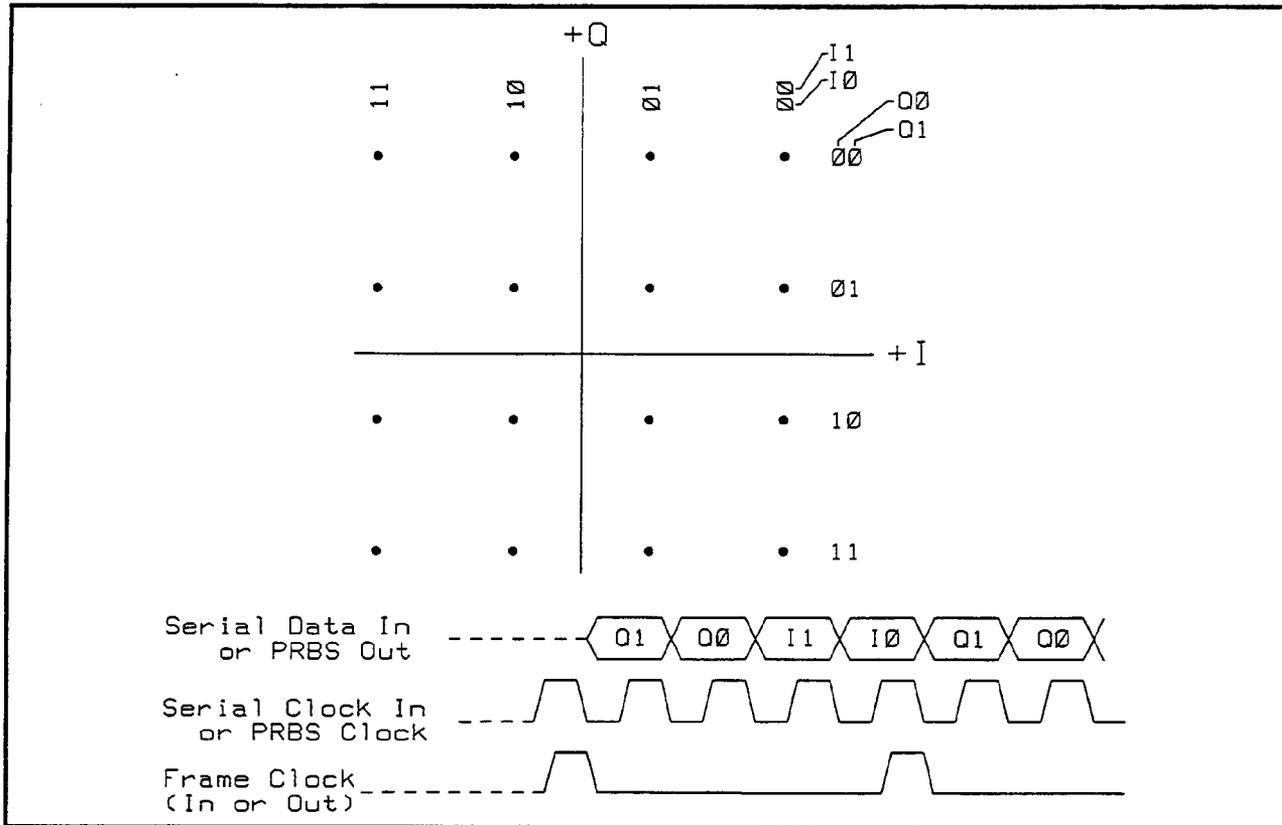
Sixty-four State Quadrature Amplitude Modulation maps six bits of data into sixty-four possible I-Q vector states. The following figure illustrates the state mapping and serial input timing.



**Figure 3-9. 64QAM Modulation**

**16QAM**

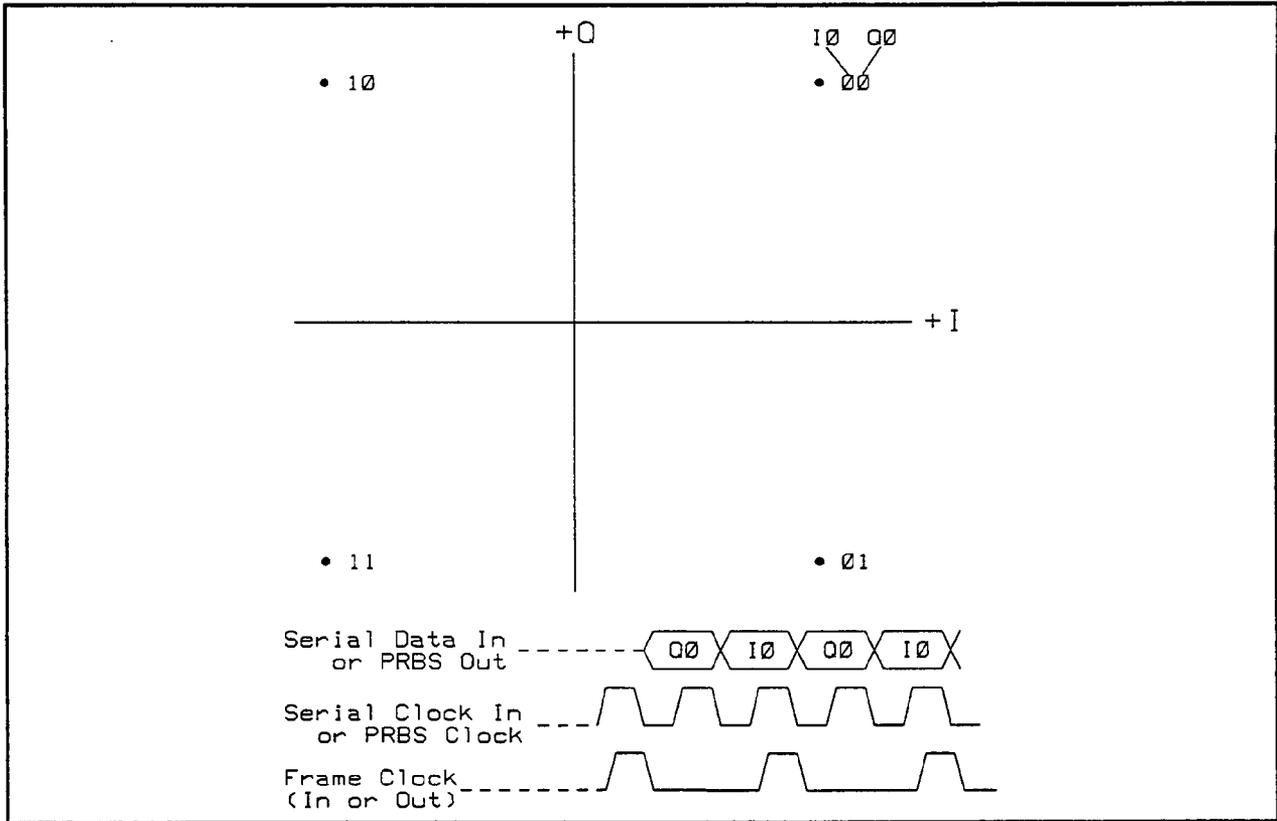
Sixteen State Quadrature Amplitude Modulation maps four bits of data into sixteen possible I-Q vector states. The following figure illustrates the state mapping and serial input timing.



**Figure 3-10. 16QAM Modulation**

**QPSK**

Quadrature Phase Shift Keying maps two bits of data into four possible states each with a 90 degree phase difference at constant amplitude. The following figure illustrates the state mapping and serial input timing.



**Figure 3-11. QPSK Modulation**

**BPSK**

Binary Phase Shift Keying maps one bit of data into two possible states. The following figure illustrates the state mapping and serial input timing.

**Note**

External framing is not supported for serial input BPSK. If external framing is selected, the Generator will substitute internal framing.

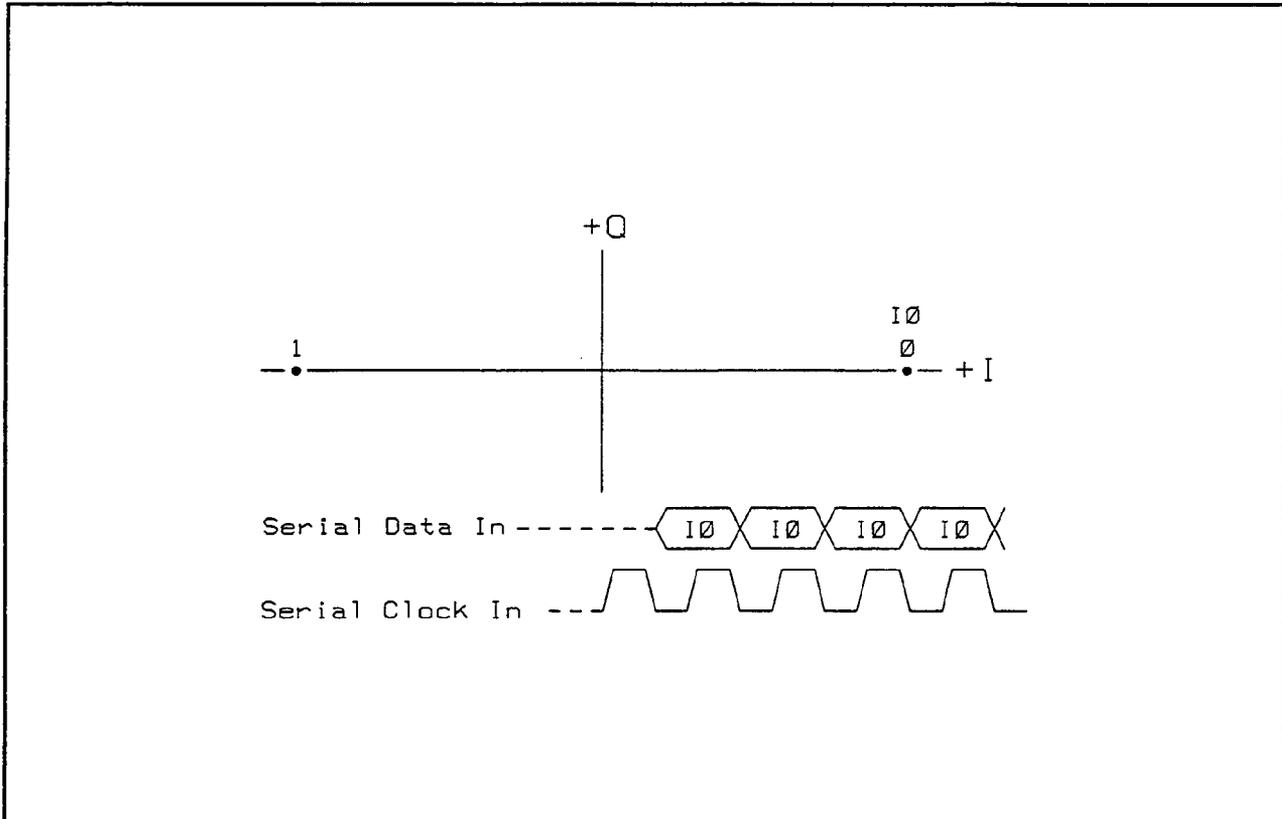


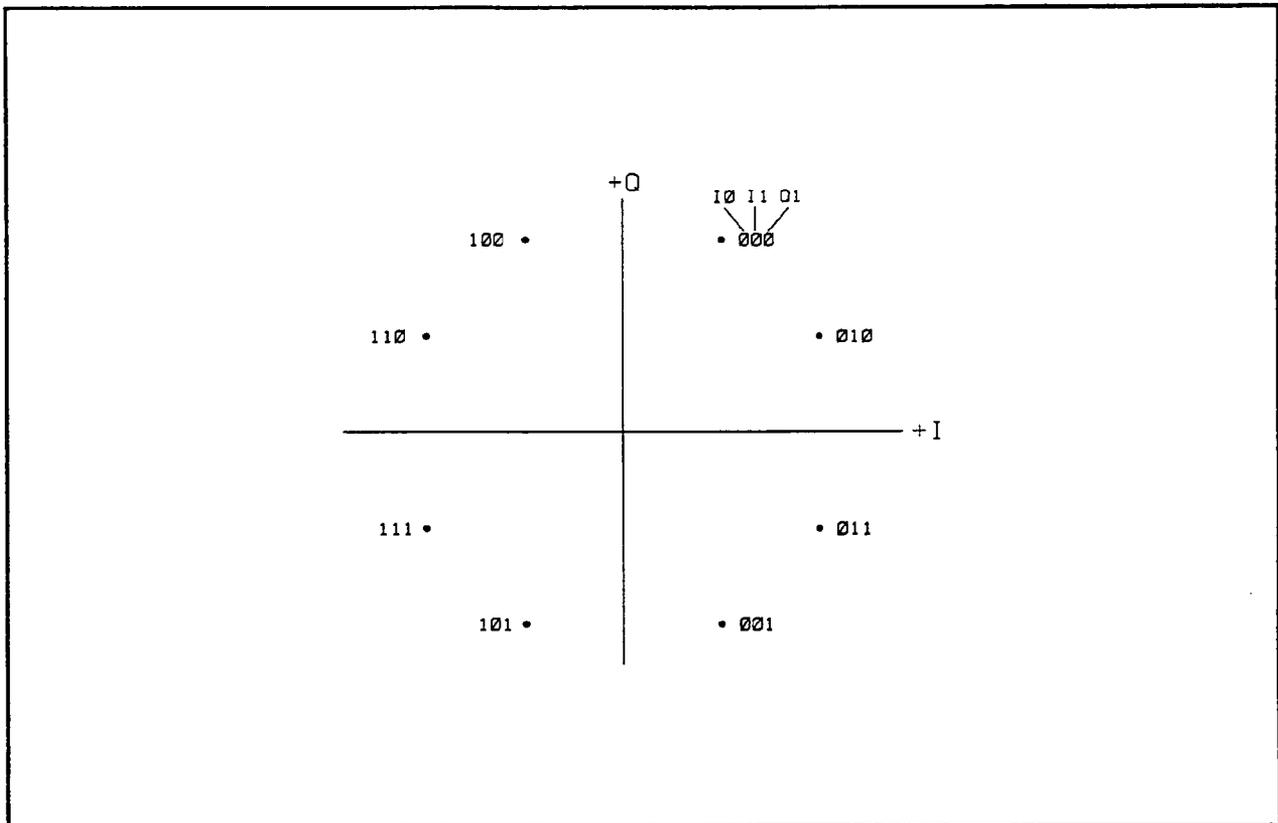
Figure 3-12. BPSK Modulation

**8PSK**

Eight Phase Shift Keying maps three bits into eight possible IQ vector states. The following figure illustrates the state mapping.

**Note**

Serial input 8PSK is not supported. If SERIAL INPUT is enabled when 8PSK is selected, the output will not be correct.



**Figure 3-13. 8PSK Constellation**

**Special PRS Modulations**

Several partial response signal modulations are available using special function 18. Use the  $\blacktriangle$  and  $\blacktriangledown$  arrow keys to select PRS modulation type. The modulations are: 9PRS, 25PRS, 49PRS and 81PRS. See Figure 3-15. When one of these special function modulations is selected the annunciator for modulation will be off and the SPC1 annunciator will be on. Pressing the modulation key when one of the special modulation formats is selected will turn off the special modulation and enable QPSK modulation with the QPSK annunciator turned on. Standard modulation formats can then be selected by repeated pressing of the **MODULATION** key.

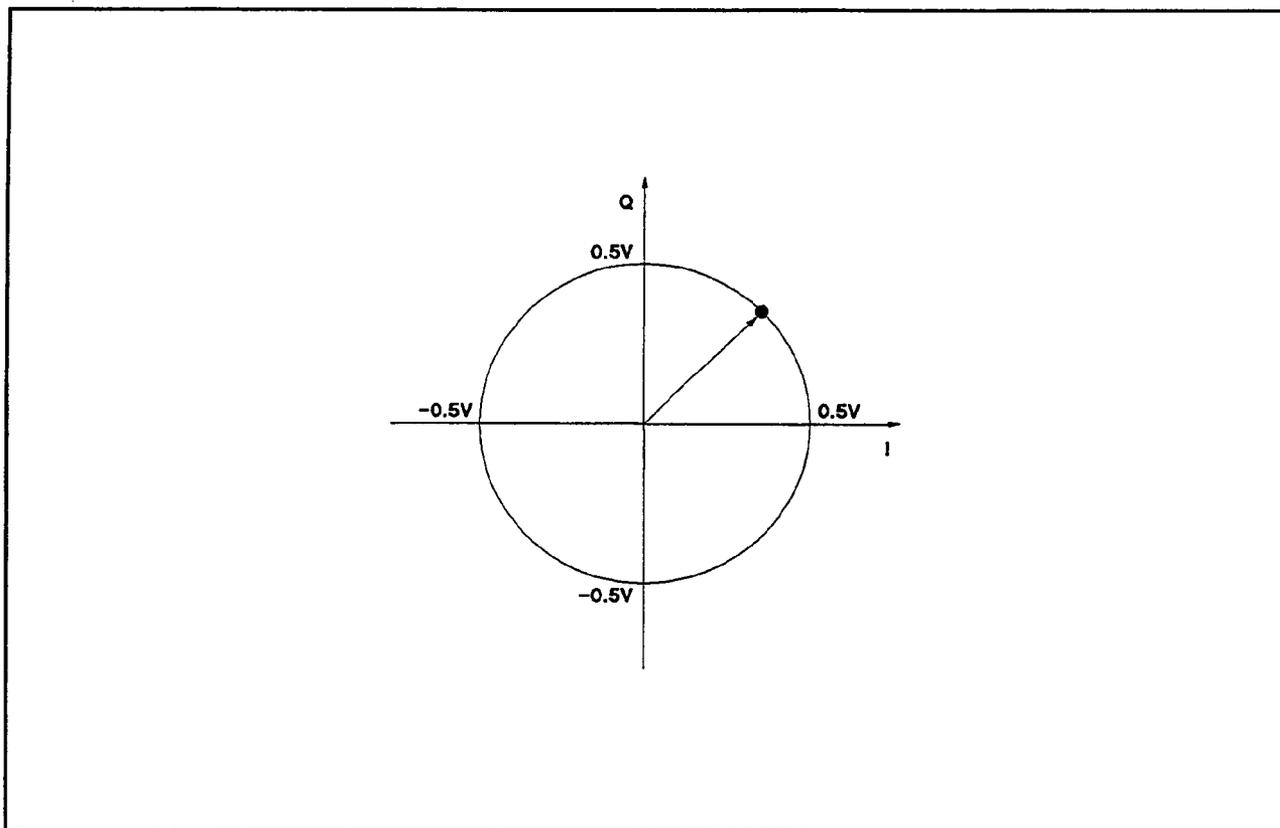
**VECTOR Modulation**

Vector modulation allows arbitrary modulation in the in phase and quadrature phase, using the front panel I and Q vector inputs.

**Note**



Scalar (AM) and Burst (PULSE) can not be used at the same time as vector modulation.



**Figure 3-14. Arbitrary Vector Modulation**

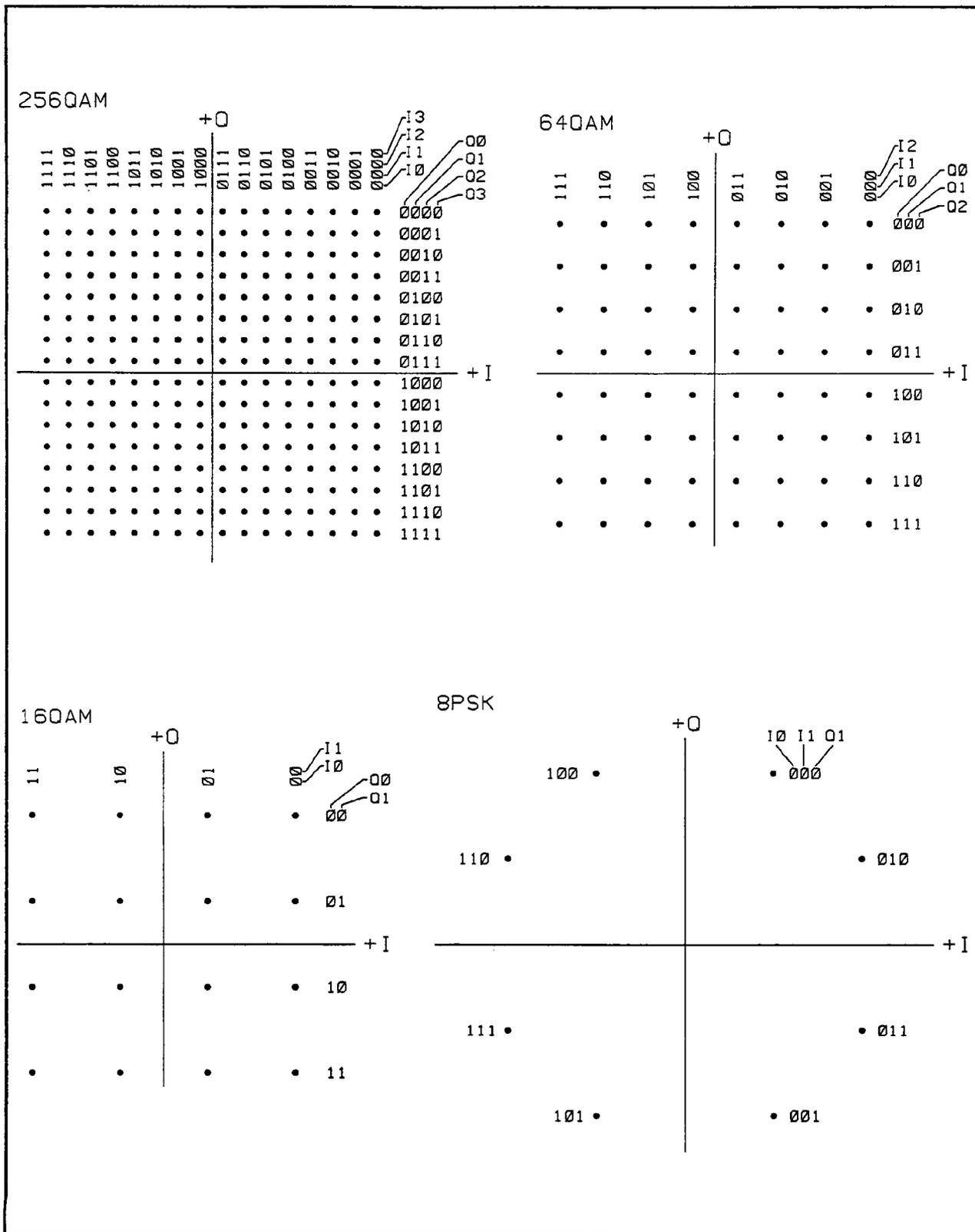


Figure 3-15. Modulation Format Constellations

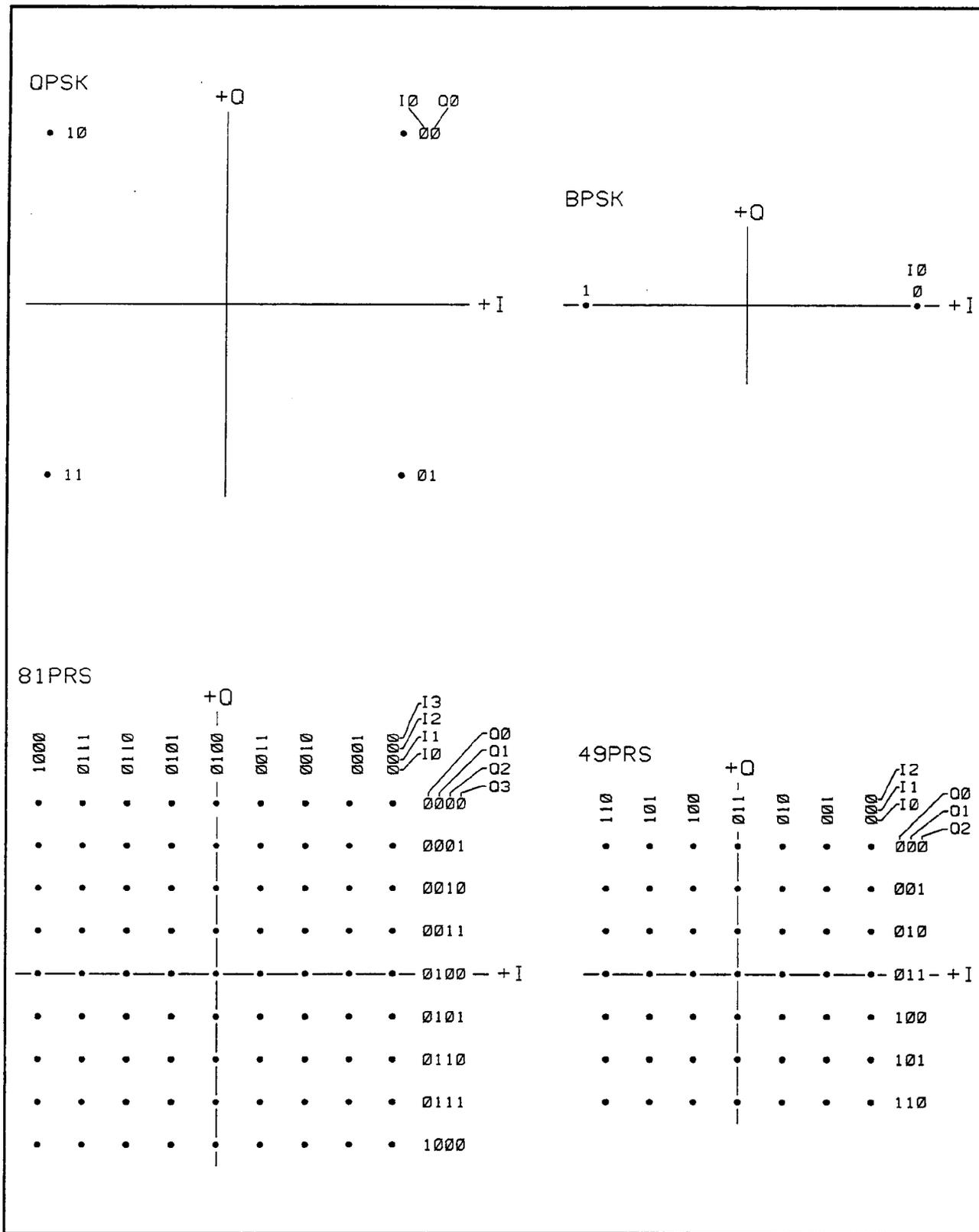


Figure 3-15. Modulation Format Constellations (Cont'd)

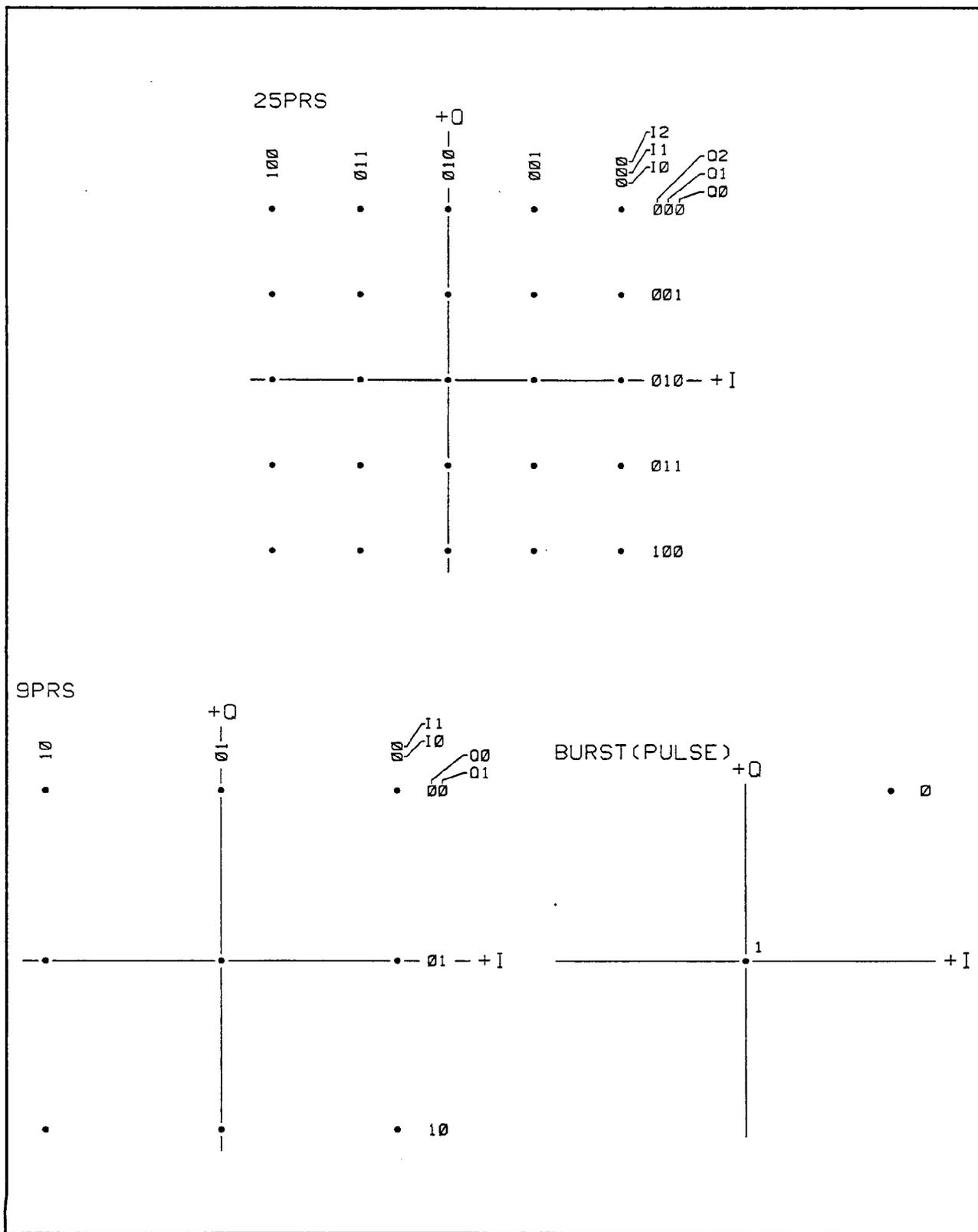


Figure 3-15. Modulation Format Constellations (Cont'd)

## Data Keys

### General Data Information

#### Data Terminations

ECL inputs on the Generator are terminated in 50 ohms to  $-2$  volts. Ground termination inputs are terminated in 50 ohms to ground. See the tabbed section Block Diagrams for relationships of clock and data signals.

### Data Level DATA LEVEL

This key (Figure 3-5) is used to select a variable data level threshold for ground terminations. The legal entry range is  $-2.5$  to  $2.5$  volts.

#### Note



This key affects all burst and serial frame inputs.

When this key is pressed the display will show (the value below is an example):

DATA LEVEL 1.0 V

The user can now enter a value for the variable data threshold or use the ▲ and ▼ arrow keys. The ECL threshold is fixed at  $-1.3$  V, independent of the data level value. ECL thresholds can only be modified by use of special function 300.

Preset value: 1.6 volts (TTL threshold) 1.0 V increment

HP-IB: "DM:THR:DATA"

### Serial Input

SERIAL INPUT

#### Serial Or Parallel Data

This key (Figure 3-4) toggles between Serial and Parallel modes of operation with SERIAL INPUT indicated by an annunciator. The data terminations and threshold levels are selected by the ECL DATA and DATA LEVEL keys. In serial mode serial input (IO) and serial clock (ICLK) clock are enabled. If serial frame is enabled, then the serial frame input (Q0) is also enabled. All other I and Q data inputs are disabled.

#### Note



Serial input 8PSK is not supported. If SERIAL INPUT is enabled when 8PSK is selected, the output will not be correct.

Preset value: PARALLEL DATA

HP-IB: "DM:DMOD"

### Emitter Coupled Logic Data **ECL DATA**

#### ECL Or Ground Termination

This key (Figure 3-4) toggles between ECL and Ground termination. The ECL termination is 50 ohms to  $-2$  V. The ECL threshold is set to trigger at  $-1.3$  V. If ECL DATA is not selected the termination is to 50 ohms to ground, with a  $\pm 2.5$  V adjustable threshold level. (See Data Level, above.) If ECL termination is selected the annunciator in the display will be turned on. See the tabbed section Block Diagrams for relationships of clock and data signals.

#### Note



This key affects all burst and serial frame inputs.

Preset value: ECL

HP-IB: "DM:COUP:DATA"

## Clock Keys

### General Clock Information

#### Clock Setup Time

All clocks should allow for a minimum of 2.5 ns of setup time. The clock pulse should occur at least 2.5 ns after the data is received and should have a rise time of less than  $1.0 \mu\text{s}$ . See the tabbed section Block Diagrams for relationships of clock and data signals.

#### Clock Hold Time

The data must be valid for at least 2.5 ns after the clock is received.

#### Clock Terminations

ECL clocks inputs on the Generator are terminated in 50 ohms to  $-2$  volts. Ground termination clocks are terminated in 50 ohms to ground.

### Clock Level **CLOCK LEVEL**

This key (Figure 3-5) is used to select a variable clock level threshold for ground terminations. The legal entry range is  $-2.5$  to  $+2.5$  volts.

When this key is pressed the display will show (the value below is an example):

CLK LEVEL 1.0 V

The user can now enter a value for the variable clock threshold or use the **▲** and **▼** arrow keys. The ECL threshold is fixed at  $-1.3$  V, independent of the clock level value. ECL thresholds can only be modified by use of special function 300.

Preset value: 1.6 volts (TTL threshold) 1.0 V increment

HP-IB: "DM:THR:CLOC"

## External Clock EXT CLK

### Parallel Mode External Clocks

This setting is valid only in Parallel mode. Make sure the serial input annunciator is off. See Serial Input for more information.

Pressing this key (Figure 3-4) will change the clock source from its current source to the next state in the sequence. Gives a choice of parallel external clocks: none, I or I & Q clocks. The choice is shown by the annunciator. If no annunciator is present, none (asynchronous) is active. Clock mode "none" (asynchronous) means that the parallel data flows directly to the modulator. Clock mode "I" means that both the I and Q data are latched on the rising edge (falling edge when inverted) of the I clock. Clock mode I & Q means that the I data is latched on the rising edge (falling edge when inverted) of the I clock, and the Q data is latched on the rising edge (falling edge when inverted) of the Q clock. I & Q clock mode allows the I and Q channels to have different symbol timing or even different data rates. I & Q clocks might be used to generate offset QPSK (OQPSK), for example.

Preset value: Asynchronous

### Note



"I & Q" clock mode gives invalid results when used with 8PSK.

---

HP-IB: "DM:CLOC:SOUR" and "DM:CLOC:MODE"

## Emitter Coupled Logic Clock ECL CLK

### ECL Or Ground Termination Clocks

This key (Figure 3-4) toggles between ECL and Ground termination. The ECL termination is 50 ohms to -2 V. The ECL threshold is set to trigger at -1.3 V. If ECL CLK is not selected the termination is 50 ohms to ground, with a  $\pm 2.5$  V adjustable threshold level. See Clock Level above. If ECL termination is selected the annunciator in the display will be turned on.

Preset value: ECL

HP-IB "DM:COUP:CLOC"

**Serial Frame****SERIAL FRAME****External Or Internal Frame**

This key (Figure 3-4) is used to select the desired serial or PRBS framing. The framing can be internally or externally generated. Pressing this key will toggle between the two states. The current frame clock is indicated by an annunciator display. When the annunciator is on, external serial framing is selected. When the annunciator is off, internal framing is selected. Digital data input Q0 serves as the external frame clock input. The trigger level and termination type are the same as the data inputs.

The frame clock serves the same purpose as the "T" clock in parallel data mode. The serial data is converted into parallel data in a shift register. The rising edge (falling edge when inverted) of the external frame clock latches the shift register parallel outputs to the modulator. The internal frame clock is generated by dividing the serial clock (which runs at the bit rate) by the correct factor. Since the Generator can not tell where the serial words are divided, the internal frame clock may have a phase error. This often does not matter for PRBS data, but if the serial data words are important, then the external frame clock must be used.

Preset value: Internal

**Note**

External framing is not supported for serial input BPSK. If external framing is selected the Generator will substitute internal framing.

HP-IB: "DM:FRAM:SOUR"

**Pseudo Random Binary Sequence Clock****PRBS CLK****External Or Internal PRBS Clock**

This key (Figure 3-4) toggles between external clock input or internal clock with external PRBS indicated by an annunciator. The terminations and clock levels are as selected by the **ECL CLK** and **CLOCK LEVEL** push buttons.

**External Divide Ratios And Internal Rates**

There is an internal divide value (preset value is 1) for the external PRBS clock that can be selected via special function 2. Possible divide values are 1, 2, 4 and 8. The rate of the internal PRBS is selectable via special function 3 to be 10 MHz (the preset value), 5 MHz, 2.5 MHz or 1.25 MHz. This rate is separate from the divide value. See the special function section for more information on these functions.

When internal clock PRBS is enabled, the I0 through I3, Q0 through Q3, and I and Q clock digital inputs are disabled. When external clock PRBS is enabled, and external serial framing is disabled, the I0 through I3, Q0 through Q3, and Q clock inputs are disabled. When external clock PRBS is enabled, and external serial framing is also

enabled, the I0 through I3 and Q1 through Q3 and Q clock inputs are disabled; Q0 serves as the frame clock input.

Preset value: internal PRBS clock

## Note



**PRBS Not Operating?** If the PRBS is operated using an external clock, and the duty-cycle of the clock signal is very high or very low, then it is possible for the PRBS Generator to suddenly stop clocking. Very low or very high duty-cycle clock signals can result from applying a sine wave input to the PRBS (I) clock input, and then setting the Vector Signal Generator's clock threshold to within  $\pm 0.3V$  of the maximum or minimum peak voltage of the sine wave. This causes a clock signal which consists of sub-nanosecond pulses. These extremely short pulses can cause improper operation of the PRBS circuits.

If the PRBS suddenly stops operating, switch to internal PRBS clocking by pressing the **PRBS CLK** key until the display annunciator above PRBS CLK is off. If the PRBS operates at this point, verify that serial frame is not enabled. Normally serial frame is used with the serial clock mode, but for some special Bit Error Rate (BER) tests, it is useful to use an external frame clock with the PRBS. If the serial frame is enabled, then there must be an appropriate clock signal provided.

If the PRBS does not operate in internal PRBS mode, turn the line power off and back on to restore correct operation.

HP-IB: "PRBS:CLOC:SOUR"

## Invert Data and Clock Inputs

The data, clock and burst input polarities are set using the **INVERT INPUT** key. Pressing the **▲** or **▼** arrow keys scrolls the display through the inverts for data, clock or burst inputs and displays their status.

### Invert Input

**INVERT INPUT**

#### Inverting Parallel Inputs

Press the **INVERT INPUT** key and the **▲** or **▼** keys until INV I or INV Q shows in the left display. This prepares the Generator to accept numeric keyboard entries to change the invert I or Q status.

The data inputs I0,1,2,3 or Q0,1,2,3 are inverted when the corresponding data input number appears in the display. Press the numbers of the inputs to be inverted, using the numeric keypad. If an input shows as inverted, pressing that same number removes the inversion.

**Example:** A particular 64QAM radio may require the I0, I2, Q0 and Q2 parallel inputs to be inverted.

Push **INVERT INPUT** and the **▲** or **▼** arrows until INV I shows in the display. The display will probably show (assuming no previous invert operations):

INV I NONE ENTER 0-3

Push **0** and **2**

The display will now show:

INV I 0,2 ENTER 0-3

Push the **▲** or **▼** keys until INV Q shows in the display.

The display will probably show:

INV Q NONE ENTER 0-3

Push **0** and **2**

The display will now show:

INV Q 0,2 ENTER 0-3

The I0, I2, Q0 and Q2 parallel inputs are now inverted.

To reconfigure the Generator for no I (or Q) inversions select INV I (or INV Q). Then push **0** and **2** (or whatever numbers show in the left side display). This will place the Generator back in its original I (or Q) state.

### Clocks, Frames And Serial Input

The I and Q clocks, frame, burst serial input, serial and PRBS clocks are toggled between inverted and not inverted by typing a **0** on the numeric key pad when the desired input is selected with the **INVERT INPUT** key and **▲** or **▼** arrow.

### Note



The entire serial data stream is inverted when the serial input is inverted. It is not possible to invert individual bits within the data stream.

**Example.** It is desired to invert the serial frame clock. Press **INVERT INPUT** and the **▲** or **▼** arrows until the LCD display shows:

INV FRAME: NO ENTER 0=YES

Push the **0** key, the display now shows:

INV FRAME: YES ENTER 0=NO

Preset value: No inverts

### HP-IB:

- "DM:POL:I" (I data)
- "DM:POL:Q" (Q data)
- "DM:POL:SER:DATA" (serial data)
- "DM:POL:SER:CLOC" (serial clock)

- "DM:POL:SER:FRAM" (serial frame)
- "DM:POL:ICL" (I clock)
- "DM:POL:QCL" (Q clock)
- "PRBS:CLOC:POL" (external PRBS clock)
- "PULM:POL" (burst)

---

## I and Q Filters

### External Filter **EXT FILT**

#### Activating External Filters

This key (Figure 3-4) is used to toggle between the external filter path and the internal filter path only when using a digital modulation format. When the external filter is selected the EXT FILT annunciator is lit. The external filters should have less than 3.00 dB of insertion loss for best accuracy. Filter loss greater than 3.00 dB may reduce Generator maximum power. (See Calibration **CAL** for filter calibration information.

Preset state: Off (internal filter)

HP-IB: "DM:FILT:SOUR"

---

## Local or HP-IB Address

### Local **LOCAL**

#### Local And Displaying HP-IB Address

Pressing this key (Figure 3-4) will remove the Generator from the remote state and put it in the local state unless local lockout is active in which case this key (as all other keys) will be ignored. See Remote Operation to deactivate local lockout. This key is also used to display the HP-IB address. As long as this key is held down the HP-IB address will be displayed. When the key is released the display returns to its normal state.

Preset value: does not change on preset. The default setting is 19 if non-volatile memory content is lost.

---

## Messages

### Message **MESSAGE**

#### Message Annunciator Flashing

The **MESSAGE** (Figure 3-4) key is used to display a message on the front panel display. A message is available when the message annunciator is lit. Messages report errors in operation or hardware conditions. For status messages the annunciator will remain on until the condition is cleared. Example: OVEN COLD will turn off when the oven reaches the proper temperature. Refer to Special Functions for logging error messages. See appendix A, "Error Messages" for more information.

#### New Messages

New messages cause the message annunciator to blink.

**HP-IB:** "SYST:ERR?"



## Special Functions

### Special Function Key

**SPECIAL**

This key is used to allow special functions to be selected with the **▲** or **▼** arrows or the numeric key pad. **ENTER SPCL** is the terminator.

See Demo Mode, special function 0 for an example of the key sequence.

### Special Function List

A list of the special functions follows.

Preset value: all specials off.

### Demo Mode: SPCL 0 DEMO

This function enables the Generator's demo mode. In this mode the Generator will sequence through various set-ups every time the **▲** arrow key is pressed (**▼** arrow key goes backwards through the list with a slight difference in the results.) To enter the demo mode press: **SPECIAL**, **0**, **ENTER SPCL**, **SPCL ON**. The sequence of demo functions is:

- BPSK
- QPSK
- 16QAM
- 64QAM
- 256QAM
- 256QAM (or BPSK) with I/Q ratio of -3.0 dB
- 256QAM (or BPSK) with quad error of 10°
- 256QAM (or BPSK) with 15° of phase adjust
- 256QAM (or BPSK) with a 3 dB fade at a 1 Hz rate.

Press **SPCL OFF**, to leave the demo mode.

Preset state: OFF

HP-IB: Not Available

### Lock Step Attenuator: SPCL 1 LOCK STP ATT

Locks the step attenuator in its current state regardless of the requested level setting. A message:

**ERROR: 602 ATTEN LOCKED**

will be generated if the output level requested cannot be generated.

Use **SPCL ON** or **SPCL OFF** to activate or deactivate.

Preset state: OFF

HP-IB: "POW:ATT:AUTO"

## Special Functions

HP 8782B

**Divide Ratio For  
External PRBS: SPCL 2  
PRBS CK DIV**

Allows selection of a divide ratio of 1, 2, 4 or 8 for the external PRBS clock. This function is activated after pushing **ENTER SPCL**, it will then prompt for a divide ratio. Select the ratio using the **▲** or **▼** arrows or the numeric key pad.

Preset state: 1 Increment: next or previous state.

HP-IB: "PRBS:DIV"

**Clock Rate For Internal  
PRBS: SPCL 3 PRBS CK  
FREQ**

Selects 10 MHz, 5 MHz, 2.5 MHz or 1.25 MHz for the internal PRBS clock. This function is activated using the **ENTER SPCL** key and then selecting the clock frequency using the **▲** or **▼** arrows or the numeric key pad.

Preset state: 10 MHz Increment: next or previous state.

HP-IB: "PRBS:FREQ"

**External Filter  
Correction On/Off:  
SPCL 4 FILT LOSS**

Special 4, 5, and 6 can be used to compensate for external filter loss by adjusting I and Q channel gain. If special function 4 is OFF, no correction is applied. Use **SPCL ON** or **SPCL OFF** to activate or deactivate filter correction. Use special functions 5 and 6 to enter the correction factors. Special functions 4, 5, and 6 also can be used to adjust the RF output power in 0.01 dB steps.

Preset state: Off

HP-IB: "DM:FILT:CORR:STAT"

**External I-Filter  
Correction: SPCL 5 I  
FILT LOSS**

Allows control of the I filter correction. This is useful for AC coupled external filters which cannot be calibrated by the calibration algorithm. This function is activated using the **ENTER SPCL** key and then entering the I filter loss using the numerical key pad or **▲** or **▼** keys. Range is 0.00 through 9.99 dB in 0.01 dB steps. Remember to activate the I and Q filter loss correction using SPCL 4.

Preset state: Off Value: 0.00 dB Increment: 1.0 dB

HP-IB: "DM:FILT:CORR:I"

**External Q-Filter  
Correction: SPCL 6 Q  
FILT LOSS**

Same as special function 5 except for Q channel filter.

HP-IB: "DM:FILT:CORR:Q"

**Carrier Leakage On/Off:  
SPCL 7 CAR LEAK**

Specials 7, 8, and 9 can be used to add carrier offset (leakage) to the RF output, when using a digital modulation format. If special 7 is off, then no correction is applied. Use **SPCL ON** and **SPCL OFF** to activate or deactivate the function. Use special function 8 to set the magnitude of the carrier leakage, and use special function 9 to set the angle of the carrier leakage.

Preset state: Off

HP-IB: "DM:LEAK:STAT"

HP 8782B

Special Functions

**Carrier Leakage  
Magnitude: SPCL 8  
CAR LEAK MAG**

Sets the magnitude of the offset to the generated pattern. The direction of the carrier leakage angle is defined by special function 9. This function is activated using the **ENTER SPCL** key and then entering the carrier magnitude using the numerical keypad or **▲** or **▼** keys. Set the angle of the carrier leakage using special 9. Do not forget to activate the leakage using special function 7.

Range: 0.0 to -40.0 dB.

Preset state: -10.0 dB Increment: 1.0 dB

HP-IB: "DM:LEAK:MAGN"

**Carrier Leakage Angle:  
SPCL 9 CAR LEAK ANG**

Defines the angle of the carrier leakage. 0 degrees is the +I direction, 90 degrees is the +Q direction. This function is activated using the **ENTER SPCL** key and then entering the carrier angle using the numerical keypad or the **▲** or **▼** arrows. Range 0.0° to ±359.9°. Set the magnitude of the carrier leakage using special function 8. Do not forget to activate the leakage using special function 7.

Preset state: Value 0.0° Increment: 1.0°

HP-IB: "DM:LEAK:ANGL"

**Fade Simulation On/Off:  
SPCL 10 FADE**

Enables a flat fade simulation. This causes the RF output voltage to rise and fall linearly versus time. This is equivalent to scalar modulation with a triangle waveform input. Special functions 11 and 12 allow selection of parameters associated with fade simulation, when using a digital modulation format. **SPCL ON** or **SPCL OFF** is used to activate or deactivate the function.

Preset state: Off

HP-IB: "AM:SOUR"

**Fade Ramp Deviation:  
SPCL 11 FADE RAMP**

This function sets the amount of RF level deviation that will be generated when the fade simulation is enabled. The Generator RF output level will be a maximum of the current SET LEVEL value and a minimum of (SET LEVEL minus ramp deviation). Deviation range is 0.0 to 20.0 dB. Press **ENTER SPCL** then change the deviation using the keypad or the **▲** or **▼** arrows. Set the ramp frequency using special function 12. Remember to activate the fade simulation using special function 10.

Preset state : 5.0 dB Increment: 1.0 dB

HP-IB: "AM:DEPT"

## Special Functions

HP 8782B

**Fade Ramp Frequency:  
SPCL 12 FADE FREQ**

This function sets the frequency of the flat fade. Range for ramp frequency is 0.1 to 10.0 Hz. Press **ENTER SPCL** then change the fade frequency using the numerical key pad or the **▲** or **▼** arrows. Set fade depth using special function 11. Remember to activate the fade simulation using special function 10.

Preset state: 1.0 Hz Increment: 0.5 Hz.

HP-IB: "AM:FREQ"

**Phase Bump: SPCL 13  
10 MHZ PHASE**

This function bumps the phase of the RF output with respect to the 10 MHz output rear panel connector by the specified amount. This bump is a relative change in phase, not an absolute setting of phase. For example, entering  $+45^\circ$  twice results in a phase change of  $+90^\circ$ . Because of this, the **▲** and **▼** keys may give confusing results. The range of entry is  $+359.9$  to  $-359.9$  degrees referenced to the current phase. This function allows adjustment of the phase between two generators that share a common 10 MHz time base. Press **ENTER SPCL** then change the phase with the numeric key pad or the **▲** or **▼** arrows.

Preset state:  $0.0^\circ$  Increment: 1.0 degree

HP-IB: "PHAS:RSIG"

**Quadrature Error  
On/Off: SPCL 14 QUAD  
ADJUST**

Specials 14 and 15 allow the user to alter the quadrature angle. Quadrature adjustment is the deviation from a  $90^\circ$  angle between the I and Q axis. Typically  $\pm 45^\circ$  of deviation is available. Because quadrature adjust and constellation rotation share the same hardware, the exact amount of available deviation depends on the status and value of constellation rotation (special functions 19 and 20). Use **SPCL ON** or **SPCL OFF** to activate or deactivate quadrature error. Set the quadrature angle adjustment using special function 15. For best results, use special function 23 to calibrate the carrier null after changing the quadrature angle.

Preset state: Off.

HP-IB: "DM:QUAD:STAT"

**Quadrature Error: SPCL  
15 SET QUAD ADJ**

This special function is used to set the quadrature adjust angle. The deviation range is typically  $\pm 45^\circ$  although any entry between  $\pm 90^\circ$  will be accepted. Because quadrature adjust and constellation rotation share the same hardware, the exact amount of available deviation depends on the status and value of constellation rotation (special functions 19 and 20). Push **ENTER SPCL** then change the quadrature error with the numeric key pad or the **▲** or **▼** arrows. Remember to activate the quadrature angle adjustment using special function 14.

Preset value:  $0.0^\circ$  Increment:  $1.0^\circ$

HP-IB: "DM:QUAD:ANGL"

HP 8782B

Special Functions

**I/Q Gain Ratio On/Off:  
SPCL 16 IQ RATIO  
On/Off**

This special function allows the user to enable the I/Q gain ratio adjustment, when using a digital modulation format. The ratio is set using special function 17. Use **SPCL ON** or **SPCL OFF** to activate or deactivate I/Q gain ratio adjustment.

Preset state: Off.

HP-IB: "DM:IQR:STAT"

**Set I/Q Gain Ratio:  
SPCL 17 SET IQ RATIO**

This function used to set the I/Q gain ratio in dB. The range allowed is +40 dB to -40 dB. Push **ENTER SPCL** then change the I/Q ratio with the numeric key pad of the **▲** and **▼** arrows. A positive value means that Q less than I; a negative value means I less than Q. Either the I or Q magnitude is reduced from the nominal value depending on the sign of the I/Q gain ratio. Remember to activate I/Q ratio using special function 16.

Preset value: 0.0 dB Increment: 1 dB

HP-IB: "DM:IQR:MAGN"

**Special Modulation  
Formats: SPCL 18  
EXTRA MOD**

This special function allows selection of various special modulation formats: 9PRS, 25PRS, 49PRS and 81PRS. Pressing the **▲** and **▼** arrow keys after selecting this special function will sequence through these modulation formats. These are not true PRS modulations in the sense that the states normally produced by the intentional introduction of intersymbol interference (ISI) are generated directly by the generator hardware, however they may prove useful for testing PRS receivers. If desired, the Generator can produce true PRS, provided filters with appropriate ISI are placed in the external filter path. Thus, with proper spectral shaping, the Generator can produce 9PRS from QPSK, 25PRS from 9PRS, 49PRS from 16QAM, and 81PRS from 25PRS.

**Note**



The Generator's PRBS function will create illegal states for PRS formats. PRS requires an external data source. See Figure 3-14 for more information on the data required for PRS formats.

For serial data input, the serial timing of 9PRS is the same as for 16QAM. 25PRS and 49PRS are the same as 64QAM. 81PRS is the same as 256QAM.

Preset value: 9PRS and Off.

HP-IB: "DM:FORM"

**Constellation Rotation**  
**On/Off: SPCL 19**  
**CONSTL ROTAT**

This function allows the user to enable constellation rotation. Constellation rotation changes the phase between the RF output and the coherent carrier. Typically  $\pm 30^\circ$  of rotation is available. Because quadrature adjust and constellation rotation share the same hardware, the exact amount of rotation available depends on the state and value of quadrature adjustment (special functions 14 and 15). Push **SPCL ON** or **SPCL OFF** to activate or deactivate the function. Set the constellation rotation using special function 20.

For best results, use special function 23 to calibrate carrier null after changing the constellation rotation.

Preset state: Off.

HP-IB: "PHAS:OUTP:STAT"

**Constellation Phase**  
**Rotation: SPCL 20**  
**CONST ANGLE**

This function sets the constellation phase rotation relative to the coherent carrier. Constellation rotation changes the phase between the RF output and the coherent carrier. Typically  $\pm 30^\circ$  of rotation is available. Because quadrature adjust and constellation rotation share the same hardware, the exact amount of rotation available depends on the state and value of quadrature angle (special functions 14 and 15). Any entry between  $\pm 90^\circ$  will be accepted. Push **ENTER SPCL** then change the phase with the **▲** or **▼** arrows or the numeric key pad. Remember to activate constellation rotation using special function 19.

For best results, use special function 23 to calibrate carrier null after changing the constellation rotation.

Preset value:  $0.0^\circ$  Increment:  $1.0^\circ$

HP-IB: "PHAS:OUTP:ADJ"

**Baseband Calibration:**  
**SPCL 21 B-BAND CAL**

Initiate the baseband section of the calibration procedure. Calibration will occur at the Generator frequency setting. Push **SPCL ON** or **ENTER SPCL** to activate. Calibration will take less than two minutes.

HP-IB: "DIAG:BBCAL?"

**Level Calibration: SPCL**  
**22 LEVEL CAL**

Initiate the RF level calibration section of the calibration procedure. Push **SPCL ON** or **ENTER SPCL** to activate.

HP-IB: "DIAG:LCAL?"

HP 8782B

Special Functions

**Null Calibration: SPCL  
23 NULL CAL**

Initiate the null calibration section of the digital or vector baseband calibration procedure according to the current modulation format selected. This adjusts the carrier leakage (carrier null) to a minimum value. Push **SPCL ON** or **ENTER SPCL** to activate.

**HP-IB:** "DIAG:NULL"

**HP-IB Address: SPCL  
24 HP-IB ADRS**

Allows the user to change the HP-IB address of the Generator. Valid range is 0 through 30. Also allowed are address 50 which enables the talk only mode and address 40 which enables the listen only mode. To change the HP-IB address push **ENTER SPCL** and press **▲** or **▼**, or use the keypad terminating it with **ENTER SPCL**.

Preset value: does not change on preset. The default setting is 19 if non-volatile memory content is lost.

**HP-IB:** Not available (must use SYST:KEY)

**Note**

To use special functions greater than 24 push **SPECIAL** and the function number with the key pad followed by **ENTER SPCL**, **SPCL ON**, or **SPCL OFF**. If you select a special function of 100 or higher the **▲** and **▼** keys will scroll through functions 100 to 1000. To return to functions 0 through 24, select the special function by number.

**Display On/Off Control:  
SPCL 100 DISPLAY**

This function will disable the LCD display and keyboard indicator lights. **SPCL ON** will turn the display on, and **SPCL OFF** will turn the display off. When the normal function display is off the display will show DISPLAY DISABLED. Front panel keys are still active.

Preset state: On (display enabled)

**HP-IB:** "DISP:STAT"

**Display Software  
Version: SPCL 110 SW  
VERSION**

Displays the version number of the installed firmware on the display. This message will remain until another key is pressed.

**HP-IB:** "\*IDN?"

**Service Voltmeter:  
SPCL 200 through 300**

These service functions display the voltage at various points in the Generator. The voltmeter mode will remain active until another key is pressed. See the service manual for details. Push **SPCL ON** to activate.

**HP-IB:** See service manual.

## Special Functions

HP 8782B

**Direct Control: SPCL  
300 I-BUS CTRL**

This service function allows direct control of the Generator hardware; see the service manual for details. Push **SPCL** 300 then **ENTER SPCL** to activate. This is not for normal use and may lead to errors in Generator operation.

**HP-IB:** See service manual.

**Game: SPCL 600 GAME**

This function enables a fun game! Push **SPCL ON** to activate. Press **PRESET** to get out of the fun game and the Generator will be in its prior state before the fun game began!

**HP-IB:** Not available.

**Service Mode On/Off:  
SPCL 901 SERVICE  
MODE**

This special function allows the software to log error messages that may be useful for service of the Generator. When this special function is off, only user errors are logged. Push **SPCL ON** or **SPCL OFF** to activate or deactivate the function.

