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# HP 70427A HP 70428A (including Opt. 002)

Serial Numbers: HP 70427A - 3240A and Above, HP 70428A - 3240A and Above

User's Guide

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HP part number: 70427-90002  
Printed in USA  
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## What You'll Find in This Manual...

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- Chapter 2, "Getting Started"
- Chapter 3, "Downconverter Operation"
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- Chapter 13, "Block Diagram"
- Chapter 14, "Performance Tests"
- Chapter 15, "Adjustments"
- Chapter 16, "Customer Support"

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## Warranty

Custom systems are warranted by contractual agreement between Hewlett-Packard Company and the Customer.

### 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, formerly NBS), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.*

### Warranty

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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.

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For assistance, call your local Hewlett-Packard Sales and Service Office (refer to "Customer Support").

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## Sound Emission

### Manufacturer's Declaration

This statement is provided to comply with the requirements of the German Sound Emission Directive, from 18 January 1991.

This product has a sound pressure emission (at the operator position) <70 dB(A).

- Sound Pressure  $L_p$  <70 dB(A).
- At Operator Position.
- Normal Operation
- According to ISO 7779:1988/EN 27779:1991 (Type Test)

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### Herstellerbescheinigung

Diese Information steht im Zusammenhang mit den Anforderungen der Maschinenlärminformationsverordnung vom 18 Januar 1991.

- Schalldruckpegel  $L_p$  <70 dB(A).
- Am Arbeitsplatz.
- Normaler Betrieb.
- Nach ISO 7779:1988/EN 27779:1991 (Typprüfung).

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## Service and Support

Any adjustment, maintenance, or repair of this product must be performed by qualified personnel. Contact your customer engineer through your local HP Service Center. You can find a list of HP Service Centers on the web at <http://www.hp.com/go/tmdir>.

If you do not have access to the Internet, one of these HP centers can direct you to your nearest HP representative:

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<b>United States:</b>	Hewlett-Packard Company Test and Measurement Call Center PO Box 4026 Englewood, CO 80155-4026 (800) 452 4844 (toll-free in US)
<b>Canada:</b>	Hewlett-Packard Canada Ltd. 5150 Spectrum Way Mississauga, Ontario L4W 5G1 (905) 206 4725
<b>Europe:</b>	Hewlett-Packard European Marketing Centre Postbox 999 1180 AZ Amstelveen The Netherlands (31 20) 547 9900
<b>Japan:</b>	Yokogawa-Hewlett-Packard Ltd. Measurement Assistance Center 9-1, Takakura-Cho, Hachioji-Shi Tokyo 192, Japan (81) 426 56 7832 (81) 426 56 7840 (FAX)
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## Safety and Regulatory Information

Review this product and related documentation to familiarize yourself with safety markings and instructions before you operate the instrument. This product has been designed and tested in accordance with international standards.

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### WARNING

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

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### CAUTION

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The **CAUTION** notice 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 the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

## Instrument Markings

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	When you see this symbol on your instrument, you should refer to the instrument's instruction manual for important information.
	This symbol indicates hazardous voltages.
	The laser radiation symbol is marked on products that have a laser output.
	This symbol indicates that the instrument requires alternating current (ac) input.
	The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven.
	The CSA mark is a registered trademark of the Canadian Standards Association.
ISM1-A	This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4).
	This symbol indicates that the power line switch is ON.
	This symbol indicates that the power line switch is OFF or in STANDBY position.

---



## **Safety Earth Ground**

This is a Safety Class I product (provided with a protective earthing terminal). 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. Whenever it is likely that the protection has been impaired, the product must be made inoperative and secured against any unintended operation.

## **Before Applying Power**

Verify that the product is configured to match the available main power source as described in the input power configuration instructions in this manual. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

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## **Declaration of Conformity**

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## Typeface Conventions

- |                           |  |
|---------------------------|--|
| <b>Italics</b>            | <ul style="list-style-type: none"> <li>• Used to emphasize important information:<br/>Use this software <i>only</i> with the HP xxxxxX system.</li> <li>• Used for the title of a publication:<br/>Refer to the <i>HP xxxxxX System-Level User's Guide</i>.</li> <li>• Used to indicate a variable:<br/>Type LOAD BIN <i>filename</i>.</li> </ul>  |
| <b>Instrument Display</b> | <ul style="list-style-type: none"> <li>• Used to show on-screen prompts and messages that you will see on the display of an instrument:<br/>The HP xxxxxX will display the message <b>CAL1 SAVED</b>.</li> </ul>   |
| <b>[Keypad]</b>           | <ul style="list-style-type: none"> <li>• Used for labeled keys on the front panel of an instrument or on a computer keyboard:<br/>Press <b>[Return]</b>.</li> </ul>  |
| <b>{Softkey}</b>          | <ul style="list-style-type: none"> <li>• Used for simulated keys that appear on an instrument display:<br/>Press <b>{Prior Menu}</b>.</li> </ul>   |
| <b>User Entry</b>         | <ul style="list-style-type: none"> <li>• Used to indicate text that you will enter using the computer keyboard; text shown in this typeface must be typed <i>exactly</i> as printed:<br/>Type LOAD PARMFILE</li> <li>• Used for examples of programming code:<br/>#endif // ifndef NO_CLASS</li> </ul>   |
| <b>Path Name</b>          | <ul style="list-style-type: none"> <li>• Used for a subdirectory name or file path:<br/>Edit the file <code>usr/local/bin/sample.txt</code></li> </ul>   |
| <b>Computer Display</b>   | <ul style="list-style-type: none"> <li>• Used to show messages, prompts, and window labels that appear on a computer monitor:<br/>The <b>Edit Parameters</b> window will appear on the screen.</li> <li>• Used for menus, lists, dialog boxes, and button boxes on a computer monitor from which you make selections using the mouse or keyboard:<br/>Double-click <b>EXIT</b> to quit the program.</li> </ul> |

## Typeface Conventions

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# 1

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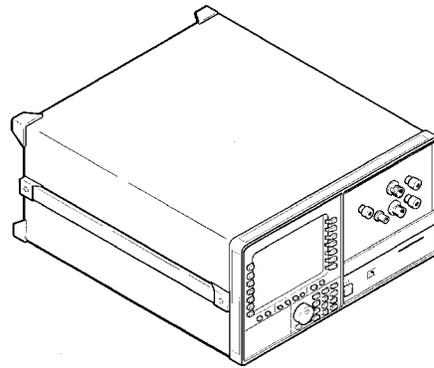
## Installation

### Overview

The HP 70427A Downconverter Module, HP 70428A Microwave Source Module, and HP 70428A Option 002 Microwave Source Module (Tunable Source) are part of the 70000 modular measurement system (MMS). Each can be used alone in a mainframe, or configured into multi-instrument workstations including:

#### Example A

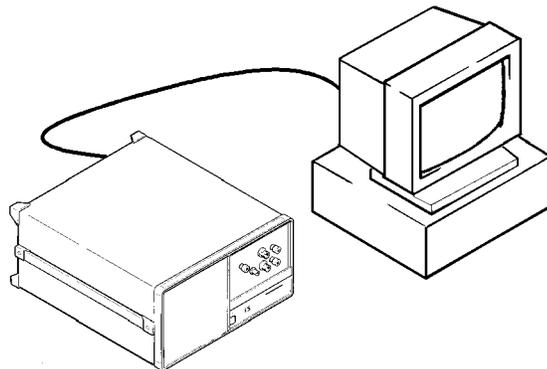
In a stand alone mainframe. (The modules may also be ordered already installed in a stand alone mainframe (HP 71707A, HP 71708A, and HP 71708A Option 002)). Does not require HP-IB or MS-IB.



*Figure 1-1 Installed in a Stand Alone Mainframe*

#### Example B

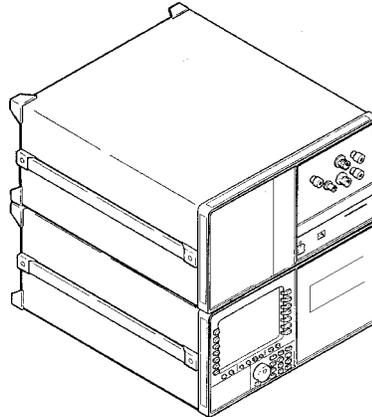
In a mainframe with no display linked to a computer via HP-IB. Requires HP-IB.



*Figure 1-2 Installed in a Main frame with No Display Linked to a Computer*

### Example C

In a mainframe with no display linked to a mainframe with a display via MS-IB. Requires MS-IB.



*Figure 1-3 Linked to a Mainframe via MS-IB*

### Tools/equipment needed

Before installation, assemble these tools:

- 8mm Hex-ball driver, for locking the units into the mainframe.
- A small flat-head screw driver or similar object, for setting MS-IB address switches.
- HP MMS Manual for your display and/or mainframe.

---

### CAUTION

---

Before proceeding, read the ESD warning at the beginning of this book. Thoroughly read the connector care booklet enclosed, to ensure proper care of the connectors.

### Installation Overview

The installation procedure for the HP 7042X varies depending on the selected configuration. It may include one or more of the following major steps:

1. Front and rear panel connector installation: installing connector savers, 50 ohm terminations, and type N to SMA adapter (if needed).
2. Preliminary work: checking line voltage, verifying MMS is already functioning properly, and setting MS-IB address (if needed).
3. Mainframe assembly: installing unit into mainframe, and connecting cables (if needed).
4. Verification: checking that the unit is working properly, using the procedure and diagnostics described.

5. Software configuration: entering the appropriate soft and hard key configurations.

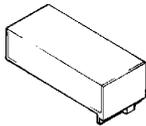
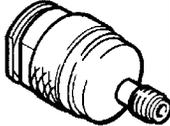
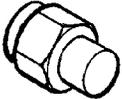
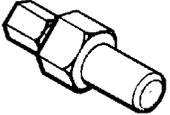
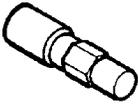
For MMS information beyond what is included in this manual, refer to the appropriate MMS manual.

## Standard Equipment Supplied

Parts listed below in *Figure 1-4* are supplied with the particular module. Refer to the MMS manual to identify additional parts included with the MMS Mainframe.

### Before you begin installation:

Verify that all parts are present and inspect for damage. If a part is missing or damaged contact your nearest Hewlett-Packard Sales or Service Office.

		QUANTITY		
		HP 70427A	HP 70428A	HP 70428A OPT 002
	<b>MODULE</b>	1	1	1
	<b>APC 3.5 CONNECTOR SAVERS</b> For the SIGNAL INPUT, MICROWAVE LO, and RF ANALYZER INPUT connectors. PN 5061-5311	3	1	2
	<b>Type N to SMA Adapter.</b>  PN 1250-1250	1	0	0
	<b>50 ohm Load</b> To terminate the BUFFERED 10 MHz, OUT, 100 MHz OUT (+8 dBm ), and 600 MHz OUT ( +20 dBm ) connectors on rear panel. PN 0960-0053	4	3	3
	<b>50 ohm Load</b> To terminate the 600 MHz (+0 dBm ) OUT connector on rear panel. PN 1250-0839	1	1	1
	<b>50 ohm Load</b> To terminate the 100 MHz (-2 dBm ) OUT connector on the rear panel. PN 1250-2076	1	1	1
	USER'S GUIDE - PN 70427-90002 CLIP SET - PN 70427-90004	1	1	1
	MICROWAVE CONNECTOR CARE GUIDE PN 08510-90064	1	1	1

*Figure 1-4 Standard HP Equipment Supplied with the Module*

## Optional Equipment

**Table 1-1** *Optional Equipment*

		HP 70427A	HP 70428A	HP 70428A Option 002
Option 915	Service-Manuals-On-a-disk:			
	70427-90003	1		
	70428-90007		1	1
	70428-90008		1	1
HP 70428 K03 (Special Option)	Service Tools and Accessory Kit			
HP 70428 K01	Tune Voltage Supply			
HP 70427A K02	Balun			
HP 3048A K21	Filter			

---

## Front Panel

### Connector Saver Installation

Install the connector savers for the appropriate module.

---

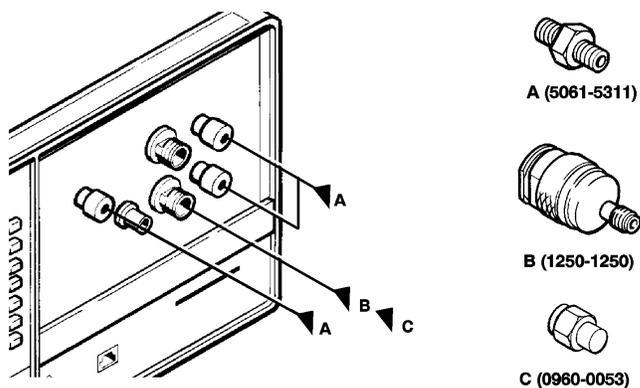
#### CAUTION

---

Proper care of connectors is essential to proper performance. See *Microwave Connector Care* Manual part number 08510-90064 for complete instructions

#### HP 70427A

1. Connect item A (3.5 APC connector savers) to: Microwave LO, Signal Input, and RF Analyzer Output.
2. Connect item B (type N to SMA adapter) to **IF** output.
3. Connect item C (50 ohm termination) to type N to SMA adapter.



*Figure 1-5 HP 70427A Connector Installation*

### HP 70428A

- Connect item A (3.5 APC connector saver) to: Microwave LO Output

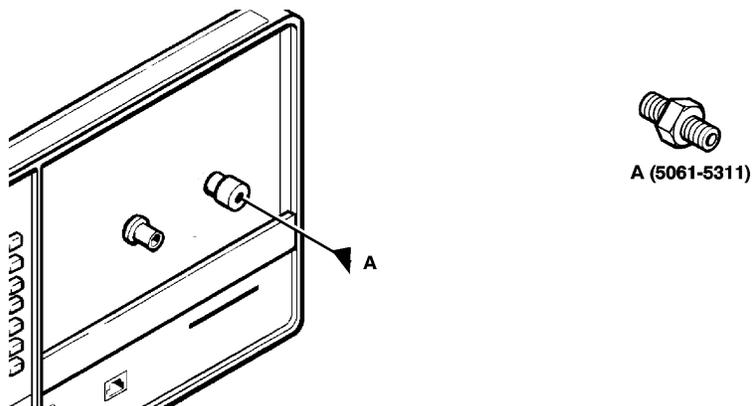


Figure 1-6 HP 70428A Connector Installation

### HP 70428A Option 002

- Connect item A (3.5 APC connector savers) to: Microwave LO Output, RF Output.

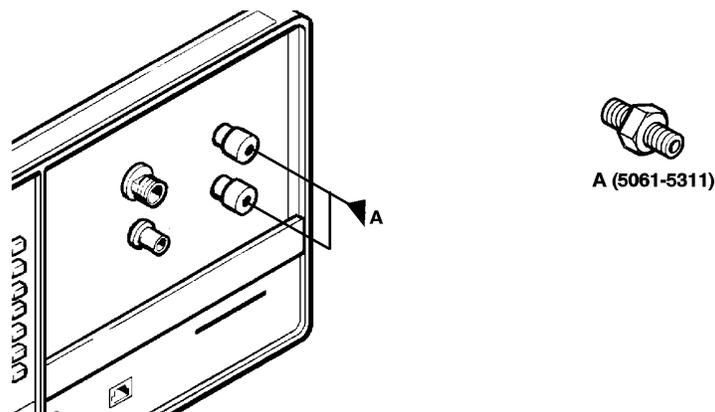


Figure 1-7 HP 70428A Option 002 Connector Installation

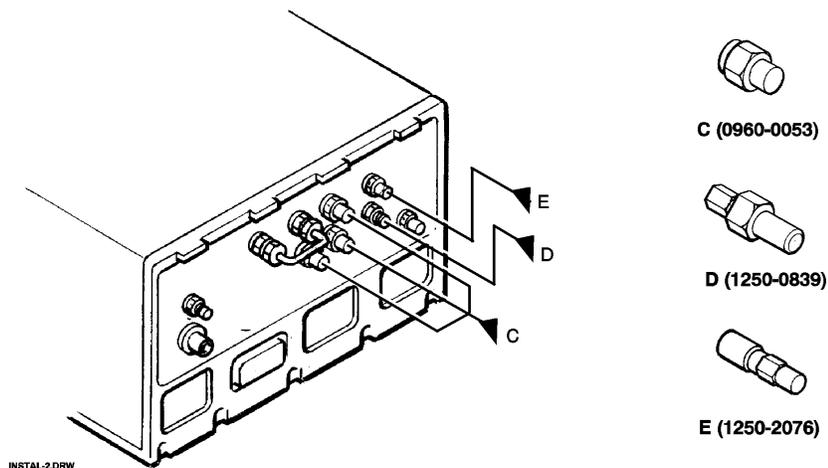
---

## Rear Panel

### 50 OHM Terminations Installation

The 50 ohm terminations for the rear panel are the same for each of the HP 70427A, HP 70428A, and HP 70428A Option 002.

1. Connect item C to: Buffered 10 MHz Out, 100 MHz Out+8 dBm, 600 MHz Out + 20 dBm
2. Connect item D to: 600 MHz Out + 0 dBm
3. Connect item E to: 100 MHz Out - 2 dBm



*Figure 1-8 50 OHM Terminations Installation Connection*

---

## Preliminary Work

### **Line Voltage**

Check line voltage. Follow the procedure and cautions defined in the MMS manual.

### **Verify MMS is Functioning Properly**

Before installing the HP 7042X module, verify that the mainframe in which the HP 7042X is to be installed and all mainframes connected with the MS-IB are working properly:

1. A screen display should be visible.
2. The address map should be accessible and show all the currently configured modules in their correct locations.
3. Note the location of all modules in Row 0.
4. There should be no errors present.

If the mainframe does not appear to be functioning properly, consult the MMS manual for troubleshooting before continuing with the installation procedure.

### **Set MS-IB Address (if Necessary)**

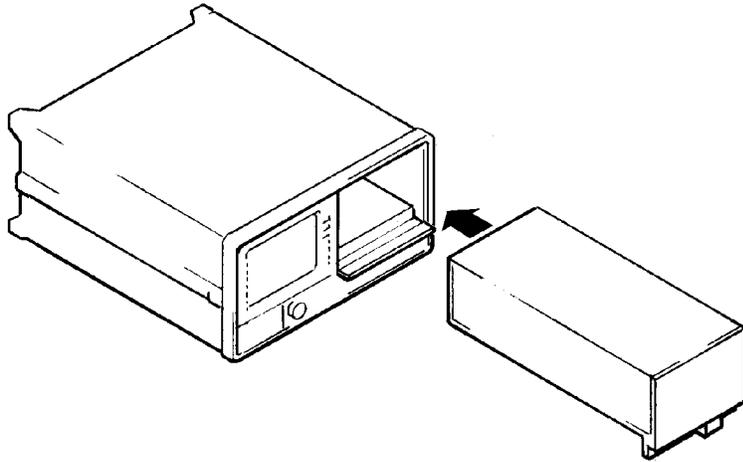
If your module will be controlled via HP-IB, set the HP-IB address to a location that does not conflict with any other module in your MMS system. Refer to procedure B at the end of this chapter for instructions to set HP-IB/MS-IB address.

---

## Mainframe Assembly

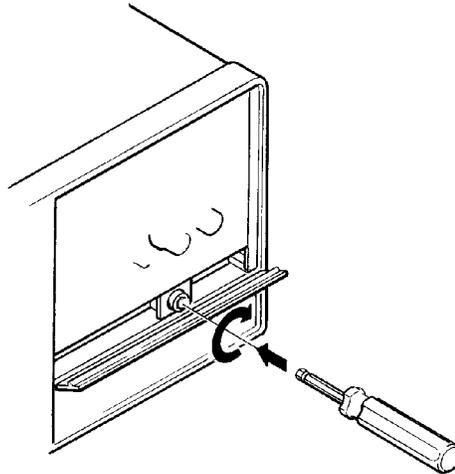
### Install Unit

1. Slide the Unit into the mainframe.



*Figure 1-9 Unit Installation*

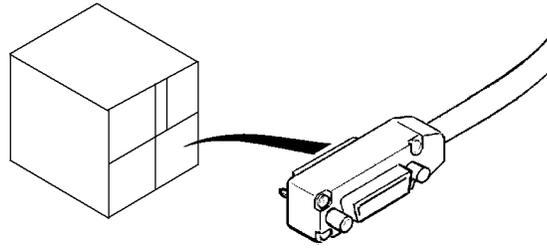
2. Tighten the bolt using the 8-mm hex ball driver. Then close lid.



*Figure 1-10 Tightening Bolt using 8-mm Hex Ball Driver*

## Connect Cables

If HP-IB is required for your configuration, install HP-IB cable.



**Figure 1-11** *HP-IB Cable Installation*

Plug in and power up. Verify that the unit is working:

- a. Six LED's on the front panel will illuminate for about six seconds, then blink off.
- b. Screen should have a display, which will vary depending upon the state of the instrument the last time it was used.
- c. Only ACT LED should remain lit on the active instrument. If the other LED's stay on, an error is present. (see chapter 2, *Getting Started* for help reading error messages.)

---

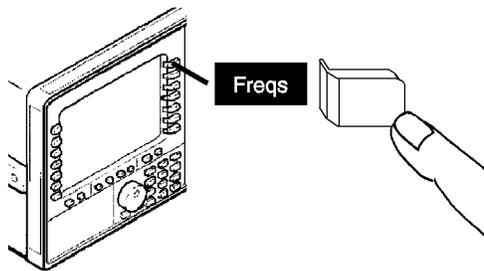
## Verification

As a first level check of proper operation:

- Enter a test frequency of 10 GHz to verify that the module responds to the mms display.

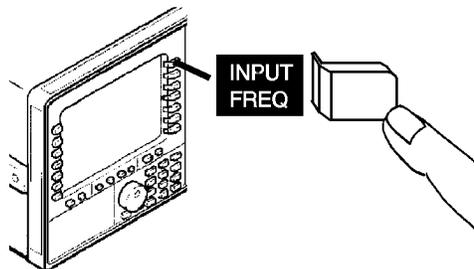
### HP 70427A Verification:

1. Press The *Freqs* softkey.



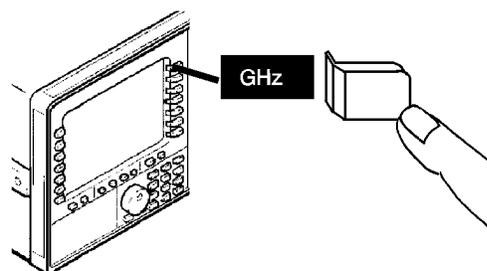
*Figure 1-12 Freqs Softkey Location*

2. Press the *INPUT FREQ* softkey.



*Figure 1-13 INPUT FREQ Softkey Location*

3. Enter 10 with the numeric keypad.
4. Then press the *GHz* softkey.

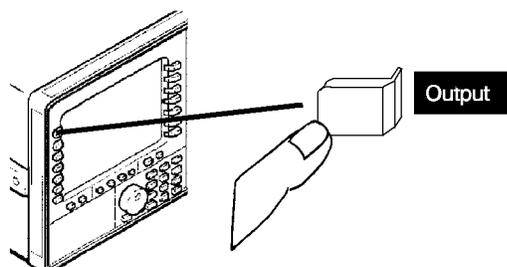


**Figure 1-14** GHz Softkey Location

The module will display **standby:tuning** for a few seconds, then it will display the output frequency

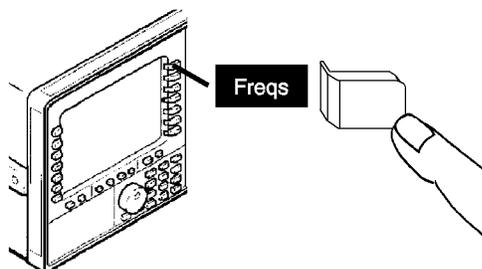
**HP 70428A Verification:**

1. Press the *Output* softkey.



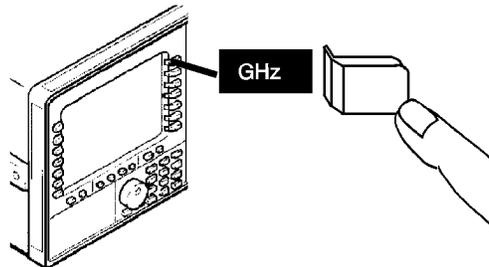
**Figure 1-15** Output Softkey Location

2. Press the *FREQ* softkey.



**Figure 1-16** FREQ Softkey Location

3. Enter 10.2 with the numeric keypad.
4. Then press the *GHz* softkey.

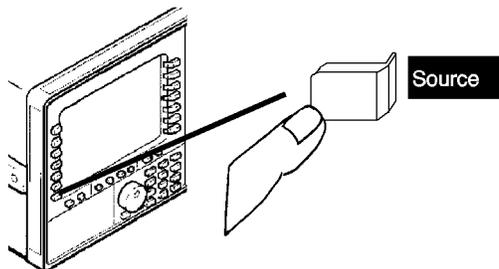


*Figure 1-17 GHz Softkey Location*

The module will display `standby:tuning` for a few seconds, then it will display the output frequency.

### HP 70428A Option 002 Verification

1. Press the *Source* softkey.



*Figure 1-18 Source Softkey Location*

2. Follow the instructions for standard HP 70428A verification.

If you are installing an HP 70428A Option 002 using an HP 8662A or HP 8663A, additional softkey configurations are necessary. See procedure A at the end of this chapter.

If you are installing an HP 70427A or HP 70428A into a mainframe with a display, installation is complete.

---

**CAUTION**

---

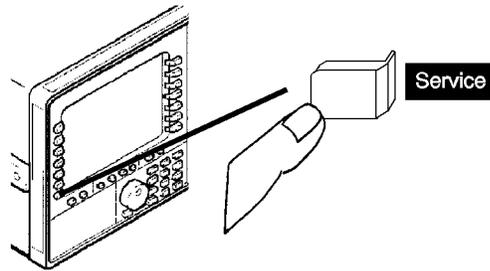
After installation is complete, consult the operation guide for proper use of the instrument.

---

## Procedure A: HP 70428A Option 002, using HP 8662A / HP 8663A Softkey Configuration

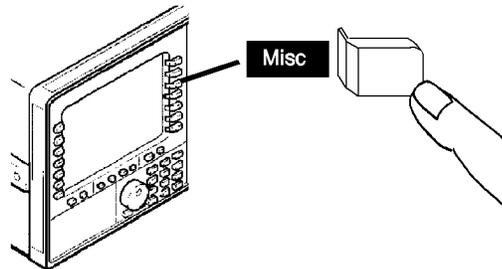
### Procedure

1. Press the *Service* softkey.



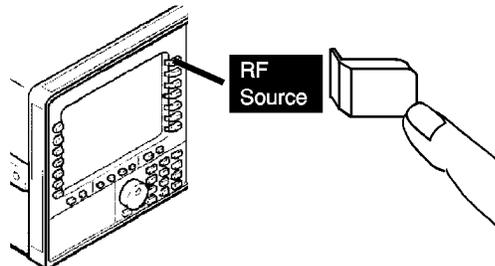
**Figure 1-19** *Service Softkey Location*

2. Press the *Misc* softkey.



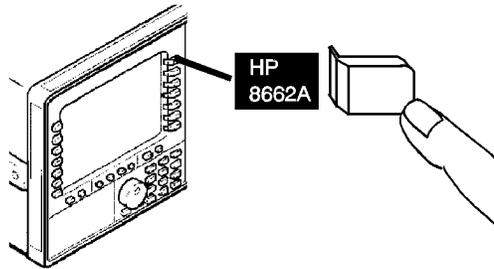
**Figure 1-20** *Misc Softkey Location*

3. Press the *RF Source* Softkey.



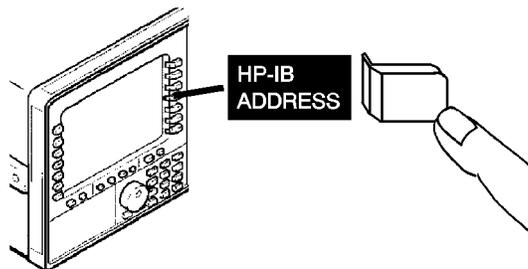
**Figure 1-21** *RF Source Softkey Location*

4. Press the *HP 8662* or *HP 8663A* softkey.



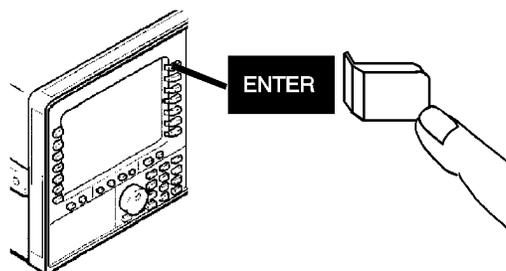
**Figure 1-22** *HP 8662 or HP 8663A Softkey Location*

Press the *HP-IB ADDRESS* softkey. The enter HP - IB Address



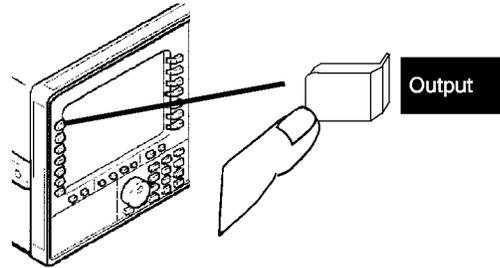
**Figure 1-23** *HP-IB ADDRESS Softkey Location*

5. Press the *Enter* softkey.



**Figure 1-24** *ENTER Softkey Location.*

6. Press the *Output* softkey.



*Figure 1-25* *Output Softkey Location*

Installation is now complete.

---

## Procedure B: Setting HP-IB Address

### Overview

The MS-IB address comes from the factory with the default set to '28'. This also represents the HP-IB default address. If this location does not conflict with any other module in your MMs, you do not need to change it.

Each module in the MMS system must have a unique HP-IB address. Check the address map on the MMS to identify available address locations. If you need to change the HP-IB address there are two ways to proceed:

I. You may temporarily change the HP-IB address using softkey configurations (described in the HP mms mainframe Operation Guide)

or

II. You may change the MS-IB address switches which will also change the HP-IB default address.

This procedure is described below:

1. The MS-IB row switches for the HP 70427A, HP 70428A, and the HP 70428A Option 002 must be set to "zero" (because each of these modules is a master in the system).
2. Set the column address to an available HP-IB address location, using binary weighted value switches.

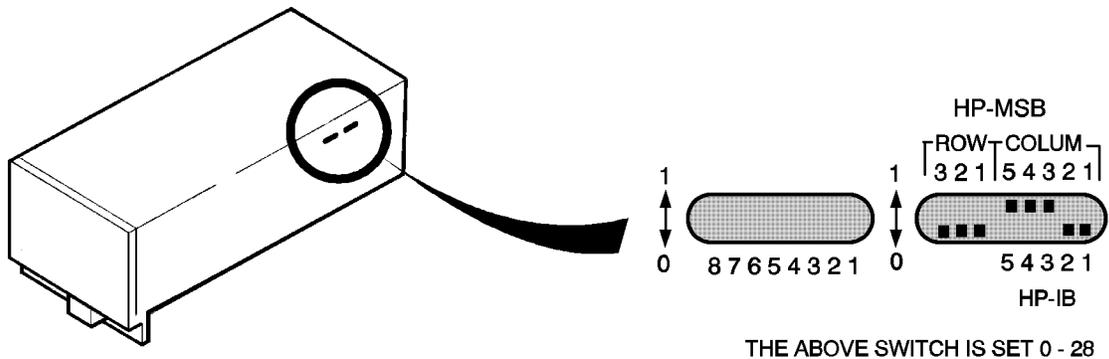


Figure 1-26 Address Switch Location

# 2

## Getting Started

### Overview

This chapter contains basic operating instructions for the HP 70427A Downconverter, HP 70428A Microwave Source, and the HP 70428A Option 002 Microwave Source (tunable source).

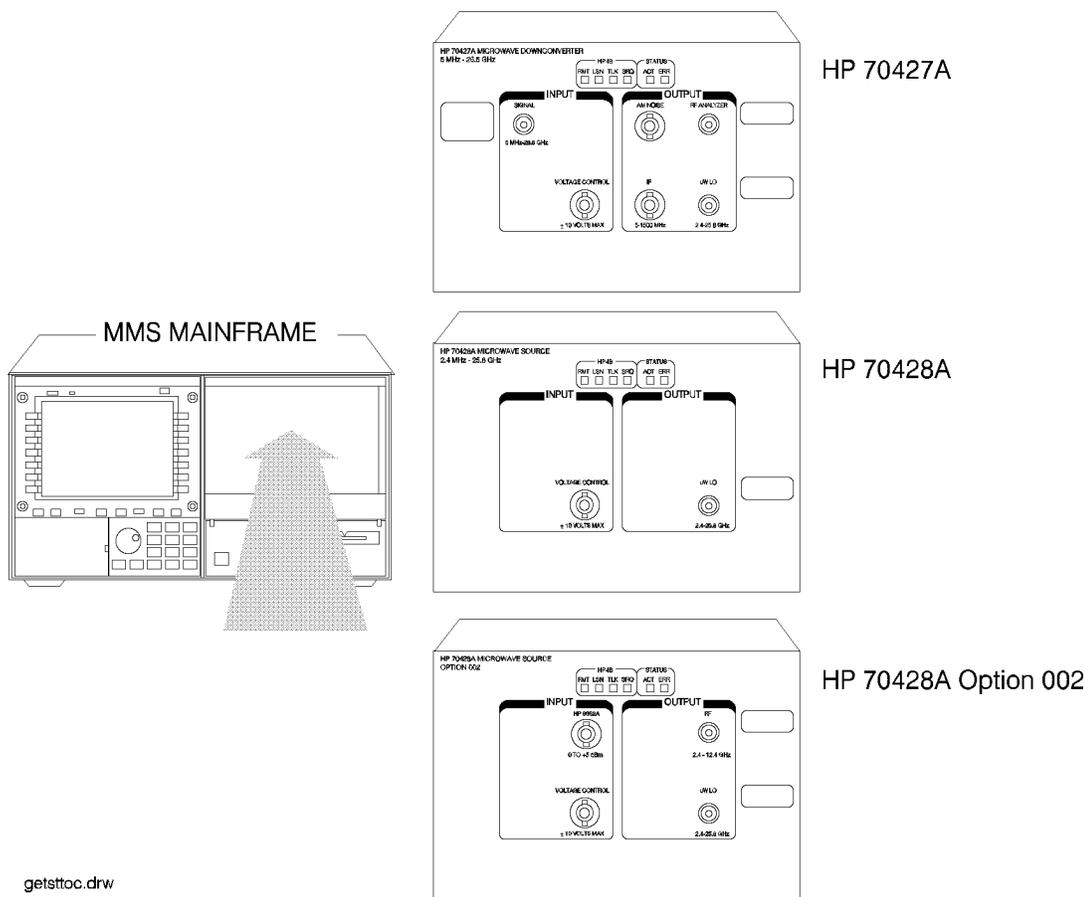


Figure 2-1 Models HP 70427A , HP 70428A , HP 70428A Option 002

## HP 70427A Microwave Downconverter

### Overview

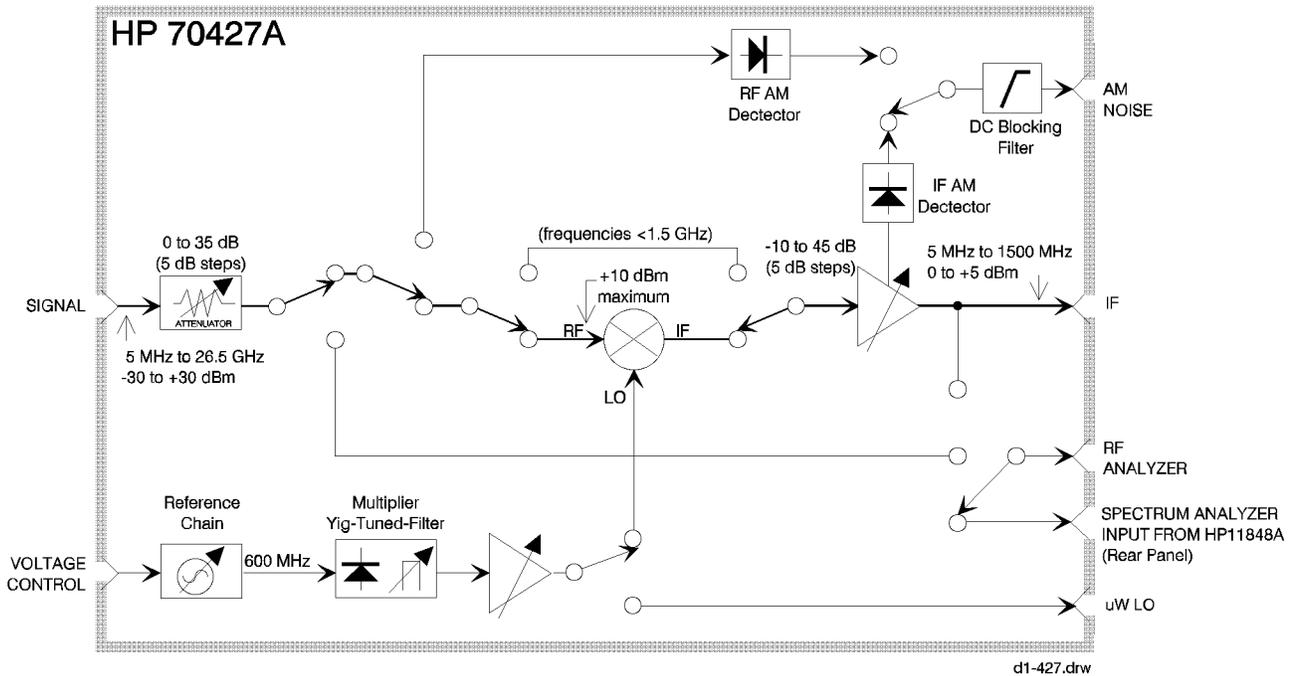


Figure 2-2 HP 70427A Microwave Downconverter

### Microwave Downconverting

The HP 70427A Downconverter accepts signals between 5 MHz and 26.5 GHz at levels from -30 dBm to +30 dBm. Signals above 1.5 GHz are mixed with an internal low-noise local oscillator (LO), which tunes in 600 MHz steps, resulting in an intermediate frequency (IF) between 300 and 900 MHz.

The input signal goes from the **SIGNAL** connector to a 0 to 35 dB step attenuator (5 dB steps) before being mixed with the LO. An adjustable IF amplifier follows the mixer. Its gain range is -10 to 45 dB in 5 dB steps.

For input frequencies below 1.5 GHz the signal goes through the input attenuator and to the IF amplifier, bypassing the mixer.

### Detecting AM noise at the RF input

The downconverter has an input AM noise mode that routes the input signal to the input attenuator and then to an RF AM detector. The detected output is routed to the **AM NOISE** connector. Input signals are not downconverted when the downconverter is in AM noise mode.

This detector is not available when an external mm wave mixer is used with the downconverter.

### Detecting AM noise at the IF output

The downconverter's IF amplifier includes an AM detector that operates unless the RF AM detector is switched in. The output of this detector is normally routed to the **AM NOISE** connector.

### Routing the input to an external instrument

The downconverter's input can be routed to the **RF ANALYZER** output. When the **VIEW IN/IF** -softkey has **IN** underlined the input signal is routed through the input attenuator and to the **RF ANALYZER** connector.

### Monitoring the IF output

When the **VIEW IN/IF** - softkey has **IF** underlined a portion of the IF amplifier's output is routed to the **IF** connector and to the **RF ANALYZER** connector so that the IF signal can be monitored while the downconverter operates normally.

### Configuring the reference chain

The downconverter's local oscillator (LO) is derived from a low-noise reference chain. The reference chain's tuning sensitivity and phase-lock-loop bandwidths can be selected from menus on the MMS display. The reference chain can also be tuned by a voltage applied to the **VOLTAGE CONTROL** connector.

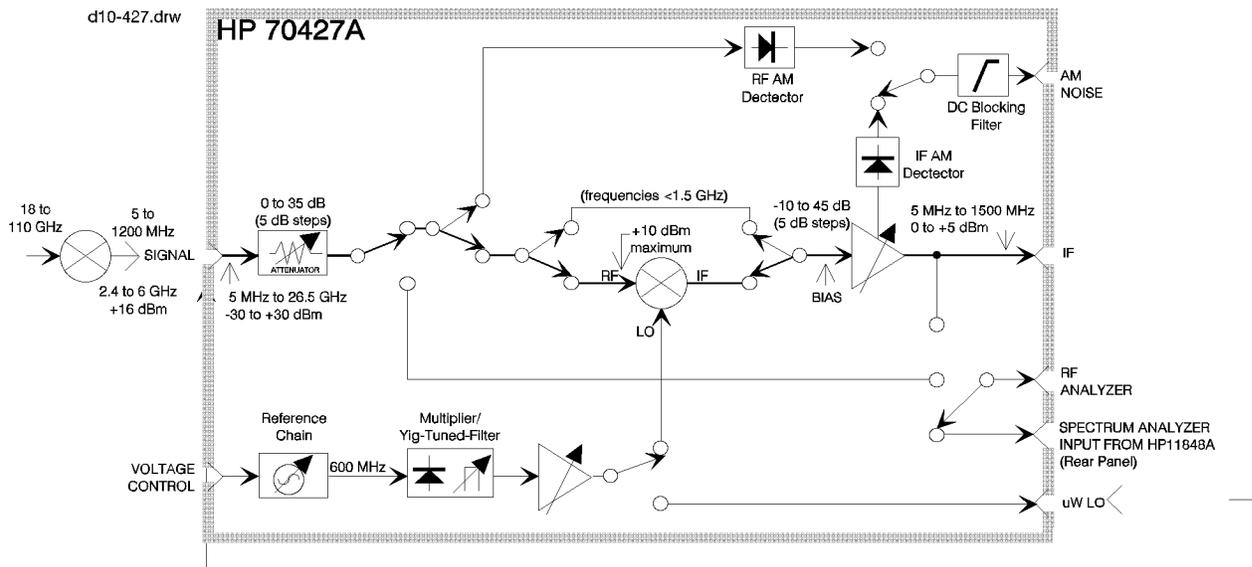


Figure 2-3 Reference Chain

### Millimeter wave downconverting

The downconverter's range can be extended to 110 GHz by adding an external millimeter (mm) wave harmonic mixer. In mm mode the

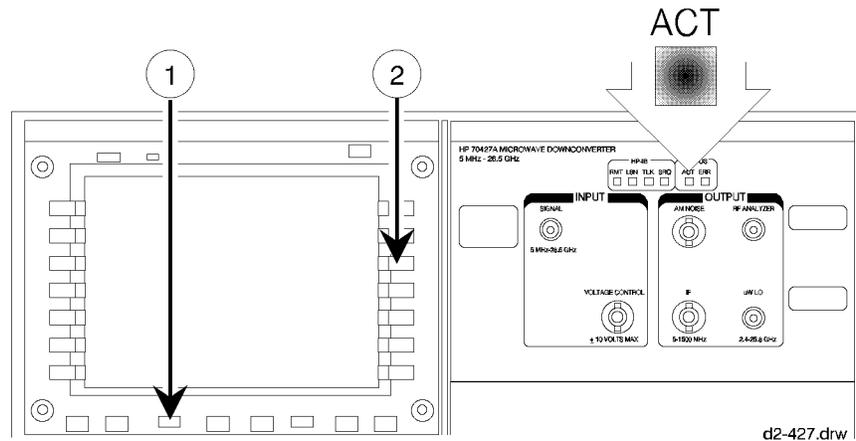
downconverter's input attenuator is set to zero and the signal goes directly to the IF amplifier.

The  $\mu$ W LO output is connected to the external mixer's LO input. The external mixer generates harmonics internally. One of these harmonics mixes with the input signal to produce an IF between 5 MHz and 1.2 GHz.

## Using the HP 70427A as a Microwave source

The HP 70427A includes the functions of the HP 70428A Microwave Source. When the module is used as a downconverter, the source hardware functions as the internal local oscillator (LO). When the *Source* softkey is pressed the microwave source screen and menus are displayed and the module acts as an HP 70428A Microwave Source.

## To Access the Downconverter Screen



**Figure 2-4** Downconverter Screen Diagram

### Step 1 - Make the downconverter the active module

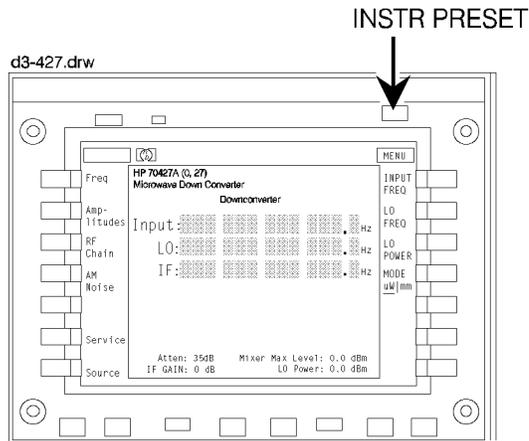
Look at the **ACT** indicator on the HP 70427A's front panel. If it is lit, the module is active and can be controlled by the MMS display. If it is not lit do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey until the HP 70427A's **ACT** indicator lights. If the MMS display is connected to more than one module, a different module will become the active module each time the **NEXT INSTR** softkey is pressed.

Getting Started  
To Access the Downconverter Screen

**Step 2 - Display the downconverter screen**

1. Press the INSTR PRESET key.



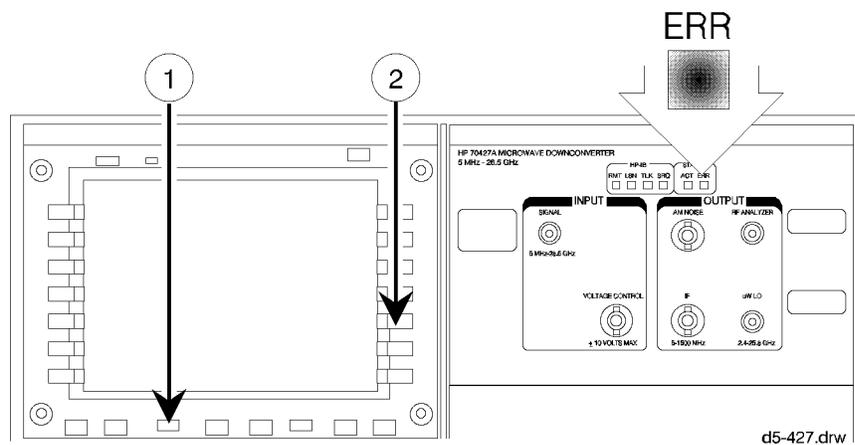
**Figure 2-5** Downconverter Display

## To read error messages

The front-panel **ERR** indicator lights when an error occurs.

### Step 1 - Access the error message screen

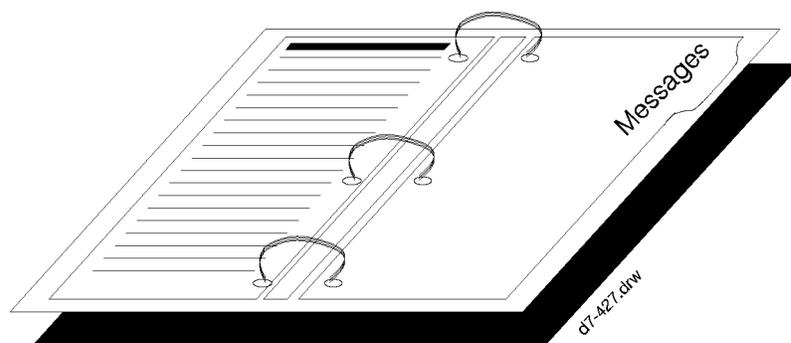
1. Press the **DISPLAY** key.
2. Press the **REPORT ERRORS** softkey.



**Figure 2-6** Message Error Access

### Step 2 - Look up the error messages

Error messages are described in the *Messages* section in the back of this manual.

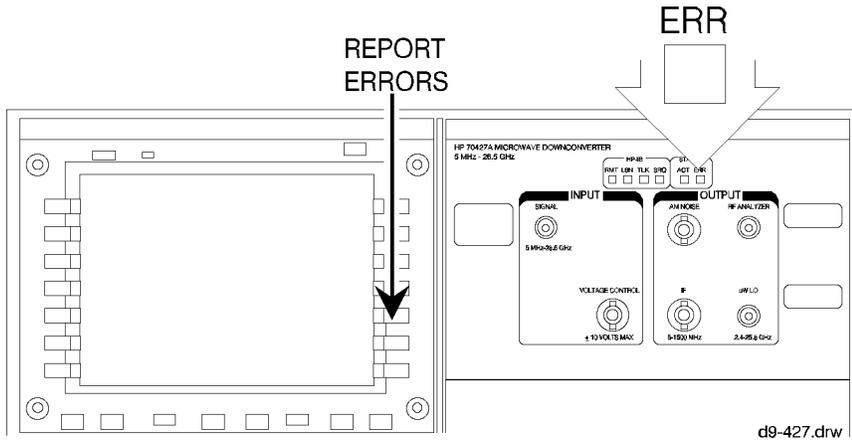


**Figure 2-7** Error Message Manual Sample

Getting Started  
To read error messages

### Step 3 - Clear the messages

Press the **REPORT ERRORS** softkey repeatedly until "No Errors" is displayed.  
If the condition that caused the error still exists the error message will re-appear.



**Figure 2-8 Report Errors Softkey**

## To Downconvert a Signal Below 26.5 GHz

The input frequency must be entered and the input attenuator and/or the IF amplifier can be adjusted.

### Step 1 - Enter the input frequency

1. Press the *Freqs* softkey.
2. Enter the input frequency with the numeric keys.
3. Complete the entry by pressing the appropriate units softkey: *GHz*, *MHz*, *kHz*, or *Hz*.

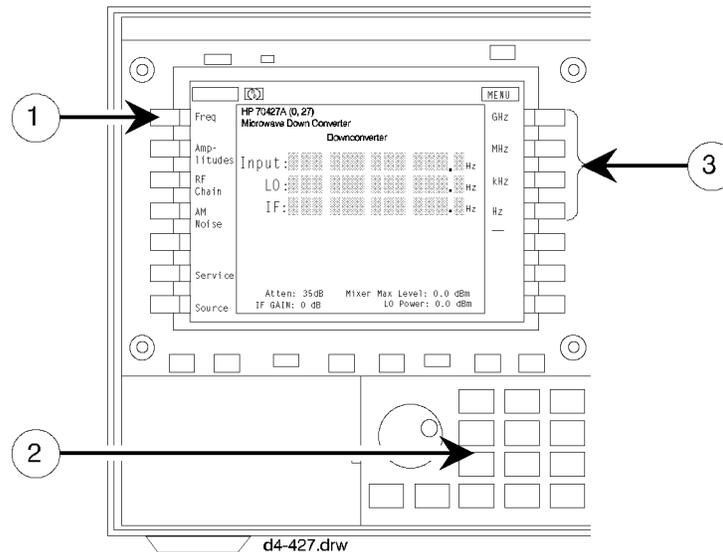


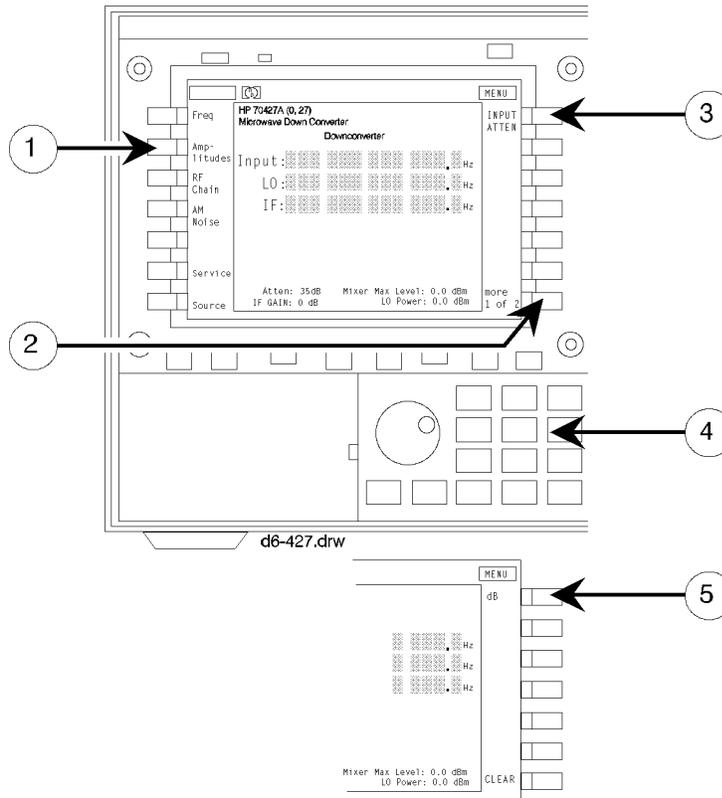
Figure 2-9 Input Frequency Screen Diagram

The module's firmware will calculate and display the IF and LO frequencies and tune the YIG-Tuned-Filter (YTF). Tuning can take up to 4 seconds.

### Step 2 - Adjust the mixer input level if necessary

1. Press the *Amplitudes* softkey.
2. Press the *more 1 of 2* softkey.
3. Press the *INPUT ATTEN* softkey.
4. Enter an attenuation up to 35 dB in 5 dB steps with the numeric keys.
5. Complete the entry by pressing the *dB* softkey.

Getting Started  
To Downconvert a Signal Below 26.5 GHz



**Figure 2-10** Mixer Level Display Diagram

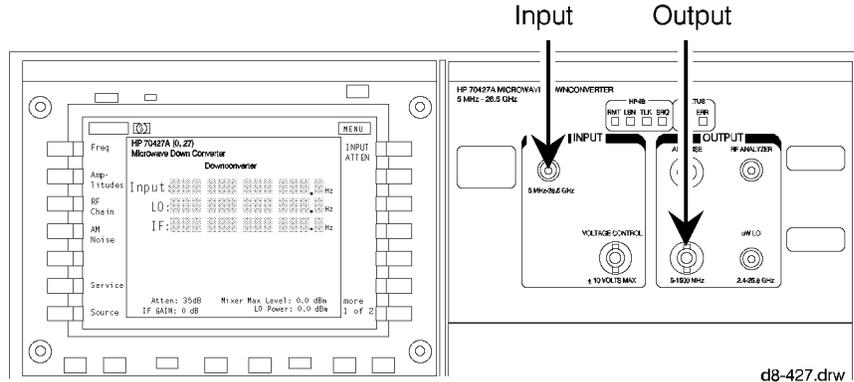
There are two maximum levels to consider. The first is that the input to the downconverter must not exceed +30 dBm. The second is that the input to the mixer must not exceed +10 dBm. For Diagram, if the input signal is +25 dBm there must be at least 15 dB of input attenuation.

The optimum level is between -10 dBm and -5 dBm.

Another way to adjust the input attenuation is to trigger a one-time auto-ranging. This must be done after a signal is connected (see step 3 below).

### Step 3 - Connect the cables

1. The signal to be downconverted goes to the input **SIGNAL** connector.
2. The **IF** output is taken from the **IF** output connector.



**Figure 2-11** Connect Cable Diagram

If a signal greater than  $-10$  dBm is present the input attenuator can be autoranged. There are two ways to do this as described below.