Preset state: Off

**HP-IB:** See service manual.

**Initialize: SPCL 1000  
INITIALIZE**

This function sets all RAM contents to zero, then performs a power-on sequence. This is useful when the Generator is removed from a secure area. Push **ENTER SPCL** to activate. If the Generator seems "dead" even after turning the power off, hold down the **⊖** while the instrument powers on. This will perform special function 1000.

**HP-IB:** See service manual.

## Remote Operation

---

### Introduction

This chapter contains the information needed to operate the instrument in Remote Mode. The chapter is broken into 4 major parts:

- Introduction to Programming

This section contains the basic information concerning addressing and program syntax. A general explanation of status reporting is also provided.

- Summary of Commands

This section consists of tables that summarize all HP-IB commands available for the HP 8782B.

- Common Commands

The common commands defined by IEEE 488.2 used in the generator are described here.

- Subsystem Commands

This instrument's subsystem commands are described in detail. Syntax tables for each subsystem, along with descriptions and examples for each command, are provided.

---

**Note**

The programming examples in this manual are written in HP Basic 4.0 for an HP 9000 Series 200/300 Controller.

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### Introduction to Programming

HP-IB commands are sent to the instrument with ASCII program messages. These messages are placed on the bus using an output command and passing the device address, program message, and terminator. Passing the device address ensures that the program message is sent to the correct interface and instrument.

## Addressing

### Interface Select Code (Selects Interface)

Each interface has its own interface select code. This address is used by the controller to direct commands and communications to the proper interface. The default is "7" in the examples for HP-IB controllers.

### Device Address (Selects Instrument)

Each instrument on the HP-IB port must have a unique instrument address between decimal 0 and 30. The device address passed with the program message must include not only the correct instrument address, but also the correct interface select code.

DEVICE ADDRESS = (Interface Select Code × 100) + (the instrument address)

For example, if the instrument address for the instrument is 19 and the interface select code is 7, when the program message is passed the routine performs its function on the instrument at device address 719.

For the specifics of setting the HP-IB address for the generator refer to the installation chapter (chapter 2) of this manual.

## Command Types

HP-IB commands can be separated into two groups: common commands and subsystem commands.

### Common Commands

Common commands are generally not measurement related and are used to manage status registers, synchronization, and data storage. Common commands are easy to recognize because they all begin with an asterisk, such as \*IDN? or \*RST. Common commands are defined by IEEE Standard 488.2.

### Subsystem Commands

Subsystem commands include all measurement functions and some general purpose functions. Subsystem commands are distinguished by the colon used between keywords, such as in :DM:CLOCK:MODE. Each command subsystem is a set of commands that roughly corresponds to a functional block inside the instrument.

There are 13 subsystems in the HP 8782B:

- AM
- Diagnostics
- Digital Modulation
- Display
- Frequency
- Output
- Phase
- Power
- Pseudo-Random Binary Sequence
- Pulse Modulation
- Status
- System
- Vector

---

## Programming Syntax

To program the instrument over the HP-IB, you must have some understanding of the command format and structure expected by the instrument. The instrument is remotely programmed with HP-IB program messages. These are composed of sequences of program message units, with each unit representing a program command or query. A program command or query is composed of a sequence of functional elements that include separators, headers, and program data. These are sent to the instrument over the system interface as a sequence of ASCII data messages. For example:

```
OUTPUT 719;":FREQ:CW 40E6"
```

```
OUTPUT 719;
```

describes which instrument on the bus will receive the command.

```
:FREQ:CW
```

is the command header.

```
40E6
```

is the program data. Note that the data is separated from the command header by a blank space.

## Command Header

The command header is the program mnemonic or mnemonics that represent the operation to be performed by the instrument. Command headers can be either simple or compound.

A simple command header contains a simple mnemonic. An example of a simple command header would be:

```
*CLS
```

A compound header is a combination of one or more program mnemonics. The first mnemonic selects the subsystem, and the last mnemonic selects the function with that subsystem. Additional

mnemonics that appear between the subsystem mnemonic and the function mnemonic select subsystems of subsystems. The mnemonics within the compound messages are separated by colons. An example of a compound header would be:

```
:FREQ: CW
```

**Query** Command headers immediately followed by a question mark (?) are queries. An example query:

```
OUTPUT 719; ":FREQ: CW?"
```

After receiving a query, the instrument interrogates the requested function and places the answer in its HP-IB output queue.

The output message remains in the queue until it is read or another command is issued. When read, the message is transmitted across the bus to the designated listener (typically a controller). The command:

```
ENTER 719; Freq
```

passes the value across the HP-IB bus to the controller and places it in the variable *Freq*.

## Program Data

Data provides the information specific to the operation being performed. It is not always necessary. When provided it should be separated from the command header by a space. When a program mnemonic has multiple data parameters, a comma separates sequential program data.

Program data can be one of four types: numeric, extended numeric, discrete, or boolean.

### Numeric Data

The instrument accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. The instrument automatically rounds numeric parameters to fit its needs.

Suffixes, such as MHZ (megahertz) and MV (millivolt) are allowed with numeric data. The suffix expresses the units and multipliers that can be used to interpret the data sent. If a suffix is not specified, the instrument assumes the data was entered in fundamental units (that is, hertz, volts, etc.).

The HP 8782B accepts the suffixes shown in the following table.

HP 8782B

Remote Operation

Table 4-1. HP 8782B Suffixes for Numeric Data

Frequency Suffix	Multiplier
EXHz	$\times 1E18$
PEHz	$\times 1E15$
THz	$\times 1E12$
GHz	$\times 1E9$
MHz	$\times 1E6$
KHz	$\times 1E3$
Hz	$\times 1$
UHz	$\times 1E-6$
NHz	$\times 1E-9$
PHz	$\times 1E-12$
FHz	$\times 1E-15$
AHz	$\times 1E-18$
Voltage Suffix	Multiplier
EXV	$\times 1E18$
PEV	$\times 1E15$
TV	$\times 1E12$
GV	$\times 1E9$
MAV	$\times 1E6$
KV	$\times 1E3$
V	$\times 1$
MV	$\times 1E-3$
UV	$\times 1E-6$
NV	$\times 1E-9$
PV	$\times 1E-12$
FV	$\times 1E-15$
AV	$\times 1E-18$
Watt Suffix	Multiplier
EXW	$\times 1E18$
PEW	$\times 1E15$
TW	$\times 1E12$
GW	$\times 1E9$
MAW	$\times 1E6$
KW	$\times 1E3$
W	$\times 1$
MW	$\times 1E-3$
UW	$\times 1E-6$
NW	$\times 1E-9$
PW	$\times 1E-12$
FW	$\times 1E-15$
AW	$\times 1E-18$

Table 4-1.  
HP 8782B Suffixes for Numeric Data (continued)

Level Suffix	Multiplier
Voltage suffixes	
Watt suffixes	
DBM	$\times 1$
DBW	$\times 1$
DBV	$\times 1$
DBMV	$\times 1$
DBUV	$\times 1$
Level Increment Suffix	Multiplier
Voltage suffixes	
Watt suffixes	
DB	$\times 1$
Relative Suffix	Multiplier
DB	$\times 1$
EXPCT	$\times 1E18$
PEPCT	$\times 1E15$
TPCT	$\times 1E12$
GPCT	$\times 1E9$
MAPCT	$\times 1E6$
KPCT	$\times 1E3$
PCT	$\times 1$
MPCT	$\times 1E-3$
UPCT	$\times 1E-6$
NPCT	$\times 1E-9$
PPCT	$\times 1E-12$
FPCT	$\times 1E-15$
APCT	$\times 1E-18$
Degree Suffix	Multiplier
EXDEG	$\times 1E18$
PEDEG	$\times 1E15$
TDEG	$\times 1E12$
GDEG	$\times 1E9$
MADEG	$\times 1E6$
KDEG	$\times 1E3$
DEG	$\times 1$
MDEG	$\times 1E-3$
UDEG	$\times 1E-6$
NDEG	$\times 1E-9$
PDEG	$\times 1E-12$
FDEG	$\times 1E-15$
ADEG	$\times 1E-18$
EXRAD	$\times 1E18$

Table 4-1.  
HP 8782B Suffixes for Numeric Data (continued)

PERAD	× 1E15
TRAD	× 1E12
GRAD	× 1E9
MARAD	× 1E6
KRAD	× 1E3
RAD	× 1
MRAD	× 1E-3
URAD	× 1E-6
NRAD	× 1E-9
PRAD	× 1E-12
FRAD	× 1E-15
ARAD	× 1E-18

### Special Form Numeric Data

If the signal generator accepts numeric data with a command or query, it will usually also accept a special form numeric of MAXimum, MINimum, UP and DOWN. UP and DOWN are only accepted only if the command has an associated increment. For example, “:FREQ:CW MAX” sets the instrument frequency to its maximum value; “:FREQ:CW MIN” sets the instrument frequency to its minimum value; “:FREQ:CW UP” increments the instrument frequency using the frequency increment value; and “:FREQ:CW DOWN” decrements the instrument frequency using the frequency increment value.

### Character Data

Character data is used to program settings that have a finite number of values. Character parameters use mnemonics to represent each valid setting. INTERNAL and EXTERNAL are examples of character data required with the HP-IB command “:DM:FILT:SOUR”.

### Boolean

Boolean data represents a single binary condition that is either true or false. There are only four possible values for a Boolean parameter: ON, OFF, 1 and 0. 1 (any non-zero numeric data is changed to 1) is the same as TRUE and 0 is the same as FALSE.

## Standard Notation

### Long Form/Short Form

HP-IB commands and data are insensitive to the case of letters (all HP-IB characters can be a combination of upper case or lower case ASCII characters). Instrument responses are always returned in upper case.

Both command and queries can be used in either long form (complete spelling) or short form (abbreviated spelling). Consider the FREQUENCY command. The short form is `FREQ` and the long form is `FREQUENCY`. Notice that the lower-case letters in `FREQUENCY` are optional; this notation is used throughout the Remote Operation section.

### Command Tables

At the beginning of each subsystem is a command table, which lists the HP-IB commands available in that subsystem. The command table also shows the command hierarchy.

An example of a portion of a command table would be:

```
[ :SOURce]
  :FREQuency
    [:CW]
      :STEP
        [:INCRement]
        [:INCRement]?
    [:CW]?
```

The indenting indicates hierarchal levels (subsystems). This is used for determining how to build an HP-IB command or query like "SOUR:FREQ:CW:STEP:INCR".

Commands enclosed in square brackets are considered optional. The instrument will respond exactly the same whether or not the optional mnemonic is present. For example, the commands `SOURCE:FREQUENCY` and `FREQUENCY` are identical.

### Command Syntax

In addition to the syntax table at the beginning of each subsystem section, command syntax is shown at the beginning of each individual command description. The command mnemonic is shown in "computer font". Variable parameters used with the command are shown in italics. If there are several choices for a required item, they are shown inside a set of curly braces - { }. Optional elements are placed inside square brackets - [ ].

## Status Reporting

The status reporting features which are available over the HP-IB include the serial and parallel polls. IEEE 488.2 defines data structures, commands, and common bit definitions for each. There are also instrument defined structures and bits. A more detailed explanation of IEEE 488.2 can be found in *ANSI/IEEE Standard Codes, Formats, Protocol, and Common Commands for use with ANSI/IEEE Std 488.1-1987 IEEE Standard Digital Interface for Programmable Instrumentation*. Part number is ISBN 471-61871-3.

### Status Byte Register

The IEEE 488.2 standard defines the Status Byte. This standard also defines the functionality of bits 4, 5, and 6 of the status byte. TMSL (Test and Measurement System Language) defines the functionality of bits 3 and 7. Bits 0, 1 and 2 are instrument dependent and are always 0 in the HP 8782B.

The bits in the Status Byte are defined as follows:

- Bit 7: Operation Status Register summary bit
- Bit 6: Request Service (RQS)
- Bit 5: Standard Event Status Register summary bit
- Bit 4: Message Available (MAV) summary bit
- Bit 3: Questionable Data/Signal Status Register summary bit
- Bit 2: always 0
- Bit 1: always 0
- Bit 0: always 0

Figure 4-1 shows an overview of the status reporting structure. The numbers used represent the bit number in the byte or register. For example, bit number 5 is the Frequency Bit in the :STAT:QUES:COND? register.

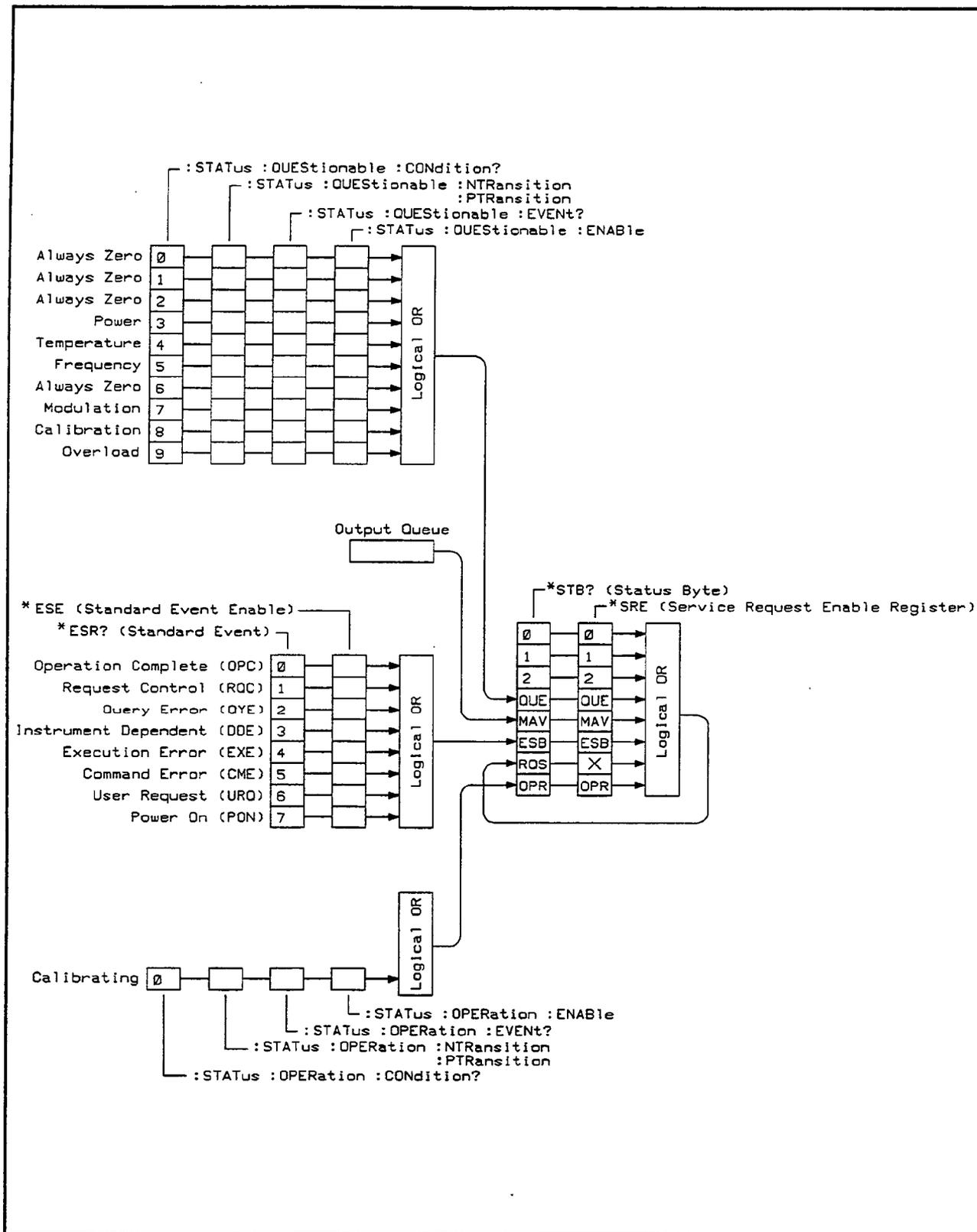


Figure 4-1. Status Reporting Structure Overview

**Enabling Service Request**

The current value of the instrument's Status Byte is returned to the controller when the Status Byte (\*STB?) query is sent to the instrument. The user can set bits in the Service Request Enable Register (SRER) with the Service Request Enable (\*SRE) command. These bits correspond to bits in the Status Byte. When a bit is set in the SRER it enables that bit in the Status Byte to request service. For example, setting bit 4 in the SRER will cause the device to request service whenever the device has data in the Output Queue.

**TMSL Operation Status Group**

The TMSL Operation Status group provides information about the state of measurement systems. TMSL Operation Status group includes a condition register, a transition filter, an event register, and an enable register. This group is accessed through the Status Subsystem.

The Standard Operation Status register is a 16-bit register. However, only bit 0 is used. All other bits are always zero. Bit 0 indicates the status of the calibration; if the bit is 1 then calibration is in progress, if it's 0 then calibration is not running.

**Standard Event Status Register**

The Standard Event Status Register is an 8 bit register that contains various information about instrument operation. The bits in the Standard Event Status Register are defined in the following table:

Table 4-2. Standard Event Status Register

Bit	Name	Description
7	Power On (PON)	This bit is set when the instrument's power supply has been turned off and then on since the last time this register was read.
6	User Request (URQ)	This bit is set when a front panel key has been pressed since the last time this register was read. This bit will be set regardless of the Remote Local state of the instrument. This provides the user with a means of getting the controller's attention.
5	Command Error (CME)	This bit is set when the instrument has detected a command error.
4	Execution Error (EXE)	This bit is set when the instrument detected an error while trying to execute a command.
3	Device Dependent Error (DDE)	This bit is set when the instrument detected an error which was not a command, query, or execution error. A device dependent error is any instrument operation that did not execute properly due to some internal condition such as "oven cold".
2	Query Error (QYE)	This bit is set when there was an attempt to read data from the Output Queue when no data was present or when data in the Output Queue was lost.
1	Request Control (RQC)	This bit is not used for the generator and is always 0.
0	Operation Complete (OPC)	This bit is set when 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.

**Output Queue**

The Output Queue is a first-in, first-out 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.

**TMSL Questionable Data/Signal Register Group**

The Questionable Data register group provides information about the quality of instrument output and measurement data. The Questionable Data register group includes a condition register, a transition filter, an event register, and an enable register. This group is accessed through the Status Subsystem.

The Questionable Data Register is a 16-bit register. The bits in the Questionable Data Register are defined as follows:

**Table 4-3. Questionable Data Register**

Bit	Name	Description
10-15	Not Used	Always Zero
9	Overload	This bit is set when the external filter inputs are overloaded.
8	Calibration	This bit is set when the instrument is not calibrated.
7	Modulation	This bit is set when the modulation is not calibrated.
6	Not Used	Always Zero
5	Frequency	This bit is set when the local oscillator loops are unlocked.
4	Temperature	This bit is set when the time base oven is not at the proper temperature.
3	Power	This bit is set when the power is not calibrated.
0-2	Not Used	Always Zero

---

## General HP-IB Information

### Remote, Local, and Local Lockout

The local, remote, and remote with local lockout modes may be used for various degrees of front panel control while a program is running.

The instrument will accept and execute bus commands while in local mode, and the front panel will also be entirely active. If the instrument is in remote mode, all instrument controls (except the power switch and the LOCAL key) are entirely locked out. Local control can only be restored by the controller or pressing the front panel LOCAL key. The following HP BASIC command can also be used:

LOCAL 719

Cycling the power will also restore local control, but this will also reset certain HP-IB states.

The instrument is placed in remote mode by setting the REN bus control line true, and then addressing the instrument to listen. The HP BASIC command is:

REMOTE 719

This command would cause the instrument located at address 719 to go into remote mode.

The instrument can be placed in local lockout mode by sending the local lockout command (LLO). The HP BASIC command is:

LOCAL LOCKOUT 7

The front panel LOCAL key will not cause the instrument to return to local control if local lockout is in effect. The instrument can be returned to local mode by either setting the REN line false, or sending the instrument the go-to-local command (GTL). The HP BASIC command is:

LOCAL 7

### Interface Capabilities

The interface capabilities of the instrument, as defined by IEEE 488.1 are SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT0, C0 and E2.

## Summary of HP-IB Commands

Table 4-4 summarizes the common commands available to the HP 8782B. Tables 4-5 through 4-15 summarize the HP 8782B commands by subsystem.

**Table 4-4. HP 8782B IEEE 488.2 Common Commands**

Command	Description
*CAL?	Perform a complete calibration and return the result.
*CLS	Clear the error queue and event registers.
*ESE	Set Standard Event Status Enable Register.
*ESE?	Query Standard Event Status Enable Register.
*ESR?	Query Standard Event Status Register.
*IDN?	Query identification string.
*IST?	Query the ist parallel poll bit.
*LRN?	Return instrument state "learn" string.
*OPC	Set operation complete bit when finished.
*OPC?	Return 1 when operation complete.
*PRE	Set Parallel Poll Enable Register.
*PRE?	Query Parallel Poll Enable Register.
*RCL	Recall a previously stored instrument state.
*RST	Reset the instrument.
*SAV	Save the present instrument setting.
*SRE	Set Service Request Enable Register.
*SRE?	Query Service Request Enable Register.
*STB?	Read Status Byte Query
*TST?	Perform a self-test and return the result.
*WAI	Wait until previous commands are finished.

Table 4-5. AM Subsystem Commands

Command	Description
[:SOURce]	
:AM	
[:DEPTh]	Set the Fade simulation depth.
[:DEPTh]?	Query the Fade simulation depth.
:FREQuency	Set the Fade simulation frequency.
:FREQuency?	Query the Fade simulation frequency.
:SOURce	Set the AM source (same as Fade on/off).
:SOURce?	Query the AM source.
:STATe	Turn scalar on/off.
:STATe?	Query scalar state.

Table 4-6. Diagnostics Subsystem Commands

Command	Description
:DIAGnostics	
:BBCal?	Performs a baseband section calibration.
:LCAL?	Performs a level calibration.
:NULLcal?	Performs a null calibration.

Table 4-7. Digital Modulation Subsystem Commands

Command	Description
[[:SOURce]	
:DM	
:CLOCK	
:MODE	Set external clock mode.
:MODE?	Query external clock mode.
:SOURce	Set clock source.
:SOURce?	Query clock source.
:COUPling	
[:ALL]	Set data and clock coupling.
:CLOCK	Set clock coupling.
:CLOCK?	Query clock coupling.
:DATA	Set data coupling.
:DATA?	Query data coupling.
:DMODe	Set digital data input mode.
:DMODe?	Query digital data input mode.
:FILTer	
:CORRection	
:I	Set the I filter correction
:STEP	
[:INCRement]	Set the I filter correction increment.
[:INCRement]?	Query the I filter correction increment.
:I?	Query the I filter correction.
:Q	Set the Q filter correction.
:STEP	
[:INCRement]	Set the Q filter correction increment.
[:INCRement]?	Query the Q filter correction increment.
:Q?	Query the Q filter correction.
[:STATe]	Turn the filter correction on and off.
[:STATe?]	Query the filter correction state.
:SOURce	Set the filter source.
:SOURce?	Query the filter source.
[:FORMat]	Set digital modulation format.
[:FORMat]?	Query digital modulation format.
:FRAMe	
:SOURce	Set frame clock source.
:SOURce?	Query frame clock source.
:IQRatio	
[:MAGNitude]	Set the I/Q ratio.
:STEP	
[:INCRement]	Set the I/Q ratio increment.
[:INCRement]?	Query the I/Q ratio increment.

Table 4-7.  
Digital Modulation Subsystem Commands (continued)

Command	Description
[:MAGNitude]?	Query the I/Q ratio.
:STATe	Turn the I/Q ratio on and off.
:STATe?	Query the I/Q ratio state.
[:SOURce]	
:DM	
:LEAKage	
:ANGLE	Set the carrier leakage angle.
:STEP	
[:INCRement]	Set the carrier leakage angle increment.
[:INCRement]?	Query the carrier leakage angle increment.
:ANGLE?	Query the carrier leakage angle.
[:MAGNitude]	Set carrier leakage magnitude.
:STEP	
[:INCRement]	Set carrier leakage magnitude increment.
[:INCRement]?	Query carrier leakage magnitude increment.
[:MAGNitude]?	Query carrier leakage magnitude.
:STATe	Turn carrier leakage on and off.
:STATe?	Query carrier leakage state.
:POLarity	
[:ALL]	Set polarity of I[n], Q[n], Iclock, Qclock, serial data, serial clock and frame.
:I[n]	Set polarity of I data input number n.
:I[n]?	Query polarity of I data input number n.
:Q[n]	Set polarity of Q data input number n.
:Q[n]?	Query polarity of Q data input number n.
:ICLock	Set polarity of I clock input.
:ICLock?	Query polarity of I clock input.
:QCLOCK	Set polarity of Q clock input.
:QCLOCK?	Query polarity of Q clock input.
:SERial	
:CLOCK	Set polarity of serial clock input.
:CLOCK?	Query polarity of serial clock input.
[:DATA]	Set polarity of serial data input.
[:DATA]?	Query polarity of serial data input.
:FRAMe	Set polarity of serial frame input.
:FRAMe?	Query polarity of serial frame input.
:QUADrature	
[:ANGLE]	Set the quadrature angle.
:STEP	
[:INCRement]	Set the quadrature angle increment.
[:INCRement]?	Query the quadrature angle increment.

**Table 4-7.**  
**Digital Modulation Subsystem Commands (continued)**

Command	Description
[:ANGLE]?	Query the quadrature angle.
:STATe	Turn the quadrature angle on and off.
:STATe?	Query quadrature angle state.
:SOURce	Set the digital data source. (Same as PRBS on/off)
:SOURce?	Query the digital data source.
[:SOURce]	
:DM	
:STATe	Turn digital modulation on/off.
:STATe?	Query digital modulation state.
:THReshold	
[:ALL]	Set data and clock thresholds.
:CLOCK	Set clock threshold.
:STEP	
[:INCRement]	Set clock threshold increment.
[:INCRement]?	Query clock threshold increment.
:CLOCK?	Query clock threshold.
:DATA	Set data threshold.
:STEP	
[:INCRement]	Set data threshold increment.
[:INCRement]?	Query data threshold increment.
:DATA?	Query data threshold.

**Table 4-8. Display Subsystem Commands**

Command	Description
:DISPlay	
[:STATe]	Turn display on/off.
[:STATe]?	Query display state.

Table 4-9. Frequency Subsystem Commands

Command	Description
[[:SOURce]]	
:FREQuency	
[:CW]	Set the carrier frequency.
:STEP	
[:INCRement]	Set the carrier frequency increment.
[:INCRement]?	Query the carrier frequency increment.
[:CW]?	Query the carrier frequency.
[:FIXed]	Set the carrier frequency.
:STEP	
[:INCRement]	Set the carrier frequency increment.
[:INCRement]?	Query the carrier frequency increment.
[:FIXed]?	Query the carrier frequency.
:MODE	Set the carrier frequency sweep mode.
:MODE?	Query the carrier frequency sweep mode.

Table 4-10. Output Control Subsystem

Command	Description
[[:SOURce]]	
:OUTPut	
:IMPedance?	Query output impedance.
[:STATe]	Turn RF output on/off.
[:STATe]?	Query RF output state.

Table 4-11. Phase Subsystem Commands

Command	Description
[[:SOURce] :PHASe [:OUTPut] [:ADJust] :STEP [:INCRement] [:INCRement]? [:ADJust]? :STATe :STATe? :RSIGnal [:ADJust] :STEP [:INCRement] [:INCRement]? [:ADJust]?]	Set the constellation phase adjustment. Set the constellation phase increment. Query the constellation phase increment. Query the constellation phase adjustment. Turn constellation phase adjustment on/off. Query constellation phase adjustment state. Bump the 10 MHz signal phase. Set the 10 MHz signal phase increment. Query the 10 MHz signal phase increment. Query the last 10 MHz signal phase bump.

Table 4-12. Power Subsystem Commands

Command	Description
[[:SOURce] :POWER :ATTenuation :AUTO :AUTO? [:LEVel] [:IMMediate] [:AMPLitude] :STEP [:INCRement] [:INCRement]? [:AMPLitude]? :MODE :MODE? :UNIT :UNIT?]	Set auto attenuation on/off. (Same as locking attenuators) Query auto attenuation state. Set the power level. Set the power level increment. Query the power level increment. Query the power level. Set the power level sweep mode. Query the power level sweep mode. Set the units for power. Query the units for power.

**Table 4-13.**  
**Pseudo-Random Binary Sequence Commands**

Command	Description
[[:SOURce]]	
:PRBS	
:CLOCK	
:POLarity	Set PRBS clock polarity.
:POLarity?	Query PRBS clock polarity.
[[:SOURce]]	Set PRBS clock source.
[[:SOURce]]?	Query PRBS clock source.
:DIVide	Set PRBS external clock divide number.
:DIVide?	Query PRBS external clock divide number.
:FREQuency	Set PRBS internal clock frequency.
:FREQuency?	Query PRBS internal clock frequency.

**Table 4-14. Pulse Modulation Subsystem Commands**

Command	Description
[[:SOURce]]	
:PULM	
:POLarity	Set polarity of burst.
:POLarity?	Query polarity of burst.
:STATe	Turn burst on/off.
:STATe?	Query burst state.

Table 4-15. Status Subsystem Commands

Command	Description
:STATus	
:OPERation	
:CONDition?	Query operation condition register.
:ENABle	Set operation event enable register.
:ENABle?	Query operation event enable reg.
[:EVENT]?	Query operation event register.
:NTRansition	Set operation negative edge register.
:NTRansition?	Query operation negative edge register.
:PTRansition	Set operation positive edge register.
:PTRansition?	Query operation positive edge register.
:QUESTionable	
:CONDition?	Query questionable condition register.
:ENABle	Set questionable event enable register.
:ENABle?	Query questionable event enable reg.
[:EVENT]?	Query questionable event register.
:NTRansition	Set questionable negative edge register.
:NTRansition?	Query questionable negative edge register.
:PTRansition	Set questionable positive edge register.
:PTRansition?	Query questionable positive edge register.

Table 4-16. System Subsystem Commands

Command	Description
:SYSTem	
:ERRor?	Returns error codes with message.
:KEY	Simulates pushing a front panel key.
:KEY?	Returns last key pressed.

Table 4-17. Vector Modulation Subsystem Commands

Command	Description
[[:SOURce]	
:VM	
:QUADrature	
[:ANGLE]	Set the quadrature angle.
:STEP	
[:INCRement]	Set the quadrature angle increment.
[:INCRement]?	Query the quadrature angle increment.
[:ANGLE]?	Query the quadrature angle.
:STATe	Turn the quadrature angle on and off.
:STATe?	Query quadrature angle state.
:STATe	Turn vector modulation on/off
:STATe?	Query vector modulation state

## Common HP-IB Commands

The common commands are defined by the IEEE 488.2 standard. These commands will be common to all instruments that comply with this standard.

The common commands control some of the basic instrument functions, such as instrument identification and reset, reading the learn (instrument setup) string, and how status is read and cleared.

The common commands used in the generator are shown in the following table:

**HP 8782B IEEE 488.2 Common Commands**

Command	Command Name
*CAL?	Calibration Command
*CLS	Clear Status Command
*ESE	Event Status Enable Command
*ESE?	Event Status Enable Query
*ESR?	Event Status Register Query
*IDN?	Identification Query
*IST?	Parallel Poll Bit Query
*LRN?	Learn Device Setup Query
*OPC	Operation Complete Command
*OPC?	Operation Complete Query
*PRE	Parallel Poll Enable Command
*PRE?	Parallel Poll Enable Query
*RCL	Recall Command
*RST	Reset Command
*SAV	Save Command
*SRE	Service Request Enable Command
*SRE?	Service Request Enable Query
*STB?	Read Status Byte Query
*TST?	Self-Test Query
*WAI	Wait-to-Continue Command

---

**\*CAL?**  
**(Calibration)**

**Syntax**      \*CAL?

**Description**    The \*CAL? query does a complete instrument calibration. The result of the query is a 0 if the calibration is completed without any errors, a 1 if an error occurred during the calibration, and a 2 if the calibration was aborted by the user.

**Example Command**      OUTPUT 719;"\*CAL?"  
                              ENTER 719;A  
                              PRINT A

**\*CLS  
(Clear Status)****Syntax**      \*CLS**Description**      The \*CLS (clear status) common command clears the status data structures, including the device defined error queue. This command also clears \*OPC and \*OPC?.

If the \*CLS command immediately follows a PROGRAM MESSAGE TERMINATOR, the output queue and the MAV bit will be cleared.

**Example Command**      OUTPUT 719; "\*CLS"

## \*ESE (Event Status Enable)

**Syntax**      \*ESE *mask*  
                  \*ESE?

**Description**    The \*ESE command sets the Standard Event Status Enable Register bits. The Standard Event Status Enable Register contains a mask value for the bits to be enabled in the Standard Event Status Register. A one in the Standard Event Status Enable Register will enable the corresponding bit in the Standard Event Status Register, a zero will disable the bit. Refer to the table below for the information about the Standard Event Status Enable Register bits, bit weights, and what each bit masks. If a bit is enabled and the corresponding bit is 1 in the Event Status Register then bit 5 of the status byte will be set. Valid number range is 0 to 255.

The \*ESE? query returns the current contents of the register.

**Event Status Enable Register Bit Definitions**

Bit	Weight	Enables
7	128	PON- Power ON
6	64	URQ- User Request
5	32	CME- Command Error
4	16	EXE- Execution Error
3	8	DDE- Device Dependent Error
2	4	QYE- Query Error
1	2	RQC- Request Control
0	1	OPC- Operation Complete

**Example Command**    OUTPUT 719;"\*ESE 64"

**Example Query**      OUTPUT 719;"\*ESE?"  
                          ENTER 719; Event  
                          PRINT Event

## \*ESR? (Event Status Register Query)

**Syntax**      \*ESR?

**Description**      The \*ESR? query returns the contents of the Standard Event Status Register.

The table below shows the Event Status Register. The table shows each bit in the Event Status Register, and the bit weight. When you read the Event Status Register, the value returned is the total bit weights of all bits that are high at the time you read the byte. The register is cleared to 0 on a \*CLS and after \*ESR? is executed. If a bit is enabled by \*ESE and the corresponding bit is 1 in the Event Status Register then bit 5 of the status byte will be set.

**HP 8782B Event Status Register Bit Definitions**

Bit	Weight	Name	Condition
7	128	PON	1 = an OFF to ON transition has occurred
6	64	URQ	0 = no front-panel key has been pressed; 1 = front-panel key has been pressed
5	32	CME	0 = no command errors; 1 = a command error has been detected
4	16	EXE	0 = no execution error; 1 = an execution error has been detected
3	8	DDE	0 = no device dependent errors; 1 = a device dependent error has been detected
2	4	QYE	0 = no query errors; 1 = a query error has been detected
1	2	RQC	0 = request control- NOT used- always 0
0	1	OPC	0 = operation is not complete; 1 = operation is complete

**Example Query**

```
OUTPUT 719;"*ESR?"
ENTER 719; Event
PRINT Event
```

---

**\*IDN?  
(Identification  
Number)**

**Syntax**        \*IDN?

**Description**    The \*IDN? query allows the instrument to identify itself. It returns the string:

HEWLETT-PACKARD,8782B,0,REVXY.Z

Where XY.Z is some number like 10.3 which is the firmware version number.

**Example Command**

```
DIM Id$[72]
OUTPUT 719;"*IDN?"
ENTER 719;Id$
PRINT Id$
```

**\*IST?  
(Individual Status)**

<b>Syntax</b>	*IST?
<b>Description</b>	The *IST? query reads the "ist" (individual status) local message without performing a parallel poll.
<b>Example Query</b>	OUTPUT 719;"*IST?" ENTER 719;Value PRINT Value

---

**\*LRN?  
(Learn)****Syntax**      \*LRN?**Description**      The \*LRN? query returns a program message that contains the current state of the instrument. This command allows you to store an instrument setup in the controller. The stored setup can then be returned to the instrument when you want that setup at a later time. The size of the learn string will be less than 2000 bytes.**Note**

---

The results of the \*LRN? query is a string of binary data which may contain any bit pattern including a line feed (LF). Therefore, the end of the \*LRN? response can only be detected by testing for EOI asserted on a LF character. The example below uses the -K option to read all data up to the LF-EOI.

---

**Example Query**

```
DIM A$[2000]
OUTPUT 719;"*LRN?"
ENTER 719 USING "-K";A$
```

To restore the instrument state captured in A\$, the following can be executed at any time:

```
OUTPUT 719;A$
```

---

**\*OPC  
(Operation  
Complete)**

**Syntax**       \*OPC  
                  \*OPC?

**Description**   The \*OPC (operation complete) command will cause the instrument to set the operation complete bit in the Standard Event Status Register when all pending device operations have finished.

The HP 8782B has no pending operations; all are completed before the next HP-IB command or query is executed. The \*OPC command is included for IEEE 488.2 compatibility.

The \*OPC? query places an ASCII "1" in the output queue when all pending device operations have finished.

**Example Command**       OUTPUT 719;"\*OPC"

**Example Query**         OUTPUT 719;"\*OPC?"  
                          ENTER 719;A  
                          PRINT A

---

**\*PRE**  
**(Parallel Poll**  
**Register Enable)**

**Syntax**        \*PRE *mask*  
                  \*PRE?

**Description**    The \*PRE command sets the parallel poll register enable bits.  
                  The Parallel Poll Enable Register contains a mask value for the bits to be enabled that can produce an "ist" during a parallel poll. If the Parallel Poll Enable Register bit is enabled and the corresponding bit in the status byte is set then "ist" will be 1. Legal number range is 0 to 255. See \*STB? mnemonic for bit definitions.  
                  The \*PRE? query returns the current value.

**Example Command**        OUTPUT 719;"\*PRE 16"

**Example Query**         OUTPUT 719;"\*PRE?"  
                          ENTER 719;Value  
                          PRINT Value

---

**\*RCL  
(Recall)**

**Syntax**      *\*RCL register*

**Description**      The \*RCL command restores the state of the instrument from the specified save/recall register. If no instrument state has been previously stored in the specified register, the PRESET state is loaded. Legal number range is 0 - 9.

**Example Command**      OUTPUT 719;"\*RCL 6"

---

**\*RST**  
**(Reset)**

**Syntax**        \*RST

**Description**    The \*RST command places the instrument in a known state. \*RST is equivalent to pressing the PRESET key on the generator's front panel. Refer to the section "Local Operation" for details on PRESET.

**Example Command**    OUTPUT 719;"\*RST"

---

**\*SAV  
(Save)**

**Syntax**      *\*SAV register*

**Description**      The \*SAV command stores the current state of the instrument in the specified save/recall register. Legal number range is 0 - 9.

**Example Command**      OUTPUT 719;"\*SAV 6"

## \*SRE (Service Request Enable)

**Syntax**      \*SRE *mask*  
                  \*SRE?

**Description**    The \*SRE command sets the Service Request Enable Register bits. The Service Request Enable Register contains a mask value for the bits to be enabled to produce an SRQ. A one in the Service Request Enable Register will enable the corresponding bit in the Status Byte Register, a zero will disable the bit. Refer to the table below for the bits in the Service Request Enable Register and what they mask. Legal number range is 0 - 255.

The \*SRE? query returns the current value.

**Service Request Enable Register**

Bit	Weight	Enables
7	128	TMSL Operation Summary Bit
6	64	RQS- Request Service
5	32	ESB- Event Status Bit
4	16	MAV- Message Available
3	8	TMSL Questionable summary bit
2	4	Not used
1	2	Not used
0	1	Not used

**Example Command**      OUTPUT 719; "\*SRE 32"

**Example Query**        OUTPUT 719; "\*SRE?"  
                              ENTER 719; Value  
                              PRINT Value

## \*STB? (Status Byte)

**Syntax**      \*STB?

**Description**      The \*STB? query returns the current value of the instrument's status byte. The MSS (Master Summary Status) bit and not RQS is reported on bit 6. The MSS indicates whether or not the device has at least one reason for requesting service. Refer to the table below for the definitions of the bits in the status byte. Note: to read the instrument's status byte with RQS reported on bit 6, use the HP-IB serial poll.

**Status Byte Bit Definitions**

Bit	Weight	Name	Condition
7	128	OPER	0= no operation status events have occurred 1= an operation status event has occurred
6	64	RQS/MSS	0= instrument has no reason for service 1= instrument is requesting service
5	32	ESB	0= no event status conditions have occurred 1= an enabled event status condition has occurred
4	16	MAV	0= no output messages are ready 1= an output message is ready
3	8	QUES	0= no questionable conditions have occurred 1= a questionable condition has occurred
2	4	-	always 0
1	2	-	always 0
0	1	-	always 0

Note: further information on bits 7 and 3 can be found in the Status subsystem

**Example Query**

```
OUTPUT 719;"*STB?"
ENTER 719;Value
PRINT Value
```

---

**\*TST?**  
**(Test)**

**Syntax**      \*TST?

**Description**    The \*TST? query causes the instrument to perform a self-test. The result of the test will be placed in the output queue. A 0 indicates that the test passed and a non-zero value indicates the test failed. If a test fails refer to the troubleshooting section of the Service Manual.

**Example Query**    OUTPUT 719;"\*TST?"  
ENTER 719;Result  
PRINT Result

**\*WAI  
(Wait)**

**Syntax**        \*WAI

**Description**    The \*WAI command causes the instrument to wait for all pending HP-IB operations to finish before processing any further commands.

**Example**        OUTPUT 719;"\*WAI"



## AM Subsystem

The AM Subsystem is used for controlling the AM modulation of the instrument.

The commands in the AM Subsystem are shown in the following table.

**AM Subsystem Commands**

Command	Description
[:SOURce]	
:AM	
[:DEPTh]	Set the Fade simulation depth.
[:DEPTh]?	Query the Fade simulation depth.
:FREQuency	Set the Fade simulation frequency.
:FREQuency?	Query the Fade simulation frequency.
:SOURce	Set the AM source. (Same as Fade on/off)
:SOURce?	Query the AM source.
:STATe	Turn scalar on/off.
:STATe?	Query scalar state.

**DEPTH****Syntax**

$$[:SOURCE]:AM[:DEPTH] \left\{ \begin{array}{l} \textit{depth} \\ \text{MAXimum} \\ \text{MINimum} \\ \text{DOWN} \\ \text{UP} \end{array} \right.$$

$$[:SOURCE]:AM[:DEPTH]? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

**Description** The DEPTH command sets the fade simulation depth.  
The following parameters can be selected:

Parameter	Description
<i>depth</i>	Allowable range is 0 to 20 dB in 0.1 dB steps or 100 to 10 percent. To enter the depth as a percentage, you must also use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the depth is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the depth to 20 dB.
MINimum	Sets the depth to 0 dB.
DOWN	Decreases the current depth setting by 1 dB.
UP	Increases the current depth setting by 1 dB.

The DEPTH? query returns the current fade simulation depth value in dB. The DEPTH? MAXIMUM query always returns 20. The DEPTH? MINIMUM query always returns 0.

Preset: 5 dB

**Example Command**

```
OUTPUT 719;":AM:DEPT 5 DB"
```

**Example Query**

```
OUTPUT 719;":AM:DEPT?"
ENTER 719; Value
PRINT Value
```

## FREQUENCY

### Syntax

```
[ :SOURce ] :AM:FREQUENCY { frequency
                             MAXimum
                             MINimum
                             DOWN
                             UP }

[ :SOURce ] :AM:FREQUENCY? [ MAXimum
                             MINimum ]
```

### Description

The FREQUENCY command sets the fade simulation frequency. The following parameters can be selected:

Parameter	Description
<i>frequency</i>	Allowable range is 0.1 to 10Hz in 0.1Hz steps.
MAXimum	Sets the frequency to 10Hz.
MINimum	Sets the frequency to 0.1 Hz.
DOWN	Decreases the current frequency setting by 0.5Hz.
UP	Increases the current frequency setting by 0.5Hz.

The FREQUENCY? query returns the current Fade simulation frequency value in hertz. The FREQUENCY? MAXIMUM query always returns 10. The FREQUENCY? MINIMUM query always returns 0.1.

Preset: 1Hz

### Example Command

```
OUTPUT 719;":AM:FREQ 2 HZ"
```

### Example Query

```
OUTPUT 719;":AM:FREQ?"
ENTER 719;Value
PRINT Value
```



**STATE****Syntax**

$$[:\text{SOURCE}]:\text{AM}:\text{STATE} \left\{ \begin{array}{l} 0 \\ 1 \\ \text{OFF} \\ \text{ON} \end{array} \right\}$$

$$[:\text{SOURCE}]:\text{AM}:\text{STATE?}$$
**Description**

The STATE command turns scalar on and off. It does NOT affect whether fade simulation is on or off.

**Note**

Vector modulation must be turned off (VM:STAT OFF) before Amplitude modulation can be turned on (AM:STAT ON).

The following parameters can be selected:

Parameter	Description
0	Turns scalar off.
1	Turns scalar on. Entering any number other than zero will also turn scalar on.
OFF	Turns scalar off.
ON	Turns scalar on.

The STATE? query returns a 0 if scalar is off and a 1 if scalar is on.

Preset: OFF

**Example Command**

```
OUTPUT 719;":AM:STAT ON"
```

**Example Query**

```
OUTPUT 719;":AM:STAT?"
ENTER 719;State
PRINT State
```

STATE

HP 8782B



## Diagnostics Subsystem

The Diagnostics Subsystem is used for controlling the segmented-calibration and diagnostics parameters of the instrument. The commands in the Diagnostics Subsystem are shown in the following table.

**Table 4-18. Diagnostics Subsystem Commands**

Command	Description
:DIAGnostics	
:BBCal?	Performs a baseband section calibration.
:LCAL?	Performs a level calibration.
:NULLcal?	Performs a null calibration.

---

**BBCal?**

**Syntax**           :DIAGnostics:BBCal?

**Description**       The BBCAL? query performs a calibration of only the baseband features of the instrument. The result of the query is a 0 if the baseband calibration is completed without any errors, a 1 if an error occurred during the calibration, and a 2 if the calibration was aborted by the user.

**Example Command**       OUTPUT 719;":DIAG:BBCAL?"

---

**LCAL?**

**Syntax**           :DIAGnostics:LCAL?

**Description**     The LCAL? query performs a calibration of only the output level features of the instrument. The result of the query is a 0 if the level calibration is completed without any errors, a 1 if an error occurred during the calibration, and a 2 if the calibration was aborted by the user.

**Example Command**     OUTPUT 719;":DIAG:LCAL?"

---

**NULLcal?**

**Syntax**           :DIAGnostics:NULLcal?

**Description**       The NULLCAL? query performs a calibration of only the null feature of the instrument. The result of the query is a 0 if the null calibration is completed without any errors, a 1 if an error occurred during the calibration, and a 2 if the calibration was aborted by the user.

**Example Command**       OUTPUT 719;":DIAG:NULLCAL?"

## Digital Modulation Subsystem

The Digital Modulation Subsystem is used for controlling the digital modulation parameters of the instrument.

The commands in the Digital Modulation Subsystem are shown in the following table.

**Digital Modulation Subsystem Commands**

Command	Description
[:SOURce]	
:DM	
:CLOCK	
:MODE	Set external clock mode.
:MODE?	Query external clock mode.
:SOURce	Set clock source.
:SOURce?	Query clock source.
:COUPling	
[:ALL]	Set data and clock coupling.
:CLOCK	Set clock coupling.
:CLOCK?	Query clock coupling.
:DATA	Set data coupling.
:DATA?	Query data coupling.
:DMODE	Set digital data input mode.
:DMODE?	Query digital data input mode.
:FILTer	
:CORRection	
:I	Set the I filter correction
:STEP	
[:INCRement]	Set the I filter correction increment.
[:INCRement]?	Query the I filter correction increment.
:I?	Query the I filter correction.
:Q	Set the Q filter correction.
:STEP	
[:INCRement]	Set the Q filter correction increment.
[:INCRement]?	Query the Q filter correction increment.
:Q?	Query the Q filter correction.
[:STATe]	Turn the filter correction on and off.
[:STATe]?	Query the filter correction state.
:SOURce	Set the filter source.
:SOURce?	Query the filter source.

## Digital Modulation Subsystem Commands (continued)

Command	Description
[[:SOURce]	
:DM	
[:FORMat]	Set digital modulation format.
[:FORMat]?	Query digital modulation format.
:FRAMe	
:SOURce	Set frame clock source.
:SOURce?	Query frame clock source.
:IQRatio	
[:MAGNitude]	Set the I/Q ratio.
:STEP	
[:INCRement]	Set the I/Q ratio increment.
[:INCRement]?	Query the I/Q ratio increment.
[:MAGNitude]?	Query the I/Q ratio.
:STATe	Turn the I/Q ratio on and off.
:STATe?	Query the I/Q ratio state.
:LEAKage	
:ANGLE	Set the carrier leakage angle.
:STEP	
[:INCRement]	Set the carrier leakage angle increment.
[:INCRement]?	Query the carrier leakage angle increment.
:ANGLE?	Query the carrier leakage angle.
[:MAGNitude]	Set carrier leakage magnitude.
:STEP	
[:INCRement]	Set carrier leakage magnitude increment.
[:INCRement]?	Query carrier leakage magnitude increment.
[:MAGNitude]?	Query carrier leakage magnitude.
:STATe	Turn carrier leakage on and off.
:STATe?	Query carrier leakage state.

## Digital Modulation Subsystem Commands (continued)

Command	Description
[[:SOURce]	
:DM	
:POLarity	
[:ALL]	Set polarity of I[n], Q[n], Iclock, Qclock, serial data, serial clock and frame.
:I[n]	Set polarity of I data input number n.
:I[n]?	Query polarity of I data input number n.
:Q[n]	Set polarity of Q data input number n.
:Q[n]?	Query polarity of Q data input number n.
:ICLock	Set polarity of I clock input.
:ICLock?	Query polarity of I clock input.
:QCLOCK	Set polarity of Q clock input.
:QCLOCK?	Query polarity of Q clock input.
:SERial	
:CLOCK	Set polarity of serial clock input.
:CLOCK?	Query polarity of serial clock input.
[:DATA]	Set polarity of serial data input.
[:DATA]?	Query polarity of serial data input.
:FRAMe	Set polarity of serial frame input.
:FRAMe?	Query polarity of serial frame input.

## Digital Modulation Subsystem Commands (continued)

Command	Description
[[:SOURce]	
:DM	
:QUADrature	
[:ANGLE]	Set the quadrature angle.
:STEP	
[:INCRement]	Set the quadrature angle increment.
[:INCRement]?	Query the quadrature angle increment.
[:ANGLE]?	Query the quadrature angle.
:STATe	Turn the quadrature angle on and off.
:STATe?	Query quadrature angle state.
:SOURce	Set the digital data source.
:SOURce?	Query the digital data source.
:STATe	Turn digital modulation on/off. (Same as PRBS on/off)
:STATe?	Query digital modulation state.
:THReshold	
[:ALL]	Set data and clock thresholds.
:CLOCK	Set clock threshold.
:STEP	
[:INCRement]	Set clock threshold increment.
[:INCRement]?	Query clock threshold increment.
:CLOCK?	Query clock threshold.
:DATA	Set data threshold.
:STEP	
[:INCRement]	Set data threshold increment.
[:INCRement]?	Query data threshold increment.
:DATA?	Query data threshold.

---

**CLOCK:MODE**

**Syntax**      [ :SOURCE ] :DM:CLOCK:MODE  $\left\{ \begin{array}{l} I \\ IQ \end{array} \right\}$

                 [ :SOURCE ] :DM:CLOCK:MODE?

**Description**    The CLOCK:MODE command selects either the I or the I & Q clock in external clock mode. This command only affects the instrument if using parallel digital inputs.

If you want the "NONE" clock mode, set the clock source to none with the ":DM:CLOC:SOUR NONE" command.

The CLOCK:MODE? query returns the clock used for external clock mode, either I or IQ.

Preset: I

**Example Command**      OUTPUT 719;":DM:CLOC:MODE I"

**Example Query**        OUTPUT 719;":DM:CLOC:MODE?"  
                          ENTER 719;Mode\$  
                          PRINT Mode\$











**FILTER:CORREction:I****Syntax**

```
[ :SOURCE ] :DM :FILTER :CORREction :I { factor
                                         MAXimum
                                         MINimum
                                         DOWN
                                         UP }
```

```
[ :SOURCE ] :DM :FILTER :CORREction :I ? [ MAXimum
                                           MINimum ]
```

```
[ :SOURCE ] :DM :FILTER :CORREction :I :STEP [ :INCRement ]
{ increment
  MAXimum
  MINimum }
```

```
[ :SOURCE ] :DM :FILTER :CORREction :I :STEP [ :INCRement ] ?
[ MAXimum
  MINimum ]
```

**Description**

The FILTER:CORRECTION:I command allows setting of the I filter correction factor. The following parameters can be selected:

Parameter	Description
<i>factor</i>	Allowable range is 0 to 9.99 dB or 100 to 31.66 percent. To enter the factor as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the correction factor is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the correction factor to 9.99 dB.
MINimum	Sets the correction factor to 0 dB.
DOWN	Decreases the current correction factor by the increment specified with the :FILTER:CORRECTION:I:STEP command.
UP	Increases the current correction factor by the increment specified with the :FILTER:CORRECTION:I:STEP command.

The FILTER:CORRECTION:I? query returns the current I correction factor setting in dB. The FILTER:CORRECTION:I? MAXIMUM query always

**FILTer:CORRection:I**

HP 8782B

returns 9.99. The **FILTER:CORRECTION:I? MINimum** query always returns 0.

Preset: 0 dB

The **FILTER:CORRECTION:I:STEP** command sets the increment for I correction. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is 0.01 to 9.99 dB or 0.01 to 68.34 percent. To enter the increment as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the increment is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the increment to 9.99 dB.
MINimum	Sets the increment to 0.01 dB.

The **FILTer:CORRECTION:I:STEP?** query returns the current I correction increment in dB. The **FILTER:CORRECTION:I:STEP? MAXIMUM** query always returns 9.99. The **FILTER:CORRECTION:I:STEP? MINimum** query always returns 0.01.

Preset: 1 dB

**Example Command**

```
OUTPUT 719;":DM:FILT:CORR:I 1.3DB"
```

**Example Query**

```
OUTPUT 719;":DM:FILT:CORR:I?"
ENTER 719;Value
PRINT Value
```

---

**FILTER:CORREction:Q**
**Syntax**

```
[ :SOURCE ]:DM:FILTer:CORRection:Q { factor
                                     MAXimum
                                     MINimum
                                     DOWN
                                     UP }
```

```
[ :SOURCE ]:DM:FILTer:CORRection:Q? [ MAXimum
                                       MINimum ]
```

```
[ :SOURCE ]:DM:FILTer:CORRection:Q:STEP [ :INCRement ]
{ increment
  MAXimum
  MINimum }
```

```
[ :SOURCE ]:DM:FILTer:CORRection:Q:STEP [ :INCRement ]?
[ MAXimum
  MINimum ]
```

**Description**

The FILTER:CORRECTION:Q command allows setting of the Q filter correction factor. The following parameters can be selected:

Parameter	Description
<i>factor</i>	Allowable range is 0 to 9.99 dB or 100 to 31.66 percent. To enter the factor as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the correction factor is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the correction factor to 9.99 dB.
MINimum	Sets the correction factor to 0 dB.
DOWN	Decreases the current correction factor by the increment specified with the :FILTER:CORRECTION:Q:STEP command.
UP	Increases the current correction factor by the increment specified with the :FILTER:CORRECTION:Q:STEP command.

The FILTER:CORRECTION:Q? query returns the current Q correction factor setting in dB. The

## FILTer:CORRection:Q

HP 8782B

FILTER:CORRECTION:Q? MAXIMUM query always returns 9.99. The FILTER:CORRECTION:Q? MINimum query always returns 0.

Preset: 0 dB

The FILTER:CORRECTION:Q:STEP command sets the increment for Q correction. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is 0.01 to 9.99 dB or 0.01 to 68.34 percent. To enter the increment as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the increment is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the increment to 9.99 dB.
MINimum	Sets the increment to 0.01 dB.

The FILTER:CORRECTION:Q:STEP? query returns the current Q correction increment. The FILTER:CORRECTION:Q:STEP? MAXIMUM query always returns 9.99. The FILTER:CORRECTION:Q:STEP? MINimum query always returns 0.01.

Preset: 1 dB

**Example Command**

```
OUTPUT 719;":DM:FILT:CORR:Q 2.0 DB"
```

**Example Query**

```
OUTPUT 719;":DM:FILT:CORR:Q?"
ENTER 719;Value
PRINT Value
```

**FILTer:CORRection:STATe****Syntax**

$$[:SOURce]:DM:FILTer:CORRection[:STATe] \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[:SOURce]:DM:FILTer:CORRection[:STATe]?$$
**Description**

The FILTER:CORRECTION:STATE command turns the filter correction on and off. The following parameters can be selected:

Parameter	Description
0	Turns the filter correction off.
1	Turns the filter correction on. Entering any number other than zero will also turn on the filter correction.
OFF	Turns the filter correction off.
ON	Turns the filter correction on.

The FILTER:CORRECTION:STATE? query returns a 0 if the filter correction is off and a 1 if the filter correction is on.

**Example Command**

```
OUTPUT 719;":DM:FILT:CORR:STAT ON"
```

**Example Query**

```
OUTPUT 719;":DM:FILT:CORR:STAT?"
ENTER 719;Value
PRINT Value
```



**FORMat****Syntax**

[ :SOURce ] :DM [ :FORMat ]	}	BPSK PSK2 QPSK PSK4 PSK8 QAM16 QAM64 QAM256 PRS9 PRS25 PRS49 PRS81
-----------------------------	---	---

[ :SOURce ] :DM [ :FORMat ] ?

**Description**

The FORMAT command sets the digital modulation format.

PRS9, PRS25, PRS49, and PRS81 are special functions so the special annunciator will light and special function 18 will be enabled when you select them.

The FORMAT? query returns the digital modulation format, either BPSK, QPSK, PSK8, QAM16, QAM64, QAM256, PRS9, PRS25, PRS49 or PRS81.

**Note**

PSK2 is a synonym for BPSK and PSK4 is a synonym for QPSK.