To auto-range the input attenuator and IF amplifier gain at the same time:

1. Press the *Amplitudes* softkey
2. Press the *AUTO RANGE* softkey.

To auto-range the input attenuator only:

1. Press the *Amplitudes* softkey,
2. Press the *more 1 of 2* softkey
3. Press the *AUTO ATTEN* softkey.

The level set by auto-ranging depends on the level shown on the **Mix Max Level**: display. This level is set by the *MIXER MAX LVL* softkey. If it is  $-5$  dBm the attenuator will be set so that the mixer input level is within optimum range.

For input signal levels less than  $-10$  dBm, the attenuator must be set manually.

#### Step 4 - Adjust the IF gain if necessary

1. Press the *Amplitudes* softkey.
2. Press the *more 1 of 2* softkey.
3. Press the *IF GAIN* softkey.
4. Enter an IF gain between  $-10$  and  $+45$  dB in 5 dB steps with the numeric keypad.
5. Complete the entry by pressing the *dB* softkey.

Getting Started  
To Downconvert a Signal Below 26.5 GHz

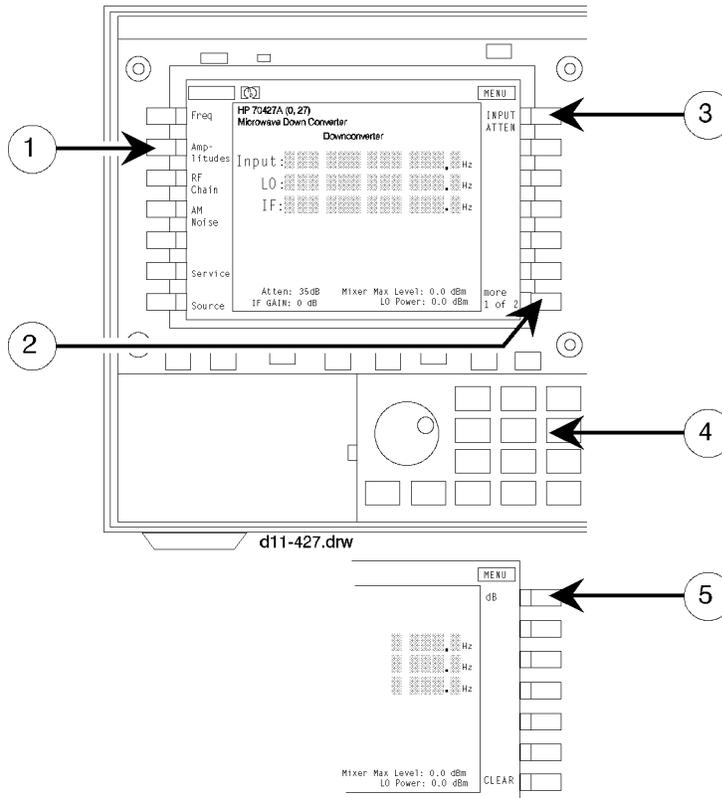


Figure 2-12 IF Gain Display Diagram

**To automatically adjust the IF gain**

Another way to adjust the IF gain is to trigger a one-time auto-ranging.

1. Press the *Amplitudes* softkey
2. Press the *more 1 of 2* softkey
3. Press the *AUTO IF GAIN* softkey.

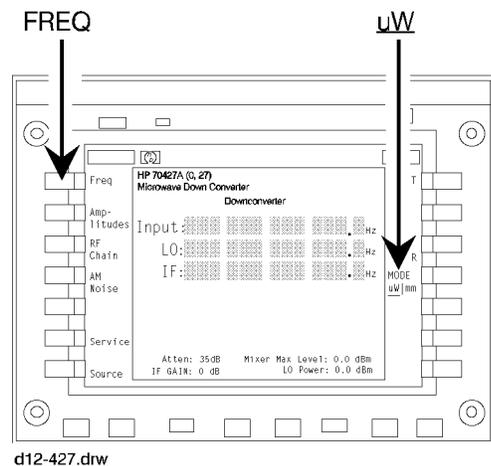
Auto-ranging sets the IF gain for an IF output level between 0 dBm and +6 dBm.

## To Demodulate AM: RF AM Detector

This mode works with signals between 5 MHz and 26.5 GHz at levels  $\geq 0$  dBm.

### Step 1 - Access the downconverter screen

Make sure the downconverter is in microwave mode. To do this press the *Freqs* softkey and look at the *MODE  $\mu W/mm$*  softkey. It must have  $\mu W$  underlined.

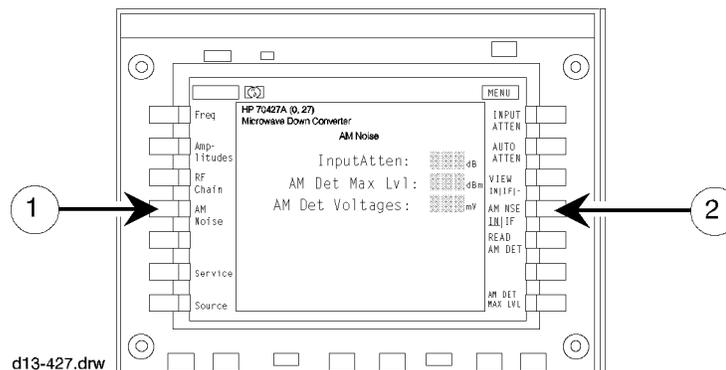


d12-427.drw

Figure 2-13 Downconverter Screen Display Diagram

### Step 2 - Select AM mode

1. Press the *AM Noise* softkey.
2. Press the *AM NSE IN/IF* softkey so that IN is underlined.



d13-427.drw

Figure 2-14 Select AM Mode Display Diagram

### Step 3 - Connect the cables

Before applying a signal, look at the **Input Atten:** and make sure enough attenuation is inserted so that the input to the detector does not exceed +20 dBm.

1. The signal to be detected goes to the input **SIGNAL** connector.
2. The demodulated signal is taken from the **AMNOISE** output connector. This output is AC coupled.

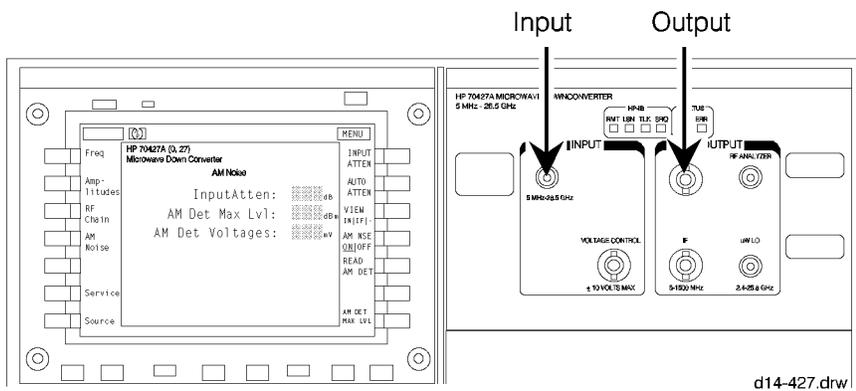
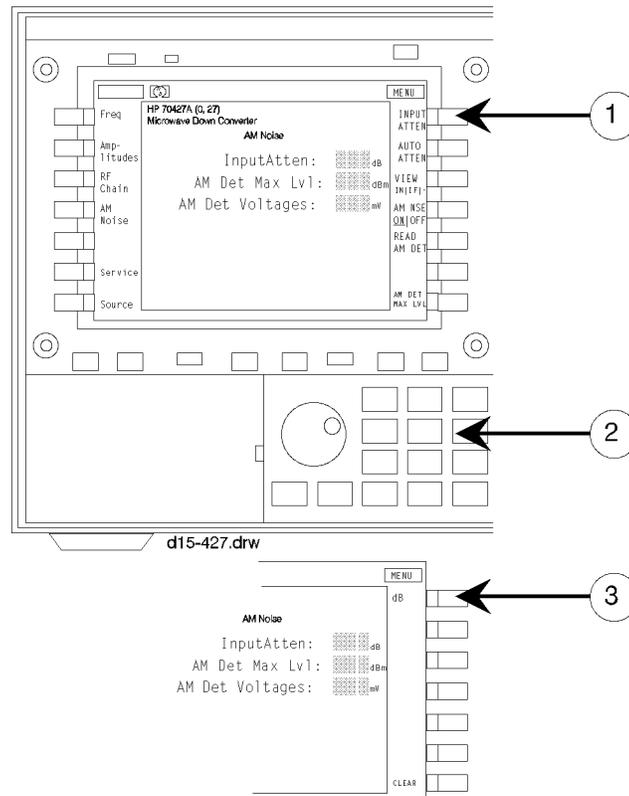


Figure 2-15 Connect Cables Diagram

#### Step 4 - Adjust the detector input level if necessary

1. Press the *INPUT ATTEN* softkey.
2. Enter an attenuation up to 35 dB in 5 dB steps with the numeric keypad.
3. Press the *dB* softkey to complete the entry.



**Figure 2-16** *Detector Input Level Display Diagram*

Enough attenuation should be used to keep the detector's input below +20 dBm. The optimum range is +10 to +15 dBm.

#### To Automatically Adjust the Input Attenuation

Another way to adjust the input attenuation is to trigger a one-time auto-ranging. To do this press the *AUTO ATTEN* softkey.

---

## To Demodulate AM: IF AM Detector

The IF AM detector is in the signal path when the downconverter is downconverting signals. It can be used in mm mode and  $\mu W$  mode (that is the *MODE*  $\mu W/mm$  softkey can have either  $\mu W$  or mm underlined).

Make sure the AM noise mode is set to IF. To do this press the *AM Noise* softkey and look at the *AM NSE IN/IF* softkey. It must have *IF* underlined.

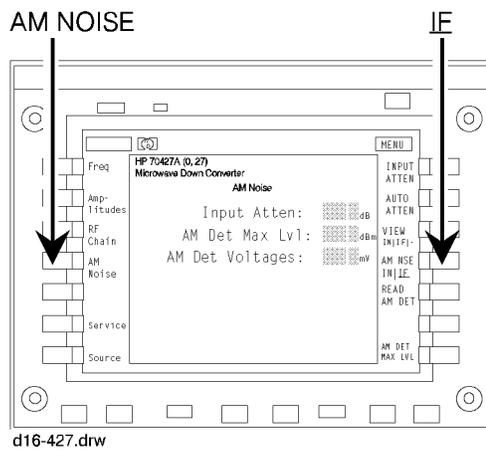


Figure 2-17 AM: IF AM Display Diagram



## Step 2 - Select the detector's output

The choices are the front-panel **AM NOISE** connector or the rear-panel **IF LEVEL** connector.

The **AM NOISE** output is AC coupled. Its signal can be analyzed with a low-frequency spectrum analyzer.

The **IF LEVEL** output is DC coupled and filtered. Its signal is a DC analog of the downconverter's IF level.

1. Press the *Amplitudes* softkey.
2. Press the *more 1 of 2* softkey.
3. Press the *IF AM Output* softkey.
4. Select the output by pressing one of the following softkeys:
  - The *IF AM NOISE* softkey selects the **AM NOISE** connector.
  - The *IF LEVEL* softkey selects the **IF LEVEL** connector.

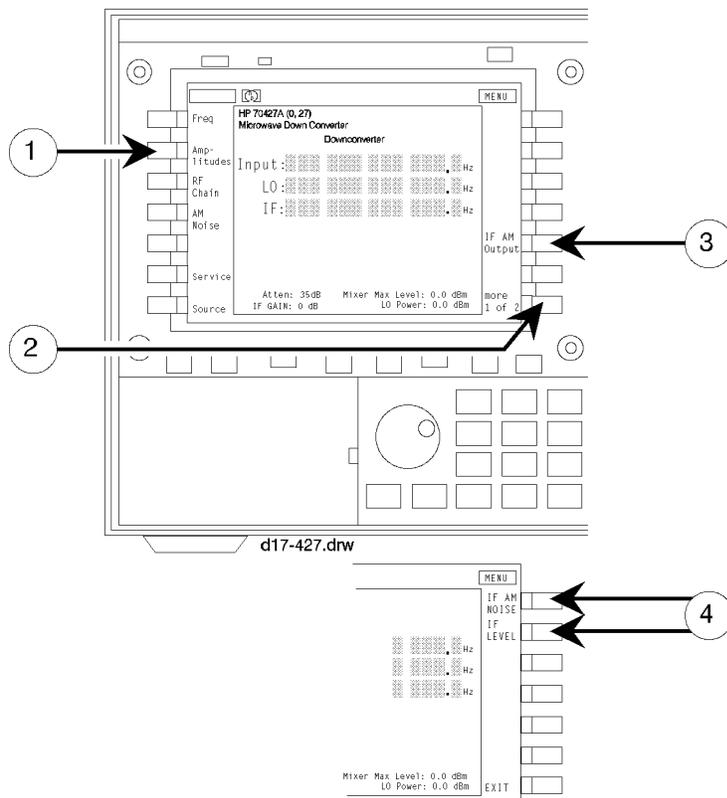


Figure 2-19 Detector's Output Selection Diagram

# To Electrically Tune the Downconverter's LO

## Step 1 - Select the tuning sensitivity

- 1. Press the *Ref Chain* softkey.
- 2. Press the *Tune Sens* softkey.
- 3. Press the *.05 ppm/v*, *1.0 ppm/v*, or *20 ppm/v* softkey.

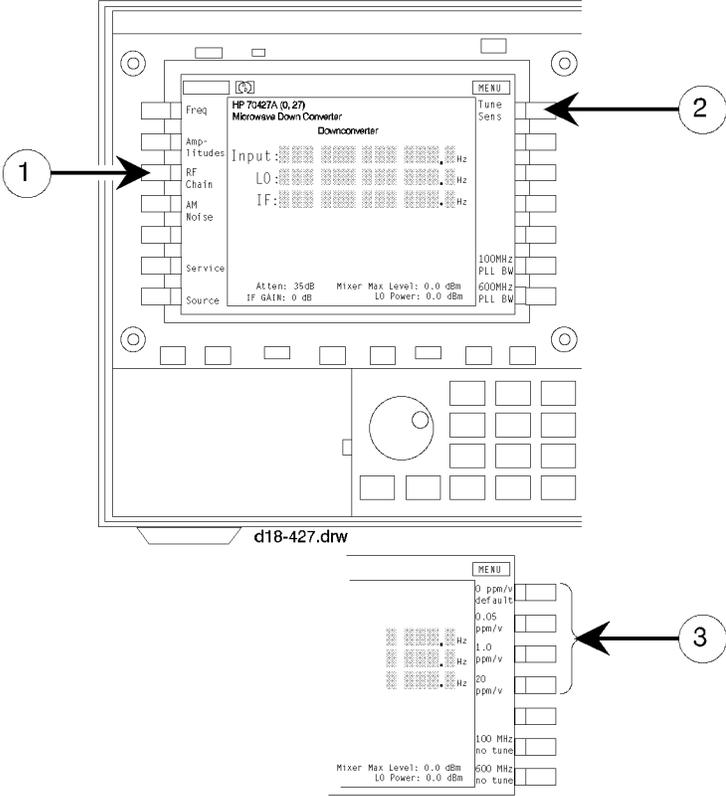
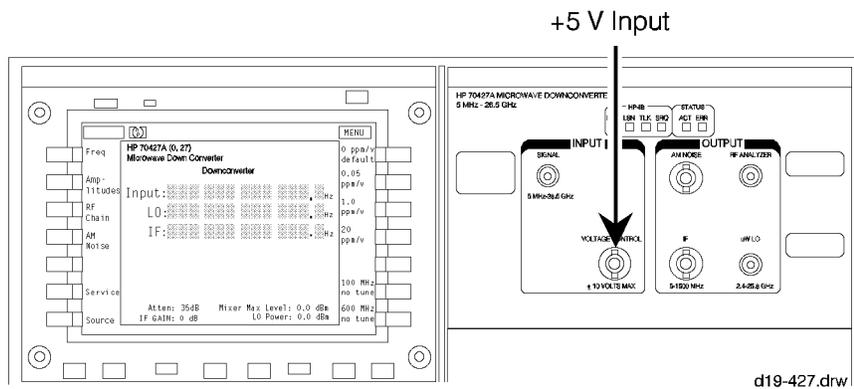


Figure 2-20 Tuning Sensitivity Diagram

## Step 2 - Connect the tuning voltage



**Figure 2-21** Tuning Voltage Connection Diagram

A  $\pm 5$  Volt tuning voltage can be used. Connect it to the front-panel **VOLTAGE CONTROL** connector.

### Tuning with a Sensitivity of 0.05 ppm/V

With a tuning sensitivity of 0.05 ppm/V the reference chain's 10 MHz oscillator is tuned. The 600 MHz oscillator is phase-locked to the 100 MHz oscillator which is phase-locked to the 10 MHz oscillator. In this configuration a 1 Volt tuning voltage will cause a 0.05 ppm change in the downconverter's LO frequency.

### Tuning with a Sensitivity of 1.0 ppm/V

With a tuning sensitivity of 1.0 ppm/V the reference chain's 100 MHz oscillator is tuned and the 600 MHz oscillator is phase-locked to it. A 1 Volt tuning voltage will cause a 1 ppm change in the downconverter's LO frequency.

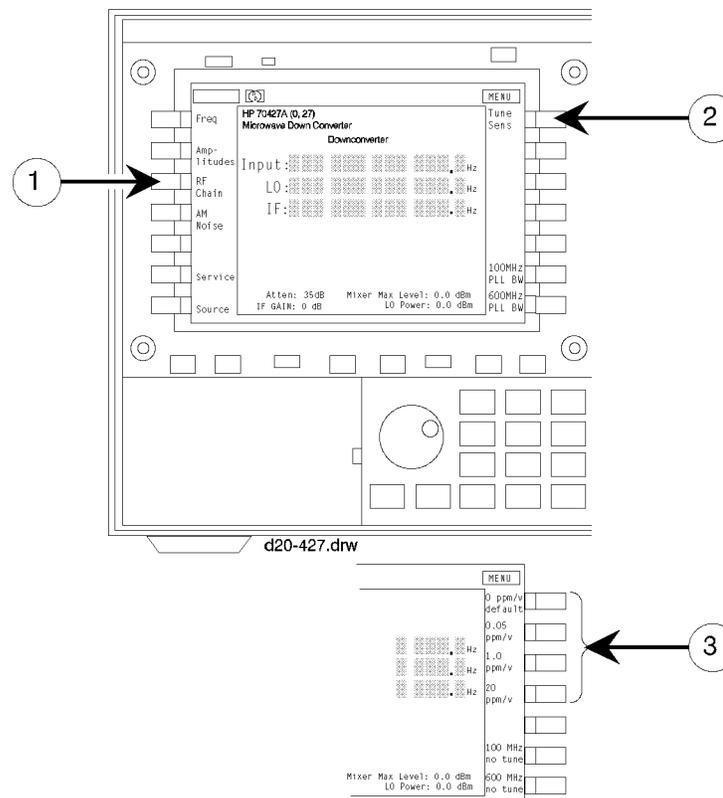
### Tuning with a Sensitivity of 20 ppm/V

With a 20 ppm/V tuning sensitivity the reference chain's 600 MHz oscillator is free running. A 1 Volt tuning voltage will cause a 20 ppm change in the downconverter's LO frequency.

## To Select the LO's Reference Chain Phase-Lock-Loop Bandwidth

### Step 1 - Determine the tuning sensitivity setting

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Note which sensitivity (on the right side of the screen) is underlined.



**Figure 2-22 Reference Chain Phase-Lock-Loop-Bandwidth Diagram**

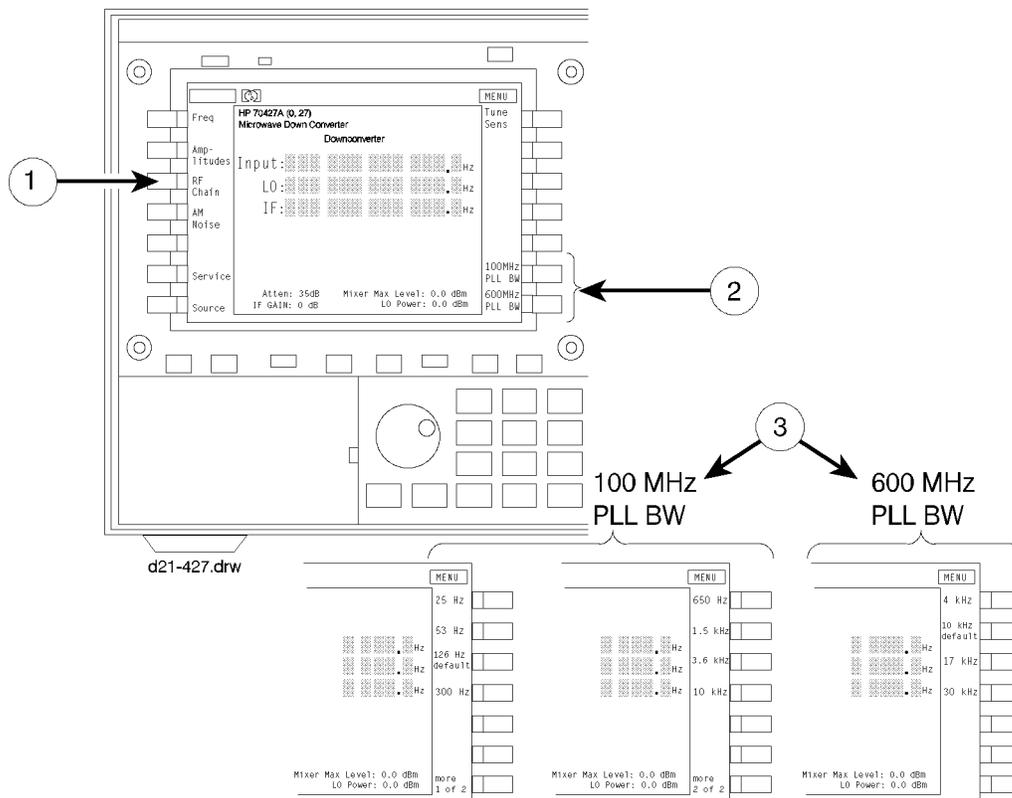
The 100 MHz and/or 600 MHz phase-lock-loop bandwidths can be set depending on the tuning sensitivity. See the following table:

**Table 2-1 The 100 MHz and/or the 600 MHz Phase-Lock-Loop Bandwidths and Tuning Sensitivity**

Tuning Sensitivity	Bandwidth Settings
0 ppm	100 MHz and/or 600 MHz phase-lock-loops
0.05 ppm / V	100 MHz and/or 600 MHz phase-lock-loops
0.1 ppm / V	600 MHz phase-lock-loop
20 ppm / V	None
100 MHz no tune	600 MHz phase-lock-loop
600 MHz no tune	None

**Step 2- Select Bandwidth**

1. Press the *Ref Chain* softkey.
2. Press either the *100 MHz PLL BW* or *600 MHz PLL BW* softkey.
3. Press the softkey that corresponds to the desired bandwidth.

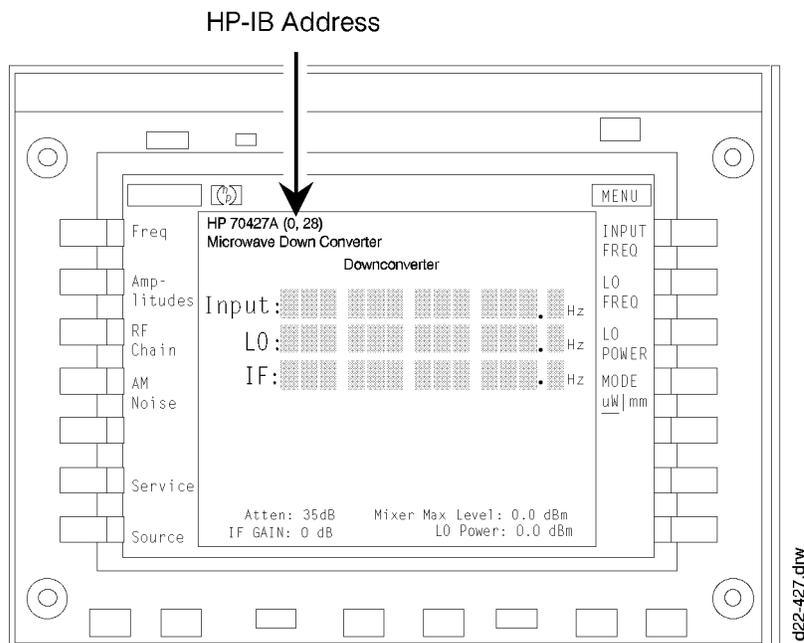


**Figure 2-23 Tuning the Sensitivity Setting Diagram**

## To Control the Downconverter over the HP-IB (IEEE 488.2)

### Step 1 - Determine the downconverter's HP-IB address

Look in the upper left corner of the display. The model number of the module followed by its HP-IB address in parentheses should be displayed. The two last two digits after the comma are the last two digits of the address.



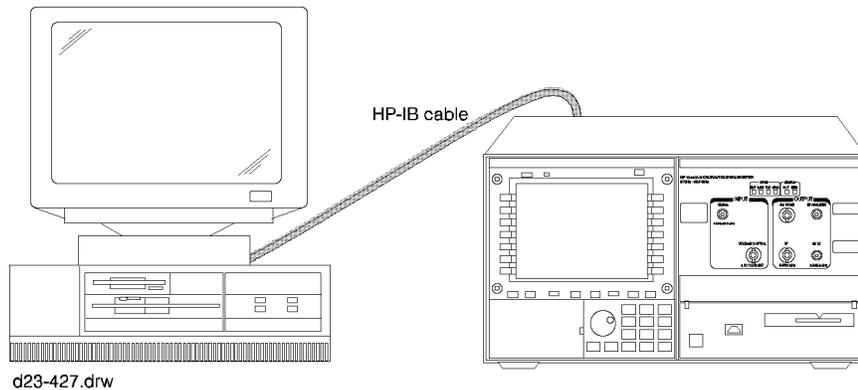
**Figure 2-24** HP-IB Address Location Diagram

For example, an HP 70724A with address 28 would display **HP 70427A (0, 28)**. The complete HP-IB address for a computer with its HP-IB interface select code set to seven would be 728.

If the downconverter doesn't respond to this address look on the MMS address map to see if it has changed. If it has, cycling power or pressing the **INSTR PRESET** key will reset the address to the number shown on the downconverter screen.

**Step 2 - Connect the HP-IB cable**

Connect the cable from the computer to the MMS mainframe that the downconverter is installed in.



**Figure 2-25** *HP-IB Connection Diagram*

**Step 3 - Enter a program and run it**

The following Diagram is for the HP BASIC on a HP 9000 series 200/300 controller. It sets the downconverter's frequency, input attenuation, and IF level. Chapter 12 has a complete table of HP-IB commands.



**Figure 2-26** *HP BASIC on an HP 9000 series 200/300 Controller*

## To Configure the Downconverter as a Microwave Source

1. Press the *source* softkey.

The HP 70428A menus and screens will be displayed. Follow the operating instructions for the source.

Frequency and amplitude settings are preserved in the source and downconverter when switching back and forth.

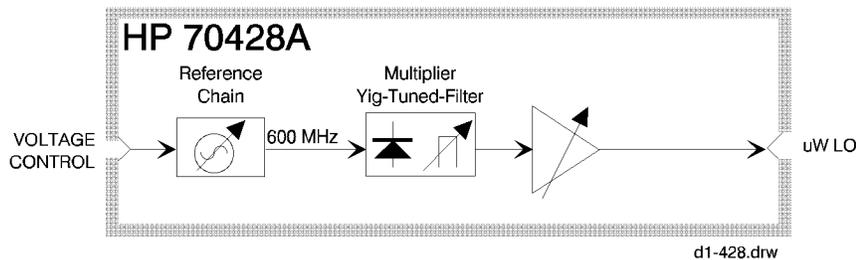
## HP 70428A Microwave Source Module Overview

The HP 70428A Microwave Source Module outputs a signal between 2.4 GHz and 26.4 GHz, in 600 MHz steps, at levels from 0 dBm up to +16 dBm (+10 dBm above 7.2 GHz).

The signal is derived from a 600 MHz oscillator which either free-runs or is phase-locked to a reference chain. The reference chain consists of a 100 MHz oscillator which can be the reference or it can be phase-locked to a 10 MHz crystal controlled reference. The reference chain's tuning sensitivity and phase-lock-loop bandwidths can be selected from menus on the MMS display. A voltage applied to the **VOLTAGE CONTROL** connector can tune the reference chain.

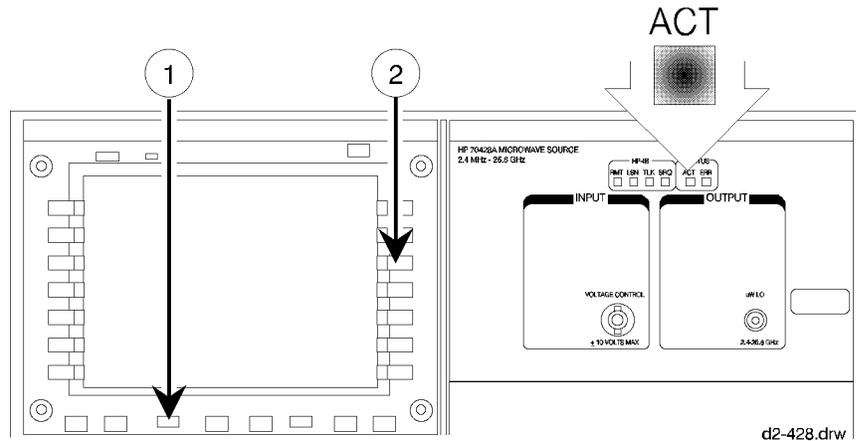
A step-recovery-diode multiplies the 600 MHz and a YIG-tuned-filter (YTF) picks off the desired frequency.

The output of the YTF is amplified by a gain adjustable amplifier. This amplifier has two operating modes that can be set with softkeys. One mode is for minimum noise, and the other lowers high order harmonics.



**Figure 2-27** HP 70428A Microwave Source Module Diagram

## To Access the Source Screen



**Figure 2-28** HP 70428A Front Panel

### Step 1 - Make the Source the active module

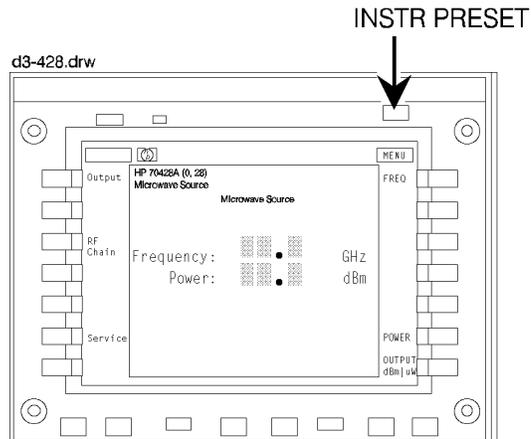
Look at the ACT indicator on the HP 70428A's front panel. If it is lit, the module is active and can be controlled by the MMS display. If it is not lit do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey until the HP 70428A's **ACT** indicator lights. If the MMS display is connected to more than one module, a different module will become the active module each time the **NEXT INSTR** softkey is pressed.

Getting Started  
To Access the Source Screen

## Step 2 - Display the Source Screen

Press the INSTR PRESET key (if the module is an HP 70427A or HP 70428A Option 002), access the source screen by pressing the *source* softkey.



**Figure 2-29** HP 70427A and HP 70428A Option 002 Source Screen

## To read error messages

The front-panel **ERR** indicator lights when an error occurs.

### Procedure

#### Step 1 - Access the error message screen

1. Press the **DISPLAY** key.
2. Press the **REPORT ERRORS** softkey.

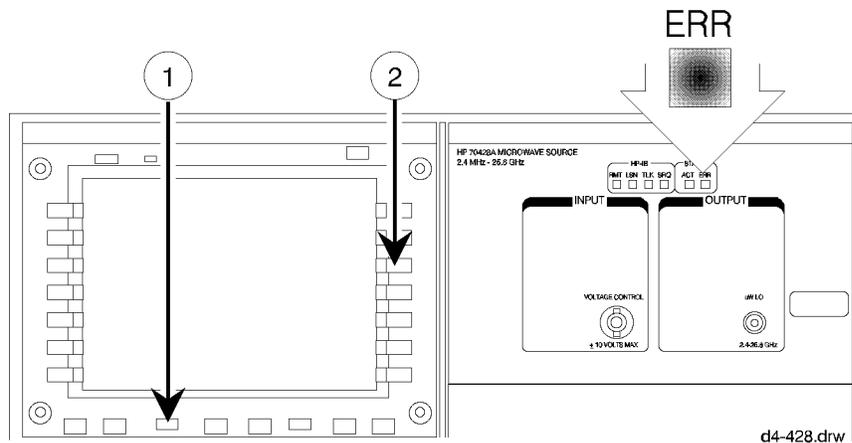


Figure 2-30 Message Error Access

#### Step 2 - Look up the error messages

Error messages are described in the *Messages* section in the back of this manual.

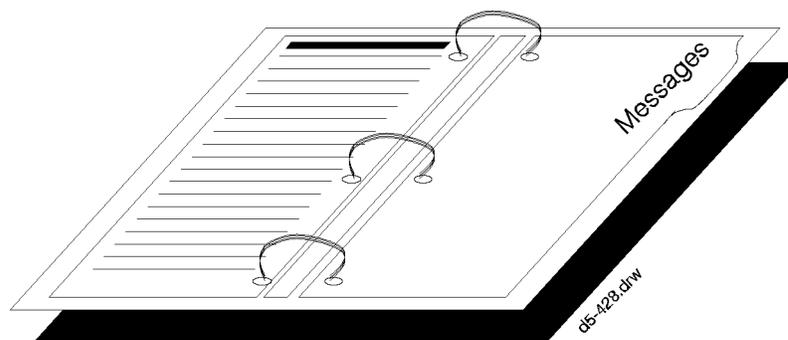
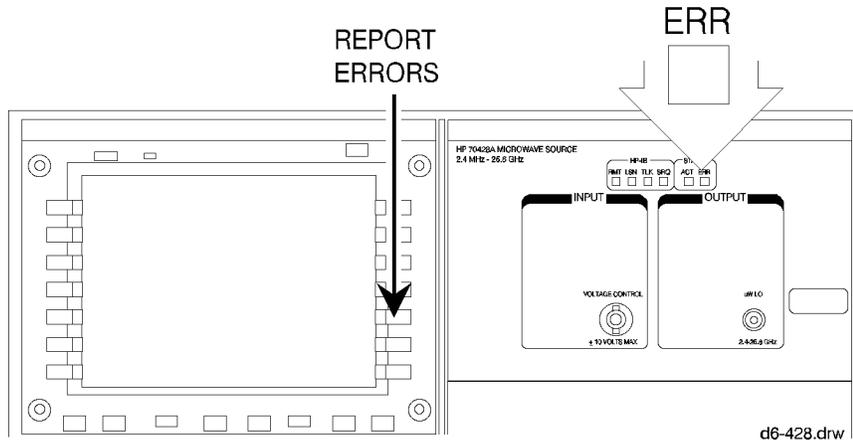


Figure 2-31 Error Message Manual Sample

### Step 3 - Clear the messages

Press the **REPORT ERRORS** softkey repeatedly until "No Errors" is displayed.  
If the condition that caused the error still exists the error message will re-appear.



**Figure 2-32** Report Errors Softkey

## To Output a Signal with a Microwave Source

### Procedure

#### Step 1 - Set the Output Frequency

1. Press the *Output* softkey.
2. Press the *FREQ* softkey.
3. Key in a frequency between 2.4 GHz and 26.4 GHz with the numeric keypad.
4. Complete the entry by pressing the appropriate units softkey.

The module's firmware will round off the entered frequency to the nearest 600 MHz. It will ignore frequencies outside the above range. The firmware will also set the power to 0 dBm.

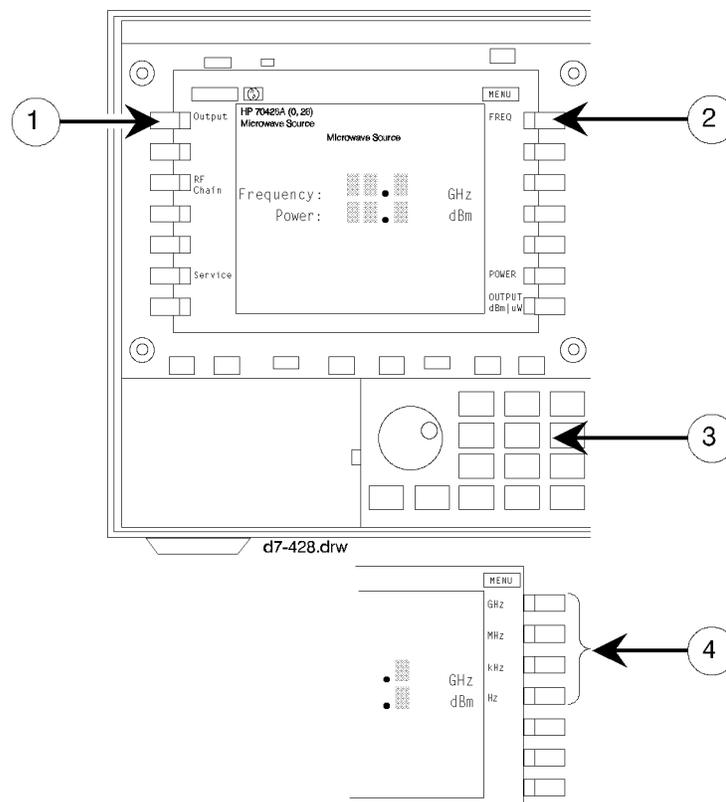


Figure 2-33 Microwave Source Signal Softkeys Locations

### Step 2 - Set the output power

A frequency must be shown in the **Frequency:** display before an output power entry will be accepted.

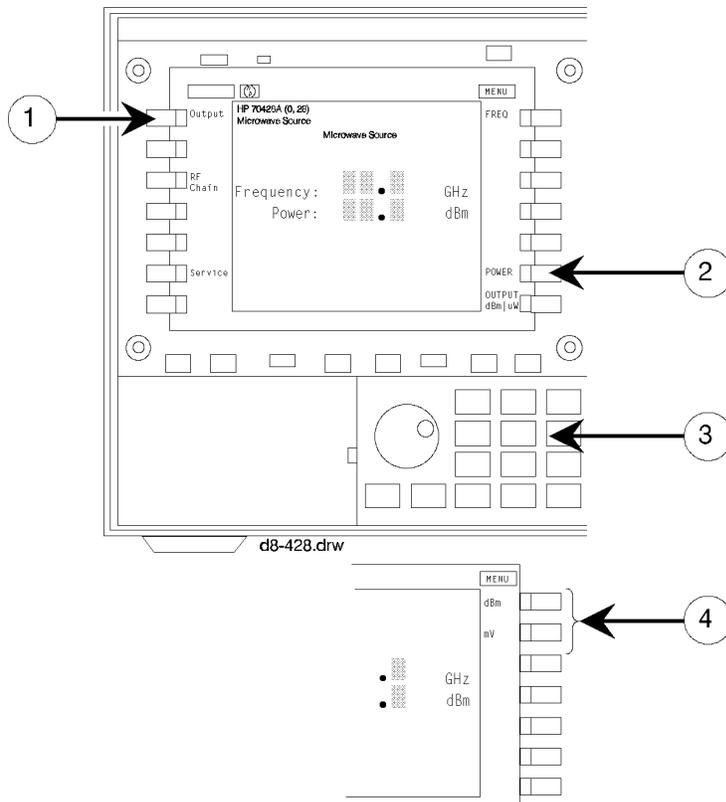
1. Press the **OUTPUT POWER** softkey.
2. Press the **POWER** softkey.
3. Key in the output power, dBm or mW, with the numeric keypad.

Power levels between 0 and +20 (100 mW), in 0.1 dB steps, can be entered. But the minimum specified power is shown below.

- 2.4 to 6.6 GHz: +16
- 7.2 to 25.8 GHz: +10

Also, the actual resolution can be as much as 0.2 dB.

4. Press the **dBm** or **mW** softkey.



**Figure 2-34** Output Power Softkey Locations

## To Electrically Tune the Source's Frequency

### Procedure

#### Step 1 - Select the tuning sensitivity

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Press the *0.05 ppm/V*, *1.0 ppm/V*, or *2.0 ppm/V* softkey.

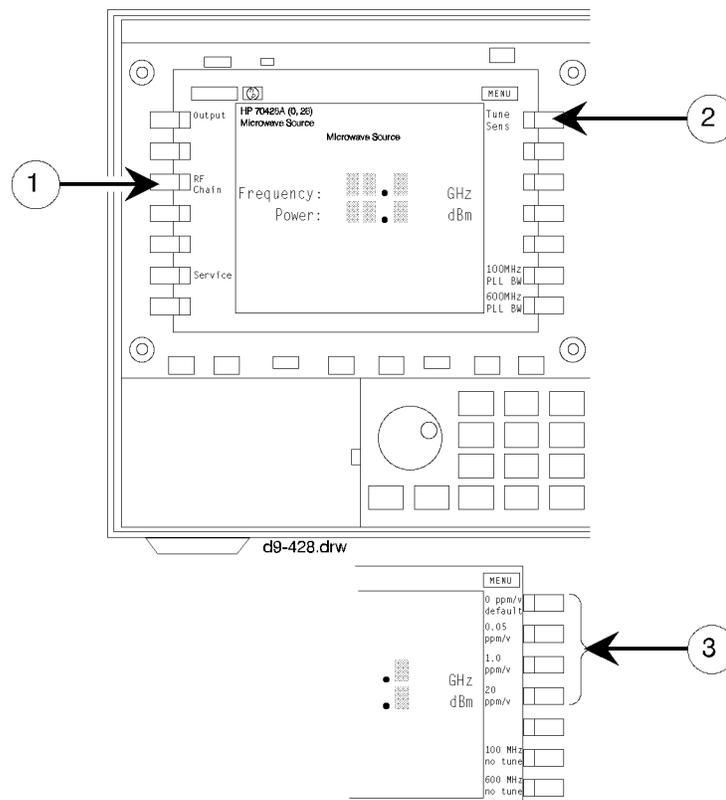
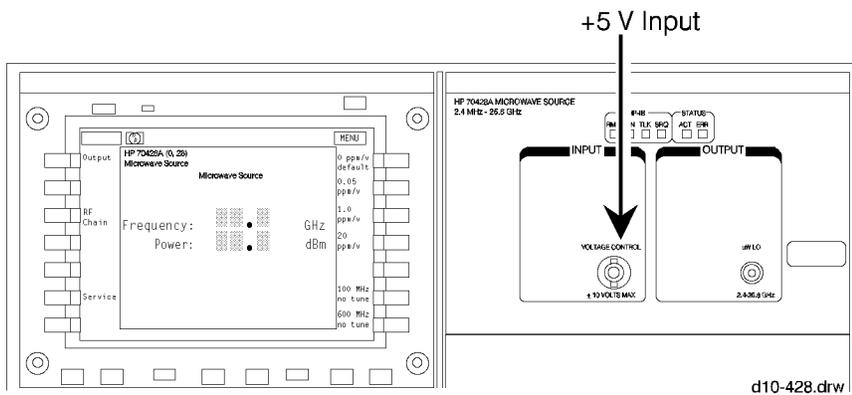


Figure 2-35 Electrically Tune Source's Softkeys

## Step 2 - Connect the tuning voltage



**Figure 2-36** Tuning Voltage Connection

A  $\pm 5$  volt tuning voltage can be used. Connect it to the front-panel **VOLTAGE CONTROL** connector.

### Tuning with a Sensitivity of 0.05 ppm/V

With a tuning sensitivity of 0.05 ppm/V the reference chain's 10 MHz oscillator is tuned. The 600 MHz oscillator is phase-locked to the 100 MHz oscillator which is phase-locked to the 10 MHz oscillator. In this configuration a 1 Volt tuning voltage will cause a 0.05 ppm change in the tunable source's output frequency.

### Tuning with a Sensitivity of 1.0 ppm/V

With a tuning sensitivity of 1.0 ppm/V the reference chain's 100 MHz oscillator is tuned and the 600 MHz oscillator is phase-locked to it. A 1 Volt tuning voltage will cause a 1 ppm change in the source's output frequency.

### Tuning with a Sensitivity of 20 ppm/V

With a 20 ppm/V tuning sensitivity the reference chain's 600 MHz oscillator is free running. A 1 Volt tuning voltage will cause a 20 ppm change in the source's output frequency.

## To Select Reference Chain Phase-Lock-Loop Bandwidth

### Procedure

#### Step 1. Determine the tuning sensitivity settings

1. Press the *REF Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Note which sensitivity (on the right side of the screen) is underlined.

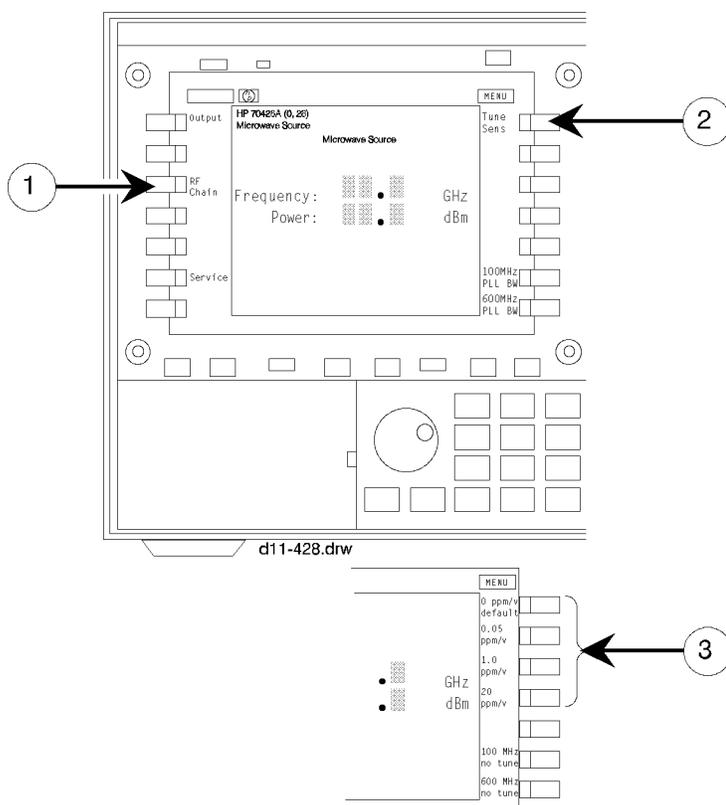


Figure 2-37 Tuning Sensitivity Softkey Locations

The 100 MHz and /or 600 MHz bandwidth can be set depending on the tuning sensitivity.

#### Tuning Sensitivity

0 ppm

0.5 ppm/V

#### Bandwidth can be set for:

100 MHz and or 600 MHz  
 phase-lock-loops.

100 MHz and or 600 MHz  
 phase-lock-loops.

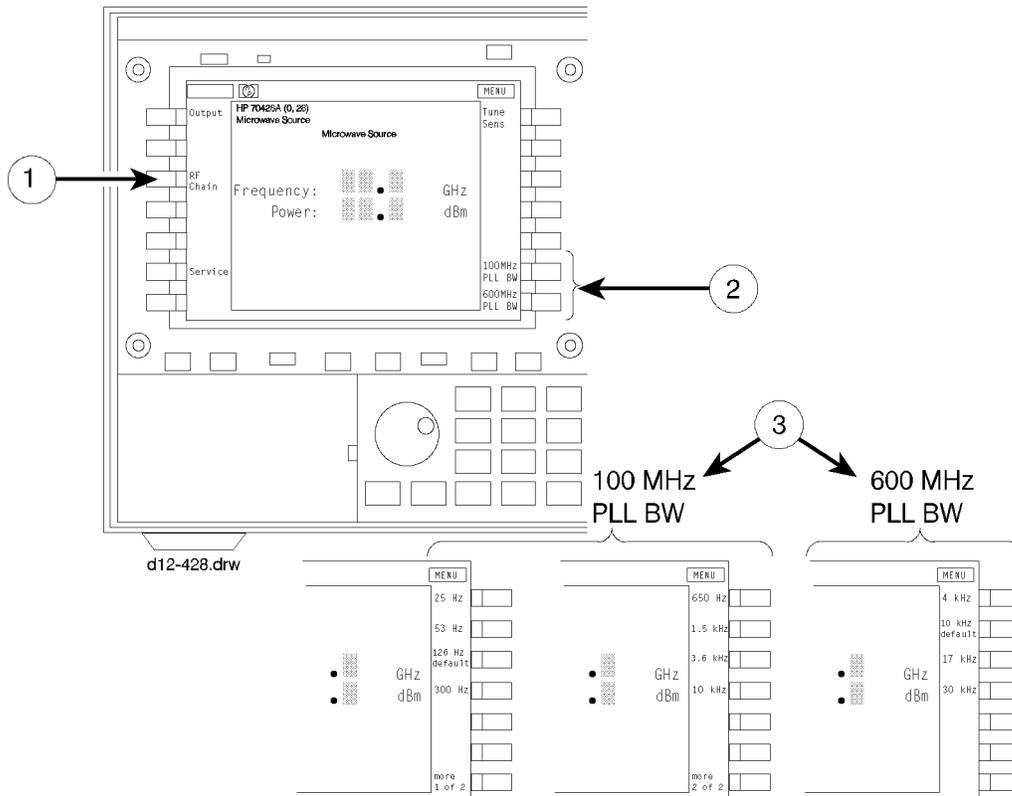
## Getting Started

### To Select Reference Chain Phase-Lock-Loop Bandwidth

1.0 ppm/V	600 MHz phase-lock-loop.
20 ppm/V	None.
100 MHz no tune	600 MHz phase-lock-loop.
600 MHz no tune	None.

### Step 2 - Select the bandwidth.

1. Press the *Ref Chain* softkey.
2. Press either *100 MHz PLL BW* or *600 MHz PLL BW* softkey.
3. Press the softkey that corresponds to the desired bandwidth.

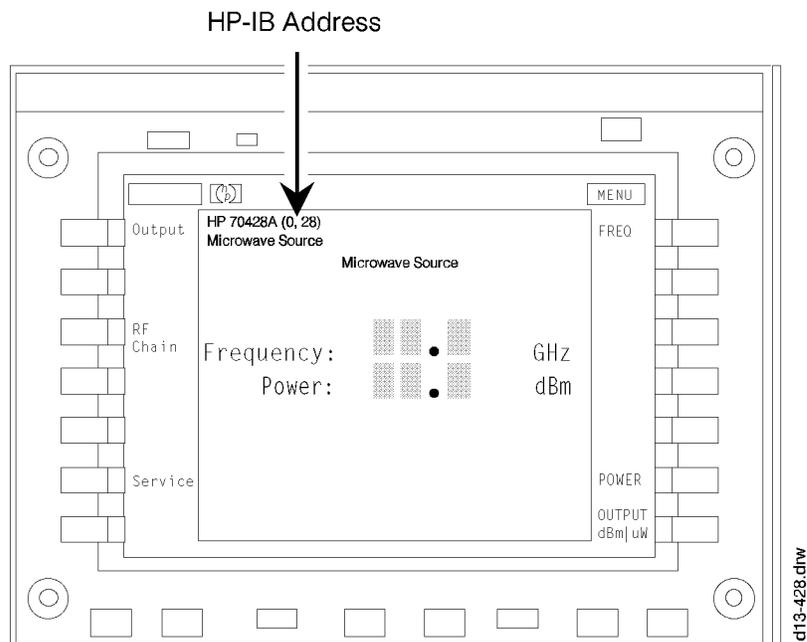


## To Control the Source Over the HP-IB (IEEE 488.2)

### Procedure

#### Step 1 - Determine the sources HP-IB address

Look in the upper left corner of the display. The model number of the module followed by its HP-IB address in parentheses should be displayed. The two digits after the coma are the last two digits of the address.



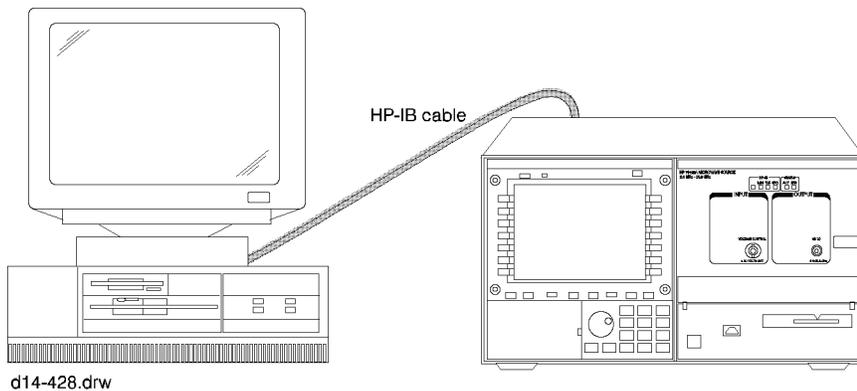
**Figure 2-39** HP-IB Address Location

For example, an HP 70428A with address 28 would display **HP 70428A (0, 28)**. The complete HP-IB address for a computer with its HP-IB interface select code set to seven would be 728.

If the source doesn't respond to this address look on the MMS address map to see if it has changed. If it has, cycling power or pressing the **INSTR PRESET** key will reset the address to the number shown on the source screen.

### Step 2 - Connect the HP-IB cable

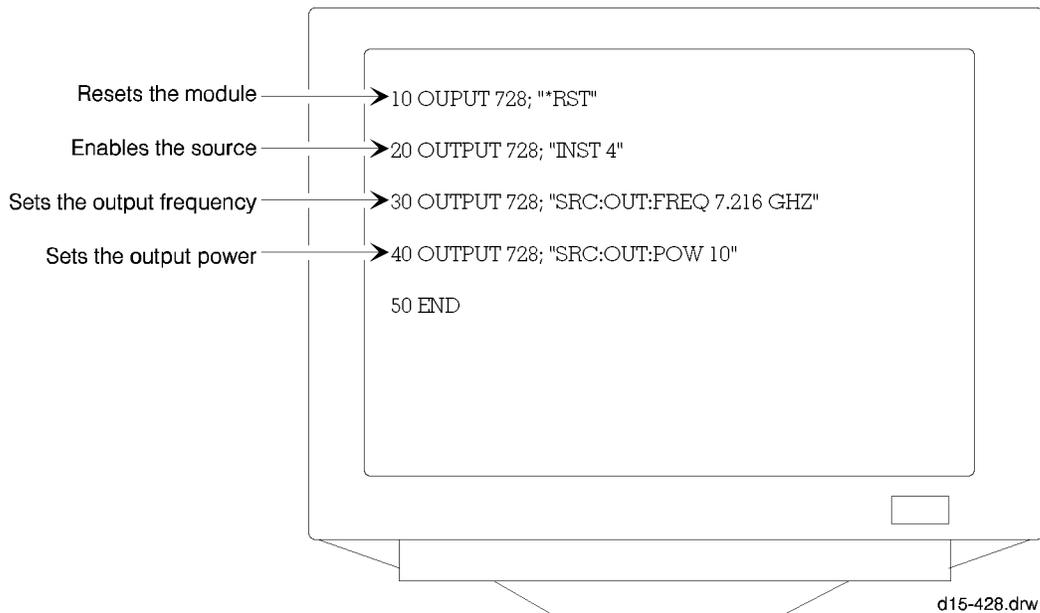
Connect the cable from the computer to the MMS mainframe that the source is installed in.