---

Preset: QPSK

**Example Command**

OUTPUT 719;":DM:FORM QPSK"

**Example Query**

OUTPUT 719;":DM:FORM?"  
 ENTER 719;Format\$  
 PRINT Format\$



## IQRatio:MAGNitude

## Syntax

```
[ :SOURce ]:DM:IQRatio [ :MAGNitude ] { magnitude
                                         MAXimum
                                         MINimum
                                         DOWN
                                         UP }
```

```
[ :SOURce ]:DM:IQRatio [ :MAGNitude ]? [ MAXimum
                                           MINimum ]
```

```
[ :SOURce ]:DM:IQRatio [ :MAGNitude ]:STEP [ :INCRement ]
{ increment
  MAXimum
  MINimum }
```

```
[ :SOURce ]:DM:IQRatio [ :MAGNitude ]:STEP [ :INCRement ]?
[ MAXimum
  MINimum ]
```

## Description

The IQRATIO:MAGNITUDE command allows setting of the I/Q ratio. The following parameters can be selected:

Parameter	Description
<i>magnitude</i>	Allowable range is -40 dB to +40 dB or 1 to 10000 percent. To enter the ratio as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the ratio is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the I/Q ratio to +40 dB.
MINimum	Sets the I/Q ratio to -40 dB.
DOWN	Decreases the current I/Q ratio by the increment specified by the IQRATIO:MAGNITUDE:STEP command.
UP	Increases the current I/Q ratio by the increment specified by the IQRATIO:MAGNITUDE:STEP command.

## IQRatio:MAGNitude

HP 8782B

The IQRATIO:MAGNITUDE? query returns the current I/Q ratio in dB. The IQRATIO:MAGNITUDE? MAXIMUM query always returns 40. The IQRATIO:MAGNITUDE? MINIMUM query always returns -40.

Preset: 0.0 dB

The IQRATIO:MAGNITUDE:STEP command sets the increment for I/Q ratio. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is -40 dB to +40 dB or 1 to 98.8 percent. To enter the increment as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the increment is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the I/Q ratio increment to +40 dB.
MINimum	Sets the I/Q ratio increment to -40 dB.

The IQRATIO:MAGNITUDE:STEP? query returns the current I/Q ratio increment in dB. The IQRATIO:MAGNITUDE:STEP? MAXIMUM query always returns 40. The IQRATIO:MAGNITUDE:STEP? MINIMUM query always returns -40.

Preset: 1 dB

**Example Command**

```
OUTPUT 719;":DM:IQR:MAGN 2.1 DB"
```

**Example Query**

```
OUTPUT 719;":DM:IQR:MAGN?"
ENTER 719;Value
PRINT Value
```

**IQRatio:STATE****Syntax**

$$[:\text{SOURCE}]:\text{DM}:\text{IQRatio}:\text{STATE} \left\{ \begin{array}{l} 0 \\ 1 \\ \text{OFF} \\ \text{ON} \end{array} \right\}$$

$$[:\text{SOURCE}]:\text{DM}:\text{FILTer}:\text{IQRatio}:\text{STATE?}$$
**Description**

The IQRATIO:STATE command turns I/Q ratio on and off. The following parameters can be selected:

Parameter	Description
0	Turns the I/Q ratio off.
1	Turns the I/Q ratio on. Entering any number other than zero will also turn on the I/Q ratio.
OFF	Turns the I/Q ratio off.
ON	Turns the I/Q ratio on.

The IQRATIO:STATE? query returns a 0 if the I/Q ratio is off and a 1 if the I/Q ratio is on.

**Example Command**

```
OUTPUT 719;":DM:IQR:STAT ON"
```

**Example Query**

```
OUTPUT 719;":DM:IQR:STAT?"
ENTER 719;Value
PRINT Value
```

## LEAKage:ANGLE

## Syntax

$$[:\text{SOURCE}]:\text{DM}:\text{LEAKage}:\text{ANGLE} \left\{ \begin{array}{l} \textit{angle} \\ \text{MAXimum} \\ \text{MINimum} \\ \text{DOWN} \\ \text{UP} \end{array} \right\}$$

$$[:\text{SOURCE}]:\text{DM}:\text{LEAKage}:\text{ANGLE}? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

$$[:\text{SOURCE}]:\text{DM}:\text{LEAKage}:\text{ANGLE}:\text{STEP} [:\text{INCREMENT}] \left\{ \begin{array}{l} \textit{increment} \\ \text{MAXimum} \\ \text{MINimum} \end{array} \right\}$$

$$[:\text{SOURCE}]:\text{DM}:\text{LEAKage}:\text{ANGLE}:\text{STEP} [:\text{INCREMENT}]? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

## Description

The LEAKAGE:ANGLE command is used to set the carrier leakage angle. The following parameters can be selected:

Parameter	Description
<i>angle</i>	Allowable range is $-359.9$ to $+359.9$ degrees. Values greater than or equal to $360$ or less than or equal to $-360$ are taken modulo $360$ . The angle may also be set in radians. The allowable range is $-2$ pi to $+2$ pi. To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the carrier leakage angle to $+359.9$ degrees.
MINimum	Sets the carrier leakage angle to $-359.9$ degrees.
DOWN	Decreases the current carrier leakage angle by the increment specified by the LEAKAGE:ANGLE:STEP command.
UP	Increases the current carrier leakage angle by the increment specified by the LEAKAGE:ANGLE:STEP command.

The LEAKAGE:ANGLE? query returns the carrier leakage angle in degrees. The LEAKAGE:ANGLE? MAXIMUM query always returns  $359.9$ . The LEAKAGE:ANGLE? MINIMUM query always returns  $-359.9$ .

HP 8782B

LEAKage:ANGLE

Preset: 0 degrees

The LEAKAGE:ANGLE:STEP command sets the increment for carrier leakage angle. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is $-359.9$ to $+359.9$ degrees. Values greater than or equal to 360 or less than or equal to $-360$ are taken modulo 360. The increment may also be set in radians. The allowable range is $-2\pi$ to $+2\pi$ . To enter the increment in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the increment is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the increment to $+359.9$ degrees.
MINimum	Sets the increment to $-359.9$ degrees.

The LEAKAGE:ANGLE:STEP? query returns the current carrier leakage angle increment in degrees. The LEAKAGE:ANGLE:STEP? MAXIMUM query always returns 359.9. The LEAKAGE:ANGLE:STEP? MINIMUM query always returns  $-359.9$ .

Preset: 1 degree

**Example Command**

OUTPUT 719;":DM:LEAK:ANGL 10.0 DEG"

**Example Query**

```
OUTPUT 719;":DM:LEAK:ANGL?"
ENTER 719;Value
PRINT Value
```

## LEAKage:MAGNitude

## Syntax

$$[:SOURCE]:DM:LEAKage[:MAGNitude] \left\{ \begin{array}{l} \textit{value} \\ \text{MAXimum} \\ \text{MINimum} \\ \text{DOWN} \\ \text{UP} \end{array} \right\}$$

$$[:SOURCE]:DM:LEAKage[:MAGNitude]? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

$$[:SOURCE]:DM:LEAKage[:MAGNitude]:STEP[:INCREMENT] \left\{ \begin{array}{l} \textit{increment} \\ \text{MAXimum} \\ \text{MINimum} \end{array} \right\}$$

$$[:SOURCE]:DM:LEAKage[:MAGNitude]:STEP[:INCREMENT]? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

## Description

The LEAKAGE:MAGNITUDE command sets the carrier leakage value. The following parameters can be selected:

Parameter	Description
<i>value</i>	Allowable range is -40 to 0 dB or 1 to 100 percent. To enter the magnitude as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the magnitude is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the carrier leakage value to 0 dB.
MINimum	Sets the carrier leakage value to -40 dB.
DOWN	Decreases the current carrier leakage value by the increment specified by the LEAKAGE:MAGNITUDE:STEP command.
UP	Increases the current carrier leakage value by the increment specified by the LEAKAGE:MAGNITUDE:STEP command.

The LEAKAGE:MAGNITUDE? query returns the current carrier leakage value in dB. The LEAKAGE:MAGNITUDE? MAXIMUM query always returns 0. The LEAKAGE:MAGNITUDE? MINIMUM query always returns -40.

Preset: 0 dB

HP 8782B

:MAGNitude

The LEAKAGE:MAGNITUDE:STEP command is used to set the increment for carrier leakage. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is 0.1 to 40 dB or 1 to 98.8 percent. To enter the increment as a percentage, you must use the PCT suffix. Otherwise, the instrument assumes the entered value is in dB. Once the increment is entered as a percentage, the instrument automatically converts the value to dB internally.
MAXimum	Sets the increment to 40 dB.
MINimum	Sets the increment to 0.1 dB.

The LEAKAGE:MAGNITUDE:STEP? query returns the current carrier leakage increment in dB. The LEAKAGE:MAGNITUDE:STEP? MAXIMUM query always returns 40. The LEAKAGE:MAGNITUDE:STEP? MINIMUM query always returns 0.1.

Preset: 1 dB

#### Example Command

```
OUTPUT 719;":DM:LEAK:MAGN -30.2 DB"
```

#### Example Query

```
OUTPUT 719;":DM:LEAK:MAGN?"
ENTER 719;Value
PRINT Value
```

**LEAKage:STATe****Syntax**

$$[ :SOURCE ] :DM:LEAKage:STATe \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[ :SOURCE ] :DM:LEAKage:STATe?$$
**Description**

The LEAKAGE:STATE command is used to turn the carrier leakage on and off. The following parameters can be selected:

Parameter	Description
0	Turns carrier leakage off.
1	Turns carrier leakage on. Entering any number other than zero will also turn carrier leakage on.
OFF	Turns carrier leakage off.
ON	Turns carrier leakage on.

The LEAKAGE:STATE? query returns a 0 if carrier leakage is off and a 1 if the carrier leakage is on.

Preset: OFF

**Example Command**

```
OUTPUT 719;":DM:LEAK:STAT ON"
```

**Example Query**

```
OUTPUT 719;":DM:LEAK:STAT?"
ENTER 719;State
PRINT State
```

















## QUADrature:ANGLE

### Syntax

$$[:SOURCE]:DM:QUADrature[:ANGLE] \left\{ \begin{array}{l} \textit{angle} \\ \text{MAXimum} \\ \text{MINimum} \\ \text{DOWN} \\ \text{UP} \end{array} \right\}$$

$$[:SOURCE]:DM:QUADrature[:ANGLE]? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

$$[:SOURCE]:DM:QUADrature[:ANGLE]:STEP[:INCREMENT] \left\{ \begin{array}{l} \textit{increment} \\ \text{MAXimum} \\ \text{MINimum} \end{array} \right\}$$

$$[:SOURCE]:DM:QUADrature[:ANGLE]:STEP[:INCREMENT]? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]$$

### Description

The QUADRATURE:ANGLE command sets the quadrature angle. The following parameters can be selected:

Parameter	Description
<i>angle</i>	Allowable range is $-90$ to $+90$ degrees. The angle may also be set in radians. The allowable range is $-\pi/2$ to $\pi/2$ . To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the quadrature angle to $+90$ degrees.
MINimum	Sets the quadrature angle to $-90$ degrees.
DOWN	Decreases the current quadrature angle by the increment specified by the QUADRATURE:ANGLE:STEP command.
UP	Increases the current carrier leakage angle by the increment specified by the QUADRATURE:ANGLE:STEP command.

The QUADRATURE:ANGLE? query returns the quadrature angle in degrees.

The QUADRATURE:ANGLE? MAXIMUM query always returns 90. The QUADRATURE:ANGLE? MINIMUM query always returns  $-90$ .

## QUADrature:ANGLE

HP 8782B

Preset: 0 degrees

The QUADRATURE:ANGLE:STEP command sets the increment for quadrature angle. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is $-90$ to $+90$ degrees. The increment may also be set in radians. The allowable range is $-\pi/2$ to $\pi/2$ . To enter the increment in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the increment is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the increment to $+90$ degrees.
MINimum	Sets the increment to $-90$ degrees.

The QUADRATURE:ANGLE:STEP? query returns the current quadrature angle increment in degrees. The QUADRATURE:ANGLE:STEP? MAXIMUM query always returns 90. The QUADRATURE:ANGLE:STEP? MINIMUM query always returns -90.

Preset: 1 degree

**Example Command**

OUTPUT 719;":DM:QUAD:ANGL 5.4 DEG"

**Example Query**

```
OUTPUT 719;":DM:QUAD:ANGL?"
ENTER 719;Value
PRINT Value
```

## QUADrature:STATe (Quadrature Angle State)

### Syntax

$$[:\text{SOURCE}]:\text{DM}:\text{QUADrature}:\text{STATe} \left\{ \begin{array}{l} 0 \\ 1 \\ \text{OFF} \\ \text{ON} \end{array} \right\}$$

$$[:\text{SOURCE}]:\text{DM}:\text{QUADrature}:\text{STATe}?$$

### Description

The QUADRATURE:STATE command turns the quadrature angle control on and off. The following parameters can be selected:

Parameter	Description
0	Turns the quadrature angle off.
1	Turns quadrature angle on. Entering any number other than zero will also turn quadrature angle on.
OFF	Turns the quadrature angle off.
ON	Turns the quadrature angle on.

The QUADRATURE:STATE? query returns a 0 if the quadrature angle is off and a 1 if the quadrature angle is on.

Preset: OFF

### Example Command

```
OUTPUT 719;":DM:QUAD:STAT ON"
```

### Example Query

```
OUTPUT 719;":DM:QUAD:STAT?"
ENTER 719;State
PRINT State
```



**STATE****Syntax**

$$[:SOURCE]:DM:STATe \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[:SOURCE]:DM:STATe?$$
**Description**

The STATE command turns the digital modulation on and off. This command has the same functionality as the "MODULATION ON" key on the front panel. The following parameters can be selected:

Parameter	Description
0	Turns the digital modulation off.
1	Turns digital modulation on. Entering any number other than zero will also turn digital modulation on.
OFF	Turns the digital modulation off.
ON	Turns the digital modulation on.

**Note**

Vector modulation must be turned off (VM:STAT OFF) before Digital modulation can be turned on (DM:STAT ON).

The STATE? query returns a 0 the digital modulation is off and a 1 if the digital modulation is on.

Preset: OFF

**Example Command**

```
OUTPUT 719;":DM:STAT ON"
```

**Example Query**

```
OUTPUT 719;":DM:STAT?"
ENTER 719;State
PRINT State
```

---

**THReshold:ALL**  
**(Data and Clock Threshold)**

**Syntax**                    [ :SOURce ] :DM :THReshold [ :ALL ]  $\left\{ \begin{array}{l} \textit{voltage} \\ \text{MAXimum} \\ \text{MINimum} \end{array} \right\}$

**Description**            The THRESHOLD:ALL command sets the threshold level for the data, clock, and burst inputs. This command only affects the instrument operation when using ground termination. The ECL threshold is fixed at -1.3 volts and is independent of the value selected by this command. The following parameters can be selected:

Parameter	Description
<i>voltage</i>	Allowable range is -2.5 to 2.5 volts.
MAXimum	Sets the threshold to 2.5 volts.
MINimum	Sets the threshold to -2.5 volts.

**Example Command**            OUTPUT 719; " :DM :THR :ALL -1.6V "

## THReshold:CLOCK

## Syntax

```
[ :SOURce ] :DM :THReshold :CLOCK { voltage
                                     MAXimum
                                     MINimum
                                     DOWN
                                     UP }
```

```
[ :SOURce ] :DM :THReshold :CLOCK? [ MAXimum
                                     MINimum ]
```

```
[ :SOURce ] :DM :THReshold :CLOCK :STEP [ :INCRement ]
{ increment
  MAXimum
  MINimum }
```

```
[ :SOURce ] :DM :THReshold :CLOCK :STEP [ :INCRement ]?
[ MAXimum
  MINimum ]
```

## Description

The THRESHOLD:CLOCK command sets the threshold level for clock inputs. This command only affects the instrument operation when using ground termination. The ECL threshold is fixed at -1.3 volts and is independent of the value selected by this command. The following parameters can be selected:

Parameter	Description
<i>voltage</i>	Allowable range is -2.5 to 2.5 volts.
MAXimum	Sets the threshold to 2.5 volts.
MINimum	Sets the threshold to -2.5 volts.
DOWN	Decreases the threshold by the increment specified by the :THRESHOLD:CLOCK:STEP command.
UP	Increases the threshold by the increment specified by the :THRESHOLD:CLOCK:STEP command.

The THRESHOLD:CLOCK? query returns the threshold level for clock inputs in volts. The THRESHOLD:CLOCK? MAXIMUM query always returns 2.5. The THRESHOLD:CLOCK? MINIMUM query always returns -2.5.

Preset: 0V

The THRESHOLD:CLOCK:STEP command sets the increment for clock threshold. The following parameters can be selected:

THReshold:CLOCK

HP 8782B

Parameter	Description
<i>increment</i>	Allowable range is -2.5 to 2.5 volts.
MAXimum	Sets the increment to 2.5 volts.
MINimum	Sets the increment to -2.5 volts.

The THRESHOLD:CLOCK:STEP? query returns the clock threshold increment in volts. The THRESHOLD:CLOCK:STEP? MAXIMUM query always returns 2.5. The THRESHOLD:CLOCK:STEP? MINIMUM query always returns -2.5.

Preset: 1V

**Example Command**

```
OUTPUT 719;":DM:THR:CLOC 1V"
```

**Example Query**

```
OUTPUT 719;":DM:THR:CLOC?"  
ENTER 719;Value  
PRINT Value
```

## THReshold:DATA

## Syntax

```

[ :SOURCE ]:DM:THReshold:DATA { voltage
                                MAXimum
                                MINimum
                                DOWN
                                UP }

[ :SOURCE ]:DM:THReshold:DATA? [ MAXimum
                                 MINimum ]

[ :SOURCE ]:DM:THReshold:DATA:STEP [ :INCRement ]
{ increment
  MAXimum
  MINimum }

[ :SOURCE ]:DM:THReshold:DATA:STEP [ :INCRement ]?
[ MAXimum
  MINimum ]

```

## Description

The THReshold:DATA command sets the threshold level for data and burst inputs. This command only affects instrument operation when using ground termination. The ECL threshold is fixed at  $-1.3$  volts and is independent of the value selected by this command. The following parameters can be selected:

Parameter	Description
<i>voltage</i>	Allowable range is $-2.5$ to $2.5$ volts.
MAXimum	Sets the threshold to $2.5$ volts.
MINimum	Sets the threshold to $-2.5$ volts.
DOWN	Decreases the threshold by the increment specified by the :THRESHOLD:DATA:STEP command.
UP	Increases the threshold by the increment specified by the :THRESHOLD:DATA:STEP command.

The THRESHOLD:DATA? query returns the threshold level for data and burst inputs in volts. The THRESHOLD:DATA? MAXIMUM query always returns  $2.5$ . The THRESHOLD:DATA? MINIMUM query always returns  $-2.5$ .

Preset:  $1.6V$

The THRESHOLD:DATA:STEP command is used to set the increment for data and burst thresholds. The following parameters can be selected:

## Display Subsystem

The Display Subsystem is used for controlling the display parameters of the instrument.

The commands in the Display Subsystem are shown in the following table.

**Display Subsystem Commands**

Command	Description
:DISPlay	
[:STATe]	Turn display on/off.
[:STATe]?	Query display state.

## STATe (Display State)

### Syntax

$$:\text{DISP}[\text{:STATe}] \left\{ \begin{array}{l} 0 \\ 1 \\ \text{OFF} \\ \text{ON} \end{array} \right\}$$

$$:\text{DISP}[\text{:STATe}]?$$

### Description

The STATE command is used to turn the display on and off.

The following parameters can be selected:

Parameter	Description
0	Turns the display off.
1	Turns the display on. Entering any number other than zero will also turn digital modulation on.
OFF	Turns the display off.
ON	Turns the display on.

The STATE? query returns a 0 if the display is off and a 1 if the display is on.

Preset: ON

### Example Command

```
OUTPUT 719;":DISP:STAT ON"
```

### Example Query

```
OUTPUT 719;":DISP:STAT?"
ENTER 719;State
PRINT State
```

## Frequency Subsystem

The Frequency subsystem is used to control the frequency of the instrument. The commands in the Frequency Subsystem are shown in the following table.

**Frequency Subsystem Commands**

Command	Description
[:SOURce]	
:FREQuency	
[:CW]	Set the carrier frequency.
:STEP	
[:INCRement]	Set the carrier frequency increment.
[:INCRement]?	Query the carrier frequency increment.
[:CW]?	Query the carrier frequency.
[:FIXed]	Set the carrier frequency.
:STEP	
[:INCRement]	Set the carrier frequency increment.
[:INCRement]?	Query the carrier frequency increment.
[:FIXed]?	Query the carrier frequency.
:MODE	Set the carrier frequency sweep mode.
:MODE?	Query the carrier frequency sweep mode.

## CW

## Syntax

$$[:SOURCE]:FREQUENCY \left[ \begin{array}{l} :CW \\ :FIXed \end{array} \right] \left\{ \begin{array}{l} \textit{frequency} \\ MAXimum \\ MINimum \\ DOWN \\ UP \end{array} \right\}$$

$$[:SOURCE]:FREQUENCY \left[ \begin{array}{l} :CW \\ :FIXed \end{array} \right] ? \left[ \begin{array}{l} MAXimum \\ MINimum \end{array} \right]$$

$$[:SOURCE]:FREQUENCY \left[ \begin{array}{l} :CW \\ :FIXed \end{array} \right] :STEP \left[ :INCRement \right]$$

$$\left\{ \begin{array}{l} \textit{increment} \\ MAXimum \\ MINimum \end{array} \right\}$$

$$[:SOURCE]:FREQUENCY \left[ \begin{array}{l} :CW \\ :FIXed \end{array} \right] :STEP \left[ :INCRement \right] ?$$

$$\left[ \begin{array}{l} MAXimum \\ MINimum \end{array} \right]$$

## Description

The CW command sets the CW frequency of the instrument. FIXed is a synonym for CW in the frequency subsystem. The following parameters can be selected:

Parameter	Description
<i>frequency</i>	Allowable range is 0 Hz to 375 MHz.
MAXimum	Sets the frequency to 375 MHz.
MINimum	Sets the frequency to 0Hz.
DOWN	Decreases the current frequency setting by the increment specified by the CW:STEP command.
UP	Increases the current frequency setting by the increment specified by the CW:STEP command.

The CW? query returns the current CW value in hertz. The CW? MAXIMUM query always returns 375E+6. The CW? MINIMUM query always returns 0.

Preset: 70 MHz

The CW:STEP command sets the frequency increment. The following parameters can be selected:

HP 8782B

CW

Parameter	Description
<i>increment</i>	Allowable range is 1 Hz to 375 MHz.
MAXimum	Sets the frequency increment 375 MHz.
MINimum	Sets the frequency increment to 1 Hz.

The CW:STEP? query returns the current CW increment value in hertz. The CW:STEP? MAXIMUM query always returns 375E+6. The CW:STEP? MINIMUM query always returns 1.

Preset: 1 MHz

**Example Command**

```
OUTPUT 719;":FREQ: CW 75 MHZ"
```

**Example Query**

```
OUTPUT 719;":FREQ: CW?"  
ENTER 719; Freq  
PRINT Freq
```



## Output Control Subsystem

The Output Control Subsystem is used for controlling the output of the instrument.

The Output Control System contains the following commands:

### Output Control Subsystem

Command	Description
[[:SOURce] :OUTPut :IMPedance? [:STATe] [:STATe]?	Query output impedance. Turn RF output on/off. Query RF output state.



**STATE****Syntax**

$$[:SOURCE]:OUTPut: [STATE] \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

`[:SOURCE]:OUTPut:[STATE]?`

**Description**

The STATE command is used to turn RF output on and off. The following parameters can be selected:

Parameter	Description
0	Turns RF output off.
1	Turns RF output on. Entering any number other than zero will also turn RF output on.
OFF	Turns RF output off.
ON	Turns RF output on.

The STATE? query returns a 0 if RF output is off and a 1 if RF is on.

Preset: ON

**Example Command**

```
OUTPUT 719;":OUTP:STAT ON"
```

**Example Query**

```
OUTPUT 719;":OUTP:STAT?"
ENTER 719;State
PRINT State
```

STATE

HP 8782B



## Phase Subsystem

The Phase Subsystem is used for controlling the phase parameters of the instrument.

The commands in the Phase Subsystem are shown in the following table.

**Phase Subsystem Commands**

Command	Description
[[:SOURce] :PHASe [:OUTPut] [:ADJust]	Set the constellation phase adjustment.
:STEP [:INCRement]	Set the constellation phase increment.
[:INCRement]?	Query the constellation phase increment.
[:ADJust]?	Query the constellation phase adjustment.
:STATe	Turn constellation phase adjustment on/off.
:STATe?	Query constellation phase adjustment state.
:RSIGnal [:ADJust]	Bump the 10 MHz signal phase.
:STEP [:INCRement]	Set the 10 MHz signal phase increment.
[:INCRement]?	Query the 10 MHz signal phase increment.
[:ADJust]?	Query the last 10 MHz signal phase bump.

## OUTPut:ADJust (Output Phase Adjust)

### Syntax

```
[ :SOURce ] : PHASe [ : OUTPut ] [ : ADJust ] { angle
                                                MAXimum
                                                MINimum
                                                DOWN
                                                UP }
```

```
[ :SOURce ] : PHASe [ : OUTPut ] [ : ADJust ] ? [ MAXimum
                                                    MINimum ]
```

```
[ :SOURce ] : PHASe [ : OUTPut ] [ : ADJust ] : STEP [ : INCRement ]
{ increment
  MAXimum
  MINimum }
```

```
[ :SOURce ] : PHASe [ : OUTPut ] [ : ADJust ] : STEP [ : INCRement ] ?
[ MAXimum
  MINimum ]
```

### Description

The OUTPUT:ADJUST command is used to set the constellation rotation angle adjustment. The following parameters can be selected:

Parameter	Description
<i>angle</i>	Allowable range is $-90$ to $+90$ degrees. The angle may also be set in radians. The allowable range is $-\pi/2$ to $\pi/2$ . To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the constellation rotation angle to $+90$ degrees.
MINimum	Sets the constellation rotation angle to $-90$ degrees.
DOWN	Decreases the current constellation rotation angle by the increment specified by the OUTPUT:ADJUST:STEP command.
UP	Increases the current constellation rotation angle by the increment specified by the OUTPUT:ADJUST:STEP command.

The OUTPUT:ADJUST? query returns the constellation rotation angle adjustment in degrees. The OUTPUT:ADJUST? MAXIMUM

HP 8782B

**OUTPut:ADJusT (Output Phase Adjust)**

query always returns 90. The OUTPUT:ADJUST? MINIMUM query always returns -90.

Preset: 0 degrees

The OUTPUT:ADJUST:STEP command is used to set the increment for the constellation rotation angle. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is -90 to +90 degrees. The angle may also be set in radians. The allowable range is $-\pi/2$ to $\pi/2$ . To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the increment to +90 degrees.
MINimum	Sets the increment to -90 degrees.

The OUTPUT:ADJUST:STEP? query returns the current constellation rotation angle increment in degrees. The OUTPUT:ADJUST:STEP? MAXIMUM query always returns 90. The OUTPUT:ADJUST:STEP? MINIMUM query always returns -90.

Preset: 1 degree

**Example Command**

```
OUTPUT 719;":PHAS:OUTP:ADJ 4 DEG"
```

**Example Query**

```
OUTPUT 719;":PHAS:OUTP:ADJ?"
ENTER 719;Value
PRINT Value
```

## OUTPut:STATe (Output Phase State)

### Syntax

$$[ :SOURce ] :PHASe [ :OUTPut ] :STATe \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[ :SOURce ] :PHASe [ :OUTPut ] :STATe?$$

### Description

The OUTPUT:STATE command turns constellation rotation adjustment on and off. The following parameters can be selected:

Parameter	Description
0	Turns the constellation rotation off.
1	Turns the constellation rotation on. Entering any number other than zero will also turn on the constellation rotation.
OFF	Turns the constellation rotation off.
ON	Turns the constellation rotation on.

The OUTPUT:STATE? query returns a 0 if constellation rotation adjustment is off and a 1 if constellation rotation adjustment is on.

Preset: OFF

### Example Command

```
OUTPUT 719;":PHAS:OUTP:STAT OFF"
```

### Example Query

```
OUTPUT 719;":PHAS:OUTP:STAT?"
ENTER 719;State
PRINT State
```

## RSIGnal:ADJust (10 MHz Adjust)

### Syntax

$$\begin{aligned}
 & [ :SOURce ] : PHASe : RSIGnal [ :ADJust ] \left\{ \begin{array}{l} \textit{angle} \\ \text{MAXimum} \\ \text{MINimum} \\ \text{DOWN} \\ \text{UP} \end{array} \right\} \\
 & [ :SOURce ] : PHASe : RSIGnal [ :ADJust ] ? \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right] \\
 & [ :SOURce ] : PHASe : RSIGnal [ :ADJust ] : STEP [ INCRement ] \\
 & \left\{ \begin{array}{l} \textit{increment} \\ \text{MAXimum} \\ \text{MINimum} \end{array} \right\} \\
 & [ :SOURce ] : PHASe : RSIGnal [ :ADJust ] : STEP [ INCRement ] ? \\
 & \left[ \begin{array}{l} \text{MAXimum} \\ \text{MINimum} \end{array} \right]
 \end{aligned}$$

### Description

The RSIGNAL:ADJUST command bumps the phase relative to the 10 MHz time base. This is always a relative change, NOT an absolute setting. For example, sending the "PHAS:RSIG 45" command twice results in a phase change of 90 degrees. The following parameters can be selected:

Parameter	Description
<i>angle</i>	Allowable range is $-359.9$ to $+359.9$ degrees. Values greater than or equal to 360 or less than or equal $-360$ are taken modulo 360. The angle may also be set in radians. The allowable range is $-2\pi$ to $+2\pi$ . To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the relative phase angle to $+359.9$ degrees.
MINimum	Sets the relative phase angle to $-359.9$ degrees.
DOWN	Decreases the value of the relative phase angle by the increment specified by the RSIGNAL:ADJUST:STEP command and then bumps the phase by the new value obtained.
UP	Increases the value of the relative phase angle by the increment specified by the RSIGNAL:ADJUST:STEP command and then bumps the phase by the new value obtained.

The RSIGNAL:ADJUST? query returns the magnitude of the last phase change in degrees. The RSIGNAL:ADJUST? MAXIMUM query always returns 359.9. The RSIGNAL:ADJUST? MINIMUM query always returns  $-359.9$ .

Preset: 0 degrees

The RSIGNAL:ADJUST:STEP command sets the increment for phase adjust. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is $-359.9$ to $+359.9$ degrees. Values greater than or equal to 360 or less than or equal $-360$ are taken modulo 360. The angle may also be set in radians. The allowable range is $-2\pi$ to $+2\pi$ . To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the phase adjust increment to $+359.9$ degrees.
MINimum	Sets the phase adjust increment to $-359.9$ degrees.

The RSIGNAL:ADJUST:STEP? query returns the phase adjust increment in degrees. The RSIGNAL:ADJUST:STEP? MAXIMUM

HP 8782B

RSIGNAL:ADJust (10 MHz Adjust)

query always returns 359.9. The RSIGNAL:ADJUST:STEP?  
MINIMUM query always returns -359.9.

Preset: 1 degree

**Example Command**

OUTPUT 719;":PHAS:RSIG:ADJ 10 DEG"

**Example Query**

OUTPUT 719;":PHAS:RSIG:ADJ?"  
ENTER 719;Value  
PRINT Value

**RSIGnal:ADJust (10 MHz Adjust)**

**HP 8782B**



**POWer Subsystem**

The Power Subsystem is used for controlling the output power of the instrument. The commands in the Power Subsystem are shown in the following table:

**Power Subsystem Commands**

Command	Description
[[:SOURce]] :POWer :ATTenuation :AUTO :AUTO?	Set auto attenuation on/off. (Same as locking attenuators) Query auto attenuation state.
[[:LEVel]] [:IMMediate] [:AMPLitude] :STEP [:INCRement] [:INCRement]?	Set the power level. Set the power level increment. Query the power level increment.
[:AMPLitude]?	Query the power level.
:MODE :MODE?	Set the power level sweep mode. Query the power level sweep mode.
:UNIT :UNIT?	Set the units for power. Query the units for power.

**ATTenuation:AUTO****Syntax**

$$[:SOURce]:POWer:ATTenuation:AUTO \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[:SOURce]:POWer:ATTenuation:AUTO?$$
**Description**

The ATTENUATION:AUTO command sets the mode of the step attenuators. ON means normal automatic step attenuators. OFF means the step attenuators are locked. If the step attenuators are locked then special function 1 will be on and the SPECIAL annunciator will light. The following parameters can be selected:

Parameter	Description
0	Turns automatic attenuation off (step attenuators are locked).
1	Turns automatic attenuation on (normal operation). Entering any number other than zero will also turn automatic attenuation on.
OFF	Turns automatic attenuation off (step attenuators are locked).
ON	Turns automatic attenuation on (normal operation).

The ATTENUATION:AUTO? query returns a 0 if automatic attenuation is off(step attenuators are locked) and a 1 if automatic attenuation is on.

Preset: ON

**Example Command**

```
OUTPUT 719;":POW:ATT:AUTO OFF"
```

**Example Query**

```
OUTPUT 719;":POW:ATT:AUTO?"
ENTER 719;State
PRINT State
```

**LEVel:IMMediate:AMPLitude**

**Syntax**

```
[ :SOURce ] :POWer [ :LEVel ] [ :IMMediate ] [ :AMPLitude ]
  {
  level
  MAXimum
  MINimum
  DOWN
  UP
  }

[ :SOURce ] :POWer [ :LEVel ] [ :IMMediate ] [ :AMPLitude ] ?
[ MAXimum
  MINimum ]

[ :SOURce ] :POWer [ :LEVel ] [ :IMMediate ] [ :AMPLitude ]
:STEP [ :INCrement ] {
  increment
  MAXimum
  MINimum
}

[ :SOURce ] :POWer [ :LEVel ] [ :IMMediate ] [ :AMPLitude ]
:STEP [ :INCrement ] ? [ MAXimum
  MINimum ]
```

**Description**

The LEVEL:IMMEDIATE:AMPLITUDE command sets the output level of the HP 8782B. This command can be programmed in dBm, volts, Watts, dBW, dBV, dBmW, or dB $\mu$ V. dBm is assumed after presetting the generator. The following parameters can be selected:

Parameter	Description
<i>level</i>	Allowable range is -150 to 19 dBm, 7 nV to +2V, 1nW to 0.08W, -180 to -11 dBW, -81.5 to 3 dBV, -51.5 to 33 dBmV, and -21.5 to 63 dB $\mu$ W. To enter the output level in any suffix you must use that suffix explicitly. Otherwise the instrument assumes the entered value is in the suffix defined by POW:UNIT. If the output level is entered with "non-assumed" suffix, the instrument automatically converts the value to the POW:UNIT suffix internally.
MAXimum	Sets the output level to the maximum allowed for the unit of power selected by POW:UNIT.
MINimum	Sets the output level to the minimum allowed for the unit of power selected by POW:UNIT.
DOWN	Decreases the output level by the increment specified by the LEVEL:IMMEDIATE:AMPLITUDE:STEP command and using the suffix selected by POW:UNIT.
UP	Increases the output level by the increment specified by the LEVEL:IMMEDIATE:AMPLITUDE:STEP command and using the suffix selected by POW:UNIT.

The LEVEL:IMMEDIATE:AMPLITUDE? query returns the current level setting in the current unit of power selected by POW:UNIT. The LEVEL:IMMEDIATE:AMPLITUDE? MAXIMUM query always returns the maximum output level allowed depending on the current unit selected by POW:UNIT. The LEVEL:IMMEDIATE:AMPLITUDE? MINIMUM query always returns the minimum output level allowed depending on the current unit selected by POW:UNIT.

Preset: -100 dBm

The LEVEL:IMMEDIATE:AMPLITUDE:STEP command sets the increment for the level. This command is programmed using the unit of power specified by the UNIT command. (If the specified unit is dBW, dBV, dBmV or dB $\mu$ V, the increment must be in dB.) dB is assumed after presetting the generator. The following parameters can be selected:

HP 8782B

LEVel:IMMediate:AMPLitude

Parameter	Description
<i>increment</i>	Allowable range is 0.1 to 169 dB (for units=dBm), 1 nV to +2V, or 1 nW to 0.08W. If the units are dBW, dBV, dBmV or dB $\mu$ V, the allowable range is 0.1 to 84.5 dB. To enter the increment in any suffix you must use that suffix explicitly. Otherwise the instrument assumes the entered value is in the suffix defined by POW:UNIT. If the increment is entered with "non-assumed" suffix, the instrument will NOT automatically convert the value to the POW:UNIT suffix internally. This is an exception because it is unclear how to properly convert a dB increment into a linear volt or watt increment.
MAXimum	Sets the increment to 169 dB, 2V, 0.08W or 84.5 dB, depending on the unit of power selected by POW:UNIT.
MINimum	Sets the increment to 0.1 dB, 1 nV, or 1 nW depending on the unit of power selected by POW:UNIT.

The LEVEL:IMMEDIATE:AMPLITUDE:STEP? query returns the current level increment in the current unit of power selected by POW:UNIT. The LEVEL:IMMEDIATE:AMPLITUDE:STEP? MAXIMUM query always returns the maximum level increment allowed depending on the current unit selected by POW:UNIT. The LEVEL:IMMEDIATE:AMPLITUDE:STEP? MINIMUM query always returns the minimum level increment allowed depending on the current unit selected by POW:UNIT.

Preset: 1 dB

**Example Command**

```
OUTPUT 719;":POW:LEV 5.0 DBM"
```

**Example Query**

```
OUTPUT 719;":POW:LEV?"
ENTER 719;Level
PRINT Level
```

---

**MODE**

**Syntax**            [ :SOURce ] :POWer:MODE FIXed

**Description**      The MODE command controls the power mode. This instrument only allows fixed power, not power sweeps.  
The MODE? query always returns FIX.

**Example Command**      OUTPUT 719;":POW:MODE FIX"

**Example Query**        OUTPUT 719;":POW:MODE?"  
ENTER 719;Mode\$  
PRINT Mode\$

---

**UNIT**
**Syntax**

```
[ :SOURce ] :POWer:UNIT {
    DBM
    DBW
    DBV
    DBMV
    DBUV
    V
    W
}
```

```
[ :SOURce ] :POWer:UNIT?
```

**Description**

The UNIT command determines which power suffix will be assumed for the LEVEL:IMMEDIATE:AMPLITUDE and LEVEL:IMMEDIATE:AMPLITUDE:STEP commands if no suffix is used. In addition, this determines what units the LEVEL:IMMEDIATE:AMPLITUDE? and LEVEL:IMMEDIATE:AMPLITUDE:STEP? queries return. This command is meant to be used only if you wish these changes. If you want to use a new unit and don't care about a more permanent change of units, then add the suffix when using the LEVEL:IMMEDIATE:AMPLITUDE or LEVEL:IMMEDIATE:AMPLITUDE:STEP command. But, if you want different units to be returned by the LEVEL:IMMEDIATE:AMPLITUDE or LEVEL:IMMEDIATE:AMPLITUDE:STEP? query, you must use this UNIT command.

The UNIT? query returns the current default unit for power, either DBM, V, W, DBW, DBV, DBMV, or DBUV.

Preset: DBM

**Example Command**

```
OUTPUT 719;":POW:UNIT V"
```

**Example Query**

```
OUTPUT 719;":POW:UNIT?"
ENTER 719;Unit$
PRINT Unit$
```

UNIT

HP 8782B



## Pseudo-Random Binary Sequence (PRBS) Subsystem

The PRBS Subsystem is used for controlling the PRBS parameters of the instrument.

The PRBS Subsystem commands are shown in the following table:

**Pseudo-Random Binary Sequence Commands**

Command	Description
[[:SOURce]	
:PRBS	
:CLOCK	
:POLarity	Set PRBS clock polarity.
:POLarity?	Query PRBS clock polarity.
[[:SOURce]	Set PRBS clock source.
[[:SOURce]?	Query PRBS clock source.
:DIVide	Set PRBS external clock divide number.
:DIVide?	Query PRBS external clock divide number.
:FREQuency	Set PRBS internal clock frequency.
:FREQuency?	Query PRBS internal clock frequency.





## DIVide

### Syntax

```
[ :SOURce ] :PRBS :DIVide { factor
                          MAXimum
                          MINimum
                        }

[ :SOURce ] :PRBS :DIVide? [ MAXimum
                           MINimum
                         ]
```

### Description

The DIVIDE command sets the divide factor for EXTERNAL PRBS clock. If you are using an internal PRBS clock, this command will have no effect on instrument operation. The following parameters can be selected:

Parameter	Description
<i>factor</i>	Allowable values are 1, 2, 4 and 8. Other values are rounded to the nearest allowable divide factor.
MAXimum	Sets the divide factor to 8.
MINimum	Sets the divide factor to 1.

The DIVIDE? query returns the divide factor for the EXTERNAL PRBS clock. The DIVIDE? MAXIMUM query always returns 8. The DIVIDE? MINIMUM query always returns 1.

Preset: 1

### Example Command

```
OUTPUT 719; ":PRBS:DIV 2"
```

### Example Query

```
OUTPUT 719; ":PRBS:DIV?"
ENTER 719; Value
PRINT Value
```

## FREQuency

### Syntax

```
[ :SOURce ] :PRBS:FREQuency { frequency
                             MAXimum
                             MINimum }
[ :SOURce ] :PRBS:FREQuency? [ MAXimum
                              MINimum ]
```

### Description

The FREQUENCY command sets the PRBS INTERNAL clock frequency. If using an external PRBS clock, this command will not affect instrument operation. The following parameters can be selected:

Parameter	Description
<i>frequency</i>	Allowable values are 1.25 MHz, 2.5 MHz, 5 MHz, and 10 MHz. Other values will be rounded to the nearest allowable frequency.
MAXimum	Sets the frequency to 10 MHz.
MINimum	Sets the frequency to 1.25 MHz.

The FREQUENCY? query returns the PRBS INTERNAL clock frequency in hertz. The FREQUENCY? MAXIMUM query always returns 10. The FREQUENCY? MINIMUM query always returns 1.25.

Preset: 10 MHz

### Example Command

```
OUTPUT 719;":PRBS:FREQ 1.25 MHZ"
```

### Example Query

```
OUTPUT 719;":PRBS:FREQ?"
ENTER 719;Value
PRINT Value
```

**FREQuency**

**HP 8782B**

## Pulse Modulation Subsystem

The Pulse Modulation Subsystem is used for controlling the burst modulation of the instrument.

The commands in the Pulse Modulation Subsystem are shown in the following table:

**Pulse Modulation Subsystem Commands**

Command	Description
[[:SOURce]	
:PULM	
:POLarity	Set polarity of burst.
:POLarity?	Query polarity of burst.
:STATe	Turn burst on/off.
:STATe?	Query burst state.



**STATe**

$$[:SOURce]:PULM:STATe \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[:SOURce]:PULM:STATe?$$
**Description**

The STATe command is used to turn pulse modulation (burst) on and off. The following parameters can be selected:

Parameter	Description
0	Turns the pulse modulation off.
1	Turns the pulse modulation on. Entering any number other than zero will also turn pulse modulation on.
OFF	Turns the pulse modulation off.
ON	Turns the pulse modulation on.

**Note**

Vector modulation must be turned off (VM:STAT OFF) before Pulse modulation can be turned on (PULM:STAT ON).

The STATe? query returns a 0 if pulse modulation is off and a 1 if pulse modulation is on.

Preset: OFF

**Syntax****Example Command**

```
OUTPUT 719;":PULM:STAT ON"
```

**Example Query**

```
OUTPUT 719;":PULM:STAT?"
ENTER 719;State
PRINT State
```

**STATE**

**HP 8782B**



---

## Status Subsystem

### Introduction

The Status Subsystem is used for reading and controlling the TMSL Operation Status group and the TMSL Questionable Data/Signal group of the generator.

A set of registers consisting of a condition register, a transition filter, and event register, and an enable register is referred to as a status group. The Operation Status group provides information about the instrument calibration. The Questionable Data/Signal group provides information about the quality of instrument output and measurement data.

### Condition Register

A condition register continuously monitors the hardware and firmware status of the instrument. There is no latching or buffering for this register, it is updated in real time. Condition registers are read-only.

### Transition Filters

The transition filters specify which types of bit state changes in the condition register will set corresponding bits in the event register. Transition filter bits may be set for positive transitions (PTR), negative transitions (NTR), or both. Positive means a condition bit changes from 0 to 1. Negative means a condition bit changes from 1 to 0. Transition filters are read-write.

### Event Register

The event register latches transition events from the condition register as specified by the transition filters. Bits in the event register are latched, and once set they remain set until cleared by querying the event register or \*CLS (clear status). There is no buffering, so while an event bit is set, subsequent events corresponding to that bit have no effect. Event registers are read-only.

### Event Enable Register

The event enable register specifies which bits in the event register can generate a summary bit. The instrument logically ANDs corresponding bits in the enable and event registers, and ORs all the resulting bits to obtain a summary bit. Summary bits are in turn recorded in the Status Byte. Event Enable registers are read-write. Querying event enable registers does not affect them.

The commands in the Status Subsystem are shown in the following table:

**Status Subsystem Commands**

Command	Description
:STATus	
:OPERation	
:CONDition?	Query operation condition register.
:ENABle	Set operation event enable register.
:ENABle?	Query operation event enable reg.
[:EVENT]?	Query operation event register.
:NTRansition	Set operation negative edge register.
:NTRansition?	Query operation negative edge register.
:PTRansition	Set operation positive edge register.
:PTRansition?	Query operation positive edge register.
:QUEStionable	
:CONDition?	Query questionable condition register.
:ENABle	Set questionable event enable register.
:ENABle?	Query questionable event enable reg.
[:EVENT]?	Query questionable event register.
:NTRansition	Set questionable negative edge register.
:NTRansition?	Query questionable negative edge register.
:PTRansition	Set questionable positive edge register.
:PTRansition?	Query questionable positive edge register.

---

**OPERation:CONDition?**

**Syntax**           :STATus:OPERation:CONDition?

**Description**     The OPERATION:CONDITION? query reads the contents of the Operation Condition Register. Reading the condition register does not alter the register's value. For the generator, only bit 0 is used; all other bits are always zero. Bit 0 indicates the status of calibration. When calibration is in progress, this bit is 1. It is a 0 at all other times.

**Example Query**     OUTPUT 719;":STAT:OPER:COND?  
                      ENTER 719;State  
                      PRINT State

---

**OPERation:ENABLE**

**Syntax**           :STATus:OPERation:ENABle *number*  
                  :STATus:OPERation:ENABle?

**Description**     The OPERATION:ENABLE command sets the contents of the Operation Event Enable Register. This enables bits in the Operation Event Register that will set the Operation Summary Bit(bit 7) in the status byte. For the generator only bit 0 is used because only bit 0 is used in the operation condition register. All other bits in the event enable register are "don't cares". See :STATUS:OPERATION:CONDITION? for the definition of bit 0. The OPERATION:ENABLE? query returns the contents of the Operation Event Enable Register.

**Example Command**        OUTPUT 719;":STAT:OPER:ENAB 1"

**Example Query**         OUTPUT 719;":STAT:OPER:ENAB?"  
                          ENTER 719;State  
                          PRINT State

---

**OPERation:EVENT?**

**Syntax**           :STATus:OPERation[:EVENT]?

**Description**     The OPERATION:EVENT? query reads the contents of the Operation Event Register. This register is set to zero after it is read by this query. It is also set to zero after a \*CLS command. This register holds a record of the state changes in the Operation Condition Register as specified by the transition filters. The bit definitions are defined under the OPERATION:CONDITION? query.

**Example Query**     OUTPUT 719;":STAT:OPER:EVEN?"  
                  ENTER 719;State  
                  PRINT State

---

**OPERation:NTRansition  
(Negative Transition)**

**Syntax**           :STATus:OPERation:NTRansition *number*  
                      :STATus:OPERation:NTRansition?

**Description**     The OPERATION:NTRANSITION command is used to define which bits in the Operation Condition Register will set the corresponding bit in the Operation Event Register on a one to zero state change. For the generator only bit 0 is used because only bit 0 is used in the operation condition register. All other bits in the negative transition filter register are "don't cares". See :STATUS:OPERATION:CONDITION? for the definition of bit 0.

The OPERATION:NTRANSITION? query returns the contents of the Operation Negative Transition Register.

**Example Command**        OUTPUT 719;":STAT:OPER:NTR 1"

**Example Query**            OUTPUT 719;":STAT:OPER:NTR?"  
                              ENTER 719;State  
                              PRINT State

---

**OPERation:PTRansition  
(Positive Transition)**

**Syntax**           :STATus:OPERation:PTRansition *number*  
                      :STATus:OPERation:PTRansition?

**Description**     The OPERATION:PTRANSITION command is used to define which bits in the Operation Condition Register will set the corresponding bit in the Operation Event Register on a zero to one state change. For the generator only bit 0 is used because only bit 0 is used in the operation condition register. All other bits in the positive transition filter register are "don't cares". See :STATUS:OPERATION:CONDITION? for the definition of bit 0.

The OPERATION:PTRANSITION? query returns the contents of the Operation Positive Transition Register.

**Example Command**     OUTPUT 719;":STAT:OPER:PTR 1"

**Example Query**       OUTPUT 719;":STAT:OPER:PTR?"  
                          ENTER 719;State  
                          PRINT State

**QUESTIONable:CONDition?**

**Syntax** :STATus:QUESTIONable:CONDition?

**Description** The QUESTIONABLE:CONDITION query reads the contents of the Questionable Condition Register. Reading this condition register does not alter the register's value. For the generator, only bits 3-5 and 7-9 are used; all other bits are always zero. When a bit is set to 1 it is a flag to the user that the condition associated with the set bit may affect the output signal's quality. The following table describes what is wrong if a bit is set in the condition register.

**Questionable Condition Register Bit Definitions**

Bit	Weight	Description
3	8	Power (uncalibrated)
4	16	Temperature (Time base oven not at temperature)
5	32	Frequency (Local oscillator loops are unlocked)
6	64	Always 0
7	128	Modulation (uncalibrated)
8	256	Calibration (instrument uncalibrated)
9	512	Overload (external filter inputs)

**Example Query**

```
OUTPUT 719;":STAT:QUES:COND?
ENTER 719;State
PRINT State
```

**QUESTIONable:ENABLE**

**Syntax**           :STATus:QUESTIONable:ENABLE *number*  
                       :STATus:QUESTIONable:ENABLE?

**Description**    The QUESTIONABLE:ENABLE command sets the contents of the Questionable Event Enable Register. This enables bits in the Questionable Event Register that will set the Questionable Summary Bit(bit 3) in the status byte.

For the generator only bits 3-5 and 7-9 are used because only those bits are used in the questionable condition register. All other bits in the event enable register are "don't cares". The bits in the Questionable Event Enable Register are defined as follows:

**Questionable Event Enable Register Bit Definitions**

Bit	Weight	Description
3	8	Power (uncalibrated)
4	16	Temperature (Time base oven not at temperature)
5	32	Frequency (Local oscillator loops are unlocked)
6	64	Always 0
7	128	Modulation (uncalibrated)
8	256	Calibration (instrument uncalibrated)
9	512	Overload (external filter inputs)

The QUESTIONABLE:ENABLE? query returns the contents of the Questionable Event Enable Register.

**Example Command**        OUTPUT 719;":STAT:QUES:ENAB 768"

**Example Query**            OUTPUT 719;":STAT:QUES:ENAB?"  
                               ENTER 719;State  
                               PRINT State

---

**QUESTIONable:EVENT?**

**Syntax**           :STATus:QUESTionable[:EVENT]?

**Description**     The QUESTIONABLE:EVENT? query reads the contents of the Questionable Event Register. This register is set to zero after it is read by this query. It is also set to zero after a \*CLS command. This register holds a record of the state changes in the Questionable Condition Register as specified by the transition filters.

The bits in the Questionable Event Register are defined as follows:

**Questionable Event Register Bit Definitions**

Bit	Weight	Description
3	8	Power (uncalibrated)
4	16	Temperature (Time base oven not at temperature)
5	32	Frequency (Local oscillator loops are unlocked)
6	64	Always 0
7	128	Modulation (uncalibrated)
8	256	Calibration (instrument uncalibrated)
9	512	Overload (external filter inputs)

**Example Query**       OUTPUT 719;":STAT:QUES:EVENT?"  
                          ENTER 719;State  
                          PRINT State

---

**QUESTIONable:NTRansition  
(Negative Transition)**

**Syntax**           :STATus:QUESTIONable:NTRansition *number*  
                  :STATus:QUESTIONable:NTRansition?

**Description**     The QUESTIONABLE:NTRANSITION command is used to define which bits in the Questionable Condition Register will set the corresponding bit in the Questionable Event Register on a one to zero state change. For the generator only bits 3-5 and 7-9 are used because only those bits are used in the questionable condition register. All other bits in the negative transition filter register are "don't cares". See the QUESTIONable:CONDition? query for bit definitions.

The QUESTIONABLE:NTRANSITION? query returns the contents of the Questionable Negative Transition Register.

**Example Command**       OUTPUT 719;":STAT:QUES:NTR 8"

**Example Query**         OUTPUT 719;":STAT:QUES:NTR?"  
                          ENTER 719;State  
                          PRINT State

---

**QUESTIONable:PTRansition  
(Positive Transition)**

**Syntax**           :STATus:QUESTionable:PTRansition *number*  
                      :STATus:QUESTionable:PTRansition?

**Description**     The QUESTIONABLE:PTRANSITION command is used to define which bits in the Questionable Condition Register will set the corresponding bit in the Questionable Event Register on a zero to one state change. For the generator only bits 3-5 and 7-9 are used because only those bits are used in the questionable condition register. All other bits in the negative transition filter register are "don't cares". See the QUESTIONable:CONDition? query for bit definitions.

The QUESTIONABLE:PTRANSITION? query returns the contents of the Questionable Positive Transition Register.

**Example Command**     OUTPUT 719;":STAT:QUES:PTR 160"

**Example Query**       OUTPUT 719;":STAT:QUES:PTR?"  
                          ENTER 719;State  
                          PRINT State

## System Subsystem

The System Subsystem commands allow you to read error messages and simulate front panel key presses.

The commands in the System Subsystem are shown in the following table:

**System Subsystem Commands**

Command	Description
:SYSTem	
:ERRor?	Returns error codes with message.
:KEY	Simulates pushing a front panel key.
:KEY?	Returns last key pressed.

---

**ERRor?**

**Syntax**           :SYSTem:ERRor?

**Description**     When an error occurs, an error number for the particular error will be stored in the error queue. The error queue is a buffer that is internal to the instrument. It can contain up to sixteen error numbers. Every time the SYST:ERR? query is executed, one error number is read from this queue. An error number is removed from the queue when it is read. Error numbers are read in a first-in/first-out basis. When an error number is returned by SYST:ERR?, a character string with a maximum of 160 characters is returned with it. This string contains a brief description of the error, and, in some cases, what is specifically wrong. Following is an example of the response to the SYST:ERR? query if the generator had been commanded to go to a frequency that is too large:

```
-222,"Data out of range;CARR FREQ(2030)"
```

The -222 and "Data out of range" part of this message are TMSL error number and TMSL error message respectively. If the front panel error message number differs from the TMSL error number, the front panel error number will be included in parenthesis - notice the front panel error number 2030 in the example above. The "CARR FREQ" part of the error message after the semi-colon is just specifics about what exactly was wrong. Many error messages have no specifics after the semi-colon because the first part of the message is explanatory enough.

If the error queue is empty, the instrument will return a message of 0, "No error". Once the error queue is full (that is, when it receives a 17th error number), the number -350 is stored in the 16th location. As error numbers are stored and read from the error queue, this number will move within the queue, but will not actually be read until all the error queue locations have been read in front of it. Therefore, reading the message -350, "Too many errors", from the error queue only indicates that the buffer did overflow at that point. The error queue is emptied by the \*CLS command.

---

**Note**

See the "Error Messages" appendix at the end of this manual for a complete listing of instrument errors.

---

The example below reads in one error message from the HP-IB error queue. The best way to read all error messages from the error queue is to repeatedly execute the example program below until the error number is 0.

HP 8782B

ERRor?

**Example Query**

```
DIM B$[160]
OUTPUT 719;":SYST:ERR?"
ENTER 719; A,B$
PRINT "ERROR NUMBER =";A
PRINT "ERROR MESSAGE =";B$
END
```

**KEY**

**Syntax**

```
:SYSTem:KEY { key code
                MAXimum
                MINimum
              }

:SYSTem:KEY? [ MAXimum
              [ MINimum
            ]
          ]
```

**Description** The KEY command simulates pressing a front panel key. The following parameters can be selected:

Parameter	Description
<i>number</i>	Allowable range is 0 to 51. See the following table for the front panel key that corresponds to key code.
MAXimum	Simulates pressing key number 51 (RF Output On).
MINimum	Simulates pressing key number 0 (Set Frequency).

The KEY? query returns the last key pressed. If -1 is returned then no key has been pressed since power on or \*RST occurred. The KEY? MAXIMUM query always returns 51. The KEY? MINIMUM query always returns 0.

You can use the SYST:KEY command to change the HP-IB address of the generator. However, use this feature with caution as there may be timing problems with changing the HP-IB address while you are using HP-IB at the old address. The following command sets the HP-IB address to 17. Replace "KEY 34;KEY 14" (keys 1 and 7) to get a different HP-IB address.

```
OUTPUT 719;"SYST:KEY 7;KEY 35;KEY 12;KEY 39;KEY 34;KEY 14;KEY 39"
```

**Example Command** OUTPUT 719;":SYST:KEY 13"

**Example Query**

```
OUTPUT 719;":SYST:KEY?"
ENTER 719;Key
PRINT Key
```

HP 8782B

KEY

## HP 8782B Key Code Definitions

Key Code	Key
0	Set Frequency
1	Set Increment
2	Up Arrow
3	Down Arrow
4	External PRBS
5	Message
6	Modulation
7	Special
8	Save
9	ECL Clock
10	Calibrate
12	4
13	5
14	7
20	Set Level
21	Clock Level
22	Data Level
23	Back Space
24	Serial Input
25	External Filter

## KEY

## HP 8782B Key Code Definitions (continued)

Key Code	Key
26	Serial Frame
27	Local
28	External Clock
29	Recall
30	ECL Data
31	Preset
32	Invert Input
33	8
34	1
35	2
36	0
37	.
38	6
39	Enter Special; MHz; Volt
40	9
41	dB; dBm; DEG
42	3
43	kHz; mV; Special ON
44	-
45	Hz; Special Off; uV
46	Scalar On
47	PRBS On
48	Modulation On
49	Burst On
50	Set Frequency
51	RF Output On

## Vector Modulation Subsystem

The Vector Modulation Subsystem is used for controlling the vector modulation parameters of the instrument.

The commands in the Vector Modulation Subsystem are shown in the following table.

**Table 4-18. Vector Modulation Subsystem Commands**

Command	Description
[:SOURce]	
:VM	
:QUADrature	
[:ANGLE]	Set the quadrature angle.
:STEP	
[:INCRement]	Set the quadrature angle increment.
[:INCRement]?	Query the quadrature angle increment.
[:ANGLE]?	Query the quadrature angle.
:STATe	Turn the quadrature angle on and off.
:STATe?	Query quadrature angle state.
:STATE	Turn vector modulation on/off
:STATE?	Query vector modulation state

## QUADrature:ANGLE

### Syntax

```
[ :SOURce ] :VM:QUADrature [ :ANGLE ] {
  angle
  MAXimum
  MINimum
  DOWN
  UP
}
```

```
[ :SOURce ] :VM:QUADrature [ :ANGLE ] ? [ MAXimum ]
[ MINimum ]
```

```
[ :SOURce ] :VM:QUADrature [ :ANGLE ] :STEP [ :INCRement ]
{
  increment
  MAXimum
  MINimum
}
```

```
[ :SOURce ] :VM:QUADrature [ :ANGLE ] :STEP [ :INCRement ] ?
[ MAXimum ]
[ MINimum ]
```

### Description

The QUADRATURE:ANGLE command sets the quadrature angle. The following parameters can be selected:

Parameter	Description
<i>angle</i>	Allowable range is $-90$ to $+90$ degrees. The angle may also be set in radians. The allowable range is $-\pi/2$ to $\pi/2$ . To enter the angle in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the angle is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the quadrature angle to $+90$ degrees.
MINimum	Sets the quadrature angle to $-90$ degrees.
DOWN	Decreases the current quadrature angle by the increment specified by the QUADRATURE:ANGLE:STEP command.
UP	Increases the current carrier leakage angle by the increment specified by the QUADRATURE:ANGLE:STEP command.

The QUADRATURE:ANGLE? query returns the quadrature angle in degrees.

The QUADRATURE:ANGLE? MAXIMUM query always returns 90. The QUADRATURE:ANGLE? MINIMUM query always returns  $-90$ .

HP 8782B

QUADrature:ANGLE

Preset: 0 degrees

The QUADRATURE:ANGLE:STEP command sets the increment for quadrature angle. The following parameters can be selected:

Parameter	Description
<i>increment</i>	Allowable range is $-90$ to $+90$ degrees. The increment may also be set in radians. The allowable range is $-\pi/2$ to $\pi/2$ . To enter the increment in radians, you must use the RAD suffix. Otherwise the instrument assumes the entered value is in degrees. Once the increment is entered in radians, the instrument automatically converts the value to degrees internally.
MAXimum	Sets the increment to $+90$ degrees.
MINimum	Sets the increment to $-90$ degrees.

The QUADRATURE:ANGLE:STEP? query returns the current quadrature angle increment in degrees. The QUADRATURE:ANGLE:STEP? MAXIMUM query always returns 90. The QUADRATURE:ANGLE:STEP? MINIMUM query always returns -90.

Preset: 1 degree

**Example Command**

OUTPUT 719;":VM:QUAD:ANGL 5.4 DEG"

**Example Query**

```
OUTPUT 719;":VM:QUAD:ANGL?"
ENTER 719;Value
PRINT Value
```

## QUADrature:STATe (Quadrature Angle State)

### Syntax

$$[:\text{SOURCE}]:\text{VM:QUADrature:STATe} \left\{ \begin{array}{l} 0 \\ 1 \\ \text{OFF} \\ \text{ON} \end{array} \right\}$$

$$[:\text{SOURCE}]:\text{VM:QUADrature:STATe?}$$

### Description

The QUADRATURE:STATE command turns the quadrature angle control on and off. The following parameters can be selected:

Parameter	Description
0	Turns the quadrature angle off.
1	Turns quadrature angle on. Entering any number other than zero will also turn quadrature angle on.
OFF	Turns the quadrature angle off.
ON	Turns the quadrature angle on.

The QUADRATURE:STATE? query returns a 0 if the quadrature angle is off and a 1 if the quadrature angle is on.

Preset: OFF

### Example Command

```
OUTPUT 719;":VM:QUAD:STAT ON"
```

### Example Query

```
OUTPUT 719;":VM:QUAD:STAT?"
ENTER 719;State
PRINT State
```

**STATe****Syntax**

$$[:SOURCE]:VM:STATe \left\{ \begin{array}{l} 0 \\ 1 \\ OFF \\ ON \end{array} \right\}$$

$$[:SOURCE]:VM:STATe?$$
**Description**

The STATE command turns the vector modulation on and off. This command has the same functionality as the "MODULATION ON" key on the front panel. The following parameters can be selected:

Parameter	Description
0	Turns the vector modulation off.
1	Turns vector modulation on. Entering any number other than zero will also turn vector modulation on.
OFF	Turns the vector modulation off.
ON	Turns the vector modulation on.

**Note**

Digital, AM and Pulse modulation types must be turned off before Vector modulation can be turned on (VM:STAT ON).

The STATE? query returns a 0 if the vector modulation is off and a 1 if the vector modulation is on.

Preset: OFF

**Example Command**

```
OUTPUT 719;":VM:STAT ON"
```

**Example Query**

```
OUTPUT 719;":VM:STAT?"
ENTER 719;State
PRINT State
```



## Performance Tests

---

### Introduction

The procedures in this chapter test the electrical performance of the generator using the specifications of Table 1-1 as performance standards. These tests are suitable for incoming inspection, troubleshooting, and preventive maintenance. All tests can be performed without access to the interior of the generator. A simpler operational test is included in "Operator's Checks" in this chapter.

### Note



To consider the performance tests valid, the following conditions must be met:

1. The Vector Signal Generator must have a 1 hour warm-up.
2. The internal automatic calibration must be performed immediately before each test. Calibration coefficients are different for internal and external filter paths. In general, if the filter mode is changed (the **EXT FILT** key), the internal automatic calibration should be performed again.
3. The line voltage for the generator must be 100, 120, 220 or 240 Vac +5%, -10%, with a line frequency of 48 to 66 Hz; or 100 or 120 Vac +5%, -10%, with a line frequency of 360 to 440 Hz. The correct line voltage switch or card setting must be selected.
4. The ambient temperature must be within the range of 0° to 55°C.

### Equipment Required

Equipment required for the performance tests is listed in "Recommended Test Equipment" in chapter 1. Any equipment that satisfies the critical specifications given in the table may be substituted.

### Performance Test Record

Results of the performance tests may be recorded in Table 5-31 "Performance Test Record". This table is located at the end of this chapter and lists all of the tested specifications and their acceptable limits. Results recorded at incoming inspection can be used for comparison in periodic maintenance and troubleshooting and after repairs or adjustments. It is a good idea to make photocopies of the blank Performance Test Record pages so that it may be used again in the future.

- Performance Tests** These tests are designed to verify published generator specifications. Perform the tests given and record the data in the Performance Test Record and/or in the data spaces provided at the end of each procedure.
- Calibration Cycle** This generator requires periodic verification of performance to ensure that it is operational within specified tolerances. The performance tests described in this chapter should be performed every two years. Under conditions of heavy usage or severe operation environments, the test should be more frequent.
- Operator's Checks** Successfully performing the internal calibration will very quickly provide a high degree of confidence that the generator is functioning properly. See "Calibration" in chapter 3, "Local Operation".
- The functions of the generator are checked using the following procedures. These checks are an abbreviated version of the Performance Tests and are designed to provide a 90% assurance that the generator is operating correctly.
- Perform the following tests or sections of tests:
- RF Output Level, Flatness and Maximum Level Power
  - Residual FM
  - RF Switch On/Off Ratio
  - Harmonics
  - Non-Harmonically Related Spurious Responses
  - Pulse (Burst) Modulation, On/Off ratio section
  - Scalar Frequency Response
  - PRBS Clock Rates
- Test Procedures** It is assumed that the person performing the test understands how to use the specified test equipment. Equipment settings, other than those for the Vector Signal Generator, are stated in general terms. It is also assumed that the person performing the test will supply whatever cables, connectors, and adapters are necessary.

## Frequency Aging Rate, Range, and Resolution

### Specification

Electrical Characteristics	Performance Limits	Conditions
Frequency		
Range	1 MHz to 250 MHz	
Resolution	1 Hz	
Accuracy and Stability	Same as reference oscillator	
Reference Oscillator		
Frequency	10 MHz	
Aging Rate	$< 1.5 \times 10^{-9}$ per day	After a ten day warm up.

### Note



The internal 10 MHz reference oscillator will typically take 24 to 48 hours to reach its specified aging rate after generator storage or shipment. In some cases, if extreme environmental conditions were encountered during storage, the reference oscillator could take as long as ten days to achieve its specified aging rate.

### Description

The test is divided into a frequency range, frequency resolution and frequency aging rate test. Each test is described below.

#### Frequency Aging Rate Test

A precision frequency standard (with long term stability better than  $1 \times 10^{-10}$  per day) is used to trigger an oscilloscope at a precise rate. The 10 MHz auxiliary output of the generator is observed on the oscilloscope display. The time required for a specific phase change is measured immediately and after a period of time. The phase changes indicate frequency errors, and from these two frequency errors, the drift rate is calculated.

#### Frequency Range Test

A frequency counter is used to verify that the generator can produce frequencies between 1 MHz and 250 MHz inclusive.

#### Frequency Resolution Test

The frequency counter is used to verify that the RF output frequency of the generator can be tuned in 1 Hz steps.

Connections

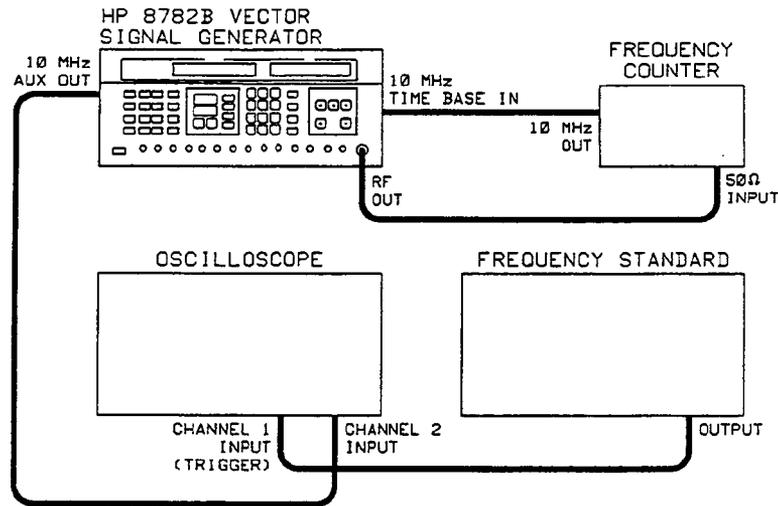


Figure 5-1. Frequency Test Setup

Equipment

- Frequency Counter ..... HP 5343A
- Frequency Standard ..... HP 5065A
- Oscilloscope ..... HP 54111A

Test Equipment Settings

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	0 dBm
TIME BASE (rear panel)	INT
<b>Frequency Counter</b>	10 Hz to 500 MHz input
Input Impedance	50Ω
<b>Oscilloscope</b>	AUTOSCALE
Input Impedance	50Ω

Procedure

Frequency Aging Rate Test

Note



For the aging rate test to be considered valid, the oscillator must be warmed up for a minimum of 24 hours (see note above). To accomplish this warm-up, the generator must be ON, and the generator's rear panel 10 MHz TIME BASE INT/EXT switch must be set to INT.

HP 8782B

## Frequency Aging Rate, Range, and Resolution

1. Connect the generator's rear panel 10 MHz time base aux out to channel 2 of the oscilloscope. Connect the frequency to channel 1 of the oscilloscope. Press **AUTOSCALE**. This will cause the oscilloscope to trigger on channel 1 (the frequency standard).
2. Observe the channel 2 trace (the generator's 10 MHz reference signal). Measure the time required for a phase change of 360°. Record the time (T1) in units of seconds.

T1 \_\_\_\_\_ seconds

3. Wait for a period of time (from 3 to 24 hours) with the generator operating. Re-measure the phase change time. Record the period of time between measurements (T2) in hours and the time for the second 360° change (T3) in seconds.

T2 \_\_\_\_\_ hours

T3 \_\_\_\_\_ seconds

4. Calculate the aging rate from the following equation:

$$\text{Aging rate} = \left[ \left( \frac{1 \text{ cycle}}{f} \right) \times \left( \frac{1}{T1} - \frac{1}{T3} \right) \times \left( \frac{T}{T2} \right) \right]$$

Where:

1 cycle = the phase change reference for the time measurement (360° in this case)

f = The generator's frequency reference (10 MHz)

T = specified time for aging rate (24 hours)

T1 = first time measurement for a 360° phase change.

T2 = time between measurements of T1 and T3 (in hours)

T3 = second time measurement for a 360° phase change.

For example:

T1 = 351 seconds

T2 = 3 hours

T3 = 349 seconds

Then

$$\text{Aging rate} = \left[ \left( \frac{1 \text{ cycle}}{10 \text{ MHz}} \right) \times \left( \frac{1}{351\text{s}} - \frac{1}{349\text{s}} \right) \times \left( \frac{24\text{h}}{3\text{h}} \right) \right]$$

$$= 1.306 \times 10^{-11} / \text{day.}$$

5. Verify that the calculated aging rate is less than  $1.5 \times 10^{-9}$  / day.

Aging rate \_\_\_\_\_  $< 1.5 \times 10^{-9}$  / day

**Note**

If the absolute frequencies of the frequency and the generator's reference oscillator are extremely close (within 1 Hz), the measurement for determining T1 and T3 can be reduced by measuring the time required for a phase change of something less than  $360^\circ$ . Change the 1 cycle constant in the formula to the appropriate value. For example if the measured phase change is  $90^\circ$ , then use 0.25 cycle. If the measure phase change is  $180^\circ$ , then use 0.5 cycle. The frequency can be adjusted to be within 1 Hz using the 10 MHz Reference Oscillator Adjustment in chapter 1, "Adjustments", of the Service Manual.

**Frequency Range Test**

1. Connect the equipment as show in Figure 5-1. The frequency counter 10 MHz reference output is connected in place of the generator's 10 MHz internal reference. Set the generator's rear panel 10 MHz TIME BASE INT/EXT switch to EXT.
2. Press the **PRESET** key on the generator.
3. Set the generator to 0.9 MHz and 0 dBm. Verify that the frequency counter indicates less than 1.0 MHz. This tests the lower limit of the frequency range specification.

Generator frequency \_\_\_\_\_  $< 1.0$  MHz

4. Set the generator to 250.1 MHz. Verify that the frequency counter indicates a frequency greater than 250 MHz. This tests the higher limit of the frequency range specification.

Generator frequency \_\_\_\_\_  $> 250$  MHz

**Frequency Resolution Test**

1. Set the generator to 50 MHz. With the frequency counter resolution set to 1 Hz, verify that the frequency counter agrees with the generator within  $\pm 1$  count.
2. Increase the generator frequency by 1 Hz and assure that the frequency counter display also increases by 1 Hz.

1 Hz Resolution \_\_\_\_\_ ( $\checkmark$ )

## RF Output Level Accuracy, Flatness and Maximum Levelled Power

### Specification

Electrical Characteristics	Performance Limits	Conditions
<b>RF OUTPUT</b>		
Calibrated Output	+7 dBm to -100 dBm	
Accuracy	< $\pm 1.5$ dB < $\pm 2.0$ dB < $\pm 2.4$ dB	Carrier $\geq -30$ dBm -30 dBm > Carrier $\geq -80$ dBm Carrier < -80 dBm
Flatness	< $\pm 1.0$ dB	1 MHz $\leq$ Carrier $\leq$ 250 MHz

**Description** The test is divided into a RF level accuracy, output level flatness, and maximum levelled power test. Each test is described below.

#### RF Level Accuracy

A measuring receiver is used to measure the RF output level down to -100 dBm. The measuring receiver uses an IF substitution technique in the tuned RF level mode to enable power measurements to be made at levels as low as -100 dBm.

#### Output Level Flatness

A power meter is used to measure the power variation as the generator is tuned from the lowest to the highest specified frequencies. Flatness is determined as one-half of the difference between the maximum and minimum levels measured.

#### Maximum Levelled Power

The power meter is used to verify that the generator can produce the specified maximum RF power.

**Connections**

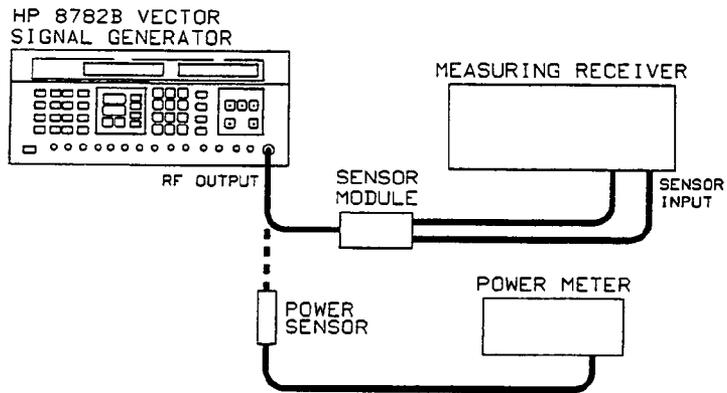


Figure 5-2. RF Level Test Setup

**Equipment**

- Measuring Receiver ..... HP 8902A
- Sensor Module ..... HP 11792A or HP 11722A
- Power Meter ..... HP 437B or HP 438A
- Power Sensor ..... HP 8482A (100 kHz to 4.2 GHz)
- Power Sensor Cable ..... HP 11730

**Test Equipment Settings**

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	<b>PRESET</b>
RF Level	+7 dBm
TIME BASE (rear panel)	INT
<b>Measuring Receiver</b>	<b>PRESET</b>
Measurement Mode	TUNED RF Level
Carrier Frequency	70.0 MHz
LOG / Linear Display	LOG
Calibration Factor	As Required
<b>Power Meter</b>	<b>PRESET</b>
LOG / Linear Display	LOG
Calibration Factor	As Required

**Procedure****RF Level Accuracy**

1. Connect the measuring receiver and sensor as shown in Figure 5-2. Set the settings as shown in the table above.

**Note**

---

The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **CAL** key on the generator.

---

2. Calibrate and zero the power meter measuring section of the measuring receiver. It is necessary to change measuring modes to do this.
3. Connect the sensor module to the generator's RF output, then set the measuring receiver to tuned RF. Press the LOG/LIN key to display the measured power in dBm. Set the measuring receiver to 70 MHz.

**Note**

---

If at any time during this test the measuring receiver RECAL annunciator lights, press the **CALIBRATE** key on the measuring receiver. If the UNCAL annunciator lights and the RECAL annunciator is not lit, then increase the generator power in 1 dB steps until the RECAL annunciator lights. Press the **CALIBRATE** key, and then set the generator back to the correct level. A measuring receiver calibration should be required when the tuned RF level function is first selected, and then at -40 dBm and -80 dBm.

---

4. The displayed power level should be  $+7 \text{ dBm} \pm 1.5 \text{ dB}$ . Record the measured level in the table below.
5. Set the generator's output level to each value shown in Table 5-1, and record the results below and in Table 5-31 "Performance Test Record".

Table 5-1. Level Accuracy Results

HP 8782B Level (dBm)	Minimum	Actual	Maximum
+7 dbm	+5.5		+8.5
-2.9 dbm	-4.4		-1.4
-10 dbm	-11.5		-8.5
-20 dbm	-21.5		-18.5
-30 dbm	-31.5		-28.5
-40 dbm	-42		-38
-50 dbm	-52		-48
-60 dbm	-62		-58
-70 dbm	-72		-68
-80 dbm	-82		-78
-90 dbm	-92.4		-87.6
-100 dbm	-102.4		-97.6

**Output Level Flatness**

1. Zero and calibrate the power meter. Connect the power sensor to the generator's RF output.
2. Preset the generator, and then set the power level to +7.0 dBm.
3. Select relative power measurement on the power meter. This establishes a reference at the current measured level.
4. Slowly tune the generator from 1.0 MHz to 250.0 MHz while observing the power meter. Record the maximum reading and the minimum reading and the frequency at which each reading occurs. The difference between the maximum level and the minimum level should be less than 2.0 dB. Adjust the power meter CAL FACTOR as the generator's frequency is changed to assure measurement accuracy.

Highest reading:

Frequency \_\_\_\_\_ MHz. Level \_\_\_\_\_ dBm

Lowest reading:

Frequency \_\_\_\_\_ MHz. Level \_\_\_\_\_ dBm

Highest - Lowest = Flatness \_\_\_\_\_ &lt; 2.0 dB

HP 8782B

**RF Output Level Accuracy, Flatness and Maximum Leveled Power****Maximum Leveled Power**

1. Set the generator frequency to the frequency at which the lowest power reading was made for the output level flatness test.
2. Turn off the power meter relative power measurement mode. Readjust the generator output level for a power meter indication of +7.0 dBm.
3. Tune the generator from 1.0 MHz to 250 MHz and verify that the power meter indicates at least +7.0 dBm at all frequencies.

1.0 MHz to 250.0 MHz, RF > +7.0 dBm \_\_\_\_\_ (✓)

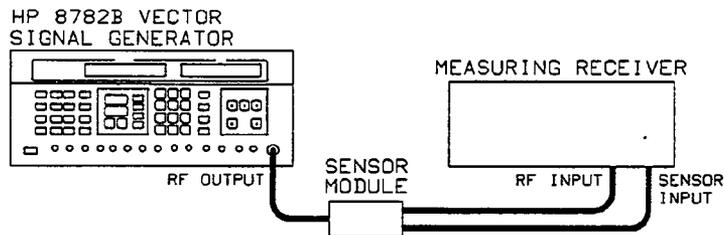
**Residual FM**

**Specification**

Electrical Characteristics	Performance Limits	Conditions
<b>SPECTRAL PURITY</b> Residual FM	< 4 Hz RMS	Measured in a 300 Hz to 3 kHz bandwidth

**Description** A measuring receiver is used to directly measure residual FM.

**Connections**



**Figure 5-3. Residual FM Test Setup**

**Equipment** Measuring Receiver .....HP 8902A  
 Sensor Module .....HP 11792A or HP 11722A

**Test Equipment Settings**

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	+7 dBm
TIME BASE (rear panel)	INT
<b>Measuring Receiver</b>	PRESET
Measurement Mode	FM
Frequency	70 MHz
High Pass Filter	300 Hz
Low Pass Filter	3 kHz
RMS Responding Detector	ON

HP 8782B

Residual FM

**Procedure**

1. Connect the equipment as shown in Figure 5-3. Set the test equipment to setting in the table above.
2. Wait for the display to stabilize. Read the residual FM directly from the measuring receiver display. The deviation should be < 4 Hz RMS.

Residual FM \_\_\_\_\_ &lt; 4 Hz RMS

**RF Switch On/Off Ratio**

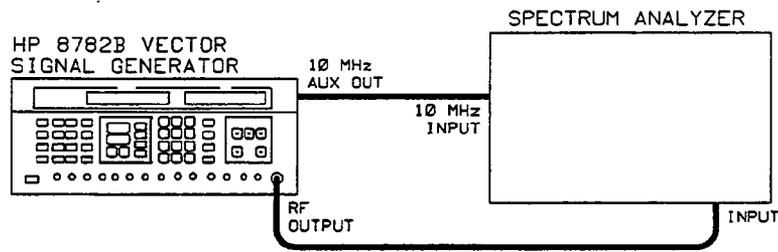
**Specification**

Electrical Characteristics	Performance Limits	Conditions
RF Output RF Switch On/Off Ratio	> 60 dB	Carrier > -40 dBm

**Description**

The generator is set to 0 dBm and the level is measured using the spectrum analyzer. The RF output is then turned off and the residual level is verified to be less than -60 dBm.

**Connections**



**Figure 5-4. RF Switch On/Off Ratio Test Setup**

**Equipment**

Spectrum Analyzer .....HP 8566B

**Test Equipment Settings**

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	0 dBm
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	70 MHz
Reference Level	0 dBm
Frequency Span	1 MHz
Resolution Bandwidth	10 kHz
Video Bandwidth	300 Hz
Marker	ON (Normal)
Frequency Reference	EXT

**Procedure**

1. Set up the equipment as shown in Figure 5-4 and the Test Equipment Settings table.
2. Measure the generator's 70 MHz signal 'ON' amplitude by pressing **PEAK SEARCH** on the spectrum analyzer. Set the markers to make a relative power measurement by pressing the **Δ** key.
3. Turn the generator RF output off by pressing the **RF OUTPUT ON** key.
4. Enable spectrum analyzer video averaging by pressing **SHIFT** **VIDEO BW**.
5. After the displayed signal has settled, measure the generator's RF Switch ON/OFF ratio by reading the spectrum analyzer dB marker value. ON/OFF ratio is actually the opposite sign of this value. Record the RF ON/OFF ratio, and verify that the value is greater than 60 dB.

RF ON/OFF RATIO \_\_\_\_\_ > 60 dB

**Harmonics**

**Specification**

Electrical Characteristics	Performance Limits	Conditions
<b>SPECTRAL PURITY</b>		
Harmonics	< -30 dBc	Carrier ≤ +7 dBm

**Description**

The harmonics of the generator's RF output signal are measured using a spectrum analyzer.

**Note**



Reasonable care must be taken during these measurements to ensure that the spectrum analyzer does not contribute to the harmonic level. Set the RF attenuation of the spectrum analyzer to at least 20 dB to prevent over-driving the spectrum analyzer.

**Connections**

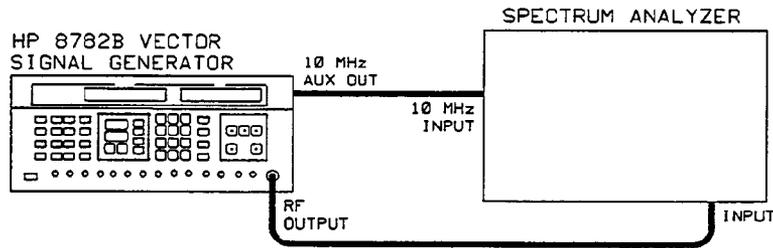


Figure 5-5. Harmonics Test Setup

**Equipment**

Spectrum Analyzer ..... HP 8566B

**Test Equipment Settings**

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	<b>PRESET</b>
RF Level	+7 dBm
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	<b>PRESET</b>
Center Frequency	1 MHz
Reference Level	+10 dBm
RF Attenuation	20 dB
Frequency Span	20 kHz
Resolution Bandwidth	1 kHz
Video Bandwidth	300 Hz
Marker	ON (Normal)
Frequency Reference	EXT

**Procedure**

1. Connect the equipment as shown in Figure 5-5. Set the test equipment settings as shown in the table above.

**Note**

The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **CAL** key on the generator.

2. Set the markers to make a relative power measurement by pressing **PEAK SEARCH** and then the **Δ** key.
3. Tune the spectrum analyzer to 2.0 MHz. The second harmonic, now displayed at 2.0 MHz, should be less than -30 dBc. Record the measured value below and in Table 5-31 "Performance Test Record".
4. Tune the spectrum analyzer to 3.0 MHz. The third harmonic, now displayed at 3.0 MHz, should be less than -30 dBc. Record the measured value below in Table 5-2 and in Table 5-31 "Performance Test Record".
5. Repeat steps 3 through 7 for each of the frequencies listed below in Table 5-2.

Table 5-2. Harmonics Results

Signal Frequency	Harmonic Frequency	Harmonic Amplitude	Limit
1.0 MHz	2.0 MHz (2nd)	_____ dBc	-30 dBc
1.0 MHz	3.0 MHz (3rd)	_____ dBc	-30 dBc
70.0 MHz	140.0 MHz (2nd)	_____ dBc	-30 dBc
70.0 MHz	210.0 MHz (3rd)	_____ dBc	-30 dBc
140.0 MHz	280.0 MHz (2nd)	_____ dBc	-30 dBc
140.0 MHz	420.0 MHz (3rd)	_____ dBc	-30 dBc
249.0 MHz	498.0 MHz (2nd)	_____ dBc	-30 dBc
249.0 MHz	747.0 MHz (3rd)	_____ dBc	-30 dBc

**Note**

249 MHz is used as the highest carrier frequency in the harmonic test because there is a spurious frequency ( $3 \times 1.00 \text{ GHz} - 2 \times 1.250 \text{ GHz}$ ) which crosses the second harmonic when the carrier is tuned to 250 MHz. This spur is generally very much smaller than the 2nd harmonic (spurs are specified to be  $-55 \text{ dBc}$ ), but to ensure that only the 2nd harmonic is measured, the carrier should be offset slightly from 250.0 MHz.

**Non-Harmonically Related Spurious Responses**

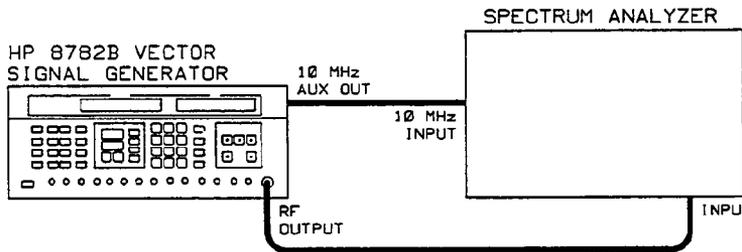
**Specification**

Electrical Characteristics	Performance Limits	Conditions
<b>SPECTRAL PURITY</b> Non-harmonically Related spurious responses	< -55 dBc	Carrier > -40 dBm 1 MHz ≤ Spur Frequency ≤ 2 GHz

**Description**

A spectrum analyzer is used to check known spurious signals to ensure that the spurious signal amplitudes are within specification. The spectrum analyzer may also be tuned anywhere within the specified frequency range (1 MHz to 2 GHz) in search of spurious signals.

**Connections**



**Figure 5-6.**  
**Non-Harmonically Related Spurious Responses Test Setup**

**Equipment**

Spectrum Analyzer ..... HP 8566B

**Test Equipment Settings**

## Non-Harmonically Related Spurious Responses

HP 8782B

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	+7 dBm
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	70 MHz
Reference Level	+10 dBm
Frequency Span	500 kHz
Resolution Bandwidth	3 kHz
Video Bandwidth	100 Hz
Marker	ON (Normal)
Frequency Reference	EXT

**Procedure**

1. Connect the equipment as shown in Figure 5-6.
2. Set the settings to those shown in the table above.
3. Set the markers to make a relative power measurement by pressing **PEAK SEARCH** and then **Δ**.
4. Tune the spectrum analyzer to 80.0 MHz. A +10.0 MHz offset spurious signal should now be displayed at 80.0 MHz. The amplitude should be less than -55 dBc. Record the measured value below in Table 5-3 and in Table 5-31 "Performance Test Record".
5. Repeat steps 3 through 5 for each carrier frequency and power level listed below.

**Table 5-3. Spurious Responses Results**

Signal Frequency	Signal Level	Spurious Frequency	Spurious Amplitude	Limit
70.0 MHz	+7.0 dBm	80.0 MHz	_____ dBc	<-55 dBc
70.0 MHz	+7.0 dBm	60.0 MHz	_____ dBc	<-55 dBc
70.0 MHz	+7.0 dBm	30.0 MHz	_____ dBc	<-55 dBc
70.0 MHz	+7.0 dBm	170.0 MHz	_____ dBc	<-55 dBc
249.0 MHz	+7.0 dBm	502.0 MHz	_____ dBc	<-55 dBc
249.0 MHz	+7.0 dBm	751.0 MHz	_____ dBc	<-55 dBc
249.0 MHz	+7.0 dBm	1000.0 MHz	_____ dBc	<-55 dBc

6. Tune the spectrum analyzer slowly from 1 MHz to 2 GHz in search of spurious responses. The amplitude of any spurious signal should be more than 55 dB below the carrier (< -55 dBc). Record the carrier frequency, spurious frequency and level

HP 8782B

## Non-Harmonically Related Spurious Responses

of any spurious responses found in Table 5-4 and in Table 5-31  
"Performance Test Record".

Table 5-4. Additional Spurious Responses

Signal Frequency	Spurious Frequency	Spurious Amplitude	Limit
_____ MHz	_____ MHz	_____ dBc	<-55 dBc
_____ MHz	_____ MHz	_____ dBc	<-55 dBc
_____ MHz	_____ MHz	_____ dBc	<-55 dBc
_____ MHz	_____ MHz	_____ dBc	<-55 dBc
_____ MHz	_____ MHz	_____ dBc	<-55 dBc
_____ MHz	_____ MHz	_____ dBc	<-55 dBc
_____ MHz	_____ MHz	_____ dBc	<-55 dBc

## Residual SSB Phase Noise

### Specification

Electrical Characteristics	Performance Limits	Conditions
<b>SPECTRAL PURITY</b> Residual Phase Noise	< -115 dBc < -125 dBc	CW, 140 MHz Carrier (Digital and scalar phase noise is the same as CW) 1 kHz offset from carrier 10 MHz offset from carrier

### Description

The generator RF output is mixed with a local oscillator signal that is in phase quadrature to produce a video noise signal. The specified offsets are then checked using a spectrum analyzer to determine the noise level.

Correction factors are applied to each measurement for using the spectrum analyzer in the log mode, for local oscillator noise contributions and for using a bandwidth greater than 1 Hz.

### Note



This test measures the total single-sideband noise of both the generator and the local oscillator. Therefore, the local oscillator must have a single-sideband phase noise ratio that is less than or equal to the generator.

Connections

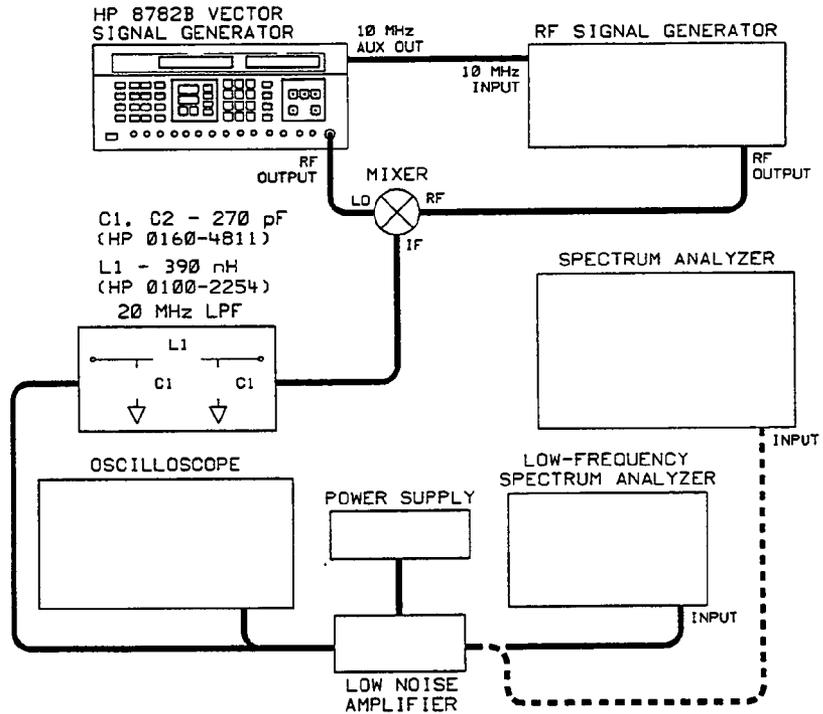


Figure 5-7. Residual SSB Phase Noise Test Setup

Equipment

Low Freq. Spectrum Analyzer.....	HP 3561A or HP 3582A
Spectrum Analyzer .....	HP 8566B
RF Signal Generator .....	HP 8662A or HP 8663A
Double Balanced Mixer .....	Watkins-Johnson M1G, Mini-Circuits ZFM-3 or equivalent
Attenuator (10 dB) .....	HP 8491A Option 010
Low Noise Amplifier .....	HP 11729-60014 or HP 08640-60506
Power Supply.....	HP 6205C
Oscilloscope .....	HP 54111A or 54111D
20 MHz Low Pass Filter .....	See Test Setup Figure 5-7.

The signal-to-phase noise ratio as measured must be corrected to compensate for 3 errors contributed by the measurement system. These are:

1. Using the spectrum analyzer in the log mode requires a +2.5 dB correction. A Fast Fourier Transform (FFT) spectrum analyzer such as the HP 3561A and HP 3582A does not require this correction.

2. Equal noise contributed by the local oscillator requires a correction of  $-3$  dB. Using the HP 8662A or HP 8663A as the RF signal generator will not require this correction. Converting the double-sideband measurement to a single-sideband measurement requires an additional  $-6$  dB correction.
3. The spectrum analyzer noise measurement must be normalized to a 1 Hz bandwidth. The noise equivalent bandwidth for Hewlett-Packard spectrum analyzers is 1.2 times the 3 dB bandwidth.

For a 10 Hz bandwidth, the correction for the normalized measurement bandwidth would be:

$$\text{Normalizing Factor (dB)} = 10 \log(1.2 \times 10 \text{ Hz}/1 \text{ Hz}) = 10.8 \text{ dB}$$

The total correction for 10 Hz bandwidth using the HP 8662A would be:

$$\text{Correction (dBc)} = 2.5 - 6 - 10.8 = -14 \text{ dB}$$

### Procedure

1. Connect the equipment as shown in Figure 5-7.
2. Set the RF signal generator to 140.010 MHz with an output level of  $-50$  dBm.
3. Set the Vector Signal Generator to 140.000 MHz at a level of  $+7$  dBm.
4. Adjust the spectrum analyzer to view the 10 kHz IF signal.
5. Move the displayed IF signal to the center of the screen and adjust the reference level until the peak of the signal is at the top of the display.
6. Adjust the reference level so the displayed signal is 6 dB below the reference level. This compensates for the 6 dB correction for a double-sideband measurement. The 2.5 dB correction for using the spectrum analyzer in the log mode is not required for the HP 3582A or HP 3561A spectrum analyzers.
7. Set the RF signal generator to 140.000 MHz and set the level to 0 dBm.
8. The top graticule of the spectrum analyzer display is now calibrated for  $-50$  dBc.
9. With the oscilloscope vertical coupling set to DC, use the Vector Signal Generator's 10 MHz Phase Adjustment special to control the relative phase between the mixer RF and LO signals. Press the following keys: **(SPECIAL)** **(1)** **(3)** **(ENTER SPCL)**(MHz) **(5)** **(DEG)**(dBm). This increments the Vector Signal Generator's phase by  $5^\circ$  relative to RF signal generator.



signal from the IF port of the mixer indicates that the RF signal generator and the Vector Signal Generator are in phase quadrature.

**Note**

---

The quadrature should be checked periodically during the test. If the oscilloscope display does not indicate 0 Vdc, quadrature has been lost and must be re-established as described above.

---

20. Set the spectrum analyzer resolution bandwidth to 100 Hz and the sweep span to 20 kHz.
21. Tune the spectrum analyzer to 10 MHz and note the displayed level. The displayed level should be more than 55 dB below the top graticule (-105 dBc).

\_\_\_\_\_ dBc Displayed level (<-105 dBc)

-20.8 dB Bandwidth Correction =  $10 \times \log(1.2 \times 100)$

\_\_\_\_\_ dBc, 10 MHz Offset (<-125 dBc)

**Pulse (Burst) Modulation**

**Specification**

Electrical Characteristics	Performance Limits	Conditions
<b>Pulse Modulation</b>		
Pulse Rates	0 to 50 MHz	
Pulse DC ON/OFF ratio	> 50 dB	70 MHz carrier

**Description**

The test is divided into a Pulse Rates test and a Pulse DC ON/OFF ratio test. Each test is described below.

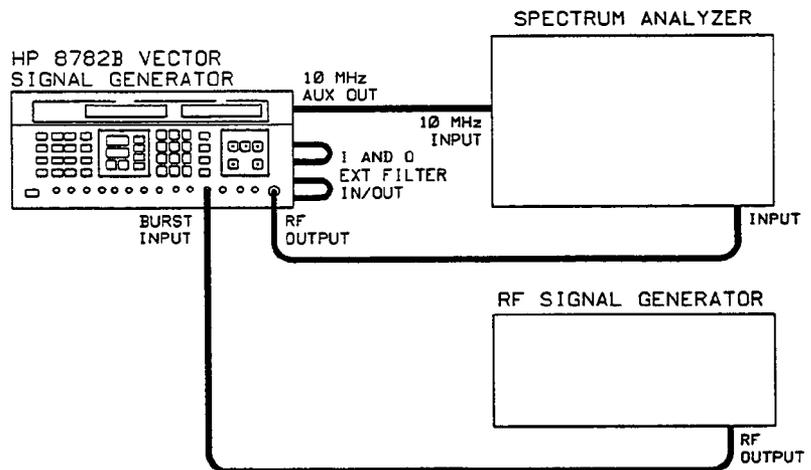
**Pulse Rates**

Pulse rates are measured by observing the RF frequency sidebands on a spectrum analyzer as the data rate to the generator's burst input is increased. The maximum rate is determined by the point where the sidebands suddenly drop in amplitude.

**Pulse (Burst) DC ON/OFF ratio**

A spectrum analyzer is used to determine the Pulse (Burst) DC ON/OFF ratio.

**Connections**



**Figure 5-8. Pulse (Burst) Modulation Test Setup**

## Pulse (Burst) Modulation

HP 8782B

## Equipment

Spectrum Analyzer ..... HP 8566B  
 RF Signal Generator ..... HP 8662A or HP 8663A or HP 8340A

## Test Equipment Settings

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
Frequency	250 MHz
RF Level	+7 dBm
External Filter	ON
Burst	ON
TIME BASE (rear panel)	EXT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	250 MHz
Reference Level	+10 dBm
Frequency Span	500 MHz
Resolution Bandwidth	1 MHz
Video Bandwidth	3 MHz
Frequency Reference	EXT
<b>RF Signal Generator</b>	PRESET
RF Level	+10 dBm
Frequency	10 MHz

## Procedure

## Pulse Rates

1. Connect the equipment as shown in Figure 5-8. Be sure to connect the two jumper cables across the Vector Signal Generator's rear panel external filter in/out connectors. Also on the rear panel, set the TIME BASE switch to EXT. It is not necessary to recalibrate at this time.
2. Select ground termination for the Vector Signal Generator's data inputs by pressing the **ECL DATA** key until the ECL DATA display annunciator is off (BURST is a DATA input rather than a CLOCK input).
3. Set the Vector Signal Generator's data threshold to +0.3 Volts by pressing the **DATA LEVEL** key and then entering the value.

## Note



Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

4. Connect an RF signal generator to the Vector Signal Generator burst input. Set the RF signal generator to 10 MHz and +10 dBm.

- Adjust the frequency of the RF signal generator from 10 MHz to greater than 50 MHz in 1 MHz steps while observing the signal on the spectrum analyzer. The frequency separation should increase smoothly and the amplitude should not drop suddenly. A failure is indicated if the sideband spacing suddenly drops in frequency or if the amplitude changes by more than 10 dB in a few MHz change in the frequency of the RF signal generator. Either change in the observed spectrum indicates that the Vector Signal Generator is not correctly producing a proper digital output from the analog input. Verify that no failures occur at or before 50 MHz pulse rate.

Pulse (Burst) rate > 50 MHz \_\_\_\_\_ (✓)

#### Pulse (Burst) ON/OFF ratio

- Press the **PRESET** key on the Vector Signal Generator, and then set the Vector Signal Generator to +7.0 dBm. This will set the Vector Signal Generator back to the internal filter path. Internal automatic calibration factors are in general different depending on which filter path is selected when the internal calibration is run.

#### Note



The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **CAL** key on the generator.

- Disconnect the RF signal generator from the BURST input.
- Set the spectrum analyzer to the following settings:

#### PRESET

Center Frequency	70 MHz
Reference Level	+10 dBm
Frequency Span	20 kHz
Resolution Bandwidth	1 kHz
Video Bandwidth	300 Hz
Frequency Reference	EXT

- Measure the generator's 70 MHz signal 'ON' amplitude by pressing **PEAK SEARCH** on the spectrum analyzer. Set the markers to make a relative power measurement by pressing the **Δ** key.
- On the generator, press the **INVERT INPUT** key, then using the **▲** and **▼** arrow keys to move through the INVERT INPUT menu until the message INV BURST:NO appears in the left display window. Press the number **0** key to invert the BURST input and put the output signal in the off state.
- Enable spectrum analyzer video averaging by pressing **SHIFT** **VIDEO BW**.

**Pulse (Burst) Modulation**

**HP 8782B**

7. After the displayed signal has settled, measure the generator's Pulse ON/OFF ratio by reading the spectrum analyzer dB marker value. ON/OFF ratio is actually the opposite sign of this value. Record the Pulse ON/OFF ratio, and verify that the value is greater than 50 dB.

Pulse ON/OFF ratio \_\_\_\_\_ > 50 dB

## Parallel Clock and Data Rates

### Specification

Electrical Characteristics	Performance Limits	Conditions
Digital Modulation Parallel Data Rates	0 to 50 MHz 0 to 100 MHz	Asynchronous Clocked Set-up time > 2.5 ns Hold time > 2.5 ns Rise time < 1 $\mu$ s

### Description

The test is divided into asynchronous data rates, single clock data rates, and dual clock data rates tests. Each test is described below.

#### Asynchronous Data Rates

Data rates are measured by observing the RF frequency sidebands on a spectrum analyzer as the data rate to the Vector Signal Generator's digital inputs is increased. The maximum rate is determined by the point where the sidebands suddenly drop in amplitude.

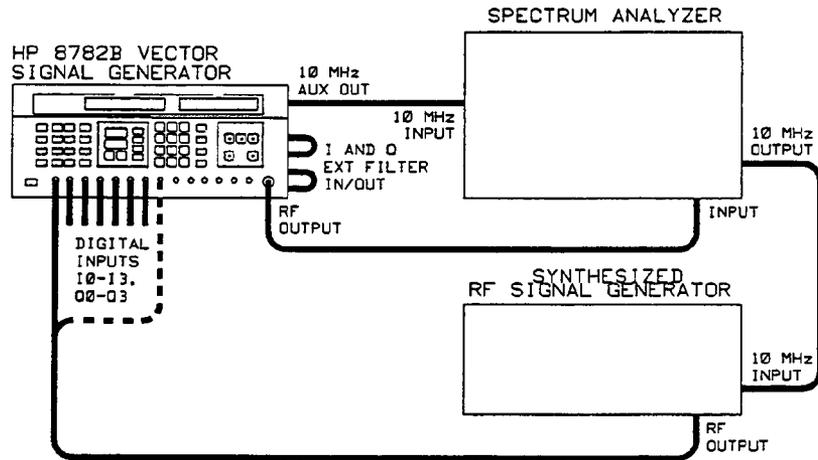
#### Single-Clock Data Rates

Clocked (synchronous) data rates are measured using the sideband spacing technique. The clock rate is set to be twice the data rate with the correct delay between the clock and data signals.

#### Dual-Clock Data Rates

This test is similar to the single clock data rates test, but the I clock and I data inputs, and Q clock and Q data inputs are measured as two separate groups.

**Connections**



**Figure 5-9. Asynchronous Data Rates Test Setup**

**Equipment**

- Spectrum Analyzer ..... HP 8566B
- Synthesized Signal Generator ..... HP 8662A or  
HP 8663A or HP 8340A
- Oscilloscope ..... HP 54111A or HP 54111D

**Test Equipment Settings**

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	0 dBm
Frequency	250 MHz
256QAM	ON
Modulation	ON
External Filter	ON
TIME BASE (rear Panel)	EXT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	250 MHz
Reference Level	+10 dBm
Frequency Span	500 MHz
Resolution Bandwidth	100 kHz
Video Bandwidth	1 kHz
Frequency Reference	EXT
<b>RF Signal Generator</b>	PRESET
RF Level	+10 dBm
CW Frequency	10 MHz
Frequency Reference	EXT
<b>Oscilloscope</b>	AUTOSCALE
Input Impedance	50Ω

## Procedure

### Asynchronous Data Rates

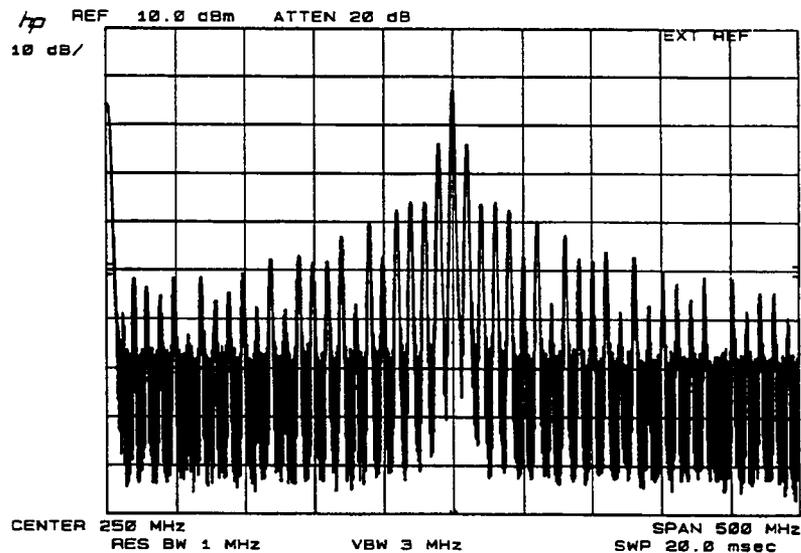
1. Connect the equipment as shown in Figure 5-9. Set the settings as shown in the table above. Be sure to connect the two jumper cables across the Vector Signal Generator's rear panel external filter in/out connectors. Set the rear panel TIME BASE switch to INT. There is no need to recalibrate at this time.
2. Select ground termination for the Vector Signal Generator's data inputs by pressing the **ECL DATA** key until the ECL DATA display annunciator is off.
3. Set the Vector Signal Generator's data threshold to +0.3 Volts by pressing the **DATA LEVEL** key and then entering the value.

### Note



Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

4. Connect an RF signal generator to the Vector Signal Generator's I/O input. Set the RF signal generator to 10 MHz and +10 dBm. The spectrum analyzer display should look like Figure 5-10.



**Figure 5-10. Good 10 MHz Asynchronous Data Rate**

5. The amplitude of the two innermost sidebands displayed on the spectrum analyzer should remain constant while you adjust the frequency of the RF signal generator in 1 MHz steps to 50 MHz. The frequency separation should increase smoothly. A failure is indicated if the sideband spacing suddenly drops in frequency or if the amplitude changes by more than 10 dB in a few MHz change

in the frequency of the RF signal generator. Either change in the observed spectrum indicates that the Vector Signal Generator is not correctly producing a proper digital output from the analog input. Verify that no failures occur at or before 50 MHz asynchronous data rate. See Figure 5-11.

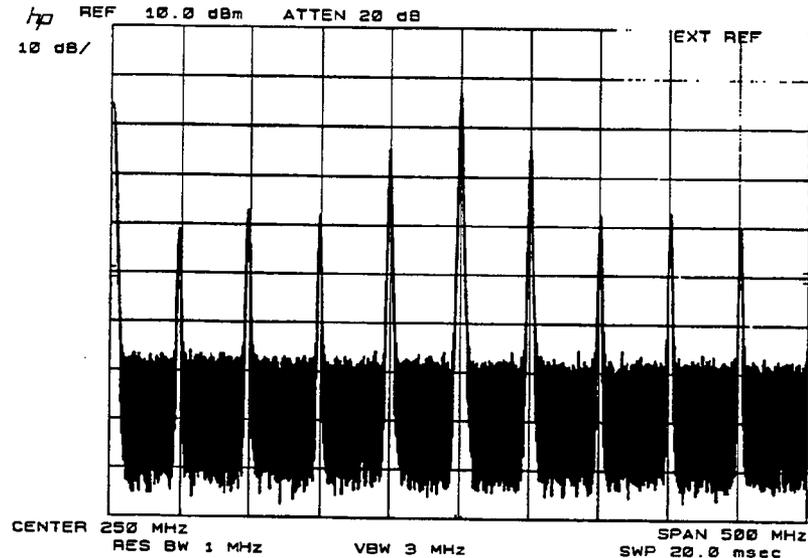


Figure 5-11. Good 50 MHz Asynchronous Data Rate

- Connect the RF signal generator to each of the remaining digital inputs I1 to I3 and Q0 to Q3 in turn, and repeat the test for each input. Record the results below and in Table 5-31 "Performance Test Record".

Asynchronous Data Rate I0 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate I1 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate I2 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate I3 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate Q0 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate Q1 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate Q2 > 50 MHz \_\_\_\_\_ (✓)

Asynchronous Data Rate Q3 > 50 MHz \_\_\_\_\_ (✓)

HP 8782B

Parallel Clock and Data Rates

Connections

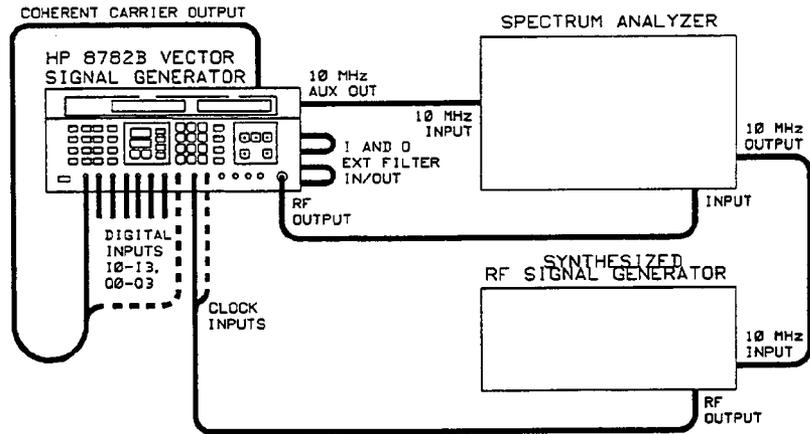


Figure 5-12. Parallel Clock Data Rate Test Setup

Equipment

- Spectrum Analyzer ..... HP 8566B
- Synthesized Signal Generator ..... HP 8662A or  
HP 8663A or HP 8340A
- Oscilloscope ..... HP 54111A or HP 54111D

Test Equipment Settings

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	<b>PRESET</b>
RF Level	+7 dBm
Frequency	10 MHz
256QAM	ON
Modulation	ON
External Filter	ON
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	<b>PRESET</b>
Center Frequency	50 MHz
Reference Level	+10 dBm
Frequency Span	100 MHz
Resolution Bandwidth	300 kHz
Video Bandwidth	3 MHz
Frequency Reference	EXT
<b>RF Signal Generator</b>	<b>PRESET</b>
RF Level	+10 dBm
CW Frequency	20 MHz
Frequency Reference	EXT
<b>Oscilloscope</b>	<b>AUTOSCALE</b>
Input Impedance	50Ω

## Procedure

### Single Clock Data Rate

1. Set the Vector Signal Generator to 10 MHz and +7.0 dBm.
2. Connect a cable from the Vector Signal Generator's rear panel coherent carrier as shown in Figure 5-12.

### Note



In order to test the clocked modes, two RF signals are required (one for data, and a second at twice the data frequency for a clock). This test is written to minimize required test equipment, so the coherent carrier signal from the Vector Signal Generator is used as the data signal. This requires changing the Vector Signal Generator's frequency, and hence the center frequency of the spectrum analyzer as the data and clock rate is increased. If a second synthesized signal generator is available, then this can be used as the data signal, and the vector signal generator and spectrum analyzer can be left at 250 MHz.

3. Connect the rear panel 10 MHz auxiliary output of the vector signal generator to the external 10 MHz input of the spectrum analyzer. Connect the 10 MHz output of the spectrum analyzer to the 10 MHz input of the RF signal generator. Select external 10 MHz reference for both the spectrum analyzer and RF signal generator. This arrangement puts all three instruments on a common time base. See Figure 5-12.
4. Set the RF signal generator to 20 MHz and +10 dBm. Connect a cable which will reach from the RF signal generator to the vector signal generator's front panel clock inputs.
5. 50 $\Omega$  terminations are required on Channel 1 and 2 of the oscilloscope. If necessary, use a 'Tee' and a 50 $\Omega$  load.
6. Connect the coherent carrier signal (using the cable selected) to channel 1 of the oscilloscope. Connect the RF signal generator output (using the cable selected) to channel 2 of the oscilloscope. Press **AUTOSCALE** on the oscilloscope to display the two sine waves and trigger on channel 1.
7. Verify that there is at least a 2.5 ns delay between the rising-edge zero volt crossings of the two sine waves. Use the Vector Signal Generator's 10 MHz Phase Adjustment special to control the relative phase between the data and clock signals. Press the following keys: **SPECIAL** **13** **ENTER SPCL**(MHz) **5** **DEG**(dBm). This increments the Vector Signal Generator's phase by 5° relative to RF signal generator.

### Note



Each time a number is entered, the phase is incremented by that value, so the **▲** and **▼** keys may give confusing results. For example, to adjust the phase in -10° steps, press **-10 DEG**, and so on.

8. Select ground termination for the Vector Signal Generator's data inputs by pressing the **ECL DATA** key until the ECL DATA display annunciator is off.
9. Set the Vector Signal Generator's data threshold to 0.3 Volts by pressing the **DATA LEVEL** key and then entering the value.

**Note**

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Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

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10. Select I clock by pressing the **EXT CLK** key until the display annunciator indicates I.
11. Select ground termination for the Vector Signal Generator's clock inputs by pressing the **ECL CLK** key until the ECL CLK display annunciator is off.
12. Set the Vector Signal Generator's clock threshold to 0.3 Volts by pressing the **CLOCK LEVEL** key and then entering the value.