**Figure 2-40** *HP-IB Cable Connection*

### Step 3 - Enter a program and run it.

The following is for HP BASIC on an HP 9000 series 200/300 controller. It sets the source's frequency and output power. Chapter 12 has a complete table of HP-IB commands.



**Figure 2-41** *HP BASIC on a HP 9000 Series 200/300 Controller*

## HP 70428A Option 002 (Tunable Source) Overview

The HP 70428A Option 002 Microwave Source Module (Tunable Source) up-converts and HP 8662/3A signal generator's output into the 2.4 GHz to 26.5 GHz range. It consists of a microwave source as described in the previous section and a mixer with a second YIG-tuned-filter.

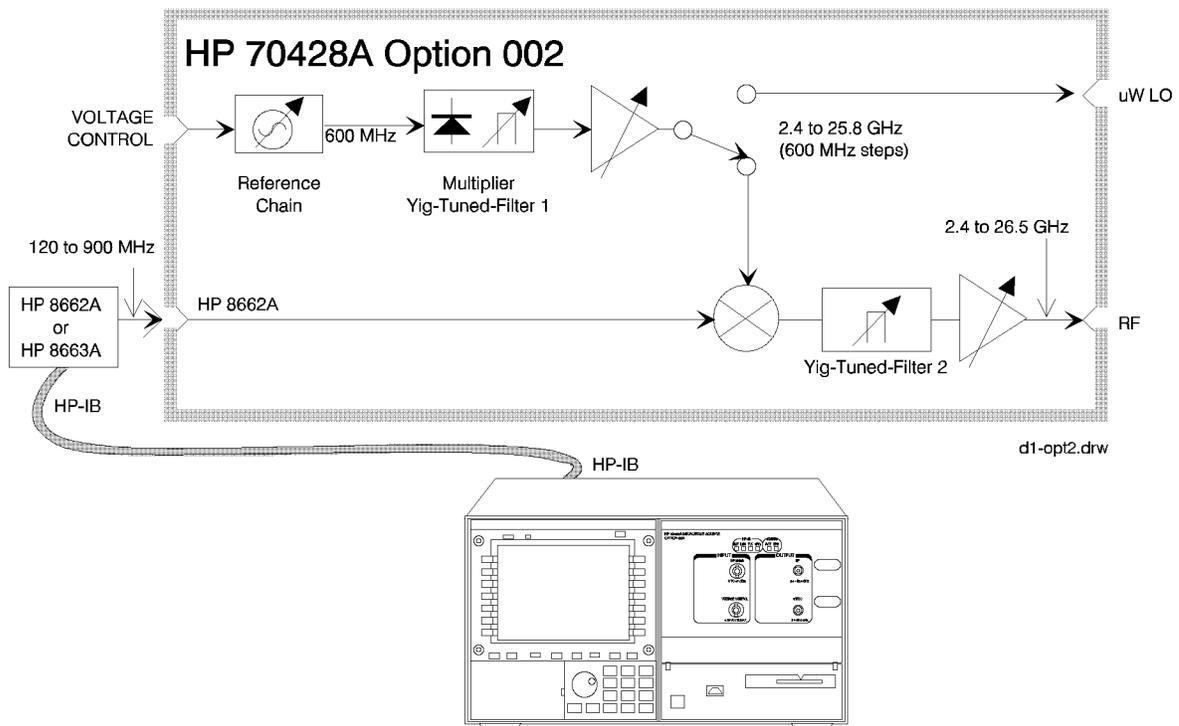
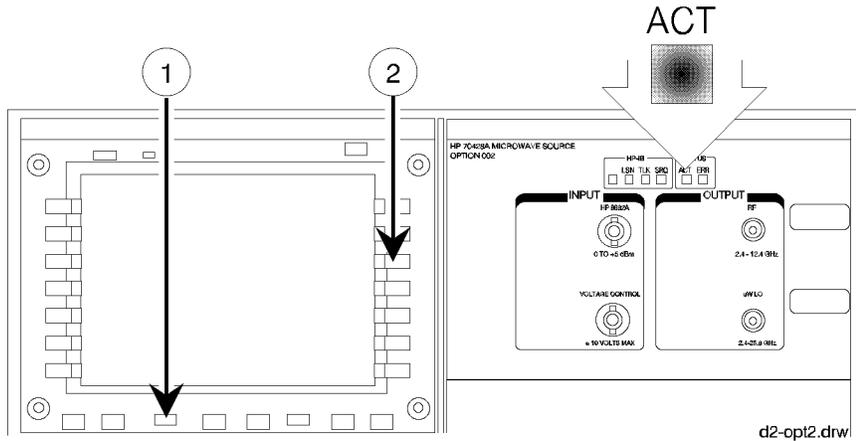


Figure 2-42 HP 70428A Option 002

---

## To Access the Tunable Source Screen



**Figure 2-43** Accessing the Tunable Source Screen

### Procedure

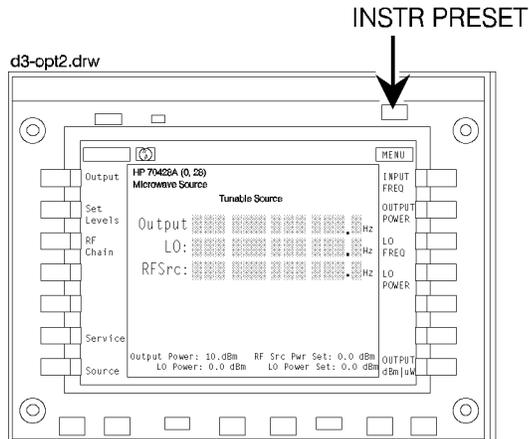
#### Step 1 - Make the tunable source the active module.

Look at the **ACT** indicator on the HP 70428A Option 002's front panel. If it is lit, the module is active and can be controlled by the MMS display. If it is not lit do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey until the HP 70428A Option 002's **ACT** indicator lights. If the MMS is connected to more than one module, a different module will become the active module each time the **NEXT INSTR** softkey is pressed.

## Step 2 - Display the tunable source

1. Press the INSTR PRESET key.



**Figure 2-44** INSTR PRESET key location

---

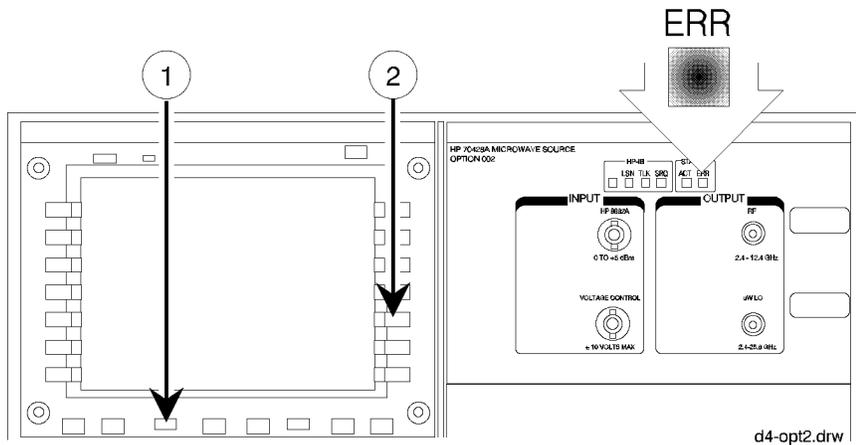
## To read error messages

The front-panel **ERR** indicator lights when an error occurs.

### Procedure

#### Step 1 - Access the error message screen

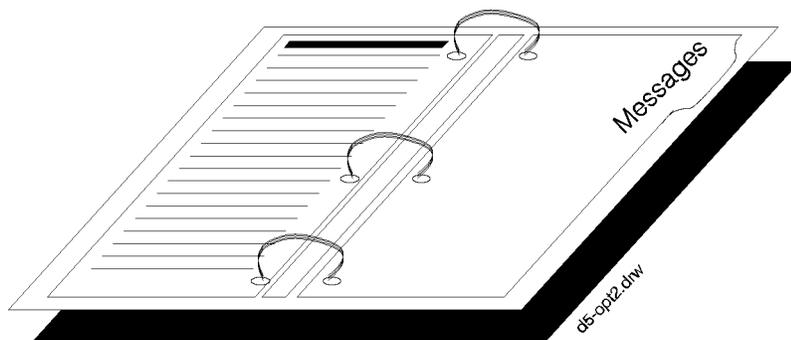
1. Press the **DISPLAY** key.
2. Press the **REPORT ERRORS** softkey.



**Figure 2-45** Message Error Access

#### Step 2 - Look up the error messages

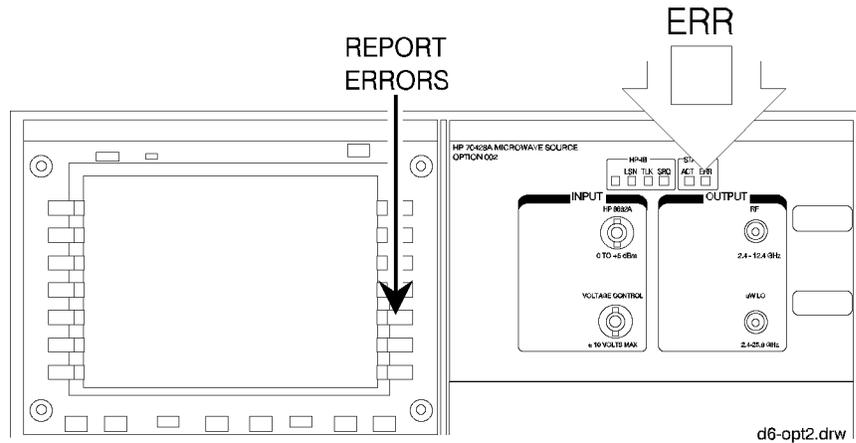
Error messages are described in the *Messages* section in the back of this manual.



**Figure 2-46** Error Message Manual Sample

### Step 3 - Clear the messages

Press the *REPORT ERRORS* softkey repeatedly until "No Errors" is displayed. If the condition that caused the error still exists the error message will re-appear.



**Figure 2-47** Report Errors Softkey

---

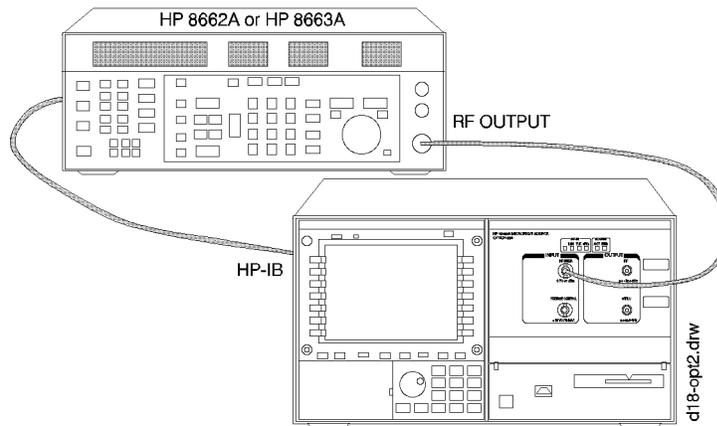
## To Output a Signal with the Tunable Source

### Overview

The procedure describes how to up-convert the output of an HP 8662A or HP 8663A signal generator with the HP 70428A Option 002.

### Procedure

#### Step 1 - Connect the Signal Generator.



**Figure 2-48** *Signal Generator Connection*

1. Connect an HP-IB cable between the signal generator and the MMS mainframe that the HP 70428A Option 002 is installed in.
2. Connect an RF cable between the signal generator's **RF OUTPUT** connector and the HP 70428A Option 002's **HP 8662A** connector.

---

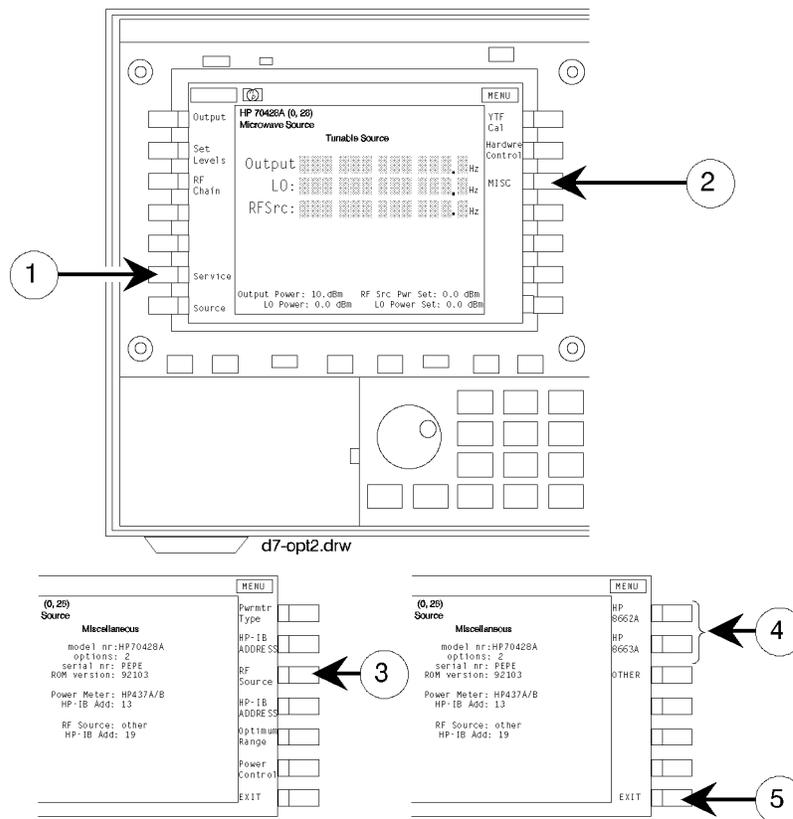
### NOTE

The HP 70428A Option 002 acts as a controller. There must be no other controller connected to the bus.

---

### Step 2 - Select the signal generator type

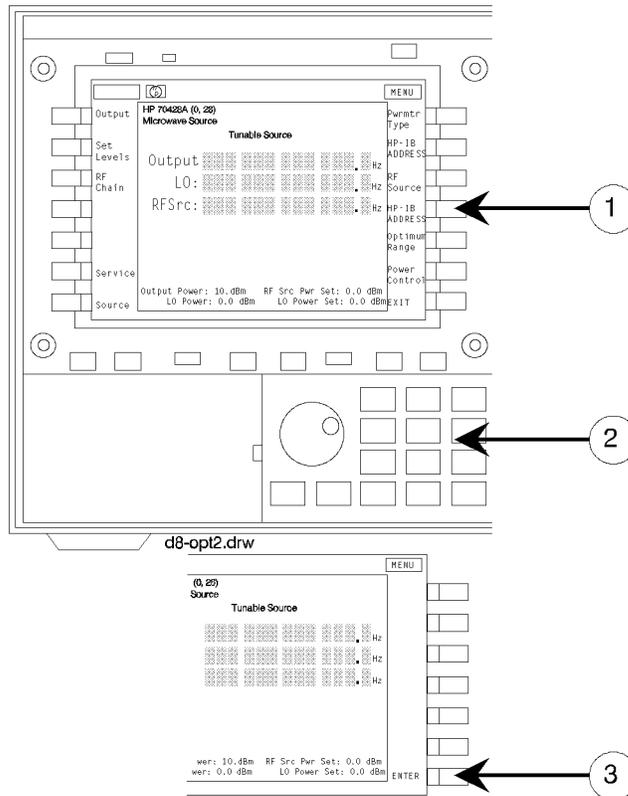
1. Press the *Service* softkey.
2. Press the *Misc* softkey.
3. Press the *RF Source* softkey.
4. Press the *HP 8662A* or *HP 8663A* softkey.
5. Press the *EXIT* softkey.



**Figure 2-49** Signal Generator Type Selection

### Step 3 - Enter the generator's HP-IB address

1. Press the *HP-IB ADDRESS* softkey
2. Enter the signal generator's HP-IB address with the numeric keypad.
3. Press the *ENTER* softkey to complete the entry.



**Figure 2-50** *HP-IB Address Key Locations*

### Step 4 - Enter the output frequency

1. Press the *Output* softkey.
2. Press the *OUTPUT FREQ* softkey
3. Key in a frequency between 2.4 GHz and 26.5 GHz with the numeric keyboard.
4. Press the *GHz*, *MHz*, or *Hz* softkey to complete the entry.

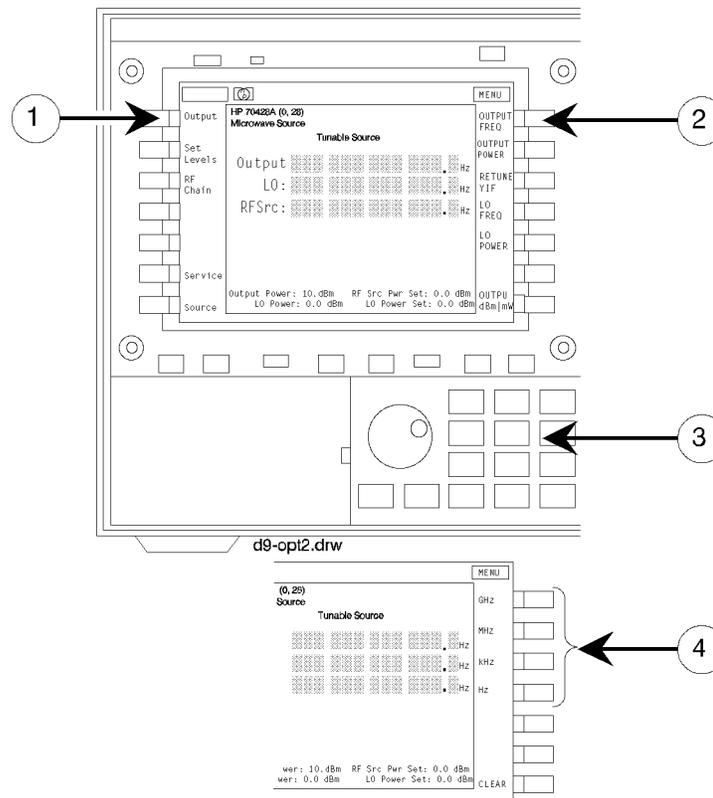


Figure 2-51 Output Frequency Softkey Locations

### Step 5 - Enter the output power

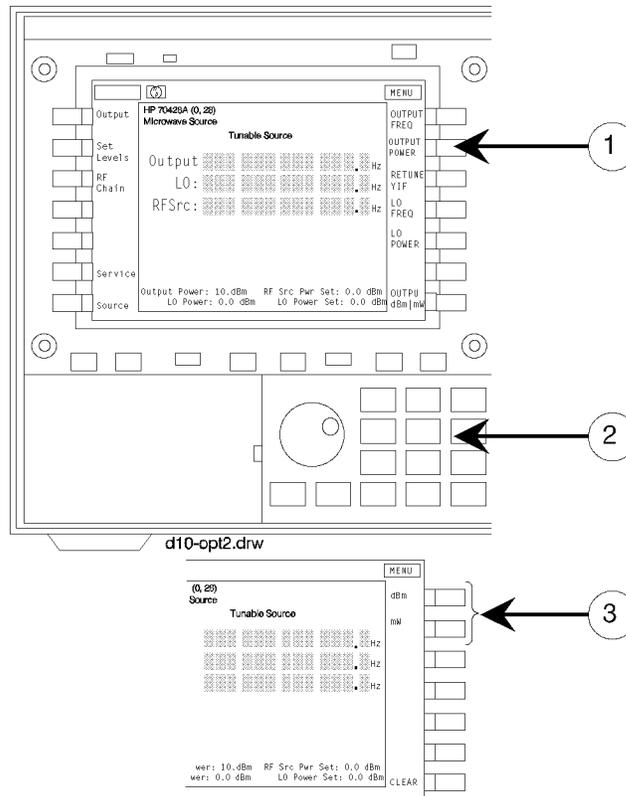
1. Press the **OUTPUT POWER** softkey.
2. Key in the output power with the numeric keypad.

Power levels between 0 and +20 (100 mW), in 0.1 dB steps, can be entered. But the minimum specified power is shown below.

- 2.4 to 6.6 GHz: +16
- 6.6 to 25.8 GHz: +10

Also actual resolution can be as much as 0.2 dB.

3. Press the **dBm** or **mW** softkey to complete the entry.



**Figure 2-52** Output Power Softkey Locations

## To Electrically Tune the Tunable Source's Frequency

### Procedure

#### Step 1 - Select the tuning sensitivity

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Press the *0.05 ppm/V*, *1.0 ppm/V*, or *2.0 ppm/V* softkey.

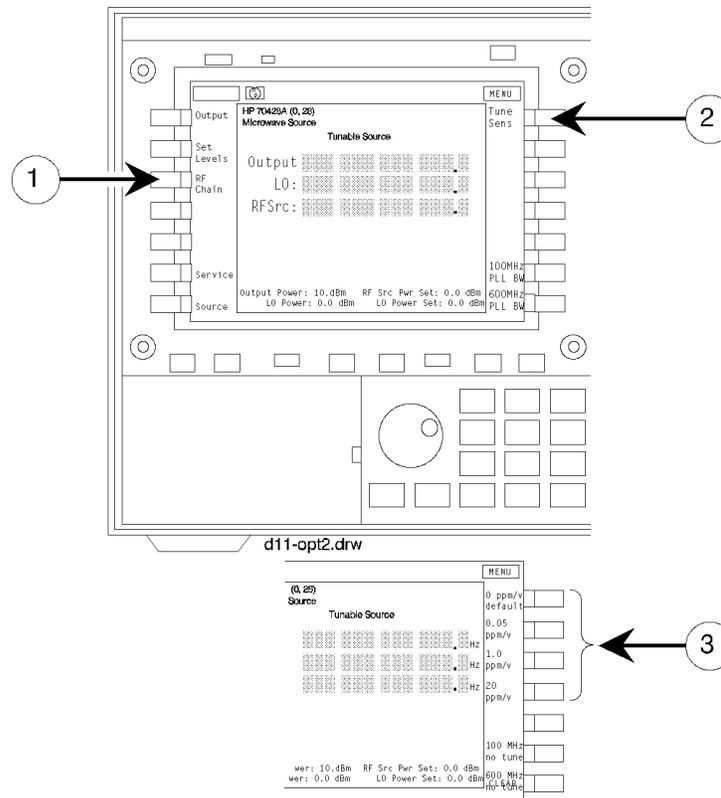
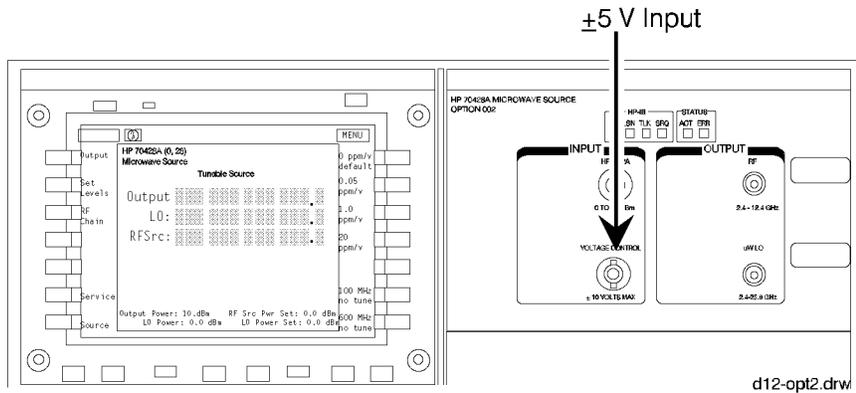


Figure 2-53 Electrically Tune Softkeys

## Step 2 - Connect the tuning voltage



**Figure 2-54** Tuning Voltage Connection

A  $\pm 5$  volt tuning voltage can be used. Connect it to the front-panel **VOLTAGE CONTROL** connector.

### Tuning with a Sensitivity of 0.05 ppm/V

With a tuning sensitivity of 0.05 ppm/V the reference chain's 10 MHz oscillator is tuned. The 600 MHz oscillator is phase-locked to the 100 MHz oscillator which is phase-locked to the 10 MHz oscillator. In this configuration a 1 Volt tuning voltage will cause a 0.05 ppm change in the tunable source's output frequency.

### Tuning with a Sensitivity of 1.0 ppm/V

With a tuning sensitivity of 1.0 ppm/V the reference chain's 100 MHz oscillator is tuned and the 600 MHz oscillator is phase-locked to it. A 1 Volt tuning voltage will cause a 1 ppm change in the source's output frequency.

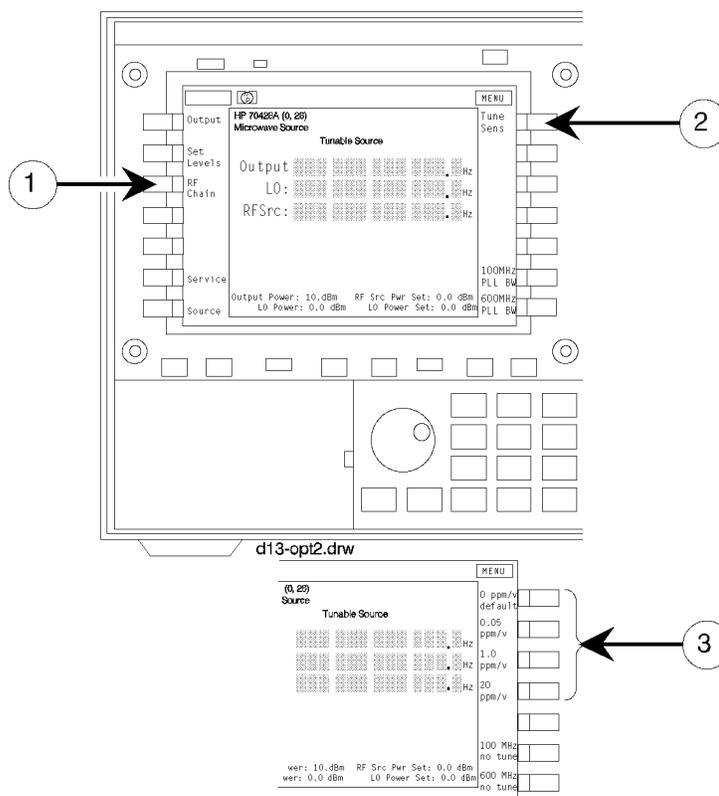
### Tuning with a Sensitivity of 20 ppm/V

With a 20 ppm/V tuning sensitivity the reference chain's 600 MHz oscillator is free running. A 1 Volt tuning voltage will cause a 20 ppm change in the source's output frequency.

## To Select Reference Chain Phase-Lock-Loop Bandwidth

### Procedure

1. Press the *REF Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Note which sensitivity (on the right side of the screen) is underlined.



**Figure 2-55** Tuning Sensitivity Softkey Locations

The 100 MHz and /or 600 MHz bandwidth can be set depending on the tuning sensitivity.

#### Tuning Sensitivity

- 0 ppm
- 0.5 ppm/V
- 1.0 ppm/V

#### Bandwidth can be set for:

- 100 MHz and or 600 MHz.  
phase-lock-loops
- 100 MHz and or 600MHz  
phase-lock-loops.
- 600 MHz phase-lock-loop.

## Getting Started

### To Select Reference Chain Phase-Lock-Loop Bandwidth

20 ppm/V	None.
100 MHz no tune	600 MHz phase-lock-loop.
600 MHz no tune	None.

#### Step 2 - Select the bandwidth.

1. Press the *Ref Chain* softkey.
2. Press either *100 MHz PLL BW* or *600 MHz PLL BW* softkey.
3. Press the softkey that corresponds to the desired bandwidth.

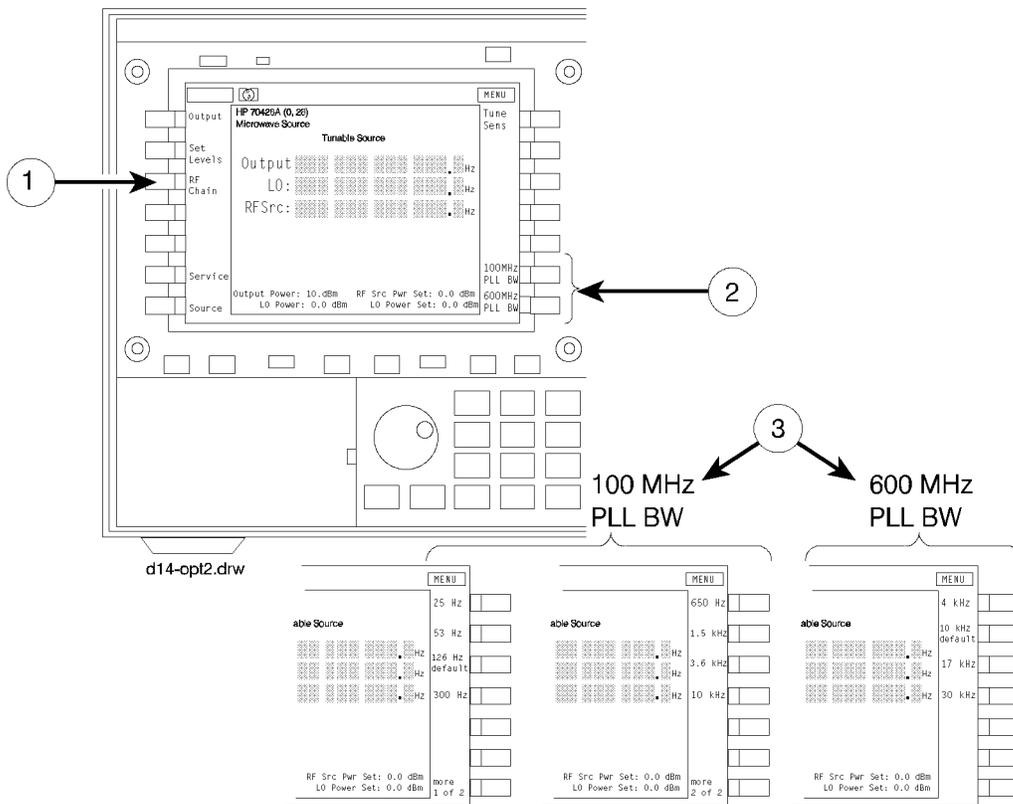


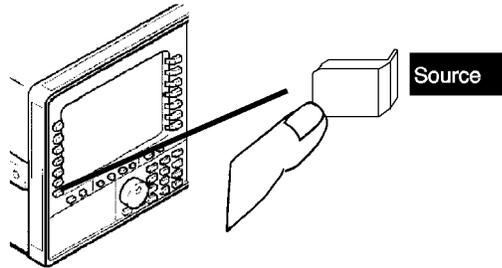
Figure 2-56 Bandwidth Softkey Locations

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## To Configure the Tunable Source as a Microwave Source

### Procedure

1. Press the *Source* softkey. The HP 70428A menus and screens will be displayed.



*Figure 2-57 Source Softkey Location*

2. Frequency and amplitude settings are preserved in the source and tunable source when switching back and forth.

Getting Started

**To Configure the Tunable Source as a Microwave Source**

# 3

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## Downconverter Operation

### Overview

This chapter contains procedures for using the HP 70427A Microwave Downconverter Module with the HP 3048A and HP 3047A Phase Noise Measurement Systems.

### Procedures

The first four procedures are for user control of the HP 70427A for use with either the HP 3048A or HP 3047A systems.

- Phase Noise Measurement <26.5 GHz . . . . . User Control
- Millimeter Phase Noise Measurement . . . . . User Control
- AM Noise Measurement (Input AM detector) . . . . . User Control
- AM Noise Measurement (IF AM detector) . . . . . User Control

The next four procedures are for system control of the HP 70427A with HP 3048A software versions A.03.00 and later.

- Phase Noise Measurement <26.5 GHz . . . . . System Control
- Millimeter Phase Noise Measurement . . . . . System Control
- AM Noise Measurement (Input AM detector) . . . . . System Control
- AM Noise Measurement (IF AM detector) . . . . . System Control

The final two procedures are for connecting the phase noise measurement system's RF spectrum analyzer to the downconverter.

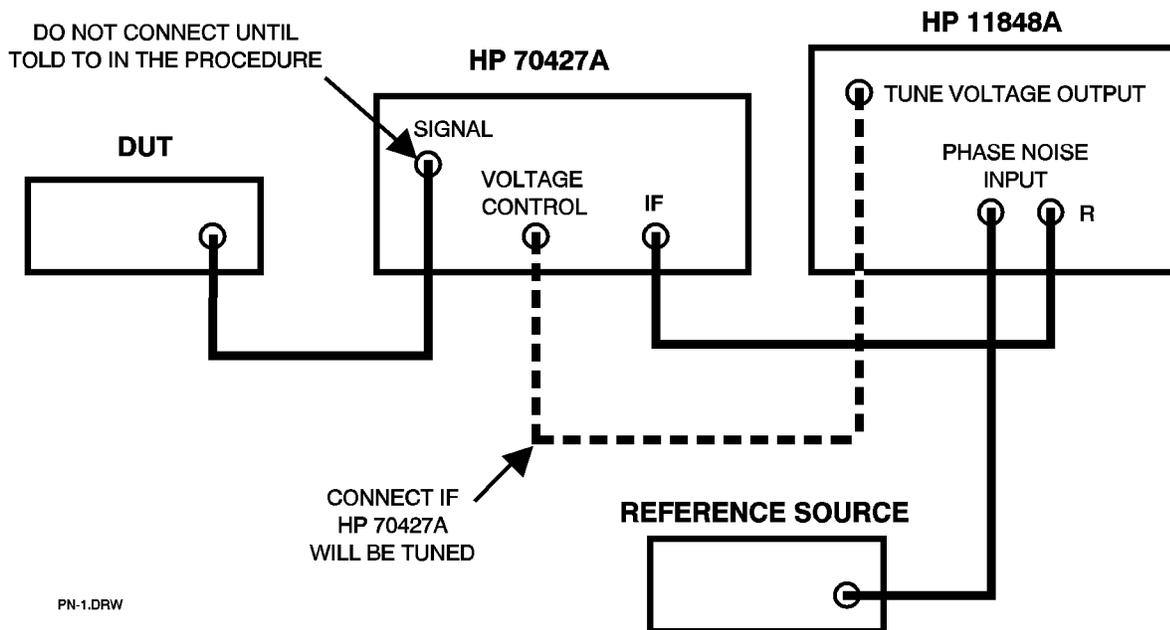
- Spectrum Analyzer connection . . . . . User Control
- Spectrum Analyzer connection . . . . . System Control

These procedures assume a knowledge of HP 3048A phase noise measurement system setup, measurement definition, and operation.

## Phase Noise Measurement <26.5 GHz User Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module with the HP 3048A or HP 3047A Phase Noise Measurement Systems. The downconverter accepts a signal from 5 MHz to 26.5 GHz and produces a signal at **IF** output between 5 MHz and 1500 MHz. Frequencies below 1.5 GHz bypass the downconverter's mixer and pass through the IF amplifier.



*Figure 3-1 Phase Noise Measurement <26.5 GHz - User Control Connection*

This procedure can be used for all HP 3048A and HP 3047A software versions. The HP 70427A is controlled manually.

The HP 70427A noise specifications in chapter 9 of the manual are provided for the HP 70427A alone and combined with the HP 8662A or HP 8663A used as the reference source.

The HP 8662A and the HP 8663A can be used under system control with any HP 3048A software version. See the HP 3048A manual for details.

## Procedure

### Step 1 - Preset the downconverter

First, make sure the downconverter's **ACT** indicator light is lit. If it isn't do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey, repeatedly if necessary, until the **ACT** indicator lights up.
3. Press the **INSTR PRESET** key.

### Step 2 - Determine the downconverter's IF frequency.

The downconverter's IF frequency will be displayed on the **IF:** display. The downconverter calculates this frequency when an input frequency is entered.

First enter the DUT frequency into the downconverter as follows:

1. Press the **Freqs** softkey.
2. Press the **INPUT FREQ** softkey.
3. Enter the frequency with the numeric keypad.
4. Press the **GHz**, **MHz**, **kHz**, or **Hz** softkey.
5. Read the IF frequency from the **IF:** display.

### Step 3 - Decide which instrument to tune

There are three choices for phase locking: by using either the DUT; the reference source; or for frequencies  $\geq 1.5$ .GHz the downconverter's LO can be turned.

#### Tuning the HP 8662A/3A

If the DUT is referenced to an oven stabilized oscillator, the HP 8662A/3A can be tuned. Connect the tune line to the EFC input. The limitation is that the HP 8662A/3A's EFC can only track a drift of  $10^{-8}$  of the output frequency from the downconverter.

The HP 8662A/3A can also be tuned by setting the modulation to DC FM. Refer to the HP 3048A manual for more information on tuning the HP 8662A/3A.

#### Tuning the HP 70427A

If the DUT is a room-temperature oscillator, the downconverter's LO should be tuned. The downconverter's tuning sensitivity can be selected so that it's tuning range will be greater than the expected drift of the DUT.

The choices are:

- 1.0 ppm/V (600 MHz PLL bandwidth must be greater than the HP 3048A PLL bandwidth)
- 20 ppm/V

Noise performance depends on tuning sensitivity so it may be necessary to trade off noise performance for tuning range. Refer to the specification table in chapter 9 for noise performance for each tuning sensitivity.

#### **Tuning the DUT:**

Refer to the Signal Source Applications chapter of the HP 3048A manual for information on tuning the DUT.

#### **Step 4 - Select the downconverter tuning sensitivity**

Do this only if the downconverter is being used.

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Press the *1.0 ppm/V* or the *20 ppm/V* softkey.

#### **Step 5 - Change the 600 MHz PLL bandwidth (if needed)**

The only reason to use anything other than the default bandwidth is if the downconverter is being tuned using the ppm/V tuning sensitivity, and the HP 3048A system PLL bandwidth is greater than 10 kHz. If the downconverter is being tuned, its phase-lock-loop bandwidth must be wider than the HP 3048A system bandwidth. If it isn't, the system software can't accurately compensate for loop suppression.

1. Press the *Ref Chain* softkey.
2. Press the *600 MHz PLL BW* softkey.
3. Press the appropriate bandwidth softkey.

#### **Step 6 - Define the measurement**

Follow the instructions in the HP 3048A manual together with the information below:

1. Specify Measurement Type and Frequency Range
  - Measurement type: Phase Noise using a Phase Lock Loop
2. Enter Source and Interface Parameters
  - Carrier Frequency: Downconverter's input frequency
  - Dectector/Disc. Input Frequency: Downconverter's IF frequency
  - VCO Tuning Constant: This depends on which instrument will be tuned:  
HP 70427A: .....carrier frequency × Tuning Sensitivity

HP 8662A/3A:EFC .....	3Hz/v
HP 8662A/3A: .....	DC FM peak deviation
• Center Voltage of VCO Tuning Curve:	
HP 70427A: .....	0 V
HP 8662A/3A: .....	0 V (EFC and DC FM)
• Voltage Tuning Range of VCO:	
HP 70427A: .....	±5 V
HP 8662A/3A: .....	±10 V (EFC and DCFM)
• VCO Tune-port Input Resistance:	
HP 70427A: .....	1 MΩ
HP 8662A/3A:EFC .....	1 MΩ
HP 8662A: DC FM .....	1 kΩ
HP 8663A: DC FM .....	600 Ω
Phase Detector-Internal Phase Detector.....	500 to 1600 MHz

3. Specify a Calibration Process

Determining PHASE DETECTOR CONSTANT: Measure the Detector Constant.

Determining the VCO TUNING CONSTANT: Measure the VCO Tuning Constant (unless the HP 8662/3A is being tuned with the DC FM, then it should be computed).

The Computed PLL Suppression WILL be verified.

4. Specify the control of Signal Sources

Downconverter: USER'S DEVICE, MANUAL CONTROL

Tune Voltage: Select the instrument that will be tuned, unless the downconverter is being tuned. If the downconverter is being tuned, select one of the sources. With phase noise using a phase-lock-loop selected as the measurement type, the software requires that something be designated as the tuned device, but the downconverter is not one of the choices. This only affects the connection diagram and does not change the measurement of the results.

**Step 7 - Start a new Measurement**

Connect the sources when the software pauses at the connection diagram. set the reference source output as follows:

Frequency ..... Same as downconverter's IF

Amplitude ..... +16 dBm

### **Step 8 - Autorange the downconverter**

1. Press the *Amplitudes* softkey
2. Press the *AUTO RANGE* softkey

This will trigger a one-time autoranging of the downconverter's input attenuator and IF gain.

### **Step 9 - Verify beatnote and proceed**

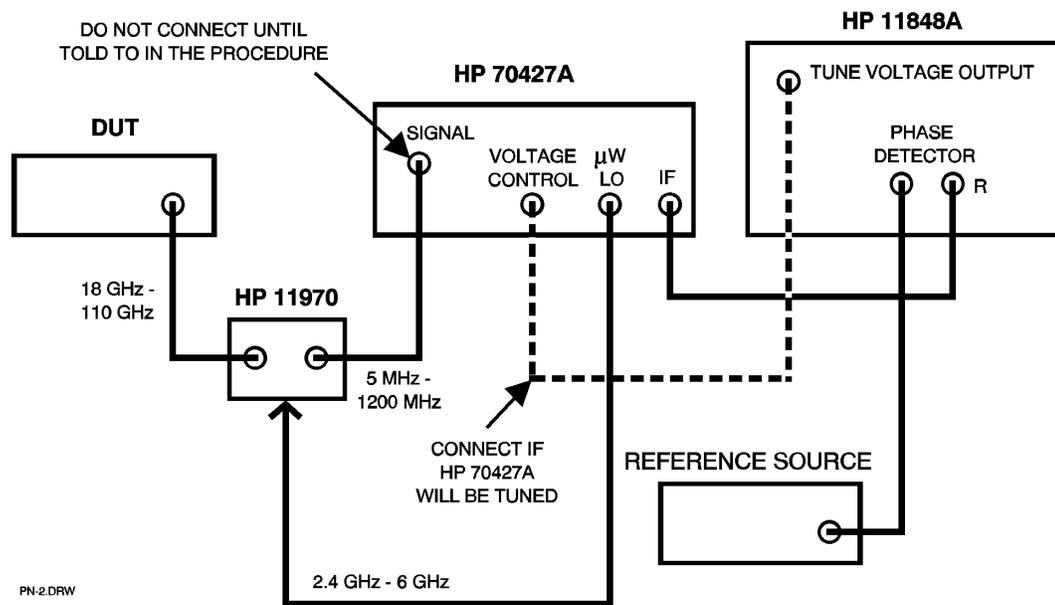
If the reference source is under user control, adjust the frequency, if necessary, to get a beatnote less than 5 % of the peak tune range ( $\text{VCO Tuning Constant} \times \text{Voltage Tuning Range of VCO}$ ). If the reference source is under system control it will be tuned automatically.

After the beatnote is within the limits the system asks for, proceed with the measurement.

## Millimeter Phase Noise Measurement - User Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module and the HP 11970 series harmonic mixer with the HP 3048A or HP 3047A Phase Noise Measurement Systems. The external harmonic mixer accepts a signal from 18 GHz to 110 GHz, depending on the mixer's frequency band, and applies a signal to the downconverter's **SIGNAL** input between 5 MHz and 1200 MHz. The downconverter supplies the external harmonic mixer with mixer bias current and a 2.4 GHz to 6 GHz signal which the harmonic mixer multiplies internally to produce the mm LO.



**Figure 3-2** Millimeter Phase Noise Measurement - User Control Connection

Refer to Hewlett-Packard Application Note 385 for information on making millimeter phase noise measurements and to the harmonic mixer manual for information on the harmonic mixer.

This procedure can be used for all HP 3048A and HP 3047A software versions. The HP 70427A is controlled manually.

The HP 8662A and HP 8663A can be used under system control with the any HP 3048A software version. See the HP 3048A manual for details.

## Procedure

### Step 1 - Preset the downconverter

First make sure the downconverter's **ACT** indicator is lit. If it isn't, do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey, repeatedly if necessary, until the **ACT** indicator lights up.
3. Press the **INSTR PRESET** key.

### Step 2 - Configure the downconverter for external mixer operation

1. Press the **Mode  $\mu$  W/mm** softkey until **mm** is underlined.
2. Press the **mm Band** softkey.
3. Press the softkey that corresponds to the DUT's frequency range and to the **mm** band of the mixer.
4. Press the **EXIT** softkey.

### Step 3 - Determine the downconverter's IF frequency

The downconverter's IF frequency will be displayed on the **IF:** display. The downconverter calculates this frequency when an input frequency is entered. In **mm** mode, the input frequency must be in the **mm** band selected in step 2.

First enter the DUT frequency into the downconverter as follows:

1. Press the **Freqs** softkey.
2. Press the **INPUT FREQ** softkey.
3. Enter the frequency with the numeric keypad.
4. Press the **GHz**, **MHz**, **KHz**, or **Hz** softkey.

Then read the IF frequency from the **IF:** display.

### Step 4 - Enable mixer bias if needed

If the message **Enable and adjust mixer bias:**, was displayed at the bottom of the MMS display when the input frequency was entered, do the following:

- Press the **BIAS ON/OFF** softkey until **ON** is underlined.

The mixer bias will be adjusted in step 11.

## Step 5 - Decide which instrument to tune

There are three choices for phase locking: by using either the DUT; the reference source; or for frequencies  $\geq 1.5$ .GHz the downconverter's LO can be turned.

### Tuning the HP 8662A/3A

If the DUT is referenced to an oven stabilized oscillator, the HP 8662A/3A can be tuned. Connect the tune line to the EFC input. The limitation is that the HP 8662A/3A's EFC can only track a drift of  $10^{-8}$  of the output frequency from the downconverter.

The HP 8662A/3A can also be tuned by setting the modulation to DC FM. Refer to the HP 3048A manual for more information on tuning the HP 8662A/3A.

### Tuning the HP 70472A

If the DUT is a room-temperature oscillator, the downconverter's LO should be tuned. The downconverter's tuning sensitivity can be selected so that its tuning range will be greater than the expected drift of the DUT. The choices are:

- 1.0 ppm / V (600 MHz PLL bandwidth must be greater than the HP 3048A PLL bandwidth)
- 20 ppm/V

### Tuning the DUT

Refer to the Signal Source Applications chapter of the HP 3048A manual for information on tuning the DUT.

## Step 6 - Select the downconverter's tuning sensitivity

Do this only if the Downconverter is being tuned.

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Press the *1.0 ppm/V* or the *20 ppm/V* softkey.

## Step 7 - Change the 600 MHz PLL bandwidth if needed

The only reason to use anything other than the default bandwidth is if the downconverter is being tuned using 1.0 ppm/V sensitivity and the HP 3048A system PLL bandwidth is greater than 10 kHz. If the downconverter is being tuned, the 600 MHz phase-lock-loop bandwidth must be wider than the HP 3048A system bandwidth. Otherwise, the system software can't accurately compensate for loop suppression.

1. Press the *Ref Chain* softkey.
2. Press the *600 MHz PLL BW* softkey.

3. Press the appropriate bandwidth softkey.

### Step 8 - Define the measurement

Follow the instructions in the HP 3048A manual together with the information below.

1. Specify Measurement Source and Interface Parameters

- Measurement type: Phase Noise using a Phase-Lock-Loop

2. Enter Source and Interface Parameters

- Carrier Frequency: mm mixer's input frequency
- Detector/Discr. Input Frequency: Downconverter's IF frequency
- VCO Tuning Constant: This depends on which instrument will be tuned:

HP 70427A: .....LO frequency  $\times$  Tuning Sensitivity

HP 8662A/3A: EFC: .....  $10^{-8} \times$  Downconverter IF frequency  
DC FM: ..... peak deviation

- Center Voltage of VCO Tuning Curve:

HP 70427A: ..... 0 V

HP 8662A/3A: ..... 0 V (EFC and DC FM)

- Voltage Tuning Range of VCO:

HP 70427A: .....  $\pm 5$  V

HP 8662A/3A: .....  $\pm 10$  V (EFC and DC FM)

- VCO Tune-port Input Resistance:

HP 70427A: ..... 1 M $\Omega$

HP 8662A/3A:EFC: ..... 1M $\Omega$   
DC FM: ..... 1k $\Omega$  (HP 8662A), 600  $\Omega$  (HP 8663A)

- Phase Detector-Internal Phase Detector. ....5 MHz to 1600 MHz

3. Specify a Calibration Process

Determining the PHASE DETECTOR CONSTANT: Measure the Detector Constant.

Determining the VCO TUNING CONSTANT: Measure the VCO Tuning Constant (unless the HP 8662A/3A is being tuned with DC FM, then it should be computed).

The Computed PLL Suppression WILL be verified.

4. Specify the Control of Signal Sources

Downconverter: USER'S DEVICE, MANUAL CONTROL

Tune Voltage: select the instrument that will be tuned, unless the downconverter is being tuned. If the downconverter is being tuned, select one of the sources. With phase noise using a phase-lock-loop selected as the measurement type, the software requires that something be designated as the tuned device. However, downconverter is not one of the available choices in A.02 or earlier software. This only affects the connection diagram and does not change the measurement or the results.

### Step 9 - Start a new measurement

Connect the sources when the software pauses at the connection diagram. Set the reference source output as follows:

Frequency: ..... Same as downconverter's IF  
Amplitude: ..... +16 dBm

### Step 10 - Adjust mixer bias if necessary

If mixer bias was enabled in step 4, adjust the mixer bias current for maximum signal level from the harmonic mixer as measured at the downconverter's IF output.

1. Connect a spectrum analyzer to monitor the downconverter's IF.
  - a. Connect a spectrum analyzer to monitor the downconverter's **RF ANALYZER** output.
  - b. Press the *Amplitudes* softkey.
  - c. Press the *VIEW IN /IF/* softkey until IF is underlined.
2. Set the downconverter's IF gain to 0 dB. This is to insure that the IF amplifier won't be driven into compression.
  - a. Press the *Amplitudes* softkey.
  - b. Press the *more 1 of 2* softkey.
  - c. Press the *IF GAIN* softkey.
  - d. Enter 0 with the numeric keypad.
  - e. Press the *dB* softkey.
3. If the DUT's output power is adjustable, set it for a harmonic mixer input level that is just below the point where the signal starts being compressed (as measured by the RF spectrum analyzer).
4. Adjust mixer bias for a maximum IF signal measured by the spectrum analyzer.
  - a. Press the *Freqs* softkey.
  - b. Press the *MIXER BIAS* softkey.

- c. Adjust the bias level with the knob, Up/Down keys, or enter a power with the numeric keypad.

Adjust the mixer LO power for maximum IF signal measured on the spectrum analyzer.

- a. Press the *LO POWER* softkey.
- b. Adjust the LO power with the knob, Up/Down keys, or enter a power with the numeric keypad.

Repeat the steps above for maximum IF output measured on the RF spectrum analyzer.

This completes the mixer bias adjustment.

5. Autorange the downconverter's IF gain as follows:
  - a. Press the *Amplitudes* softkey
  - b. Press the *AUTO RANGE* softkey.

### Step 11 - Verify the beatnote and proceed

If the reference source is under the user control, adjust its frequency if necessary to get a beatnote less than 5% of peak tuning range. If the reference source is under system control it will be tuned automatically.

After the beatnote is within the limits the system asks for, proceed with the measurement.

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#### NOTE

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When the downconverter is configured for mm operation don't apply a high-level microwave signal to the input. Change the mode back to  $\mu\text{W}$  and press the *INSTR PRESET* key. This will protect the IF amplifier from damage.

---

## AM Noise Measurement (Input AM Detector) User Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module with the HP 3048A Phase Noise measurement System. The downconverter accepts a signal from 5 MHz to 26.5 GHz and produces a baseband signal.

This procedure can be used for all HP 3048A and HP 3047A Phase Noise measurement software. The HP 70427A is controlled manually.

With HP 3048A software versions A.03.00, or later, the HP 70427A can be controlled by the software.

### Procedure

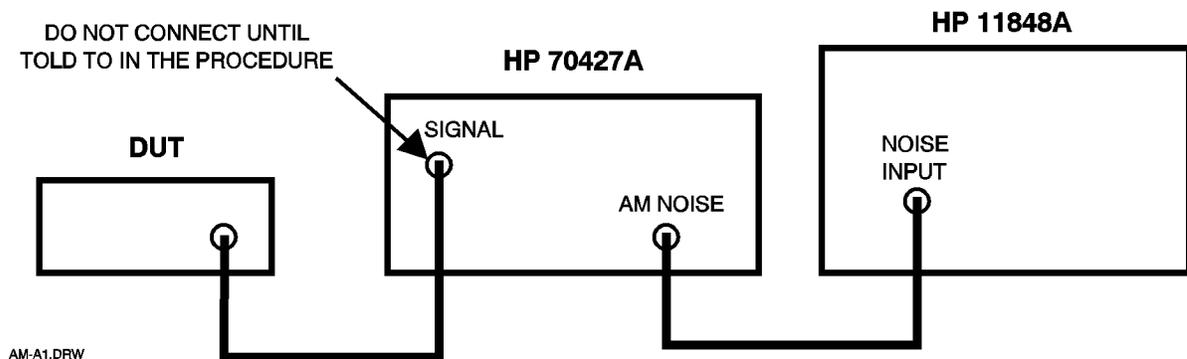


Figure 3-3 AM Noise Measurement (Input AM Detector) User Control Connection

#### Step 1 - Preset the Converter

First, make sure the downconverter's **ACT** indicator light is lit. If it isn't, do the following:

- Press the **DISPLAY** key.
- Press the **NEXT INSTR** softkey, repeatedly if necessary, until the **ACT** indicator lights.
- Press the **INSTR PRESET** key.

#### Step 2 - Enable the input AM detector

- Press the **AM Noise** softkey.
- Press the **AM NSE IN / IF** softkey until the **IN** is underlined.

When the input AM detector is enabled the signal is routed through the downconverter's input attenuator and to the AM detector. The detector's output is routed to **AM NOISE** output.

The downconverter's mixer is not in the signal path.

### **Step 3 - Define the measurement**

Follow the instructions in the HP 3048A manual along with the following information:

1. Specify Measurement Type and Frequency Range
  - Measurement Type: AM Noise.
2. Enter Source and Interface Parameters
  - Carrier Frequency: DUT frequency.
  - Detector/Discr. Input Frequency: DUT frequency.
  - Detector - External Phase / AM Detector.
3. Specify a Calibration Process
  - Phase Detector Constant: Derive from Double Sided Spur
  - Spur Amplitude: - 26 dBc
  - Spur Frequency: 1kHz
4. Specify the Control of Signal Sources
  - CAL sources: USERS DEVICE, MANUAL CONTROL

### **Step 4 - Begin a new measurement**

When the HP 3048A software pauses at the system connect diagram, connect the DUT to the downconverter's **SIGNAL** input and make any other connections shown that haven't been done yet. The filter shown on the connect diagram is not needed because the HP 70427A has a filter in it.

### **Step 5 - Set the DUT power to +10 dBm**

The downconverter's AM detector is specified at an input level of +10 dBm, but it will work with input levels as low as 0 dBm.

### **Step 6 - Autorange the downconverter**

1. Press the *AUTO ATTEN* softkey.
2. Press the *AUTO RANGE* softkey.

This triggers a one-time autoranging of the downconverter's input attenuator.

### Step 7 - Measure the AM detector's output voltage

The detector's output voltage is measured with the downconverter's internal voltmeter.

1. Read the **AM Det voltage:** display.
2. Press the **READ AM DET** softkey.
3. Press the **READ AM DET** softkey again.
4. Repeat from step 1 above until the reading on the **AM DET voltage:** display doesn't change from one reading to the next.
5. Record the final reading for use in the following step.