**Note**

---

Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

---

13. Set the spectrum analyzer to the following settings:

Center Frequency	50 MHz
Frequency Span	100 MHz
14. Connect the RF signal generator to the Vector Signal Generator's I Clock input. Connect the coherent carrier signal to the I0 data input.

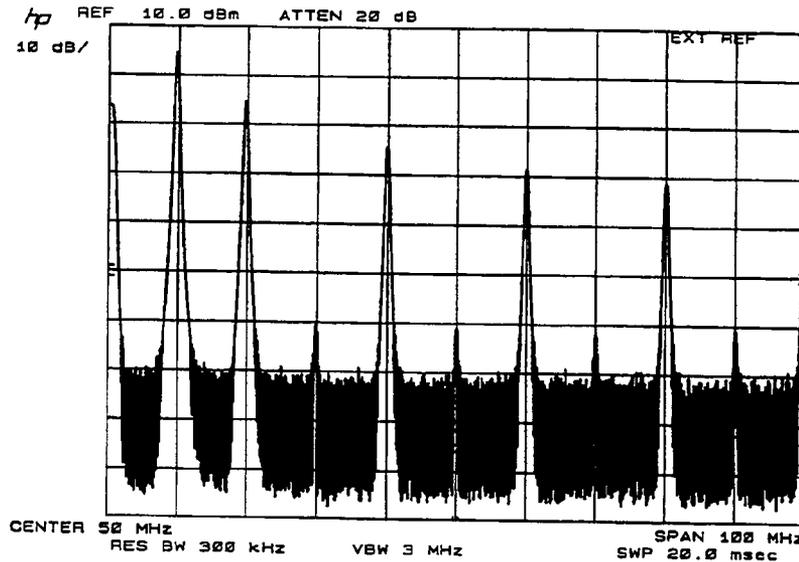


Figure 5-13. Good 10 MHz Single Clock Data Rate

15. Adjust the frequency of the RF signal generator from 20 MHz to greater than 200 MHz in 4 MHz steps, and adjust the Vector Signal Generator's frequency from 10 MHz to greater than 100 MHz in 2 MHz steps (maintain a two-to-one frequency ratio). Observe the signal on the spectrum analyzer. Change the spectrum analyzer center frequency and span as required to display the sidebands. The sideband frequency separation should increase smoothly and the amplitude of the sideband at the frequency equal to twice the Vector Signal Generator frequency should not drop suddenly. The lower sidebands will be aliased because of the low carrier frequency of the Vector Signal Generator (This problem is reduced by using two separate signal generators).

**Note**



In order to allow enough set-up time for the data, the clock signal must be delayed by at least 2.5 ns. Since the delay time changes when the frequency setting is changed, there will be places where the signal drops out or displays a noisy spectrum. This is normal and should not be taken as a failure. Re-check the delay using the oscilloscope and make delay adjustments as required. (See step 13.)

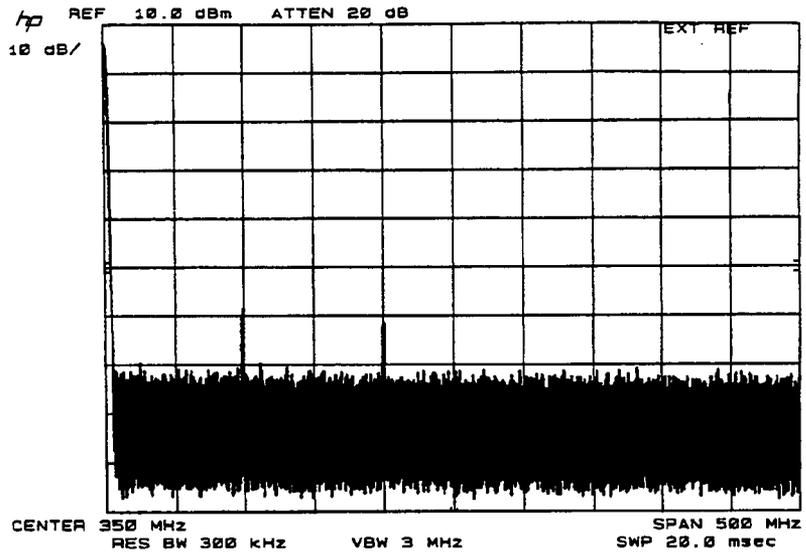


Figure 5-14. Failed Clock Rate Signal

A failure (see Figure 5-14) is indicated if the sideband spacing suddenly drops in frequency or if the amplitude changes by more than 10 dB in a few MHz change in the frequency of the RF signal generator. Either change in the observed spectrum indicates that the Vector Signal Generator is not correctly producing a proper digital output from the analog input. Verify that no failures occur at or before 100 MHz Single-Clock Data Rate.

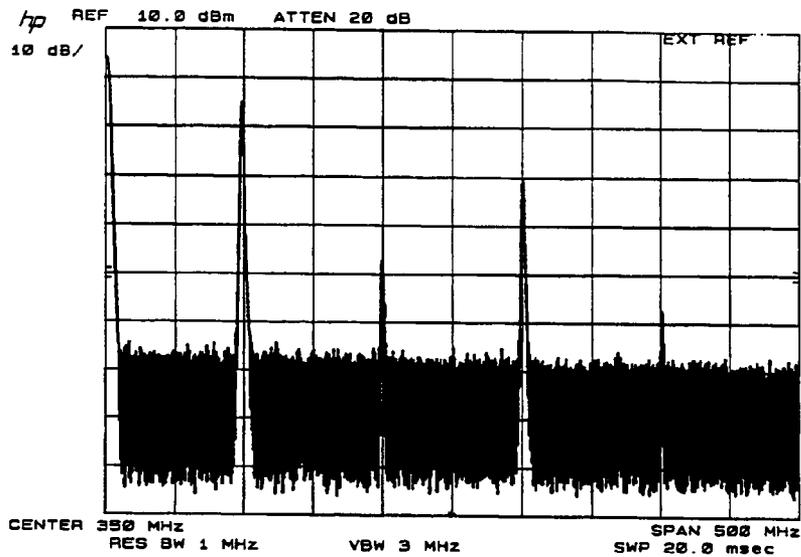


Figure 5-15. Good 100 MHz Single Clock Data Rate

16. Connect the coherent carrier signal to each of the remaining digital inputs I1 to I3 and Q0 to Q3 in turn, and repeat step 21 for each input. Record the results below and in Table 5-31 "Performance Test Record".

Single-Clock Data Rate I0 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate I1 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate I2 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate I3 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate Q0 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate Q1 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate Q2 > 100 MHz \_\_\_\_\_ (✓)

Single-Clock Data Rate Q3 > 100 MHz \_\_\_\_\_ (✓)

#### Dual-Clock Data Rate

17. The performance test setup for Dual Clock Data Rate is the same as Single Clock Data Rate. See Figure 5-12.
18. Set the RF signal generator to 20 MHz and +10 dBm.
19. Select I and Q clocks by pressing the **EXT CLK** key until the display annunciator indicates I&Q.
20. Set the spectrum analyzer to the following settings:
- |                  |         |
|------------------|---------|
| Center Frequency | 50 MHz  |
| Frequency Span   | 100 MHz |
21. Connect the RF signal generator to the Vector Signal Generator's I clock input. Connect the coherent carrier signal to the I0 data input.

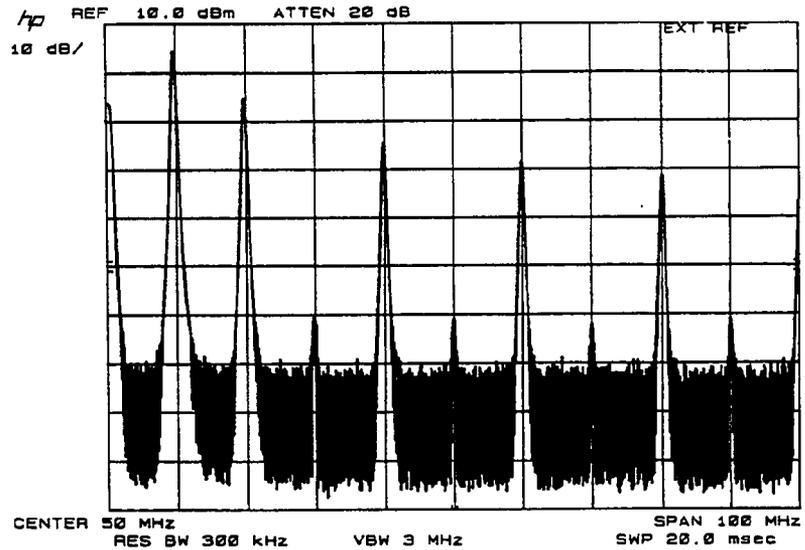


Figure 5-16. Good 10 MHz Dual Clock Data Rate

22. Adjust the frequency of the RF signal generator from 20 MHz to greater than 200 MHz in 4 MHz steps, and adjust the Vector Signal Generator's frequency from 10 MHz to greater than 100 MHz in 2 MHz steps (maintain a two-to-one frequency ratio). Observe the signal on the spectrum analyzer. Change the spectrum analyzer center frequency and span as required to display the sidebands. The sideband frequency separation should increase smoothly and the amplitude should not drop suddenly. The lower sidebands will be aliased because of the low carrier frequency of the Vector Signal Generator (This problem is reduced by using two separate signal generators).

**Note**



In order to allow enough set-up time for the data, the clock signal must be delayed by at least 2.5 ns. Since the delay time changes when the frequency setting is changed, there will be places where the signal drops out or displays a noisy spectrum. This is normal and should not be taken as a failure. Re-check the delay using the oscilloscope and make delay adjustments as required. (See step 13.)

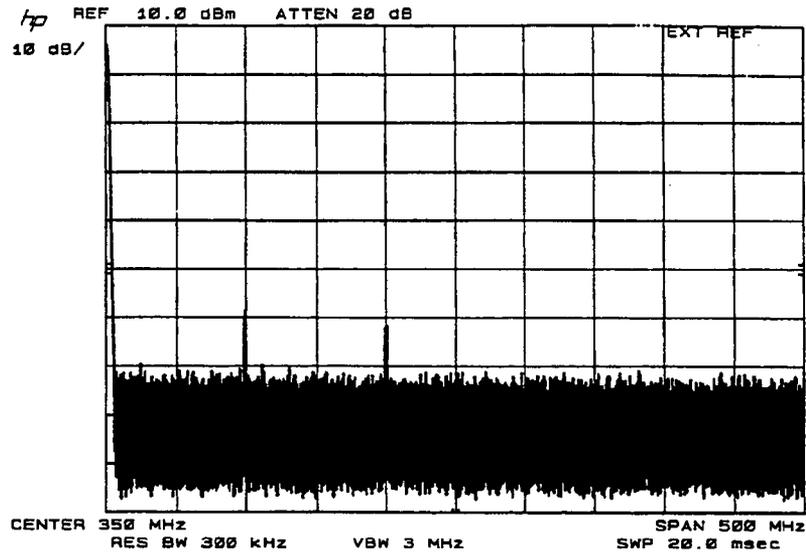


Figure 5-17. Failed Dual Clock Data Rate

A failure is indicated if the sideband spacing suddenly drops in frequency or if the amplitude changes by more than 10 dB in a few MHz change in the frequency of the RF signal generator. Either change in the observed spectrum indicates that the Vector Signal Generator is not correctly producing a proper digital output from the analog input. Verify that no failures occur at or before 100 MHz Dual-Clock Data Rate.

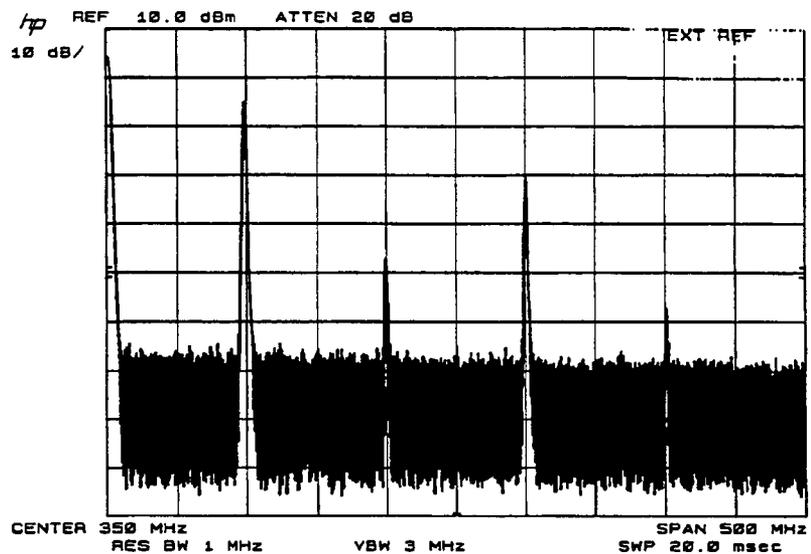


Figure 5-18. Good 100 MHz Single Clock Data Rate

23. Connect the coherent carrier signal to each of the remaining I digital inputs I1 to I3 in turn, and repeat step 28 for each input. Record the results below and in Table 5-31 "Performance Test Record".
- Dual-Clock Data Rate I0 > 100 MHz \_\_\_\_\_ (✓)  
Dual-Clock Data Rate I1 > 100 MHz \_\_\_\_\_ (✓)  
Dual-Clock Data Rate I2 > 100 MHz \_\_\_\_\_ (✓)  
Dual-Clock Data Rate I3 > 100 MHz \_\_\_\_\_ (✓)
24. Set the Vector Signal Generator to 10 MHz and the RF signal generator to 20 MHz. Use the oscilloscope to verify that the delay is correct.
25. Set the spectrum analyzer to the following settings:
- |                  |         |
|------------------|---------|
| Center Frequency | 50 MHz  |
| Frequency Span   | 100 MHz |
26. Connect the RF signal generator to the Vector Signal Generator's Q Clock input.
27. Connect the coherent carrier signal to the Q0 through Q3 in turn. Repeat step 28 for Q clock. Record the results below and in Table 5-31.
- Dual-Clock Data Rate Q0 > 100 MHz \_\_\_\_\_ (✓)  
Dual-Clock Data Rate Q1 > 100 MHz \_\_\_\_\_ (✓)  
Dual-Clock Data Rate Q2 > 100 MHz \_\_\_\_\_ (✓)  
Dual-Clock Data Rate Q3 > 100 MHz \_\_\_\_\_ (✓)

**Serial Clock and Data Rates**

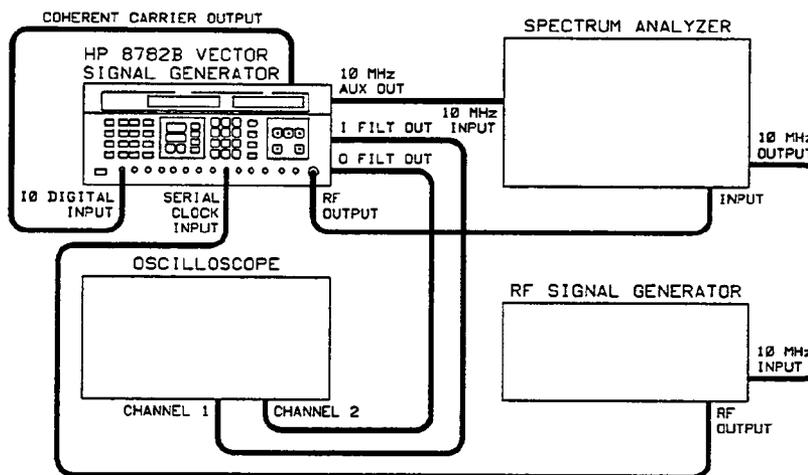
**Specification**

Electrical Characteristics	Performance Limits	Conditions
<b>DIGITAL MODULATION</b>  Serial Clock and Data Rates	0 to 200 MHz	Set-up time > 2.5 ns Hold time > 2.5 ns Rise time < 1 $\mu$ s

**Description**

Serial data rates are measured by observing the RF frequency sidebands on a spectrum analyzer as the data rate to the Vector Signal Generator's digital inputs is increased. The maximum rate is determined by the point where it is no longer possible to obtain a clean, noise-free signal. The correct data sequence is verified by observing the external filter output signals on an oscilloscope.

**Connections**



**Figure 5-19. Serial Clock and Data Rates Test Setup**

**Equipment**

- Spectrum Analyzer ..... HP 8566B
- Synthesized Signal Generator ..... HP 8662A or  
HP 8663A or HP 8340A
- Oscilloscope ..... HP 54111A or HP 54111D

HP 8782B

Serial Clock and Data Rates

## Test Equipment Settings

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	0 dBm
Frequency	40 MHz
256QAM	ON
Modulation	ON
Serial Input	ON
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	40 MHz
Reference Level	10 dBm
Frequency Span	50 MHz
Resolution Bandwidth	100 kHz
Video Bandwidth	300 kHz
Frequency Reference	EXT
<b>RF Signal Generator</b>	PRESET
RF Level	+10 dBm
CW Frequency	45 MHz
<b>Oscilloscope</b>	AUTOSCALE
Input Impedance	50Ω

## Procedure

1. Connect the equipment as shown in Figure 5-19.
2. Set the equipment settings according to the table above.
3. Select ground termination for the Vector Signal Generator's data inputs by pressing the **ECL DATA** key until the ECL DATA display annunciator is off.
4. Set the Vector Signal Generator's data threshold to +0.3 Volts by pressing the **DATA LEVEL** key and then entering the value.

## Note



Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

5. Select serial input mode by pressing the **SERIAL INPUT** key until the serial input display annunciator is on.
6. Select ground termination for the Vector Signal Generator's clock inputs by pressing the **ECL CLK** key until the ECL CLK display annunciator is off.
7. Set the Vector Signal Generator's clock threshold to +0.3 Volts by pressing the **CLOCK LEVEL** key and then entering the value.

**Note**

Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

8. Connect the Vector Signal Generator's rear panel coherent carrier output to the front panel I0 digital input.

**Note**

In order to test the serial mode, two RF signals are required (one for data, and a second at 1.125 times the data frequency for a clock). This test is written to minimize required test equipment, so the coherent carrier signal from the Vector Signal Generator is used as the data signal. This requires changing the Vector Signal Generator's frequency, and hence the center frequency of the spectrum analyzer as the data and clock rate is increased. If a second synthesized signal generator is available, then this can be used as the data signal, and the vector signal generator and spectrum analyzer center frequency should be set to 250 MHz.

9. Connect the rear panel 10 MHz auxiliary output of the vector signal generator to the external 10 MHz input of the spectrum analyzer. Connect the 10 MHz output of the spectrum analyzer to the 10 MHz input of the RF signal generator. Select external 10 MHz reference for both the spectrum analyzer and RF signal generator. This arrangement puts all three instruments on a common time base.
10. Set the RF signal generator to 45 MHz and +10 dBm. Connect the RF signal generator to the Vector Signal Generator's front panel serial (I) clock input.

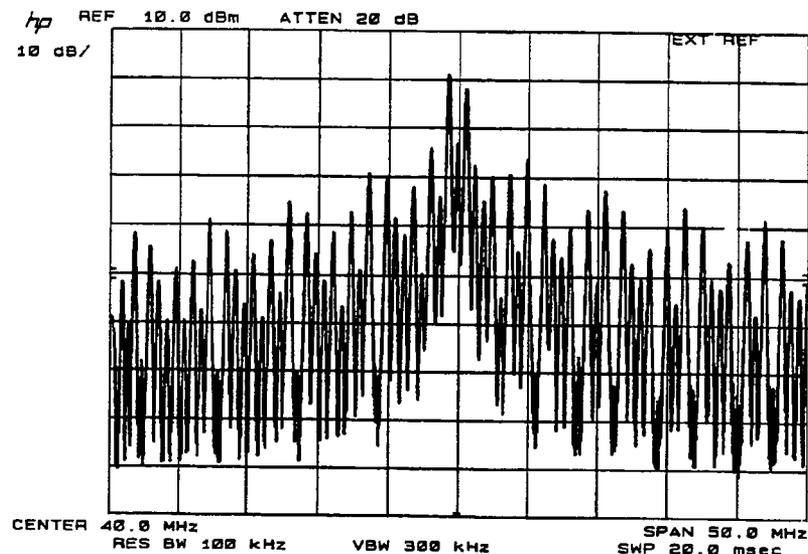


Figure 5-20. Example of a good 40 MHz serial test spectrum

11. The display on the spectrum analyzer should appear like Figure 5-20.
12. Set the RF signal generator frequency controls to increase in 9 MHz steps. Press the Vector Signal Generator **SET INCR** and set the Frequency increments to 8 MHz.
13. While watching the spectrum analyzer display, adjust the frequency of the RF signal generator upwards to 54 MHz in one 9 MHz step. At the same time, increase the Vector Signal Generator to 48 MHz in one 8 MHz step.
14. The spectrum should look similar to Figure 5-21 below. The noise floor is low, and the sidebands are very prominent.

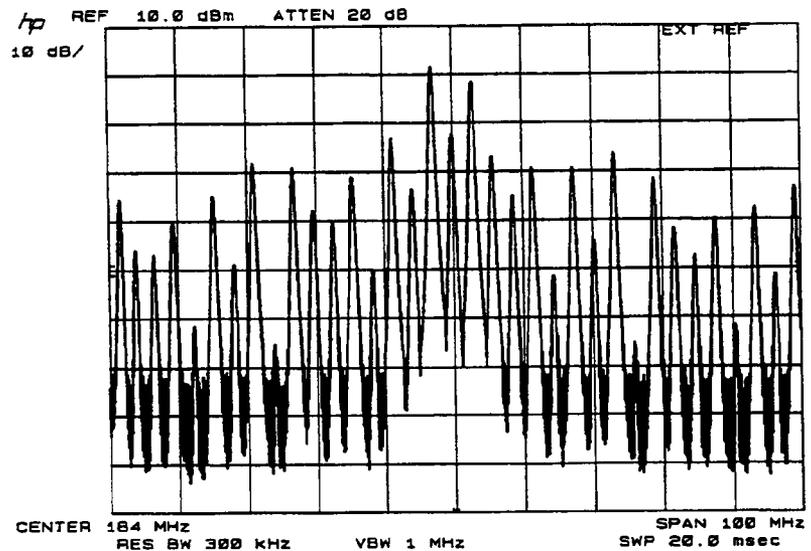


Figure 5-21. Example of a good serial test spectrum

15. Sometimes when the frequencies of the clock and data signals are changed, the phase relationship is such that a noisy signal is produced. This may look like Figure 5-22 below. Before this is determined to be a failure, the phase must be adjusted over a range to see if a clean spectrum can be produced. Use the Vector Signal Generator's 10 MHz Phase Adjustment special to control the relative phase between the data and clock signals. Press the following keys: **SPECIAL** **13** **ENTER SPCL** (MHz) **5** **DEG** (dBm). This increments the Vector Signal Generator's phase by 5° relative to RF signal generator.

**Note**

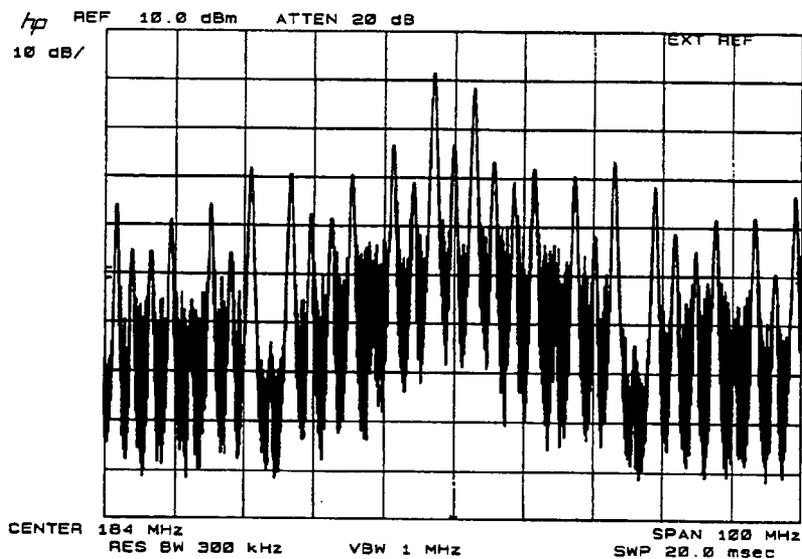


Each time a number is entered, the phase is incremented by that value, so the **▲** and **▼** keys may give confusing results. For example, to adjust the phase in -10° steps, press **-10 DEG**, **-10 DEG**, and so on.

If the spectrum is now clean, then the serial mode is verified at this frequency. If the spectrum is still noisy, then increment the phase again by pressing **5** **DEG**, **5** **DEG** ... up to 18 times (90°) until a clean spectrum is obtained.

**Note**

A failure is indicated if it is not possible to obtain a noise-free spectrum after changing the relative phase of the clock and data signals by at least 90°. A failure is also indicated if the sidebands disappear completely (some residual clock leakage may still appear). Either change in the observed spectrum indicates that the Vector Signal Generator is not correctly producing a proper digital output from the analog input.



**Figure 5-22. Example of a bad serial test spectrum**

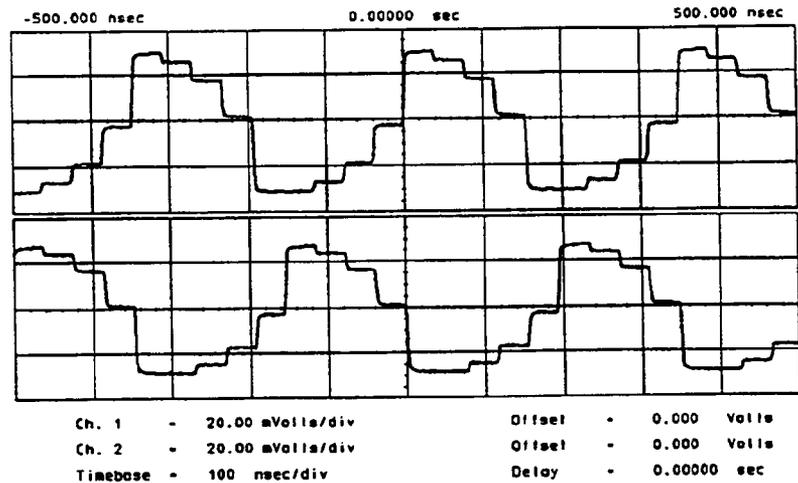
16. If the spectrum is now clean, then the serial mode is verified at this frequency. Verify the next frequency step (RF Generator at 63 MHz and Vector Signal Generator at 56 MHz).
17. Maintaining a nine-to-eight RF generator-to-Vector Signal Generator frequency ratio, verify at each frequency step until the RF Generator frequency is greater than 200 MHz and the Vector Signal Generator frequency is greater than 178 MHz.

You will need to change the spectrum analyzer center frequency and span as required to display the sidebands. Also note the resolution bandwidth and video bandwidth settings in Figure 5-21. The lower sidebands will be aliased because of the low carrier frequency of the Vector Signal Generator (This problem is reduced by using two separate signal generators).

HP 8782B

## Serial Clock and Data Rates

18. Verify that the oscilloscope input impedance is  $50\Omega$ . If necessary, place a "Tee" with a  $50\Omega$  load on channel 1 and channel 2 of the oscilloscope.
19. Verify that the spectrum is still clean. Adjust the phase using special 13 if needed, then connect the Vector Signal Generator's rear panel external filter I and Q outputs to channel 1 and channel 2 of the oscilloscope. Select external filters on the Vector Signal Generator by pressing the **EXT FILT** key until the EXT FILT display annunciator is on. (The spectrum sidebands will disappear.) Press **AUTOSCALE** on the oscilloscope to display the two waveforms and trigger on channel 1.
20. Observe the I and Q signals on the oscilloscope. The signals should look close to Figure 5-23 shown below. A failure is indicated by extra or misplaced steps. Press the **EXT FILT** key again to return to internal filters and restore the modulated RF output.



**Figure 5-23. Example of a good serial test oscilloscope trace**

21. Verify that no failures occur at or before 200 MHz Serial clock and data rate. Record the results below and in Table 5-31 "Performance Test Record".

Serial Clock and Data Rate > 200 MHz \_\_\_\_\_ (✓)

**Scalar DC Residual**

**Specification**

Electrical Characteristics	Performance Limits	Conditions
Scalar Modulation DC Residual Carrier	< 1% of Full Scale	70 MHz carrier

**Description**

Scalar DC residual carrier is the carrier signal present at the generator's RF output when in scalar modulation mode with a scalar input of 0 volts. A spectrum analyzer is used to determine the residual carrier.

**Connections**

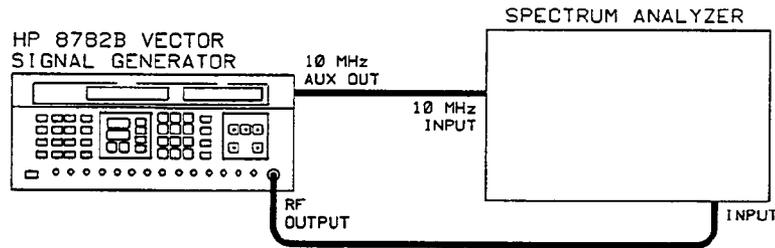


Figure 5-24. DC Residual Test Setup

**Equipment**

Spectrum Analyzer ..... HP 8566B

**Test Equipment Settings**

Item	Setting
HP 8782B Vector Signal Generator	PRESET
RF Level	+7 dBm
TIME BASE (rear panel)	INT
Spectrum Analyzer	PRESET
Center Frequency	70 MHz
Reference Level	+10 dBm
Frequency Span	20 kHz
Resolution Bandwidth	1 kHz
Video Bandwidth	300 Hz
Frequency Reference	EXT

**Procedure**

1. Connect the generator RF output to the spectrum analyzer as shown in Figure 5-24.
2. Set the test equipment settings according to the table above.

**Note**

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The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **CAL** key on the generator.

---

3. Set the markers to make a relative power measurement by pressing **PEAK SEARCH** and then **Δ**.
4. Verify that the scalar input on the generator front panel is not connected to any external sources. Turn on scalar modulation by pressing the **SCALAR ON** key on the generator front panel.
5. Read the dBc value of the residual signal. -40 dBc corresponds to 1% of full scale. Record the result below and in Table 5-31 "Performance Test Record".

DC Residual \_\_\_\_\_ < -40 dBc (1 % of Full Scale)

## Scalar Frequency Response

### Specification

Electrical Characteristics	Performance Limits	Conditions
<b>Modulation</b>		
Frequency Response	0 to 50 kHz	less than 3 dB down. 70 MHz Carrier

### Description

frequency response is measured by applying a low frequency signal to the Vector Signal Generator front panel scalar input, and then observing the modulation sidebands on the RF signal as the scalar modulation signal frequency is increased to 50 kHz.

### Caution



The function generator can exceed the the 0 to +1 Volt limit for the Vector Signal Generator scalar input. Do not connect the function generator until after correctly setting the power levels as described in the test equipment settings table.

### Connections

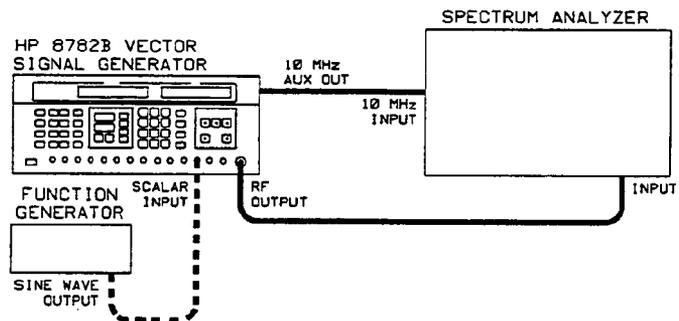


Figure 5-25. Frequency Response Test Setup

### Equipment

Spectrum Analyzer ..... HP 8566B  
Pulse/Function Generator ..... HP 8116A

### Test Equipment Settings

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	+7 dBm
	ON
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	70 MHz
Reference Level	+10 dBm
Frequency Span	120 kHz
Resolution Bandwidth	1 kHz
Video Bandwidth	3 kHz
Frequency Reference	EXT
<b>Function Generator</b>	
Waveform	Sine Wave
Amplitude (into 50 $\Omega$ load)	0.2 V
Offset (into 50 $\Omega$ load)	0.25 V
Frequency	5 kHz

**Procedure**

1. Connect the Vector Signal Generator RF output to the spectrum analyzer as shown in Figure 5-25. Do not connect the function generator until the correct voltage settings are made.

**Note**

The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **(CAL)** key on the generator.

2. Set the test equipment settings according to the table above.

**Note**

The scalar input is high impedance (10 K $\Omega$ ), and the function generator display assumes a 50 $\Omega$  load. As a result, actual function generator output voltages will be *double* the displayed value. Be careful not to exceed the 0 to +1 Volt range for the scalar input.

3. Connect the function generator output to the Vector Signal Generator front panel scalar input. Turn on scalar modulation by pressing the **(SCALAR ON)** key on the Vector Signal Generator front panel.
4. Observe the modulation sidebands on the spectrum analyzer. Turn the markers ON (normal), and set the marker to the peak of one of the 5 kHz sidebands. Make this power level the reference for a delta measurement by pressing the **( $\Delta$ )** key.

## Scalar Frequency Response

HP 8782B

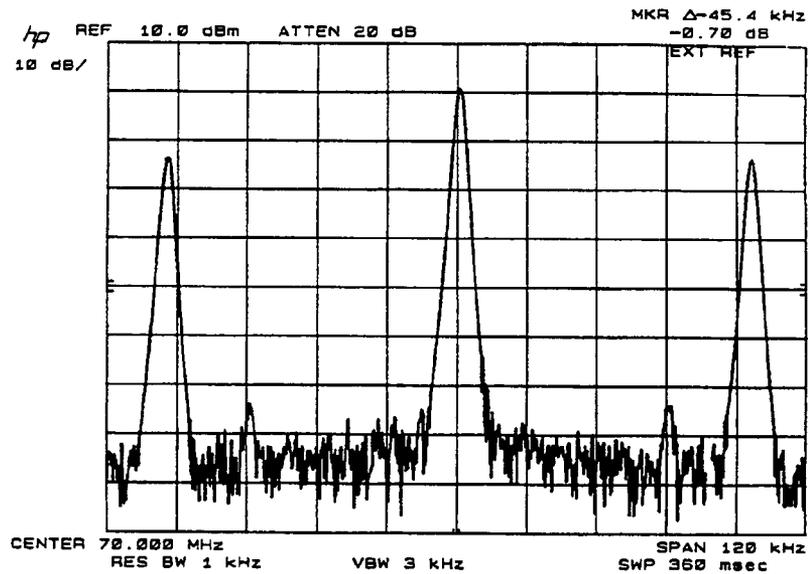


Figure 5-26. Good Frequency Response Signal

- Increase the function generator frequency to 50 kHz. Move the spectrum analyzer marker frequency to measure the same sideband (upper or lower) at the new, higher frequency. Note the dB value of the the relative sideband power. This is the scalar frequency response at 50 kHz. Verify that this value is greater than  $-3$  dB ( $-0.7$  dB is better than  $-3$  dB). Record the result below and in Table 5-31 "Performance Test Record".

frequency response at 50 kHz \_\_\_\_\_  $>$   $-3$  dB

**PRBS Clock Rates**

**Specification**

Electrical Characteristics	Performance Limits	Conditions
<b>PRBS</b>		
Internal clock rates	1.125 MHz, 2.5 MHz 5.0 MHz, 10 MHz	
External clock rates	> 100 MHz	rise time < 1 $\mu$ s

**Description**

The Vector Signal Generator contains a Pseudo-Random Binary Sequence (PRBS) generator. The PRBS can be clocked internally or externally. This test is divided into internal clock and external clock tests. Each test is described below.

**Internal clock rates**

The Vector Signal Generator's 10 MHz reference serves as a time base for the internal PRBS clock. The various clock frequencies are verified by observing the Vector Signal Generator's modulated RF output using a spectrum analyzer.

**External clock rates**

External clock rates are measured by observing the Vector Signal Generator's modulated RF output signal on a spectrum analyzer as the clock rate to the Vector Signal Generator's ext PRBS input is increased. The maximum clock rate is determined by the point where the carrier null suddenly increases.

**Connections**

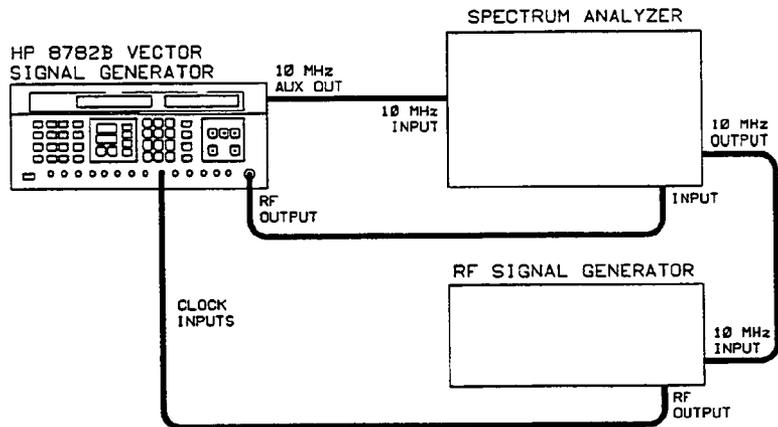


Figure 5-27. PRBS Clock Rates Test Setup

## PRBS Clock Rates

HP 8782B

## Equipment

Spectrum Analyzer ..... HP 8566B  
 RF Signal Generator ..... HP 8662A or HP 8663A

## Test Equipment Settings

Item	Setting
<b>HP 8782B Vector Signal Generator</b>	PRESET
RF Level	+7 dBm
Modulation	ON
PRBS	ON
TIME BASE (rear panel)	INT
<b>Spectrum Analyzer</b>	PRESET
Center Frequency	70 MHz
Reference Level	+10 dBm
Frequency Span	20 MHz
Resolution Bandwidth	10 kHz
Video Bandwidth	1 kHz
Marker	ON (Normal)
Frequency Reference	EXT
<b>RF Signal Generator</b>	PRESET
CW Frequency	10 MHz
RF Level	+10 dBm

## Procedure

## Internal PRBS Clock Rates

1. Connect the equipment as shown in Figure 5-27.
2. Set the test equipment settings according to the table above.
3. Enable the internal PRBS modulation by pressing the vector signal generator's **MODULATION ON** and **PRBS ON** keys.
4. Observe the characteristic pattern on the spectrum analyzer. There should be a center lobe which drops to a null on each side, and then side lobes farther in frequency away from the center. Use the spectrum analyzer delta-markers to measure the frequency difference of the nulls on each side of the center lobe. Verify that the nulls are 10 MHz  $\pm$ 1 MHz apart.

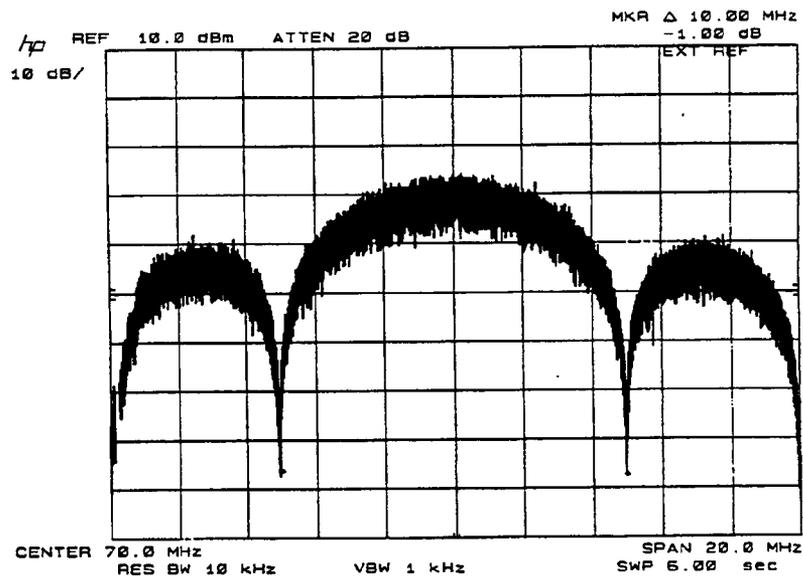


Figure 5-28. Good 10 MHz PRBS Clock Frequency Example

QPSK, 10 MHz PRBS clock frequency.

Nulls 10 MHz  $\pm$ 1 MHz apart \_\_\_\_\_ (✓)

5. Change the PRBS rate by pressing **SPECIAL** **3** **ENTER SPCL (MHz)**, and then using the **▲** and **▼** arrow keys to change the internal PRBS clock frequency to 5.0 MHz.
6. Change the spectrum analyzer frequency span to 10 MHz. Again, measure the frequency difference of the nulls on each side of the center lobe. Verify that the nulls are 5 MHz  $\pm$ 0.5 MHz apart.

QPSK, 5 MHz PRBS clock frequency.

Nulls 5 MHz  $\pm$ 0.5 MHz apart \_\_\_\_\_ (✓)

7. Repeat steps 5 through 7 for the other two internal clock frequencies. Change the spectrum analyzer frequency span to twice the internal PRBS clock frequency for each measurement.

QPSK, 2.5 MHz PRBS clock frequency.

Nulls 2.5 MHz  $\pm$ 0.25 MHz apart \_\_\_\_\_ (✓)

QPSK, 1.25 MHz PRBS clock frequency.

Nulls 1.25 MHz  $\pm$ 0.125 MHz apart \_\_\_\_\_ (✓)

8. Set the internal PRBS clock frequency to 10 MHz. Set the spectrum analyzer frequency span to 10 MHz.
9. Select 16QAM modulation format by pressing the **MODULATION** key until the display annunciator indicates 16QAM.

**Note**



The Vector Signal Generator is not capable of producing a true PRBS signal for 8PSK modulation. When PRBS and 8PSK modulation are selected together, the generator creates a low

frequency sequence which is intended primarily for calibrating the HP 8981A Vector Demodulator.

---

10. Measure the frequency difference of the nulls on each side of the center lobe. Verify that the nulls are 5 MHz  $\pm$ 0.5 MHz apart.

16QAM, 10 MHz PRBS clock frequency.  
Nulls 5 MHz  $\pm$ 0.5 MHz apart \_\_\_\_\_ (✓)

11. Select 64QAM modulation format by pressing the **MODULATION** key until the display annunciator indicates 64QAM.

12. Set the spectrum analyzer frequency span to 5 MHz. Measure the frequency difference of the nulls on each side of the center lobe. Verify that the nulls are 3.33 MHz  $\pm$ 0.3 MHz apart.

64QAM, 10 MHz PRBS clock frequency.  
Nulls 3.33 MHz  $\pm$ 0.3 MHz apart \_\_\_\_\_ (✓)

13. Select 256QAM modulation format by pressing the **MODULATION** key until the display annunciator indicates 256QAM.

14. Measure the frequency difference of the nulls on each side of the center lobe. Verify that the nulls are 2.5 MHz  $\pm$ 0.25 MHz apart.

256QAM, 10 MHz PRBS clock frequency.  
Nulls 2.5 MHz  $\pm$ 0.25 MHz apart \_\_\_\_\_ (✓)

#### External PRBS Clock Rates

- The Vector Signal Generator should still have 256QAM modulation enabled. Select ground termination for the Vector Signal Generator's clock inputs by pressing the **ECL CLK** key until the ECL CLK display annunciator is off.
- Set the Vector Signal Generator's clock threshold to +0.3 Volts by pressing the **CLOCK LEVEL** key and then entering the value.

#### Note



Variable threshold only functions when ground termination is selected. When ECL (-2 Volt) termination is selected, the threshold is fixed at -1.3 Volts.

---

Vector Signal Generator's front panel EXT PRBS (I) clock input.  
Set the RF signal generator to 10 MHz and +10 dBm

- Select external clocking for the PRBS by pressing **PRBS CLK** until the PRBS CLK display annunciator is ON.
- Set the spectrum analyzer to the following settings:

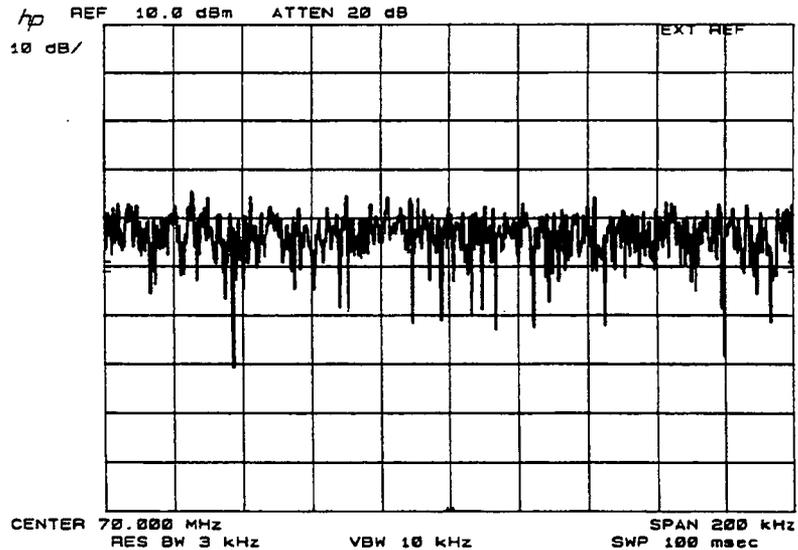
Center Frequency	70 MHz
Frequency Span	200 kHz
Resolution Bandwidth	3 kHz
Video Bandwidth	10 kHz
Marker	Off
Frequency Reference	EXT

HP 8782B

PRBS Clock Rates

**Note**

It is very important to have the external 10 MHz reference input of the spectrum analyzer connected to the rear panel 10 MHz auxiliary output of the Vector Signal Generator.



**Figure 5-29. Good PRBS External Clock Rates**

- Observe the spectrum analyzer display, and note a central lobe in the display trace. Increase the frequency of the RF signal generator from 10 MHz to more than 100 MHz in 10 MHz steps. As the clock frequency is increased, the central lobe will gradually increase in power. The maximum clock rate is exceeded when the central lobe jumps up in power by about 10 dB or more in a single 10 MHz step. The maximum external clock frequency is the RF signal generator frequency setting just before the jump occurs. Verify that the maximum external PRBS clock frequency is greater than 100 MHz.

Maximum Ext. PRBS Clock Frequency > 100 MHz \_\_\_\_\_ (✓)

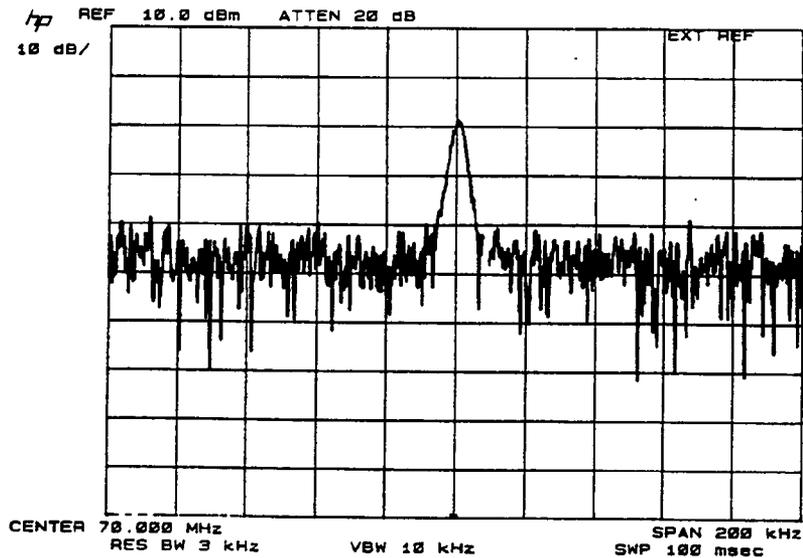


Figure 5-30. Failed PRBS External Clock Rates

**PRBS Not Operating?****Note**

If the PRBS is operated using an external clock, and the duty-cycle of the clock signal is very high or very low, then it is possible for the PRBS generator to suddenly stop clocking. Very low or very high duty-cycle clock signals can result from applying a sine wave input to the EXT PRBS (I) clock input, and then setting the Vector Signal Generator's clock threshold very close to the maximum or minimum peak voltage of the sine wave. This causes a clock signal which consists of sub-nanosecond pulses. These extremely short pulses can cause improper operation of the PRBS circuits.

If the PRBS suddenly stops operating, switch to internal PRBS clocking by pressing the **PRBS CLK** key until the display annunciator above EXT PRBS is off. If the PRBS operates at this point, verify that serial frame is not enabled. Normally serial frame is used with the serial clock mode, but for some special Bit Error Rate (BER) tests, it is useful to use an external frame clock with the PRBS. If the serial frame is enabled, then there must be an appropriate clock signal provided.

If the PRBS does not operate in internal PRBS mode, turn the line power off and back on to restore correct operation.

## Digital Modulation DC Accuracy

### Specification

Electrical Characteristics	Performance Limits	Conditions
Digital Modulation		
State dc Accuracy	<1.0% of Full Scale	70 MHz Carrier <+7 dBm Levels

### Description

The RF output and the coherent carrier output of the generator are connected to a network analyzer to view the real and imaginary (I and Q) components of the RF signal. The network analyzer is calibrated to represent 100% as a full scale reading. Different modulation "states" are generated by using the invert input function on the generator.

### Connections

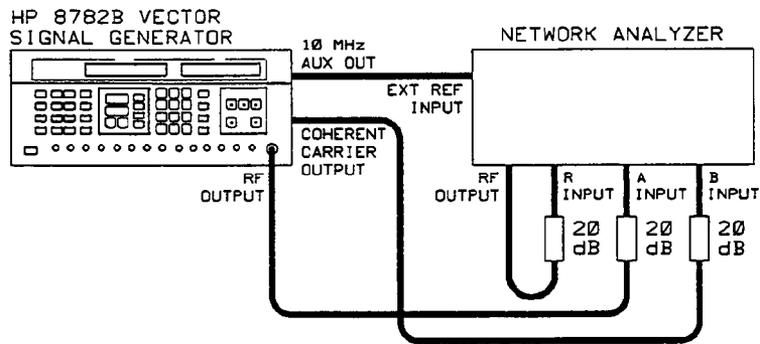


Figure 5-31. Digital Modulation DC Accuracy Test Setup

### Equipment

Network Analyzer ..... HP 8753A or HP 8753B  
 20 dB Attenuator (Quantity 3) ..... HP 8491A Option 020

### Note



In order to obtain the stability for making the following measurements, all instruments must have a warm up time of at least one hour. In addition, the network analyzer and generator must use a common 10 MHz time base to prevent a frequency error between instruments. A frequency error will produce a noisy measurement.

**Set-up Procedure**

1. Connect the equipment as shown in Figure 5-31. The generator 10 MHz auxiliary output must be connected to the network analyzer to provide a common time base for the measurements. The connection from the network analyzer RF source to the R input is only required for the HP 8753 A/B. This is required to phase lock the internal frequency sources.
2. Press the **PRESET** key on the generator, then set the generator an output level of +7 dBm.

**Note**

The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **CAL** key on the generator.

3. Select BPSK by pressing the **MODULATION** key repeatedly until the right display annunciator indicates BPSK. Turn the modulation on by pressing the **MODULATION ON** key.
4. Set the network analyzer to the following settings:

**Table 5-5. Network Analyzer Settings**

Setting	HP 8753A/B Press these keys/softkeys
Preset	<b>PRESET</b>
Input	<b>MEAS</b> <b>INPUT PORTS</b> <b>A/B</b>
Display Mode	<b>FORMAT</b> <b>POLAR</b>
Frequency Sweep Mode	<b>MENU</b> <b>NUMBER OF POINTS</b> <b>3</b> <b>x1</b>
Frequency	<b>MENU</b> <b>CW FREQ</b> <b>70</b> <b>M</b> (MHz)
Amplitude	<b>MENU</b> <b>POWER</b> <b>-10</b> <b>x1</b> (dBm)
Bandwidth	<b>AVG</b> <b>IF BW</b> <b>10</b> <b>x1</b> (Hz)

5. Normalize the network analyzer by entering the following key sequence. Normalizing the displayed signal will place the signal on the horizontal axis (0° phase) with a full scale magnitude. This step is required to calibrate the network analyzer display to the RF output signal of the generator and to cancel phase shifts due to test setup and frequency related effects.

HP 8753A/B: **DISPLAY** **DATA > MEMORY** **DATA/MEN**

6. Set the network analyzer to read the signal in terms of the real and imaginary components (corresponding to the I and Q components) by entering the following key sequence.

HP 8753A/B: **MKR** **MARKER MODE MENU** **POLAR MKR MENU**  
**Re/Im MKR**

**Note**

It is sufficient to verify the 8PSK and 256QAM modulation formats to assure performance of all the modulation formats. In situations where it is desired to check some or all of the other formats, equations for the general case are given at the end of this test under the heading Other Formats.

**8PSK**

1. Select digital modulation with 8PSK format by pressing the **MODULATION** key on the generator until the display annunciator indicates 8PSK, and then press the **MODULATION ON** key.
2. With the generator data inputs set to ECL terminations and thresholds (the preset state) and if the inputs are open circuited, then internal  $-2V$  terminations will pull the inputs low, creating a logic 0. To create a logic 1, the input can be inverted by using the **INVERT INPUT** key.

**Note**

A "1" under the DIGITAL INPUT column indicates the input should be inverted. A 0 indicates that the input should be in the non-inverting (normal) mode. An inverted input is indicated by its number appearing in the appropriate "INV I" or "INV Q" display.

When required, change the digital modulation state by pressing the **INVERT INPUT** key followed by the **▲** and **▼** keys to bring up the I or Q input invert menu. Press the numeric key corresponding to the input to change its state. The input is inverted when its number is displayed in the invert menu. (see "Inverting data and clock inputs" - Local Operation section)

3. Record the real and imaginary components as indicated by the network analyzer display in the Table 5-6 below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 999 mU on the network analyzer represents 99.9%. A reading of  $100\mu U$  represents 0.01%.
4. Invert DIGITAL INPUT 1 by pressing the **INVERT INPUT** key followed by **▲** or **▼** until "INV I" is displayed. Then press numeric key **1** to invert DIGITAL INPUT 1.
5. Record the real and imaginary components as indicated by the network analyzer display in the Table 5-6 below.
6. Continue measuring the remaining six states and record the results below.

All measurements should be within 1.0% of the indicated values.

Table 5-6. 8PSK Results

Digital Inputs			Real (I) Component	Imaginary (Q) Component
I0	I1	Q1		
0	0	0	_____ ( $\approx 38.3\%$ )	_____ ( $\approx 92.4\%$ )
0	1	0	_____ ( $\approx 92.4\%$ )	_____ ( $\approx 38.3\%$ )
0	1	1	_____ ( $\approx 92.4\%$ )	_____ ( $\approx -;38.3\%$ )
0	0	1	_____ ( $\approx 38.3\%$ )	_____ ( $\approx -;92.4\%$ )
1	0	1	_____ ( $\approx -38.3$ )	_____ ( $\approx -92.4\%$ )
1	1	1	_____ ( $\approx -92.4\%$ )	_____ ( $\approx -38.3\%$ )
1	1	0	_____ ( $\approx -92.4\%$ )	_____ ( $\approx 38.3\%$ )
1	0	0	_____ ( $\approx -38.3\%$ )	_____ ( $\approx 92.4\%$ )

**Note**

If all measurements are within specification, record the results in Table 5-6 and in Table 5-31 "Performance Test Record".

If any measurement does not meet specifications, refer to the section entitled "Correction Factors" at the end of this procedure to determine whether a correction factor must be applied to bring the measurement within specification.

**256QAM**

1. Press the **PRESET** key on the generator to reset the generator.
2. Set the generator to 70 MHz at an output level of +7 dBm.
3. Select digital modulation with 256QAM format by pressing the **MODULATION** key on the generator until the display annunciator indicates 256QAM, and then press key **MODULATION ON** key.
4. Record the real and imaginary components as indicated by the network analyzer display in the Table 5-7 below.
5. Invert DIGITAL INPUT 1 by pressing the **INVERT INPUT** key followed by up or down arrows until "INV I" is displayed. Then press numeric key **1** to invert DIGITAL INPUT 1.

**Note**

---

A "1" under the DIGITAL INPUT column indicates the input should be inverted. A 0 indicates that the input should be in the non-inverting (normal) mode. An inverted input is indicated by its number appearing in the appropriate "INV I" or "INV Q"

---

6. Record the real and imaginary components as indicated by the network analyzer display in the Table 5-7 below.
7. Continue measuring the remaining sixteen states and record the results below.

All measurements should be within 1.0% of the indicated values.

Table 5-7. 256QAM Results

I Digital Input				Q Digital Input				Real (I) Component	Imaginary (Q) Component
I0	I1	I2	I3	Q0	Q1	Q2	Q3		
0	0	0	0	0	0	0	0	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 70.7\%$ )
0	0	0	1	0	0	0	0	_____ ( $\approx 61.3\%$ )	_____ ( $\approx 70.7\%$ )
0	0	1	0	0	0	0	0	_____ ( $\approx 51.9\%$ )	_____ ( $\approx 70.7\%$ )
0	1	0	0	0	0	0	0	_____ ( $\approx 33.0\%$ )	_____ ( $\approx 70.7\%$ )
1	0	0	0	0	0	0	0	_____ ( $\approx -4.7\%$ )	_____ ( $\approx 70.7\%$ )
1	1	1	1	0	0	0	0	_____ ( $\approx -70.7\%$ )	_____ ( $\approx 70.7\%$ )
0	0	0	0	0	0	0	1	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 61.3\%$ )
0	0	0	0	0	0	1	0	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 51.9\%$ )
0	0	0	0	0	1	0	0	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 33.0\%$ )
0	0	0	0	1	0	0	0	_____ ( $\approx 70.7\%$ )	_____ ( $\approx -4.7\%$ )
0	0	0	0	1	1	1	1	_____ ( $\approx 70.7\%$ )	_____ ( $\approx -70.7\%$ )
0	1	1	1	1	1	1	1	_____ ( $\approx 4.7\%$ )	_____ ( $\approx -70.7\%$ )
1	0	0	0	1	1	1	1	_____ ( $\approx -4.7\%$ )	_____ ( $\approx -70.7\%$ )
1	1	1	1	1	1	1	1	_____ ( $\approx -70.7\%$ )	_____ ( $\approx -70.7\%$ )
1	1	1	1	1	0	0	0	_____ ( $\approx -70.7\%$ )	_____ ( $\approx -4.7\%$ )
1	1	1	1	0	1	1	1	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 4.7\%$ )
0	1	1	1	0	1	1	1	_____ ( $\approx 4.7\%$ )	_____ ( $\approx 4.7\%$ )
1	1	0	0	1	1	0	0	_____ ( $\approx -42.4\%$ )	_____ ( $\approx -42.4\%$ )

**Note**

---

If all measurements are within specification, record the results in Table 5-7 and in Table 5-31 "Performance Test Record".