### Step 8 - Measure and adjust the calibration source power

Connect the calibration source's output to the downconverter's **SIGNAL** input. Set the calibration source as follows:

- Frequency:  
IF DUT frequency is <500 MHz: Use the DUT frequency.  
IF DUT frequency is >500 MHz: Use the 500 MHz (if the cal source can tune the DUT frequency use the DUT frequency).
- Power: +10 dBm
- Modulation: OFF

Now, adjust the calibration source power so that the voltage measured at the output of the AM detector is within  $\pm 5\%$  of what it was with the DUT connected to the downconverter.

1. Read the **AM Det voltage:** display.
2. Press the **READ AM DET** softkey.
3. Press the **READ AM DET** softkey again.
4. Repeat from step 1 until the reading on the **AM Det voltage:** display doesn't change from one reading to the next.
5. If necessary, increment/decrement the calibration source's output power.
6. Repeat steps 1 through 4 to read the detector's output at the new power.
7. Repeat steps 1 through 5 until the calibration source's detector voltage is within  $\pm 5\%$  of the DUT's detector voltage.

### Step 9 - Run the calibration

Modulate the calibration source as follows:

- Type: AM

Downconverter Operation

**AM Noise Measurement (Input AM Detector) User Control**

- Depth: 10%
- Frequency: 1 kHz

**Step 10 - Proceed with the measurement**

Re-connect the DUT to the downconverter's **SIGNAL** input and proceed with the measurement.

## AM Noise Measurement (IF AM Detector) User Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module with the HP 3048A Phase Noise Measurement System. The downconverter accepts a signal from 5 MHz to 26.5 GHz and produces a baseband signal as well as an **IF** output.

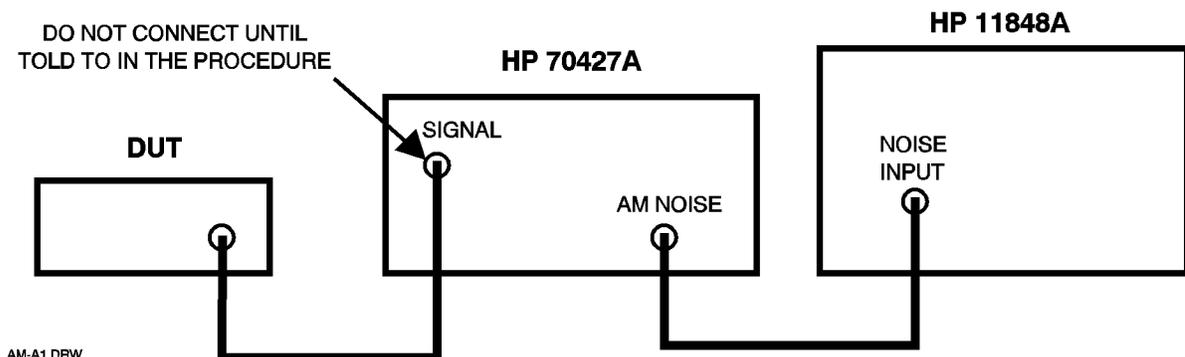
The downconverter's AM specifications only apply to the RF AM detector. The reason for choosing the IF AM detector for a noise measurement is that a lower carrier power can be measured. The RF AM detector is limited to carrier levels greater than 0 dBm.

With the IF Am detector, carrier levels down to -30 dBm can be measured because the signal is amplified by the IF amplifier before going to the IF Am detector.

The IF AM detector can also be used with the downconverter in mm mode (external harmonic mixer). To do this, set up the downconverter for downconverting a mm wave signal as if for a phase noise measurement, then follow the procedure starting at step 3.

The procedure can be used for all HP 3048A and HP 3047A Phase Noise Measurement software. The HP 70427A is controlled manually.

With HP 3048A software versions A.03.00, or later, the HP 70427A can be controlled by the software.



*Figure 3-4 AM Noise Measurement (IF AM Detector) Connection Diagram*

## Procedure

### Step 1 - Preset the Downconverter

First make sure the downconverter's **ACT** indicator is lit. If it isn't, do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey, repeatedly if necessary, until the **ACT** indicator lights.
3. Press the **INSTR PRESET** key.

### Step 2 - Enter the input frequency

1. Press the **Freqs** softkey.
2. Press the **INPUT FREQ** softkey.
3. Enter the DUT's carrier frequency with the numeric keypad.
4. Press the **GHz**, **MHz**, **KHz**, or **Hz** softkey.

### Step 3 - Enable the IF AM detector

1. Press the **AM Noise** softkey.
2. Press the **AM NSE IN / IF** softkey until the IF is underlined.
3. Press the **Freqs** softkey.

### Step 4 - Define the measurement

Follow the instructions in the HP 3048A manual together with the information below:

1. Specify Measurement Type and Frequency Range
  - Measurement Type: AM Noise.
2. Enter Source and Interface Parameters
  - Carrier Frequency: DUT frequency.
  - Detector/Discr. Input Frequency: IF frequency.
  - Detector - External Phase / AM Detector.
3. Specify a Calibration Process
  - Phase Detector Constant: Derive from Double Sided Spur
  - Spur Amplitude: - 26 dBc
  - Spur Frequency: 1kHz
4. Specify the Control of Signal Sources
  - CAL sources: USERS DEVICE, MANUAL CONTROL

### Step 5 - Begin a new Measurement

When the HP 3048A software pauses at the system connect diagram, connect the DUT to the downconverter's **SIGNAL** input and make any other connections shown that haven't been done yet.

The filter shown on the connect diagram is not needed because the HP 70427A has a filter in it.

### Step 6 - Autorange the downconverter

1. Press the *Amplitudes* softkey
2. Press the *AUTO RANGE* softkey
3. This will trigger a one-time autoranging of the downconverter's input attenuator and IF gain.

### Step 7 - Measure the IF AM detector's output voltage

The detector's output voltage is measured with the downconverter's internal voltmeter.

1. Press the *AM Noise* softkey.
2. Read the **AM Det Voltage:** display.
3. Press the *READ AM DET* softkey.
4. Press the *READ AM DET* softkey again.
5. Repeat from step 1 above until the reading on the **AM DET Voltage:** display doesn't change from one reading to the next.
6. Record the final reading for use in the following step.

### Step 8 - Measure and adjust the calibration source power

Connect the calibration source's output to the downconverter's **SIGNAL** input. Set the calibration source as follows:

- Frequency: Use the IF frequency.
- Power: Use DUT power- Input Atten: – 6dB
- Modulation: OFF

Then change the downconverter's input frequency to IF frequency. Now, adjust the calibration source power so that the voltage measured at the output of the AM detector is within  $\pm 5\%$  of what it was with the DUT connected to the downconverter.

1. Read the **AM DET Voltage:** display.
2. Press the *READ AM DET* softkey.
3. Press the *READ AM DET* softkey again.

**AM Noise Measurement (IF AM Detector) User Control**

4. Repeat from step 1 until the reading on the **AM Det voltage:** display doesn't change from one reading to the next.
5. If necessary, increment/decrement the calibration source's output power.
6. Repeat steps 1 through 4 to read the detector's output at the new power.
7. Repeat steps 1 through 5 until the calibration source's detector voltage is within  $\pm 5\%$  of the DUT's detector voltage.

**Step 9 - Run the calibration**

Modulate the calibration source as follows:

- Type: AM
- Depth: 10%
- Frequency: 1 kHz

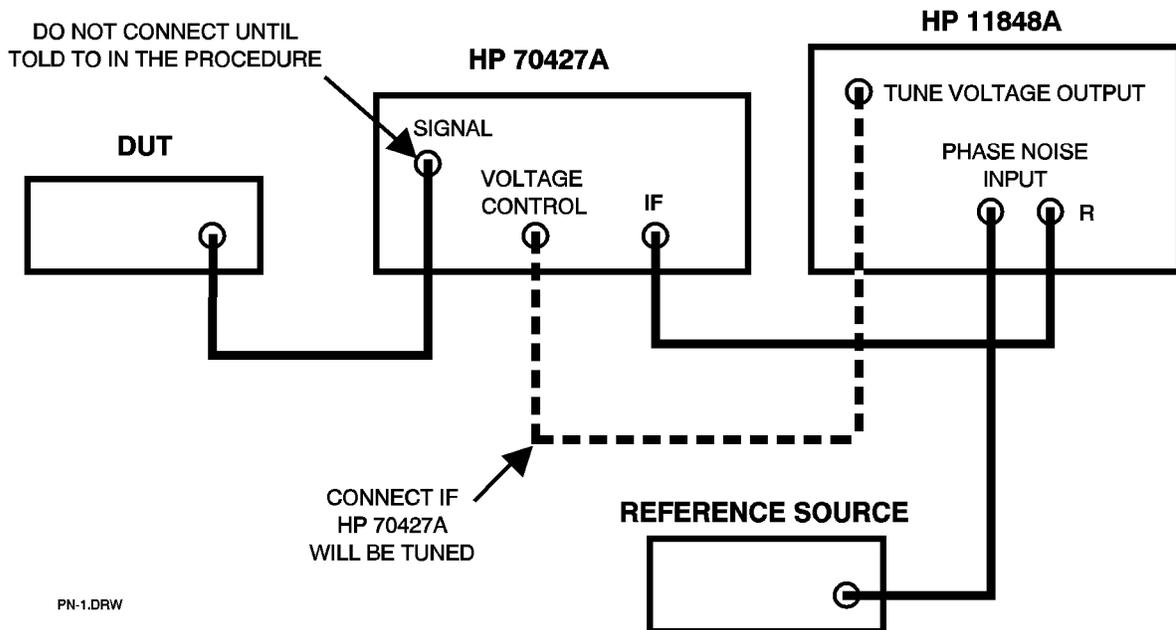
**Step 10 - Proceed with the measurement**

Re-connect the DUT to the downconverter's **SIGNAL** input, retune the downconverters to the DUT's output frequency, and proceed with the measurement.

## Phase Noise Measurement <26.5 GHz System Control

This procedure describes how to use the HP 70427A Downconverter Module with the HP 3048A Phase Noise Measurement System. The downconverter accepts a signal from 5 MHz to 26.5 GHz and produces a signal at the **IF** output between 5 MHz and 1500 MHz. Frequencies below 1.5 GHz bypass the downconverter's mixer and pass through the IF amplifier.

This procedure can be used for all HP 3048A software versions A.03.00 or later. The software can be configured for system control of the HP 70427A. With earlier versions of the software, the HP 70427A must be controlled manually.



**Figure 3-5** Phase Noise Measurement <26.5 GHz System Control Connection

The HP 70427A noise specifications in chapter 9 of this manual are provided for the HP 70427A alone and combined with the HP 8662A or HP 8663A used as the reference source.

The HP 8662A and HP 8663A can be used under system control with any HP 3048A software version. See HP 3048A manual for details.

## Step 1 - Decide which instrument to tune

There are three choices for phase locking: by using either the DUT; the reference source; or for frequencies  $\geq 1.5$ .GHz the downconverter's LO can be turned.

### Tuning the HP 8662A/3A

If the DUT is referenced to an oven stabilized oscillator, the HP 8662A/3A can be tuned. Connect the tune line to the EFC input. The limitation is that the HP 8662A/3A's EFC can only track a drift of  $10^{-8}$  of the output frequency from the downconverter.

The HP 8662A/3A can also be tuned by setting the modulation to DC FM. Refer to the HP 3048A manual for more information on tuning the HP 8662A/3A.

### Tuning the HP 70427A

If the DUT is a room-temperature oscillator, the downconverter's LO should be tuned. The downconverter's tuning sensitivity can be selected so that its tuning range will be greater than the expected drift of the DUT.

The choices are:

- 1.0 ppm/V (600 MHz PLL bandwidth must be greater than the HP 3048A PLL bandwidth)
- 20 ppm/V

Noise performance depends on tuning sensitivity so it may be necessary to trade off noise performance for tuning range. Refer to a specification table in chapter 9 for noise performance for each tuning sensitivity.

### Tuning the DUT:

Refer to the Signal Source Applications chapter of the HP 3048A manual for information on tuning the DUT.

## Step 2 - Define the measurement

Follow the instructions in the HP 3048A manual together with the information below:

1. System Configuration
  - Enter the downconverter in the system configuration table. Refer to chapter 1 in this manual for information on determining and setting the HP 70427A's HP-IB address.
2. Specify Measurement Type and Frequency Range
  - Measurement type: Phase Noise Using a Phase-Lock-Loop

3. Enter Source and Interface Parameters

- Carrier Frequency: Downconverter's input frequency
- Detector/Disc. Input Frequency: Downconverter's IF frequency
- VCO Tuning Constant: This depends on which instrument will be tuned:  
HP 70427A: ..... carrier frequency  $\times$  Tuning Sensitivity  
HP 8662A/3A: EFC: ..... 3Hz/v  
DC FM: .....peak deviation
- Center Voltage of VCO Tuning Curve:  
HP 70427A: .....0V  
HP 8662a/3A: .....0 V (EFC and DC FM)
- Voltage Tuning Range of VCO:  
HP 70427A: ..... $\pm 5$  V  
HP 8662A/3A: ..... $\pm 10$  V (EFC and DC FM)
- VCO Tune-port Input Resistance:  
HP 70427A: .....  $1M\Omega$   
HP 8662A/3A: ..... EFC  $1M\Omega$   
HP 8662A: DC FM .....  $1k\Omega$   
HP 8663A: DC FM .....  $600\Omega$   
Phase Detector-Internal Phase Detector: ..... 5 MHz to 1600 MHz

4. Specify a Calibration Process

- Determining PHASE DETECTOR CONSTANT: Measure the Detector Constant.
- Determining the VCO TUNING CONSTANT: Measure the VCO Tuning Constant (unless the HP 8662A/3A is being tuned with the DC FM, then it should be computed).

The Computed PLL Suppression WILL be verified.

5. Enter the downconverter parameters

1. Press the *Source Control* softkey

Press the *70427A Parms* softkey on the HP 3048A controller.

---

**NOTE**

---

The Up/Down arrow keys select the parameter, and the Left/Right arrow keys select the parameters values.

- Spectrum Analyzer View: IF

- Microwave/mm band: ( $\mu$  W) 0 – 26.5
- Auto/Manual Input Attenuation & IF Gain: Auto
- Input Attenuation: determined by system if Auto is selected.
- IF Gain: determined by system if Auto is selected.
- Mixer Maximum Level: system enters factory default value, –5 dBm.

Tuning Sensitivity: select the sensitivity determined in step 1 (if the HP 70427A is being tuned).

- LO Power: system enters factory default value, +10 dbm.
- Auto/Manual LO Frequency selection: Auto
- LO Frequency: determined by the system.
- 100 MHz Ref. Chain PLL Bandwidth: use the default, 126 Hz.
- 600 MHz Ref. Chain PLL Bandwidth: use the default, 10 kHz\*.

\*Unless use of a wider bandwidth is dictated by the tuning sensitivity and the HP 3048A PLL bandwidth (see step 1). The only reason to use anything other than the default bandwidth is if the downconverter is being tuned using 1.0 ppm/V tuning sensitivity and the HP 3048A system bandwidth is greater than 10 kHz. If the downconverter is being tuned, the 600 MHz PLL bandwidth must be wider than the HP 3048A system bandwidth.

### Step 3 - Start a new measurement

Connect the sources when the software pause at the connection diagram. Set the reference source output as follows:

- Frequency: Same as downconverter's IF.
- Amplitude: +16 dBm

### Step 4 - Autorange the downconverter

1. Press the *AUTO Range* softkey of the HP 3048A controller.

This will trigger a one-time autoranging of the downconverter's input attenuator and IF gain.

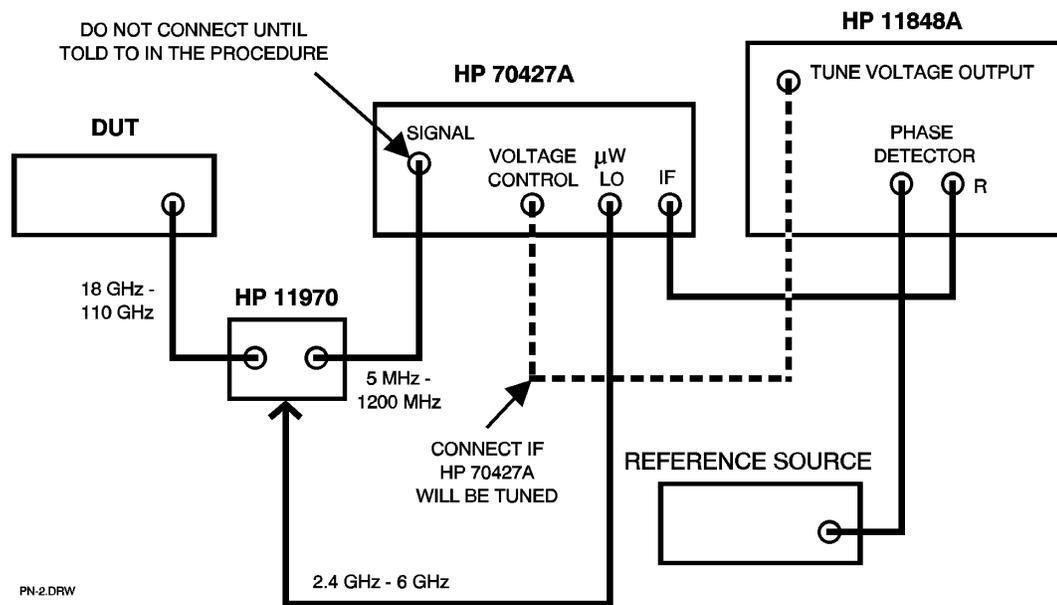
### Step 5 - Verify beatnote and proceed

If the reference source is under user control tune it, if necessary, to get a beatnote less than 5% of the peak tuning range. If the reference source is under system control it will be tuned automatically.

## Millimeter Phase Noise Measurement System Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module and the HP 11970 series harmonic mixer with the HP 3048A or HP 3047A Phase Noise Measurement Systems. The external harmonic mixer accepts a signal from 18 GHz to 110 GHz, depending on the mixer's frequency band, and applies a signal to the downconverter's **SIGNAL** input between 5 MHz and 1200 MHz. The downconverter supplies the external harmonic mixer with mixer bias current and a 2.4 GHz to 6 GHz signal which the harmonic mixer multiplies internally to produce the mm LO.



**Figure 3-6** Millimeter Phase Noise Measurement System Control Connection

Refer to Hewlett-Packard Application Note 385 for information on making millimeter phase noise measurements and to the harmonic mixer manual for information on the harmonic mixer.

This procedure can be used for all HP 3048A software versions A.03.00 or later. The software can be configured for system control of the HP 70427A. With earlier versions of the software, the HP 70427A must be controlled manually.

## Step 1 - Decide which instrument to tune

There are three choices for phase locking: by using either the DUT; the reference source; or for frequencies  $\geq 1.5$ .GHz the downconverter's LO can be turned.

### Tuning the HP 8662A/3A

If the DUT is referenced to an oven stabilized oscillator, the HP 8662A/3A can be tuned. Connect the tune line to the EFC input. The limitation is that the HP 8662A/3A's EFC can only track a drift of  $10^{-8}$  of the output frequency from the downconverter.

The HP 8662A/3A can also be tuned by setting the modulation to DC FM. Refer to the HP 3048A manual for more information on tuning the HP 8662A/3A.

### Tuning the HP 70427A

If the DUT is a room-temperature oscillator, the downconverter's LO should be tuned. The downconverter's tuning sensitivity can be selected so that its tuning range will be greater than the expected drift of the DUT.

The choices are:

- 1.0 ppm/V (600 MHz PLL bandwidth must be greater than the HP 3048A PLL bandwidth)
- 20 ppm/V

Noise performance depends on tuning sensitivity so it may be necessary to trade off noise performance for tuning range. Refer to a specification table in chapter 9 for noise performance for each tuning sensitivity.

### Tuning the DUT:

Refer to the Signal Source Applications chapter of the HP 3048A manual for information on tuning the DUT.

## Step 2 - Define the measurement

Follow the instructions in the HP 3048A manual together with the information below:

### 1. System Configuration

Enter the downconverter in the system configuration table. Refer to chapter 1 in this manual for information on determining and setting the HP 70427A's HP-IB address.

### 2. Specify Measurement Type and Frequency Range

- Measurement type: Phase Noise Using a Phase-Lock-Loop

### 3. Enter Source and Interface Parameters

- Carrier Frequency: External mixer's input frequency (DUT frequency).
- Detector/Discr. Input Frequency: Downconverter's IF frequency
- VCO Tuning Constant: This depends on which instrument will be tuned:  
 HP 70427A: ..... carrier frequency  $\times$  Tuning Sensitivity  
 HP 8662A/3A: EFC: .....  $10^{-8} \times$  Downconverter IF frequency,  
 DC FM: ..... peak deviation

---

**NOTE**

---

To find the IF frequency, manually enter the carrier frequency into the HP 70427A. it will calculate and display the IF frequency.

- Center Voltage of VCO Tuning Curve:  
 HP 70427A: ..... 0 V  
 HP 8662A/3A: ..... 0 V (EFC and DC FM)
- Voltage Tuning Range of VCO:  
 HP 70427A: .....  $\pm 5$  V  
 HP 8662A/3A: .....  $\pm 10$  V (EFC and DC FM)
- VCO Tune-port Input Resistance:  
 HP 70427A: .....  $1M\Omega$   
 HP 8662A/3A:EFC .....  $1M\Omega$   
 HP 8662A: DC FM .....  $1k\Omega$   
 HP 8663A: DC FM .....  $600\Omega$   
 Phase Detector-Internal Phase Detector ..... 5 MHz to 1600 MHz

4. Specify a Calibration Process

Determining PHASE DETECTOR CONSTANT: Measure the Detector Constant.

Determining the VCO TUNING CONSTANT: Measure the VCO Tuning Constant (unless the HP 8662/3A is being tuned with the DC FM, then it should be computed).

The Computed PLL Suppression WILL be verified.

5. Specify the Control of Signal Sources

- Downconverter: HP 70427A SYSTEM CONTROL
- Tune Voltage: Select the instrument to be tuned.

6. Enter the downconverter parameters

- Press the *70427A Parms* softkey on the HP 3048A controller.

---

**NOTE**

---

The Up/Down arrow keys select the parameter, and the Left/Right arrow keys select the parameters values.

- Spectrum Analyzer View: IF
- Microwave/mm band: MM band of the external mixer.
- Auto/Manual Input Attenuation & IF Gain: AUTO
- IF Gain: determined by system if Auto is selected.
- mm Band Mixer Bias ON/OFF: OFF (bias may need to be enabled in step 3 below)
- mm Band Mixer Bias: 5 mA (bias may need to be adjusted in step 4 below).
- Tuning Sensitivity: select the sensitivity determined in step 1 above (if the HP 70427A is being tuned).
- LO Power: system enters factory default value.
- Auto/Manual LO Frequency selection: Auto
- LO Frequency: determined by the system.
- 100 MHz Ref. Chain PLL Bandwidth: use the default, 126 Hz.
- 600 MHz Ref. Chain PLL Bandwidth: use the default, 10 kHz\*.

\*Unless use of a wider bandwidth is dictated by the tuning sensitivity and the HP 3048A PLL bandwidth (see step 1). The only reason to use anything other than the default bandwidth is if the downconverter is being tuned using 1.0 ppm/V tuning sensitivity and the HP 3048A system bandwidth is greater than 10 kHz. If the downconverter is being tuned, the 600 MHzx PLL bandwidth must be wider than the HP 3048A system bandwidth.

- System Spectrum Analyzer Connection Port: HP 11848A

### Step 3 - Start a new measurement

Connect the sources when the software pause at the connection diagram. Set the reference source output as follows:

- Frequency: Same as downconverter's IF.
- Amplitude: +16 dBm

Now look at the HP 70427A's MMS display. If the message, **Enable and Adjust mixer bias:**, is displayed press the **70427A Parms** softkey on the HP 3048A controller. Move the cursor to the **mm Band Mixer Bias ON/OFF** line and select ON. Go to step 4.

#### Step 4 - Adjust mixer bias if necessary

If mixer bias was enabled in step 3 adjust the mixer bias current for maximum signal level from the harmonic mixer as measured at the downconverter's **IF** output.

1. Press the *70427A Params* softkey on the HP 3048A controller.
  - a. Connect a spectrum analyzer to the downconverter's **RF ANALYZER** output.
  - b. Move the cursor to the **Spectrum Analyzer view** line.
  - c. Select **IF** with the left/right arrow keys.
2. Set the downconverter's **IF** gain to 0 dB. This is to insure that the **IF** amplifier won't be driven into compression.
  - a. Move the cursor to the **IF Gain** line.
  - b. Select 0 dB with the left/right arrow keys.
3. If the DUT's output power is adjustable, set it for a harmonic mixer input level that is just below the point where the signal starts being compressed (as indicated by the RF spectrum analyzer).
4. Adjust mixer bias for a minimum **IF** signal measured by the spectrum analyzer.
  - a. Move the cursor to the **mm Band Mixer Bias** line.
  - b. Adjust the bias level with the Left/Right arrow keys.

Repeat these steps for maximum **IF** output measured on the RF spectrum analyzer.

#### Step 5 - Autorange the downconverter's IF gain

1. Press the *Done* softkey
2. Press the *Autorange downconverter* softkey.

#### Step 6 - Verify beatnote and proceed

If the reference source is under user control adjust its frequency, if necessary, to get a beatnote less than 5% of the peak tuning range. If the reference source is under system control it will be tuned automatically.

After the beatnote is within the limits the system asks for proceed with the measurement.

---

#### NOTE

---

When the downconverter is configured for mm operation don't apply a high-level microwave signal to the input. Change the mode back to  $\mu$ W and press the **INSTR PRESET** key. This will protect the **IF** amplifier from damage.

---

## AM Noise Measurement (Input AM Detector) System Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module with the HP 3048A Phase Noise Measurement System. The downconverter accepts a signal from 5 MHz to 26.5 GHz and produces a baseband signal.

This procedure can be used for all HP 3048A Phase Noise measurement software versions A.03.00 or later. The software can be configured for system control of the downconverter.

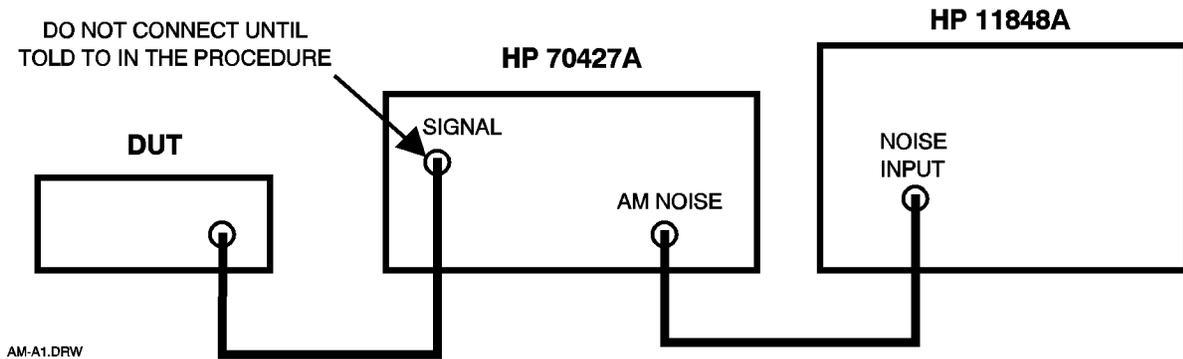


Figure 3-7 AM Noise Measurement (Input AM Detector) System Control Connection

### Procedure

#### Step 1 - Define the Measurement

Follow the instructions in the HP 3048A manual together with the information below:

1. System Configuration

Enter the downconverter in the system configuration table. Refer to chapter 1 in this manual for information on determining and setting the HP 70427A's HP-IB address.

2. Specify Measurement Type and Frequency Range

- Measurement type: AM Noise

3. Enter Source and Interface Parameters

- Carrier Frequency: DUT frequency.
- Detector/Discr. Input Frequency: DUT frequency

- Detector: HP 70427A Input AM Detector
4. Specify a Calibration Process
    - Phase Detector Constant: Derive from Double Sided Spur
    - Spur Amplitude: -26 dBc
    - Spur Frequency: 1 kHz
  5. Specify the Control of Signal Sources
    - AM Detector: HP 70427A, SYSTEM CONTROL
    - CAL source: HP 8662A, MANUAL CONTROL

#### **70727A Parm**

- Spectrum Analyzer View: None
- Auto/Manual Input Attenuation and IF Gain: AUTO
- Input Attenuation: determined by the system if AUTO is selected.
- AM Detector Maximum Level: system enters the default value.
- System Spectrum Analyzer Connection Port: HP 11848A

### **Step 2 - Begin a new measurement**

When the HP 3048A software pauses at the system connect diagram, connect the DUT to the downconverter's **SIGNAL** input and make any other connections shown that haven't been done yet.

Also, set the DUT power to + 10 dBm. The downconverter's AM detector is specified at an input level of + 10 dBm, but it will work with input levels as low as 0 dBm.

### **Step 3 - Autorange the downconverter**

Press the *DC AUTO RANGE* softkey on the HP 3048A controller.

This will trigger a one-time autoranging of the downconverter's input attenuator and IF gain.

#### Step 4 - Measure the AM detector's output voltage

The detector's output voltage is measured with the downconverter's internal voltmeter.

1. Read the **AM DET voltage:** display.
2. Press the HP 3048A *Update AM Det.* softkey.
3. Press the HP 3048A *Update AM Det.* softkey again.
4. Repeat from step 1 until the reading on the **AM Det voltage:** display doesn't change from one reading to the next.
5. Record the final reading for use in the next step.

#### Step 5 - Measure and adjust the calibration source power

Connect the calibration source's output to the downconverter's SIGNAL unput. Set the calibration as follows:

- Frequency:

IF DUT frequency is <500 MHz: Use the DUT frequency.

IF DUT frequency is >500 MHz: Use the 500 MHz (if the cal source can tune the DUT frequency use the DUT frequency).

- Power: +10 dBm
- Modulation: OFF

Adjust the calibration source power so that the voltage measured at the output AM detector is within  $\pm 5\%$  of what it was with the DUT connected to the downconverter.

1. Read the **AM DET voltage:** display.
2. Press the *READ AM DET* softkey.
3. Press the *READ AM DET* softkey again.
4. Repeat from step 1 above until the reading on the **AM Det voltage:** display doesn't change from one reading to the next.
5. If necessary, increment/decrement the calibration source's ouyput power.
6. Repeat steps 1 through 4 above to read the detector's output at the new power.
7. Repeat steps 1 through 5 above until the calibration source's detector voltage is within  $\pm 5\%$  of the DUT's detector voltage.

### **Step 6- Run the calibration**

Modulate the calibration source as follows:

- Type: AM
- Depth: 10%
- Frequency: 1 kHz

### **Step 7- Proceed with the measurement**

Re-connect the DUT to the downconverter's **SIGNAL** input and proceed with the measurement.

---

## AM Noise Measurement(IF AM Detector) System Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module with the HP 3048A Phase Noise Measurement System. The downconverter accepts a signal from 5 MHz to 26.5 GHz and produces a baseband signal as well as an IF output.

The downconverter's AM specifications only apply to the RF AM detector. The reason for choosing the IF AM detector for a noise measurement is that a lower-power carrier can be measured. The RF AM detector is limited to carrier levels greater than 0 dBm. With the IF AM detector, carrier levels down to -30 dBm can be measured because the signal is amplified by the IF amplifier before going to the IF AM detector.

The IF AM detector can also be used with the downconverter in mm mode (external harmonic mixer). To do this set up the downconverter for downconverting a mm wave signal as if for a phase noise measurement, then follow this procedure.

This procedure can be used for HP 3048A Phase Noise measurement software versions A.03.00 and later. The software can be configured for system control of the downconverter.

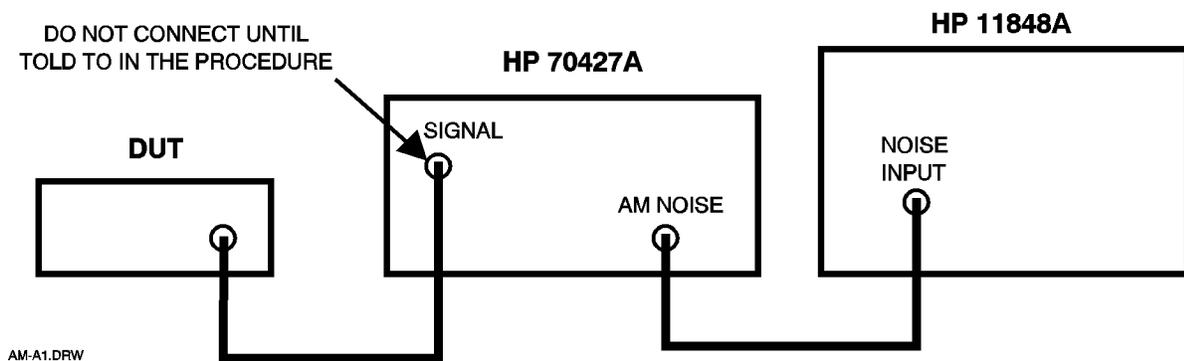


Figure 3-8 AM Noise measurement (IF AM Detector) System Control Connection

## Step 1 - Define the measurement

Follow the instructions in the HP 3048A manual along with the following information:

### 1. System Configuration

Enter the downconverter in the system configuration table. Refer to chapter 1 in this manual for information on determining and setting the HP 70427A's HP-IB address.

### 2. Specify Measurement Type and Frequency Range

- Measurement Type: AM Noise.
- 3. Enter Source and Interface Parameters
  - Carrier Frequency: DUT frequency.
  - Detector/Discr. Input Frequency: downconverter's IF frequency.

---

#### NOTE

---

To find the IF frequency, manually enter the carrier frequency into the HP 70427A. It will calculate and display the IF frequency.

- Detector - HP 70427A IF AM Detector.
- 4. Specify a Calibration Process
  - Phase Detector Constant: Derive from Double Sided Spur
  - Spur amplitude: -26 dBc
  - Spur frequency: 1 kHz
- 5. Specify the Control of Signal Sources

AM Detector: 70427A, SYSTEM CONTROL

CAL source: USERS DEVICE, MANUAL CONTROL.

### 70427A ParmS

Press the *70427A ParmS* softkey on the HP 70428A controller.

---

#### NOTE

---

The Up/Down arrow keys select the parameters, and the Left/Right arrow keys select the parameters value.

- Spectrum Analyzer View: IF
- Microwave/mm Band: select ( $\mu$ W) 0 - 26.5 if an external harmonic mixer is not being used, otherwise select the mm band of the external mixer.
- Auto/Manual Input Attenuation & IF Gain: AUTO

## AM Noise Measurement(IF AM Detector) System Control

- Input Attenuation: determined by the system if AUTO is selected above.
- IF Gain: determined by the system if AUTO is selected above.
- Mixer Maximum Level: system enters factory default value, -5 dBm.
- Tuning Sensitivity: system enters factory default value.
- LO Power: system enters factory default value.
- Auto/Manual LO Frequency Selection: AUTO
- LO Frequency: determined by the system.
- 100 MHz Ref. Chain PLL Bandwidth: system enters factory default value.
- 600 MHz Ref. Chain PLL Bandwidth: system enters factory default value.
- System Spectrum Analyzer Connection Port: HP 11848A

### Step 2 - Begin a new measurement

When the HP 3048A software pauses at the system connect diagram, connect the DUT to the downconverter's **SIGNAL** input and make any other connections shown that haven't been done yet.

### Step 3 - Autorange the downconverter

Press the *DC Auto Range* softkey on the HP 3048A controller.

This triggers a one-time autoranging of the downconverter's input attenuator.

### Step 4 - Measure the AM detector's output voltage

The detector's output voltage is measured with the downconverter's internal voltmeter.

1. Read the **AM DET voltage:** display.
2. Press the HP 3048A *Update AM Det.* softkey.
3. Press the HP 3048A *Update AM Det.* softkey again.
4. Repeat from step 1 above until the reading on the **AM Det Voltage:** display doesn't change from one reading to the next.
5. Record the final reading for use in the next step.

### Step 5 - Measure and adjust the calibration source power

Connect the calibration source's output to the downconverter's **SIGNAL** input.

Set up the calibration source as follows:

- Frequency: Use the DUT frequency.

- Power: Same as DUT power.
- Modulation: OFF

Adjust the calibration source power so that the voltage measured at the output AM detector is within  $\pm 5\%$  of what it was with the DUT connected to the downconverter.

1. Read the **AM DET voltage:** display.
2. Press the **READ AM DET** softkey.
3. Press the **READ AM DET** softkey again.
4. Repeat from step 1 above until the reading on the **AM Det voltage:** display doesn't change from one reading to the next.
5. If necessary, increment/decrement the calibration source's output power.
6. Repeat steps 1 through 4 above to read the detector's output at the new power.
7. Repeat steps 1 through 5 above until the calibration source's detector voltage is within  $\pm 5\%$  of the DUT's detector voltage.

### **Step 6 - Run the calibration**

Modulate the calibration source as follows:

- Type: AM
- Depth: 10%
- Frequency: 1 kHz

### **Step 7 - Proceed with the measurement**

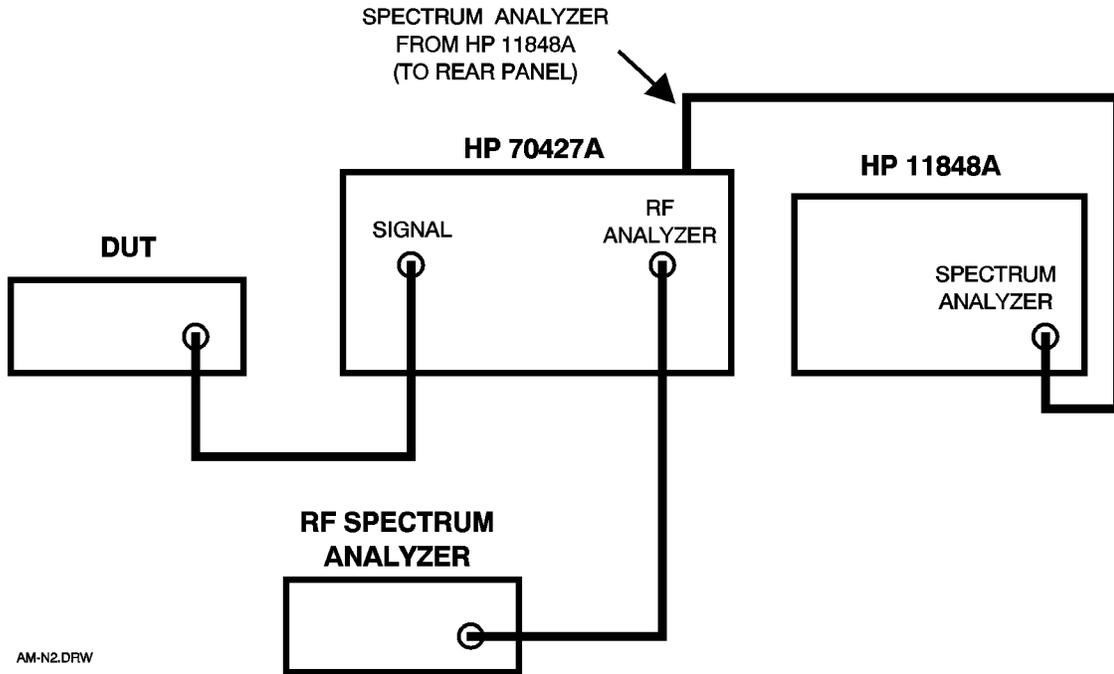
Re-connect the DUT to the downconverter's **SIGNAL** input and proceed with the measurement.

---

## Spectrum Analyzer Connection User Control

### Overview

This procedure describes how to use a supported RF analyzer for both the HP 3048A and to view the HP 70427A's input and IF without re-cabling.



**Figure 3-9** *Spectrum Analyzer Connection User Control*

With the RF spectrum analyzer and the HP 11848A connected to the downconverter as shown above, the downconverter's input or IF can be routed to the RF spectrum analyzer, or the HP 11848A RF analyzer output can be routed to the RF spectrum analyzer.

This procedure can be used for all HP 3048A software versions. The downconverter is controlled manually.

At the connection diagram, the RF spectrum analyzer can be routed to view the HP 3048A beat note or the downconverter's input signal or IF output.

---

### NOTE

The view must be set to - to route the RF spectrum analyzer to the HP 3048A before proceeding with the measurement. See step 4 on the next page.

## Procedure

### Step 1 - Start a new measurement

- Use *New Measurement* softkey to reach the connect diagram for the defined measurement.

When the software pauses at the connect diagram go to step 2 below.

### Step 2 - Access the *VIEW IN|IF|* softkey.

1. From the Downconverter screen, press the *Amplitudes* softkey.
2. From the AM Noise screen, the *VIEW IN | IF | -* is displayed when the *AM Noise* softkey is pressed.

### Step 3 - Select the spectrum analyzer connection

1. Press the *VIEW IN|IF|* softkey until the IN is underlined.
  - a. The downconverter's input signal is routed to the RF spectrum analyzer after it passes through the input attenuator. It does not go to the mixer or **IF** output.
2. Press the *VIEW IN|IF|* softkey until the IF is underlined.
  - a. A sample of the downconverter's **IF** output is routed to the RF spectrum analyzer. The downconverter operates normally.
3. Press the *HP 11848A* softkey until the - is underlined.
  - a. The spectrum analyzer signal from the HP 11848A is routed to the RF spectrum analyzer (if the HP 11848A's **SPECTRUM ANALYZER** output is connected to the downconverter's rear-panel **SPECTRUM ANALYZER FROM HP 11848A** connector). With this selection the HP 3048A beatnote can be monitored.

### Step 4 - Route the RF spectrum analyzer for measurement

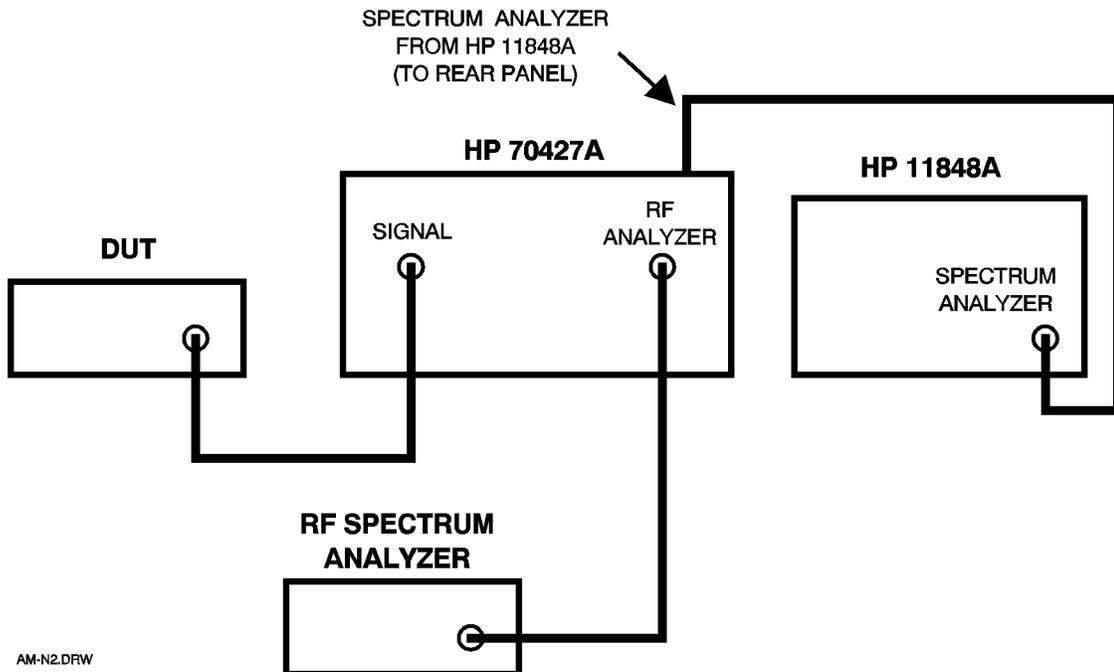
1. Press the *VIEW IN|IF|* softkey until - is underlined.
2. Proceed with the measurement.

---

## Spectrum Analyzer Connection System Control

### Overview

This procedure describes how to use the HP 70427A Downconverter Module to route signals to the HP 3048A Phase Noise Measurement system's RF spectrum analyzer.



*Figure 3-10 Spectrum Analyzer Connection - System Control*

With the RF spectrum analyzer and the HP 11848A connected to the downconverter as shown above, the downconverter's input or IF can be routed to the RF spectrum analyzer, or the HP 11848A can be routed to the RF spectrum analyzer.

This procedure can be used for HP 3048A software versions A.03.00. The software can be configured for system control of the downconverter.

---

### NOTE

This procedure assumes that the HP 3048A software has already been configured for a phase noise using a phase-lock-loop measurement or an AM noise measurement with the HP 70427A under system control.

## Procedure

### Step 1 - Change the HP 70427A Parameters

- a. Press the *Source Control* softkey.
- b. Press the *70427A Parms* softkey.

Move the cursor to the **System Spectrum Analyzer Connection Port** line and select HP 70427A.

### Step 2 - Begin Measurement

The HP 3048A software will connect the RF spectrum analyzer to the appropriate signals throughout the measurement. When the software pauses as the connect diagram, the beatnote will be displayed.

### Step 3 - To manually switch the RF spectrum analyzer connection

The RF spectrum analyzer view can be selected from the connect diagram.

1. When the software pauses at the connect diagram, access the **HP 70472 PARAMETERS** screen by pressing the *70427A Parms* softkey.
2. Move the cursor to the **spectrum Analyzer View** line and select the RF spectrum analyzer as follows:
  - a. Downconverter input: select **INPUT**

The downconverter's input signal is routed to the RF spectrum analyzer after it passes through the input attenuator. It does not go to the mixer or IF output.

- b. Downconverter IF: select **IF**

A sample of the downconverter's IF output is routed to the RF spectrum analyzer. The downconverter operates normally.

- c. HP 11848A: select **None**

The spectrum analyzer signal from the HP 11848A is routed to the RF spectrum analyzer (if the HP 11848A's **SPECTRUM ANALYZER** output is connected to the downconverter's rear-panel **SPECTRUM ANALYZER FROM HP 11848A** connector).

Proceed with the measurement. The software will resume control of the RF spectrum analyzer connection.

Downconverter Operation  
**Spectrum Analyzer Connection System Control**

# 4

---

## Source Operation

### Overview

This chapter consists of a procedure for using the HP 70428A Microwave Source Module (or HP 70427A or HP 70428A Option 002 in source mode) as the reference source for microwave phase noise measurements.

The following is a list of considerations for using the HP 70428A in any application:

- **Power accuracy:** Measure output power with a power meter if accuracy is important. The HP 70428A's output power is nominally set but is not calibrated.
- **Harmonics:** Use a low-pass filter at the HP 70428A's output if the application requires that harmonics be lower than  $-10$  dBc.
- **Broadband noise-floor:** Use a bandpass filter at the HP 70428A's output if the application requires extremely low noise at offsets greater than 100 MHz.

## Phase Noise Measurement With PLL

### Overview

This procedure describes how to use the HP 70428A Microwave Source Module as the reference source for phase noise measurements using a phase lock loop. The  $\mu\text{W LO}$  output of the HP 70427A Microwave Downconverter Module and the HP 70428A Microwave Source Module Option 002 (Tunable Source) can also be used as a microwave source.

The microwave source can output a signal between 2.4 GHz and 26.4 GHz in 600 MHz steps. The output power can be at least +16 dBm at frequencies below 6.6 GHz and at least +10 dBm at frequencies up to 25.8 GHz.

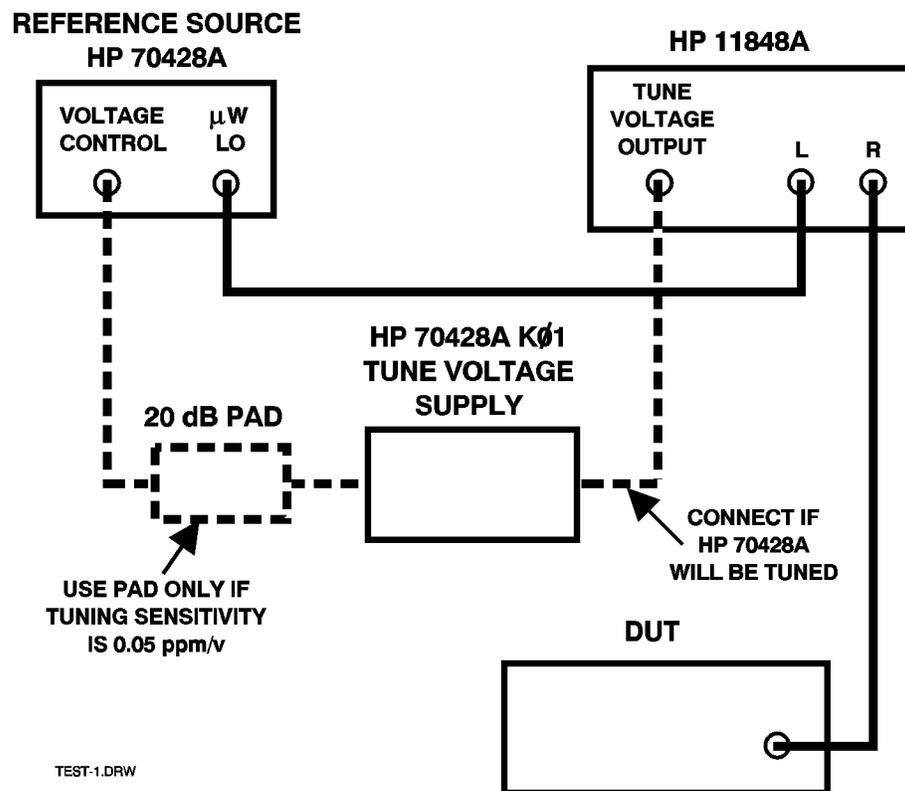


Figure 4-1 Phase Noise Measurement with PLL Test One

### Procedure

This procedure can be used for all HP 3048A software versions. The microwave source is not supported by any version of HP 3048A software; therefore, it must be controlled manually.

The HP 3048A system must be equipped with option 201 which adds a 1.2 GHz to 18 GHz phase detector to the HP 11848A. For measurements above 18 GHz, the HP 3048A system must also include option H26.

### Step 1 - Preset the HP 70428A

First, make sure the module's **ACT** indicator is lit. If it isn't, do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey, repeatedly if necessary, until the **ACT** indicator lights.

Then, press the **INSTR PRESET** key.

If the module is an HP 70427A or HP 70428A Option 002 press the **Source** softkey to put it in source mode.

### Step 2 - Enter HP 70428A frequency and power

1. Set the HP 70428A to the DUT frequency. The HP 70428A's frequency is set in 600 MHz steps, so the DUT must be at a frequency to which it can be set.
  - a. Press the **Output** softkey.
  - b. Press the **FREQ** softkey.
  - c. Enter the frequency with the numeric keypad.
  - d. Press the **GHz**, **MHz**, **kHz**, or **Hz** softkey to complete the entry.
2. Enter a power of +10 dBm.
  - a. Press the **Output** softkey.
  - b. Press the **POWER** softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the **dBm** softkey to complete the entry.

### Step 3 - Decide which instrument to tune

Either the DUT or the HP 70428A must be the VCO. If the DUT is the VCO go to step 6 below.

### Step 4 - Select HP 70428A tuning sensitivity

Do this only if the HP 70428A is being tuned. First, determine which sensitivity to use as described below:

The HP 70428A's tuning must be selected so that its tuning range will be greater than the expected drift of the DUT. The left column of the following table shows the choices.

Noise performance depends on tuning sensitivity so it may be necessary to trade off noise performance for tuning range. Refer to the specification table in chapter 9 for noise performance for each tuning sensitivity.

When the 0.05 ppm/V tuning sensitivity is used, a 10 dB pad must be inserted in the tune line between the HP 11848A's **TUNE VOLTAGE OUTPUT** connector and the HP 70428A K01 Tune Voltage Supply. This forces the system to select a phase lock loop bandwidth that is much less than the 100 MHz PLL bandwidth of 126 Hz in the HP 70428A's reference chain.

**Table 4-1 Tuning Sensitivity**

Source Tuning Sensitivity	DUT Max Drift	DUT Freq accuracy
.05 ppm/V	$2 \times 10^{-9}$	$2 \times 10^{-7}$
1 ppm/V	1 ppm	5 ppm
20 ppm/V	20 ppm	60 ppm

The middle and right columns of the above table show how the frequency accuracy and drift characteristics of the DUT determine which tuning sensitivity to select. These two columns of the table are described below:

#### **DUT Max Drift**

This column shows how much the DUT frequency can drift and still be tracked by the HP 70428A.

#### **DUT Freq Accuracy**

This column shows how close the DUT must be to the nominal frequency of the HP 70428A in order to be sure that its frequency can be pulled to the DUT frequency during a measurement. The accuracy value takes into account the full tuning range of the HP 70428A plus its absolute accuracy.

Then, enter the tuning sensitivity as follows:

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Press the *0.05 ppm/V*, *1.0 ppm/V*, or *20 ppm/V* softkey.

#### **Step 5 - Change the source's PLL bandwidths if needed**

The only reason to use anything other than the default bandwidths is if the source is being tuned using the 0.05 ppm/V or 1.0 ppm/V tuning sensitivity and the HP 3048A system PLL bandwidth is not much less than the HP 70428A's default bandwidths. The following table shows reference chain configuration and default bandwidths for each tuning sensitivity.

**Table 4-2 HP 700428A Reference Chain Parameters**

Tune Sens	Osc. Tuned	PLL	Default PLL BW
0.05 ppm/V	10 MHz	100 MHz	126 Hz
1.0 ppm/V	100 MHz	600 MHz	10 kHz
20 ppm/V	600 MHz	none	n/a

Loop suppression cannot be calculated accurately if the HP 3048A PLL bandwidth approaches the bandwidth of the narrowest HP 70428A PLL bandwidth. The narrowest HP 70428A PLL bandwidth should be at least 5 times greater than the HP 3048A system bandwidth.

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**NOTE**

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Increasing the HP 70428A's 100 MHz PLL bandwidth or 600 MHz PLL bandwidth will degrade phase noise at some offsets.

Enter the bandwidth as follows:

1. Press the *Ref Chain* softkey.
2. Press the *100 MHz PLL BW* or the *600 MHz PLL BW* softkey.
3. Press the appropriate bandwidth softkey.

**Step 6 - Define the measurement**

Follow the instructions in the HP 3048A manual together with the information below.

**Specify Measurement Type and Frequency Range**

- Measurement Type: Phase Noise Using a Phase Lock Loop

**Enter Source and Interface Parameters**

- Carrier Frequency: DUT's output frequency.
- Detector/Discr. Input Frequency: DUT's output frequency.
- VCO Tuning Constant: *See table below.*
- Center Voltage of VCO Tuning Curve: 0V
- Voltage Tuning Range of VCO: *See table below.*
- VCO Tune-port Input Resistance: 1 M $\Omega$
- Phase Detector: Internal Phase Detector - 1.2 GHz to 18 GHz

**Table 4-3** *VCO Tuning Constant and Range vs. HP 70428A Tuning Sensitivity*

Tune Sens	Tuning Constant	Tuning Range
.05 ppm/V	$0.15 \times 10^{-6} \times \text{Carrier Freq}$	0.2 V
1.0 ppm/V	$10^{-6} \times \text{Carrier Freq}$	5V
20 ppm/V	$2 \times 10^{-5} \times \text{Carrier Freq}$	5V

### **Specify a Calibration Process**

- Determining PHASE DETECTOR CONSTANT: Measure the Detector Constant.
- Determining VCO TUNING CONSTANT: Measure the VCO Tuning Constant.