If any measurement does not meet specifications, refer to the section entitled "Correction Factors" at the end of Table 5-7 to determine whether a correction factor must be applied to bring the measurement within specification.

---

**Correction Factors**

The specification for dc accuracy is presented as a percentage of full scale magnitude. There is an implied I/Q coordinate system which can be described by the Full Scale I Vector. Normalizing the network analyzer to the +I BPSK state approximately finds the Full Scale I Vector. The definition of the Full Scale I Vector is that the vector has a magnitude and phase almost equal to the +I BPSK state, and that the exact magnitude and phase is such that the maximum I or Q error is minimized. Vectors with magnitudes much larger than the magnitude of the +I BPSK state will appear to minimize the error (because error is expressed as a percent of full scale), but clearly this is not the correct value for full scale.

Defining the Full Scale I vector as something near the +I BPSK state is equivalent to compensating for a length of physical transmission line connected on the output of the signal generator. If a length of transmission line were added, the magnitude and phase of the signal will change; the I/Q coordinate system and hence the reference vector would need to change accordingly.

For engineers familiar with Digital Microwave radio, picking the I Full Scale vector is equivalent to setting the automatic gain control (AGC) and carrier lock angle for minimum bit error rate (BER).

Note that for this DC Accuracy test, I and Q offsets (carrier leakage) are *NOT* altered by the choice of the I Full Scale Vector. The scalar accuracy test breaks the I and Q errors into two parts, the offsets, and the remaining errors.

To pick the best I Full Scale vector requires minimizing the maximum I or Q error. This is a complicated optimization problem which requires a computer to solve. It is somewhat easier to reduce the maximum magnitude and phase errors especially when some assumptions are made about the error mechanisms in the signal.

In most cases, selecting one of the full scale states as the full scale value is sufficient to verify that the generator is within specification. However, if the reference selected is at one extreme (maximum or minimum), the test may not pass if another value is at the other extreme.

To correct for this error, a scaling factor must be calculated to scale all of the measured values according to the average full scale reading. For example, if the maximum magnitude is 99%, and the minimum magnitude is 98%, all of the values must be divided by a scaling factor (the average of 98% and 99%) so that the two measurements

correspond to 100.5% and 99.5% ( $100\% \pm 0.5\%$ ). This reduces the error measured to within the specification.

### 8PSK Correction factors

1. Square the real and imaginary component of the measured values of the first state (0 0 0). Record the values.

\_\_\_\_\_ Real Component Squared ( $\approx 1464.5$ )

\_\_\_\_\_ Imaginary Component Squared ( $\approx 8535.5$ )

2. Add the two values together and then take the square root of the result. This is the measured magnitude of the first state. Record this value in Table 5-8 below.

\_\_\_\_\_ Magnitude of State (0 0 0) ( $\approx 100$ )

3. Repeat the root-sum-square procedure for the other seven states and record the measured magnitudes in Table 5-8 below.

4. Take the largest and smallest magnitudes, add them together, and then divide the result by two. Divide this number by 100 (this number should not be in percent). This is the 8PSK Magnitude Scaling Factor. Record the value.

\_\_\_\_\_ 8PSK Magnitude Scaling Factor ( $\approx 1$ )

Divided each of the 8PSK magnitudes by the Magnitude scaling factor and record the results in Table 5-10 below .

**Table 5-8. 8PSK Magnitude Error Worksheet**

Digital Inputs I0 I1 Q1	Measured Mag. $= \sqrt{\text{Real}^2 + \text{Imag}^2}$
(0 0 0)	_____ ( $\approx 100\%$ )
(0 1 0)	_____ ( $\approx 100\%$ )
(0 1 1)	_____ ( $\approx 100\%$ )
(0 0 1)	_____ ( $\approx 100\%$ )
(1 0 1)	_____ ( $\approx 100\%$ )
(1 1 1)	_____ ( $\approx 100\%$ )
(1 1 0)	_____ ( $\approx 100\%$ )
(1 0 0)	_____ ( $\approx 100\%$ )

5. Divide the real and imaginary component of the measured values of the first state (0 0 0). Record the values.

\_\_\_\_\_ Imaginary  $\div$  Real part (0 0 0) ( $\approx 2.414$ )

6. Compute the Inverse Tangent (in degrees) of the quotient, and record the result below.

\_\_\_\_\_  $\text{Tan}^{-1}(\text{Imaginary} \div \text{Real}) (\approx 67.5^\circ)$

- Subtract the ideal angle for state (0 0 0) from the measured angle. This is the phase error for this state. A positive error means that this state has moved counter-clockwise from its ideal location.

Measured angle state (0 0 0) - 67.5° = \_\_\_\_\_ Phase error state (0 0 0)

- Repeat this procedure for each of the remaining states according to the Table 5-9 below. Note that the  $\text{Tan}^{-1}$  function is only defined for  $\pm 90^\circ$ . For states in any but the upper right quadrant it is necessary to add a quadrant correction of either 180° or 360°.

Table 5-9. 8PSK Phase Error Worksheet

Digital Inputs I0 I1 Q1	Imaginary ÷ Real	$\text{Tan}^{-1}$	Quad. Corr.	Meas. Phase = $\text{Tan}^{-1}$ + Quad. Correction	Ideal Phase	Phase Error = Meas. Phase - Ideal Phase
(0 0 0)	_____	_____	0°	_____	67.5°	_____
(0 1 0)	_____	_____	0°	_____	22.5°	_____
(0 1 1)	_____	_____	360°	_____	337.5°	_____
(0 0 1)	_____	_____	360°	_____	292.5°	_____
(1 0 1)	_____	_____	180°	_____	247.5°	_____
(1 1 1)	_____	_____	180°	_____	202.5°	_____
(1 1 0)	_____	_____	180°	_____	157.5°	_____
(1 0 0)	_____	_____	180°	_____	112.5°	_____

- Take the largest and smallest phase errors, add them together, and then divide the result by two. This is the 8PSK Phase Scaling Factor. Record the value.

\_\_\_\_\_ 8PSK Phase Scaling Factor

- Subtract the 8PSK Phase Scaling Factor from each of the measured phases computed in Table 5-9 (The  $\text{Tan}^{-1}$  + Quad. Correction values). This is the corrected phase. Record the result in the 8PSK corrected measurement worksheet Table 5-10 below.
- Using the corrected magnitude and corrected phase for 8PSK state (0 0 0), compute the corrected real and imaginary parts.

Corrected Real = Corrected Magnitude × Cos(Corrected Phase)

Corrected Imaginary = Corrected Magnitude × Sin(Corrected Phase)

Record these two numbers in the 8PSK Corrected Measurement Worksheet Table 5-10 below, and compare the new real and imaginary parts to the specified values in Table 5-6 above.

**Table 5-10. 8PSK Corrected Measurement Worksheet**

Digital Inputs I0 I1 Q1	Corrected Mag. = Measured Mag. ÷ Mag. Scaling Factor	Corrected Phase = Measured Phase - Phase Scaling Fact.	Corrected Real Part = Corrected Mag. × Cos(Corrected Phase)	Corrected Imag. Part = Corrected Mag. × Sin(Corrected Phase)
(0 0 0)	_____	_____	_____	_____
(0 1 0)	_____	_____	_____	_____
(0 1 1)	_____	_____	_____	_____
(0 0 1)	_____	_____	_____	_____
(1 0 1)	_____	_____	_____	_____
(1 1 1)	_____	_____	_____	_____
(1 1 0)	_____	_____	_____	_____
(1 0 0)	_____	_____	_____	_____

**256QAM Correction factors**

1. Square the real and imaginary component of the measured values of the first state (0 0 0 0, 0 0 0 0). Record the values.

\_\_\_\_\_ Real Component Squared (≈ 5000.0)  
 \_\_\_\_\_ Imaginary Component Squared (≈ 5000.0)

2. Add the two values together and then take the square root of the result. This is the measured magnitude of the first state. Record this value below and in Table 5-11.

\_\_\_\_\_ Magnitude of State (0 0 0 0, 0 0 0 0) (≈ 100)

3. Divide the Measured Magnitude by the Ideal Magnitude for State (0 0 0 0, 0 0 0 0) which is 100. This is the Magnitude error for State (0 0 0 0, 0 0 0 0). Record this value below and in Table 5-11.

\_\_\_\_\_ Magnitude Error of State (0 0 0 0, 0 0 0 0) (≈ 1)

4. Repeat the procedure for the other seventeen states and record the measured magnitudes and magnitude errors in Table 5-11 below.

5. Take the largest and smallest magnitude errors, add them together, and then divide the result by two. This is the 256QAM Magnitude Scaling Factor. Record the value.

\_\_\_\_\_ 256QAM Magnitude Scaling Factor (≈ 1)

Divided each of the 256QAM magnitudes by the Magnitude scaling factor and record the results in Table 5-13 below.

Table 5-11. 256QAM Magnitude Error Worksheet

Digital Inputs I0 I1 I2 I3, Q0 Q1 Q2 Q3	Measured Mag. $= \sqrt{\text{Real}^2 + \text{Imag}^2}$	Ideal Mag.	Mag. Error $= \text{Measured Mag.} \div \text{Ideal Mag.}$
(0 0 0 0, 0 0 0 0)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(0 0 0 1, 0 0 0 0)	_____ ( $\approx 93.57\%$ )	93.57%	_____
(0 0 1 0, 0 0 0 0)	_____ ( $\approx 87.69\%$ )	87.69%	_____
(0 1 0 0, 0 0 0 0)	_____ ( $\approx 78.03\%$ )	78.03%	_____
(1 0 0 0, 0 0 0 0)	_____ ( $\approx 70.87\%$ )	70.87%	_____
(1 1 1 1, 0 0 0 0)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(0 0 0 0, 0 0 0 1)	_____ ( $\approx 93.57\%$ )	93.57%	_____
(0 0 0 0, 0 0 1 0)	_____ ( $\approx 87.69\%$ )	87.69%	_____
(0 0 0 0, 0 1 0 0)	_____ ( $\approx 78.03\%$ )	78.03%	_____
(0 0 0 0, 1 0 0 0)	_____ ( $\approx 70.87\%$ )	70.87%	_____
(0 0 0 0, 1 1 1 1)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(0 1 1 1, 1 1 1 1)	_____ ( $\approx 70.87\%$ )	70.87%	_____
(1 0 0 0, 1 1 1 1)	_____ ( $\approx 70.87\%$ )	70.87%	_____
(1 1 1 1, 1 1 1 1)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(1 1 1 1, 1 0 0 0)	_____ ( $\approx 70.87\%$ )	70.87%	_____
(1 1 1 1, 0 1 1 1)	_____ ( $\approx 70.87\%$ )	70.87%	_____
(0 1 1 1, 0 1 1 1)	_____ ( $\approx 6.67\%$ )	6.67%	_____
(1 1 0 0, 1 1 0 0)	_____ ( $\approx 60.00\%$ )	60.00%	_____

6. Divide the real and imaginary component of the measured values of the first state (0 0 0 0, 0 0 0 0). Record the values.

\_\_\_\_\_ Imaginary  $\div$  Real part (0 0 0 0, 0 0 0 0) ( $\approx 1.00$ )

7. Compute the Inverse Tangent (in degrees) of the quotient, and record the result below.

\_\_\_\_\_  $\text{Tan}^{-1}(\text{Imaginary} \div \text{Real})$  ( $\approx 45.0^\circ$ )

8. Subtract the ideal angle for state (0 0 0 0, 0 0 0 0) ( $45^\circ$ ) from the measured angle. This is the phase error for this state. A positive error means that this state has moved counter-clockwise from its ideal location.

Measured angle state (0 0 0 0, 0 0 0 0) - 45.0° =  
 \_\_\_\_\_ Phase error state (0 0 0 0, 0 0 0 0)

9. Repeat this procedure for each of the remaining states according to Table 5-12 below. Note that the  $\text{Tan}^{-1}$  function is only defined for  $\pm 90^\circ$ . For states in any but the upper right quadrant it is necessary to add a quadrant correction of either  $180^\circ$  or  $360^\circ$ .

Table 5-12. 256QAM Phase Error Worksheet

Digital Inputs I0 I1 I2 I3, Q0 Q1 Q2 Q3	Imaginary ÷ Real	$\text{Tan}^{-1}$	Quad. Corr.	Meas. Phase = $\text{Tan}^{-1}$ + Quad. Correction	Ideal Phase	Phase Error = Meas. Phase - Ideal
(0 0 0 0, 0 0 0 0)	_____	_____	0°	_____	45.00°	_____
(0 0 0 1, 0 0 0 0)	_____	_____	0°	_____	49.09°	_____
(0 0 1 0, 0 0 0 0)	_____	_____	0°	_____	53.75°	_____
(0 1 0 0, 0 0 0 0)	_____	_____	0°	_____	64.98°	_____
(1 0 0 0, 0 0 0 0)	_____	_____	180°	_____	93.81°	_____
(1 1 1 1, 0 0 0 0)	_____	_____	180°	_____	135.00°	_____
(0 0 0 0, 0 0 0 1)	_____	_____	0°	_____	40.91°	_____
(0 0 0 0, 0 0 1 0)	_____	_____	0°	_____	36.25°	_____
(0 0 0 0, 0 1 0 0)	_____	_____	0°	_____	25.02°	_____
(0 0 0 0, 1 0 0 0)	_____	_____	360°	_____	356.19°	_____
(0 0 0 0, 1 1 1 1)	_____	_____	360°	_____	315.00°	_____
(0 1 1 1, 1 1 1 1)	_____	_____	360°	_____	273.81°	_____
(1 0 0 0, 1 1 1 1)	_____	_____	180°	_____	266.19°	_____
(1 1 1 1, 1 1 1 1)	_____	_____	180°	_____	225.00°	_____
(1 1 1 1, 1 0 0 0)	_____	_____	180°	_____	183.81°	_____
(1 1 1 1, 0 1 1 1)	_____	_____	180°	_____	176.19°	_____
(0 1 1 1, 0 1 1 1)	_____	_____	0°	_____	45.00°	_____
(1 1 0 0, 1 1 0 0)	_____	_____	180°	_____	225.00°	_____

10. Take the largest and smallest phase errors, add them together, and then divide the result by two. This is the 256QAM Phase Scaling Factor. Record the value.

\_\_\_\_\_ 256QAM Phase Scaling Factor

11. Subtract the 256QAM Phase Scaling Factor from each of the measured phases computed in Table 5-12 (The  $\text{Tan}^{-1}$  + Quad. Correction values). This is the corrected phase. Record the

result in the 256QAM Corrected Measurement Worksheet Table 5-13 below.

12. Using the corrected magnitude and corrected phase for 256QAM state (0 0 0 0, 0 0 0 0), compute the corrected real and imaginary parts.

$$\text{Corrected Real} = \text{Corrected Magnitude} \times \text{Cos}(\text{Corrected Phase})$$

$$\text{Corrected Imaginary} = \text{Corrected Magnitude} \times \text{Sin}(\text{Corrected Phase})$$

Record these two numbers in the 256QAM Corrected Measurement Worksheet Table 5-13 below, and compare the new real and imaginary parts to the specified values in Table 5-7 above.

**Table 5-13. 256QAM Corrected Measurement Worksheet**

Digital Inputs I0 I1 I2 I3, Q0 Q1 Q2 Q3	Corrected Mag. = Measured Mag. ÷ Mag. Scaling Factor	Corrected Phase = Measured Phase - Phase Scaling Fact.	Corrected Real Part = Corrected Mag. × Cos(Cor. Phase)	Corrected Imag. Part = Corrected Mag. × Sin(Cor. Phase)
(0 0 0 0, 0 0 0 0)	_____	_____	_____	_____
(0 0 0 1, 0 0 0 0)	_____	_____	_____	_____
(0 0 1 0, 0 0 0 0)	_____	_____	_____	_____
(0 1 0 0, 0 0 0 0)	_____	_____	_____	_____
(1 0 0 0, 0 0 0 0)	_____	_____	_____	_____
(1 1 1 1, 0 0 0 0)	_____	_____	_____	_____
(0 0 0 0, 0 0 0 1)	_____	_____	_____	_____
(0 0 0 0, 0 0 1 0)	_____	_____	_____	_____
(0 0 0 0, 0 1 0 0)	_____	_____	_____	_____
(0 0 0 0, 1 0 0 0)	_____	_____	_____	_____
(0 0 0 0, 1 1 1 1)	_____	_____	_____	_____
(0 1 1 1, 1 1 1 1)	_____	_____	_____	_____
(1 0 0 0, 1 1 1 1)	_____	_____	_____	_____
(1 1 1 1, 1 1 1 1)	_____	_____	_____	_____
(1 0 0 0, 1 1 1 1)	_____	_____	_____	_____
(0 1 1 1, 1 1 1 1)	_____	_____	_____	_____
(0 1 1 1, 0 1 1 1)	_____	_____	_____	_____
(1 1 0 0, 1 1 0 0)	_____	_____	_____	_____

**Other Formats**

In order to measure the DC accuracy of modulation formats other than the ones listed in this manual, the ideal real and imaginary values for each state must be calculated. All of the 8PSK (Digital Modulation DC Accuracy test) and 16QAM (Scalar Modulation DC Accuracy test) states are listed in this manual. Eighteen of the 256 states in 256QAM are listed in the Digital Modulation DC Accuracy test. This section describes how to calculate the parameters of any state in any of the rectangular modulations.

1. Calculate N which gives the number of states along a side of a rectangular modulation.

$$N = \sqrt{\text{Number of states}}$$

For example, 25PRS has 25 states, so  $N = 5$ .

2. Compute the binary value of the I and Q parts of the data input corresponding to the state. Refer to the Modulation Format Constellation diagram in chapter 3, "Local Operation". I0 and Q0 are the most significant bits. For example, the lower right state in 25PRS has an I value of:

$$\begin{aligned} I_{\text{binary}} &= 000_{\text{binary}} \\ &= 0 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 \\ &= 0 \times 4 + 0 \times 2 + 0 \times 1 \\ &= 0_{\text{decimal}} \end{aligned}$$

The Q value is:

$$\begin{aligned} Q_{\text{binary}} &= 100_{\text{binary}} \\ &= 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 \\ &= 1 \times 4 + 0 \times 2 + 0 \times 1 \\ &= 4_{\text{decimal}} \end{aligned}$$

3. From the binary values, compute the I (real) and Q (imaginary) components:

$$I \text{ or } Q \text{ value} = \frac{1 - \left(\frac{2}{(N-1)}\right) \times (\text{Binary Value})}{\sqrt{2}}$$

Using the same 25PRS example as before:

$$\begin{aligned} \text{I value} &= \frac{1 - \left(\frac{2}{5-1}\right) \times (0)}{\sqrt{2}} \\ &= \frac{1}{\sqrt{2}} \\ &= 0.7071 \end{aligned}$$

$$\begin{aligned} \text{Q value} &= \frac{1 - \left(\frac{2}{5-1}\right) \times (4)}{\sqrt{2}} \\ &= \frac{1 - \left(\frac{1}{2}\right) \times (4)}{\sqrt{2}} \\ &= \frac{-1}{\sqrt{2}} \\ &= -0.7071 \end{aligned}$$

**Note**



The above equations do not apply to BPSK and 8PSK modulation. BPSK and 8PSK are not rectangular modulations. 8PSK is fully calculated in the Digital Modulation DC Accuracy test. BPSK has I values of  $\pm 1.00$  and Q values of 0.00.

4. To use these I and Q values to compare with measured data, convert these two values to percent by multiplying by 100.

For example, 0.7071 becomes 70.71%.

5. Compute the magnitude of the state using the I and Q values, (not the percent values).

$$\text{Magnitude} = \sqrt{I^2 + Q^2}$$

For the 25PRS example:

$$\begin{aligned} \text{Magnitude} &= \sqrt{0.7071^2 + -0.7071^2} \\ &= \sqrt{\frac{1}{2} + \frac{1}{2}} \\ &= 1 \end{aligned}$$

6. Compute the phase of the state. Since the range of arctangent ( $\text{Tan}^{-1}$ ) is only defined for  $\pm 90^\circ$ , it is necessary to consider several special cases:

For  $I > 0$ , and  $Q \geq 0$ :

$$\text{Phase} = \text{Tan}^{-1} \left( \frac{Q}{I} \right)$$

For  $I > 0$ , and  $Q < 0$ :

$$\text{Phase} = \text{Tan}^{-1} \left( \frac{Q}{I} \right) + 360^\circ$$

For  $I = 0$ , and  $Q > 0$ :

$$\text{Phase} = 90^\circ$$

For  $I = 0$ , and  $Q = 0$ :

Phase = Indeterminate

For  $I = 0$ , and  $Q < 0$ :

$$\text{Phase} = 90^\circ$$

For  $I < 0$ :

$$\text{Phase} = \text{Tan}^{-1} \left( \frac{Q}{I} \right) + 180^\circ$$

### Note



If the phase is indeterminate, (the magnitude of a vector of zero length is undefined), then *DO NOT* use this state to calculate the magnitude or phase correction factors.

Going back to the 25PRS example,  $I$  is  $> 0$  and  $Q$  is  $< 0$  so the correct phase equation is:

$$\begin{aligned} \text{Phase} &= \text{Tan}^{-1} \left( \frac{Q}{I} \right) + 360^\circ \\ &= \text{Tan}^{-1} \left( \frac{-0.7071}{0.7071} \right) + 360^\circ \\ &= \text{Tan}^{-1}(-1) + 360^\circ \\ &= -45^\circ + 360^\circ \\ &= 315^\circ \end{aligned}$$

## Scalar Modulation DC Accuracy

### Specification

Electrical Characteristics	Performance Limits	Conditions
Digital Modulation Scalar DC Accuracy	<1.0% of Full Scale	70 MHz Carrier <+7 dBm Levels $0 \leq \text{Attenuation} < 10 \text{ dB}$ ( $0.32 \text{ V} < \text{Scalar Input} \leq 1.0 \text{ V}$ )
	<2.0% of Full Scale	70 MHz Carrier <+7 dBm Levels $10 \leq \text{Attenuation} < 20 \text{ dB}$ ( $0.1 \text{ V} < \text{Scalar Input} \leq 0.32 \text{ V}$ )

### Description

The RF output and the coherent carrier output of the generator are connected to a network analyzer to view the real and imaginary (I and Q) components of the RF signal. The network analyzer is calibrated to represent 100% as a full scale reading. Scalar attenuation values are set using a function generator and voltmeter. Different modulation "states" are generated by using the invert input function on the generator.

### Caution



The function generator can exceed the 0 to +1 Volt limit for the Vector Signal Generator scalar input. Do not connect the function generator until after correctly setting the power levels as described in the test equipment settings table.

## Connections

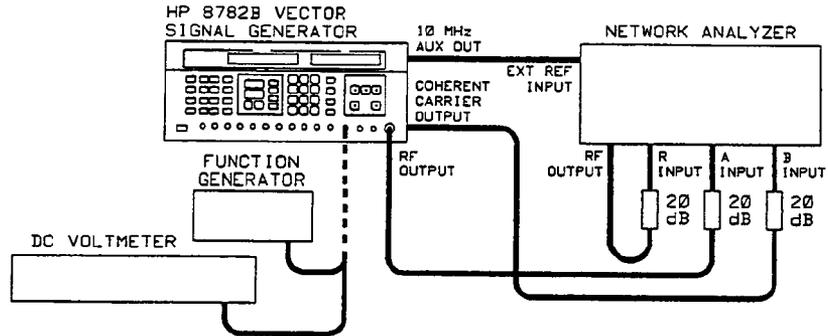


Figure 5-32. Scalar Modulation DC Accuracy Test Setup

<b>Equipment</b>	Network Analyzer.....	HP 8753A or HP 8753B
	20 dB Attenuator (Quantity 3).....	HP 8491A Option 020
	Function Generator.....	HP 8116A
	Digital Voltmeter.....	3456A

**Note**

In order to obtain the stability for making the following measurements, all instruments must have a warm up time of at least one hour. In addition, the network analyzer and generator must use a common 10 MHz time base to prevent a frequency error between instruments. A frequency error will produce a noisy measurement.

**Set-up Procedure**

1. Connect the equipment as shown in Figure 5-32. The generator 10 MHz auxiliary output must be connected to the network analyzer to provide a common time base for the measurements. The connection from the network analyzer RF source to the R input is only required for the HP 8753 A/B. This is required to phase lock the internal frequency sources. Make sure the function generator is disconnected from the HP 8782B. Connect the function generator to the voltmeter.
2. Set the function generator to give a 1.0 Vdc output into the high-impedance input of the voltmeter. Most function generators assume a 50Ω load, so set the function generator to a +0.5 Vdc offset. Turn the AC signals off.

**Note**

Do not exceed the 0 to +1.0 volt range on the scalar input to the vector signal generator. The scalar input is high impedance (10 kΩ).

3. Press the **PRESET** key on the generator, then set the generator an output level of +7 dBm.

**Note**

The generator depends on an internal calibration routine to obtain high accuracy. The calibration routine must be run after allowing 1 hour for generator warm-up, and immediately before testing. The internal calibration routine requires about two minutes to execute. The internal calibration is enabled by pressing the **CAL** key on the generator.

4. Select BPSK by pressing the **MODULATION** key repeatedly until the right display annunciator indicates BPSK. Turn the modulation on by pressing the **MODULATION ON** key.
5. Set the network analyzer to the following settings:

**Table 5-14. Network Analyzer Settings**

Setting	HP 8753A/B Press these keys/softkeys
Preset	<b>PRESET</b>
Input	<b>MEAS</b> <b>INPUT PORTS</b> <b>A/B</b>
Display Mode	<b>FORMAT</b> <b>POLAR</b>
Frequency Sweep Mode	<b>MENU</b> <b>NUMBER OF POINTS</b> <b>3</b> <b>x1</b>
Frequency	<b>MENU</b> <b>CW FREQ</b> <b>70</b> <b>M</b> (MHz)
Amplitude	<b>MENU</b> <b>POWER</b> <b>-10</b> <b>x1</b> (dBm)
Bandwidth	<b>AVG</b> <b>IF BW</b> <b>10</b> <b>x1</b> (Hz)

6. Normalize the network analyzer by entering the following key sequence. Normalizing the displayed signal will place the signal on the horizontal axis (0° phase) with a full scale magnitude. This step is required to calibrate the network analyzer display to the RF output signal of the generator and to cancel phase shifts due to test setup and frequency related effects.

HP 8753A/B: **DISPLAY** **DATA >** **MEMORY** **DATA/MEM**

7. Set the network analyzer to read the signal in terms of the real and imaginary components (corresponding to the I and Q components) by entering the following key sequence.

HP 8753A/B: **MKR** **MARKER MODE MENU** **POLAR MKR MENU**  
**Re/Im MKR**

**Note**

It is sufficient to verify the 16QAM modulation format to assure performance of all the modulation formats. In situations where it is desired to check some or all of the other formats, equations for the general case are given at the end of this test under the heading Other Formats.

## Establish Correction Factors

1. Select digital modulation with 16QAM format by pressing the **MODULATION** key on the generator until the display annunciator indicates 16QAM, and then press the **MODULATION ON** key.
2. With the generator data inputs set to ECL terminations and thresholds (the preset state) and the inputs open circuited, the internal  $-2V$  terminations will pull the inputs low, creating a logic 0. To create a logic 1, the input can be inverted by using the **INVERT INPUT** key.

**Note**

For this test, a “1” under the DIGITAL INPUT column indicates the input should be inverted. A 0 indicates that the input should be in the non-inverting (normal) mode. An inverted input is indicated by its number appearing in the appropriate “INV I” or “INV Q” display.

When required, change the digital modulation state by pressing the **INVERT INPUT** key followed by the **▲** and **▼** keys to bring up the I or Q input invert menu. Press the numeric key corresponding to the input to change its state. The input is inverted when its number is displayed in the invert menu. (see “Inverting data and clock inputs” - Local Operation section)

**Note**

If correction factors were required in the Digital Modulation DC Accuracy test, then correction factors will probably be required for this test.

3. Record the real and imaginary components as indicated by the network analyzer display in the Table 5-15 16QAM Results (Scalar Off) below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 999 mU on the network analyzer represents 99.9%. A reading of 100 $\mu$ U represents 0.01%.
4. Invert DIGITAL INPUT Q1 by pressing the **INVERT INPUT** key followed by **▲** or **▼** until “INV Q” is displayed. Then press numeric key **1** to invert DIGITAL INPUT Q1.
5. Record the real and imaginary components as indicated by the network analyzer display in the Table 5-15 16QAM Results (Scalar Off) below.
6. Continue measuring the remaining fourteen states and record the results below.

These measurements will be used to compute correction factors if required.

Table 5-15. 16QAM Results (Scalar Off)

Digital Inputs				Real (I) Component	Imaginary (Q) Component
I0	I1	Q0	Q1		
0	0	0	0	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 70.7\%$ )
0	0	0	1	_____ ( $\approx 70.7\%$ )	_____ ( $\approx 23.6\%$ )
0	0	1	0	_____ ( $\approx 70.7\%$ )	_____ ( $\approx -23.6\%$ )
0	0	1	1	_____ ( $\approx 70.7\%$ )	_____ ( $\approx -70.7\%$ )
0	1	0	0	_____ ( $\approx 23.6\%$ )	_____ ( $\approx 70.7\%$ )
0	1	0	1	_____ ( $\approx 23.6\%$ )	_____ ( $\approx 23.6\%$ )
0	1	1	0	_____ ( $\approx 23.6\%$ )	_____ ( $\approx -23.6\%$ )
0	1	1	1	_____ ( $\approx 23.6\%$ )	_____ ( $\approx -70.7\%$ )
1	0	0	0	_____ ( $\approx -23.6\%$ )	_____ ( $\approx 70.7\%$ )
1	0	0	1	_____ ( $\approx -23.6\%$ )	_____ ( $\approx 23.6\%$ )
1	0	1	0	_____ ( $\approx -23.6\%$ )	_____ ( $\approx -23.6\%$ )
1	0	1	1	_____ ( $\approx -23.6\%$ )	_____ ( $\approx -70.7\%$ )
1	1	0	0	_____ ( $\approx -70.7\%$ )	_____ ( $\approx 70.7\%$ )
1	1	0	1	_____ ( $\approx -70.7\%$ )	_____ ( $\approx 23.6\%$ )
1	1	1	0	_____ ( $\approx -70.7\%$ )	_____ ( $\approx -23.6\%$ )
1	1	1	1	_____ ( $\approx -70.7\%$ )	_____ ( $\approx -70.7\%$ )

**Measure: Scalar Input = 1.0V**

1. Verify that the function generator output is approximately 1.00 Vdc into a high impedance load, and record the exact value below.

Scalar Input voltage. \_\_\_\_\_ V.

2. Connect the function generator to the generator's scalar input, and turn scalar modulation on by pressing the **SCALAR ON** key.
3. Set the I and Q digital inputs to non-inverted. If required, change the digital modulation state by pressing the **INVERT INPUT** key followed by the **▲** and **▼** keys to bring up the I or Q input invert menu. Press the numeric key corresponding to the input to change its state. The input is inverted when its number is displayed in the invert menu. (see "Inverting data and clock inputs" - Local Operation section)
4. Record the real and imaginary components as indicated by the network analyzer display in Table 5-16 16QAM results (Scalar = 1.00 V) below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 999 mU on the network analyzer represents 99.9%. A reading of 100 $\mu$  represents 0.01%.
5. Invert DIGITAL INPUT Q1 by pressing the **INVERT INPUT** key followed by **▲** or **▼** until "INV Q" is displayed. Then press numeric key **1** to invert DIGITAL INPUT Q1.
6. Record the real and imaginary components as indicated by the network analyzer display in Table 5-16 16QAM results (Scalar = 1.00 V) below.
7. Continue measuring the remaining fourteen states and record the results in Table 5-16 16QAM results (Scalar = 1.00 V) below.

Table 5-16. 16QAM Results (Scalar = 1.0 V)

Digital Inputs				Real (I) Component	Imaginary (Q) Component
I0	I1	Q0	Q1		
0	0	0	0	_____ (≈70.7%)	_____ (≈70.7%)
0	0	0	1	_____ (≈70.7%)	_____ (≈23.6%)
0	0	1	0	_____ (≈70.7%)	_____ (≈-23.6%)
0	0	1	1	_____ (≈70.7%)	_____ (≈-70.7%)
0	1	0	0	_____ (≈23.6%)	_____ (≈70.7%)
0	1	0	1	_____ (≈23.6%)	_____ (≈23.6%)
0	1	1	0	_____ (≈23.6%)	_____ (≈-23.6%)
0	1	1	1	_____ (≈23.6%)	_____ (≈-70.7%)
1	0	0	0	_____ (≈-23.6%)	_____ (≈70.7%)
1	0	0	1	_____ (≈-23.6%)	_____ (≈23.6%)
1	0	1	0	_____ (≈-23.6%)	_____ (≈-23.6%)
1	0	1	1	_____ (≈-23.6%)	_____ (≈-70.7%)
1	1	0	0	_____ (≈-70.7%)	_____ (≈70.7%)
1	1	0	1	_____ (≈-70.7%)	_____ (≈23.6%)
1	1	1	0	_____ (≈-70.7%)	_____ (≈-23.6%)
1	1	1	1	_____ (≈-70.7%)	_____ (≈-70.7%)

8. Divide each measured I and Q (real and imaginary) component by the scalar input voltage. This normalizes the measured data to the full scale reference. Record each value in Table 5-17 16QAM Measurement Worksheet (1.0 V) below.

Table 5-17. 16QAM Measurement Worksheet (1.0 V)

Digital Inputs I0 I1, Q0 Q1	Normalized Real Part = Measured Real ÷ Scalar Input Volt.	Normalized Imag. Part = Measured Imag. ÷ Scalar Input Volt.	Computed Real Part = Normalized Real Part - I-channel Offset	Computed Imag. Part = Normalized Imag. Part - Q-channel Offset
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

9. Add all the normalized I components, divide by 16, and record the value. This number is the I-channel offset, and should be close to 0.

I-channel offset \_\_\_\_\_ ( $\approx 0$ )

10. Add all the normalized Q components, divide by 16, and record the value. This number is the Q-channel offset, and should be close to 0.

Q-channel offset \_\_\_\_\_ ( $\approx 0$ )

11. Subtract the I-channel offset from each of the normalized I components, and subtract the Q-channel offset from each of the normalized Q components. This is the computed value. Record each value in Table 5-17 16QAM Measurement Worksheet (1.0 V). Compare these values to the ideal values given in Table 5-15 16QAM Results (Scalar Off). All measured data should be within  $\pm 1\%$  of the ideal values.

**Note**

If all measurements are within specification, record the results in Table 5-31 "Performance Test Record".

If any measurement does not meet specifications, refer to the section entitled "Correction Factors" at the end of this procedure to determine whether a correction factor must be applied to bring the measurement within specification.

**Measure: Scalar Input = 0.33V**

1. Connect the function generator output to the voltmeter, and set the function generator output to approximately 0.33 V. Record the exact value.

Scalar Input voltage. \_\_\_\_\_ V.

2. Connect the function generator to the generator's scalar input, and turn scalar modulation on by pressing the **SCALAR ON** key.
3. Set the I and Q digital inputs to non-inverted. If required, change the digital modulation state by pressing the **INVERT INPUT** key followed by the **▲** and **▼** keys to bring up the I or Q input invert menu. Press the numeric key corresponding to the input to change its state. The input is inverted when its number is displayed in the invert menu. (see "Inverting data and clock inputs" - Local Operation section)
4. Record the real and imaginary components as indicated by the network analyzer display in Table 5-18 16QAM Results (Scalar = 0.33 V) below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 999 mU on the network analyzer represents 99.9%. A reading of 100  $\mu$ U represents 0.01%.
5. Invert DIGITAL INPUT Q1 by pressing the **INVERT INPUT** key followed by **▲** or **▼** until "INV Q" is displayed. Then press numeric key **1** to invert DIGITAL INPUT Q1.
6. Record the real and imaginary components as indicated by the network analyzer display in Table 5-18 16QAM Results (Scalar = 0.33 V) below.
7. Continue measuring the remaining fourteen states and record the results in Table 5-18 16QAM Results (Scalar = 0.33 V) below.

Table 5-18. 16QAM Results (Scalar = 0.33 V)

Digital Inputs				Real (I) Component	Imaginary (Q) Component
I0	I1	Q0	Q1		
0	0	0	0	_____ ( $\approx 23.3\%$ )	_____ ( $\approx 23.3\%$ )
0	0	0	1	_____ ( $\approx 23.3\%$ )	_____ ( $\approx 7.78\%$ )
0	0	1	0	_____ ( $\approx 23.3\%$ )	_____ ( $\approx -7.78\%$ )
0	0	1	1	_____ ( $\approx 23.3\%$ )	_____ ( $\approx -23.3\%$ )
0	1	0	0	_____ ( $\approx 7.78\%$ )	_____ ( $\approx 23.3\%$ )
0	1	0	1	_____ ( $\approx 7.78\%$ )	_____ ( $\approx 7.78\%$ )
0	1	1	0	_____ ( $\approx 7.78\%$ )	_____ ( $\approx -7.78\%$ )
0	1	1	1	_____ ( $\approx 7.78\%$ )	_____ ( $\approx -23.3\%$ )
1	0	0	0	_____ ( $\approx -7.78\%$ )	_____ ( $\approx 23.3\%$ )
1	0	0	1	_____ ( $\approx -7.78\%$ )	_____ ( $\approx 7.78\%$ )
1	0	1	0	_____ ( $\approx -7.78\%$ )	_____ ( $\approx -7.78\%$ )
1	0	1	1	_____ ( $\approx -7.78\%$ )	_____ ( $\approx -23.3\%$ )
1	1	0	0	_____ ( $\approx -23.3\%$ )	_____ ( $\approx 23.3\%$ )
1	1	0	1	_____ ( $\approx -23.3\%$ )	_____ ( $\approx 7.78\%$ )
1	1	1	0	_____ ( $\approx -23.3\%$ )	_____ ( $\approx -7.78\%$ )
1	1	1	1	_____ ( $\approx -23.3\%$ )	_____ ( $\approx -23.3\%$ )

8. Divide each measured I and Q (real and imaginary) component by the scalar input voltage. This normalizes the measured data to the full scale reference. Record each value in Table 5-19 16QAM Measurement Worksheet (0.33 V) below.

Table 5-19. 16QAM Measurement Worksheet (0.33 V)

Digital Inputs I0 I1, Q0 Q1	Normalized Real Part = Measured Real ÷ Scalar Input Volt.	Normalized Imag. Part = Measured Imag. ÷ Scalar Input Volt.	Computed Real Part = Normalized Real Part - I-channel Offset	Computed Imag. Part = Normalized Imag. Part - Q-channel Offset
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

9. Add all the normalized I components, divide by 16, and record the value. This number is the I-channel offset, and should be close to 0.

I-channel offset \_\_\_\_\_ ( $\approx 0$ )

10. Add all the normalized Q components, divide by 16, and record the value. This number is the Q-channel offset, and should be close to 0.

Q-channel offset \_\_\_\_\_ ( $\approx 0$ )

11. Subtract the I-channel offset from each of the normalized I components, and subtract the Q-channel offset from each of the normalized Q components. This is the computed value. Record each value in Table 5-19 16QAM Measurement Worksheet (0.33 V). Compare these values to the ideal values given in Table 5-15 16QAM Results (Scalar Off). All measured data should be within  $\pm 1\%$  of the ideal values.

**Note**

If all measurements are within specification, record the results in Table 5-31 "Performance Test Record".

If any measurement does not meet specifications, refer to the section entitled "Correction Factors" at the end of this procedure to determine whether a correction factor must be applied to bring the measurement within specification.

**Measure: Scalar Input = 0.10V**

1. Connect the function generator output to the voltmeter, and set the function generator output to approximately 0.10 V. Record the exact value.

Scalar Input voltage. \_\_\_\_\_ V.

2. Connect the function generator to the generator's scalar input, and turn scalar modulation on by pressing the **SCALAR ON** key.
3. Set the I and Q digital inputs to non-inverted. If required, change the digital modulation state by pressing the **INVERT INPUT** key followed by the **▲** and **▼** keys to bring up the I or Q input invert menu. Press the numeric key corresponding to the input to change its state. The input is inverted when its number is displayed in the invert menu. (see "Inverting data and clock inputs" - Local Operation section)
4. Record the real and imaginary components as indicated by the network analyzer display in Table 5-20 16QAM Results (Scalar = 0.10 V) below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 999 mU on the network analyzer represents 99.9%. A reading of 100 $\mu$  represents 0.01%.
5. Invert DIGITAL INPUT Q1 by pressing the **INVERT INPUT** key followed by **▲** or **▼** until "INV Q" is displayed. Then press numeric key **1** to invert DIGITAL INPUT Q1.
6. Record the real and imaginary components as indicated by the network analyzer display in Table 5-20 16QAM Results (Scalar = 0.10 V) below.
7. Continue measuring the remaining fourteen states and record the results in Table 5-20 16QAM Results (Scalar = 0.10 V) below.

Table 5-20. 16QAM Results (Scalar = 0.10 V)

Digital Inputs				Real (I) Component	Imaginary (Q) Component
I0	I1	Q0	Q1		
0	0	0	0	_____ (≈7.07%)	_____ (≈7.07%)
0	0	0	1	_____ (≈7.07%)	_____ (≈2.36%)
0	0	1	0	_____ (≈7.07%)	_____ (≈-2.36%)
0	0	1	1	_____ (≈7.07%)	_____ (≈-7.07%)
0	1	0	0	_____ (≈7.07%)	_____ (≈7.07%)
0	1	0	1	_____ (≈2.36%)	_____ (≈2.36%)
0	1	1	0	_____ (≈2.36%)	_____ (≈-2.36%)
0	1	1	1	_____ (≈2.36%)	_____ (≈-7.07%)
1	0	0	0	_____ (≈-2.36%)	_____ (≈7.07%)
1	0	0	1	_____ (≈-2.36%)	_____ (≈2.36%)
1	0	1	0	_____ (≈-2.36%)	_____ (≈-2.36%)
1	0	1	1	_____ (≈-2.36%)	_____ (≈-7.07%)
1	1	0	0	_____ (≈-7.07%)	_____ (≈7.07%)
1	1	0	1	_____ (≈-7.07%)	_____ (≈2.36%)
1	1	1	0	_____ (≈-7.07%)	_____ (≈-2.36%)
1	1	1	1	_____ (≈-7.07%)	_____ (≈-7.07%)

8. Divide each measured I and Q (real and imaginary) component by the scalar input voltage. This normalizes the measured data to the full scale reference. Record each value in Table 5-21 16QAM Measurement Worksheet (0.10 V) below.

Table 5-21. 16QAM Measurement Worksheet (0.10 V)

Digital Inputs I0 I1, Q0 Q1	Normalized Real Part = Measured Real ÷ Scalar Input Volt.	Normalized Imag. Part = Measured Imag. ÷ Scalar Input Volt.	Computed Real Part = Normalized Real Part - I-channel Offset	Computed Imag. Part = Normalized Imag. Part - Q-channel Offset
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

9. Add all the normalized I components, divide by 16, and record the value. This number is the I-channel offset, and should be close to 0.

I-channel offset \_\_\_\_\_ ( $\approx 0$ )

10. Add all the normalized Q components, divide by 16, and record the value. This number is the Q-channel offset, and should be close to 0.

Q-channel offset \_\_\_\_\_ ( $\approx 0$ )

11. Subtract the I-channel offset from each of the normalized I components, and subtract the Q-channel offset from each of the normalized Q components. This is the computed value. Record each value in Table 5-21 16QAM Measurement Worksheet (0.10 V). Compare these values to the ideal values given in Table 5-15 16QAM Results (Scalar Off). All measured data should be within  $\pm 2\%$  of the ideal values.

**Note**

If all measurements are within specification, record the results in Table 5-31 "Performance Test Record".

If any measurement does not meet specifications, refer to the section entitled "Correction Factors" at the end of this procedure to determine whether a correction factor must be applied to bring the measurement within specification.

**Correction Factors**

The specification for scalar dc accuracy is presented as a percentage of full scale magnitude. There is an implied I/Q coordinate system which can be described by the Full Scale I Vector. The Full Scale I Vector for scalar mode is defined to be the same as the Full Scale I Vector for non-scalar mode. This is important since scalar modulation with exactly 1.00 V input should be exactly the same as digital modulation with scalar off. The reference for scalar modulation is found by measuring digital modulation DC accuracy with scalar off, and then using the same process as in the Digital Modulation DC Accuracy test. This procedure is reviewed below.

Normalizing the network analyzer to the +I BPSK state approximately finds the Full Scale I Vector for non-scalar digital modulation. The definition of the Full Scale I Vector is that the vector has a magnitude and phase almost equal to the +I BPSK state, and that the exact magnitude and phase is such that the non-scalar maximum I or Q error is minimized. Vectors with magnitudes much larger than the magnitude of the +I BPSK state will appear to minimize the error (because error is expressed as a percent of full scale), but clearly this is not the correct value for full scale.

Defining the Full Scale I vector as something near the +I BPSK state is equivalent to compensating for a length of physical transmission line connected on the output of the signal generator. If a length of transmission line were added, the magnitude and phase of the signal will change; the I/Q coordinate system and hence the reference vector would need to change accordingly.

For engineers familiar with Digital Microwave radio, picking the I Full Scale vector is equivalent to setting the automatic gain control (AGC) and carrier lock angle for minimum bit error rate (BER).

To pick the best I Full Scale vector requires minimizing the maximum I or Q error. This is a complicated optimization problem which requires a computer to solve. It is somewhat easier to reduce the maximum magnitude and phase errors especially when some assumptions are made about the error mechanisms in the signal.

In most cases, selecting one of the full scale states as the full scale value is sufficient to verify that the generator is within specification. However, if the reference selected is at one extreme (maximum or minimum), the test may not pass if another value is at the other extreme.

To correct for this error, a scaling factor must be calculated to scale all of the measured values according to the average full scale reading. For example, if the maximum magnitude is 99%, and the minimum magnitude is 98%, all of the values must be divided by a scaling factor (the average of 98% and 99%) so that the two measurements correspond to 100.5% and 99.5% ( $100\% \pm 0.5\%$ ). This reduces the error measured to within the specification.

Note that for this Scalar DC Accuracy test, I and Q offsets (carrier leakage) *ARE* subtracted from the measured data. This breaks the I and Q errors into two parts, the offsets, and the remaining errors. Only the remaining errors are specified. Note that in the Digital Modulation DC Accuracy test, both the offsets and remaining errors are specified. Since the Scalar DC Accuracy test uses the non-scalar mode to find the Full Scale I vector, any gain or offset errors in the scalar input circuits *ARE* specified.

### 16QAM Correction factors

1. Square the real and imaginary component of the measured values of the first state (0 0, 0 0). Record the values.

\_\_\_\_\_ Real Component Squared ( $\approx 5000.0$ )  
 \_\_\_\_\_ Imaginary Component Squared ( $\approx 5000.0$ )

2. Add the two values together and then take the square root of the result. This is the measured magnitude of the first state. Record this value below and in Table 5-22 16QAM Magnitude Error Worksheet.

\_\_\_\_\_ Magnitude of State (0 0, 0 0) ( $\approx 100$ )

3. Divide the Measured Magnitude by the Ideal Magnitude for State (0 0, 0 0) which is 100. This is the Magnitude error for State (0 0, 0 0). Record this value below and in Table 5-22 16QAM Magnitude Error Worksheet.

\_\_\_\_\_ Magnitude Error of State (0 0, 0 0) ( $\approx 1$ )

4. Repeat the procedure for the other fifteen states and record the measured magnitudes and magnitude errors in Table 5-22 16QAM Magnitude Error Worksheet below.

5. Take the largest and smallest magnitude errors, add them together, and then divide the result by two. This is the 16QAM Magnitude Scaling Factor. Record the value.

\_\_\_\_\_ 16QAM Magnitude Scaling Factor ( $\approx 1$ )

Divide each of the 16QAM magnitudes by the Magnitude scaling factor and record the results in Table 5-24 16QAM Corrected Measurement Worksheet (Scalar Off) below.

Table 5-22. 16QAM Magnitude Error Worksheet (Scalar Off)

Digital Inputs I0 I1, Q0 Q1	Measured Mag. $= \sqrt{\text{Real}^2 + \text{Imag}^2}$	Ideal Mag.	Mag. Error $= \text{Measured Mag.} \div \text{Ideal Mag.}$
(0 0, 0 0)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(0 0, 0 1)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(0 0, 1 0)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(0 0, 1 1)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(0 1, 0 0)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(0 1, 0 1)	_____ ( $\approx 33.33\%$ )	33.33%	_____
(0 1, 1 0)	_____ ( $\approx 33.33\%$ )	33.33%	_____
(0 1, 1 1)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(1 0, 0 0)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(1 0, 0 1)	_____ ( $\approx 33.33\%$ )	33.33%	_____
(1 0, 1 0)	_____ ( $\approx 33.33\%$ )	33.33%	_____
(1 0, 1 1)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(1 1, 0 0)	_____ ( $\approx 100.0\%$ )	100.0%	_____
(1 1, 0 1)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(1 1, 1 0)	_____ ( $\approx 74.54\%$ )	74.54%	_____
(1 1, 1 1)	_____ ( $\approx 100.0\%$ )	100.0%	_____

6. Divide the real and imaginary component of the measured values of the first state (0 0, 0 0). Record the values.

\_\_\_\_\_ Imaginary  $\div$  Real part (0 0, 0 0) ( $\approx 1.00$ )

7. Compute the Inverse Tangent (in degrees) of the quotient, and record the result below.

\_\_\_\_\_  $\text{Tan}^{-1}(\text{Imaginary} \div \text{Real})$  ( $\approx 45.0^\circ$ )

8. Subtract the ideal angle for state (0 0, 0 0) ( $45^\circ$ ) from the measured angle. This is the phase error for this state. A positive error means that this state has moved counter-clockwise from its ideal location.

Measured angle state (0 0, 0 0) -  $45.0^\circ$  = \_\_\_\_\_ Phase error state (0 0, 0 0)

9. Repeat this procedure for each of the remaining states according to Table 5-23 16QAM Phase Error Worksheet below. Note that the  $\text{Tan}^{-1}$  function is only defined for  $\pm 90^\circ$ . For states in any but the upper right quadrant it is necessary to add a quadrant correction of either  $180^\circ$  or  $360^\circ$ .

Table 5-23. 16QAM Phase Error Worksheet (Scalar Off)

Digital Inputs I0 I1, Q0 Q1	Imaginary ÷ Real	$\tan^{-1}$	Quad. Corr.	Meas. Phase = $\tan^{-1}$ + Quad. Correction	Ideal Phase	Phase Error = Meas. Phase - Ideal
(0 0, 0 0)			0°		45.00°	
(0 0, 0 1)			0°		71.57°	
(0 0, 1 0)			180°		108.43°	
(0 0, 1 1)			180°		135.00°	
(0 1, 0 0)			0°		18.43°	
(0 1, 0 1)			0°		45.00°	
(0 1, 1 0)			180°		135.00°	
(0 1, 1 1)			180°		161.57°	
(1 0, 0 0)			360°		341.57°	
(1 0, 0 1)			360°		315.00°	
(1 0, 1 0)			180°		225.0°	
(1 0, 1 1)			180°		198.43°	
(1 1, 0 0)			360°		315.00°	
(1 1, 0 1)			360°		288.43°	
(1 1, 1 0)			180°		251.57°	
(1 1, 1 1)			180°		225.00°	

10. Take the largest and smallest phase errors, add them together, and then divide the result by two. This is the 16QAM Phase Scaling Factor. Record the value.

\_\_\_\_\_ 16QAM Phase Scaling Factor

11. Subtract the 16QAM Phase Scaling Factor from each of the measured phases computed in Table 5-23 16QAM Phase Error Worksheet (The  $\tan^{-1}$  + Quad. Correction values). This is the corrected phase. Record the result in the 16QAM Corrected Measurement Worksheet Table 5-24 below.

12. Using the corrected magnitude and corrected phase for 16QAM state (0 0, 0 0), compute the corrected real and imaginary parts.

Corrected Real = Corrected Magnitude × Cos(Corrected Phase)

Corrected Imaginary = Corrected Magnitude × Sin(Corrected Phase)

Record these two numbers in the 16QAM Corrected Measurement Worksheet Table 5-24 below, and compare the new

real and imaginary parts to the specified values in Table 5-15 16QAM Results (Scalar Off) above.

13. If the corrected 16QAM (Scalar Off) measurement is in specification, then the magnitude and phase correction factors may be applied to the three sets of scalar accuracy measurements. Worksheets are given for each of the three scalar input voltages. First compute the magnitude and phase of each state using the same technique as used above. Be sure to use the "Computed" Real and Imaginary parts from the 16QAM Measurement Worksheets. These values have be scaled and had offsets subtracted. Record the magnitudes and phases in the 16QAM Magnitude and Phase Worksheets. Next apply the correction factors, and record the corrected measurements in the 16QAM Corrected Measurement Worksheets.
14. Compare the corrected I and Q (Real and Imaginary) components to the ideal values given in Table 5-15 16QAM Results (Scalar Off). Note that the different scalar input voltages have different specifications. Record the corrected values in Table 5-31 "Performance Test Record".

Table 5-24. 16QAM Corrected Measurement Worksheet (Scalar Off)

Digital Inputs I0 I1, Q0 Q1	Corrected Mag. = Measured Mag. ÷ Mag. Scaling Factor	Corrected Phase = Measured Phase - Phase Scaling Fact.	Corrected Real Part = Corrected Mag. × Cos(Cor. Phase)	Corrected Imag. Part = Corrected Mag. × Sin(Cor. Phase)
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

HP 8782B

Scalar Modulation DC Accuracy

Table 5-25. 16QAM Magnitude and Phase Worksheet (Scalar = 1.0 V)

Digital Inputs I0 I1, Q0 Q1	Measured Mag. $= \sqrt{\text{Real}^2 + \text{Imag}^2}$	Ideal Mag.	Imaginary $\div$ Real	$\text{Tan}^{-1}$	Quad. Corr.	Meas. Phase $= \text{Tan}^{-1} +$ Quad. Corr.	Ideal Phase
(0 0, 0 0)		100.0%			0°		45.00°
(0 0, 0 1)		74.54%			0°		71.57°
(0 0, 1 0)		74.54%			180°		108.43°
(0 0, 1 1)		100.0%			180°		135.00°
(0 1, 0 0)		74.54%			0°		18.43°
(0 1, 0 1)		33.33%			0°		45.00°
(0 1, 1 0)		33.33%			180°		135.00°
(0 1, 1 1)		74.54%			180°		161.57°
(1 0, 0 0)		74.54%			360°		341.57°
(1 0, 0 1)		33.33%			360°		315.00°
(1 0, 1 0)		33.33%			180°		225.00°
(1 0, 1 1)		74.54%			180°		198.43°
(1 1, 0 0)		100.0%			360°		315.00°
(1 1, 0 1)		74.54%			360°		288.43°
(1 1, 1 0)		74.54%			180°		251.57°
(1 1, 1 1)		100.0%			180°		225.00°

Table 5-26. 16QAM Corrected Measurement Worksheet (Scalar = 1.0 V)

Digital Inputs I0 I1, Q0 Q1	Corrected Mag. = Measured Mag. ÷ Mag. Scaling Factor	Corrected Phase = Measured Phase - Phase Scaling Fact.	Corrected Real Part = Corrected Mag. × Cos(Cor. Phase)	Corrected Imag. Part = Corrected Mag. × Sin(Cor. Phase)
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

HP 8782B

Scalar Modulation DC Accuracy

Table 5-27. 16QAM Magnitude and Phase Worksheet (Scalar = 0.33 V)

Digital Inputs I0 I1, Q0 Q1	Measured Mag. $= \sqrt{\text{Real}^2 + \text{Imag}^2}$	Ideal Mag.	Imaginary $\div$ Real	$\text{Tan}^{-1}$	Quad. Corr.	Meas. Phase $= \text{Tan}^{-1} +$ Quad. Corr.	Ideal Phase
(0 0, 0 0)		100.0%			0°		45.00°
(0 0, 0 1)		74.54%			0°		71.57°
(0 0, 1 0)		74.54%			180°		108.43°
(0 0, 1 1)		100.0%			180°		135.00°
(0 1, 0 0)		74.54%			0°		18.43°
(0 1, 0 1)		33.33%			0°		45.00°
(0 1, 1 0)		33.33%			180°		135.00°
(0 1, 1 1)		74.54%			180°		161.57°
(1 0, 0 0)		74.54%			360°		341.57°
(1 0, 0 1)		33.33%			360°		315.00°
(1 0, 1 0)		33.33%			180°		225.00°
(1 0, 1 1)		74.54%			180°		198.43°
(1 1, 0 0)		100.0%			360°		315.00°
(1 1, 0 1)		74.54%			360°		288.43°
(1 1, 1 0)		74.54%			180°		251.57°
(1 1, 1 1)		100.0%			180°		225.00°

## Scalar Modulation DC Accuracy

HP 8782B

Table 5-28. 16QAM Corrected Measurement Worksheet (Scalar = 0.33 V)

Digital Inputs I0 I1, Q0 Q1	Corrected Mag. = Measured Mag. ÷ Mag. Scaling Factor	Corrected Phase = Measured Phase - Phase Scaling Fact.	Corrected Real Part = Corrected Mag. × Cos(Cor. Phase)	Corrected Imag. Part = Corrected Mag. × Sin(Cor. Phase)
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

HP 8782B

Scalar Modulation DC Accuracy

Table 5-29. 16QAM Magnitude and Phase Worksheet (Scalar = 0.10 V)

Digital Inputs I0 I1, Q0 Q1	Measured Mag. $= \sqrt{\text{Real}^2 + \text{Imag}^2}$	Ideal Mag.	Imaginary $\div$ Real	$\text{Tan}^{-1}$	Quad. Corr.	Meas. Phase $= \text{Tan}^{-1} +$ Quad. Corr.	Ideal Phase
(0 0, 0 0)		100.0%			0°		45.00°
(0 0, 0 1)		74.54%			0°		71.57°
(0 0, 1 0)		74.54%			180°		108.43°
(0 0, 1 1)		100.0%			180°		135.00°
(0 1, 0 0)		74.54%			0°		18.43°
(0 1, 0 1)		33.33%			0°		45.00°
(0 1, 1 0)		33.33%			180°		135.00°
(0 1, 1 1)		74.54%			180°		161.57°
(1 0, 0 0)		74.54%			360°		341.57°
(1 0, 0 1)		33.33%			360°		315.00°
(1 0, 1 0)		33.33%			180°		225.00°
(1 0, 1 1)		74.54%			180°		198.43°
(1 1, 0 0)		100.0%			360°		315.00°
(1 1, 0 1)		74.54%			360°		288.43°
(1 1, 1 0)		74.54%			180°		251.57°
(1 1, 1 1)		100.0%			180°		225.00°

Scalar Modulation DC Accuracy

HP 8782B

Table 5-30. 16QAM Corrected Measurement Worksheet (Scalar = 0.10 V)

Digital Inputs I0 I1, Q0 Q1	Corrected Mag. = Measured Mag. ÷ Mag. Scaling Factor	Corrected Phase = Measured Phase - Phase Scaling Fact.	Corrected Real Part = Corrected Mag. × Cos(Cor. Phase)	Corrected Imag. Part = Corrected Mag. × Sin(Cor. Phase)
(0 0, 0 0)	_____	_____	_____	_____
(0 0, 0 1)	_____	_____	_____	_____
(0 0, 1 0)	_____	_____	_____	_____
(0 0, 1 1)	_____	_____	_____	_____
(0 1, 0 0)	_____	_____	_____	_____
(0 1, 0 1)	_____	_____	_____	_____
(0 1, 1 0)	_____	_____	_____	_____
(0 1, 1 1)	_____	_____	_____	_____
(1 0, 0 0)	_____	_____	_____	_____
(1 0, 0 1)	_____	_____	_____	_____
(1 0, 1 0)	_____	_____	_____	_____
(1 0, 1 1)	_____	_____	_____	_____
(1 1, 0 0)	_____	_____	_____	_____
(1 1, 0 1)	_____	_____	_____	_____
(1 1, 1 0)	_____	_____	_____	_____
(1 1, 1 1)	_____	_____	_____	_____

**Other Formats**

In order to measure the DC accuracy of modulation formats other than the ones listed in this manual, the ideal real and imaginary values for each state must be calculated. All of the 8PSK (Digital Modulation DC Accuracy test) and 16QAM (Scalar Modulation DC Accuracy test) states are listed in this manual. Eighteen of the 256 states in 256QAM are listed in the Digital Modulation DC Accuracy test. This section describes how to calculate the parameters of any state in any of the rectangular modulations.