### **Specify the Control of Signal Sources**

- DUT: USER'S SOURCE, MANUAL CONTROL
- REF SOURCE: USER'S SOURCE, MANUAL CONTROL

### **Step 7 - Start a new measurement**

If the HP 70428A K01 Tune Voltage Supply is being used, adjust the pot for minimum, and turn it on at this time.

### **Step 8 - Verify beatnote and proceed**

If the HP 70428A is being tuned use the HP 70428A K01 to adjust its frequency for a beatnote within 5% of the peak tuning range.

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#### **NOTE**

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The HP 70428A K01 consists of a 9 V battery and a ten-turn pot.

# 5

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## Tunable Source Operation

### Overview

This chapter describes the procedure for using the HP 70428A Option 002 Microwave Source (Tunable Source) as the reference source for microwave phase noise measurements.

The following is a list of considerations for using the HP 70428A Option 002 in any application:

- **Power accuracy:** Measure output power with a power meter if accuracy is important. The HP 70428A Option 002's output power is nominally set but is not calibrated.
- **Harmonics:** Use a low-pass filter at the HP 70428A Option 002's output if the application requires that harmonics be lower than  $-10$  dBc.
- **Broadband noise-floor:** Use a bandpass filter at the HP 70428A Option 002's output if the application requires extremely low noise at offsets greater than 100 MHz.

## Phase Noise Measurement With PLL

### Procedure

This procedure describes how to use the HP 70428A Option 002 Microwave Source Module (Tunable Source) as the reference source for phase noise measurements using a phase lock loop.

The microwave source can output a signal between 2.4 GHz and 26.5 GHz in 0.1 Hz steps (see the HP 8662/3A specifications). The output power can be at least +16 dBm at frequencies below 6.6 GHz and at least +10 dBm at frequencies up to 25.8 GHz.

This procedure can be used for all HP 3048A software versions.

The HP 70428A Option 002 is not supported by any version of HP 3048A software; therefore, it must be controlled manually.

The HP 3048A system must be equipped with option 201 which adds a 1.2 GHz to 18 GHz phase detector to the HP 11848A. For measurements above 18 GHz, the HP 3048A system must also include option H26.

### Step 1 - Preset the HP 70428A Option 002

First, make sure the module's **ACT** indicator is lit. If it isn't, do the following:

1. Press the **DISPLAY** key.
2. Press the **NEXT INSTR** softkey, repeatedly if necessary, until the **ACT** indicator lights.
3. Then, press the **INSTRPRESET** key.

### Step 2 - Configure the HP 70428A Option 002

1. Connect the HP 8662/3A:
  - a. Connect an HP-IB cable between the signal generator and the MMS mainframe that the HP 70428A Option 002 is installed in.

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### NOTE

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The HP 70428A Option 002 acts as a controller. There must be no other controller connected to the bus.

- b. Connect an RF cable between the HP 8662/3A's **RF OUTPUT** and the HP 70428A Option 002's HP 8662A connector.

2. Select the Signal generator type
  - a. Press the *Service* softkey.
  - b. Press the *Misc* softkey.
  - c. Press the *RF Source* softkey.
  - d. Press the *HP 8662A* or *HP 8663A* softkey.
  - e. Press the *EXIT* softkey.
3. Enter the HP 8662/3A's HP-IB address:
  - a. Press the *HP-IB ADDRESS* softkey.
  - b. Enter the last two digits of the signal generator's HP-IB address with the numeric keypad.
  - c. Press the *ENTER* softkey.

### **Step 3 - Enter HP 70428A Option 002 frequency and power**

1. Set the HP 70428A Option 002 to the DUT frequency.
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT FREQ* softkey.
  - c. Enter the frequency with the numeric keypad
  - d. Press the *GHz*, *MHz*, *kHz*, or *Hz* softkey to complete the entry.
2. Enter a power of +10 dBm.
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT POWER* softkey.
  - c. Enter 10 with the numeric keypad.
    - a. Press the *dBm* softkey to complete the entry.

### **Step 4 - Decide which instrument to tune**

Either the DUT, the HP 70428A Option 002, or the HP 8662/3A can be the VCO.

### **Tuning the DUT**

Refer to the Signal Source Applications chapter of the HP 3048A manual for information on tuning the DUT.

If the DUT is the VCO go to step 7 below.

### Tuning the HP 8662A/3A

If the DUT is referenced to an oven stabilized oscillator, the HP 8662A/3A can be tuned. Connect the tune line to the EFC input. The limitation is that the HP 8662A/3A's EFC can only track a drift of  $10^{-8}$  of the output frequency from the downconverter.

The HP 8662A/3A can also be tuned by setting modulation to DC FM, but phase noise for offsets <10 kHz will be degraded. Refer to the HP 3048A manual for more information on tuning the HP 8662A/3A.

If the HP 3662/3A is the VCO go to step 7 below.

### Tuning the HP 70428A Option 002

The HP 70428A Option 002 has several tuning sensitivities. The choices are:

- 0.05 ppm/V: Use this sensitivity if the DUT is locked to a crystal-controlled, temperature-stabilized reference.
- 1.0 ppm/V: Use this sensitivity if the DUT is referenced to an ambient temperature crystal oscillator. (600 MHz PLL bandwidth must be greater than HP 3048A PLL bandwidth)
- 20 ppm/V: Use this sensitivity if the 1.0 ppm/V sensitivity does not provide adequate drift tracking.

Noise performance depends on tuning sensitivity so it may be necessary to trade off noise performance for tuning range. Refer to the specification table in chapter 9 for noise performance for each tuning sensitivity.

### Step 5 - Select HP 70428A Option 002 tuning sensitivity

Do this only if the HP 70428A Option 002 is being tuned.

First determine which sensitivity to use as described below:

The HP 70428A Option 002 tuning sensitivity must be selected so that its tuning range will be greater than the expected drift to the DUT. The left column of the following table shows the choices.

Noise performance depends on tuning sensitivity so it may be necessary to trade off noise performance for tuning range. Refer to the specification table in chapter 9 for noise performance for each tuning sensitivity.

When the 0.05 ppm/V tuning sensitivity is used, a 10 dB pad must be inserted in the tune line between HP 70428A **TUNE VOLTAGE OUTPUT** connector and the HP 70428A Option 002's **VOLTAGE CONTROL** input. This forces the system to select a phase-lock-loop bandwidth that is much less than 100 MHz PLL bandwidth of 126 Hz in the HP 70428A Option 002's reference chain.

**Table 5-1 Tuning Sensitivity**

Source Tuning Sensitivity	DUT Max Drift
.05 ppm/V	$2 \times 10^{-9}$
1 ppm/V	1 ppm
20 ppm/V	20 ppm

The DUT max drift column of the table shows how much the DUT frequency can drift and be tracked by the HP 70428A Option 002.

If the HP 70428A Option 002 frequency is within  $\pm 10$  MHz of the DUT frequency, the HP 70428A Option 002 can be tuned by stepping the frequency of the HP 8662/3A. If the HP 8662/3A frequency must be changed more than 10 MHz in order to get the HP 70428A Option 002's frequency close enough to the DUT frequency, press the **RETUNE YTF** softkey to re-peak the HP 70428A Option 002's Yig-Tuned-Filter.

Enter the tuning sensitivity as follows:

1. Press the **Ref Chain** softkey.
2. Press the **Tune Sens** softkey.
3. Press the **0.05 ppm/V**, **1.0 ppm/V**, or **20 ppm/V** softkey.

### Step - 6 Change the source's PLL bandwidths if needed

A change in one of the default bandwidths is necessary if the source is being tuned using the 0.05 ppm/V or 1.0 ppm/V tuning sensitivity and the HP 3048A system PLL bandwidth is not much less than the HP 70428A Option 002's default bandwidths. The following table shows reference chain configuration and default bandwidths for each tuning sensitivity.

**Table 5-2 HP 70428A Option 002 Reference Chain Parameters**

Tune Sens	Osc. Tuned	PLL	Default PLL BW
0.05 ppm/V	10 MHz	100 MHz	126 Hz
1.0 ppm/V	100 MHz	600 MHz	10 kHz
20 ppm/V	600 MHz	none	n/a

---

**NOTE**

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To determine HP 3048A PLL bandwidth see the *HP 3048A Reference Manual*

Loop suppression cannot be calculated accurately if the HP 3048A PLL bandwidth approaches the bandwidth of the narrowest HP 70428A Option 002 PLL bandwidth in use. The narrowest HP 70428A Option 002 PLL bandwidth should be at least 5 times greater than the HP 3048A system bandwidth.

Note that increasing the HP 70428A Option 002's 100 MHz PLL bandwidth or 600 MHz PLL bandwidth will degrade phase noise at some offsets.

Enter the bandwidth as follows:

1. Press the *Ref Chain* softkey.
2. Press the *100 MHz PLL BW* or the *600 MHz PLL BW* softkey.
3. Press the appropriate bandwidth softkey.

### Step 7 - Define the measurement

Follow the instructions in the HP 3048A manual together with the information below.

#### Specify Measurement Type and Frequency Range

- Measurement Type: Phase Noise Using a Phase Lock Loop

#### Enter Source and Interface Parameters

- Carrier Frequency: DUT's output frequency.
- Detector/Discr. Input Frequency: DUT's output frequency.
- VCO Tuning Constant: *See table below.*
- Center Voltage of VCO Tuning Curve: 0V
- Voltage Tuning Range of VCO: *See table below.*
- VCO Tune-port Input Resistance: 1 M $\Omega$
- Phase Detector: Internal Phase Detector - 1.2 GHz to 18 GHz

**Table 5-3** *VCO Tuning Constant and Range vs. HP 70428A Tuning Sensitivity*

Source Tuning Sensitivity	Tuning Constant	Tuning Range
.05 ppm/V	$0.05 \times 10^{-6} \times \text{Carrier Freq}$	0.2 V
1 ppm/V	$10^{-6} \times \text{Carrier Freq}$	5V
20 ppm/V	$2 \times 10^{-5} \times \text{Carrier Freq}$	5V

### **Specify a Calibration Process**

- Determining PHASE DETECTOR CONSTANT: Measure the Detector Constant.
- Determining VCO TUNING CONSTANT: Measure the VCO Tuning Constant.
- PLL suppression: The computed PLL suppression WILL be verified.

### **Specify the Control of Signal Sources**

- DUT: USER'S SOURCE, MANUAL CONTROL
- REF SOURCE: USER'S SOURCE, MANUAL CONTROL

### **Step 8 - Start a new measurement**

Connect the sources when the software pauses at the connection diagram.

### **Step 9 - Verify beatnote and proceed**

Adjust the HP 8662/3A's frequency, if necessary, to get a beatnote less than 5% of the peak tune range ( $\text{VCO Tuning Constant} \times \text{Voltage Tuning Range of VCO}$ ).

After the beatnote is within the limits the system asks for, proceed with the measurement.

Tunable Source Operation  
**Phase Noise Measurement With PLL**

# 6

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## Reference Chain Configuration

### Overview

All three modules use the same reference chain. In the HP 70427A Microwave Downconverter the reference chain is the local oscillator. With the HP 70428A Microwave Source the reference chain is the source, likewise with the HP 70427A and HP 70428A Option 002 in source mode. In the HP 70428A Option 002 Microwave Source the reference chain generates a local oscillator signal that is used to upconvert the output of an HP 8662A/3A Signal Generator.

The reference chain consists of three oscillators: 10 MHz reference, 100 MHz, and 600 MHz. The chain can be configured with all three oscillators locked together, the 600 MHz oscillator locked to the 100 MHz oscillator, or the 600 MHz oscillator free-running. All of the configurations can be tuned externally. Also, the bandwidths of the 100 MHz and 600 MHz phase-lock-loops can be selected from a menu.

## To Select Tuning Sensitivity

**Step 1 - Determine the appropriate sensitivity**

**Step 2 - Decide whether to use external tuning**

**Step 3 - Enter the tuning sensitivity**

1. Press the *Ref Chain* softkey.
2. Press the *Tune Sens* softkey.
3. Press the softkey corresponding to the sensitivity chosen above.

## To Select Phase-lock-loop Bandwidth

### Step 1 - Determine the appropriate bandwidth

### Step 2 - Enter the bandwidth

1. Press the *Ref Chain* softkey.
2. Press either the *100 MHz PLL BW* or *600 MHz PLL BW* softkey.
3. Press the softkey that corresponds to the bandwidth selected above.

## To Select Noise Performance

The bias level of the amplifier at the reference chain's output can be selected to optimize noise-floor or spurious performance.

### **Step 1 - Determine the appropriate mode**

### **Step 2 - Enter the mode**

1. Press the *Service* softkey.
2. Press the *Misc* softkey.
3. Press the *Power Control* softkey.
4. Press either the *LowNoise* or *Linear* softkey.

# 7

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## Remote Programming

### Overview

This chapter provides instructions and examples for programming the HP 7042XA series of instruments over the Hewlett-Packard Interface Bus (HP-IB). Remote operation is controlled with commands that largely correspond to front panel key functions.

Programming the HP 70427A , HP 70428A , and functions other than frequency for the HP 70428A Option 002 is straight forward. Simple examples are given in chapter 2 - *Getting Started* and more detailed examples are given at the end of this chapter. Programming of the status reporting system is complex, but included in this chapter is an explanation of the system and a detailed program example. Program codes for all functions are listed in chapter 12 - *Remote Commands* .

## Command guidelines

The following topics discuss rules and guidelines that must be followed when operating the HP 7042XA series of the instruments using HP-IB.

### Command name syntax

Commands are not case sensitive providing the same case is used throughout the command. Also, commands names of >4 characters can use a specified abbreviated form (a complete list of the commands in their abbreviated form can be found in chapter 12 - *Remote Commands* ). For example, to set an output frequency, any of the following commands could be used:

- SRC:OUTPUT:FREQUENCY 2.4GHZ
- SRC:OUT:FREQ 2.4GHZ
- src:output:frequency 2.4ghz
- src:out:freq 2.4ghz

### Command Punctuation

#### Language Considerations

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#### NOTE

The punctuation for the HP-IB commands conforms to the IEEE 488.2. It is possible a given programming language may not accept some of the punctuation used in the BASIC examples. It is therefore necessary to have an understanding of the punctuation of the language being used for HP-IB operation.

#### Using Spaces

When changing a field setting, a space must always precede the setting value in the command (command <space> value), regardless of field type. For example:

- SRC:OUT:FREQ<space>2.4GHZ
- DC:AMPL:INP:ATT<space>MAX

#### Using colons to separate commands

HP-IB command syntax is arranged by a control hierarchy that is comparable to manual operation.

When the instrument is set using front panel controls, the main screen is accessed, the desired function is selected, and then the appropriate setting is made. The HP-IB commands are used the same way. For example, the

HP 70427A front panel controls to do downconvert a 10 GHz signal are *Freqs INPUT FREQ 10 GHz*. The corresponding HP-IB command is:

- `DC:FREQ:INP 10GHZ`

### Using semicolons for multiple commands

Multiple commands can be used in one program line by separating the commands with a semicolon (;). The semicolon tells the HP 7042XA to back up one level of hierarchy and accept the next command at the same level as the previous command. For example, to set the HP 70428A to 2.4 GHz at +10 dBm on one command line, the command would be:

- `SRC:OUT:FREQ 2.4GHZ;POW 10DBM`

A semicolon followed by a colon (;:) tells the HP 7042XA that the next command is at the top level of the command hierarchy. The example below sets the HP 7042XA to downconvert a 2.4 GHz signal with its input attenuator and IF amplifier autoranged.

- `DC:FREQ:INP 2.4GHZ;:DC:AMPL:AUTO`

### Using question marks to query

The question mark (?) is used to query (read-back) an instrument setting or measured value, and is entered immediately after a command. Queried information must be read into a variable before it can be displayed, printed, or used as a numeric value in a program.

Queried information is returned in the same format used to set the value (a queried numeric entry function returns numeric data; quoted string functions return quoted string information). To return an HP 7042XA's manufacturer, instrument type, serial number and firmware date code, the commands in BASIC would be:

- `OUTPUT 728;"*IDN?"`
- `ENTER 727;Id$`
- `PRINT Id$`

## HP 7042XA error reporting

The types of errors reported are generally the same errors encountered using manual control. These include problems with the HP 7042XA hardware and executing or attempting to execute an improper command.

Error messages are read-back using the System Error query and then entering the returned value into a string variable. The following should be considered when reading error messages.

- DIMension the variable for  $\leq 255$  characters
- Error messages are stored in a first-in-first-out (**FIFO**) block of memory
- Each message contains a number and a quoted string description
- Reading an error message removes it from memory
- Once an event has generated an error message, any additional, identical event will not produce any additional error messages until the original message has been removed from memory.

## **HP 7042XA Status Reporting**

The Status Byte is an 8-bit register that can be used to alert the operator to certain hardware conditions in the HP 7042XA . Each binary-weighted bit corresponds to other registers or message queues that monitor specific instrument conditions.

When a condition change occurs in any of these registers, the corresponding bit in the Status Byte is 'asserted' (turned on), causing a service request (SRQ) if enabled. Querying the contents of the affected status register(s) allows you to read-back the condition that caused the service request.

### **Level of Information**

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#### **NOTE**

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The following information is specific to the HP 7042XA 's status structures and commands, and is not meant as a complete tutorial on status reporting over HP-IB. For more detailed information on status reporting, refer to the IEEE 488.1 and IEEE 488.2 standards, or the *Tutorial Description of the Hewlett-Packard Interface Bus*, HP P/N 5952-0156.

Refer to the IEEE 488.2 *Common Commands* in chapter 12 for more information on the commands used with the Status Byte.

# Status Byte Reporting Structure

## STATUS BYTE REPORTING STRUCTURE

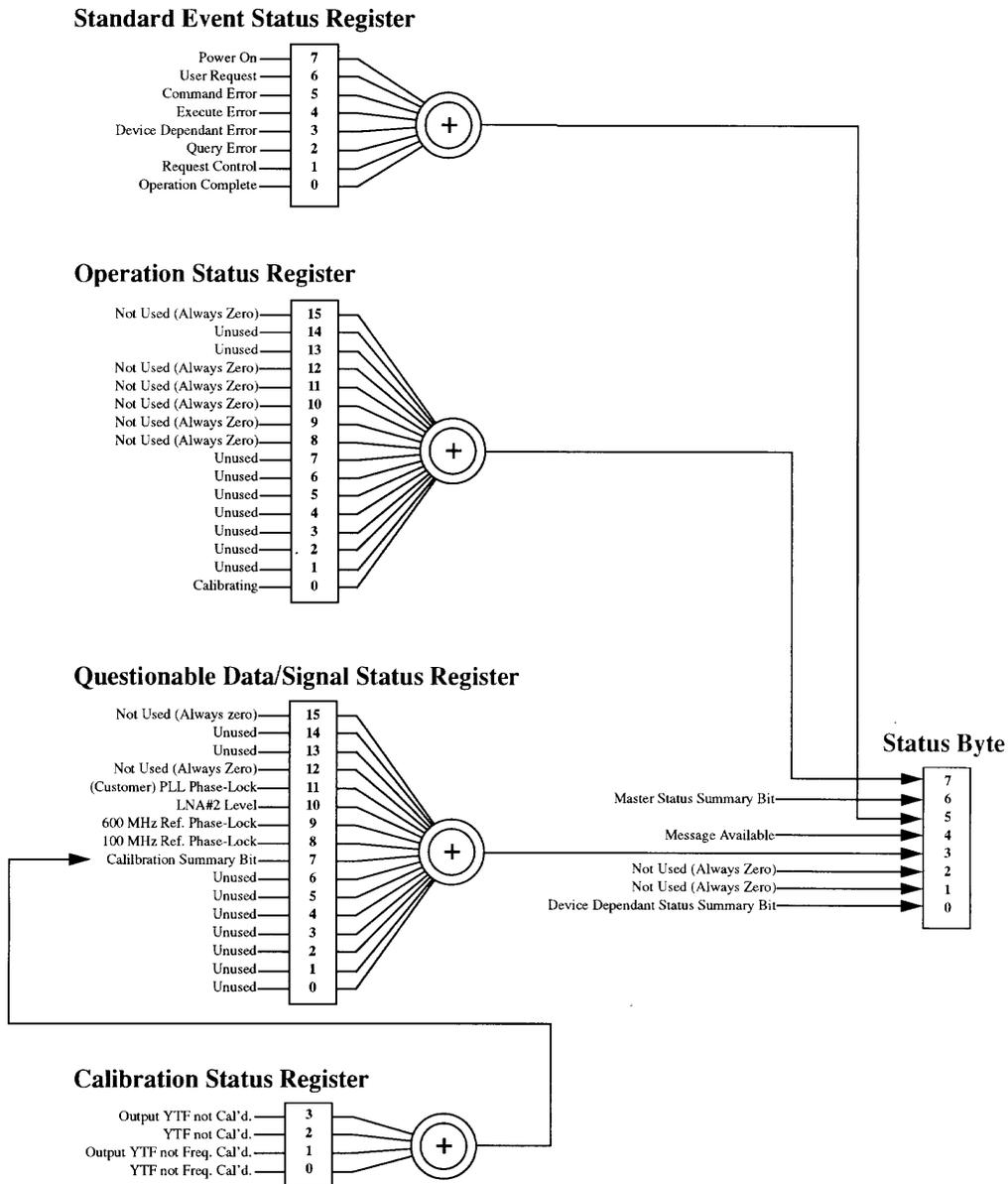


Figure 7-1 Status Byte Reporting Structure Illustration

## Enabling the Status Byte

The sum of the binary-weighted values for each desired register are used with the \*SRE command to specify what register(s) can cause a service request (SRQ). The RQS bit (6) is always enabled, but can not be asserted unless one or more other register or queue summary bits are enabled.

The following example sets the Status Byte to allow the Standard Event Status Register and Output Queue summary bits to cause a service request:

```
OUTPUT 728;"*SRE 48"
```

### Reading the Status Byte Enable Setting

Use the query form (\*SRE?) to read-back the current enable setting of the Status Byte. Example -

```
OUTPUT 728;"*SRE?"
```

Since you cannot set bit 6 (RQS), the returned value will be in the range of 0 to 63, or 128 to 191.

### Reading The Status Byte

The \*STB? Common Command reads the value of the Status Byte. If the returned value is >0, a Service Request has been asserted by one or more registers you have enabled.

Syntax- \*STB?

Example- OUTPUT 728;"\*STB?"

You can also use a Serial Poll to query the Status Byte value: SPOLL(728)

### Defining the Service Request Settings

Use the following sequence to define what conditions you want to allow a service request (assert bit 6 of the Status Byte).

1. From all of the status registers and queues, decide what condition(s) you want to cause a service request.
2. Enable the corresponding status register bits for those conditions.
3. Enable the Status Byte to allow the desired register(s) and queues to cause a service request.

**Register and Queue  
 Contents**

**Operational Status Register**

*Table 7-1 Operational Status Register (Status Bit 7)*

Bit Number	Binary Weighing	Condition
15	32768	Not Used (Always 0)
14	16384	Unused in HP 7042XA
13	8192	Unused in HP 7042XA
12	4096	Not used (Always 0)
11	2048	Not Used (Always 0)
10	1024	Not Used (Always 0)
9	512	Not Used (Always 0)
8	256	Not Used (Always 0)
7	128	Unused in HP 7042XA
6	64	Unused in HP 7042XA
5	32	Unused in HP 7042XA
4	16	Unused in HP 7042XA
3	8	Unused in HP 7042XA
2	4	Unused in HP 7042XA
1	2	Unused in HP 7042XA
0	1	Calibrating

## Standard Event Status Register

*Table 7-2 Standard Event Status Register (Status Bit 5)*

Bit Number	Binary Weighing	Function
15	32768	Not Used (Always 0)
14	16384	Reserved by IEEE 488.2 (Always 0)
13	8192	Reserved by IEEE 488.2 (Always 0)
12	4096	Reserved by IEEE 488.2 (Always 0)
11	2048	Reserved by IEEE 488.2 (Always 0)
10	1024	Reserved by IEEE 488.2 (Always 0)
9	512	Reserved by IEEE 488.2 (Always 0)
8	256	Reserved by IEEE 488.2 (Always 0)
7	128	Power on
6	64	User Request
5	32	Command Error
4	16	Execution Error
3	8	Device Dependent Error
2	4	Query Error
1	2	Request Control
0	1	Operation Complete

## Questionable Data/Signal Status Register

Bit 7 of this register is the summary message for the Calibration register. You must enable this bit to allow a condition in the Calibration register to cause an SRQ with the Status Byte properly enabled.

**Table 7-3 Questionable Status Register (Status Bit 3)**

Bit Number	Binary Weighing	Condition
15	32768	Not Used (Always 0)
14	16384	Unused in HP 7042XA
13	8192	Unused in HP 7042XA
12	4096	Not Used (Always 0)
11	2048	(Customer) PLL Phase-Lock
10	1024	LNA#2 Level
9	512	600 MHz Reference Phase-Lock
8	256	600 MHz Reference Phase-Lock
7	128	Calibration Summary Bit
6	64	Unused in HP 7042XA
5	32	Unused in HP 7042XA
4	16	Unused in HP 7042XA
3	8	Unused in HP 7042XA
2	4	Unused in HP 7042XA
1	2	Unused in HP 7042XA
0	1	Unused in HP 7042XA

### Calibration Register

The summary message for this register appears as bit 7 in the Questionable Status/Signal register.

**Table 7-4 Calibration Status Register**

Bit Number	Binary Weighing	Condition
3	8	Output YTF Not Calibrated
2	4	YTF Not Calibrated
1	2	Output YTF Not Calibrated
0	1	YTF Not Frequency Calibrated

## Remote setup procedure

The following instructions explain how to set up the equipment for remote operation.

### Step 1 - Determine the HP-IB address(es)

#### HP 7042XA

The last two digits of the HP-IB address are shown in the upper left corner of the MMS display when the HP 7042XA is the selected instrument. For example, if the MMS display shows HP 70427A ( 0, 28 ) the last two digits of the HP-IB address are 28.

#### HP 8662/3A (HP 70427A Option 002 only)

Select special function 82 and read the address as follows:

1. Press the **(blue)** key.
2. Press the **(Amplitude)** key.
3. Enter "82" with the **Data** keys.
4. Read the address on the FREQUENCY display. The digits displayed are the last two digits of the HP-IB address.

### Step 2- Configure the tunable source (HP 70428A Option 002 only)

1. Press the *Service* softkey.
2. Press the *Misc* softkey.
3. Press the *RF Source* softkey.
4. Press the *OTHER* softkey. (The RF source must be set to other so the HP 70428A Option 002 won't act as an HP-IB controller. The computer must be the only controller on the bus.)

### Step 3- Connect the HP-IB cables

Connect (a) cable(s) from the computer to the MMS mainframe the HP 7042XA is installed in and to the HP 8662/3A (HP 70428A Option 002 only).

---

## Sample HP-IB programs

The following sample programs were written on an HP 9000 Series 300 controller using Rocky Mountain Basic (RMB). These programs are guidelines on controlling the HP 70427A , HP 70428A , and HP 70428A Option 002.

## HP 70428A Microwave Source program example

This program example first resets the instrument and then sets it up to output a 2.4 GHz signal at +10 dBm with a 100 MHz phase-lock-loop bandwidth of 53 Hz and a 600 MHz bandwidth of 4 KHz. A short routine at the end of the program checks and displays any HP 70428A errors.

Comments for the program follow the program listing.

```
10     DIM Error_message$(40)
20     OUTPUT 728;"*RST"
30     !
40     !
50     OUTPUT 728;"INST?"
60     ENTER 728;Instrument_type
70     IF Instrument_type<4 THEN
80         OUTPUT 728;"INST 4"
90     END IF
100    !
110    !
120    ! START OF TEST PROGRAM
130    !
140    OUTPUT 728;"SRC:OUT:FREQ 2.4GHZ"
150    OUTPUT 728;"SRC:OUT:POW 10DBM"
160    OUTPUT 728;"REF:BW:PLL100 1"
170    OUTPUT 728;"REF:BW:PLL600 0"
180    OUTPUT 728;"REF:TS 1"
190    !
200    !
210    ! CHECK FOR INSTRUMENT ERRORS
220    LOOP
230        OUTPUT 728;"SYST:ERR?"
240        ENTER 728;Error_number,Error_message$
250    EXIT IF Error_number=0
260        PRINT "An error has occurred..."
270        PRINT "The error number and message
is: ",VAL$(Error_number)&Error_message$
280        PRINT
290    END LOOP
300    !
310    ! END OF TEST PROGRAM
320    !
330    !
340    END
```

## Microwave Source Program Comments

- 20     Reset the instrument.
- 50     Determine the type of Instrument: 3 is an HP 70427A , 4 is an HP 70428A, 5 is an HP 70428A Option 002.
- 80     Configure the HP 70427A Downconverter or HP 70428A Option 002 Tunable Source as a Microwave Source.
- 140    Set an output frequency of 2.4 GHz.
- 150    Set an output power of +10 dBm.
- 160    Set the 100 MHz reference phase-lock-loop bandwidth to 53 Hz.
- 170    Set the 600 MHz reference phase-lock-loop bandwidth to 4 KHz.
- 180    Set the tuning sensitivity to .05 ppm/V.
- 220    Start a loop to read any error messages in queue.
- 230    Query any error message.
- 240    Read any error message.
- 250    Exit loop if there are no error messages or when they are all read.

## HP 70427A Downconverter program example

This program example first resets the instrument and then sets it up to downconvert a 10 GHz signal and autoranges both the input attenuation and IF gain individually. The program then reads and displays the LO frequency, IF frequency, input attenuation and IF gain. A short routine at the end of the program checks and displays and HP 70427A errors.

Comments for the program follow the program listing.

```
10     DIM Error_message$(40)
20     !
30     !
40     ! SET UP THE DOWNCONVERTER
50     OUTPUT 728;"*RST"
60     OUTPUT 728;"DC:FREQ:INP 10GHZ"
70     OUTPUT 728;"DC:AMPL:INP:ATT AUTO"
80     OUTPUT 728;"DC:AMPL:IF:GAIN AUTO"
90     !
100    !
110    ! CHECK DOWNCONVERTER LO, IF FREQUENCIES, INPUT
ATTENUATION AND IF GAIN
120    OUTPUT 728;"DC:FREQ:INP?"
130    ENTER 728;Input_frequency
140    OUTPUT 728;"DC:FREQ:LO?"
150    ENTER 728;Lo_frequency
160    OUTPUT 728;"DC:FREQ:IF?"
170    ENTER 728;If_frequency
180    OUTPUT 728;"DC:AMPL:INP:ATT?"
190    ENTER 728;Input_atten
200    OUTPUT 728;"DC:AMPL:IF:GAIN?"
210    ENTER 728;If_gain
220    !
230    !
240    ! PRINT DOWNCONVERTER PARAMETERS
250    PRINT "The Downconverter's parameters are,"
260    PRINT "Input frequency: ";Input_frequency
270    PRINT "LO frequency: ";Lo_frequency
280    PRINT "IF frequency: ";If_frequency
290    PRINT "Input attenuation: ";Input_atten
300    PRINT "IF gain: ";If_gain
310    !
320    !
```

```
330      ! CHECK FOR INSTRUMENT ERRORS
340      LOOP
350          OUTPUT 728;"SYST:ERR?"
360          ENTER 728;Error_number,Error_message$
370      EXIT IF Error_number=0
380          PRINT "An error has occurred..."
390          PRINT "The error number and message
is:      ",VAL$(Error_number)&Error_message$
400      PRINT
410      END LOOP
420      ! END OF TEST PROGRAM
430      !
440      !
450      END
```

## Downconverter Program Comments

50 Reset the instrument.

60 Setup for an input frequency of 10 GHz.

70 Autorange the input attenuator.

80 Autorange the IF amplifier.

120 Query the input frequency.

130 Read the input frequency.

140 Query the LO frequency.

150 Read the LO frequency.

160 Query the IF frequency.

170 Read the IF frequency.

180 Query the input attenuation.

190 Read the input attenuation.

200 Query the IF amplifier gain.

210 Read the IF amplifier gain.

340 Start a loop to read any error messages in queue.

350 Query any error message.

360 Read any error message.

370 Exit loop if there are no error messages or they have all been read.

## HP 70428A Option 002 Tunable Source Program Example

### Overview

This program example first rests the instrument and then asks for a desired output frequency (the frequency must be within the specified range of the operation). It will then set up the HP 70428A Option 002 to output that frequency at +10 dBm. To set the output frequency the program must use an algorithm to determine the correct LO and RF source frequencies. A short routine at the end of the program checks and displays the HP 70428A Option 002 errors.

A short description of the tuning algorithm and comments for the program follow the program listing.

```
10   DIM Error-message$(40)
20   !
30   !
40   OUTPUT 728;"*RST"
50   !
60   !
70   INPUT "Enter desired RF output frequency in
GHz",Rf-output-freq
80   Rf-output-freq=Rf-output-freq*1000 ! Convert to MHz.
90   !
100  !
110  Comblin-nim=(Rf-output-freq) DIV 600
120  !
130  !
140  SELECT Rf-output-freq
150  CASE <25800
160      Comblin-nw--Comblin-num+1
170      Lo-f req=Comblin-nim*600
180      Rf-source-freq--ABS(Lo-freq-Rf-output-freq)
190      IF Rf-source-freq<300 OR Rf-source-freq>600 THEN
200          Lo-freq--(Comblin-nim-1)*600
210          Rf-source-freq=ABS(Lo-freq-Rf-output-freq)
220      END IF
230  CASE >=25800
240      Lo-freq=Comblin-nim*600
250      Rf-source-freq--ABS(Lo-freq-Rf-output-freq)
260      IF Rf-source-freq<300 THEN
270          Lo-f req= (Comblin-nim-1) *600
```

```
280         Rf-source-freq=ABS(Rf-output-freq-Lo-freq)
290     END IF
300 END SELECT
310 320
330 OUTPUT 719;"FR",Rf-source-freq,"MZ AP ODBII
340 350
360 Lo-freq$=VAL$(Lo-freq/1000)
370 OUTPUT 728;"TS:OUT:LO:FREQ "&Lo-freq$&IIGHZ"
380 !
390 !
400 Rf-output-freq$=VAL$(Rf-output-freq/1000)
410 OUTPUT 728;"TS:OUT:FREQ "&Rf-output-freq$&"GHZ"
420
430
440 OUTPUT 728;"TS:OUT:POW 10DBM"
450
460
470 CHECK FOR INSTRUMENT ERRORS
480 LOOP
490     OUTPUT 728;"SYST:ERR?"
500     ENTER 728;Error-number,Error-message$
510     EXIT IF Error-number=0
520     PRINT "An error has occurred..."
530     PRINT "The error number and message
is: ",VAL$(Error-number)&Error-message$
540     PRINT
550     END LOOP
560 !
570 !
580 ! END OF TEST PROGRAM
590 !
600 !
610 END
```

## Tuning Algorithm Description

The portion of the algorithm for determining the HP 70428A option 002's LO and the RF source's output frequencies is shown below:

- I. Determine the desired tuneable source output frequency in MHz.
- II. Calculate the nearest 600 MHz Harmonic (referred to as a combline) and its number.
- III. Set the LO and RF source frequencies.
  - A. If the desired tuneable source output frequency  $< 25800$  MHz.
    1. Increment the combline number by I to ensure desired tuneable source output and LO frequencies are not the same.
    2. Convert the combline number to an LO frequency.
    3. Determine the RF source frequency.
      - a. If the RF source frequency  $< 300$  MHz or  $> 600$  MHz.
      - b. Decrement the LO frequency by 1 combline number.
    4. Set the LO and RF source frequency.
  - B. If the desired tuneable source output frequency  $\geq 5900$  MHz.
    1. Convert the combline number to a frequency.
    2. Determine the RF source frequency.
      - a. If the RF source frequency  $< 300$  MHz.
      - b. Decrement the LO frequency by 1 combline number
    3. Set the LO and RF source frequency

## Tunable Source Program Comments

- 40     Reset the instrument.
- 70     Input desired tuneable source output frequency.
- 80     Convert RF output frequency from GHz to MHz.
- 110    Calculate the nearest combline.
- 160    Ensure the first combline attempted will generate an LO frequency above the RF output frequency. This must be done since there is no combline available below 2.4 GHz.
- 170    Convert the combline number into an LO frequency.
- 180    Calculate the RF source frequency.
- 190    Make sure the RF source frequency is in the correct range.
- 200    The RF source frequency was out of range so change the LO frequency.
- 210    Re-calculate the RF source frequency.
- 240    Convert the combline number into an LO frequency.
- 250    Calculate the RF source frequency.
- 260    Make sure the RF source frequency is at least 300 MHz. Since there is not a 26.4 GHz combline, an RF source frequency of greater than 600 MHz is ok.
- 270    The RF source frequency was less than 300 MHz so change the LO frequency.
- 280    Re-calculate the RF source frequency.
- 330    Set the RF source to the correct frequency and output power.
- 360    Convert the LO frequency to GHz and to a string expression.
- 370    Set the LO frequency.
- 400    Convert the RF output frequency to GHz and to a string expression.
- 410    Set the RF output frequency.
- 40     Set the RF output power to +10 dBm.
- 480    Start a loop to read any error messages in queue.
- 490    Query any error message.
- 500    Read any error message.
- 510    Exit loop if there are no error messages or they have all been read.

## HP 7042XA Reading Errors Program Example

### Overview

The following sample program will intentionally generate errors in the HP 70427A. The program attempts to set up the HP 7042XA to output a 2.4 GHz signal at +30 dBm with a 100 MHz reference loop phase-lock-loop bandwidth of 53 Hz, a 600 MHz reference loop phase-lock-loop bandwidth of 4 KHz, and a tuning sensitivity of .05 ppm/V. To generate errors, the program contains two defects. First, the desired output power is beyond the specifications of the HP 7042XA and second, the command to set the 600 MHz reference phase-lock-loop bandwidth to 4 KHz has a syntax error. A short routine at the end of the program will check and display the HP 7042XA errors.

Comments for the program follow the program listing.

```
10     DIM Error-message$(40)
20     OUTPUT 728;"*RST"
30     !
40     !
50     OUTPUT 728;"INST?"
60     ENTER 728;Instrument-type
70     IF Instrument-type<>4 THEN
80         OUTPUT 728;"INST 4"
90     END IF
100    !
110   !
120   !   START OF TEST PROGRAM
130   !
140   OUTPUT 728;"SRC:OUT:FREQ 2.4GHZ"
150   OUTPUT 728;"SRC:OUT:POW 30DBM"
160   OUTPUT 728;"REF:BW:PLLIOO I"
170   OUTPUT 728;"REF:BW:PL 600 0"
180   OUTPUT 728;"REF:TS 1"
190   !
200   !
210   CHECK FOR INSTRUMENT ERRORS
220   LOOP
230       OUTPUT 728;"SYST:ERR?"
240       ENTER 728;Error_number,Error-message$
250   EXIT IF Error-number=0
260       PRINT "An error has occurred..."
```

```
270      PRINT "The error number and message  
is: ", VAL$(Error-number)&Error-message$  
280      PRINT  
290      END LOOP  
300      !  
310      END OF TEST PROGRAM  
320      !  
330      !  
340      END
```

### Reading Errors Program Comments

20 Reset the instrument.

50 Determine the type of Instrument: 3 is an HP 70427A, 4 is an  
HP 70428A, 5 is an HP 70428A Option 002.

80 Configure the HP 70427A Downconverter or HP 70428A Option  
002 Tunable Source as a Microwave Source.

140 Set an output frequency of 2.4 GHz.

150 This command tries to set an output power of +30 dBm which is  
beyond the specifications of the instrument.

160 Set the 100 MHz reference phase-lock-loop bandwidth to 53 Hz.

170 This command tries to set the 600 MHz reference phase-lock-loop  
bandwidth to 4 KHz, but has a syntax error.

180 Set the tuning sensitivity to .05 ppm/V.

220 Start a loop to read any error messages in queue.

230 Query any error message.

240 Read any error message.

250 Exit loop if there are no error messages or when they are all read.

## HP 7042XA Traping Errors Using SRQ program Example

### Overview

The following sample program enables the HP 7024XA SRQ and then intentionally generates errors in the HP 7024XA causing an HP-IB interrupt. The program attempts to set up the HP 7024XA to output a 2.4 GHz signal at +30 dBm with a 100 MHz reference loop phase-lock-loop bandwidth of 53 Hz, a 600 MHz reference loop phase-lock-loop bandwidth of 4KHz, and a tuning sensitivity of .05 ppm/V. To generate errors, the program contains two defects. First, the desired output power is beyond the specifications of the HP 7024XA and second, the command to set 600 MHz reference phase-lock-loop bandwidth to 4 KHz has a syntax error. After detecting an interrupt, the program will check and display the HP 7024XA errors and pause. Pressing proceed at this point will continue the program and a second interrupt will be generated and the error displayed.

Comments for the program follow in the program listing.

```
10      COM Error_message$[40]
20      !
30      !
40      OUTPUT 728;"*RST"
50      !
60      !
70      OUTPUT 728;"inst?"
80      ENTER 728;Instrument_type
90      IF Instrument_type<>4THEN
100         OUTPUT 728;"INST 4"
110     END IF
120     !
130     !
140     OUTPUT 728;"*CLS"
150     OUTPUT 728;"*SRE 32"
160     OUTPUT 728;"*ESE 4"
170     !
180     !
190     ON INTR 7 CALL Srq_status
200     ENABLE INTR 7;2
210     !
220     !
230     ! START OF TEST PROGRAM
```

```
240      !
250      OUTPUT 728;"SRC:OUT:FREQ 2.4GHZ"
260      OUTPUT 728;"SRC:OUT:POW 30DBM"
270      OUTPUT 728;"REF:BW:PL 600 0"
290      OUTPUT 728;"REF:TS 1"
300      WAIT 10
310      !
320      ! END OF TEST PROGRAM
330      !
340      !
350      END
360      !
370      !
380      Srq_status:SUB Srq_status
390      COM Error_message$
400      PRINT "Test interrupted due to SRQ"
410      PRINT
420      !
430      !
440      OUTPUT 728;"*STB?"
450      ENTER 728;Status_byte
460      PRINT "Status byte=";Status_byte
470      !
480      !
490      OUTPUT 728;"*ESR?"
500      ENTER 728;Standard_event
510      PRINT "Standard Event=";Standard_event
520      !
530      !
540      LOOP
550          OUTPUT 728;"SYST:ERR?"
560          ENTER 728;Error_number,Error_message$
570          EXIT IF Error_number=0
580          PRINT "Error number and message is:
";VAL$(Error_number)&Error_message$
590      END LOOP
600      PRINT
610      !
620      !
630      PRINT "Program paused, press CONTINUE to proceed"
640      PAUSE
650      ENABLE INTR 7;2
660      SUBEND
```

**SRQ Program Comments**

40      Reset the instrument.

70      Determine the type of Instrument: 3 is an HP 70427A , 4 is an HP 70428A , 5 is an HP 70428A Option 002.

100     Configure the HP 70427A Downconverter or HP 70428A Option 002 Tunable Source as a Microwave Source.

140     Clear the Status reporting system.

150     Enable the Status byte to see the Standard Event Register.

160     Define the Standard Event register an event that can cause an SRQ. In this case, a Query Error.

190     Jump to the status reporting subroutine when an SRQ is detected.

200     Enable an SRQ interrupt over the bus.

250     Set an output frequency of 2.4 GHz.

260     This command tries to set an output power of +30 dBm which is beyond the specifications of the instrument.

270     Set the 100 MHz reference phase-lock-loop bandwidth to 53 Hz.

280     This command tries to set the 600 Mhz reference phase-lock-loop bandwidth to 4 Khz, but has a syntax error.

290     Set the tuning sensitivity to .05 ppm/V.

300     Just wait for the SRQ to occur.

440     Query the Status byte.

450     Read the Status byte.

490     Query the Standard Event Register.

500     Read the Standard Event Register.

540     Start a loop to read all the error messages in queue.

550     Query an error message.

560     Read an error message.

570     Exit loop when all the error messages are read.

650     Re-enable an SRQ interrupt over the bus.

# 8

---

## Advanced Hardware Control

### Overview

The Advanced Hardware control function allows user control of latches, relays and multiplexers that are normally controlled by the HP 7042XA's firmware. While the hardware control feature is not typically used in normal instrument operation, it can be a beneficial troubleshooting tool.

---

### NOTE

---

To assure proper operation of the HP 7042XA after using the Advanced Hardware feature, the module should be reset by pressing **INSTR PRESET** .

### Blocks

Related groups of latches are known as a blocks. Block names correspond to their functions and are indicated by the heading of the tables at the end of this chapter. They are also labeled in the lower right corner of the block diagrams at the end of chapter 13.

### Latches

Related groups of bits are know as latches. Theses latches may or may not directly correspond to physical latches controlling the hardware. Latch numbers are shown in the tables at the end of this chapter and on the block diagrams at the end of chapter 13. For more specific circuit details refer to the Component Level Information Packet (CLIP set) 70427-90003.

### Bits

Bits are the information that control the physical hardware. Bit numbers, their associated weights, mnemonics, and descriptions are shown in the tables at the end of this chapter. Similar information may be found on the block diagrams at the end of chapter 13. For more specific circuit details refer to the Component Level Information Packet (CLIP set) 70427-90003.

### Relays

Relays are microwave switches used to route signals in the RF and IF stages in the instrument. Relay numbers, mnemonics, and descriptions are shown in a table at the end of the chapter. Additional information can be found on the simplified block diagrams in chapter 13.

### Multiplexers

Multiplexers connect various monitor points in the instrument to it's internal voltmeter.

## To Set A Hardware Latch

Latches are set by first selecting the desired block and latch, then evaluating the existing latch data, calculating new data and entering it.

### Step 1 - Determine which latch and bit(s) to set

The following information is needed to determine the correct latch and bit(s):

- Block name: this is found as the heading of one of the tables at the end of this chapter. It can also be found in the lower right corner of the block diagrams at the end of chapter 13.
- Latch number: this is found in the tables at the end of this chapter or on the block diagrams at the end of chapter 13.
- Bit number(s): this is found in the tables at the end of this chapter or on the block diagrams at the end of chapter 13.

---

#### NOTE

The block diagrams at the end of chapter 13 label the latches and bits as follows:

$$\begin{aligned} L_n, B_m * 0 &= X \\ &1 = Y \\ &(z) \end{aligned}$$

Where n is the latch number, m is the bit number, x and y are the bit's functions for the corresponding values, z is the bit mnemonic and the (\*) indicates the Power-on/Reset state.

---

### Step 2 - Access the hardware control softkeys

1. Press the *Service* softkey.
2. Press the *Hardware Control* softkey.

### Step 3 - Select the block

Press the *BLOCK* softkey until the name of the desired block is shown next to the Block: display.

### Step 4 - Select the latch

1. Preset the *LATCH NUMBER* softkey.
2. Enter the latch number with the numeric keypad and press the *ENTER* softkey or use the up/down keys to select the latch. (The latch number will be shown next to the *Latch :* display.

### **Step 5 - Read the existing latch data**

Read the decimal number next to the data: display.

### **Step 6 - Evaluate the latch data**

1. Convert the decimal latch data to its binary equivalent.
2. From the tables at the end of this chapter, evaluate each of the latch's bits.

### **Step 7 - Calculate and enter the new latch data**

1. Change the appropriate bit(s).
2. Convert the binary number back to decimal. (If needed, refer to the tables at the end of this chapter for the bits' weight.)
3. This decimal number is the new latch data.
4. Press the *LATCH DATA* softkey and enter the calculated latch data with the numeric keypad and then press the *ENTER* softkey.

## To Set A Relay

Relays are set by selecting the desired relay and then toggling it's state.

### Step 1 - Determine which relay to set

There are twelve functional relays in the HP 70427A and one functional relay in the HP 70428A Option 002. (The HP 70427A has no functional relays.) These relays are numbered 0 to 15 with 5,13,14 and 15 unused. Relay numbers, mnemonics, and descriptions are shown in a table at the end of this chapter. Additional information can be found on the simplified block diagrams in chapter 13.

### Step 2 - Access the hardware control softkeys

1. Press the *Service* softkey.
2. Press the *Hardware Control* softkey.

### Step 3 - Enter the relay number

1. Press the *RELAY NUMBER* softkey.
2. Enter the relay number with the numeric keypad and press the *ENTER* softkey or use the up/down keys to select the relay.

### Step 4 - Set the relay state

Press the *RELAY STATE* softkey to toggle the relay state between Normal and Out states and their descriptions are shown in tables at the end of the chapter.

## To Select a Multiplexer (Voltmeter Monitor Point)

A multiplexer is read by first selecting the desired block and multiplexer point, then reading the voltmeter.

### Step 1 - Determine which point to monitor

Available multiplexer points are listed in the tables at the end of this chapter on the block diagrams at the end of chapter 13.

### Step 2 - Access the hardware control softkeys.

1. Press the *Service*.
2. Press the *Hardware Control* softkey.

### Step 3 - Select the block

Press the block softkey until the name of the desired block is shown next to the **Block:** display.

### Step 4 - Select the multiplexer point

1. Press the *VOLTMETER* softkey.
2. Enter the multiplexer point with the numeric keypad and press the **ENTER** softkey or use the up/down keys to select the point. (The multiplexer point is shown on the **Mux:** display.)

### Step 5 - Read the Voltage

The voltage is shown on the **volt:** display. Generally the value displayed is in millivolts, however, it may, in some cases, represent current millamperes.

---

#### NOTE

The voltage reading is not continuously update. To generate a new reading, press **UPDATE DISPLAY**.

Advanced Hardware Control  
 To Select a Multiplexer (Voltmeter Monitor Point)

**Table 8-1 A3 AM Dectector**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/ Reset State	
0	7	128	Unavailable	n/a	
	6	64	Unavailable	n/a	
	5	32	Unused	n/a	
	4	16	PEAK_HOLD_RESET	0: Peak detect *1: Reset	
	3	8	AM_OUTPUT_RLY	*0: AM output 1: RF level detect	
				*0: AM detector voltage 1: Negative peak-hold detector 2: Pre-peak detector voltage 3: -7.5v sense 4: Overload interrupt 5: Ground 6: Ground 7: Ground	
	1	7	128	Unused	n/a
		6	64	Unused	n/a
		5	32	Unused	n/a
		4	16	Unused	n/a
3		8	Unused	n/a	
2		4	Unused	n/a	
1		2	Unused	n/a	
0		1	Unused	n/a	
2	7	128	Unused	n/a	
	6	64	Unused	n/a	
	5	32	Unused	n/a	
	4	16	Unused	n/a	
	3	8	Unused	n/a	
	1	2	Unused	n/a	

**Table 8-1 A3 AM Dectector**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/ Reset State
	2	4	Unused	
	0	1	Unused	n/a
3	0	1	OVERLOAD_INTERRUPT	0: AM detector overload 1: AM detector normal

**Table 8-2 A4 IF Amplifier**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
0	7	128	Unavailable	n/a
	6	64	Unavailable	n/a
	5	32	RF_OUT	0: Front panel IF OUTPUT off *1: Front panel IF OUTPUT on
	4	16	RF_ANA	* 0: RF analyzer view: IF
	3	8	AM	0: IF level output *1: AM detector output
	2 to 1	4 to 2	MUX2,1	0: Ground *1: IF level 2: Peak IF level 3: Overload interrupt
	0	1	ATTEN	*0: 5 dB attenuator in 1: 5 dB attenuator out
1	7	128	SPARE_1	No functionality
	6	64	SPARE_5	0: Stage 5 amplifier power off *1: Stage 5 amplifier power on
	5	32	ST5_R	*0: Stage 5 amplifier +10 dB gain 1: Stage 5 amplifier bypassed
	4	16	PEAK_RESET	0: Peak detect *1: Reset peak detector
	3	8	NOISE_R	*0: Rear panel in from HP 11848A disable : 1:Rear panel in from HP 11848A enable

Advanced Hardware Control  
 To Select a Multiplexer (Voltmeter Monitor Point)

**Table 8-2 A4 IF Amplifier**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
	2	4	ST4_R	0: Stage 4 amplifier +10 dB gain 1: Stage 4 amplifier bypassed
	1	2	ST3_R	0: Stage 4 amplifier +10 dB gain *1: Stage 3 amplifier bypassed
	0	1	ST2_R	0: Stage 3 amplifier +10 dB gain *1: Stage 2 amplifier bypassed
2	7	128	Unused	n/a
	6	64	Unused	n/a
	5	32	ST1_R	0: Stage 1 amplifier +10 dB gain * 1: Stage 2 amplifier bypassed
	4	16	Unused	n/a
	3	8	STAGE_3	* 0: Stage 3 amplifier off 1: Stage 3 amplifier on
	2	4	STAGE_4	* 0: Stage 4 amplifier off 1: Stage 4 amplifier on
	1	2	STAGE_1	*0: Stage 1 amplifier off 1: Stage 1 amplifier on
	0	1	STAGE_2	*0: Stage 2 amplifier off 0: Stage 2 amplifier on
3	0	1	OVERLOAD_INPT	No functionality
4	11	4095	mm Mixer Bias DAC	40000= 10.2 mA
	to	to		*2000= 0 mA
	0	0		0= +10.2 mA

**Table 8-3 A7A1 100 MHz Reference Loop**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
0	7	128	Unavailable	n/a
	6	64	Unavailable	n/a
	5	32	10 MHz_CNTL	0: 10 MHz reference oscillator off *1: 10 MHz reference oscillator on
	4	16	Unused	n/a
	3	8	Unused	n/a
	2 to 1	4 to 2	10MHz_TUNE_2,1	*0: 10 MHz tuning disable (grounded) 1: 10 MHz reference oscillator on 2: Ground 3: Ground
	0	1	100MHz_CNTL	*0: 100 MHz main output on 1: 100 MHz main output off
1	7	128	YTO_TUNE_CNTL	*0: YTO tuning port disabled 1: YTO tuning port enabled
	6	64	Unused	n/a
	5	32	Unused	n/a
	4	16	Unused	n/a
	3	8	Unused	n/a
	2	4	CUST/INT_CNTL	*0: Internal tune 1: Customer tune
	1 to 0	2 to 1	MUX_4,2,1	*0: Ground 1: Analog burst 2: 100 MHz phase detector 3: 100 MHz tune 4: Oven monitor 5: Ground 6: Ground 7: Ground

Advanced Hardware Control  
 To Select a Multiplexer (Voltmeter Monitor Point)

**Table 8-4 A7A1 100 MHz Reference Loop**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
2	7	128	MUX_1	See latch 0, bits 1 to 0
	6 to 4	64 to 16	100 MHz_BW_4,2,1	0: 25 Hz PII bandwidth 1: 53 Hz PLL bandwidth * 2: 126 Hz PLL bandwidth 3: 300 Hz PLL bandwidth 4: 650 Hz PLL bandwidth 5: 1.53 kHz PLL bandwidth 6: 3.63 kHz PLL bandwidth 7: 10.4 kHz PLL bandwidth
	3 to 2	8 to 4	100MHz_TUNE_2,1	0: Ground 1: Customer/internal tune * 2: PLL tune line 3: Ground
	1	2	SW_+15 V	* 0: 10 to 100 MHz multiplier power on 1: 100 MHz oscillator power off
	0	1	SW_-10 V	* 0: 10 to 100 MHz multiplier power on 1: 10 to 100 MHz multiplier power off
3	0	1	100MHz_00L_INPUT	0: 100 MHz PLL out of lock 1: 100 MHz PLL locked

**Table 8-5 A7A2 600 MHz Reference Loop**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
0	7	128	Unavailable	n/a
	6	64	Unavailable	n/a
	5	32	-10 V CONTROL	0: 100 to 600 MHz multiplier power off *1: 600 MHz oscillator power on
	4	16	+15 V CONTROL	0: 600 MHz oscillator power off *1: 600 MHz oscillator power on
	3	8	Unused	n/a
	2	4	Unused	n/a
	1	2	Unused	n/a
	0	1	Unused	n/a
1	7	128	Unused	n/a
	6	64	Unused	n/a
	5	32	Unused	n/a
	4	16	Unused	n/a
	3	8	Unused	n/a
	2	4	Unused	n/a
	1	2	Unused	n/a
	0	1	Unused	n/a

Advanced Hardware Control  
 To Select a Multiplexer (Voltmeter Monitor Point)

**Table 8-6 A7A2 600 MHz Reference Loop**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
2	7	128	SWEEP ENABLE	*0: Sweep to lock enabled 1: Sweep to lock disabled
	6	64	SWEEP SPEED-UP	*0: Sweep to lock speed up enabled 1: Sweep to lock speed up disabled
	5 to 3	32 to 8	MUX_4,2,1	*0: Out of lock interrupt 1: Tune line voltage 2: Beat-note voltage 3: Sweep voltage 4: Integrator output 5: Ground 6: Switched +15v supply 7: Switched -10v supply
	2 to 0	4 to 1	BW_4,2,1	0: 4 KHz PLL bandwidth *1: 10 KHz PLL bandwidth 2: 17 KHz PLL bandwidth 3: 30 KHz PLL bandwidth 4: Tune input 5: Ground 6: Ground 7: Ground
3	0	1	00L INTERRUPT	0: 600 MHz PLL out of lock 1: 600 MHz PLL locked

**Table 8-7 A8 & A9 YTF & GaAs FET Amplifier Drive**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
2	11 to 0	4095 to 0	Main Tuning DAC	YTF main tuning DAC ~ 7.32 MHz/step 4095= 400 mA YTF current (max freq) * 100 0= 0 mA YTF current (min freq)
3	11 to 0	4095 to 0	Fine Tuning LDAC	YTF fine tuning DAC ~ 85.2 KHz/step 4095= minimum added YTF current *2048 0= maximum added YTF current
6	11 to 0	4095 to 0	Tune Span DAC	Rear panel tune span DAC 4095= 9.95 V *0= 4.33 V
6	11 to 0	4095 to 0	Output Level DAC	4095= maximum gain *0= minimum gain

Advanced Hardware Control  
 To Select a Multiplexer (Voltmeter Monitor Point)

**Table 8-8 A8 & A9 YTF & GaAs FET Amplifier Drive**

Latch	Bit	Bit Weight	Bit Mnemonic	Bit Description *Power-on/Reset State
7	7	128	Unavailable	n/a
	6	64	Unavailable	n/a
	5	32	OUT_LEV_CONTROL	*0: GaAs FET amplifiers gate control 1: GaAs FET amplifiers drain control
	4	16	NOISE FILTER	*0: Adaptive noise filter disabled 1: Adaptive noise filter enabled
	3 to 0	8 to 1	MUX8,4,2,1	*0: 3rd stage amplifier drain current (mA) 1: +10 V reference voltage 2: 2nd stage amplifier gate voltage 3: +10 V power supply voltage 4: 5th stage amplifier drain current (mA) 5: Fine tune DAC voltage 6: 1st stage amplifier drain current (mA) 7: +20 V power supply voltage 8: 4th stage amplifier drain current (mA) 9: Tuning voltage output 10: Level detector voltage 11: YIG current (mA) 12: 6th stage amplifier drain current (mA) 13: Main tune DAC voltage 14: 2nd stage amplifier drain current (mA) 15: YIG heater current (mA)

**Table 8-9 Relays**

Number	Mnemonic	Description *Power-on/Reset State
0	5 dB attenuator section	*5 dB attenuator section Out: 0 dB Attenuation
1	10 dB attenuator section	*Normal: 10 dB Attenuation Out: 0 dB attenuation
2	20 dB attenuator section	*Normal: 20 dB attenuation Out: 0 dB attenuation
3	Signal Input relay	*Normal: Downconverter path Out: RF Analyzer path
4	RF Analyzer relay	*Normal: View input signal Out: View IF amplifier output signal
5	Unused	n/a
6	IF Amplifier Input relay	Normal: No connection * Out: IF amplifier selected
7	Microwave Mixer X-port relay	*Normal: Microwave mixer bypassed Out: Microwave mixer selected
8	Microwave Mixer R-port relay	* Normal: Microwave mixer bypassed Out: Microwave mixer selected
9	AM Detector relay	*Normal: AM detector bypassed Out: AM detector selected
10	Microwave Phase Detector	*Normal : Downconverter path Out: No connection
11	RF Phase Detector relay	*Normal: No connection * Out: No connection
12	Microwave LO relay	Normal: Microwave LO to front panel *Out: Microwave LO to mixer
13	Unused	n/a
14	Unused	n/a
15	Unused	n/a

Advanced Hardware Control  
To Select a Multiplexer (Voltmeter Monitor Point)

# 9

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## Technical Data

### Overview

This chapter lists specifications, supplemental characteristics, and available options for the HP 7042X family of MMS modules.

The specifications are grouped by modules in the following order:

- **HP 71707A/70427A Specifications**, page 9-2
- **HP 71708A/70428A Specifications**, page 9-19
- **HP 70428A Option 002 Specifications**, page 9-25

## HP 71707A/70427A Specifications

**Specifications** describe the instrument's warranted performance and apply after a 30 minute warm-up. These specifications are valid over its operating/environmental range unless otherwise noted.

**Supplemental Characteristics** (*shown in italics*) are intended to provide additional information, useful in applying the instrument by giving typical (expected), but not warranted performance parameters. These characteristics are shown in italics or labeled as "typical", "usable to", or "nominal".

### Microwave Downconverter

#### RF Input

##### Frequency Range:

- 1.5 GHz to 26.5 GHz for downconversion to an IF between 300 and 900 MHz
- 5 MHz to 26.5 GHz for AM detection and input attenuator
- 5 MHz to 1.5 GHz for IF amplification

##### Input Power:

- +30 dBm maximum
- -30 dBm minimum (phase noise floor degrades if <0 dBm)

##### Mixer Linearity:

- $\pm 0.4$  dB, mixer input  $\leq -5$  dBm, LO power control in linear mode

##### Input Attenuator:

- 0 to 35 dB in 5 dB steps

##### Spectral Purity:

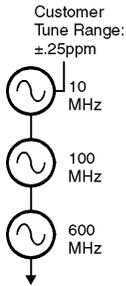
Spectral purity specifications include the phase noise of the LO and IF section. Also, the internal reference oscillators can be locked together in three configurations, each with different phase noise performance and tuning bandwidths. All noise levels are in units of dBc/Hz unless otherwise noted. Spurious and phase noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points. These specification apply to input signals  $\geq 0$  dBm.

**Configuration 1 - All Oscillators Locked:**

Best phase noise <100 Hz frequency offsets, narrow tuning sensitivity (LO and IF noise only). Refer to Table 9-1.

**Table 9-1 HP 70427A Configuration 1 - All Oscillators Locked**

Input Frequency	Offset From Carrier (Hz)										Spurious (dBc)	
	1	10	100	1k	10k	100k	1M	10M	40M	10 to 100	≥ 1k	
1.5 to 3.0 GHz	Typ.	-50	-80	-100	-128	-138	-145	-145	-145	-145	-60	-75
	Spec.	-45	-75	-95	-123	-133	-140	-140	-140	-140	-50	-65
3.0 to 4.2 GHz	Typ.	-47	-77	-97	-125	-136	-146	-147	-147	-147	-54	-80
	Spec.	-42	-72	-92	-120	-131	-141	-142	-142	-142	-44	-70
4.2 to 6.0 GHz	Typ.	-44	-74	-94	-122	-134	-144	-147	-147	-147	-54	-80
	Spec.	-39	-69	-89	-117	-129	-139	-142	-142	-142	-44	-70
6.0 to 7.8 GHz	Typ.	-42	-72	-92	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	-37	-67	-87	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	-40	-70	-90	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	-35	-65	-85	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	-38	-68	-88	-116	-128	-140	-143	-143	-143	-50	-80
	Spec.	-33	-63	-83	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	-35	-65	-85	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	-30	-60	-80	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 26.5 GHz	Typ.	-32	-62	-82	-110	-122	-130	-130	-130	-130	-44	-65
	Spec.	-27	-57	-77	-105	-117	-125	-125	-125	-125	-34	-55

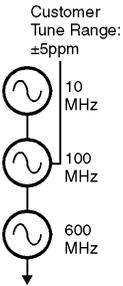


**Configuration 2 - 100 and 600 MHz Oscillators Locked:**

Better phase noise <10 kHz frequency offsets, moderate tuning sensitivity (LO and IF noise only). Refer to Table 9-2.

**Table 9-2 HP 70427A Configuration 2 - 100 And 600 MHz Oscillators Locked**

Input Frequency	Offset From Carrier (Hz)										Spurious (dBc)	
	1 <sup>1</sup>	10 <sup>2</sup>	100	1k	10k	100k	1M	10M	40M	100	≥ 1k	
1.5 to 3.0 GHz	Typ.	+2	-48	-98	-128	-138	-145	-145	-145	-145	-60	-75
	Spec.	+7	-43	-93	-123	-133	-140	-140	-140	-140	-50	-65
3.0 to 4.2 GHz	Typ.	+5	-45	-95	-125	-136	-146	-147	-147	-147	-54	-80
	Spec.	+10	-40	-90	-120	-131	-141	-142	-142	-142	-44	-70
4.2 to 6.0 GHz	Typ.	+8	-42	-92	-122	-134	-144	-147	-147	-147	-54	-80
	Spec.	+13	-37	-87	-117	-129	-139	-142	-142	-142	-44	-70
6.0 to 7.8 GHz	Typ.	+10	-40	-90	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	+15	-35	-85	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	+12	-38	-88	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	+17	-33	-83	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	+14	-36	-86	-116	-128	-140	-143	-143	-143	-50	-80
	Spec.	+19	-31	-81	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	+17	-33	-83	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	+22	-28	-78	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 26.5 GHz	Typ.	+20	-30	-80	-110	-122	-130	-130	-130	-130	-44	-65
	Spec.	+25	-25	-75	-105	-117	-125	-125	-125	-125	-34	-55



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

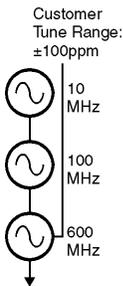
<sup>2</sup> All noise levels above -40 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

### Configuration 3 - 600 MHz Free-running Oscillator:

Good phase noise <10 kHz frequency offsets, wide tuning sensitivity (LO and IF noise only). Refer to Table 9-3.

**Table 9-3 HP 70427A Configuration 3 - 600 MHz Free-running Oscillator**

Input Frequency	Offset From Carrier (Hz)										Spurious (dBc)		
	1 <sup>1</sup>	10 <sup>2</sup>	100	1k	10k	100k	1M	10M	40M	100	1k	≥ 10k	
1.5 to 3.0 GHz	Typ.	+15	-35	-75	-113	-138	-145	-145	-145	-145	-40	-75	-80
	Spec.	+20	-30	-70	-108	-133	-140	-140	-140	-140	-30	-65	-70
3.0 to 4.2 GHz	Typ.	+18	-32	-72	-111	-136	-146	-147	-147	-147	-34	-74	-80
	Spec.	+23	-27	-67	-106	-131	-141	-142	-142	-142	-24	-64	-70
4.2 to 6.0 GHz	Typ.	+21	-29	-69	-109	-134	-144	-147	-147	-147	-34	-74	-80
	Spec.	+26	-24	-64	-104	-129	-139	-142	-142	-142	-24	-64	-70
6.0 to 7.8 GHz	Typ.	+23	-27	-67	-107	-132	-143	-147	-147	-147	-34	-74	-80
	Spec.	+28	-22	-62	-102	-127	-138	-142	-142	-142	-24	-64	-70
7.8 to 10.2 GHz	Typ.	+25	-25	-65	-105	-130	-141	-145	-145	-145	-30	-70	-80
	Spec.	+30	-20	-60	-100	-125	-136	-140	-140	-140	-20	-60	-70
10.2 to 12.6 GHz	Typ.	+27	-23	-63	-103	-128	-140	-143	-143	-143	-30	-70	-80
	Spec.	+32	-18	-58	-98	-123	-135	-138	-138	-138	-20	-60	-70
12.6 to 18.0 GHz	Typ.	+30	-20	-60	-100	-125	-137	-140	-140	-140	-27	-67	-70
	Spec.	+35	-15	-55	-95	-120	-132	-135	-135	-135	-17	-57	-60
18.0 to 26.5 GHz	Typ.	+33	-17	-57	-97	-122	-130	-130	-130	-130	-24	-64	-70
	Spec.	+38	-12	-52	-92	-117	-125	-125	-125	-125	-14	-54	-60



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

<sup>2</sup> All noise levels above -40 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

### RF Input Supplemental Characteristics

#### Input Power:

- <-30 dBm with IF power output reduction

#### Input Impedance:

- 50 Ω

#### SWR:

- ≥5 dB input attenuation: 2:1

#### Noise Figure:

- 20 dB

**Spectral Purity:**

- For input signals <0 dBm, noise at offsets  $\geq 1$  kHz may increase by 1 dB for every 1 dB of input power reduction.

**Conversion Loss:**

- < 15 dB

**Mixer Linearity:**

- $\pm 0.1$  dB for -10 dBm input level
- $\pm 0.4$  dB for -5 dBm input level
- LO power control in low-noise mode

**IF Output**

**Frequency Range:**

- 5 MHz to 1200 MHz

**Mixing Spurious (mixer input level -5dBm):**

- < 6 GHz
  - ▲  $< -50$  dBc except for those listed in Table 9-4 on page 9-6.
- > 6 GHz
  - ▲  $< -70$  dBc

**Table 9-4 HP 70427A Mixing Spurious**

Carrier frequency range (GHz) where a mixing spur will occur $\leq 40$ MHz from carrier	Typical spurious level (dBc)
1.586 - 1.614 (levels $\leq 10$ dBm)	-20
1.790 - 1.810, 1.912 - 1.928 2.392 - 2.408, 2.872 - 2.888 2.990 - 3.000	-30
1.708 - 1.720, 1.993 - 2.007 2.240 - 2.260, 2.493 - 2.507 2.737 - 2.749, 3.592 - 3.600	-40
2.051 - 2.063, 2.095 - 2.100 2.565 - 2.578, 2.793 - 2.807 3.000 - 3.007, 3.080 - 3.092 3.493 - 3.507, 4.108 - 4.120 4.193 - 4.200	-50

**IF Output Supplemental Characteristics**

**IF Frequency Range:**

- 5 MHz to 1500 MHz

***IF Gain Range:***

- 0 to 45 dB in 5 dB steps

***Absolute Output Power (input signal  $\geq 30$  dBm):***

- 0 to +5 dBm

***LO Feedthrough (LO = 2.4 GHz, input signal power = 0 dBm):***

- $< -70$  dBc

***Carrier Feedthrough (input power = 0 dBm):***

- 1.5 GHz  $< -20$  dBc
- 2.0 GHz  $< -50$  dBc

**Local Oscillator**

**Frequency Range:**

- 2.4 GHz to 25.8 GHz

**Frequency Resolution:**

- 600 MHz

**Spectral Purity:**

- See Spectral Purity tables under Microwave Source specifications.

**Am Noise:**

- See AM Noise table under Microwave Source specifications.

**Local Oscillator Supplemental Characteristics**

***Frequency Switching Speed:***

- 3 seconds

***Reference Tuning:***

- Voltage control of the internal reference oscillators is available through a port on the front panel.

***Tuning Range (sensitivity):***

- Configuration 1:
  - ▲  $\pm 0.25$  ppm (0.05 ppm/volt)
- Configuration 2:
  - ▲  $\pm 5$  ppm (1 ppm/volt)
- Configuration 3:
  - ▲  $\pm 100$  ppm (20 ppm/volt)

***Tuning Port Voltage Range:***

- $\pm 5$  volts (overrange  $\pm 10$  volts)

***Tuning Port Input Impedance:***

- 27.5 kΩ (0.05 ppm/volt)
- 100 kΩ (1 ppm/volt and 20 ppm/volt)

**AM Noise Detection**

**Input Power:**

- 0 dBm to +30 dBm

**Offset Frequency Range:**

- 1 Hz to 40 MHz

**AM Detector Noise Floor Specifications (+15 dBm):**

***Table 9-5 HP 70427A AM Detector Noise Floor Specifications (+15 dBm)***

		Offset From Carrier (Hz)								Spurious (dBc)		
		1	10	100	1k	10k	100k	1M	10M	40M	10	1k to 40M
<b>dBc/Hz</b>	Typ.	-113	-123	-133	-143	-150	-155	-155	-155	-155	-60	-80
	Spec.	-108	-118	-128	-138	-145	-150	-150	-150	-150	-50	-70

## HP 70427A Microwave Source

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### NOTE

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For front panel microwave source operations, you must enter the “Microwave Source” control menus of the MMS user interface. Entering this menu routes the internal local oscillator to the LO output port on the front panel and disables the downconverter operation.

### RF Output

#### Frequency Range:

- 2.4 GHz to 25.8 GHz

#### Frequency Resolution:

- 600 MHz

#### Output Power:

- 2.4 to 6.6 GHz
  - ▲ 0 to +16 dBm
- 7.2 to 25.8 GHz
  - ▲ 0 to +10 dBm

#### Spectral Purity:

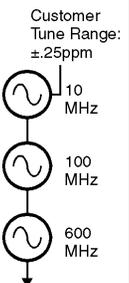
The internal reference oscillators can be locked together in three configurations, each with different phase noise performance and tuning bandwidths. All noise levels have units of dBc/Hz unless otherwise noted. Spurious and phase noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points.

**Configuration 1 - All Oscillators Locked:**

Best phase noise <100 Hz frequency offsets, narrow tuning sensitivity. Refer to Table 9-6.

**Table 9-6 HP 70427A Source Configuration 1 - All Oscillators Locked**

Output Frequency	Offset From Carrier (Hz)										Spurious (dBc)	
	1 <sup>1</sup>	10	100	1k	10k	100k	1M	10M	40M	10 to 100	1k to 100 MHz	
2.4 to 3.0 GHz	Typ.	-50	-80	-100	-128	-138	-148	-152	-152	-152	-60	-80
	Spec.	-45	-75	-95	-123	-133	-143	-147	-147	-147	-50	-70
3.0 to 4.2 GHz	Typ.	-47	-77	-97	-125	-136	-146	-150	-150	-150	-54	-80
	Spec.	-42	-72	-92	-120	-131	-141	-145	-145	-145	-44	-70
4.2 to 6.0 GHz	Typ.	-44	-74	-94	-122	-134	-144	-148	-148	-148	-54	-80
	Spec.	-39	-69	-89	-117	-129	-139	-143	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	-42	-72	-92	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	-37	-67	-87	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	-40	-70	-90	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	-35	-65	-85	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	-38	-68	-88	-116	-128	-140	-143	-143	-143	-50	-80
	Spec.	-33	-63	-83	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	-35	-65	-85	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	-30	-60	-80	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 25.8 GHz	Typ.	-32	-62	-82	-110	-122	-134	-136	-136	-136	-44	-70
	Spec.	-27	-57	-77	-105	-117	-129	-131	-131	-131	-34	-60



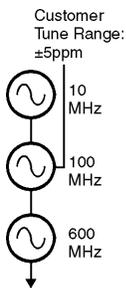
<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$ .

**Configuration 2 - 100 and 600 MHz Oscillators Locked:**

Better phase noise <10 kHz frequency offsets, moderate tuning sensitivity.  
 Refer to Table 9-7.

**Table 9-7 HP 70427A Source Configuration 2 - 100 And 600 MHz Oscillators Locked**

Output Frequency	Offset From Carrier (Hz)										Spurious (dBc)	
	1 <sup>1</sup>	10 <sup>2</sup>	100	1k	10k	100k	1M	10M	40M	100	1k to 100 MHz	
2.4 to 3.0 GHz	Typ.	+2	-48	-98	-128	-138	-148	-152	-152	-152	-60	-80
	Spec.	+7	-43	-93	-123	-133	-143	-147	-147	-147	-50	-70
3.0 to 4.2 GHz	Typ.	+5	-45	-95	-125	-136	-146	-150	-150	-150	-54	-80
	Spec.	+10	-40	-90	-120	-131	-141	-145	-145	-145	-44	-70
4.2 to 6.0 GHz	Typ.	+8	-42	-92	-122	-134	-144	-148	-148	-148	-54	-80
	Spec.	+13	-37	-87	-117	-129	-139	-143	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	+10	40	-90	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	+15	-35	-85	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	+12	-38	-88	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	+17	-33	-83	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	+14	-36	-86	-116	-128	-140	-143	-143	-143	-50	-80
	Spec.	+19	-31	-81	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	+17	-33	-83	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	+22	-28	-78	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 25.8 GHz	Typ.	+20	-30	-80	-110	-122	-134	-136	-136	-136	-44	-70
	Spec.	+25	-25	-75	-105	-117	-129	-131	-131	-131	-34	-60



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

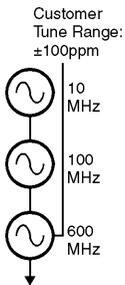
<sup>2</sup> All noise levels above -40 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

**Configuration 3 - 600 MHz Free-running Oscillator:**

Good phase noise <10 kHz frequency offsets, wide tuning sensitivity. Refer to Table 9-8.

**Table 9-8 HP 70427A Source Configuration 3 - 600 MHz Free-running Oscillator**

Output Frequency	Offset From Carrier (Hz)										Spurious (dBc)		
	1 <sup>1</sup>	10 <sup>2</sup>	100	1k	10k	100k	1M	10M	40M	100	1k	10k to 100 MHz	
2.4 to 3.0 GHz	Typ.	+15	-35	-75	-113	-138	-148	-152	-152	-152	-40	-80	-80
	Spec.	+20	-30	-70	-108	-133	-143	-147	-147	-147	-30	-70	-70
3.0 to 4.2 GHz	Typ.	+18	-32	-72	-111	-136	-146	-150	-150	-150	-34	-74	-80
	Spec.	+23	-27	-67	-106	-131	-141	-145	-145	-145	-24	-64	-70
4.2 to 6.0 GHz	Typ.	+21	-29	-69	-109	-134	-144	-148	-148	-148	-34	-74	-80
	Spec.	+26	-24	-64	-104	-129	-139	-143	-143	-143	-24	-64	-70
6.0 to 7.8 GHz	Typ.	+23	-27	-67	-107	-132	-143	-147	-147	-147	-34	-74	-80
	Spec.	+28	-22	-62	-102	-127	-138	-142	-142	-142	-24	-64	-70
7.8 to 10.2 GHz	Typ.	+25	-25	-65	-105	-130	-141	-145	-145	-145	-30	-70	-80
	Spec.	+30	-20	-60	-100	-125	-136	-140	-140	-140	-20	-60	-70
10.2 to 12.6 GHz	Typ.	+27	-23	-63	-103	-128	-140	-143	-143	-143	-30	-70	-80
	Spec.	+32	-18	-58	-98	-123	-135	-138	-138	-138	-20	-60	-70
12.6 to 18.0 GHz	Typ.	+30	-20	-60	-100	-125	-137	-140	-140	-140	-27	-67	-70
	Spec.	+35	-15	-55	-95	-120	-132	-135	-135	-135	-17	-57	-60
18.0 to 25.8 GHz	Typ.	+33	-17	-57	-97	-122	-134	-136	-136	-136	-24	-64	-70
	Spec.	+38	-12	-52	-92	-117	-129	-131	-131	-131	-14	-54	-60



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

<sup>2</sup> All noise levels above -40 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

**AM Noise:**

Specifications apply for +10 dBm output power. All noise levels in dBc/Hz. AM noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points.

**Table 9-9 HP 70427A AM Detector Noise Floor Specifications (+10 dBm)**

Output Frequency		Offset From Carrier (Hz)								Spurious (dBc)		
		1	10	100	1k	10k	100k	1M	10M	40M	10	1k to 40M
2.4 to 18.0 GHz	Typ.	-100	-110	-117	-133	-143	-153	-155	-155	-155	-60	-80
	Spec.	-95	-105	-112	-128	-138	-148	-150	-150	-150	-50	-70
18.0 to 24.8 GHz	Typ.	-100	-110	-117	-130	-139	-147	-151	-151	-151	-60	-80
	Spec.	-95	-105	-112	-125	-134	-142	-146	-146	-146	-50	-70

**Supplemental Characteristics**

**Frequency Overrange:**

- 26.4 GHz with degraded output power

**Output Level Entry Resolution:**

- 0.1 dB

**Tuning Sensitivity:**

- See Microwave Downconverter LO Supplemental specifications

**Harmonics:**

- -10 dBc

**Frequency Switching Transients:**

- Output power can peak at +22 dBm during frequency switching

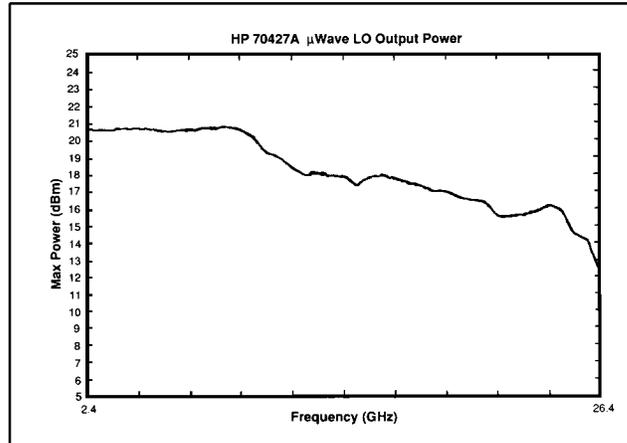
**Output Power Drift:**

- <1 dB after warm-up

**Output power settling time:**

- <100 ms

*Maximum Output Power:*



## HP 71707A HP 70427A General Specifications

### HP 71707A System Components:

- HP 70004A Color Display/Mainframe
- HP 70427A Microwave Downconverter Module

### Internal Reference Oscillator:

- **Internal 10 MHz reference oscillator:**
  - ▲ 10 MHz quartz oscillator
- **Aging rate:**
  - ▲  $<1 \times 10^{-9}$ /day after 10 day warm-up
- **Temperature Stability**
  - ▲  $<2 \times 10^{-8}$  over 0 to 55° C

### Rear Panel Connections:

- 10 MHz IN (+7 dBm required)
- Buffered 10 MHz OUT (Typical +7 dBm)
- 10 MHz OVEN OUT (Typical +10 dBm)
- 100 MHz OUT (Typical -2 dBm)
- 100 MHz OUT (Typical +8 dBm)
- 600 MHz OUT (Typical +20 dBm)
- 600 MHz OUT (Typical 0 dBm)
- TUNE SPAN OUTPUT (not specified)
- MULTIPLEXER OUT (not specified)
- TUNE OUTPUT (not specified)
- IF LEVEL (not specified)
- SPECTRUM ANALYZER FROM 11848A
  - ▲ Allows the use of spectrum analyzer for RF, IF, and phase noise measurements without reconnection.

### Environmental Temperature:

- Operational, 0 to 55° C
- Storage, -40 to +75° C

### Humidity:

- Operational, 0 to 95% relative humidity at 45° C

### Warm-up Time:

- 30 minutes recommended

### EMC:

- Meets MIL-STD 461B

### Power Requirements:

- HP 71707A supplied by the HP 70004 mainframe
- HP 70427 requires 50 watts from the mainframe

**Weight (nominal) HP 71707A:**

- 28.75 kg (63.3 lb) nominal

**Weight (nominal) HP 70427A:**

- 9.3 kg (20.5 lb) nominal

**Warranty:**

- One year (extendible with options)

**Calibration Cycle:**

- One year recommended

**Supported power meters of output power calibration (of HP 71707A):**

- HP 70100A Power Meter
- HP 437B Power Meter
- HP 438A Power Meter

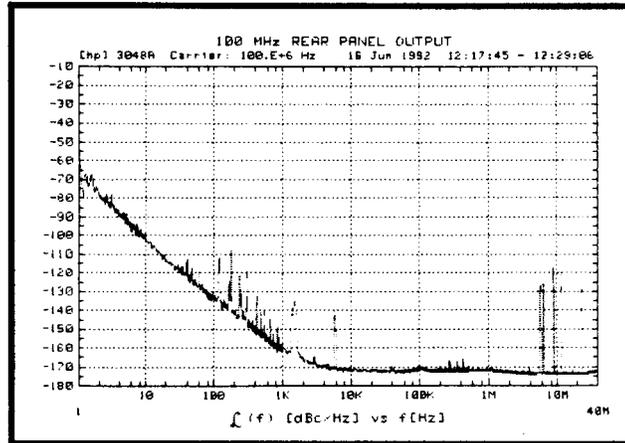
**Supported Display and Mainframe:**

- HP 70004A Color Display/Mainframe
- HP 70207B Display \* (software interface) with HP 70001A Mainframe

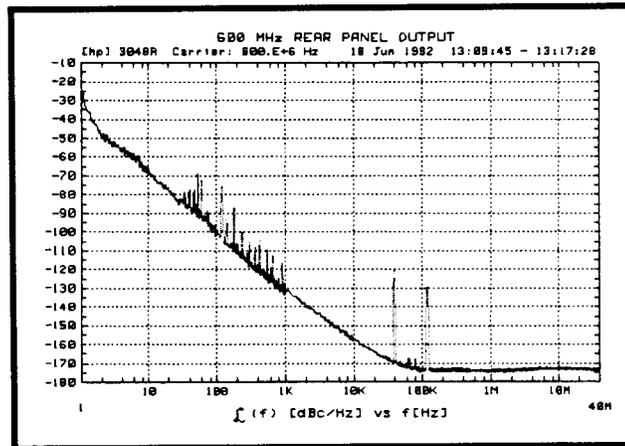
\* For more information, call your local Hewlett-Packard sales office listed in the telephone directory.

### General Specification Supplemental Characteristics

- **10 MHz Rear Panel Output:**
  - ▲ *Typical Phase Noise Performance*
- **100 MHz Rear Panel Output:**

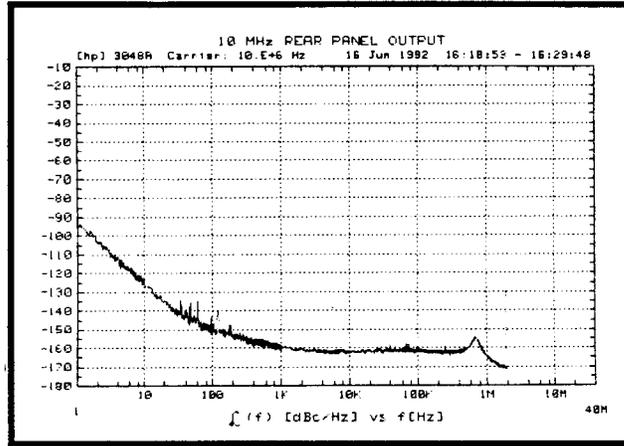


▲ *Typical Phase Noise Performance*



Technical Data  
HP 71707A/70427A Specifications

- **600 MHz Rear Panel Output:**
  - ▲ *Typical Phase Noise Performance*



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## HP 71708A/70428A Specifications

**Specifications** describe the instrument's warranted performance and apply after a 30 minute warm-up. These specifications are valid over its operating/environmental range unless otherwise noted.

**Supplemental Characteristics** (*shown in italics*) are intended to provide additional information, useful in applying the instrument by giving typical (expected), but not warranted performance parameters. These characteristics are shown in italics or labeled as "typical", "usable to", or "nominal".

### Microwave Source

#### RF Output

##### Frequency Range:

- 2.4 GHz to 25.8 GHz

##### Frequency Resolution:

- 600 MHz

##### Output Power:

- 2.4 to 6.6 GHz
  - ▲ 0 to +16 dBm
- 7.2 to 25.8 GHz
  - ▲ 0 to +10 dBm

##### Spectral Purity:

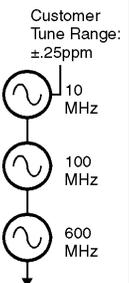
The internal reference oscillators can be locked together in three configurations, each with different phase noise performance and tuning bandwidths. All noise levels have units of dBc/Hz unless otherwise noted. Spurious and phase noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points.

**Configuration 1 - All Oscillators Locked:**

Best phase noise <100 Hz frequency offsets, narrow tuning sensitivity. Refer to Table 9-10.

**Table 9-10 HP 70428A Source Configuration 1 - All Oscillators Locked**

Output Frequency	Offset From Carrier (Hz)										Spurious (dBc)	
	1 <sup>1</sup>	10	100	1k	10k	100k	1M	10M	40M	10 to 100	1k to 100 MHz	
2.4 to 3.0 GHz	Typ.	-50	-80	-100	-128	-138	-148	-152	-152	-152	-60	-80
	Spec.	-45	-75	-95	-123	-133	-143	-147	-147	-147	-50	-70
3.0 to 4.2 GHz	Typ.	-47	-77	-97	-125	-136	-146	-150	-150	-150	-54	-80
	Spec.	-42	-72	-92	-120	-131	-141	-145	-145	-145	-44	-70
4.2 to 6.0 GHz	Typ.	-44	-74	-94	-122	-134	-144	-148	-148	-148	-54	-80
	Spec.	-39	-69	-89	-117	-129	-139	-143	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	-42	-72	-92	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	-37	-67	-87	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	-40	-70	-90	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	-35	-65	-85	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	-38	-68	-88	-116	-128	-140	-143	-143	-143	-50	-50
	Spec.	-33	-63	-83	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	-35	-65	-85	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	-30	-60	-80	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 25.8 GHz	Typ.	-32	-62	-82	-110	-122	-134	-136	-136	-136	-44	-70
	Spec.	-27	-57	-77	-105	-117	-129	-131	-131	-131	-34	-60



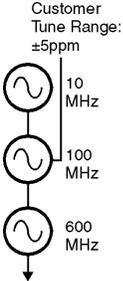
<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

**Configuration 2 - 100 and 600 MHz Oscillators Locked:**

Better phase noise <10 kHz frequency offsets, moderate tuning sensitivity.  
 Refer to Table 9-11.

**Table 9-11 HP 70428A Source Configuration 2 - 100 And 600 MHz Oscillators Locked**

Output Frequency	Offset From Carrier (Hz)										Spurious (dBc)	
	1 <sup>1</sup>	10 <sup>2</sup>	100	1k	10k	100k	1M	10M	40M	100	1k to 100 MHz	
2.4 to 3.0 GHz	Typ.	+2	-48	-98	-128	-138	-148	-152	-152	-152	-60	-80
	Spec.	+7	-43	-93	-123	-133	-143	-147	-147	-147	-50	-70
3.0 to 4.2 GHz	Typ.	+5	-45	-95	-125	-136	-146	-150	-150	-150	-54	-80
	Spec.	+10	-40	-90	-120	-131	-141	-145	-145	-145	-44	-70
4.2 to 6.0 GHz	Typ.	+8	-42	-92	-122	-134	-144	-148	-148	-148	-54	-80
	Spec.	+13	-37	-87	-117	-129	-139	-143	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	+10	-40	-90	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	+15	-35	-85	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	+12	-38	-88	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	+17	-33	-83	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	+14	-36	-86	-116	-128	-140	-153	-153	-153	-50	-50
	Spec.	+19	-31	-81	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	+17	-33	-83	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	+22	-28	-78	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 25.8 GHz	Typ.	+20	-30	-80	-110	-122	-134	-136	-136	-136	-44	-70
	Spec.	+25	-25	-75	-105	-117	-129	-131	-131	-131	-34	-60



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

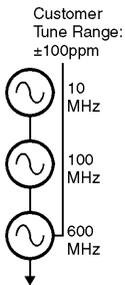
<sup>2</sup> All noise levels above -40 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to  $1 \text{ rad}^2/\text{Hz}$

**Configuration 3 - 600 MHz Free-running Oscillator:**

Good phase noise <10 kHz frequency offsets, wide tuning sensitivity. Refer to Table 9-12.

**Table 9-12 HP 70428A Source Configuration 3 - 600 MHz Free-running Oscillator**

Output Frequency	Offset From Carrier (Hz)										Spurious (dBc)		
	1 <sup>1</sup>	10 <sup>2</sup>	100	1k	10k	100k	1M	10M	40M	100	1k	10k to 100 MHz	
2.4 to 3.0 GHz	Typ.	+15	-35	-75	-113	-138	-148	-152	-152	-152	-40	-80	-80
	Spec.	+20	-30	-70	-108	-133	-143	-147	-147	-147	-30	-70	-70
3.0 to 4.2 GHz	Typ.	+18	-32	-72	-111	-136	-146	-150	-150	-150	-34	-74	-80
	Spec.	+23	-27	-67	-106	-131	-141	-145	-145	-145	-24	-64	-70
4.2 to 6.0 GHz	Typ.	+21	-29	-69	-109	-134	-144	-148	-148	-148	-34	-74	-80
	Spec.	+26	-24	-64	-104	-129	-139	-143	-143	-143	-24	-64	-70
6.0 to 7.8 GHz	Typ.	+23	-27	-67	-107	-132	-143	-147	-147	-147	-34	-74	-80
	Spec.	+28	-22	-62	-102	-127	-138	-142	-142	-142	-24	-64	-70
7.8 to 10.2 GHz	Typ.	+25	-25	-65	-105	-130	-141	-145	-145	-145	-30	-70	-80
	Spec.	+30	-20	-60	-100	-125	-136	-140	-140	-140	-20	-60	-70
10.2 to 12.6 GHz	Typ.	+27	-23	-63	-103	-128	-140	-143	-143	-143	-30	-70	-80
	Spec.	+32	-18	-58	-98	-123	-135	-138	-138	-138	-20	-60	-70
12.6 to 18.0 GHz	Typ.	+30	-20	-60	-100	-125	-137	-140	-140	-140	-27	-67	-70
	Spec.	+35	-15	-55	-95	-120	-132	-135	-135	-135	-17	-57	-60
18.0 to 25.8 GHz	Typ.	+33	-17	-57	-97	-122	-134	-136	-136	-136	-24	-64	-70
	Spec.	+38	-12	-52	-92	-117	-129	-131	-131	-131	-14	-54	-60



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

<sup>2</sup> All noise levels above -40 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

### AM Noise

Specifications apply for +10 dBm output power. All noise levels in dBc/Hz. AM noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points.

**Table 9-13 HP 70428A AM Detector Noise Floor Specifications (+10 dBm)**

Output Frequency		Offset From Carrier (Hz)									Spurious (dBc)	
		1	10	100	1k	10k	100k	1M	10M	40M	10	1k to 40M
2.4 to 18.0 GHz	Typ.	-100	-110	-117	-133	-143	-153	-155	-155	-155	-60	-80
	Spec.	-95	-105	-112	-128	-138	-148	-150	-150	-150	-50	-70
18.0 to 24.8 GHz	Typ.	-100	-110	-117	-130	-139	-147	-151	-151	-151	-60	-80
	Spec.	-95	-105	-112	-125	-134	-142	-146	-146	-146	-50	-70

### Supplemental Characteristics

**Frequency Overrange:**

- 26.4 GHz with degraded output power

**Output Level Entry Resolution:**

- 0.1 dB

**Absolute Power Accuracy:**

- ±3 dB

**Harmonics:**

- -10 dBc

**Frequency Switching Transients:**

- Output power can peak at +22 dBm during frequency switching

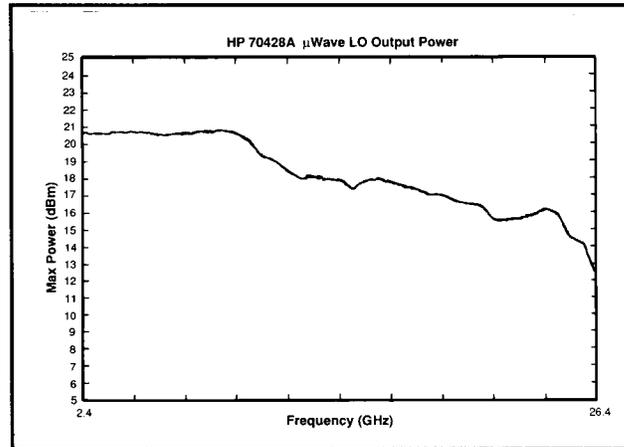
**Output Power Drift:**

- <1 dB after warm-up

**Output power settling time:**

- <100 ms

**Maximum Output Power vs Frequency:**



**Frequency Switching Speed:**

- Standard:
  - ▲ 3 seconds
- Option 002:
  - ▲ 6 seconds

**Reference Tuning:**

- Voltage control of the internal reference oscillators is available through a port on the front panel.

**Tuning Range (sensitivity):**

- Configuration 1:
  - ▲  $\pm 0.25$  ppm (0.05 ppm/volt)
- Configuration 2:
  - ▲  $\pm 5$  ppm (1 ppm/volt)
- Configuration 3:
  - ▲  $\pm 100$  ppm (20 ppm/volt)

**Tuning Port Voltage Range:**

- $\pm 5$  volts (overrange  $\pm 10$  volts)

**Tuning Port Input Impedance:**

- 27.5 k $\Omega$  (0.05 ppm/volt)
- 100 k $\Omega$  (1 ppm/volt and 20 ppm/volt)

---

## HP 70428A Option 002 Specifications

### RF Output

#### Frequency Range:

- 2.4 GHz to 25.8 GHz

#### Frequency Resolution:

- 0.1 Hz: 2.4 to 26.5 GHz
- Exceptions:
  - ▲ 0.2 Hz:  $25.84 \text{ GHz} \leq \text{Carrier Frequency} < 26.1 \text{ GHz}$
  - ▲ 0.2 Hz:  $26.44 \text{ GHz} \leq \text{Carrier Frequency} \leq 26.5 \text{ GHz}$

#### Output Power:

- 2.4 to 6.6 GHz
  - ▲ 0 to +16 dBm
- 6.6 to 25.8 GHz
  - ▲ 0 to +10 dBm
- 25.8 to 26.5 GHz
  - ▲ 0 to +7 dBm

#### Requires HP 8662A or HP 8663A as an RF Source:

Add capability to the HP 70428A such that an RF source can be mixed with the microwave source. The front panel frequency of the RF source is automatically controlled by the 70428A over HP-IB.

#### HP 70428A Option 002 Spectral Purity:

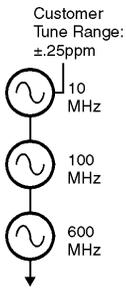
The following spectral purity table (Table 9-14) combines the HP 70428A Option 002, configuration 1, with the HP 8662A or HP 8663A synthesized signal generators when used as a microwave source. All noise levels are in units of dBc/Hz unless otherwise noted. Spurious and phase noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points. To combine the HP 8662A/3A phase noise with configuration 2 and 3 tables, use the phase noise numbers from this table for offsets  $\geq 1$  kHz and configuration 2 and 3 tables for offsets  $\leq 100$  Hz.

**Configuration 1 - All Oscillators Locked:**

Best phase noise <100 Hz frequency offsets, narrow tuning sensitivity. Refer to Table 9-14.

**Table 9-14 HP 70428A Option 002 Configuration 1 - All Oscillators Locked**

Output Frequency	Offset From Carrier (Hz)												Spurious (dBc) <sup>2</sup>	
	1 <sup>1</sup>	10	100	1k	3k	5k	10k	100k	1M	10M	40M	10 to 100	1k to 100 MHz	
2.4 to 3.0 GHz	Typ.	-50	-80	-100	-119	-121	-124	-130	-130	-135	-147	-147	-60	-80
	Spec.	-43	-73	-92	-112	-112	-114	-124	-124	-130	-142	-142	-50	-70
3.0 to 4.2 GHz	Typ.	-47	-77	-97	-122	-129	-130	-133	-136	-141	-149	-149	-54	-80
	Spec.	-42	-72	-92	-115	-117	-120	-128	-131	-136	-144	-144	-44	-70
4.2 to 6.0 GHz	Typ.	-44	-74	-94	-120	-124	-127	-131	-136	-141	-148	-148	-54	-80
	Spec.	-39	-69	-89	-114	-117	-119	-126	-131	-136	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	-42	-72	-92	-119	-123	-125	-130	-136	-140	-147	-147	-54	-80
	Spec.	-37	-67	-87	-113	-116	-118	-125	-131	-135	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	-40	-70	-90	-118	-121	-124	-129	-135	-139	-145	-145	-50	-80
	Spec.	-35	-65	-85	-112	-115	-117	-124	-130	-134	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	-38	-68	-88	-116	-121	-123	128	-134	-138	-143	-143	-50	-80
	Spec.	-33	-63	-83	-111	-114	-116	-123	-129	-133	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	-35	-65	-85	-113	-119	-121	-125	-133	-137	-140	-140	-47	-70
	Spec.	-30	-60	-80	-108	-112	-114	-120	-128	-132	-135	-135	-37	-60
18.0 to 26.5 GHz	Typ.	-32	-62	-82	-110	-115	-117	-122	-128	-133	-136	-136	-44	-65
	Spec.	-27	-57	-77	-105	-108	-110	-117	-123	-127	-131	-131	-34	-60



<sup>1</sup> All noise levels above -30 dBc/Hz are 3 dB below  $S_{\phi}(f)$  expressed in dB with respect to 1 rad<sup>2</sup>/Hz

<sup>2</sup> Mixing an RF source with the microwave LO in the HP 70428A Option 002 may result in some mixing spurious exceeding spurious specifications, see mixing spurious table on page X.

### AM Noise Of HP 70428A Option 002

Specifications apply for +10 dBm output power. All noise levels in dBc/Hz. AM noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points.

**Table 9-15 HP 70428A Opt. 002 AM Detector Noise Floor Specifications (+10 dBm)**

Output Frequency		Offset From Carrier (Hz)									Spurious (dBc)	
		1	10	100	1k	10k	100k	1M	10M	40M	10	1k to 40M
2.4 to 18.0 GHz	Typ.	-97	-107	-114	-130	-140	-150	-152	-152	-152	-60	-80
	Spec.	-92	-102	-106	-125	-135	-145	-147	-147	-147	-50	-70
18.0 to 26.5 GHz	Typ.	-97	-107	-114	-130	-139	-147	-151	-151	-151	-60	-80
	Spec.	-92	-102	-107	-125	-134	-142	-146	-146	-146	-50	-70

#### Mixing Spurious:

- < 6 GHz
  - ▲ <- 60 dBc except for those listed in Table 9-16 on page 9-27.
- > 6 GHz
  - ▲ <- 70 dBc

**Table 9-16 HP 70428A Option 002 Mixing Spurious**

Carrier frequency range (GHz) where a mixing spur will occur ≤ 40 MHz from carrier	Typical spurious level (dBc)
2.872 - 2.888, 2.990 - 3.010	-30
2.400 - 2.408, 2.737 - 2.749, 2.793 - 2.807 3.592 - 3.608, 4.193 - 4.207	-40
2.493 - 2.507, 2.565 - 2.578, 2.620 - 2.630 2.695 - 2.705, 3.422 - 3.435, 3.493 - 3.507	-50
2.662 - 2.672, 2.832 - 2.840, 2.928 - 2.938 3.080 - 3.092, 3.370 - 3.380, 4.108 - 4.120	-60

#### AM Noise Supplemental Characteristics

**LO feedthrough at a harmonic of 600 MHz 430-480 MHz offset below carrier:**

- <-25 dBc typical

## General Specifications

### HP 71708A System Components:

- HP 70004A Color Display/Mainframe
- HP 70428A Microwave Source Module

### Internal Reference Oscillator:

- **Internal 10 MHz reference oscillator:**
  - ▲ 10 MHz quartz oscillator
- **Aging rate:**
  - ▲  $<1 \times 10^{-9}$ /day after 10 warm-up
- **Temperature Stability**
  - ▲  $<2 \times 10^{-8}$  over 0 to 55° C

### Rear Panel Connections:

- 10 MHz IN (+7 dBm required)
- Buffered 10 MHz OUT (Typical +7 dBm)
- 10 MHz OVEN OUT (Typical +10 dBm)
- 100 MHz OUT (Typical -2 dBm)
- 100 MHz OUT (Typical +8 dBm)
- 600 MHz OUT (Typical +20 dBm)
- 600 MHz OUT (Typical 0 dBm)
- TUNE SPAN OUTPUT (not specified)
- MULTIPLEXER OUT (not specified)
- TUNE OUTPUT (not specified)

### Environmental Temperature:

- Operational, 0 to 55° C
- Storage, -40 to +75° C

### Humidity:

- Operational, 0 to 95% relative humidity at 45° C

### Warm-up Time:

- 30 minutes recommended

### EMC:

- Meets MIL-STD 461B

### Power Requirements:

- HP 71707A supplied by the HP 70004 mainframe
- HP 70428A requires as much as 80 watts of regulated power from the mainframe

### Weight (nominal) HP 71708A:

- 26.8 kg (58.9 lb) nominal

### Weight (nominal) HP 71708A Option 002:

- 29.3 kg (64.5 lb) nominal

**Weight (nominal) HP 70428A:**

- 7.4 kg (16.1 lb) nominal

**Weight (nominal) HP 70428A Option 002:**

- 9.9 kg (21.7 lb) nominal

**Warranty:**

- One year (extendible with options)

**Calibration Cycle:**

- One year recommended

**Supported power meters of output power calibration (of HP 71707A):**

- HP 70100A Power Meter
- HP 437B Power Meter
- HP 438A Power Meter

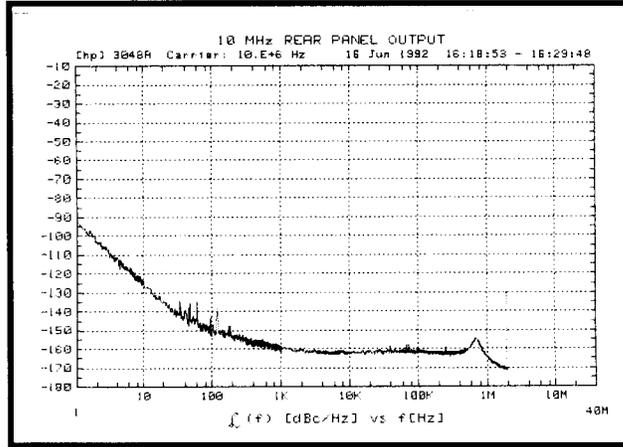
**Supported Display and Mainframe:**

- HP 70004A Color Display/Mainframe
- HP 70207B Display \* (software interface) with HP 70001A Mainframe

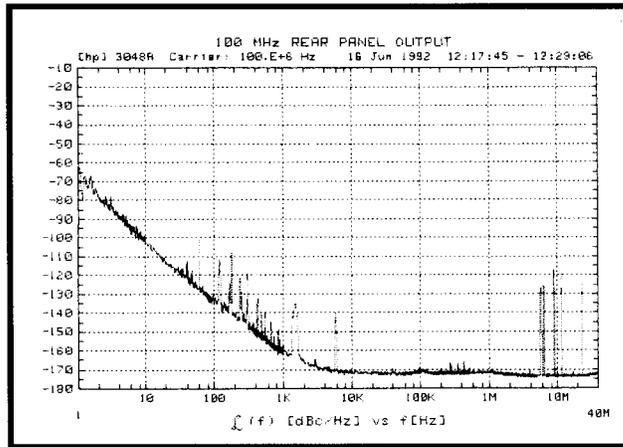
\* For more information, call your local Hewlett-Packard sales office listed in the telephone directory.

### General Specification Supplemental Characteristics

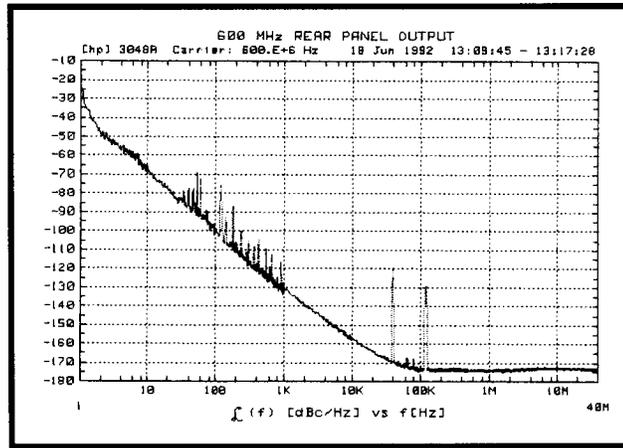
- **10 MHz Rear Panel Output:**
  - ▲ *Typical Phase Noise Performance*
- **100 MHz Rear Panel Output:**



▲ *Typical Phase Noise Performance*



- **600 MHz Rear Panel Output:**
  - ▲ *Typical Phase Noise Performance*



Technical Data  
**HP 70428A Option 002 Specifications**

# 10

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## Softkeys and Displays

### Overview

This chapter describes each softkey and screen in alphanumeric order. The softkeys and screens for the following modules are listed in order without regard for which module they belong to:

- HP 70427A Downconverter Module
- HP 70428A Microwave Source Module
- HP 70428A Option 002 Microwave Source Module (Tunable Source)

Softkey maps are on foldout pages at the end of this chapter.

## 120-300, 480-600

This softkey tells the HP 70428A Option 002 to select an external RF source frequency between 120 and 300 MHz or between 480 and 600 MHz. The selection is stored in non-volatile memory.

The 120-300 MHz range has the lowest phase noise, but spurs may be higher.

**Path**                    *Service*    *Misc*    *Optimum Range*    120-300, 480-600

**HP-IB command**                    TS:RANG:MODE 1

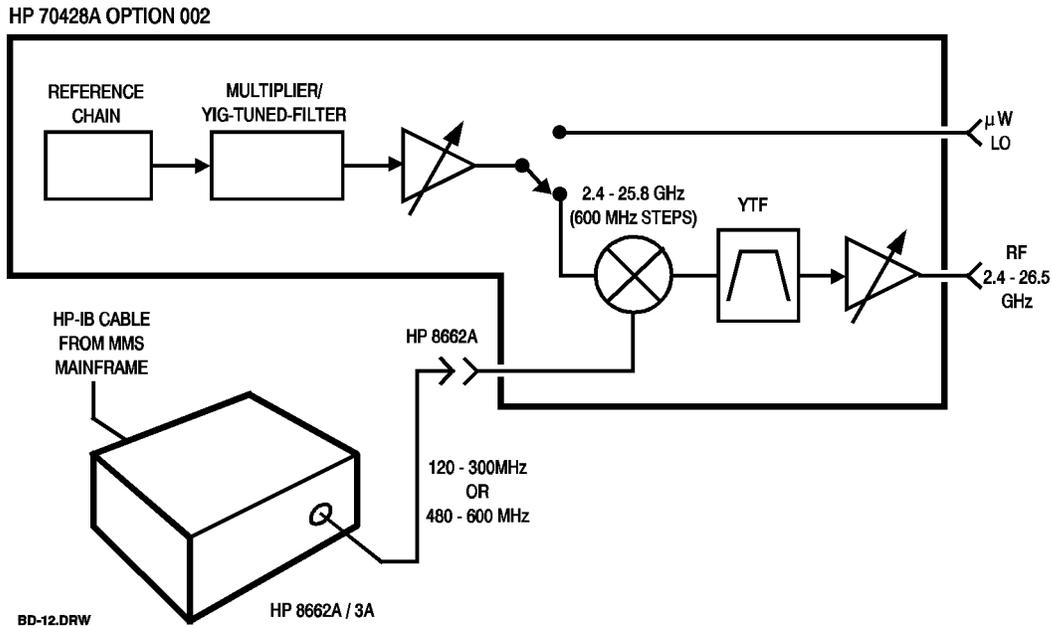


Figure 10-1 HP 70428A Option 002

## 300-600 Only

This softkey tells the HP 70428A Option 002 to select a frequency for the external RF source between 300 and 600 MHz. The selection is stored in non-volatile memory.