1. Calculate N which gives the number of states along a side of a rectangular modulation.

$$N = \sqrt{\text{Number of states}}$$

For example, 25PRS has 25 states, so  $N = 5$ .

2. Compute the binary value of the I and Q parts of the data input corresponding to the state. Refer to the Modulation Format Constellation diagram in Section 3, Local Operation. I0 and Q0 are the most significant bits. For example, the lower right state in 25PRS has an I value of:

$$\begin{aligned} I_{\text{binary}} &= 000_{\text{binary}} \\ &= 0 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 \\ &= 0 \times 4 + 0 \times 2 + 0 \times 1 \\ &= 0_{\text{decimal}} \end{aligned}$$

The Q value is:

$$\begin{aligned} Q_{\text{binary}} &= 100_{\text{binary}} \\ &= 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 \\ &= 1 \times 4 + 0 \times 2 + 0 \times 1 \\ &= 4_{\text{decimal}} \end{aligned}$$

3. From the binary values, compute the I (real) and Q (imaginary) components:

$$I \text{ or } Q \text{ value} = \frac{1 - \left(\frac{2}{(N-1)}\right) \times (\text{Binary Value})}{\sqrt{2}}$$

Using the same 25PRS example as before:

$$\begin{aligned} \text{I value} &= \frac{1 - \left(\frac{2}{5-1}\right) \times (0)}{\sqrt{2}} \\ &= \frac{1}{\sqrt{2}} \\ &= 0.7071 \end{aligned}$$

$$\begin{aligned} \text{Q value} &= \frac{1 - \left(\frac{2}{5-1}\right) \times (4)}{\sqrt{2}} \\ &= \frac{1 - \left(\frac{1}{2}\right) \times (4)}{\sqrt{2}} \\ &= \frac{-1}{\sqrt{2}} \\ &= -0.7071 \end{aligned}$$

**Note**




---

The above equations do not apply to BPSK and 8PSK modulation. BPSK and 8PSK are not rectangular modulations. 8PSK is fully calculated in the Digital Modulation DC Accuracy test. BPSK has I values of  $\pm 1.00$  and Q values of 0.00.

---

4. To use these I and Q values to compare with measured data, convert these two values to percent by multiplying by 100.

For example, 0.7071 becomes 70.71%.

5. Compute the magnitude of the state using the I and Q values, (not the percent values).

$$\text{Magnitude} = \sqrt{I^2 + Q^2}$$

For the 25PRS example:

$$\begin{aligned} \text{Magnitude} &= \sqrt{0.7071^2 + -0.7071^2} \\ &= \sqrt{\frac{1}{2} + \frac{1}{2}} \\ &= 1 \end{aligned}$$

6. Compute the phase of the state. Since the range of arctangent ( $\text{Tan}^{-1}$ ) is only defined for  $\pm 90^\circ$ , it is necessary to consider several special cases:

For  $I > 0$ , and  $Q \geq 0$ :

$$\text{Phase} = \text{Tan}^{-1} \left( \frac{Q}{I} \right)$$

For  $I > 0$ , and  $Q < 0$ :

$$\text{Phase} = \text{Tan}^{-1} \left( \frac{Q}{I} \right) + 360^\circ$$

For  $I = 0$ , and  $Q > 0$ :

$$\text{Phase} = 90^\circ$$

For  $I = 0$ , and  $Q = 0$ :

Phase = Indeterminate

For  $I = 0$ , and  $Q < 0$ :

$$\text{Phase} = 90^\circ$$

For  $I < 0$ :

$$\text{Phase} = \text{Tan}^{-1} \left( \frac{Q}{I} \right) + 180^\circ$$

### Note



If the phase is indeterminate, (the magnitude of a vector of zero length is undefined), then *DO NOT* use this state to calculate the magnitude or phase correction factors.

Going back to the 25PRS example,  $I$  is  $> 0$  and  $Q$  is  $< 0$  so the correct phase equation is:

$$\begin{aligned} \text{Phase} &= \text{Tan}^{-1} \left( \frac{Q}{I} \right) + 360^\circ \\ &= \text{Tan}^{-1} \left( \frac{-0.7071}{0.7071} \right) + 360^\circ \\ &= \text{Tan}^{-1} (-1) + 360^\circ \\ &= -45^\circ + 360^\circ \\ &= 315^\circ \end{aligned}$$

## Vector Modulation DC Accuracy

### Specification

Electrical Characteristics	Performance Limits	Conditions
VECTOR MODULATION		
I and Q Inputs Sensitivity	$\pm 0.5$ volts into $50\Omega$	Produces $\pm 100\%$ of full scale
dc Accuracy	$< 1.5\%$ of full scale	140 MHz Carrier < +7 dBm Levels ( $I^2 + Q^2$ ) $< 0.25$ volts <sup>2</sup>

### Description

The RF output and the coherent carrier of the Generator are connected to a network analyzer to view the real and imaginary (I and Q) components of the RF signal. The network analyzer is calibrated to represent 100% as a full scale reading. Various I and Q component settings are measured with the network analyzer to determine dc accuracy.

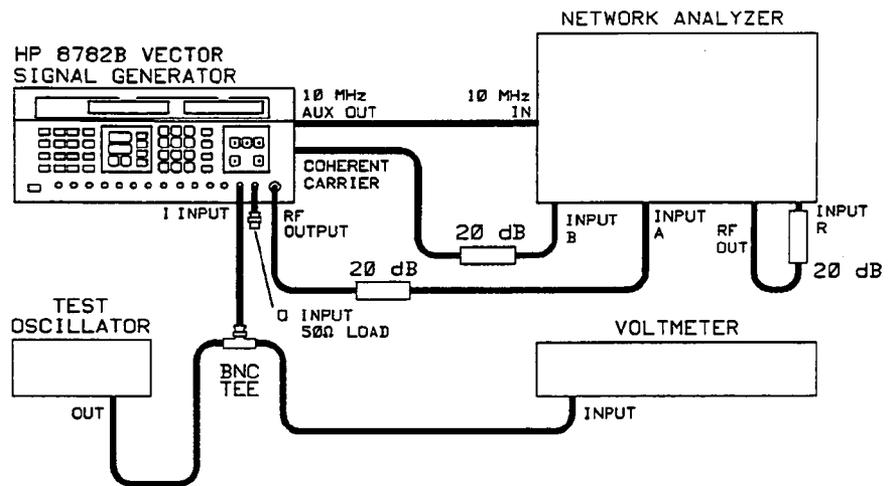
### Equipment

Network Analyzer ..... HP 8753C  
 Test Oscillator ..... HP 8116A  
 Digital Voltmeter (DVM) ..... HP 3456A  
 Termination, BNC  $50\Omega$  ..... HP 11593A  
 20 dB Attenuator (3 off) ..... HP 8491A Option 020

HP 8782B

Vector Modulation DC Accuracy

**Connections**



**Figure 5-33. Vector dc Accuracy Test Setup**

**Procedure**

1. Connect the equipment as shown in Figure 5-33. The Generator 10 MHz auxiliary output must be connected to the network analyzer to provide a common timebase for the measurements.
2. Press the INSTR PRESET key on the Generator. Press the CAL key to perform a self-calibration.
3. Once the calibration is complete, set the Generator to 140 MHz at an output level of +7 dBm.
4. Set the network analyzer to the following settings:

**Network Analyzer Settings**

Setting	HP 8753C Press these keys/softkeys
Preset	PRESET
Input	MEAS, A/B
Display Mode	FORMAT, POLAR
Frequency Sweep Mode	MENU, NUMBER OF POINTS, 3, X1
Frequency	MENU, CW FREQ, 140, M (MHz)
Amplitude	MENU, POWER, -10 X1 (dBm)
Bandwidth	AVG, IF BW, 10, X1 (Hz)

**Note**

---

In order to obtain the stability for making the following measurements, all instruments must have a warm up time of at least one hour. In addition, the network analyzer and Generator must use a common timebase to prevent a frequency error between instruments. A frequency error will produce a continuous phase shift (rotation) of the displayed signal.

---

5. Connect the test oscillator to VECTOR I INPUT on the Generator.
6. Connect the 50Ω load to the VECTOR Q INPUT.
7. Press the **MODULATION** key until Vector Modulation is indicated on the display, then press the **MODULATION ON** key.
8. Set the test oscillator for a dc output of  $+500 \pm 1$  mVdc as indicated by the voltmeter. This will set the output signal to full scale at a phase angle of  $0^\circ$ .

**Note**

---

To use the test oscillator as a dc source, disable the waveform and use the dc offset control. If necessary, reduce the test oscillator frequency setting to less than 10 Hz to avoid a residual signal at the output.

Using a 6 dB attenuator between the test oscillator output and the voltmeter - VECTOR I INPUT connection will provide better resolution on setting the input voltage. The test oscillator setting will be approximately twice the desired voltage.

---

9. Normalize the network analyzer by entering the following key sequence. Normalizing the displayed signal will place the signal on the horizontal axis ( $0^\circ$  phase) with a full scale magnitude. This step is required to calibrate the network analyzer display to the RF output signal of the Generator and to cancel phase shifts due to test setup and frequency related effects.

**HP 8753C:** CAL, CALIBRATE MENU, RESPONSE, THRU, DONE:RESPONSE (when done)

10. Set the network analyzer to read the signal in terms of the real and imaginary components (corresponding to the I and Q components) by entering the following key sequence.

**HP 8753C:** MKR, MARKER MODE MENU, POLAR MKR MENU, Re/Im MKR

---

**Note**

---

In the following procedure, maximum averaging (16 points for the HP 8753A) should be used on the network analyzer to provide the highest resolution readings. However, to improve overall measurement speed, turn off averaging when changing the modulation input voltage. This will enable the network analyzer to respond faster to the change in magnitude and phase. Reactivate averaging once the displayed signal has settled.

---

11. Record the real and imaginary components as indicated by the network analyzer display in the table below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 993E-3 (993 mU on the HP 8753A) on the network analyzer represents 99.3%. A reading of 100E-6 (100  $\mu$ U on the HP 8753A) represents 0.01%.
12. Reset the test oscillator dc output for each of the levels indicated and record the results below. The level at the input of the Generator must be within 1 mVdc of the level indicated.

**I Channel Results**

VECTOR I input	Real Component	Imaginary (Residual) Component
+500 mVdc	_____ %	_____ %
+250 mVdc	_____ %	_____ %
-250 mVdc	_____ %	_____ %
-500 mVdc	_____ %	_____ %

13. Connect the test oscillator to the VECTOR INPUT Q and connect the 50 $\Omega$  load to the VECTOR I INPUT.
14. Set the test oscillator output for +500  $\pm$ 1 mVdc as indicated by the voltmeter.
15. Record the real and imaginary components as indicated by the network analyzer display in the table below. Convert the measured readings to percent by multiplying each reading by 100%. For example, a reading of 995E-3 on the network analyzer represents 99.5%.
16. Reset the test oscillator output for each of the levels indicated and record the results below. The level at the input of the Generator must be within 1 mVdc of the value indicated.

**Q Channel Results**

VECTOR Q input	Real (Residual) Component	Imaginary Component
+500 mVdc	_____ %	_____ %
+250 mVdc	_____ %	_____ %
-250 mVdc	_____ %	_____ %
-500 mVdc	_____ %	_____ %

17. Complete the following table using the values entered in the tables above. Copy the real column results from the first table into the I

column below. Copy the imaginary column results from the second table into the Q column below.

Verify also that the worst-case residual level in each of the two tables is within  $\pm 1.0\%$  of 0%. If all measurements are within specification, copy the results table into Table 5-31 and proceed with the next test.

\_\_\_\_\_ % Worst-Case Residual ( $0 \pm 1.0\%$ )

#### Vector dc Accuracy Results

VECTOR INPUT	Expected Result	I Channel Results	Q Channel Results
+500 mVdc	$100 \pm 1.0\%$	_____ %	_____ %
+250 mVdc	$50 \pm 1.0\%$	_____ %	_____ %
-250 mVdc	$-50 \pm 1.0\%$	_____ %	_____ %
-500 mVdc	$-100 \pm 1.0\%$	_____ %	_____ %

#### Note



If any of the results are not within specification, a correction factor must be applied to account for the use of the first measurement point as the true full-scale value. The remaining part of this procedure is used to account for the full scale error introduced by the procedure. The following steps are not required if all measurements are within specification.

18. Calculate the average full scale value by adding the four full scale ( $\pm 500$  mVdc inputs) and dividing by four.

For example, the average full scale value for readings of  $+100.0\%$ ,  $-101.6\%$ ,  $+99.9\%$  and  $-100.3\%$  would be:

$$(100.0 + 101.6 + 99.9 + 100.3)/4 = 100.45\%$$

\_\_\_\_\_ % Average Full Scale Value

19. Calculate the correction factor by dividing the first measured value ( $+500$  mVdc I channel) by the average full scale value calculated above. The first measured value is used in the calculation since the network analyzer is normalized to this value (making it the full scale reference). This correction will be used to scale each of the readings to the correct scale using the average full scale value as full scale.

\_\_\_\_\_ Correction Factor (First Measurement / Average Full Scale)

20. Multiply each of the readings in the results table by the correction factor to determine the corrected reading. Each reading should now fall within the indicated limits.

HP 8782B

## Vector Modulation DC Accuracy

Verify also that all residual readings are within  $\pm 1.0\%$  of 0% after being multiplied by the correction factor. Copy the corrected results table and the worst case corrected residual into Table 5-31.

\_\_\_\_\_ % Worst-Case Corrected Residual ( $0 \pm 1.0\%$ )

## Vector dc Accuracy Corrected Results

VECTOR INPUT	Expected Results	I Channel (Corrected)	Q Channel (Corrected)
+500 mVdc	$100 \pm 1.0\%$	_____ %	_____ %
+250 mVdc	$50 \pm 1.0\%$	_____ %	_____ %
-250 mVdc	$-50 \pm 1.0\%$	_____ %	_____ %
-500 mVdc	$-100 \pm 1.0\%$	_____ %	_____ %

## Vector Modulation Frequency Response

### Specification

Electrical Characteristics	Performance Limits	Conditions
VECTOR MODULATION		
dc Residual	<1% of Full Scale	Residual I and Q Output for 0 volt I and Q Input, 140 MHz Carrier
Frequency Response (1 dB Bandwidth)	dc to 50 MHz	140 MHz Carrier

**Description** The test is divided into a frequency response test and a dc residual test. Each test is described below.

#### Vector Modulation Frequency Response

The output of the Generator is a double-sideband suppressed carrier signal when vector modulation is selected. The power level is directly proportional to the modulation level plus the frequency response of the modulation circuitry.

By maintaining the modulation signal power constant over the entire modulation frequency range, a direct power measurement of the Generator output level can be made to determine the frequency response. The output level of the Generator should not vary more than 1 dB over the entire modulation frequency range.

#### Vector Modulation dc Residual

A spectrum analyzer is used to measure the (residual) carrier level with 0 volt modulation inputs. The residual carrier should be more than 40 dB (1%) below the carrier when vector modulation is selected with no modulation input.

<b>Equipment</b>	Test Oscillator .....	HP 8116A
	Signal Generator .....	HP 8662A/8663A
	Spectrum Analyzer .....	HP 8566B
	Power Meter (two required) .....	HP 437B/438A
	Power Sensor (two required) .....	HP 8482A
	Power Splitter .....	HP 11667A
	Digital Voltmeter (DVM) .....	HP 3456A
	Termination, BNC 50Ω (two required) .....	HP 11593A

HP 8782B

## Vector Modulation Frequency Response

## Connections

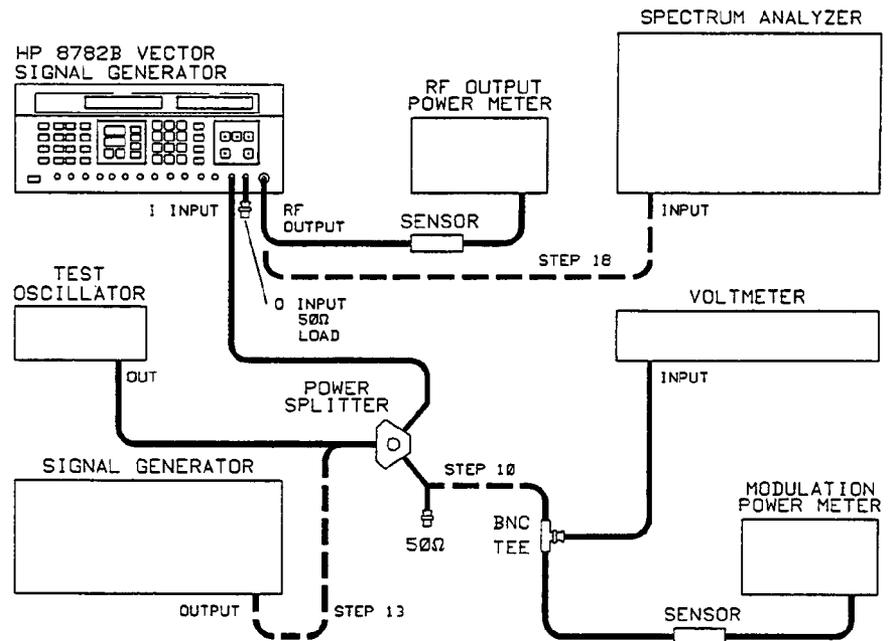


Figure 5-34. Vector Frequency Response Test Setup

## Procedure

## Vector Modulation Frequency Response

1. Connect the equipment as shown in figure 5-34.
2. Press the INSTR PRESET key on the Generator. Press the CAL key to begin a self-calibration of the Generator.
3. Set the test oscillator to 100 Hz and adjust the output level for a voltmeter indication of 0.353 Vrms (2 Vp-p into 50Ω at the test oscillator output).
4. Set the Vector Generator to 140 MHz at an output level of 0 dBm.
5. Activate vector modulation by pressing the **MODULATION** key on the Generator until the modulation indicator is above vector on the display, then press the **MODULATION ON** key.

## Note



In the remainder of the procedure, the power meter connected to the Generator RF output will be referred to as the RF output power meter. The power meter connected to the power splitter will be referred to as the modulation power meter.

6. Adjust the test oscillator output level for a Vector Generator output level of -3.0 dBm  $\pm$ 0.1 dB as indicated by the RF output power meter.

## Vector Modulation Frequency Response

HP 8782B

7. Record the modulation voltage level indicated by the voltmeter. This will be the reference voltage for modulation frequencies less than 100 kHz.

\_\_\_\_\_ mVrms Modulation Level Reference

8. Tune the test oscillator from 100 Hz to 100 kHz while monitoring the power meter reading. Maintain the output level of the test oscillator at the modulation level reference recorded above. Record the highest and lowest power meter readings.

\_\_\_\_\_ dBm Maximum Reading (100 Hz to 100 kHz)

\_\_\_\_\_ dBm Minimum Reading (100 Hz to 100 kHz)

9. Disconnect the voltmeter, BNC tee and 50Ω load from the power splitter and connect the modulation power meter sensor to the power splitter.

**Note**

The modulation power meter sensor should be connected to the power splitter using a cable that is the same type and length as the cable between the power splitter and the vector modulation input.

10. Record the modulation signal power as indicated by the modulation power meter (connected to the power splitter). This will be used to maintain the modulation signal power at the same level for the remainder of the test.

\_\_\_\_\_ dBm Modulation Signal Power Level (about +4 dBm)

11. Tune the test oscillator from 100 kHz to 50 MHz while observing the RF output power meter. Adjust the test oscillator output level as necessary to maintain the modulation power meter reading at the reference level recorded above. Record the maximum and minimum readings from the RF output power meter.

\_\_\_\_\_ dBm Maximum Reading (100 kHz to 50 MHz)

\_\_\_\_\_ dBm Minimum Reading (100 kHz to 50 MHz)

12. Verify that the frequency response over the 100 Hz to 50 MHz is less than 1 dB. The frequency response is calculated by taking the largest reading of the two bands tested (100 Hz to 100 kHz, 100 kHz to 10 MHz, and 10 MHz to 50 MHz) and subtracting the smallest reading of the two bands.

For example, if the largest (Maximum Reading) reading of 0 dBm occurred in the 100 Hz to 100 kHz range and the smallest (Minimum Reading) reading of -0.4 dBm occurred in the 10 MHz to 50 MHz band, the frequency response would be  $0 - (-0.4) = 0.4$  dB.

Mark a check in the following space and in the appropriate entry of Table 5-31 if the frequency response is within specification.

\_\_\_\_\_ (✓) Vector I Channel Bandwidth, 100 Hz to 50 MHz

HP 8782B

## Vector Modulation Frequency Response

13. Repeat steps 3 through 16 with the test oscillator connected to the VECTOR Q INPUT and the 50 $\Omega$  load connected to the VECTOR I INPUT.

\_\_\_\_\_ ( $\checkmark$ ) Vector Q Channel Bandwidth, 100 Hz to 50 MHz

## Vector Modulation dc Residual

14. Disconnect all equipment from the Vector Generator.
15. Press the INSTR PRESET key on the Generator.
16. Connect the spectrum analyzer to the Generator RF output.
17. Set the Generator to 140 MHz at an output level of 0 dBm.
18. Adjust the spectrum analyzer to display the 140 MHz CW signal. Use a resolution bandwidth and frequency span combination to place the noise floor at more than 40 dB below the peak of the displayed 70 MHz signal.
19. Connect a 50 $\Omega$  load to the VECTOR I and Q inputs of the Generator. The loads will ensure the input voltage is 0 volts.
20. Activate vector modulation by pressing the **MODULATION** key on the Generator until the modulation indicator is above vector on the display, then press the **MODULATION ON** key. The displayed 140 MHz signal should drop by at least 40 dB (<-40 dBc). Record the dc residual level below and in Table 5-31.

\_\_\_\_\_ (<-40 dBc) Vector Modulation dc Residual



HP 8782B

Performance Test Record

Hewlett-Packard Company  
 Model HP 8782B  
 Vector Signal Generator

Tested By \_\_\_\_\_

Serial Number \_\_\_\_\_

Date \_\_\_\_\_

Table 5-31. Performance Test Record

Test	Minimum	Actual Result	Maximum
<b>FREQUENCY RANGE, RESOLUTION AND AGING RATE</b>			
Frequency Aging Rate		_____	$1.5 \times 10^{-9}$ / 24 Hours
Frequency Range			
Minimum Frequency		_____ (✓)	1 MHz
Maximum Frequency	250 MHz	_____ (✓)	
Frequency Resolution (1 Hz)		_____ (✓)	
<b>RF OUTPUT LEVEL, FLATNESS AND MAXIMUM LEVELED POWER</b>			
RF Level Accuracy			
+7 dbm	+5.5	_____	+8.5
-2.9 dbm	-4.4 dBm	_____	-1.4 dBm
-10 dbm	-11.5 dBm	_____	-8.5 dBm
-20 dbm	-21.5 dBm	_____	-18.5 dBm
-30 dbm	-31.5 dBm	_____	-28.5 dBm
-40 dbm	-42 dBm	_____	-38 dBm
-50 dbm	-52 dBm	_____	-48 dBm
-60 dbm	-62 dBm	_____	-58 dBm
-70 dbm	-72 dBm	_____	-68 dBm
-80 dbm	-82 dBm	_____	-78 dBm
-90 dbm	-92.4 dBm	_____	-87.6 dBm
-100 dbm	-102.4 dBm	_____	-97.6 dBm
Output Level Flatness		_____	2 dB
Maximum Leveled Power	+7 dBm	_____	

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>RESIDUAL FM</b>		_____	4 Hz RMS
<b>RF SWITCH ON/OFF RATIO</b>	60 dB	_____	
<b>HARMONICS</b>			
1.0 MHz Carrier		_____	
2.0 MHz (2nd)		_____	-30 dBc
3.0 MHz (3rd)		_____	-30 dBc
70.0 MHz Carrier		_____	
140.0 MHz (2nd)		_____	-30 dBc
210.0 MHz (3rd)		_____	-30 dBc
140.0 MHz Carrier		_____	
280.0 MHz (2nd)		_____	-30 dBc
420.0 MHz (3rd)		_____	-30 dBc
249.0 MHz Carrier		_____	
498.0 MHz (2nd)		_____	-30 dBc
747.0 MHz (3rd)		_____	-30 dBc

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>NON—HARMONICALLY RELATED SPURIOUS RESPONSES</b>			
70.0 MHz, +7 dBm Carrier 80.0 MHz		_____	-55 dBc
70.0 MHz, +7 dBm Carrier 60.0 MHz		_____	-55 dBc
70.0 MHz, +7 dBm Carrier 30.0 MHz		_____	-55 dBc
70.0 MHz, +7 dBm Carrier 170.0 MHz		_____	-55 dBc
249.0 MHz, +7 dBm Carrier 751.0 MHz		_____	-55 dBc
249.0 MHz, +7 dBm Carrier 1000.0 MHz		_____	-55 dBc
249.0 MHz, +7 dBm Carrier 502.0 MHz		_____	-55 dBc
_____ MHz Carrier _____ MHz		_____	-55 dBc
_____ MHz Carrier _____ MHz		_____	-55 dBc
_____ MHz Carrier _____ MHz		_____	-55 dBc
_____ MHz Carrier _____ MHz		_____	-55 dBc
_____ MHz Carrier _____ MHz		_____	-55 dBc
_____ MHz Carrier _____ MHz		_____	-55 dBc

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>NON—HARMONICALLY RELATED SPURIOUS RESPONSES (continued)</b>			
_____ MHz Carrier			
_____ MHz		_____	-55 dBc
<b>RESIDUAL SSB PHASE NOISE</b>			
CW, 140 MHz carrier			
1 kHz offset from carrier		_____	-115 dBc
10 MHz offset from carrier		_____	-125 dBc
<b>PULSE (BURST) MODULATION</b>			
Pulse Rates	50 MHz	_____ (✓)	
Pulse ON/OFF Ratio	50 dB	_____	
<b>PARALLEL CLOCK AND DATA RATES</b>			
Asynchronous Data Rate I0	50 MHz	_____ (✓)	
Asynchronous Data Rate I1	50 MHz	_____ (✓)	
Asynchronous Data Rate I2	50 MHz	_____ (✓)	
Asynchronous Data Rate I3	50 MHz	_____ (✓)	
Asynchronous Data Rate Q0	50 MHz	_____ (✓)	
Asynchronous Data Rate Q1	50 MHz	_____ (✓)	
Asynchronous Data Rate Q2	50 MHz	_____ (✓)	
Asynchronous Data Rate Q3	50 MHz	_____ (✓)	
Single-Clock Data Rate I0	100 MHz	_____ (✓)	
Single-Clock Data Rate I1	100 MHz	_____ (✓)	
Single-Clock Data Rate I2	100 MHz	_____ (✓)	
Single-Clock Data Rate I3	100 MHz	_____ (✓)	
Single-Clock Data Rate Q0	100 MHz	_____ (✓)	
Single-Clock Data Rate Q1	100 MHz	_____ (✓)	
Single-Clock Data Rate Q2	100 MHz	_____ (✓)	
Single-Clock Data Rate Q3	100 MHz	_____ (✓)	

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>PARALLEL CLOCK AND DATA RATES (continued)</b>			
Dual-Clock Data Rate I0	100 MHz	_____ (✓)	
Dual-Clock Data Rate I1	100 MHz	_____ (✓)	
Dual-Clock Data Rate I2	100 MHz	_____ (✓)	
Dual-Clock Data Rate I3	100 MHz	_____ (✓)	
Dual-Clock Data Rate Q0	100 MHz	_____ (✓)	
Dual-Clock Data Rate Q1	100 MHz	_____ (✓)	
Dual-Clock Data Rate Q2	100 MHz	_____ (✓)	
Dual-Clock Data Rate Q3	100 MHz	_____ (✓)	
<b>SERIAL CLOCK AND DATA RATES</b>	200 MHz	_____ (✓)	
<b>SCALAR DC RESIDUAL</b>		_____	1% of Full Scale (-40 dBc)
<b>SCALAR FREQUENCY RESPONSE</b>			
Frequency Response at 50 kHz		_____	-3 dB
<b>PRBS CLOCK RATES</b>			
Internal PRBS Clock Rates			
QPSK, 10 MHz		_____ (✓)	
QPSK, 5 MHz		_____ (✓)	
QPSK, 2.5 MHz		_____ (✓)	
QPSK, 1.25 MHz		_____ (✓)	
16QAM, 10 MHz		_____ (✓)	
64QAM, 10 MHz		_____ (✓)	
256QAM, 10 MHz		_____ (✓)	
External PRBS Clock Rates	100 MHz	_____ (✓)	

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>DIGITAL MODULATION DC ACCURACY</b>			
8PSK State Accuracy			
(0 0 0) I Component	37.3%	_____	39.3%
(0 0 0) Q Component	91.4%	_____	93.4%
(0 1 0) I Component	91.4%	_____	93.4%
(0 1 0) Q Component	37.3%	_____	39.3%
(0 1 1) I Component	91.4%	_____	93.4%
(0 1 1) Q Component	-39.3%	_____	-37.3%
(0 0 1) I Component	37.3%	_____	39.3%
(0 0 1) Q Component	-93.4%	_____	-91.4%
(1 0 1) I Component	-39.3%	_____	-37.3%
(1 0 1) Q Component	-93.4%	_____	-91.4%
(1 1 1) I Component	-93.4%	_____	-91.4%
(1 1 1) Q Component	-39.3%	_____	-37.3%
(1 1 0) I Component	-93.4%	_____	-91.4%
(1 1 0) Q Component	37.3%	_____	39.3%
(1 0 0) I Component	-39.3%	_____	-37.3%
(1 0 0) Q Component	91.4%	_____	93.4%
256QAM State Accuracy			
(0 0 0 0, 0 0 0 0) I Component	69.7%	_____	71.7%
(0 0 0 0, 0 0 0 0) Q Component	69.7%	_____	71.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>DIGITAL MODULATION DC ACCURACY (continued)</b>			
(0 0 0 1, 0 0 0 0) I Component	60.3%	_____	62.3%
(0 0 0 1, 0 0 0 0) Q Component	69.7%	_____	71.7%
(0 0 1 0, 0 0 0 0) I Component	50.9%	_____	52.9%
(0 0 1 0, 0 0 0 0) Q Component	69.7%	_____	71.7%
(0 1 0 0, 0 0 0 0) I Component	32.0%	_____	34.0%
(0 1 0 0, 0 0 0 0) Q Component	69.7%	_____	71.7%
(1 0 0 0, 0 0 0 0) I Component	-5.7%	_____	-3.7%
(1 0 0 0, 0 0 0 0) Q Component	69.7%	_____	71.7%
(1 1 1 1, 0 0 0 0) I Component	-71.7%	_____	-69.7%
(1 1 1 1, 0 0 0 0) Q Component	69.7%	_____	71.7%
(0 0 0 0, 0 0 0 1) I Component	69.7%	_____	71.7%
(0 0 0 0, 0 0 0 1) Q Component	60.3%	_____	62.3%
(0 0 0 0, 0 0 1 0) I Component	69.7%	_____	71.7%
(0 0 0 0, 0 0 1 0) Q Component	50.9%	_____	52.9%
(0 0 0 0, 0 1 0 0) I Component	69.7%	_____	71.7%
(0 0 0 0, 0 1 0 0) Q Component	32.0%	_____	34.0%
(0 0 0 0, 0 1 0 0) I Component			
(0 0 0 0, 1 0 0 0) I Component	69.7%	_____	71.7%
(0 0 0 0, 1 0 0 0) Q Component	-5.7%	_____	-3.7%
(0 0 0 0, 1 1 1 1) I Component	69.7%	_____	71.7%
(0 0 0 0, 1 1 1 1) Q Component	-71.7%	_____	-69.7%
(0 1 1 1, 1 1 1 1) I Component	3.7%	_____	5.7%
(0 1 1 1, 1 1 1 1) Q Component	-71.7%	_____	-69.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>DIGITAL MODULATION DC ACCURACY (continued)</b>			
256QAM State Accuracy (Continued)			
(1 0 0 0, 1 1 1 1) I Component	-5.7%	_____	-3.7%
(1 0 0 0, 1 1 1 1) Q Component	-71.7%	_____	-69.7%
(1 1 1 1, 1 1 1 1) I Component	-71.7%	_____	-69.7%
(1 1 1 1, 1 1 1 1) Q Component	-71.7%	_____	-69.7%
(1 1 1 1, 1 0 0 0) I Component	-71.7%	_____	-69.7%
(1 1 1 1, 1 0 0 0) Q Component	-5.7%	_____	-3.7%
(1 1 1 1, 0 1 1 1) I Component	-71.7%	_____	-69.7%
(1 1 1 1, 0 1 1 1) Q Component	3.7%	_____	5.7%
(0 1 1 1, 0 1 1 1) I Component	3.7%	_____	5.7%
(0 1 1 1, 0 1 1 1) Q Component	3.7%	_____	5.7%
(1 1 0 0, 1 1 0 0) I Component	-43.4%	_____	-41.4%
(1 1 0 0, 1 1 0 0) Q Component	-43.4%	_____	-41.4%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>SCALAR MODULATION DC ACCURACY</b>			
16QAM Accuracy (Scalar = 1.00 V)			
(0 0, 0 0) I Component	69.7%	_____	71.7%
(0 0, 0 0) Q Component	69.7%	_____	71.7%
(0 0, 0 1) I Component	69.7%	_____	71.7%
(0 0, 0 1) Q Component	22.6%	_____	24.6%
(0 0, 1 0) I Component	69.7%	_____	71.7%
(0 0, 1 0) Q Component	-24.6%	_____	-22.6%
(0 0, 1 1) I Component	69.7%	_____	71.7%
(0 0, 1 1) Q Component	-71.7%	_____	-69.7%
(0 1, 0 0) I Component	22.6%	_____	24.6%
(0 1, 0 0) Q Component	69.7%	_____	71.7%
(0 1, 0 1) I Component	22.6%	_____	24.6%
(0 1, 0 1) Q Component	22.6%	_____	24.6%
(0 1, 1 0) I Component	22.6%	_____	24.6%
(0 1, 1 0) Q Component	-24.6%	_____	-22.6%
(0 1, 1 1) I Component	22.6%	_____	24.6%
(0 1, 1 1) Q Component	-71.7%	_____	-69.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>SCALAR MODULATION DC ACCURACY (continued)</b>			
16QAM Accuracy (Scalar = 1.00 V)			
(1 0, 0 0) I Component	-24.6%	_____	-22.6%
(1 0, 0 0) Q Component	69.7%	_____	71.7%
(1 0, 0 1) I Component	-24.6%	_____	-22.6%
(1 0, 0 1) Q Component	22.6%	_____	24.6%
(1 0, 1 0) I Component	-24.6%	_____	-22.6%
(1 0, 1 0) Q Component	-24.6%	_____	-22.6%
(1 0, 1 1) I Component	-24.6%	_____	-22.6%
(1 0, 1 1) Q Component	-71.7%	_____	-69.7%
(1 1, 0 0) I Component	-71.7%	_____	-69.7%
(1 1, 0 0) Q Component	69.7%	_____	71.7%
(1 1, 0 1) I Component	-71.7%	_____	-69.7%
(1 1, 0 1) Q Component	22.6%	_____	24.6%
(1 1, 1 0) I Component	-71.7%	_____	-69.7%
(1 1, 1 0) Q Component	-24.6%	_____	-22.6%
(1 1, 1 1) I Component	-71.7%	_____	-69.7%
(1 1, 1 1) Q Component	-71.7%	_____	-69.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>SCALAR MODULATION DC ACCURACY (continued)</b>			
16QAM Accuracy (Scalar = 0.33 V)			
(0 0, 0 0) I Component	69.7%	_____	71.7%
(0 0, 0 0) Q Component	69.7%	_____	71.7%
(0 0, 0 1) I Component	69.7%	_____	71.7%
(0 0, 0 1) Q Component	22.6%	_____	24.6%
(0 0, 1 0) I Component	69.7%	_____	71.7%
(0 0, 1 0) Q Component	-24.6%	_____	-22.6%
(0 0, 1 1) I Component	69.7%	_____	71.7%
(0 0, 1 1) Q Component	-71.7%	_____	-69.7%
(0 1, 0 0) I Component	22.6%	_____	24.6%
(0 1, 0 0) Q Component	69.7%	_____	71.7%
(0 1, 0 1) I Component	22.6%	_____	24.6%
(0 1, 0 1) Q Component	22.6%	_____	24.6%
(0 1, 1 0) I Component	22.6%	_____	24.6%
(0 1, 1 0) Q Component	-24.6%	_____	-22.6%
(0 1, 1 1) I Component	22.6%	_____	24.6%
(0 1, 1 1) Q Component	-71.7%	_____	-69.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>SCALAR MODULATION DC ACCURACY (continued)</b>			
16QAM Accuracy (Scalar = 0.33 V)			
(1 0, 0 0) I Component	-24.6%	_____	-22.6%
(1 0, 0 0) Q Component	69.7%	_____	71.7%
(1 0, 0 1) I Component	-24.6%	_____	-22.6%
(1 0, 0 1) Q Component	22.6%	_____	24.6%
(1 0, 1 0) I Component	-24.6%	_____	-22.6%
(1 0, 1 0) Q Component	-24.6%	_____	-22.6%
(1 0, 1 1) I Component	-24.6%	_____	-22.6%
(1 0, 1 1) Q Component	-71.7%	_____	-69.7%
(1 1, 0 0) I Component	-71.7%	_____	-69.7%
(1 1, 0 0) Q Component	69.7%	_____	71.7%
(1 1, 0 1) I Component	-71.7%	_____	-69.7%
(1 1, 0 1) Q Component	22.6%	_____	24.6%
(1 1, 1 0) I Component	-71.7%	_____	-69.7%
(1 1, 1 0) Q Component	-24.6%	_____	-22.6%
(1 1, 1 1) I Component	-71.7%	_____	-69.7%
(1 1, 1 1) Q Component	-71.7%	_____	-69.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>SCALAR MODULATION DC ACCURACY (continued)</b>			
16QAM Accuracy (Scalar = 0.10 V)			
(0 0, 0 0) I Component	68.7%	_____	72.7%
(0 0, 0 0) Q Component	68.7%	_____	72.7%
(0 0, 0 1) I Component	68.7%	_____	72.7%
(0 0, 0 1) Q Component	21.6%	_____	25.6%
(0 0, 1 0) I Component	68.7%	_____	72.7%
(0 0, 1 0) Q Component	-25.6%	_____	-21.6%
(0 0, 1 1) I Component	68.7%	_____	72.7%
(0 0, 1 1) Q Component	-72.7%	_____	-68.7%
(0 1, 0 0) I Component	21.6%	_____	25.6%
(0 1, 0 0) Q Component	68.7%	_____	72.7%
(0 1, 0 1) I Component	21.6%	_____	25.6%
(0 1, 0 1) Q Component	21.6%	_____	25.6%
(0 1, 1 0) I Component	21.6%	_____	25.6%
(0 1, 1 0) Q Component	-25.6%	_____	-21.6%
(0 1, 1 1) I Component	21.6%	_____	25.6%
(0 1, 1 1) Q Component	-72.7%	_____	-68.7%

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>SCALAR MODULATION DC ACCURACY (continued)</b>			
16QAM Accuracy (Scalar = 0.10 V)			
(1 0, 0 0) I Component	-25.6%	_____	-21.6%
(1 0, 0 0) Q Component	68.7%	_____	72.7%
(1 0, 0 1) I Component	-25.6%	_____	-21.6%
(1 0, 0 1) Q Component	21.6%	_____	25.6%
(1 0, 1 0) I Component	-25.6%	_____	-21.6%
(1 0, 1 0) Q Component	-25.6%	_____	-21.6%
(1 0, 1 1) I Component	-25.6%	_____	-21.6%
(1 0, 1 1) Q Component	-72.7%	_____	-68.7%
(1 1, 0 0) I Component	-72.7%	_____	-68.7%
(1 1, 0 0) Q Component	68.7%	_____	72.7%
(1 1, 0 1) I Component	-72.7%	_____	-68.7%
(1 1, 0 1) Q Component	21.6%	_____	25.6%
(1 1, 1 0) I Component	-72.7%	_____	-68.7%
(1 1, 1 0) Q Component	-25.6%	_____	-21.6%
(1 1, 1 1) I Component	-72.7%	_____	-68.7%
(1 1, 1 1) Q Component	-72.7%	_____	-68.7%

HP 8782B

Performance Test Record

Table 5-31. Performance Test Record (continued)

Test	Minimum	Actual Result	Maximum
<b>VECTOR MODULATION DC ACCURACY</b>			
Worst Case Residual	-1%	_____	+1.0%
Input I, +500 mVdc	+98.5%	_____	+101.5%
Input Q, +500 mVdc	+98.5%	_____	+101.5%
Input I, +250 mVdc	+48.5%	_____	+51.5%
Input Q, +250 mVdc	+48.5%	_____	+51.5%
Input I, -250 mVdc	-51.5%	_____	-48.5%
Input Q, -250 mVdc	-51.5%	_____	-48.5%
Input I, -500 mVdc	-101.5%	_____	-98.5%
Input Q, -500 mVdc	-101.5%	_____	-98.5%
<b>VECTOR MODULATION FREQUENCY RESPONSE</b>			
I CHANNEL 1 dB BANDWIDTH	50 MHz	_____ (✓)	
Q CHANNEL 1 dB BANDWIDTH	50 MHz	_____ (✓)	
Vector Modulation dc Residual		_____	-40 dBc



## HP 8780A Compatibility Commands

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### HP 8780A HP-IB MNEMONICS SUPPORTED BY THE HP 8782B

HP 8780A Mnemonic	Description (and TMSL equivalent mnemonic)
PR	Preset. Same as "*RST".
SV x	Save state x(0-9). Same as "*SAV x".
ST x	Same as "SV x".
RC x	Recall state x(0-9); recall 0 = "undo" is not supported. Same as "*RCL x".
CL	Do a full calibration. Same as "*CAL?" but not a query.
EC0	External clocks = none. Same as "DM:CLOC:SOUR NONE".
EC1	External clocks = one; Opt64 = parallel not supported. Same as "DM:CLOC:SOUR EXT;;DM:CLOC:MODE I".
EC2	External clocks = two; Opt64 = serial not supported. Same as "DM:CLOC:SOUR EXT;;DM:CLOC:MODE IQ".
CK0	Clock level to AUTO - auto mode doesn't exist in 8782 so this is just the same as "DM:COUP:CLOC GRO".
CK1	Clock level to ECL. Same as "DM:COUP:CLOC ECL".
CK2	Clock level to GND. Same as "DM:COUP:CLOC GRO;;DM:THR:CLOC 0V".
DL0	Data level to VAR. Same as "DM:COUP:DATA GRO".
DL1	Data level to ECL. Same as "DM:COUP:DATA ECL".
DL2	Data level to GND. Same as "DM:COUP:DATA GRO;;DM:THR:DATA 0V".
EF0	Internal filters; same as "DM:FILT:SOUR INT".
EF1	External filters; same as "DM:FILT:SOUR EXT".
IFI x	Invert input x; x defined as: 0=I0, 1=I1, 2=Q0, 3=Q1, 4=I CLK, 5=Q CLK, 6=none.

## HP 8780A Compatibility Commands

HP 8782B

IFN x	Non-Invert input x; see IFI for meaning of x.
UP	Increment current active field
DOWN	Decrement current active field
FR xxx.xx[freq suff]	Set frequency. [freq suff] = GZ MZ KZ HZ
CF xxx.xx[freq suff]	Same as "FR xxx.xx[freq suff]".
LV xxx.xx[lvl suff]	Set level. [lvl suff] = DBM VL MV UV
LE xxx.xx[lvl suff]	Same as "LV xxx.xx[lvl suff]".
AP xxx.xx[lvl suff]	Same as "LV xxx.xx[lvl suff]".
PL xxx.xx[lvl suff]	Same as "LV xxx.xx[lvl suff]".
SIQ xxx.xx[rel suff]	Set I<Q. [rel suff] = DBR PC
VA xx.x[volt suff]	Set the variable data level. [volt suff] = VL MV UV
IS xx.x[all 8780 suff]	Set increment of currently active parameter. [all 87 80 suff] = GZ MZ KZ HZ DBM VL MV UV DBR PC EN
CW	Turn off all modulations. Same as "DM:STAT OFF; :PULS:STAT OFF; :AM:STAT OFF"
BP0	Turn BPSK off. Does a "DM:STAT OFF" if mod format is BPSK.
BP1	Turn BPSK on. Same as "DM BPSK;:DM:STAT ON".
EP0	Turn 8PSK off. Does a "DM:STAT OFF" if mod format is PSK8.
EP1	Turn 8PSK on. Same as "DM PSK8;:DM:STAT ON".
QP0	Turn QPSK off. Does a "DM:STAT OFF" if mod format is QPSK.
QP1	Turn QPSK on. Same as "DM QPSK;:DM:STAT ON".
QA0	Turn 16QAM off. Does a "DM:STAT OFF" if mod format is QAM16.
QA1	Turn 16QAM on. Same as "DM QAM16;:DM:STAT ON".
SQ0	Turn 64QAM off. Does a "DM:STAT OFF" if mod format is QAM64.
SQ1	Turn 64QAM on. Same as "DM QAM64;:DM:STAT ON".
BR0	Turn burst off. Same as "PULS:STAT OFF".
BR1	Turn burst on. Same as "PULS:STAT ON".
SC0	Turn scalar off. Same as "AM:STAT OFF".
SC1	Turn scalar on. Same as "AM:STAT ON".
IQ0	Turn I<Q off. Same as "DM:IQR:STAT OFF".

HP 8782B

HP 8780A Compatibility Commands

IQ1	Turn I<Q on. Same as "DM:IQR:STAT ON".
RF0	Turn RF off. Same as "OUTP:STAT OFF".
RF1	Turn RF on. Same as "OUTP:STAT ON".
RM	Return service request mask. Same as *SRE?
CS	Set status byte to zero. Same as *CLS
LP1	Same as *LRN?
LP2	Same as *LRN?
DE	Turn on display. Same as "DISP:STAT ON"
DD	Turn off display. Same as "DISP:STAT OFF"
OUTPIDEN	Same as *IDN?
OI	Same as "OUTPIDEN".
OUTPCL	Return 1 is calibrating. Same as STAT:OPER:COND?
OC	Same as "OUTPCL".
OUTPACTI	Return active parameter value ( only the numeric value is returned - no suffix is included )
OA	Same as "OUTPACTI".
WM	Set SRQ mask; same as *SRE
WD w,x,y,z	Direct Control. Same as "DIAG:IBUS:DIR"
VM0	Turn vector off (same as VM:STAT ON)
VM1	Turn vector on (same as VM:STAT OFF)

Note: EN is allowed as a suffix for all numeric parameters of the HP 8780A compatibility commands.

THE FOLLOWING HP 8780A MNEMONICS ARE NOT SUPPORTED BY THE HP 8782B

HP 8780A Mnemonic	Description
SP0	Turn off all special functions
SPP xx.xEN	Turn on special function xx.x
DF0	AC FM
DF1	DC FM
IFM0	Non-Invert FM
IFM1	Invert FM
IO xx.xEN	Set two state I1 coordinate
IT xx.xEN	Set two state I2 coordinate
QO xx.xEN	Set two state Q1 coordinate
QT xx.xEN	Set two state Q2 coordinate
RO xx.xEN	Set two state R1 coordinate
RT xx.xEN	Set two state R2 coordinate
AO xx.xEN	Set two state phi1 coordinate
AT xx.xEN	Set two state phi2 coordinate
SFM xxx.xx[freq suff]	Set FM frequency. [freq suff] = GZ MZ KZ HZ
SAL xxx.xx[rel suff]	Set alternate level. [rel suff] = DBR PC
AI xxx.xx[rel suff]	Set alternate level I. [rel suff] = DBR PC
FM0	Turn FM off
FM1	Turn FM on
TS0	Turn two-state off
TS1	Turn two-state on
AL0	Turn alternate level off
AL1	Turn alternate level on
CR	Position the cursor in field
DA	Turn on all display segments
@1	Set BINARY Request service mask
@2	Contain in the learn string
SM	Return system status message

## Error Messages

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### Introduction

In this table the Error ID column gives ID numbers for each type of error and are unique for the generator. This error ID is the number reported by the front panel **MESSAGE** key. The TMSL Error ID numbers are standardized error numbers for TMSL (Test and Measurement System Language) and may be the same as the Message ID column if they only occur once. The third column gives the abbreviated error message as reported by the front panel. The fourth column gives the detailed error message as reported by querying the instrument over HP-IB. The fifth column contains a corrective action.

## Error Messages

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
-440	-440	HP-IB ERROR	Query UNTERMINATED after indefinite response	Correct the HP-IB controller program so that the query that returns indefinite length block data is the last item on the program line.
-430	-430	HP-IB ERROR	Query DEADLOCKED	Correct the HP-IB controller program so that no more than eight queries are executed within the same line of the program.
-420	-420	HP-IB ERROR	Query UNTERMINATED	Correct the HP-IB controller program so that the controller terminates commands with the new line character (NL) before the controller attempts to read query response data.
-410	-410	HP-IB ERROR	Query INTERRUPTED	Check the HP-IB controller program to see if the controller is programmed to read the entire query response data before issuing a subsequent command.
-350	-350	N/A	Too many errors	The HP-IB error queue overflowed at this point and this message replaced the 16th error. No action is necessary. Note: to clear the error queue, use *CLS.
-223	-223	HP-IB ERROR	Too much data	Correct the HP-IB controller program so that there is less data on a single command line. The instrument does not have enough memory to buffer all the data.
-222	-222	HP-IB ERROR	Data out of range	Correct the HP-IB numeric data so that it is within the range of 1e9999 to 1e-9999.
-178	-178	HP-IB ERROR	Expression data not allowed	Correct the HP-IB controller program so that the data included with the HP-IB command does not contain parentheses.
-168	-168	HP-IB ERROR	Block data not allowed	Correct the HP-IB controller program so that the data included with the HP-IB command is not block data ( no "#" ).
-161	-161	HP-IB ERROR	Invalid block data	Correct the HP-IB controller program so that it contains a correct block data type. A block data type should begin with "#" followed by a number.
-158	-158	HP-IB ERROR	String data not allowed	Correct the HP-IB controller program so that the data included with the HP-IB command does not contain single or double quotes ( ' or " ).

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
-148	-148	HP-IB ERROR	Character data not allowed	Correct the HP-IB controller program so that the data included with the HP-IB command is not character data.
-144	-144	HP-IB ERROR	Character data too long	Correct the HP-IB controller program so that the character data included with the HP-IB command is less than 13 characters long.
-138	-138	HP-IB ERROR	Suffix not allowed	Correct the HP-IB controller program so that the decimal data included with the HP-IB command does not use a suffix. Use exponential notation instead.
-131	-131	HP-IB ERROR	Invalid suffix	Correct the HP-IB controller program so that the decimal data included with the HP-IB command contains a valid suffix for the data.
-128	-128	HP-IB ERROR	Numeric data not allowed	Correct the HP-IB controller program so that the decimal data included with the HP-IB command is not numeric data.
-123	-123	HP-IB ERROR	Exponent too large	Correct the HP-IB numeric data so that it has an exponent from -32768 to 32767.
-120	-120	HP-IB ERROR	Numeric data error	Correct the HP-IB controller program so that the data included with the HP-IB command follows the correct syntax for a number.
-110	-110	HP-IB ERROR	Command header error	An invalid mnemonic has been received. Correct the HP-IB controller program so that the HP-IB mnemonic is a mnemonic available in the instrument.
-107	-107	HP-IB ERROR	Incorrect number of parameters	Correct the HP-IB controller program so that the HP-IB command contains the correct number of parameters. Unlike other -107 errors which have detailed error messages, it is not known which HP-IB command caused the error.
-105	-105	HP-IB ERROR	GET not allowed	Correct the HP-IB controller program so that the group execute trigger does not occur within a line of HP-IB program code.
-104	-104	HP-IB ERROR	Data type error	Correct the HP-IB controller program so that the data included with the HP-IB command is a type of data understood by the instrument.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
-103	-103	HP-IB ERROR	Invalid separator	Correct the HP-IB controller program so that data included with the HP-IB command is separated only by commas and spaces.
0	0	N/A	No Error	No action needed. The HP-IB error queue contains no errors.
102	102	TRY AGAIN	Function not completed, try again	Try actions suggested for error number 1902.
110	110	OVEN COLD	Oven cold	The reference oscillator's temperature is too cold to meet frequency specifications. Wait until this error message goes away (typically, it will take 10 minutes).
111	111	FLT OVERLOAD	External filter overload	The input level from external filters is too high. The instrument will usually switch to internal filter mode automatically and message number 112 will appear also.
112	112	INT FLT ENBL	Switched to internal filter due to external filter overload	The input level from external filters is too high. The instrument switched to internal filter mode.
113	113	INT FLT ENBL	Vector Modulation disabled due to input overload condition	Reduce input level and re-select vector input
501	501	CANT CAL EXT	External filter cal not possible	External filter cal was not successful. Calibration was done with internal filters instead.
502	502	NO RF DETECT	No power change detected when RF on	Try calibration again. If this error message recurs, make sure you are calibrating with internal filters. If the instrument calibration meets your needs despite this error message, ignore the message.
510	510	NULL CAL BAD	Null cal does not converge to a null	Try calibration again. If the instrument "null" meets your needs despite this error message, ignore the message. If this error message recurs and you need perfect "nulls", make sure you are calibrating with internal filters.
512	512	BRST CAL BAD	Burst cal does not converge to a null	Try calibration again. If the instrument burst "null" meets your needs or you do not need the burst feature, ignore the message. If this error message recurs and you need perfect burst "nulls", make sure you are calibrating with internal filters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
513	513	CAL FAILURE	Baseband cal failed—cal does not converge	Try calibration again. If this error message recurs, make sure you are using internal filters (external filters may have been too difficult to calibrate). If the instrument calibration meets your needs despite this error message, ignore the message.
514	514	CAL LO ERROR	LO system error during cal	The local oscillator did not operate perfectly during calibration. Try the calibration again. If this message recurs, try turning the instrument off and on. If the instrument calibration meets your needs despite this error message, ignore the message.
515	515	NULL DAC BAD	Detect no change as null dacs change	Changing the null dacs appears to have no effect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.
516	516	INT FILT CAL	Unable to calibrate with internal filter	A hardware "pre-check" failed at the beginning of calibration. Try the calibration again. If this message recurs, try turning the instrument off and on.
517	517	EXT FILTER ?	No external filter detected, used internal filter for calibration	The calibration routine measured the external filters and decided that it was an open circuit. Internal calibration was performed instead.
520	520	NULL CAL BAD	Null detector not used in null cal - null may be bad	See actions described for error number 510.
522	522	BURST NULL	Null detector not used in burst cal - burst may be bad	See actions described for error number 512.
523	523	QUAD BAD	Can't set quadrature to 90 degrees	Quadrature calibration could not attain a quadrature of 90 degrees in a QPSK pattern. Try the calibration again. If the error recurs, try turning the instrument off and on.
524	524	BAD CONSTL	Constellation not measurable. Two or more points at 0 volts	QPSK pattern only has 3 distinct points and calibration needs 4. Try the calibration again. If the error recurs, try turning the instrument off and on.
525	525	I-NULL DAC	Changing I null dac does not change null level.	Changing the I null dac appears to have no effect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
526	526	Q-NULL DAC	Changing Q null dac does not change null level.	Changing the Q null dac appears to have no affect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.
527	527	NULL DET BAD	Null detector not working	Try the calibration again. If this message recurs, try turning the instrument off and on.
528	528	I-ZERO DAC	Changing I zero state dac does not affect signal	Changing the I zero state dac appears to have no affect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.
529	529	Q-ZERO DAC	Changing Q zero state dac does not affect signal	Changing the Q zero state dac appears to have no affect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.
530	530	I-CURR DAC	Changing I current source dac does not affect signal	Changing the I current source dac appears to have no affect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.
531	531	Q-CURR DAC	Changing Q current source dac does not affect signal	Changing the Q current source dac appears to have no affect on the instrument. Try the calibration again. If this message recurs, try turning the instrument off and on.
532	532	ANLG ATT BAD	Can't level up I and Q channels in vector mode	Try calibration again. If calibration still fails, instrument requires service.
533	533	BAD FN DATA	Bad data to function call	Try calibration again. If calibration still fails, instrument requires service.
534	534	BAD VECT ATT	Vector baseband gain can not be set	Try calibration again. If calibration still fails, instrument requires service.
600	600	INSUFF POWER	Insufficient power at some frequencies	The level calibration at some frequency(ies) was not able to attain at least 7 dBm of output power. Try the calibration again. This error is just a warning and can be ignored; error 601 will tell you when you don't have enough power while using the instrument.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
601	601	INSUFF POWER	Insufficient output power at this frequency	This error message warns that the power level requested is not attainable at the current frequency. The instrument will get as close to the requested power level as it can.
602	602	ATTEN LOCKED	Unable to set level with step attenuator locked	Because the step attenuator is locked, the instrument cannot attain the requested power level. The instrument will get as close to the requested power level as it can. Either unlock the step attenuator or ignore this message if the output power is sufficient.
604	604	POWER UNCAL	Power uncalibrated at this frequency	Level calibration was not performed at this frequency for some reason. Perform a calibration of the instrument.
1101	1101	CHAIN NUMBER	Shift chain number invalid	Correct the HP-IB command DIAG:IBUS:DIR or DIAG:IBUS:DIR? so that its chain number is 0 through 7. If this error occurs even though these two HP-IB commands are not being used, there is some problem with hardware control in the instrument; to fix this problem try the actions suggested for error number 1902.
1102	1102	START BIT	Shift chain start bit invalid	Correct the HP-IB command DIAG:IBUS:DIR or DIAG:IBUS:DIR? so that its start bit is in range for the given chain number. If this error occurs even though these two HP-IB commands are not being used, there is some problem with hardware control in the instrument; to fix this problem try the actions suggested for error number 1902.
1103	1103	DATA LENGTH	Shift chain bit-field length invalid	Select an instrument control data value which fits in the requested bit-field number. If this error occurs even though the instrument control function is not being used, there is some problem with hardware control in the instrument; to fix this problem try the actions suggested for error number 1902.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
1106	1106	LARGE DATA	Shift chain data too large for bit-field length	Select an instrument control bit-field number from 0 to 60. If this error occurs even though the instrument control function is not being used, there is some problem with hardware control in the instrument; to fix this problem try the actions suggested for error number 1902.
1206	1206	CARRIER LEAK	Unable to set carrier leakage at this level - value too large	The requested carrier leakage is too large for the instrument. The instrument will get as close to the requested carrier leakage as it can.
1207	1207	QUAD TOO BIG	Unable to set Quadrature - value too large	The requested positive quadrature angle is too large for the instrument. The instrument will get as close to the requested quadrature angle as it can.
1208	1208	QUAD TOO LOW	Unable to set Quadrature - value too small	The requested negative quadrature angle is too large for the instrument. The instrument will get as close to the requested quadrature angle as it can.
1209	1209	CONST ROTATE	Constellation rotated to allow quadrature setting	The requested quadrature correction and constellation rotation combined are too much for the instrument to achieve. The instrument gives quadrature priority; therefore, the constellation rotation is always altered to give exactly the quadrature angle requested.
1210	1210	QUAD CAL?	Cannot set quadrature error or rotation - Try to calibrate	Quadrature and/or rotation calibration was not completed for some reason. Perform a calibration of the instrument.
1211	1211	CARR LK CAL?	Cannot set carrier leakage - Try to calibrate	Carrier leakage calibration was not completed for some reason. Perform a calibration of the instrument.
1409	1409	LO NO REPLY	LO does not respond	The local oscillator is not responding to commands. Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on.
1420	-220	LO PREFX ERR	Parameter error;LO system reports invalid prefix on entry	Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on. If this error occurred while using the "LO direct write feature," check the LO command to insure that it is included in the LO command list.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
1421	-131	LO SUFF ERR	Invalid suffix;LO system reports invalid suffix on entry	Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on. If this error occurred while using the "LO direct write feature," check the LO command to insure that it is using a proper suffix for the data.
1422	-220	LO COMMAND	Parameter error;LO system reports range or data type error	Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on. If this error occurred while using the "LO direct write feature," check the LO command to insure that it has the correct syntax.
1423	1423	LO UNLOCKED	LO unlocked	The local oscillator's reference loop is not locked. Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on.
1424	1424	LO HANDSHAKE	LO fractional-N handshake error	The local oscillator's fractional-N section is not responding correctly. Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on.
1425	1425	LO CHECKSUM	LO checksum error on power up	The local oscillator reported a checksum error in its ROM. Try turning the instrument off and on again. If the instrument is unaffected despite this error message, the error may not be important enough to troubleshoot.
1426	1426	10MZ UNLCKED	LO reports time base loop not locked - check 10 MHz reference	The local oscillator's timebase is not locked. Check that the 10 MHz reference jumper on the back of the instrument is in place. If using an external 10 MHz source, insure that it is working correctly. If the 10 MHz reference seems OK and this error message doesn't go away, try turning the instrument off and on.
1427	1427	LO UNLOCKED	LO reports fractional-N loop not locked	The local oscillator's fractional-N loop is not locked. Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on.
1428	1428	LO UNLOCKED	LO reports sum loop not locked	The local oscillator's sum loop is not locked. Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
1429	1429	LO UNLOCKED	LO reports reference loop not locked	The local oscillator's reference loop is not locked. Repeat the function that caused this error message. If this message recurs, try turning the instrument off and on.
1490	1490	A/D CAL FAIL	A/D cal failed	The Analog to Digital converter was not correctly calibrated. Error message number 1491 or 1496 will accompany error 1490. See these two error messages for more specific information on what to do.
1491	1491	A/D TIME-OUT	A/D failed - time-out error	The Analog to Digital converter is either broken or the voltage that it attempted to measure was beyond its capabilities. If this error was given along with error number 1490 then the Analog to Digital converter calibration did not work. Try turning the instrument off and on. If this error occurred alone, the instrument calibration didn't work perfectly. You should repeat the calibration until this error goes away.
1492	-222	LIMIT ERROR	Data out of range;BAD NUMBER OF AVERAGES SENT TO ADC	Select a number of A/D averages from 1 to 100.
1494	-220	ADC CHANNEL	Parameter error;BAD ADC CHANNEL SELECTED	Select an A/D channel from the voltage source list.
1495	-241	NO QAM1024	Hardware missing;QAM1024 NOT INSTALLED	QAM1024 is not available in the instrument. Only digital inputs 0 through 3 are available and QAM256 is the most complex modulation format available.
1496	1496	CAL -5V=GND	GND equal -5V in A/D cal	The Analog to Digital converter calibration failed. Try turning the instrument off and on. If this error occurred during instrument calibration, the instrument calibration didn't work perfectly. You should repeat the calibration until this error goes away.
1505	1505	HP-IB ERROR	HP-IB was addressed to talk with nothing to say	Check the HP-IB controller program to make sure that the controller always issues a query command before attempting to read the query response data.
1523	-109	HP-IB ERROR	Missing parameter;EMPTY DATA FIELD	Correct the HP-IB controller program so that the HP-IB command does not have an empty data field. Empty data fields occur when commas are present without data.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
1526	-141	HP-IB ERROR	Invalid character data;Invalid character in character data	Correct the HP-IB controller program so that the character data included with the HP-IB command contains only the characters A—Z, a—z, 0—9 or underscore.
1527	-141	HP-IB ERROR	Invalid character data;Unrecognized character data	Correct the HP-IB controller program so that the character data included with the HP-IB command is an acceptable parameter for the command.
1528	-151	HP-IB ERROR	Invalid string data;Improper string termination	Correct the HP-IB controller program so that the string data included with the HP-IB command is terminated with a single or double quote ( ' or " ). The terminator must be the same as the leading quote of the string.
1532	-161	HP-IB ERROR	Invalid block data;Improper block termination	Correct the HP-IB controller program so that it terminates the indefinite length block data with the new line character.
1533	-120	HP-IB ERROR	Numeric data error;Non-decimal data not allowed	Correct the HP-IB controller program so that the data included with the HP-IB command is not non-decimal data.
1534	-121	HP-IB ERROR	Invalid character in number;Invalid character in non-decimal data	Correct the HP-IB controller program so that the non-decimal data included with the HP-IB command contains only the following characters: Binary data(#B): 0 or 1 Octal data(#Q): 0 through 7 Hexadecimal data(#H): 0—9, A—F, a—f.
1535	-222	HP-IB ERROR	Data out of range;NON-DECIMAL DATA TYPE DATA OVERFLOW	Correct the non-decimal data so that it contains eight bytes or less.
1536	-120	HP-IB ERROR	Numeric data error;Improper non-decimal termination	Correct the HP-IB controller program so that the non-decimal data included with the HP-IB command contains 8 bytes or less of numeric data.
1539	-121	HP-IB ERROR	Invalid character in number;Invalid character in decimal data	Correct the HP-IB controller program so that the decimal data included with the HP-IB command only contains acceptable numeric characters: 0 through 9, -, +, E or e.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
1545	-113	HP-IB ERROR	Undefined header;Query not allowed for this mnemonic	Correct the HP-IB controller program so that the HP-IB mnemonic does not have a question mark (?) following it. Only the command is defined for the mnemonic.
1547	-121	HP-IB ERROR	Invalid character in number;Improper non-decimal data format	Correct the HP-IB controller program so that it contains a correct non-decimal type. A non-decimal data type should begin with “#” followed by a b, B, q, Q, h, or H.
1548	-171	HP-IB ERROR	Invalid expression;Improper expression termination	Correct the HP-IB controller program so that the expression data included with the HP-IB command is terminated with a right parenthesis [)].
1551	-161	HP-IB ERROR	Invalid block data;Invalid character in block length field	Correct the HP-IB controller program so that the definite block's length field only contains the characters 0 through 9.
1902	1902	HP-IB ERROR	Function not completed, try again	The operation (function selection, data entry, etc.) that was attempted at the time was not executed. Try the operation again. If this error keeps recurring, some troubleshooting is necessary. Begin by presetting the instrument. If this is unsuccessful in eliminating these errors from recurring, turn the instrument off and on. If this doesn't help, use the INITIALIZE MEMORY special function. If the generator seems “dead” even after turning it on and off, hold down the  key while the instrument powers on. This will force a PRESETTING INSTRUMENT message on power up and will completely reset all generator features.
2006	-107	HP-IB ERROR	Incorrect number of parameters;BURST ON-OFF	Correct the HP-IB controller program so that the HP-IB burst command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2007	-221	SETNG CNFLCT	Settings conflict; BURST ON-OFF	Turn vector modulation OFF before turning burst (PULM) modulation on.
2016	-107	HP-IB ERROR	Incorrect number of parameters;EXT CLOCK SELECT	Correct the HP-IB controller program so that the HP-IB ext clock select commands have exactly 1 parameter; the HP-IB query may have exactly 0 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2021	-107	HP-IB ERROR	Incorrect number of parameters;CLOCK COUPLING	Correct the HP-IB controller program so that the HP-IB clock coupling command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2025	-222	LIMIT ERROR	Data out of range;CLOCK LEV	Select a clock threshold level from -2.5 to 2.5 volts.
2026	-107	HP-IB ERROR	Incorrect number of parameters;CLOCK LEV	Correct the HP-IB controller program so that the HP-IB clock level command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2030	-222	LIMIT ERROR	Data out of range;CARR FREQ	Select a carrier frequency from 0 to 375 MHz.
2031	-107	HP-IB ERROR	Incorrect number of parameters;CARR FREQ	Correct the HP-IB controller program so that the HP-IB frequency command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2036	-107	HP-IB ERROR	Incorrect number of parameters;DATA MODE	Correct the HP-IB controller program so that the HP-IB data mode command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2041	-107	HP-IB ERROR	Incorrect number of parameters;DATA COUPLING	Correct the HP-IB controller program so that the HP-IB data coupling command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2045	-222	LIMIT ERROR	Data out of range;DATA LEV	Select a data threshold level from -2.5 to 2.5 volts.
2046	-107	HP-IB ERROR	Incorrect number of parameters;DATA LEV	Correct the HP-IB controller program so that the HP-IB data level command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2051	-107	HP-IB ERROR	Incorrect number of parameters;MODULATION ON-OFF	Correct the HP-IB controller program so that the HP-IB modulation on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2052	-221	SETNG CNFLCT	Settings conflict; DIGITAL MOD ON-OFF	Turn vector modulation OFF before turning digital (DM) modulation on.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2056	-107	HP-IB ERROR	Incorrect number of parameters;FILTER SELECT	Correct the HP-IB controller program so that the HP-IB filter select command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2057	-221	SETNG CNFLCT	Settings conflict; FILTER SELECT	External filters can not be selected in vector modulation mode
2061	-107	HP-IB ERROR	Incorrect number of parameters;MOD FORMAT	Correct the HP-IB controller program so that the HP-IB modulation format command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2066	-107	HP-IB ERROR	Incorrect number of parameters;FRAME SELECT	Correct the HP-IB controller program so that the HP-IB frame select command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2070	-222	LIMIT ERROR	Data out of range;POWER LEVEL	Select an output power level from -150 to 19 dBm.
2071	-107	HP-IB ERROR	Incorrect number of parameters;POWER LEVEL	Correct the HP-IB controller program so that the HP-IB power level command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2076	-107	HP-IB ERROR	Incorrect number of parameters;PRBS CLOCK SELECT	Correct the HP-IB controller program so that the HP-IB PRBS clock select command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2080	-222	LIMIT ERROR	Data out of range;PRBS DIVIDE	Select a PRBS divide value of 1, 2, 4 or 8.
2081	-107	HP-IB ERROR	Incorrect number of parameters;PRBS DIVIDE	Correct the HP-IB controller program so that the HP-IB PRBS divide command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2086	-107	HP-IB ERROR	Incorrect number of parameters;DATA SOURCE(PRBS ON-OFF)	Correct the HP-IB controller program so that the HP-IB PRBS on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2091	-107	HP-IB ERROR	Incorrect number of parameters;RF OUT ON-OFF	Correct the HP-IB controller program so that the HP-IB RF output on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2096	-107	HP-IB ERROR	Incorrect number of parameters;AM(SCALAR) ON-OFF	Correct the HP-IB controller program so that the HP-IB scalar on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2097	-221	SETNG CNFLCT	Settings conflict; AM(SCALAR) ON-OFF	Turn vector modulation OFF before turning scalar (AM) modulation ON
2105	-220	HP-IB ERROR	Parameter error;INCORRECT BLOCK SIZE WITH SYST:SET	The "learn string" sent to the instrument is corrupt (incorrect length). Check that the HP-IB controller is sending the string correctly. In addition, insure that the controller loaded the learn string correctly in the first place. The *LRN? function always returns the same length string regardless of the state of the instrument.
2106	-107	HP-IB ERROR	Incorrect number of parameters;SYST:SET	The "learn string" sent to the instrument is corrupt. Check that the HP-IB controller is sending the string correctly. In addition, insure that the controller loaded the learn string correctly in the first place.
2116	-107	HP-IB ERROR	Incorrect number of parameters;LOCK STEP ATT	Correct the HP-IB controller program so that the HP-IB lock step attenuator command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2121	-107	HP-IB ERROR	Incorrect number of parameters;POW:UNIT	Correct the HP-IB controller program so that the HP-IB power unit command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2135	-222	LIMIT ERROR	Data out of range; CONSTELLATION ANGLE	Select a constellation angle from $-90^\circ$ to $90^\circ$ .
2136	-107	HP-IB ERROR	Incorrect number of parameters;CONSTELLATION ANGLE	Correct the HP-IB controller program so that the HP-IB constellation angle command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2145	-222	LIMIT ERROR	Data out of range;SYST:KEY	Select a key number from 0 to 51.
2146	-107	HP-IB ERROR	Incorrect number of parameters;SYST:KEY	Correct the HP-IB controller program so that the HP-IB SYST:KEY command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2151	-107	HP-IB ERROR	Incorrect number of parameters;DM:POL:ALL	Correct the HP-IB controller program so that the HP-IB DM:POL:ALL command has exactly 1 parameter.
2156	-107	HP-IB ERROR	Incorrect number of parameters;FREQ:MODE	Correct the HP-IB controller program so that the HP-IB FREQ:MODE command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2171	-107	HP-IB ERROR	Incorrect number of parameters; DM:COUP:ALL	Correct the HP-IB controller program so that the HP-IB DM:COUP:ALL command has exactly 1 parameter.
2175	-222	LIMIT ERROR	Data out of range;DM:THR:ALL	Select a clock and data threshold level from -2.5 to 2.5 volts.
2176	-107	HP-IB ERROR	Incorrect number of parameters;DM:THR:ALL	Correct the HP-IB controller program so that the HP-IB DM:THR:ALL command has exactly 1 parameter.
2181	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:ABUS?	Correct the HP-IB controller program so that the HP-IB DIAG:ABUS? query has exactly 1 parameter.
2186	-107	HP-IB ERROR	Incorrect number of parameters;CARR LK ANGLE	Correct the HP-IB controller program so that the HP-IB carrier leakage angle command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2190	-222	LIMIT ERROR	Data out of range;DIAG:AVER	Correct the DIAG:AVER HP-IB command so that the number of averages is from 1 to 100.
2191	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:AVER	Correct the HP-IB controller program so that the HP-IB DIAG:AVER command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2196	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:ABUS:CAL	Correct the HP-IB controller program so that the HP-IB DIAG:ABUS:CAL command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2200	-222	LIMIT ERROR	Data out of range; DIAG:IBUS:DIR	Correct the HP-IB command DIAG:IBUS:DIR or DIAG:IBUS:DIR? so that its parameters are within the following ranges: Shift chain (1st parameter): 0 to 7 Start bit (2nd parameter): 0 to 71 Bit field length (3rd parameter): 1 to 32 Data (4th parameter [Command only]): 0 to 2147483647

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2201	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:IBUS:DIR	Correct the HP-IB controller program so that the HP-IB DIAG:IBUS:DIR command has exactly 4 parameters; the HP-IB query may have 3 or 4 parameters.
2206	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:ATT	Correct the HP-IB controller program so that the HP-IB DIAG:ATT command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2215	-222	LIMIT ERROR	Data out of range;PRBS FREQ	Select a PRBS frequency of 1.25 MHz, 2.5 MHz, 5 MHz, or 10 MHz.
2216	-107	HP-IB ERROR	Incorrect number of parameters;PRBS FREQ	Correct the HP-IB controller program so that the HP-IB PRBS frequency command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2220	-222	LIMIT ERROR	Data out of range;I FILT LOSS	Select an I filter loss correction from 0 to 9.99 dB.
2221	-107	HP-IB ERROR	Incorrect number of parameters;I FILT LOSS	Correct the HP-IB controller program so that the HP-IB I filter correction command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2230	-222	LIMIT ERROR	Data out of range;IQ RATIO MAG	Select an I/Q ratio magnitude from 40 to -40 dB.
2231	-107	HP-IB ERROR	Incorrect number of parameters;IQ RATIO MAG	Correct the HP-IB controller program so that the HP-IB I/Q ratio magnitude command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2235	-222	LIMIT ERROR	Data out of range;CARR LK MAG	Select a carrier leakage magnitude from -40 to 0 dB.
2236	-107	HP-IB ERROR	Incorrect number of parameters;CARR LK MAG	Correct the HP-IB controller program so that the HP-IB carrier leakage magnitude command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2241	-107	HP-IB ERROR	Incorrect number of parameters;POW:MODE	Correct the HP-IB controller program so that the HP-IB POW:MODE command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2245	-222	LIMIT ERROR	Data out of range;QUAD ANGLE	Select a quadrature angle from -90 to 90 degrees.
2246	-107	HP-IB ERROR	Incorrect number of parameters;QUAD ANGLE	Correct the HP-IB controller program so that the HP-IB quadrature angle command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2271	-107	HP-IB ERROR	Incorrect number of parameters;IQ RATIO ON-OFF	Correct the HP-IB controller program so that the HP-IB I/Q ratio on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2276	-107	HP-IB ERROR	Incorrect number of parameters;CARR LK ON-OFF	Correct the HP-IB controller program so that the HP-IB carrier leakage on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2281	-107	HP-IB ERROR	Incorrect number of parameters;QUAD ON-OFF	Correct the HP-IB controller program so that the HP-IB quadrature angle on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2285	-222	LIMIT ERROR	Data out of range;Q FILT LOSS	Select a Q filter loss correction from 0 to 9.99 dB.
2286	-107	HP-IB ERROR	Incorrect number of parameters;Q FILT LOSS	Correct the HP-IB controller program so that the HP-IB Q filter correction command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2290	-222	LIMIT ERROR	Data out of range;INSTRUMENT CONTROL	Select instrument control values within the following ranges: Destination number: 0 to 60 New value: 0 to 16383
2291	-107	HP-IB ERROR	Incorrect number of parameters;INSTRUMENT CONTROL	Correct the HP-IB controller program so that the HP-IB instrument control command has exactly 2 parameters; the HP-IB query may have 1 or 2 parameters.
2301	-107	HP-IB ERROR	Incorrect number of parameters;I DATA INV	Correct the HP-IB controller program so that the HP-IB I data invert commands has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2306	-107	HP-IB ERROR	Incorrect number of parameters;Q DATA INV	Correct the HP-IB controller program so that the HP-IB Q data invert commands has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2316	-107	HP-IB ERROR	Incorrect number of parameters;BURST INV	Correct the HP-IB controller program so that the HP-IB burst invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2321	-107	HP-IB ERROR	Incorrect number of parameters;10MHZ PHASE	Correct the HP-IB controller program so that the HP-IB 10MHZ phase bump command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2325	-222	LIMIT ERROR	Data out of range; POWER LEVEL INC	Select a output power level increment from 0.1 to 169 dB.
2326	-107	HP-IB ERROR	Incorrect number of parameters;POWER LEVEL INC	Correct the HP-IB controller program so that the HP-IB power level increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2330	-222	LIMIT ERROR	Data out of range;CARR FREQ INC	Select a carrier frequency increment from 1 Hz to 375 MHz.
2331	-107	HP-IB ERROR	Incorrect number of parameters;CARR FREQ INC	Correct the HP-IB controller program so that the HP-IB frequency increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2335	-222	LIMIT ERROR	Data out of range;DATA LEV INC	Select a data threshold level increment from -2.5 to 2.5 volts.
2336	-107	HP-IB ERROR	Incorrect number of parameters;DATA LEV INC	Correct the HP-IB controller program so that the HP-IB data level increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2340	-222	LIMIT ERROR	Data out of range;CLOCK LEV INC	Select a clock threshold level increment from -2.5 to 2.5 volts.
2341	-107	HP-IB ERROR	Incorrect number of parameters;CLOCK LEV INC	Correct the HP-IB controller program so that the HP-IB clock level increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2345	-222	LIMIT ERROR	Data out of range;STATE SAVE	Select a save register number from 0 to 9.
2346	-107	HP-IB ERROR	Incorrect number of parameters;STATE SAVE	Correct the HP-IB controller program so that the HP-IB save command (*SAV) has exactly 1 parameter.
2350	-222	LIMIT ERROR	Data out of range;STATE RECALL	Select a recall register number from 0 to 9.
2351	-107	HP-IB ERROR	Incorrect number of parameters;STATE RECALL	Correct the HP-IB controller program so that the HP-IB recall command (*RCL) has exactly 1 parameter.
2355	-222	LIMIT ERROR	Data out of range;SPECIAL KEY	Select a special function number from the special function list.
2360	-222	LIMIT ERROR	Data out of range;CARR LK MAG INC	Select a carrier leakage magnitude increment from 0.1 to 40 dB.
2361	-107	HP-IB ERROR	Incorrect number of parameters;CARR LK MAG INC	Correct the HP-IB controller program so that the HP-IB carrier leakage magnitude increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2366	-107	HP-IB ERROR	Incorrect number of parameters;CARR LK ANGLE INC	Correct the HP-IB controller program so that the HP-IB carrier leakage angle increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2370	-222	LIMIT ERROR	Data out of range;IQ RATIO MAG INC	Select an I/Q ratio magnitude increment from 0.1 to 40 dB.
2371	-107	HP-IB ERROR	Incorrect number of parameters;IQ RATIO MAG INC	Correct the HP-IB controller program so that the HP-IB I/Q ratio magnitude increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2381	-107	HP-IB ERROR	Incorrect number of parameters;10MHZ PHASE INC	Correct the HP-IB controller program so that the HP-IB 10MHZ phase bump increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2385	-222	LIMIT ERROR	Data out of range;I FILT LOSS INC	Select an I filter loss correction increment from 0.01 to 9.99 dB.
2386	-107	HP-IB ERROR	Incorrect number of parameters;I FILT LOSS INC	Correct the HP-IB controller program so that the HP-IB I filter correction increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2390	-222	LIMIT ERROR	Data out of range;Q FILT LOSS INC	Select a Q filter loss correction increment from 0.01 to 9.99 dB.
2391	-107	HP-IB ERROR	Incorrect number of parameters;Q FILT LOSS INC	Correct the HP-IB controller program so that the HP-IB Q filter correction increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2405	-222	LIMIT ERROR	Data out of range;QUAD ANGLE INC	Select a quadrature angle increment from -90 to 90 degrees.
2406	-107	HP-IB ERROR	Incorrect number of parameters;QUAD ANGLE INC	Correct the HP-IB controller program so that the HP-IB quadrature angle increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2410	-222	LIMIT ERROR	Data out of range; CONSTELLATION ANGLE INC	Select a constellation angle increment from -90° to 90°.
2411	-107	HP-IB ERROR	Incorrect number of parameters;CONSTELLATION ANGLE INC	Correct the HP-IB controller program so that the HP-IB constellation angle increment command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2415	-222	LIMIT ERROR	Data out of range;HPIB ADDRESS	Select an HP-IB address from 0 to 30, or 40, or 50.
2421	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:DUMP:STAT	Correct the HP-IB controller program so that the HP-IB DIAG:DUMP:STAT command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2425	-222	LIMIT ERROR	Data out of range;AM RAMP DEPTH	Select an AM fade depth from 0 to 20 dB.
2426	-107	HP-IB ERROR	Incorrect number of parameters;AM RAMP DEPTH	Correct the HP-IB controller program so that the HP-IB AM fade depth command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.
2430	-222	LIMIT ERROR	Data out of range;AM RAMP DEPTH INC	Select an AM fade depth increment from 0.1 to 20 dB.
2435	-222	LIMIT ERROR	Data out of range;AM FREQ	Select an AM fade frequency from 0.1 to 10 Hz.
2436	-107	HP-IB ERROR	Incorrect number of parameters;AM FREQ	Correct the HP-IB controller program so that the HP-IB AM fade frequency command has exactly 1 parameter; the HP-IB query may have 0 or 1 parameters.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2440	-222	LIMIT ERROR	Data out of range;AM FREQ INC	Select an AM fade frequency increment from 0.1 to 10 Hz.
2446	-107	HP-IB ERROR	Incorrect number of parameters;AM SOURCE	Correct the HP-IB controller program so that the HP-IB fade on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2476	-107	HP-IB ERROR	Incorrect number of parameters;SERVICE ON-OFF	Correct the HP-IB controller program so that the HP-IB service on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2546	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:CHUR :DEB:STAT	Correct the HP-IB controller program so that the HP-IB DIAG:CHUR:DEB:STAT command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2561	-107	HP-IB ERROR	Incorrect number of parameters;DIAG:CHUR :SEND	Correct the HP-IB controller program so that the HP-IB DIAG:CHUR:SEND command has exactly 1 parameter. This error message is also given when the string parameter is too long (> 1024 characters).
2566	-107	HP-IB ERROR	Incorrect number of parameters;OUTP:IMP?	Correct the HP-IB controller program so that the HP-IB OUTP:IMP? query has 0 or 1 parameters.
2571	-107	HP-IB ERROR	Incorrect number of parameters; CONSTELLATION ON-OFF	Correct the HP-IB controller program so that the HP-IB constellation on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2575	-222	LIMIT ERROR	Data out of range; INSTRUMENT CONTROL INC	Select instrument control increment values within the following ranges: Destination number increment: 0 to 9 Data value increment: 0 to 1000
2591	-107	HP-IB ERROR	Incorrect number of parameters;DISPLAY ON-OFF	Correct the HP-IB controller program so that the HP-IB display on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2605	-222	LIMIT ERROR	Data out of range;IFI, IFN	Select an IFI or IFN value from 0 to 7.
2606	-107	HP-IB ERROR	Incorrect number of parameters;IFI, IFN	Correct the HP-IB controller program so that the HP-IB IFI or IFN command has exactly 1 parameter.

## Error Messages (continued)

Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2611	-107	HP-IB ERROR	Incorrect number of parameters;IS	Correct the HP-IB controller program so that the HP-IB IS command has exactly 1 parameter.
2612	2612	HP-IB ERROR	No increment allowed for active parameter	The current active parameter on the front panel display does not have an increment value that can be altered by the HP-IB command IS.
2617	2617	HP-IB ERROR	No query allowed for active parameter	The current active parameter on the front panel display cannot be queried with the HP-IB mnemonics OA or OUTPACTI.
2636	-107	HP-IB ERROR	Incorrect number of parameters;FILT LOSS ON-OFF	Correct the HP-IB controller program so that the HP-IB filter correction on/off command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2641	-107	HP-IB ERROR	Incorrect number of parameters;I CLOCK INV	Correct the HP-IB controller program so that the HP-IB I clock invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2646	-107	HP-IB ERROR	Incorrect number of parameters;Q CLOCK INV	Correct the HP-IB controller program so that the HP-IB Q clock invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2651	-107	HP-IB ERROR	Incorrect number of parameters;FRAME INV	Correct the HP-IB controller program so that the HP-IB serial frame invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2656	-107	HP-IB ERROR	Incorrect number of parameters;SERIAL DATA INV	Correct the HP-IB controller program so that the HP-IB serial data invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2661	-107	HP-IB ERROR	Incorrect number of parameters;PRBS CLOCK INV	Correct the HP-IB controller program so that the HP-IB PRBS clock invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.
2666	-107	HP-IB ERROR	Incorrect number of parameters;SERIAL CLOCK INV	Correct the HP-IB controller program so that the HP-IB serial clock invert command has exactly 1 parameter; the HP-IB query may have exactly 0 parameters.

## Error Messages (continued)

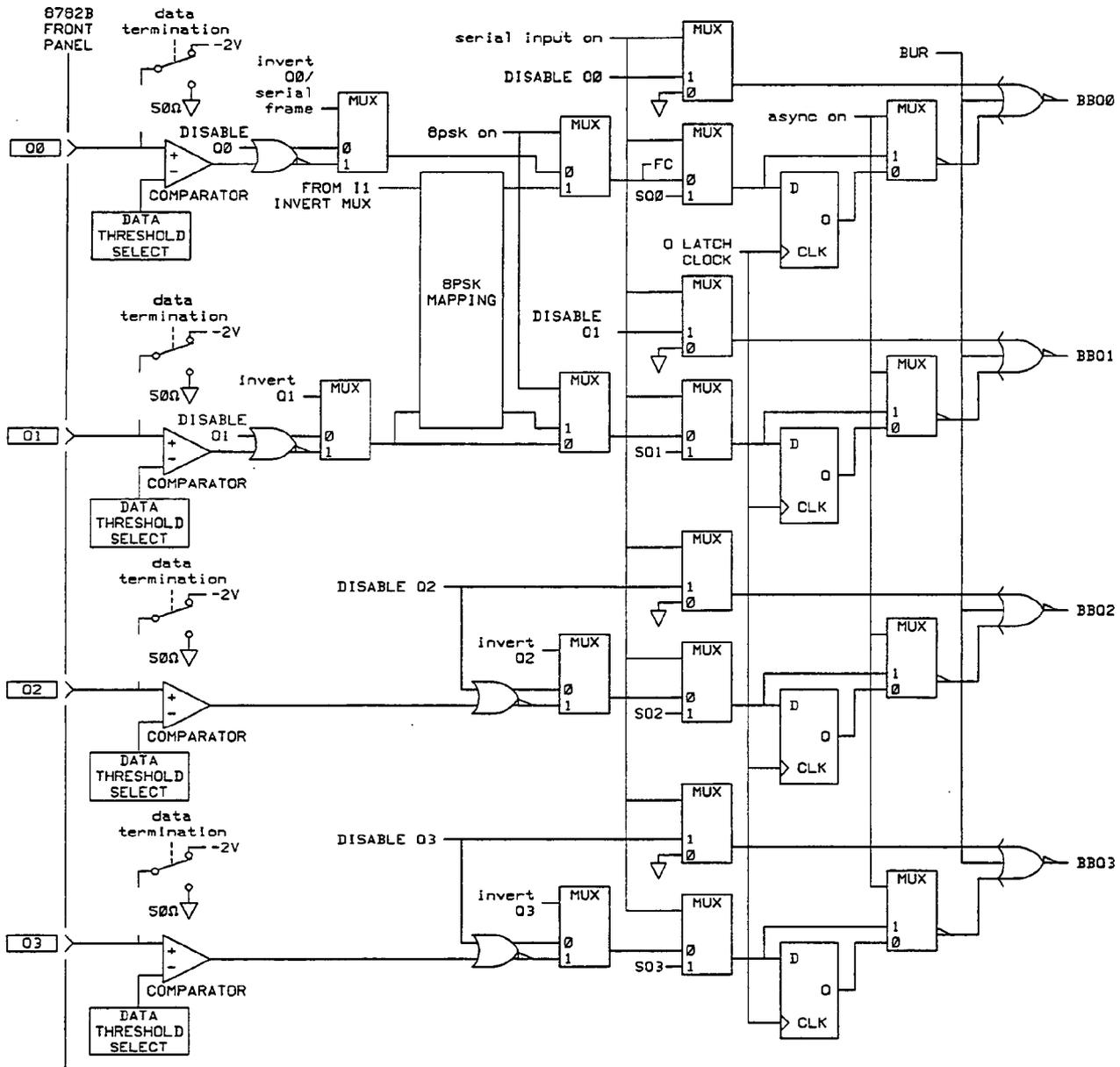
Error ID	TMSL Error ID	Front Panel Message	HP-IB Message	Action Required
2670	-222	LIMIT ERROR	Data out off range; VECTOR MOD ON-OFF	Only 0, 1, ON or OFF are allowed as parameters to VM:STATE.
2671	-107	HP-IB ERROR	Incorrect number of parameters; VECTOR MOD ON-OFF	Only one parameter allowed on command VM:STATE.
2672	-221	SETNG CNFLCT	Settings conflict; VECTOR MOD ON-OFF	Vector modulation can not be turned ON if scalar (AM), digital (DM), burst (PULM) modulation type are ON.

## **HP 8782B Block Diagrams**

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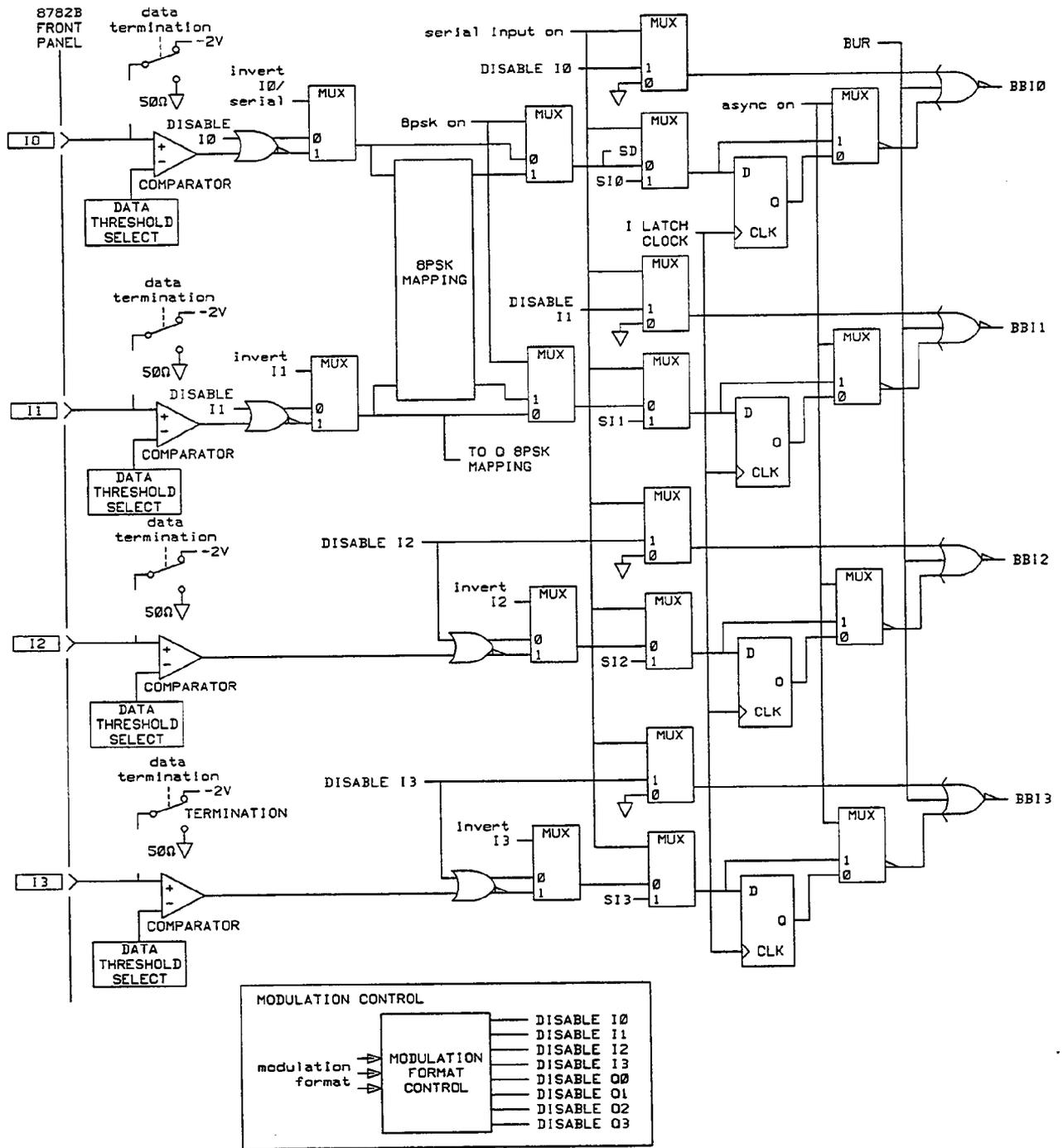
### **Introduction**

The following block diagrams are included to help you understand how the front panel settings effect data and clock signals. The diagrams are a logical representation of the instrument and do not represent the actual circuits.



NOTE:  
 MNEMONICS IN lower case INDICATE  
 SIGNALS FROM THE MICROPROCESSOR.

HP 8782B Block Diagram (1 of 3)

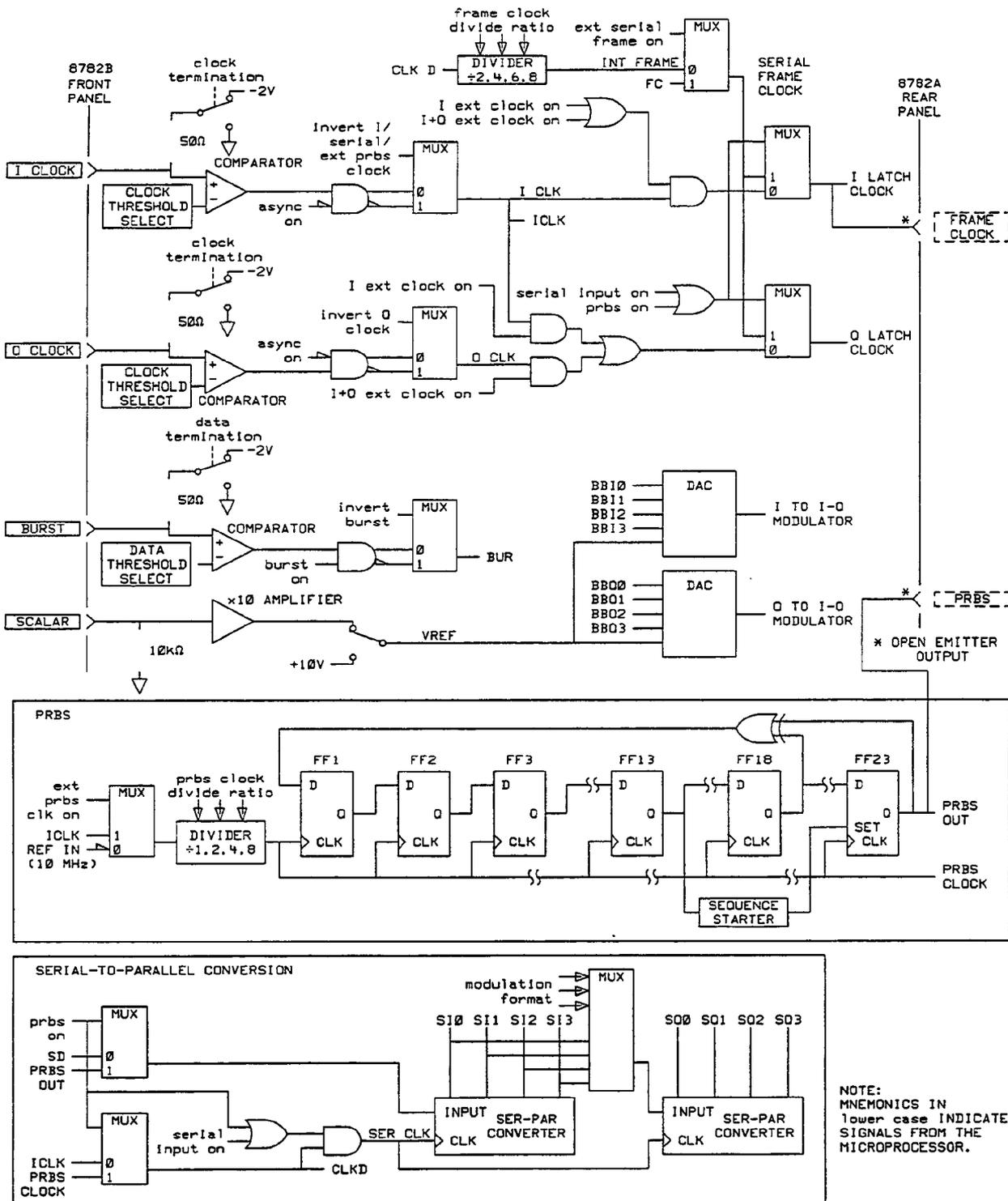


NOTE:  
 MNEMONICS IN lower case INDICATE  
 SIGNALS FROM THE MICROPROCESSOR.

HP 8782B Block Diagram (2 of 3)

Block Diagrams

HP 8782B



HP 8782B Block Diagram (3 of 3)

## Index

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- 1** 10 MHz adjust, 4-111  
16QAM, 3-22  
1 GHz output, 3-7
- 2** 256QAM, 3-20
- 6** 64QAM, 3-21
- 8** 8PSK, 3-19, 3-25  
8PSK Phase Scaling Factor, 5-69
- A** accessories, 1-4  
addressing, 4-2  
AM, 3-18  
AM source, 4-46  
AM state, 4-47  
AM subsystem  
  command summary, 4-43  
AM Subsystem  
  DEPTH, 4-44  
  FREQUENCY, 4-45  
  SOURCE, 4-46  
  STATE, 4-47  
annunciators, 3-9  
Asynchronous Data Rates, 5-31  
attenuator, 3-39  
attenuator mode, 4-116
- B** BACK SP, 3-4  
back space, 3-17  
baseband calibration, 4-50  
battery, 3-2  
boolean data, 4-7  
BPSK, 3-19, 3-24  
burst, 5-27, 5-29  
burst input polarity, 4-130

- C** cable, 1-4
  - \*CAL?, 4-26
  - calibrating HP 8981A, 3-19
  - calibration, 3-11, 4-26
  - calibration abort, 3-11
  - calibration conditions, 3-11
  - carrier leakage angle, 4-74
  - carrier leakage magnitude, 4-76
  - carrier leakage state, 4-78
  - changes, 1-4
  - character data, 4-7
  - clear status, 4-27
  - clock external, 3-32
  - clock external frame, 3-33
  - clock inputs, 3-5, 3-34
  - clock internal frame, 3-33
  - clock level, 3-31
  - CLOCK LEVEL, 3-3, 3-31
  - clock mode I & Q, 3-32
  - clock serial, 3-33
  - clock setup time, 3-31
  - clock termination, 3-31
  - \*CLS, 4-27
  - coherent carrier, 3-7, 3-19
  - command header, 4-3
  - command syntax, 4-8
  - command tables, 4-8
  - common commands, 4-2, 4-25
    - \*CAL?, 4-26
    - \*CLS, 4-27
    - \*ESE, 4-28
    - \*ESR?, 4-29
    - \*IDN?, 4-30
    - \*IST?, 4-31
    - \*LRN?, 4-32
    - \*OPC, 4-33
    - \*PRE, 4-34
    - \*RCL, 4-35
    - \*RST, 4-36
    - \*SAV, 4-37
    - \*SRE, 4-38
    - \*STB?, 4-39
    - summary, 4-25
    - \*TST?, 4-40
    - \*WAI, 4-41
  - condition register, 4-133
  - connections, 3-4
  - connectors, 2-6
  - constellation rotation angle, 4-108
  - constellation rotation state, 4-110
  - correction factors, 5-67, 5-91
    - 16QAM, 5-92
    - 256QAM, 5-70
    - 8PSK, 5-68
  - CW frequency, 4-100

- D** data
  - boolean, 4-7
  - character, 4-7
  - numeric, 4-4
  - special form numeric, 4-7
- data input mode, 4-62
- data input polarity, 4-79, 4-80, 4-81
- data inputs, 3-4
- data level, 3-30
- DATA LEVEL, 3-3
- dc Accuracy, 5-61
- DEG, 3-4
- demo mode, 3-39
- description, 1-1
- Diagnostics Subsystem
  - BBCal?, 4-50
  - command summary, 4-49
  - LCAL?, 4-51
  - NULLcal?, 4-52
- digital modulation
  - 16QAM, 5-80
  - 256QAM, 5-64
  - 8PSK, 5-63
- Digital Modulation, 5-61, 5-77
- digital modulation data source, 4-90
- digital modulation format, 4-69
- digital modulation state, 4-91
- Digital Modulation Subsystem
  - CLOCK:MODE, 4-57
  - CLOCK:SOURce, 4-58
  - command summary, 4-53
  - COUPling:ALL, 4-59
  - COUPling:CLOCK, 4-60
  - COUPling:DATA, 4-61
  - DMODE, 4-62
  - FILTer:CORRection:I, 4-63
  - FILTer:CORRection:Q, 4-65
  - FILTer:CORRection:STATe, 4-67
  - FILTer:SOURce, 4-68
  - FORMat, 4-69
  - FRAMe:SOURce, 4-70
  - IQRatio:MAGNitude, 4-71
  - IQRatio:STATe, 4-73
  - LEAKage:ANGLE, 4-74
  - LEAKage:MAGNitude, 4-76
  - LEAKage:STATe, 4-78
  - POLarity:ALL, 4-79
  - POLarity:ICLock, 4-82
  - POLarity:I[n], 4-80
  - POLarity:QCLOCK, 4-83
  - POLarity:Q[n], 4-81
  - POLarity:SERial:FRAMe, 4-86
  - QUADrature:ANGLE, 4-87
  - QUADrature:STATe, 4-89
  - SOURce, 4-90

- STATE, 4-91
  - THReshold:ALL, 4-92
  - THReshold:CLOCK, 4-93
  - THReshold:DATA, 4-95
  - display, 3-3, 3-9
  - display state, 4-98
  - Display Subsystem
    - command summary, 4-97
    - STATE, 4-98
  - divide ratio, 3-33
  - Dual-Clock Data Rate, 5-40
  - Dual-Clock Data Rates, 5-31
  - Dual Clock Data Rates, 5-31
- E**
- ECL, 3-31, 3-32
  - ECL CLK, 3-3
  - ECL DATA, 3-3
  - ECL thresholds, 3-31
  - ENTER SPCL, 3-4
  - environment, 2-7, 3-11
  - error messages, 3-37
  - error query, 4-146
  - \*ESE, 4-28
  - \*ESR?, 4-29
  - event enable register, 4-133
  - event register, 4-133
  - event status enable, 4-28
  - event status register, 4-29
  - EXT CLK, 3-3, 3-32
  - external clock, 5-55
  - external filters, 3-7, 3-36
  - EXT FILT, 3-4, 3-36
- F**
- fade simulation depth, 4-44
  - fade simulation frequency, 4-45
  - filter correction factor, 4-63, 4-65
  - filter correction state, 4-67
  - filters AC coupled, 3-12
  - filters external, 3-12
  - filters internal, 3-12
  - filter source, 4-68
  - fixed frequency, 4-100
  - frame clock, 3-7
  - frame source, 4-70
  - frequency
    - aging rate, 5-3
    - range, 5-3
    - resolution, 5-3
  - Frequency, 3-4
  - Frequency Aging Rate, 5-4
  - frequency mode, 4-102
  - Frequency Range, 5-6
  - Frequency Resolution, 5-6
  - Frequency Subsystem

- command summary, 4-99
- CW, 4-100
- MODE, 4-102
- front panel, 3-2
- function keys, 3-3
- fuse, 1-4, 2-2, 3-1, 3-2

**H** Harmonics, 5-16

- non-harmonic, 5-19
- HP-IB, 3-4
- HP-IB address, 2-5
- HP-IB command summary, 4-15-24

**I** I clock input polarity, 4-82

- identification, 4-30
- \*IDN?, 4-30
- imaginary components, 5-63, 5-80
- individual status, 4-31
- inspection, 2-1
- interface functions, 4-14
- internal clock, 5-55
- internal rate, 3-33
- INT EXT, 3-6
- invert, 3-34, 3-35
- invert input, 5-63, 5-80
- INVERT INPUT, 3-3
- IQ ratio, 4-71
- IQ ratio state, 4-73
- IQ vector inputs, 3-5
- \*IST?, 4-31

**J** jumper, 3-6

**K** keys clock, 3-3

**L** learn device setup, 4-32

- Level, 3-4
- level calibration, 4-51
- line frequencies, 2-2
- local, 3-36, 4-14
- LOCAL, 3-4
- local lockout, 4-14
- \*LRN?, 4-32

- M**
  - magnitude of state, 5-70, 5-92
  - magnitude scaling factor, 5-71, 5-92
  - main
    - performance test records, 5-117
  - maintenance, 3-2
  - memory, 3-2
  - message, 3-37
  - MESSAGE, 3-3
  - modulation, 3-4, 3-19
  - MODULATION, 3-3
  - modulation inputs, 3-4
  
- N**
  - negative transition filter, 4-133, 4-138, 4-143
  - network analyzer, 5-61, 5-78
  - null calibration, 4-52
  - numeric data, 4-4
    - suffixes, 4-4
  - numeric entry, 3-4
  
- O**
  - \*OPC, 4-33
  - operation complete, 4-33
  - operation condition register, 4-135
  - operation enable register, 4-136
  - operation event register, 4-137
  - operation status group, 4-11
  - operator's checks, 5-2
  - option 001, 3-7
  - options, 1-2
  - output impedance, 4-104
  - output queue, 4-13
  - output state, 4-105
  - Output Subsystem
    - command summary, 4-103
    - IMPedance?, 4-104
    - STATe, 4-105
  
- P**
  - parallel data, 3-30
  - parallel poll register enable, 4-34
  - performance tests
    - calibration cycle, 5-2
    - clock, 5-31
    - conditions, 5-1
    - data rates, 5-31
    - equipment, 5-1
    - frequency, 5-3
    - harmonics, 5-16
    - operator's checks, 5-2
    - Phase Noise, 5-22
    - PRBS clock rates, 5-55
    - procedures, 5-2
    - pulse modulation, 5-27
    - Pulse ON/OFF ratio, 5-29
    - residual FM, 5-12

- Residual SSB Phase Noise, 5-22
- RF output, 5-7
- RF switch ON/OFF, 5-14
- scalar dc, 5-50
- scalar frequency, 5-52
- serial data rates, 5-44
- spurious, 5-19
- test record, 5-1
- phase error, 3-33
- Phase Subsystem
  - command summary, 4-107
  - OUTPut:AJDust, 4-108
  - OUTPut:STATe, 4-110
  - RSIGnal:ADJust, 4-111
- positive transition filter, 4-133, 4-139, 4-144
- power cable, 2-4
- power cord, 1-4
- power level, 3-16, 4-117
- power mode, 4-120
- power requirements, 2-2, 2-2
- Power Subsystem
  - Attenuation:AUTO, 4-116
  - command summary, 4-115
  - LEVel:IMMediate:AMPLitude, 4-117
  - MODE, 4-120
  - UNIT, 4-121
- power suffix, 4-121
- power up, 3-1
- PRBS, 3-7, 3-19, 3-34, 3-40
  - failure, 3-34, 5-60
- PRBS CLK, 3-3
- PRBS clock sense, 4-124
- PRBS clock source, 4-125
- PRBS divide factor, 4-126
- PRBS External Clock Rates, 5-58
- PRBS internal clock frequency, 4-127
- PRBS Internal Clock Rates, 5-56
- \*PRE, 4-34
- preset, 3-10
- program data, 4-4
  - boolean, 4-7
  - character, 4-7
  - numeric, 4-4
  - special form numeric, 4-7
- programming syntax, 4-3-8
- PRS modulations, 3-25
- Pseudo-Random Binary Sequence (PRBS) Subsystem
  - CLOCK:POLarity, 4-124
  - CLOCK:SOURce, 4-125
  - command summary, 4-123
  - DIVide, 4-126
  - FREQuency, 4-127
- Pulse (Burst) ON/OFF ratio, 5-29
- Pulse Modulation, 5-27
- pulse modulation state, 4-131

Pulse Modulation Subsystem  
command summary, 4-129  
POLarity, 4-130  
STATe, 4-131

**Q** Q clock input polarity, 4-83  
QPSK, 3-23  
quadrant correction, 5-72, 5-93  
quadrature angle, 4-87, 4-152  
quadrature angle state, 4-89, 4-154  
query, 4-4  
questionable condition register, 4-140  
questionable data/signal register group, 4-13  
questionable enable register, 4-141  
questionable event register, 4-142

**R** rack mounting, 2-7  
\*RCL, 4-35  
rear panel, 3-1, 3-6  
recall, 4-35  
RECALL, 3-14  
reference oscillator, 5-6  
relative phase adjustment, 4-111  
remote, 4-14  
reset, 4-36  
residual FM, 5-12  
RF, 3-4  
RF output, 3-19  
accuracy, 5-7  
level accuracy, 5-7, 5-9  
leveled flatness, 5-7  
leveled power, 5-11  
level flatness, 5-10  
RF switch ON/OFF, 5-14  
\*RST, 4-36

**S** safety, 1-3  
\*SAV, 4-37  
save, 4-37  
SAVE, 3-14  
Scalar Accuracy  
DC, 5-77  
Scalar dc, 5-50  
Scalar Frequency, 5-52  
scalar input, 3-5  
Scalar Modulation, 5-50, 5-52  
scalar on, 3-18  
self test, 3-1  
serial clock input polarity, 4-84  
Serial Data Rates, 5-44  
serial frame, 3-19, 3-33, 3-34  
SERIAL FRAME, 3-3  
serial frame input polarity, 4-86  
serial input, 3-4, 3-30

- service request, 4-11
- service request enable, 4-38
- Set Frequency, 3-15
- SET INCR, 3-4
- set increment, 3-17
- Single Clock Data Rate, 5-36
- Single-Clock Data Rates, 5-31
- SPCL OFF, 3-4
- SPCL ON, 3-4
- special, 3-39
- SPECIAL, 3-4
- special form numeric data, 4-7
- specifications, 1-4
- spurious signals, 5-19
- \*SRE, 4-38
- standard event status register, 4-11
- standard notation, 4-8
- status, 3-9
- status byte, 4-9
- status byte query, 4-39
- status byte register, 4-9
- status reporting, 4-9-13
- Status Subsystem
  - command summary, 4-134
  - OPERation:CONDition?, 4-135
  - OPERation:ENABLE, 4-136
  - OPERation:EVENT?, 4-137
  - OPERation:NTRansition, 4-138
  - OPERation:PTRansition, 4-139
  - QUESTionable:CONDition?, 4-140
  - QUESTionable:ENABLE, 4-141
  - QUESTionable:EVENT?, 4-142
  - QUESTionable:NTRansition, 4-143
  - QUESTionable:PTRansition, 4-144
- \*STB?, 4-39
- subsystem commands, 4-2
- subsystems, 4-2
- suffixes, 4-4-7
- supplemental characteristics, 1-4
- System Subsystem
  - command summary, 4-145
  - ERRor?, 4-146
  - KEY, 4-148

**T** termination, 3-30, 3-31, 3-32, 3-33

- test equipment, 1-11
- test query, 4-40
- threshold level, 4-92, 4-93, 4-95
- time base, 3-6
- transition filters, 4-133
- trigger level, 3-33
- \*TST?, 4-40
- turn on, 3-1

- U** units, 3-4
  
- V** vector modulation state, 4-155  
Vector Modulation Subsystem  
command summary, 4-151  
QUADrature:ANGLE, 4-152  
QUADrature:STATe, 4-154  
STATe, 4-155
  
- W** \*WAI, 4-41  
wait-to-continue, 4-41  
warm up, 3-11



1 of 1 for 3602A00410

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