When the external RF source is an HP 8662A or HP 8663A the 300-600 MHz range gives the best spur performance. But, noise performance is better when the HP 8662A/8663A frequency is between 120 and 300 MHz.

**Path**                    *Service    Misc    Optimum Range    300-600 Only*

**HP-IB command**            TS:RANG:MODE 0

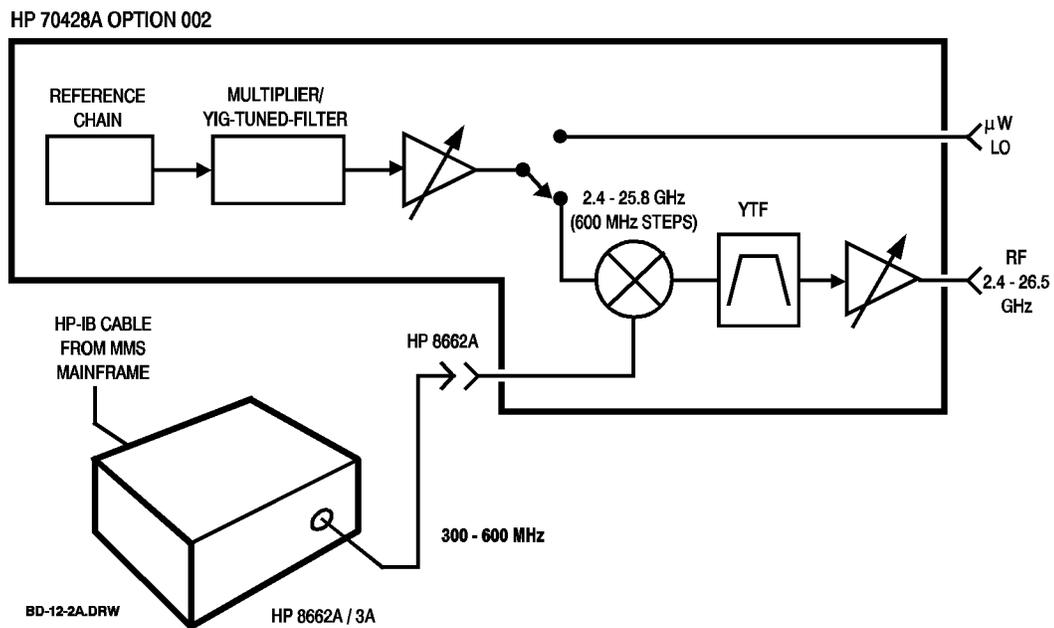


Figure 10-2 HP 70428A Option 002

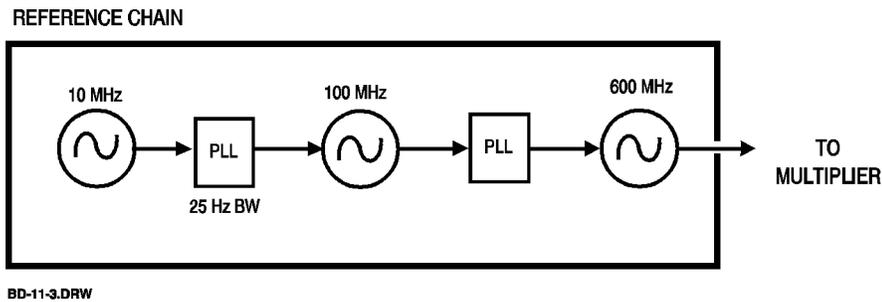
---

## 25 Hz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 25 Hz.

**Path** *Ref Chain 100 MHz PLL BW 25 Hz*

**HP-IB command** REF:BW:PLL100 0



*Figure 10-3 Reference Chain*

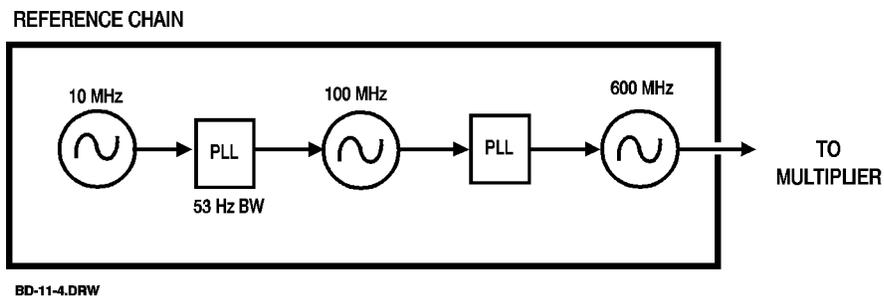
---

## 53 Hz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 53 Hz.

**Path** *Ref Chain 100 MHz PLL BW 53 Hz*

**HP-IB command** REF:BW:PLL100 1



*Figure 10-4 Reference Chain*

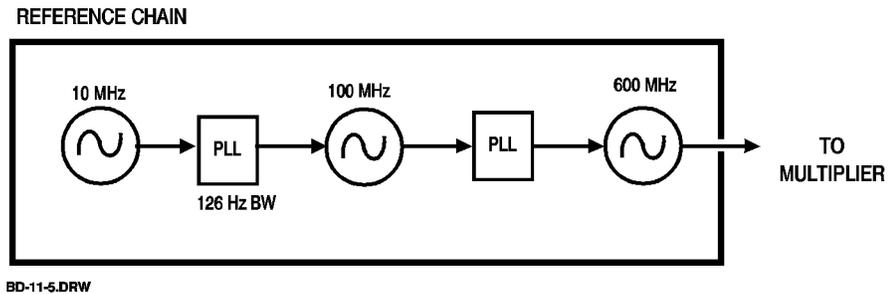
---

## 126 Hz default

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 126 Hz.

**Path** *Ref Chain 100 MHz PLL BW 126 Hz default*

**HP-IB command** REF:BW:PLL100 2



*Figure 10-5 Reference Chain*

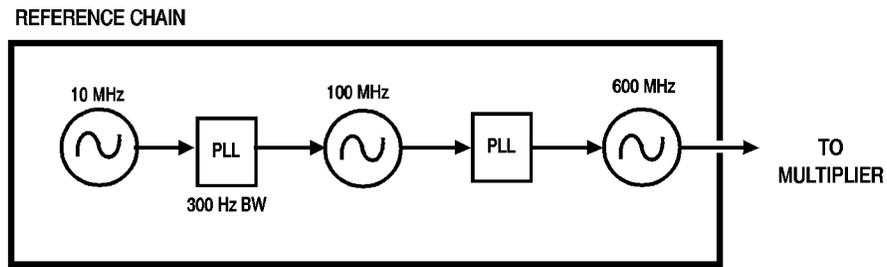
---

## 300 Hz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 300 Hz.

**Path** *Ref Chain 100 MHz PLL BW 300 Hz*

**HP-IB command** REF:BW:PLL100 3



BD-11-6.DRW

*Figure 10-6 Reference Chain*

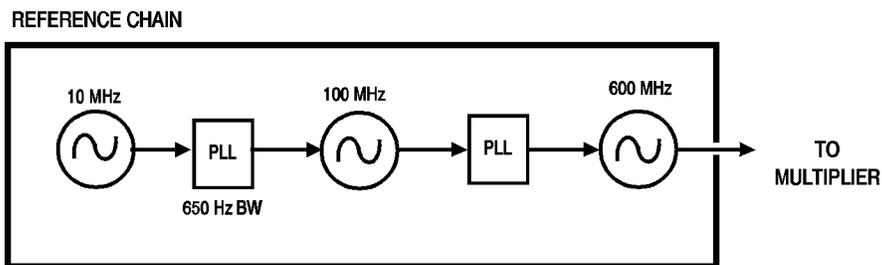
---

## 650 Hz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 650 Hz.

**Path** *Ref Chain 100 MHz PLL BW more 1 of 2 650 Hz*

**HP-IB command** REF:BW:PLL100 4



BD-11-7.DRW

*Figure 10-7 Reference Chain*

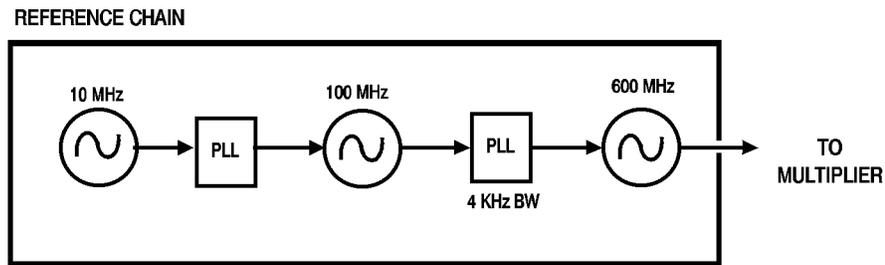
---

## 4 kHz

This softkey sets the 600 MHz oscillator's phase-lock-loop bandwidth to 4 kHz.

**Path** *Ref Chain 600 MHz PLL BW 4 kHz*

**HP-IB command** REF:BW:PLL600 0



BD-11-8.DRW

*Figure 10-8 Reference Chain*

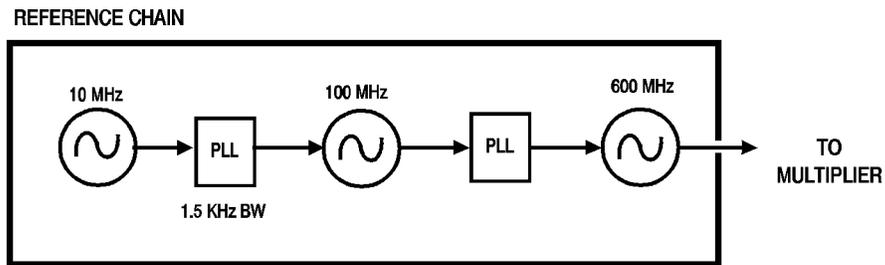
---

## 1.5 kHz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 1.5 kHz.

**Path** *Ref Chain 100 MHz PLL BW more 1 of 2 1.5 kHz*

**HP-IB command** REF:BW:PLL100 5



BD-11-9.DRW

*Figure 10-9 Reference Chain*

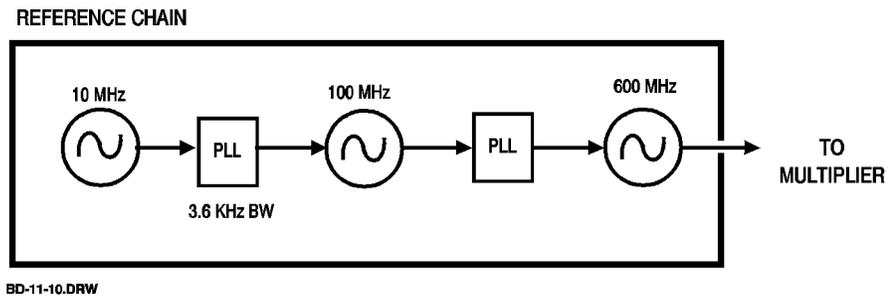
---

## 3.6 kHz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 3.6 kHz.

**Path** *Ref Chain 100 MHz PLL BW more 1 of 2 3.6 kHz*

**HP-IB command** REF :BW :PLL100 6



*Figure 10-10 Reference Chain*

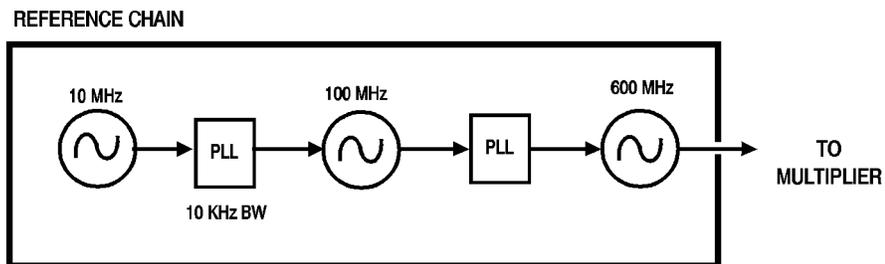
---

## 10 kHz/default

This softkey sets the phase-lock-loop bandwidth of the 600 MHz oscillator to 10 MHz.

**Path** *Ref Chain 600 MHz PLL BW 10 kHz*

**HP-IB command** REF:BW:600PLL 1



BD-11-11.DRW

*Figure 10-11 Reference Chain*

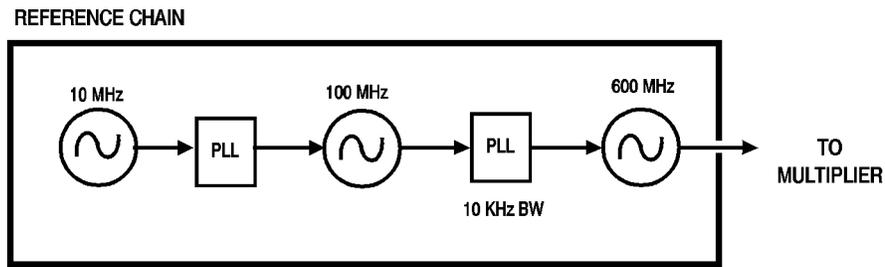
---

## 10 kHz

This softkey sets the phase-lock-loop bandwidth of the 100 MHz oscillator to 10 kHz.

**Path** *Ref Chain 100 MHz PLL BW more 1 of 2 10 kHz*

**HP-ID command** REF: BW: PLL1007



BD-11-12.DRW

*Figure 10-12 Reference Chain*

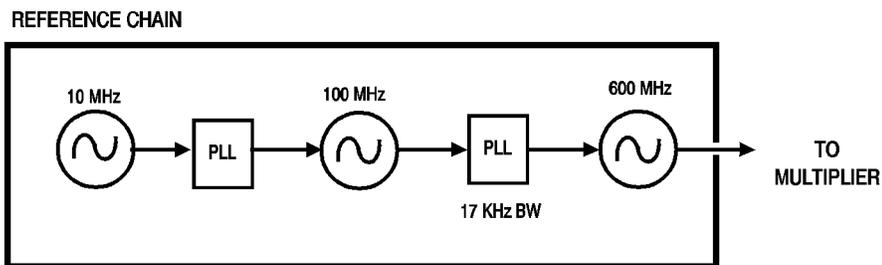
---

## 17 kHz

This softkey sets the phase-lock-loop bandwidth of the 600 MHz oscillator to 17 kHz.

**Path** *Ref Chain 600 MHz PLL BW 17 kHz*

**HP-IB command** `REF:BW:PLL600 2`



BD-11-13.DRW

*Figure 10-13 Reference Chain*

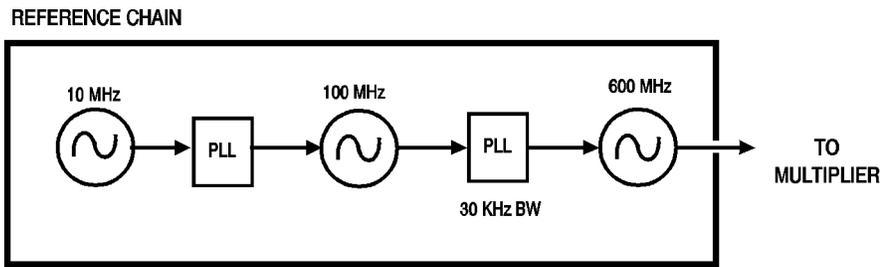
---

## 30 kHz

This softkey sets the phase-lock-loop bandwidth of the 600 MHz oscillator to 30 kHz.

**Path** *Ref Chain 600 MHz PLL BW 30 kHz*

**HP-IB command** REF:BW:PLL600 3



BD-11-14.DRW

*Figure 10-14 Reference Chain*

---

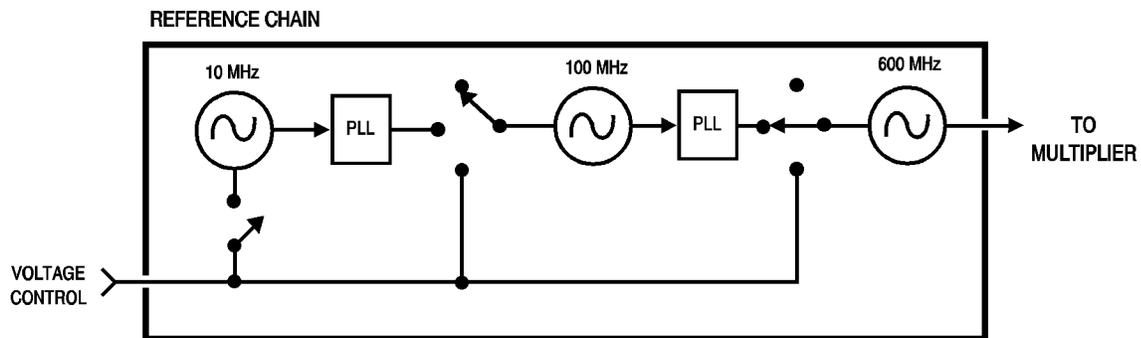
## 100 MHz no tune

This softkey disables the external tuning of the reference chain. The 100 MHz oscillator is free-running and the 600 MHz oscillator is locked to it.

Select this sensitivity for applications that require the best phase noise at >1 kHz offsets and when external tuning is not needed.

**Path** *Ref Chain Tune Sens 100 MHz no tune*

**HP-IB command** REF:TS 4



BD-10.DRW

*Figure 10-15 Reference Chain*

## 100 MHz PLL BW

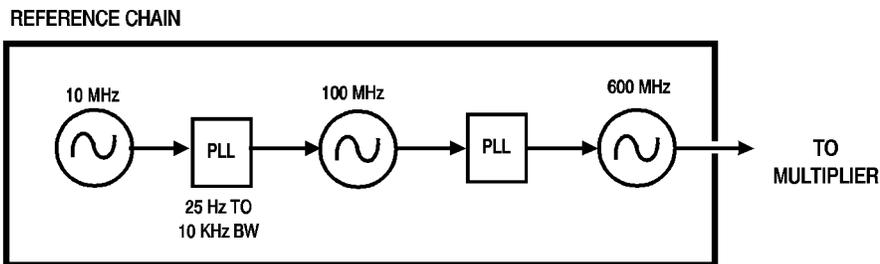
This softkey displays a menu of phase-lock-loop bandwidths for the 100 MHz oscillator . The choices are listed below. The default setting is 126 Hz.

**Path** *Ref Chain 100 MHz PLL BW*

**HP-IB commands** REF:BW:PLL100 *n*

Where *n* is as follows:

Bandwidth	<i>n</i>
25 Hz	0
53 Hz	1
126 Hz	2
300 Hz	3
650 Hz	4
1.5 kHz	5
3.6 kHz	6
10 kHz	7



BD-11-16.DRW

*Figure 10-16 Reference Chain*

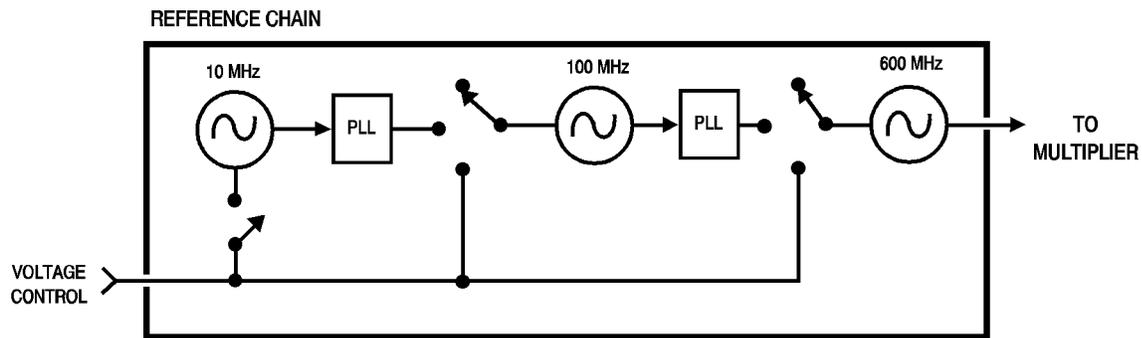
---

## 600 MHz no tune

This softkey disables external tuning of the reference chain. The 600 MHz oscillator is free-running, that is, it is not locked to the 100 MHz oscillator.

**Path** *Ref Chain Tune Sens 600 MHz no tune*

**HP-IB command** REF:TS 5



BD-10-17.DRW

Figure 10-17 Reference Chain

## 600 MHz PLL BW

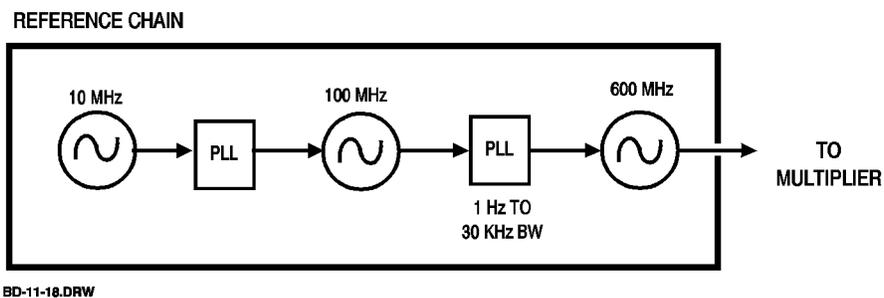
This softkey displays a menu of phase-lock-loop bandwidths for the 600 MHz oscillator. The choices are listed below. The default setting is 10 kHz.

**Path** *Ref Chain 600 MHz PLL BW*

**HP-IB commands** *REF:BW:PLL600 n*

Where *n* is as follows:

Bandwidth	<i>n</i>
1 kHz	0
10 kHz	1
17 kHz	2
30 kHz	3



BD-11-18.DRW

*Figure 10-18 Reference Chain*

---

## 0 ppm/V default

This softkey disables front-panel tuning of the reference chain. The 100 MHz oscillator is locked to the 10 MHz reference and the 600 MHz oscillator is locked to the 100 MHz oscillator.

Select this sensitivity for applications requiring the lowest possible noise at all offsets  $\leq$  and where external tuning is not needed.

**Path**                    *Ref Chain*    *Tune Sens*    0 ppm/V default

**HP-IB command**                    REF:TS 0

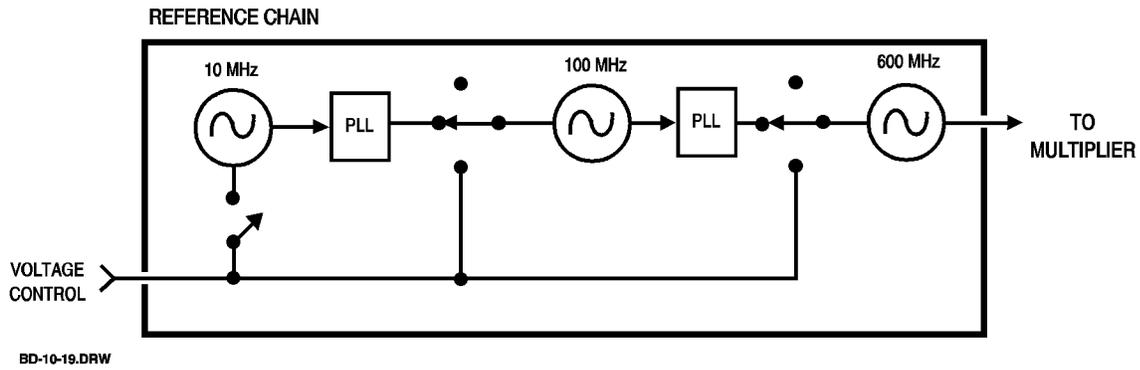


Figure 10-19 Reference Chain

## 0.05 ppm/V

This softkey sets the reference chain's tuning sensitivity to 0.25 parts-per-million (0.05 ppm/volt). The 10 MHz reference can be tuned externally from the front-panel **TUNE VOLTAGE** connector. The 100 MHz oscillator is locked to the 10 MHz reference and the 600 MHz oscillator is locked to the 100 MHz oscillator.

Select this sensitivity for applications requiring the lowest possible noise at offsets  $\leq 100$  Hz.

If the module is being used with the HP 3048 Phase Noise Measurement System with this tuning sensitivity, the 100 MHz PLL bandwidth must be set wider than the HP 3048's loop bandwidth.

**Path** *Ref Chain Tune Sens 0.05 ppm/V*

**HP-IB command** *REF:TS 1*

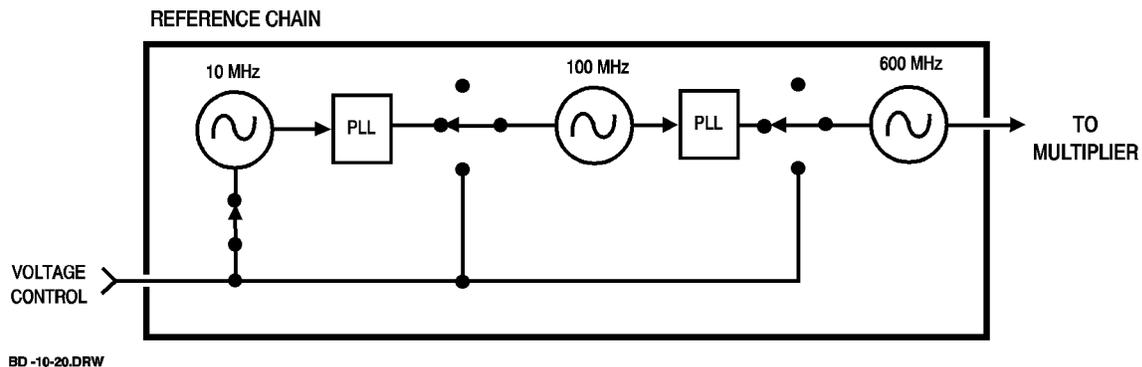


Figure 10-20 Reference Chain

---

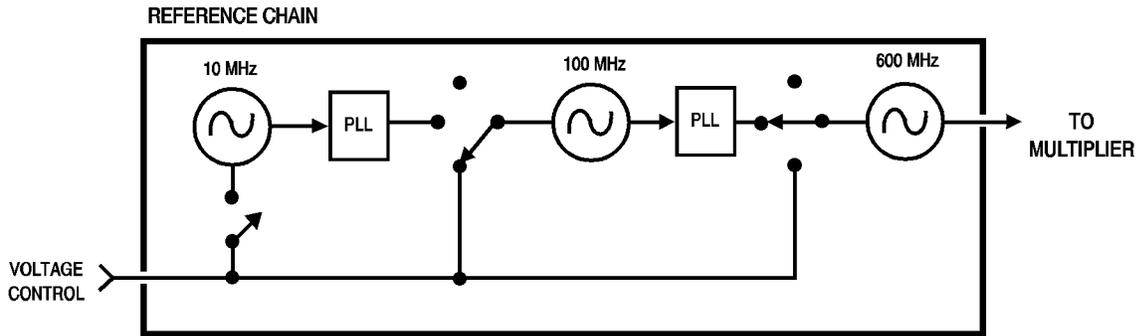
## 1.0 ppm/V

This softkey sets the reference chain's tuning sensitivity to 5 parts-per-million (1 ppm/volt). The 100 MHz oscillator is free running and can be tuned externally from the front-panel **TUNE VOLTAGE** connector. The 600 MHz oscillator is locked to the 100 MHz oscillator.

Select this sensitivity for applications that require the best phase noise at offsets  $\leq 1$  kHz and a moderate tuning range.

**Path** *Ref Chain Tune Sens 1.0 ppm/V*

**HP-IB command** REF:TS 2



BD-10-21.DRW

Figure 10-21 Reference Chain

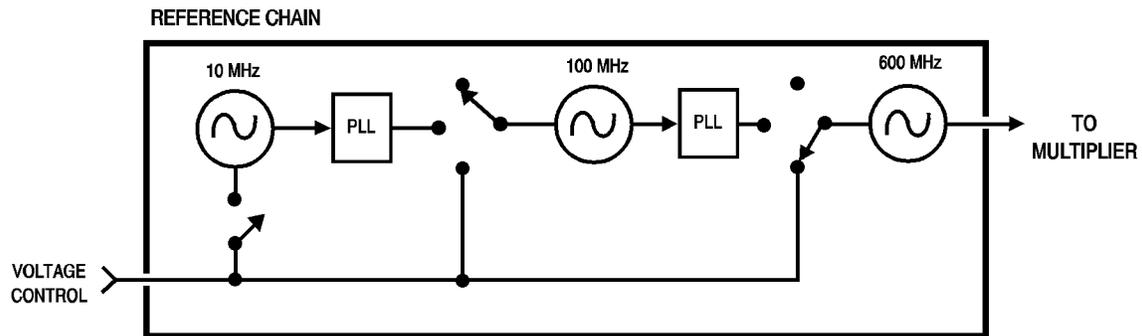
## 20 ppm/V

This softkey sets the reference chain's tuning sensitivity to 100 parts-per-million (20 ppm/volt). The 600 MHz oscillator is free running and can be tuned externally from the front-panel **TUNE VOLTAGE** connector.

Select this sensitivity for applications that require a wide tuning range and a low noise floor at offsets  $\geq 10$  kHz.

**Path** *Ref Chain Tune Sens 20 ppm/V*

**HP-IB command** REF:TS 3



BD-10-22.DRW

Figure 10-22 Reference Chain

## A band 26.5 - 40

This softkey allows entry of a frequency from 26.4 GHz to 40.1 GHz. This frequency is the input frequency of an external mmWave harmonic mixer.

The downconverter computes and displays the LO, IF, and comb line frequencies when an input frequency in this range is entered. Attempts to enter input frequencies outside of this range are ignored.

**Path** This softkey is only displayed when the *MODE*  $\mu W/mm$  softkey has *mm* underlined.

*Freqs mm Band A band 26.5 - 40*

**HP-IB command**

DC:FREQ:MM:BAND 1

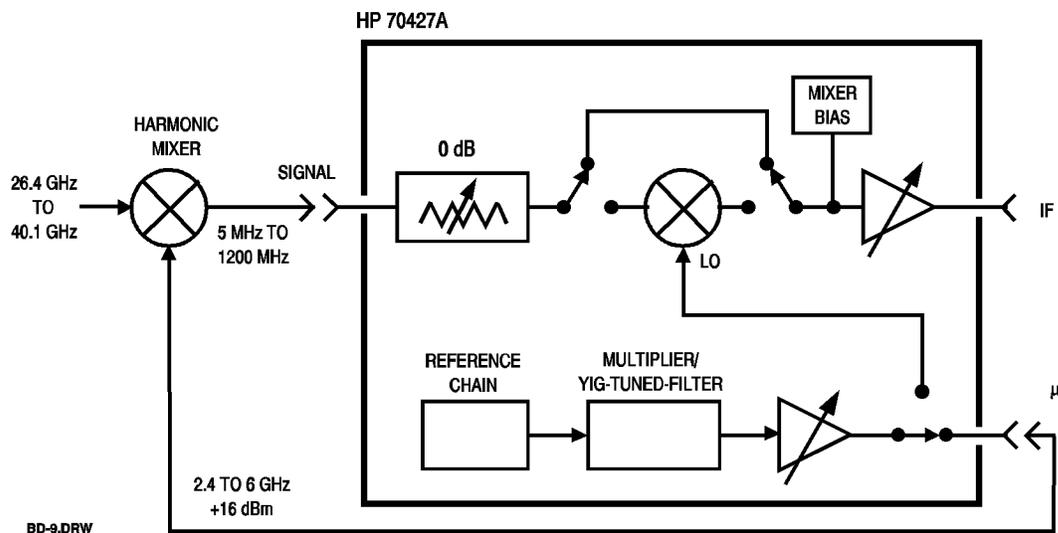


Figure 10-23 HP 70427A

## ALC ON| OFF

This softkey enables or disables the triggering of an automatic leveling process for the source and for the downconverter and tunable source LO. When *ON* is underlined, the leveling process is triggered each time a new output power (source) or LO power (downconverter and tunable source) is entered.

The leveling process lasts for a few seconds. During this time the level is measured repeatedly with the internal voltmeter and then the level is adjusted.

**Path** *Service Misc Power Control ALC ON | OFF*

**HP-IB Command** *SOUR:ALC 0 selects OFF*

*SOUR:ALC 1 selects ON*

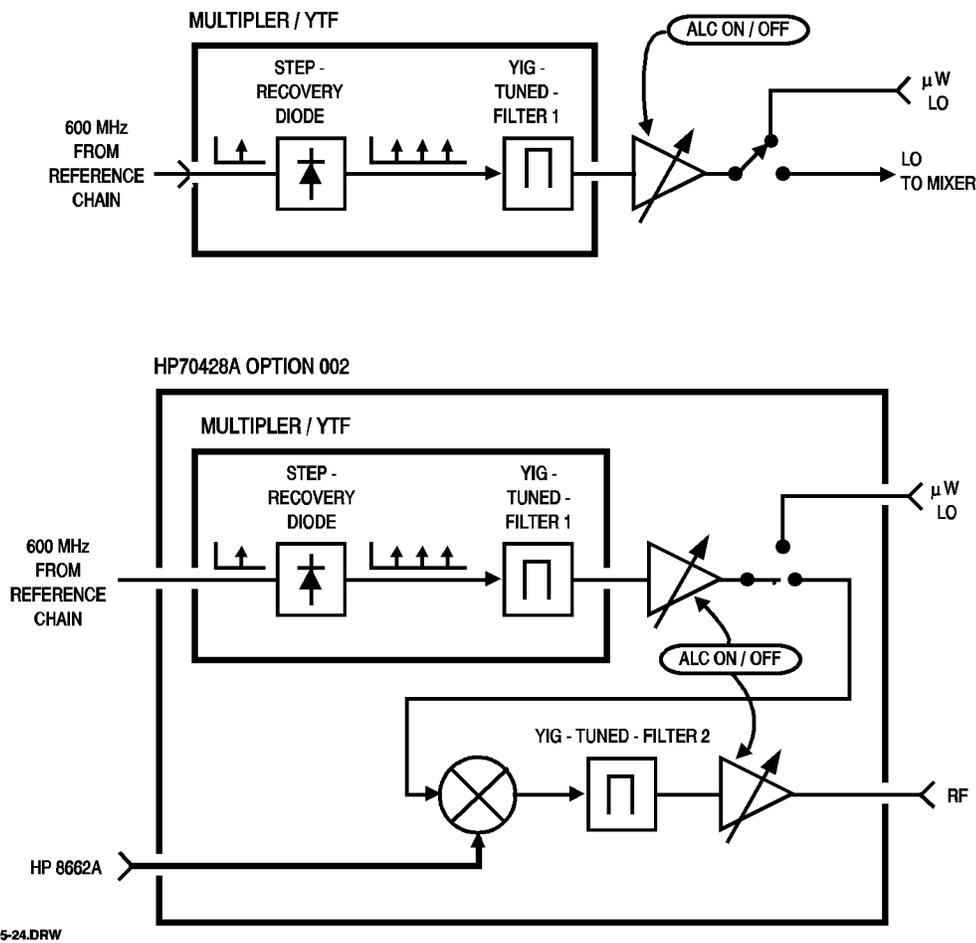


Figure 10-24 Multiplier / YTF

## AM Det Max Lvl

This display shows the AM detector's maximum level that was entered with the *AM DET MAX LVL* softkey.

The displayed value is used by the downconverter to set the maximum level of the RF AM detector's input when the *AUTO ATTEN* softkey is pressed from the *AM Noise* menu (with AM NSE on).

**Path** *AM Noise*

**HP-IB command** DC : AMN : AMD : MAXL ?

A real number is returned.

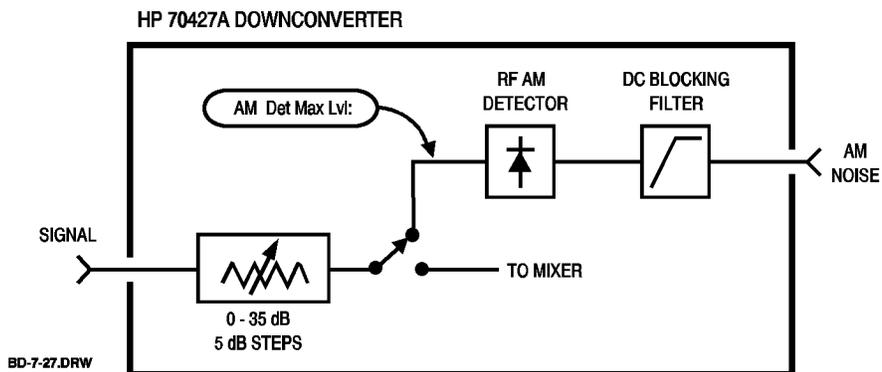


Figure 10-25 HP 70427A Downconverter

## AM DET MAX LVL

AM DET MAX LVL AM Detector maximum input level This softkey allows entry of a maximum input level for the RF AM detector. The entered level sets the trip point for autoranging the input attenuator.

The level range is 0 to +20 dBm (default is +15 dBm).

This softkey is disabled when the downconverter is in the mm mode.

**Path** `AM Noise` `AM DET MAX LVL`

**HP-IB command** `DC:AMN:AMD:MAXL value`

Where *value* is a real number between 0 dBm and +20 dBm.

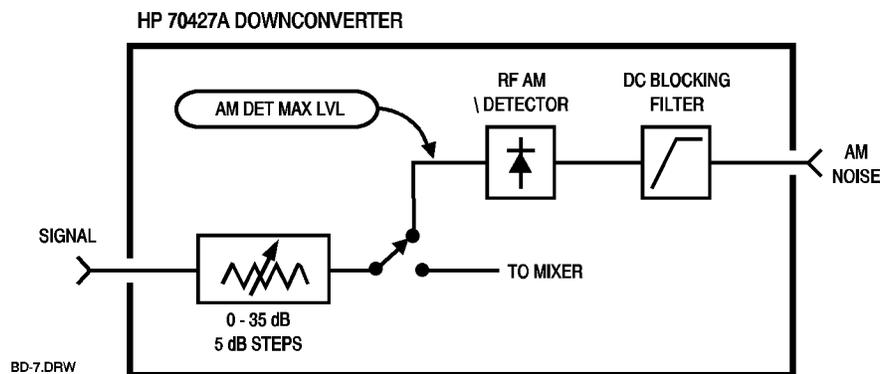


Figure 10-26 HP 70427A Downconverter

## AM Det Voltage

This display shows the output voltage of the RF or IF AM detector as of the last time a measurement was triggered. A measurement is triggered by pressing the *READ AMDET* softkey, or by accessing the AM Noise menu.

The measurement response time depends on the load connected to the **AM NOISE** connector. It can be as long as a few seconds. To check if the measurement has stabilized press the *READ* softkey several times.

The measurement is made with the internal voltmeter.

Path *AM Noise*

HP-IB command `DC:AMN:AMD?`

This command triggers an AM detector voltage measurement and returns the detector voltage in mV.

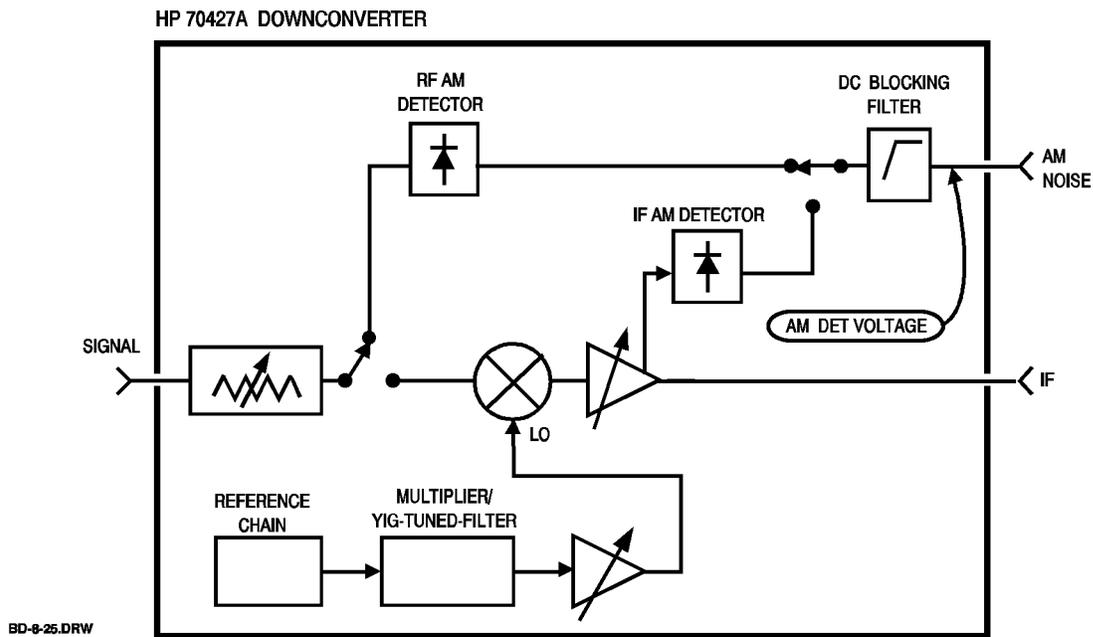


Figure 10-27 HP 70427A Downconverter

## AM Noise

This softkey displays a menu of choices for AM noise detector operation. It also changes the downconverter's display to show the **Input Atten:**, **AM Det Max Lvl:**, and **AM Det Voltage:**.

The RF AM detector is disabled when the downconverter is in the mm mode (*Freqs MODE  $\mu W/mm$* , with mm underlined). The IF AM detector can be used in mm mode.

**Path** *AM Noise*

**HP-IB command** None.

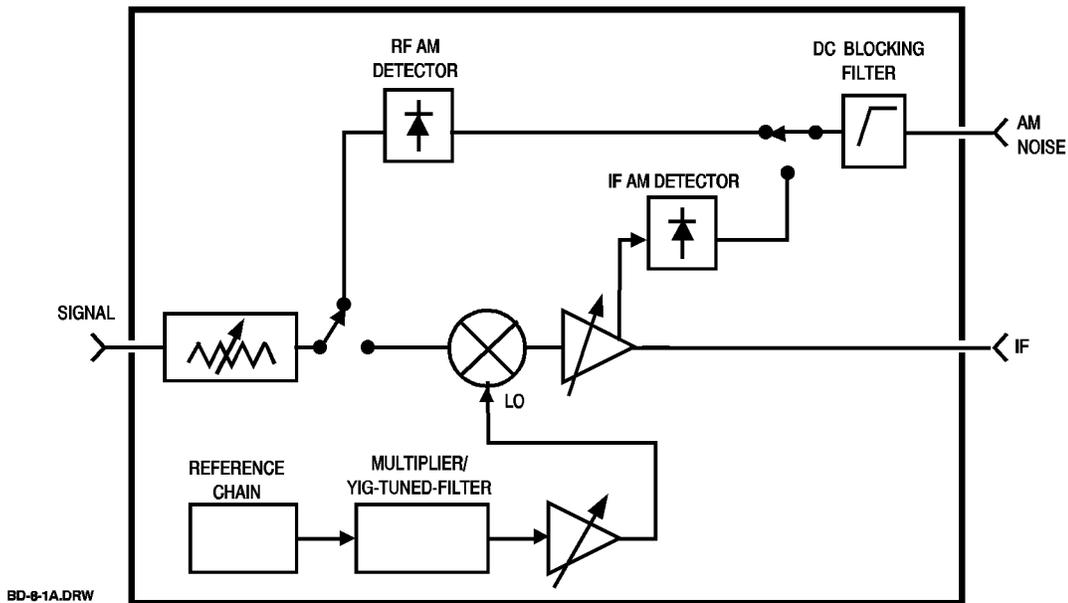


Figure 10-28 HP 70427A Downconverter

## AM NSE IN | IF

This softkey selects either the RF or IF AM detector.

When IN is underlined, the RF AM detector is selected and its output is routed to the front-panel **AM NOISE** output. The downconverter's mixer is disabled.

When IF is underlined, the IF AM detector is selected and its output is routed to the front-panel **AM NOISE** output. The downconverter operates normally.

The RF AM detector is disabled when an external mm wave mixer is used; the IF AM detector can be used.

**Path** *AM Noise* AM NSE IN | IF

**HP-IB command** DC:AMN:AMN 0 selects IF

DC:AMN:AMN 1 selects IN

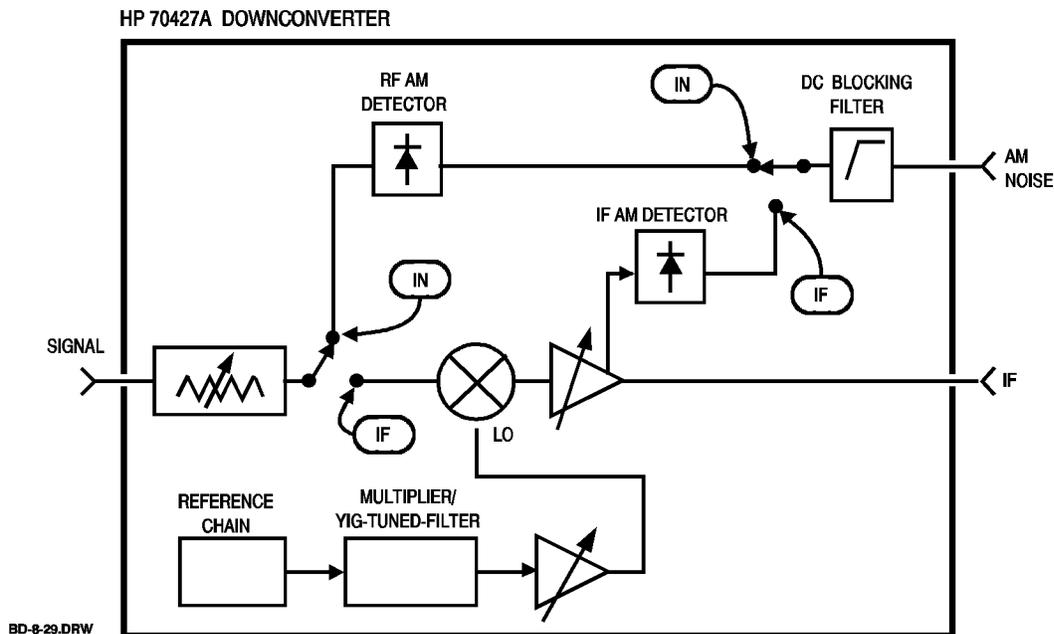


Figure 10-29 HP 70427A Downconverter

---

## *Amplitudes*

This softkey displays the following MENU of downconverter amplitude settings:

- AUTO RANGE
- VIEW IN | IF| -
- more 1 of 2
- INPUT ATTEN
- AUTO ATTEN
- IF GAIN
- Auto IF GAIN
- IF AM Output
- MIXER MAX LVL

**Path** *Amplitudes*

**HP-IB command** None.

## Atten

This display shows the setting of the downconverter's input attenuator.

The input attenuator is set with the *INPUT ATTEN* softkey, the *AUTO ATTEN* softkey, or the *AUTO RANGE* softkey.

If the downconverter is in mm mode (the *MODE  $\mu$ W/mm* softkey has mm underlined) zero is displayed and the input attenuator is set to 0 dB.

**Path**                    *Freqs*  
                                  or,  
                                  *Amplitudes*  
                                  or,  
                                  *AM Noise*

**HP-IB command**            DC:AMPL:INP:ATT?

An integer is returned: 0, 5, 10, 15, 20, 25, 30, 35.

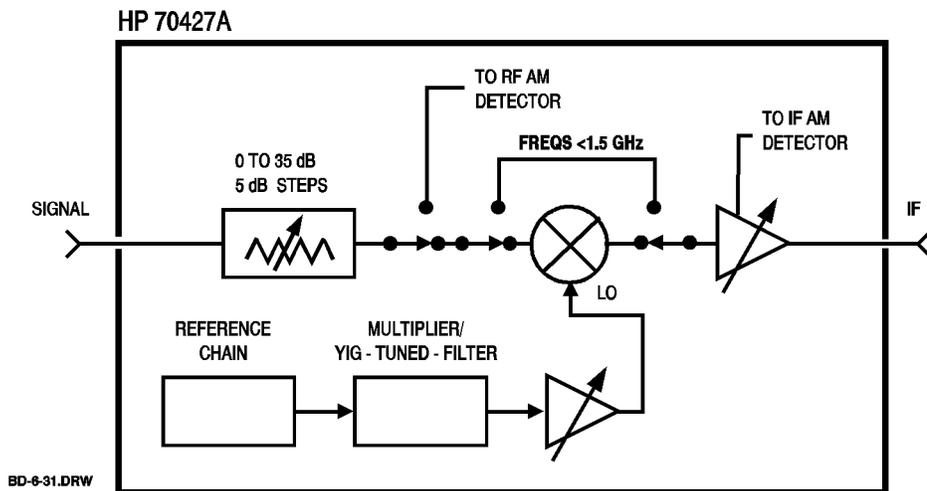


Figure 10-30 HP 70427A Downconverter

## **AUTO ATTEN**

This softkey triggers a one-time autoranging of the downconverter's input attenuator.

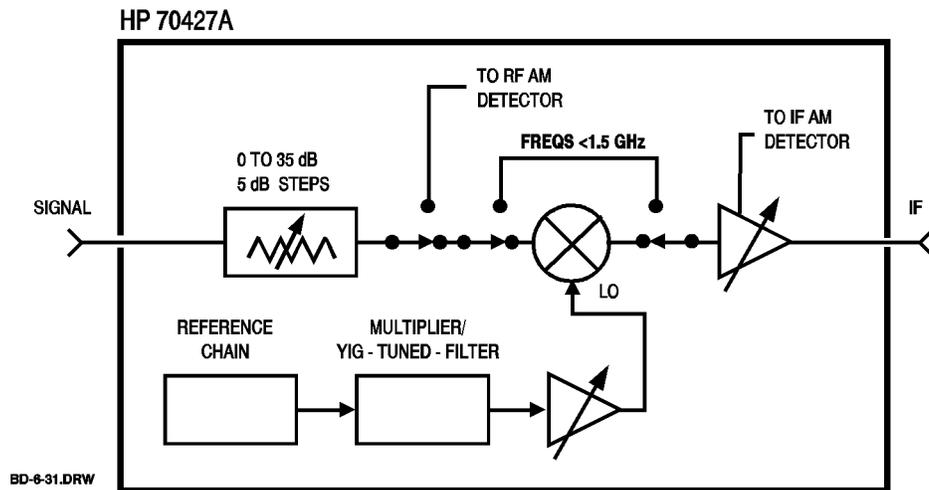
The downconverter autoranges by first setting the attenuator to its maximum attenuation (35 dB) then reducing the attenuation in 5 dB steps until the mixer's (or RF AM detector's) input level is between 0 and 5 dB below the limit shown on the **Mixer Max Level:** ( or **AM DET MAX Lvl:**) display. The level is measured by the downconverter's internal voltmeter. If no signal is measured when the attenuation reaches 0 dB, the attenuator is reset to 35 dB.

**Path** *Amplitudes more 1 of 2 AUTO ATTEN*

or,

*AM Noise AUTO ATTEN*

**HP-IB command** `DC:AMPL:INP:ATT AUTO`



*Figure 10-31 HP 70427A Downconverter*

## AUTO IF GAIN

This softkey triggers a one-time autoranging of the downconverter's IF gain.

The downconverter autoranges the IF amplifier's gain by first setting the gain to its minimum (-10 dB) then stepping the gain up in 5 dB steps until the signal level at the IF amplifier's output is between 0 and +6 dBm.

This function is disabled when the downconverter is in the AM noise mode (*AMNSE ON/OFF* softkey has ON underlined).

**Path** *Amplitudes more 1 of 2 AUTO IF GAIN*

**HP-IB command** DC:AMPL:IF:GAIN AUTO

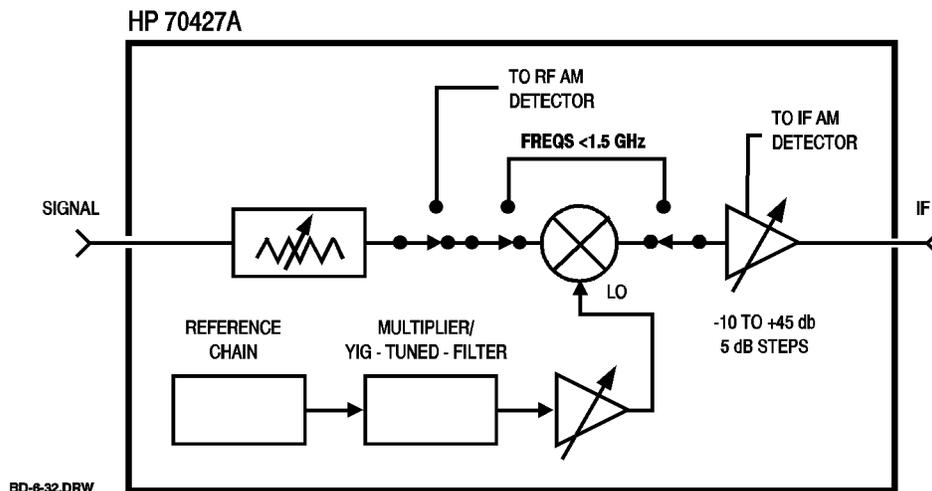


Figure 10-32 HP 70427A Downconverter

## AUTO RANGE

This softkey trigger's a one-time autoranging of the downconverter's input attenuator and IF gain. See the *AUTO ATTEN* and *AUTO IF GAIN* softkey descriptions for explanations of how the attenuator's settings and IF gains are determined.

**Path** *Amplitudes* *AUTO RANGE*

**HP-IB command** DC:AMPL:AUTO

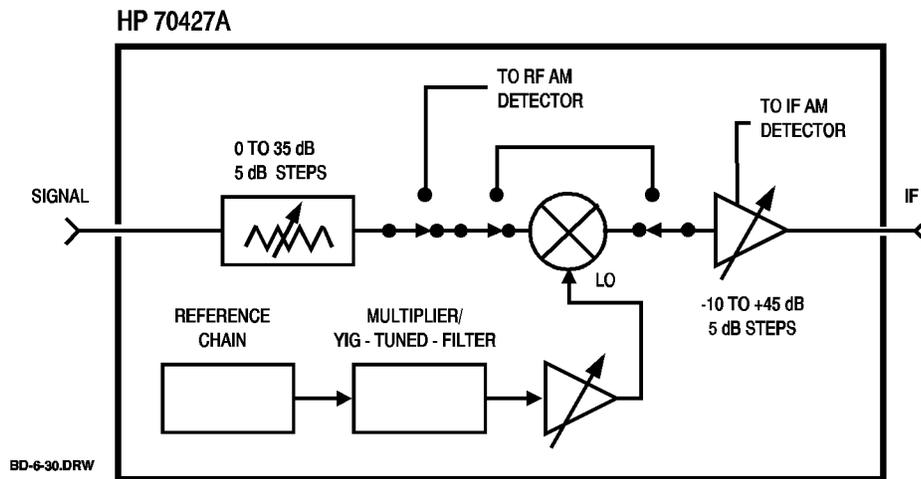


Figure 10-33 HP 70427A Downconverter

**BEGIN**

This softkey triggers a YIG-Tuned-Filter (YTF) frequency or power calibration.

**Path**            *Service*    *YTF Cal*    *YTFn Freq*    *BEGIN*

or,

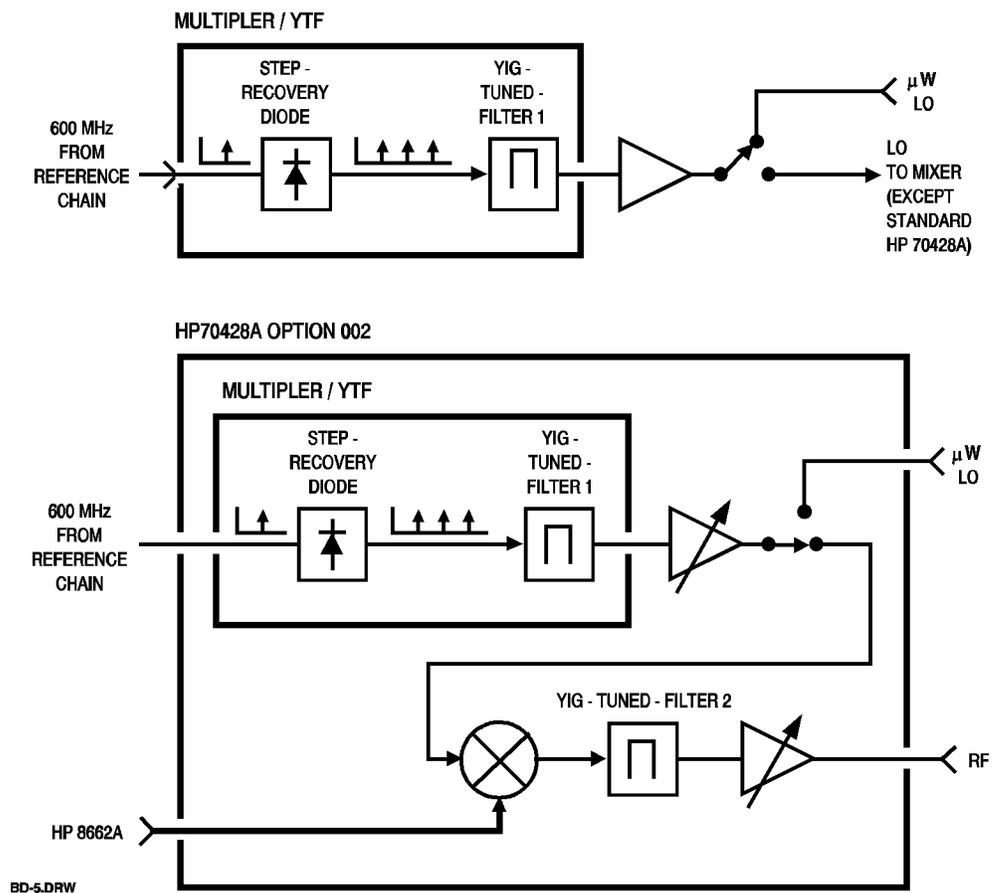
*Service* *YTF Cal* *YTFn Power* *BEGIN*

Where  $n$  is 1 or 2.

**HP-IB command**    *SOUR:FREQ:CAL* *calibrates frequency*

*SOUR:POW:CAL* *calibrates power*

**See Also**            Chapter 15 - Adjustments



**Figure 10-34** *Multiplier / YTF*

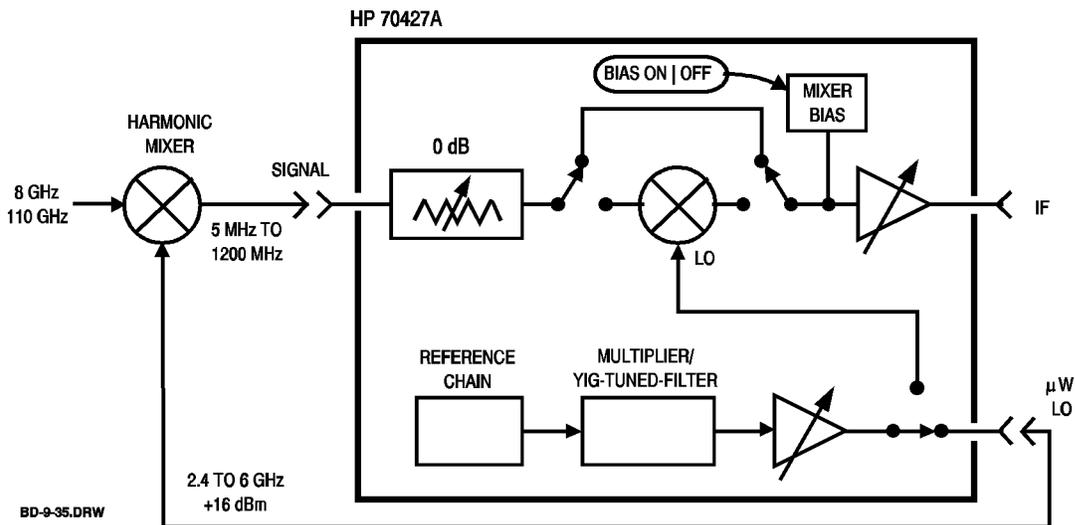
## **BIAS ON| OFF**

This softkey turns the bias current that the downconverter supplies to an external mixer bias on and off. The bias current level is set with the *Mixer Bias* softkey.

**Path** *Freqs*

This softkey is present only when the *MODE  $\mu$ W/mm* softkey has mm underlined.

**HP-IB command** `DC:FREQ:BIAS 0 sets bias off`  
`DC:FREQ:BIAS 1 sets bias on`



**Figure 10-35** HP 70427A

## ***BLOCK***

This softkey allows you to designate a circuit block for setting latches and relays and reading voltages with the *LATCH DATA*, *RELAY STATE*, and *VOLTMETER* softkeys.

Each time it is pressed it selects the next block and displays it in the **Block** :

Block names are shown on the block diagram in chapter 13.

**Path**                    *Service    Hardware Control    BLOCK*

**HP-IB command**            *DIAG:BLOCK n*

Where *n* is the block number listed in chapter 13.

**See Also**            Chapter 8 - Advanced Hardware Control.

---

## Block

This display shows the block name selected with the **BLOCK** softkey.

**Path**            *Service*    *Hardwre Control*

**HP-IB command**            *DIAG:BLOCK?*

Returns an integer that represents a block name.

**See Also**            Chapter 8 - Advanced Hardware Control.

---

## Data

This display shows the value of the latch designated by the **Latch:** display. The latch value is set with the **LATCH DATA** softkey.

**Path**                    *Service*    *Hardwre*   *Control*

**HP-IB command**            DIAG:LATC:DATA?

Returns an integer.

## Det

This display shows the voltage measured during a YIG-Tuned-Filter (YTF) calibration.

**Path**                    *Service*    *YTF Cal*

**HP-IB command**                    None.

**See Also**                    Chapter 15 - Adjustments.

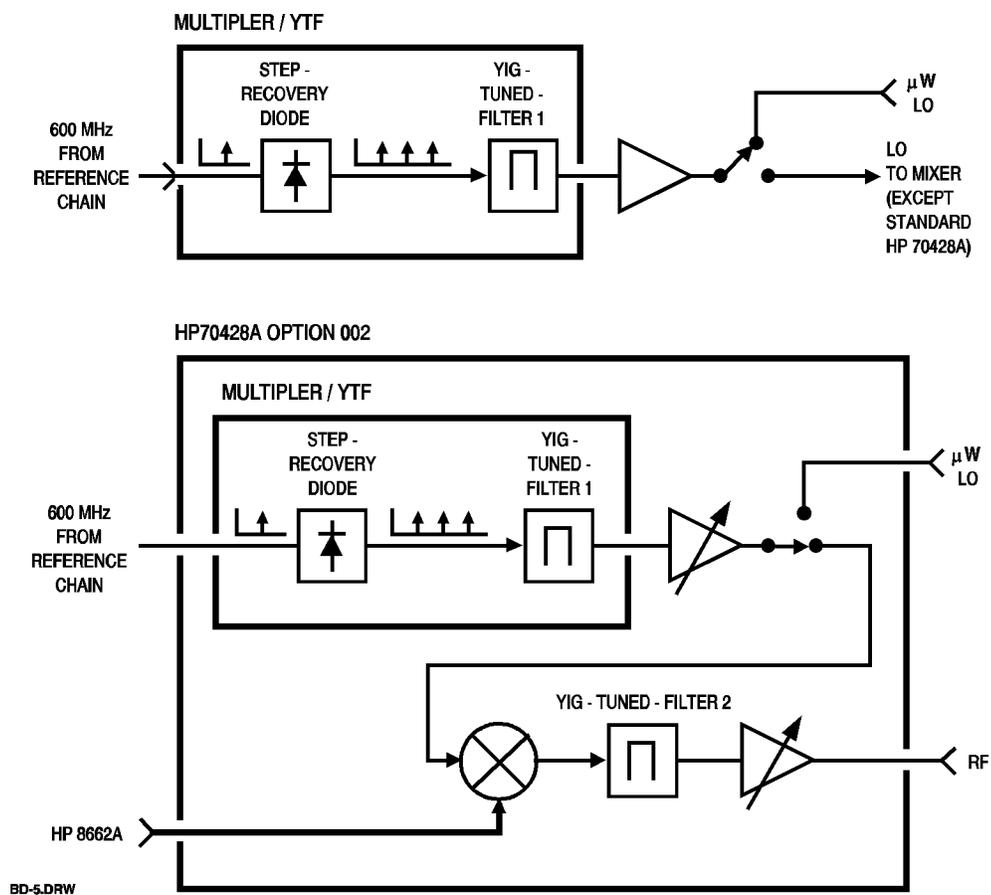


Figure 10-36 Multiplier / YTF

## ***Down Convert***

This softkey puts the HP 70427A in downconverter mode. It is displayed only when the HP 70427A is in source mode. Any source settings such as frequency and power will be preserved.

**Path**                    *Down Convert*

**HP-IB command**        INST 3

---

## ***EXIT***

This softkey selects the previous menu.

**Path** See the softkey maps at the end of this chapter.

**HP-IB command** None.

---

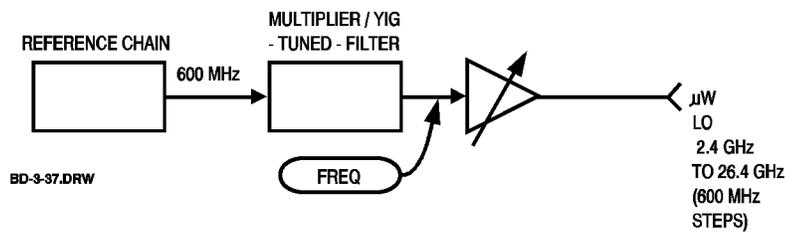
## FREQ

This softkey allows entry of the source's output frequency.

**Path**                      *Output FREQ*

**HP-IB command**        *SRC:OUT:FREQ frequency*

Where *frequency* is a real number between 2.4 GHz and 26.4 GHz in 600 MHz steps.



*Figure 10-37 Reference Chain*

## Freq

This display shows the YIG-Tuned-Filter (YTF) frequency as a YTF frequency calibration is being done.

**Path**                    *Service*    *YTF Cal*

**HP-IB command**                    None.

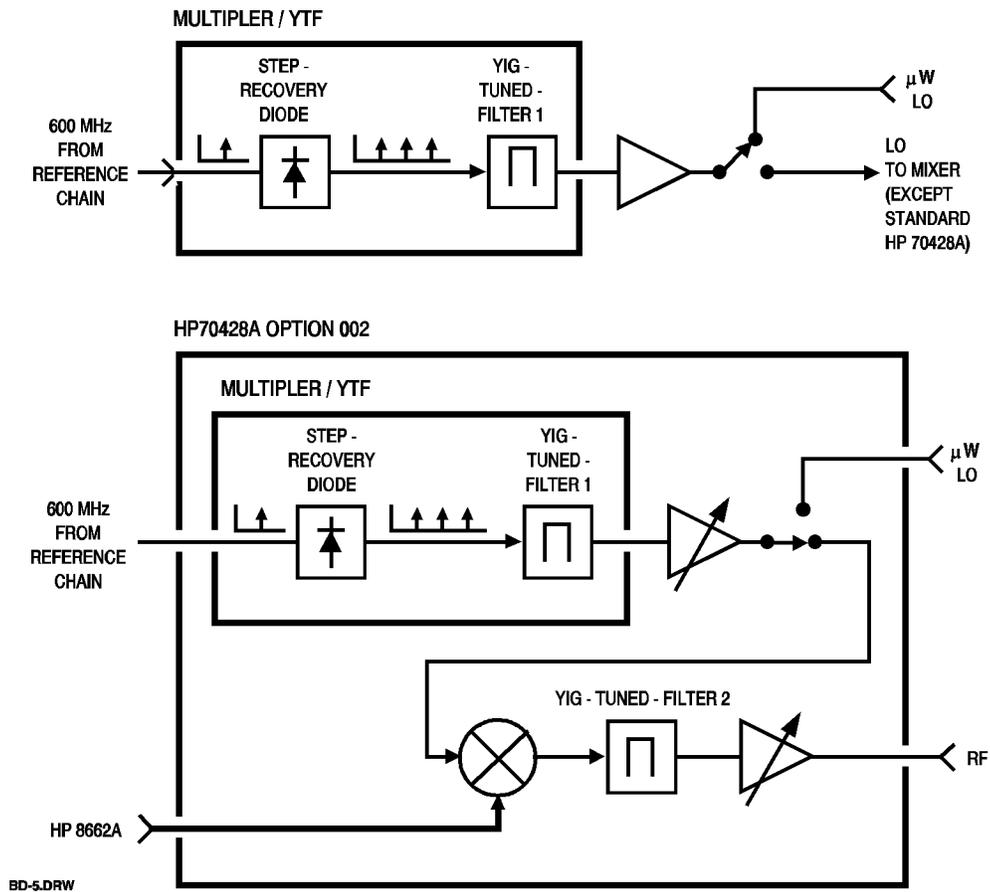


Figure 10-38 Multiplier /YTF

---

## Frequency

This display shows the source's output frequency.

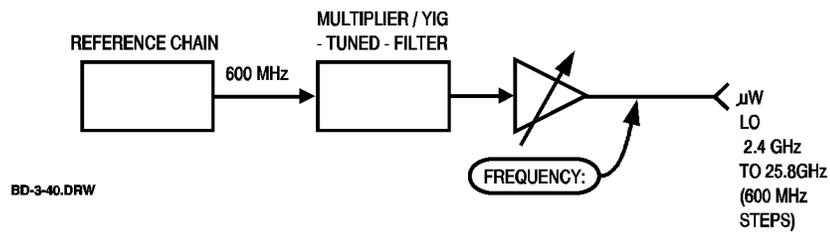
**Path**                    *Output*

or,

*Ref Chain*

**HP-IB command**        SOUR:FREQ?

Returns a real number.



*Figure 10-39 Reference Chain*

---

## *Freqs*

This softkey displays a menu softkeys for setting the downconverter's frequency. The softkeys are:

*INPUT FREQ*

*LO FREQ*

*LO Power*

*MODE  $\mu$ W/mm*

**Path** *Freqs*

**HP-IB command** None.

For downconverting input signals below 26.5 GHz, the *MODE  $\mu$ W* softkey must have  $\mu$ W underlined. In this mode, only the input frequency must be entered (*INPUT FREQ* softkey). The downconverter's firmware computes and displays the LO frequency and uses a factory default LO power.

For downconverting signals up to 110 GHz, the *MODE  $\mu$ W/mm* softkey must have mm underlined. In this mode the following additional softkeys will be displayed:

*mm Band*

*Mixer Bias*

*BIAS ON/OFF*

In this mode, the mm band must be selected and the frequency of the external mixer's input signal must be entered.

---

## *Hardwre Control*

This softkey displays a menu of hardware control choices.

The softkeys on this menu allow front-panel control of latches, relays, and internal voltmeter measurement points normally controlled by the module's firmware. The latches, relays, and voltmeter measurement points are arranged in logical blocks. Blocks, latches, and voltmeter measurement points are shown on the block diagram in chapter 13.

**Path**                    *Service    Hardwre Control*

**HP-IB command**        None.

**See Also**              Chapter 8 - Advanced Hardware Control.

---

## ***HP 437A/B***

This softkey designates an HP 473A/B as the power meter for a YIG-Tuned-Filter (YTF) calibration.

**Path**                    *Service Misc Pwrmttr Type HP 437A/B*

**HP-IB command**                    None.

## HP 8662A

This softkey designates an HP 8662A as the HP 70428A Option 002's external RF source.

**Path**                    *Service   Misc   RF Source   HP   8662A*

**HP-IB command**        None.

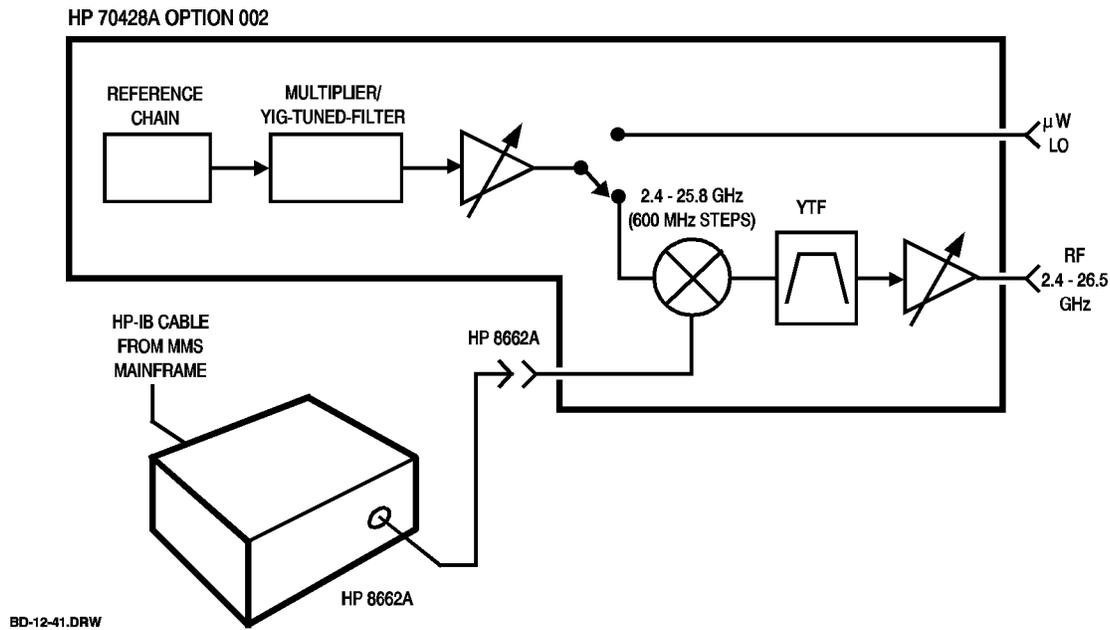


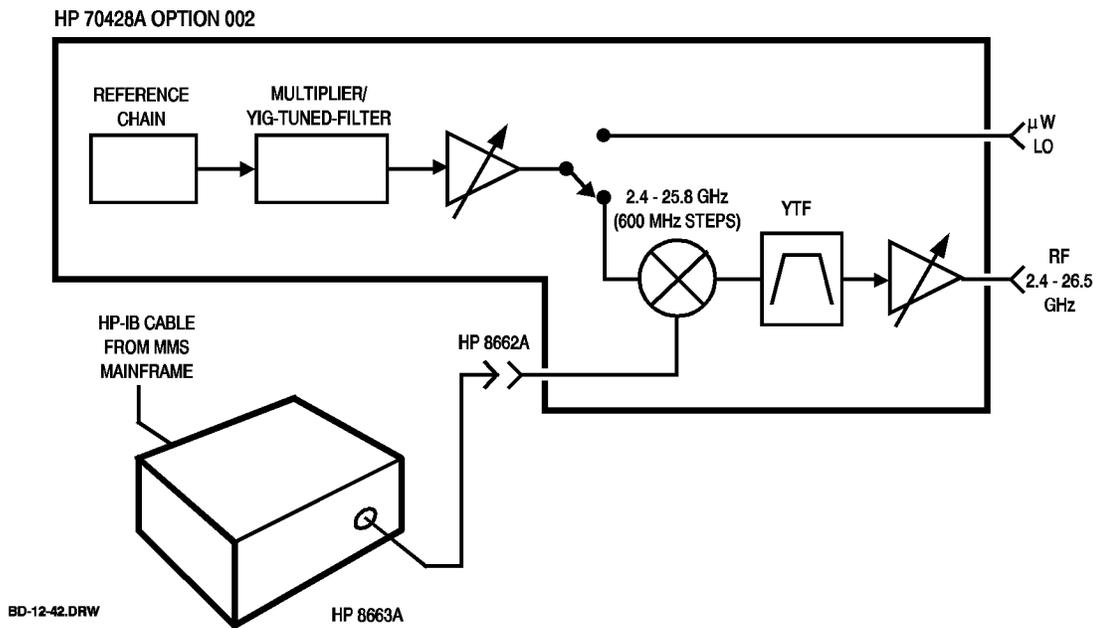
Figure 10-40 HP 70428A Option 002

## HP 8663A

This softkey designates an HP 8663A as the HP 70428A Option 002's external RF source.

**Path**                    *Service    Misc    RF Source    HP   8663A*

**HP-IB command**                    None.



*Figure 10-41 HP 70428A Option 002*

## ***HP 70100A***

This softkey designates an HP 70100A as the power meter for a YIG-Tuned-Filter (YTF) calibration.

**Path**                    *Service Misc Pwrmttr Type HP 70100A*

**HP-IB command**        None.

---

## HP-IB Addr

This display shows the HP-IB address of a power meter that will be used for YIG-Tuned-Filter (YTF) calibration. The address is entered with the *HP-IB ADDRESS* softkey.

In the HP 70428A Option 002, the other HP -IB Addr: display shows the HP-IB address of the HP 8662A or HP 8663A signal generator.

<b>Path</b>	<i>Service</i>	<i>Misc</i>
<b>HP-IB command</b>		None.

---

## ***HP-IB ADDRESS***

This softkey allows entry of the HP-IB address of a power meter that will be used for YIG-Tuned-Filter (YTF) calibration.

In the HP 70428A Option 002 it allows you to enter the HP-IB address of the HP 8662A or HP 8663A signal generator.

**Path**                    *Service*    *Misc*    *HP-IB ADDRESS*

**HP-IB command**        None.

---

## IF

This display shows the downconverter's IF frequency.

When an input frequency is entered with the **INPUT FREQ** softkey, the downconverter computes the IF frequency and displays it.

The IF frequency can be changed by changing the LO frequency with the **LO FREQ** softkey. The new IF frequency will be calculated and displayed even if it is out of range.

If only an LO frequency was entered, the **IF:** and **Input:** displays will be blank and it is up to you to keep track of the input and IF frequencies.

**Path**                    *Freqs*

or,

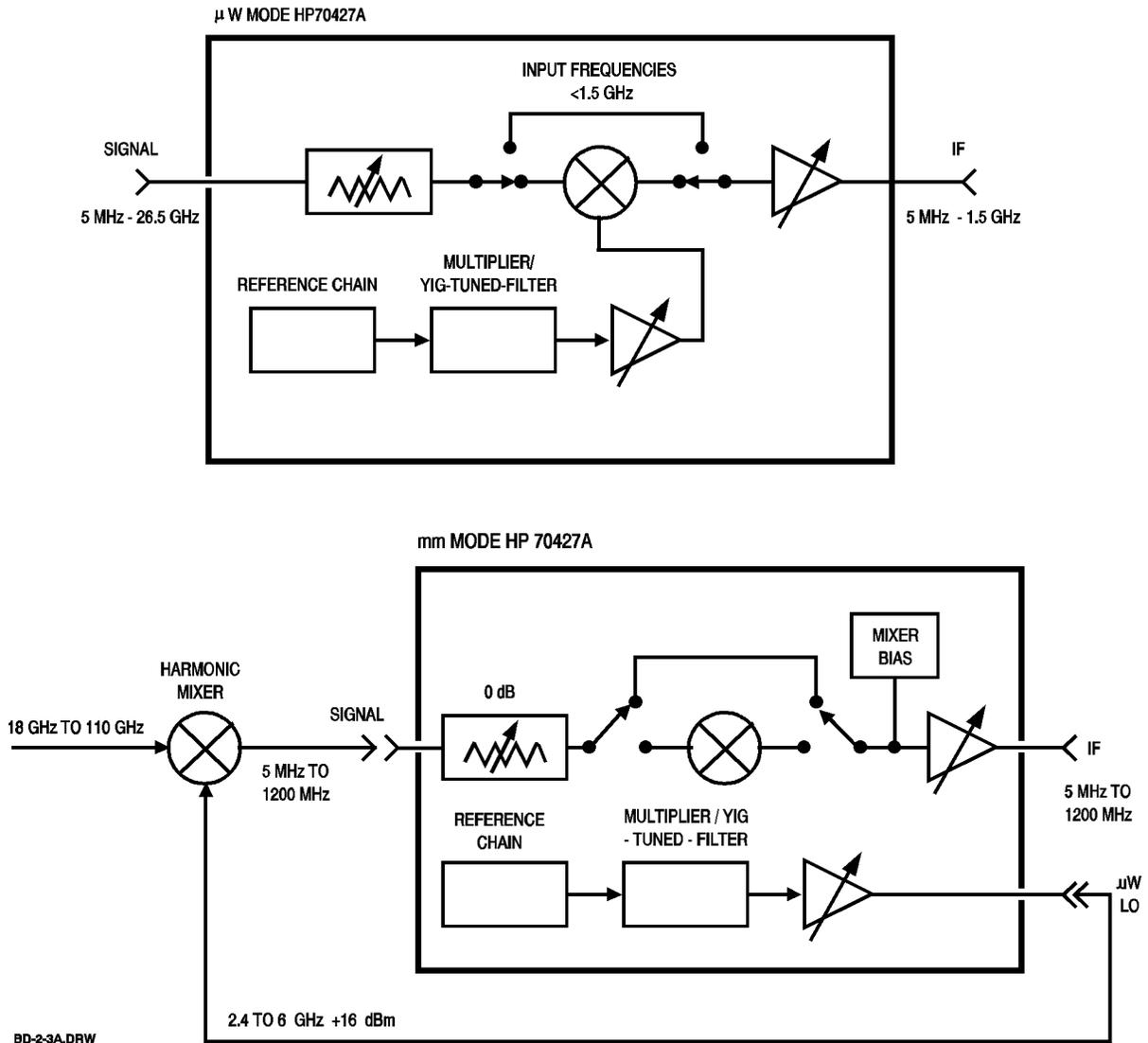
*Amplitudes*

or,

*Ref Chain*

**HP-IB command**                    DC:FREQ:IF?

Returns a real number.



BD-2-3A.DRW

Figure 10-42  $\mu$ W Mode HP70472A

## IF AM NOISE

This softkey routes the output of the downconverter's IF AM detector to the front-panel AM NOISE connector.

**Path** *Amplitudes more 1 of 2 IF AM Output IF AM NOISE*

**HP-IB command** DC:AMPL:IF:AM 1

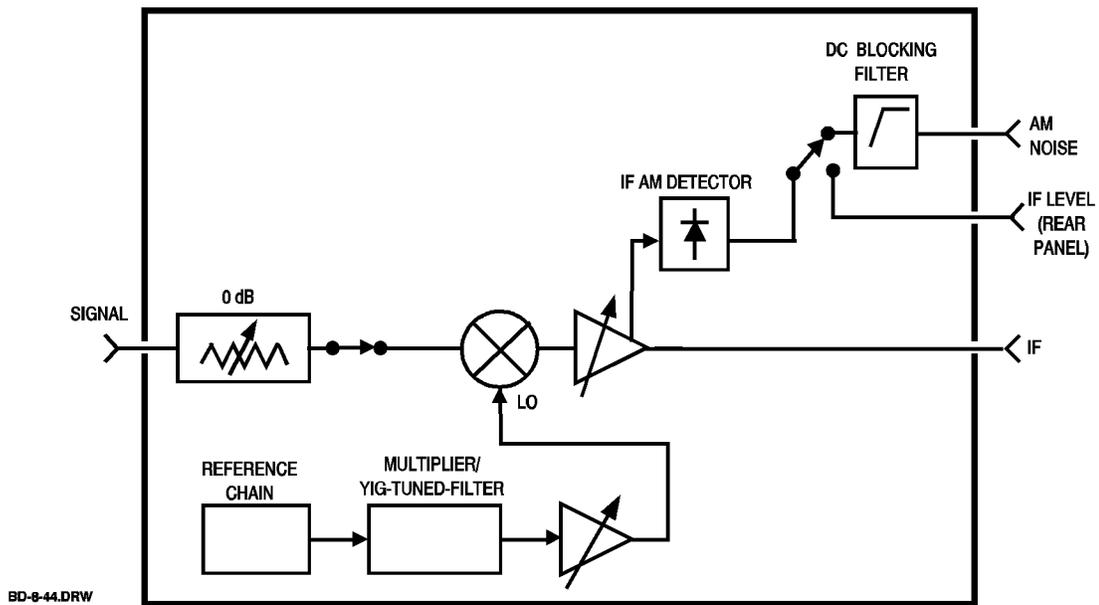


Figure 10-43 HP 70427A Downconverter

## IF AM Output

This softkey displays a menu of choices for routing the output of the downconverter's IF AM detector.

The *IF AM NOISE* softkey selects the front-panel **AM NOISE** output, and the *IF LEVEL* softkey selects the rear-panel **IF LEVEL** output.

The **AM NOISE** output is AC coupled, and the **IF LEVEL** output is DC coupled.

**Path** *Amplitudes more 1 of 2 IF AM Output*

**HP-IB command** DC:AMPL:IF:AM 0

*selects the rear-panel IF LEVEL output*

DC:AMPL:IF:AM 1

*selects the front-panel AM NOISE output*

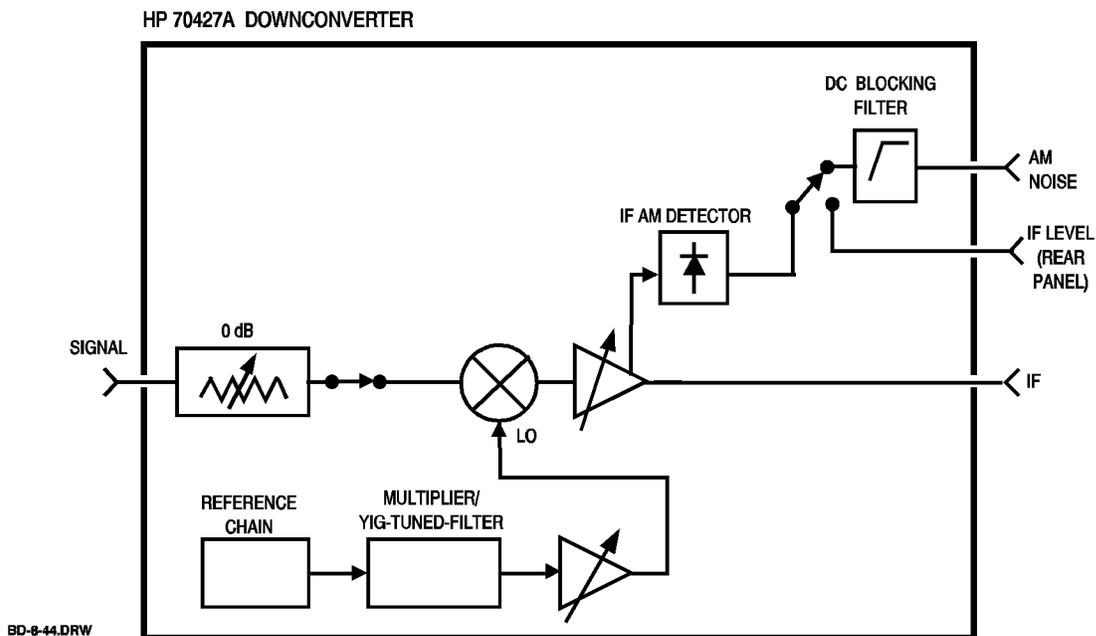


Figure 10-44 HP 70427A Downconverter

---

## ***IF GAIN***

This softkey allows you entry of the downconverter's IF gain from -10 to +45 dB in 5 dB steps.

**Path**                    *Amplitudes*    *more 1 of 2*    *IF GAIN*

**HP-IB command**            DC:AMPL:IF:GAIN gain

Where gain is an integer: -10 -5, 0,5,10,15,20,25,30,35,40,45.

## IF Gain

This display shows the downconverter's IF gain setting.

IF gain is entered with the *IF GAIN* softkey or set automatically when the *AUTO IF GAIN* softkey or the *AUTO RANGE* softkey is pressed.

**Path** *Amplitudes more 1 of 2 IF GAIN*

**HP-IB command** DC:AMPL:IF:GAIN?

Returns an integer.

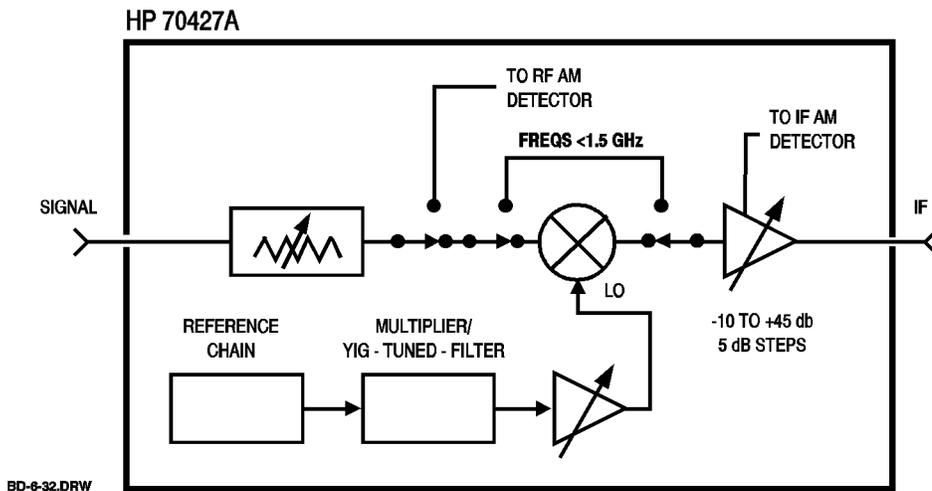


Figure 10-45 HP 70427A

## IF LEVEL

This softkey routes the output of the downconverter's IF AM detector to the rear-panel **IF LEVEL** connector.

**Path**    *Amplitudes*    *more 1 of 2*    *IF AM Output*    *IF LEVEL*

**HP-IB command**    DC:AMPL:IF:AM 0

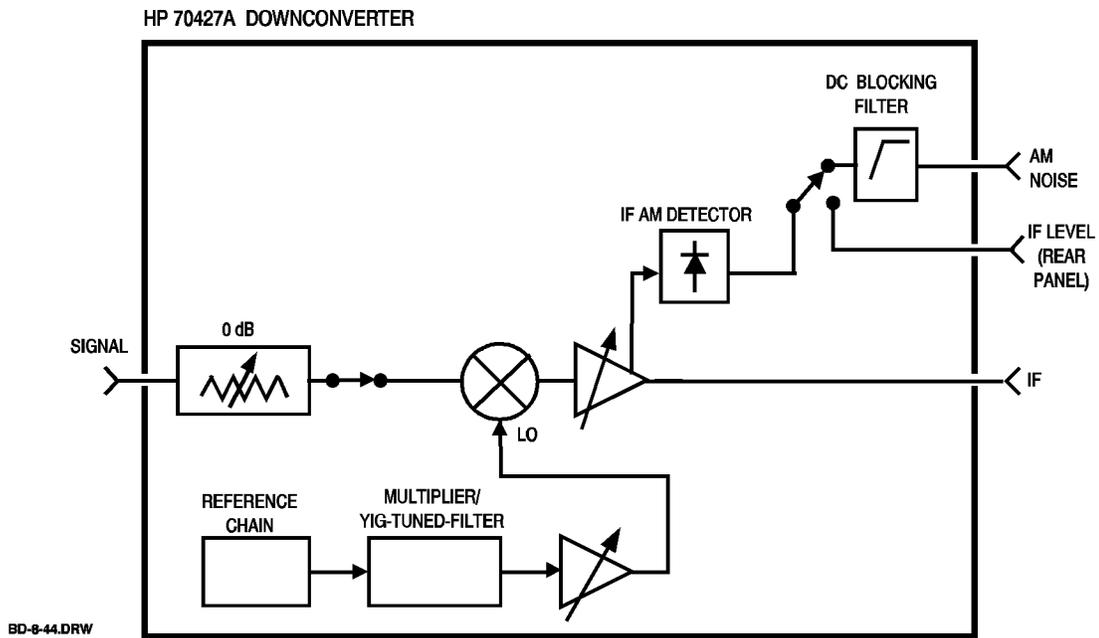


Figure 10-46 HP 70427A Downconverter

## Input

This display shows the value of the downconverter's input frequency that was entered with the *INPUT FREQ* softkey.

When the downconverter is in mm mode, it is the frequency of the input to an external harmonic mixer. This frequency is used to calculate LO and IF frequencies and to determine if bias current must be supplied to the external mixer.

**Path***Freqs*

or,

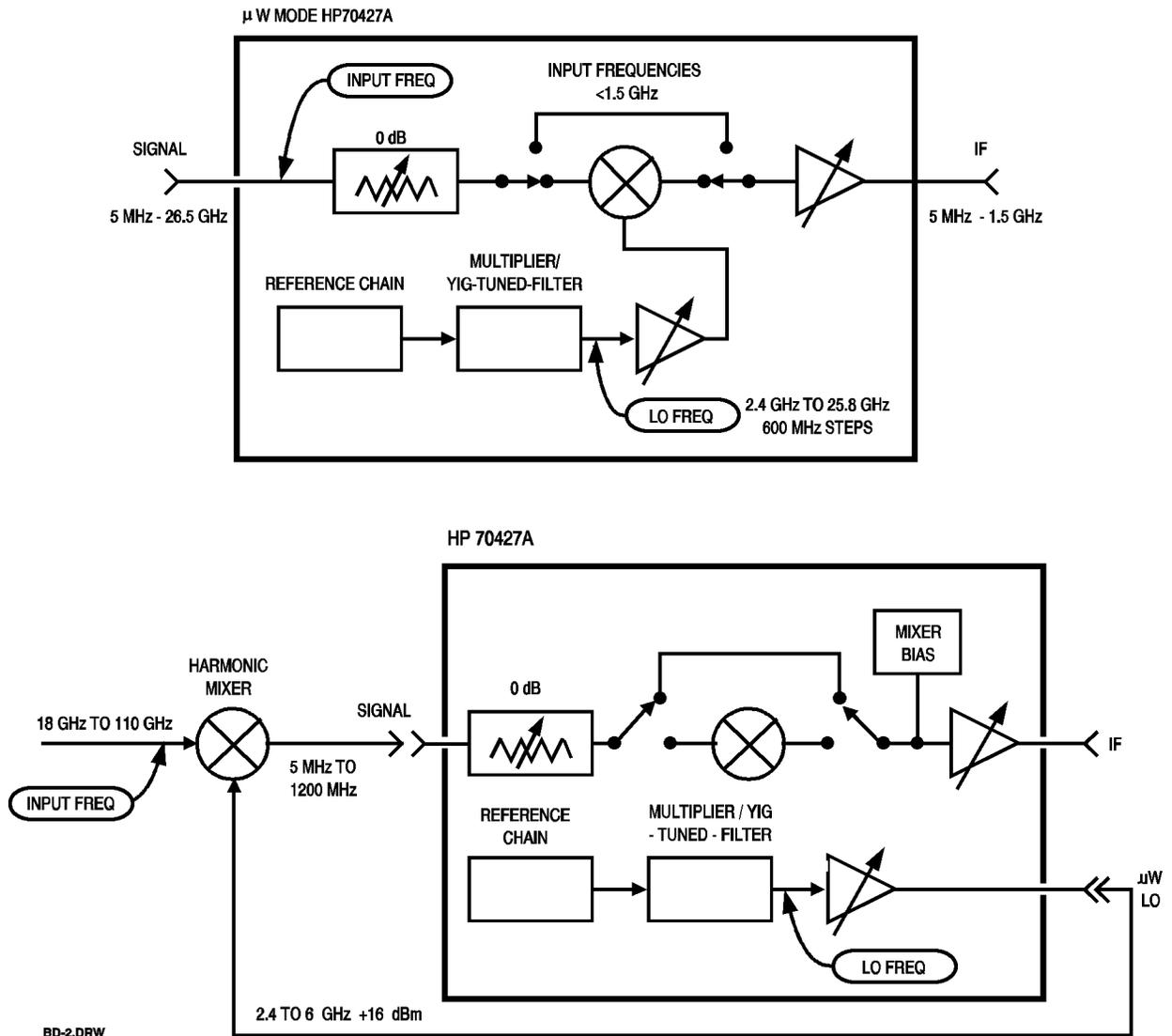
*Amplitudes*

or,

*Ref Chain***HP-IB command**

DC:FREQ:INP?

Returns a real number.



**Figure 10-47**  $\mu$ W Mode HP 70427A

**INPUT ATTEN**

This softkey allows entry of the downconverter's input attenuation setting.

The range is 0 dB to 35 dB in 5 dB steps. The default setting is 35 dB.

**Path** *Amplitudes more 1 of 2 INPUT ATTEN*

This softkey is not available when the downconverter is in mm mode.

**HP-IB command** DC:AMPL:INP:ATT *attenuation*

Where *attenuation* is an integer: 0,5,10,15,20,25,30,35.

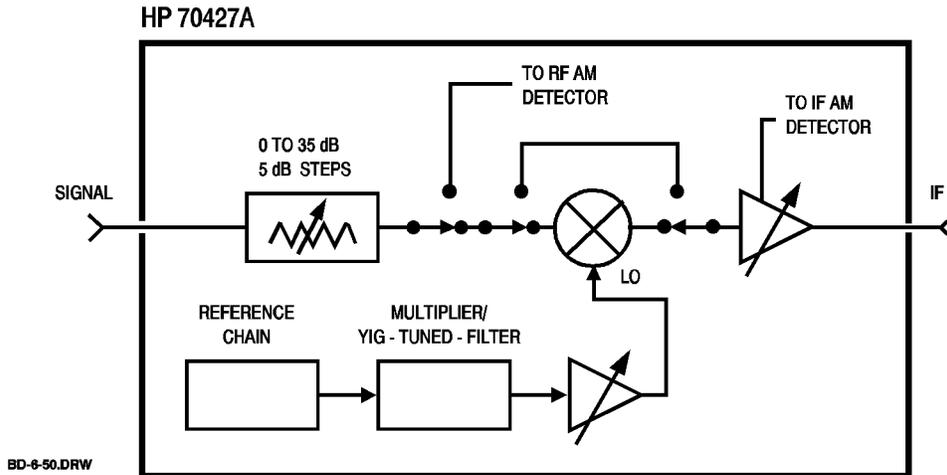


Figure 10-48 HP 70427A

---

## INPUT FREQ

This softkey allows entry of the downconverter's input frequency.

When the downconverter is in  $\mu$ W mode you can enter a frequency between 4.9 MHz and 26.5 GHz. The downconverter will compute and display the LO and IF frequencies.

When the downconverter is in mm mode, and the appropriate mm band has been selected, a frequency between 17.9 GHz and 110.1 GHz can be entered. This frequency will be the input to an external harmonic mixer. The downconverter will compute and display the LO, IF, and comb line frequencies.

**Path**                      *Freqs*      *INPUT FREQ*

**HP-IB command**                      DC:FREQ:INP *frequency*

Where *frequency* is a real number.

Softkeys and Displays  
**INPUT FREQ**

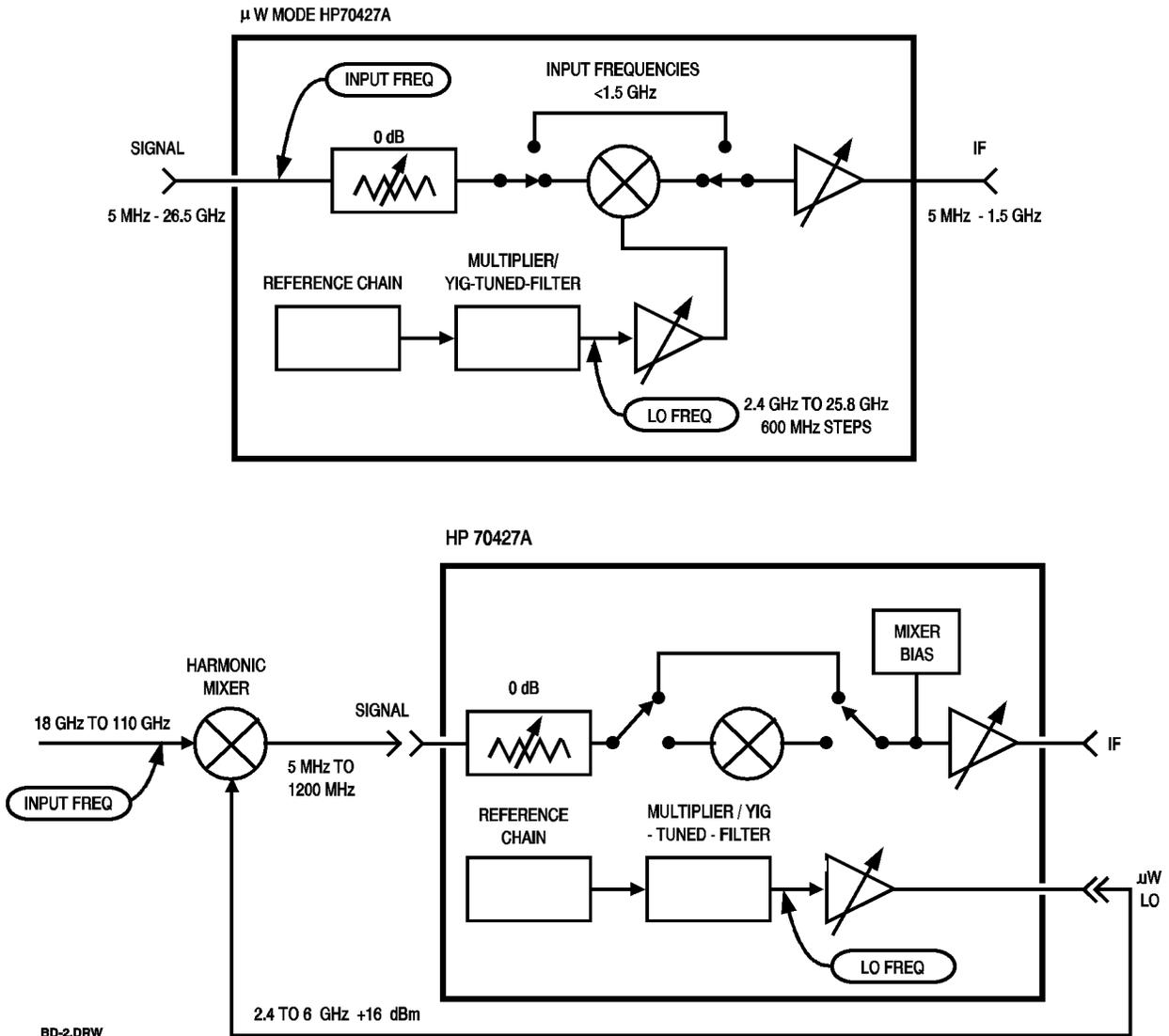


Figure 10-49  $\mu$ W Mode HP 70427A

## K band 18-26.5

This softkey allows entry of a frequency from 17.9 GHz to 26.6 GHz. This frequency is the input frequency of an external mmWave harmonic mixer.

The downconverter computes and displays the LO, IF, and comb line frequencies when an input frequency in this range is entered.

Attempts to enter input frequencies outside of the K-band range are ignored.

**Path** This softkey is only displayed when the *MODE μW mm* softkey has mm underlined.

Freqs mm Band K band 18-26.5

### HP-IB command

DC:FREQ:MM:BAND 0

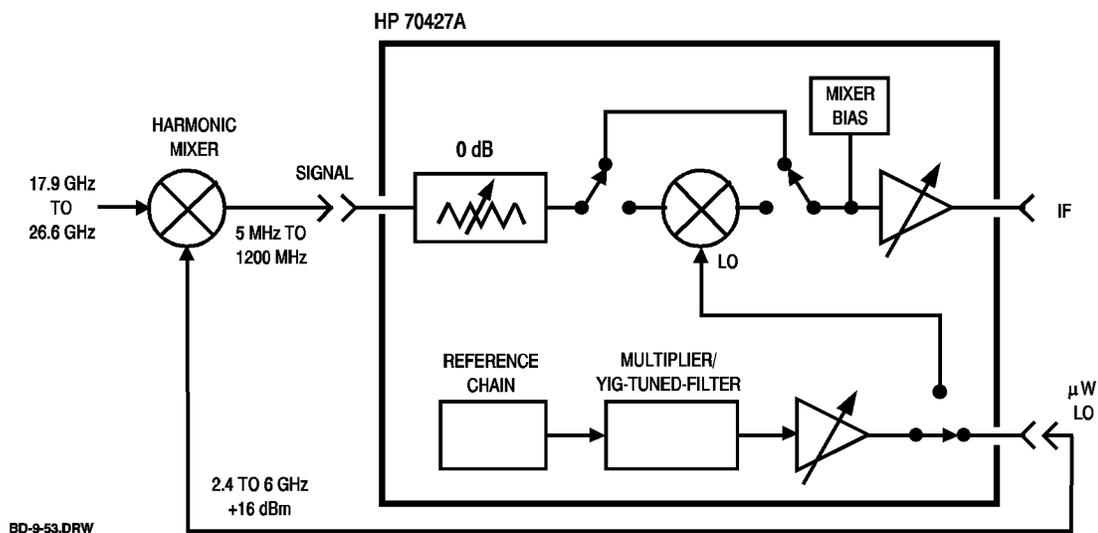


Figure 10-50 HP 70427A

## **Latch**

This display shows the hardware latch number that was entered with the *LATCH NUMBER* softkey.

**Path**                    *Service*    *Hardwre Control*

**HP-IB command**                    *DIAG:LATC:NUMB?*

Returns an integer.

**See Also**            Chapter 8 - Advanced Hardware Control.

---

## ***LATCH DATA***

This softkey allows entry of data into the latch shown on the **Latch:** display. The value you enter will be displayed on the **Data:** display.

**Path**                    *Service    Hardware Control    LATCH DATA*

**HP-IB command**        *DIAG:LATC:DATA value*

Where *value* is an integer between 0 and 255.

**See Also**            Chapter 8 - Advanced Hardware Control.

---

## ***LATCH NUMBER***

This softkey allows entry of a hardware latch number. This number designates the latch that will receive a value from the *LATCH DATA* softkey. The latch number is shown on the **Latch:** display.

**Path**                    *Service    Hardware Control    LATCH NUMBER*

**HP-IB command**                    *DIAG:LATC:NUMB number*

Where *number* is an integer.

**See Also**                    Chapter 8 - Advanced Hardware Control

## Level1

This display shows the value of YIG-Tuned-Filter's (YTF) level DAC during a YTF calibration

**Path** *Service YTF Cal*

**HP-IB command** None.

**See Also** Chapter 15 - Adjustments

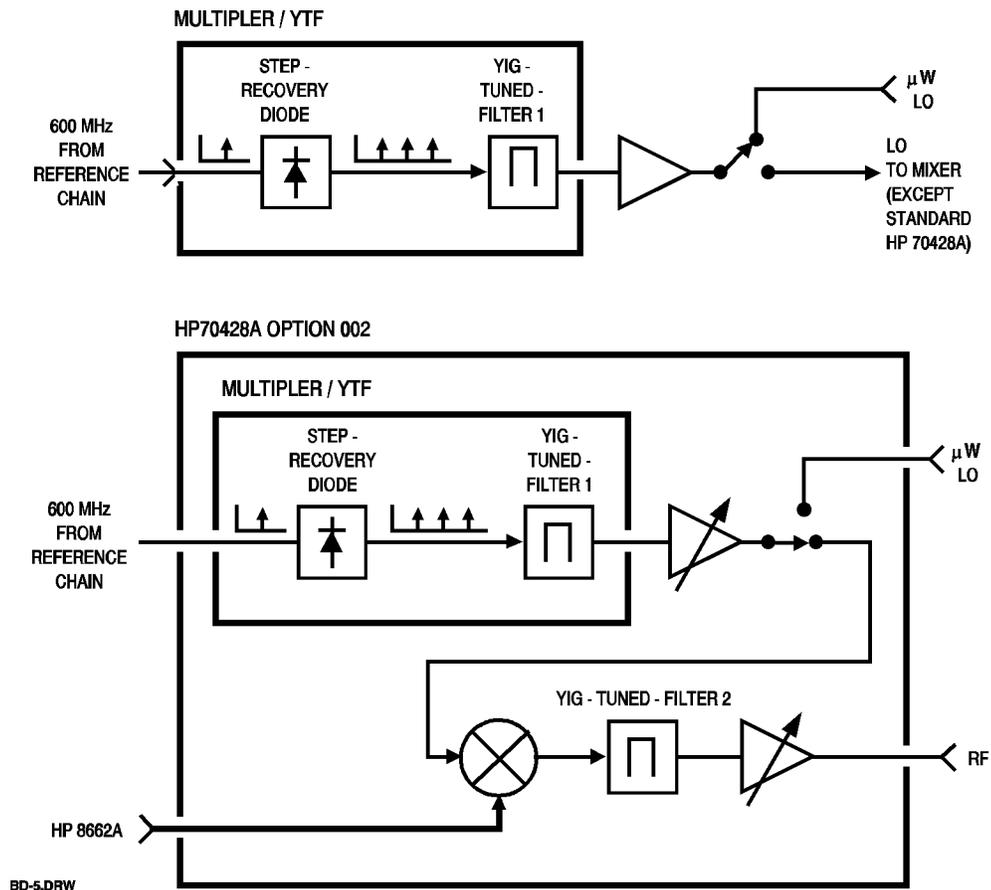


Figure 10-51 HP 70427A Option 002

---

**LINEAR**

This softkey puts the local oscillator or source in a linear mode. In this mode the amplifiers at the output of the YIG-Tuned-Filter (YTF) are biased in the linear region.

**Path** *Service Misc Power Control Linear*

**HP-IB command** None.



*Figure 10-52 Reference Chain*

---

## LO (Downconverter)

This display shows the downconverter's local oscillator's frequency. The LO frequency is computed when an input frequency is entered, or you can enter it with the *LO FREQ* softkey.

When an input frequency less than 1.5 GHz is entered, the **LO:** display will show a series of rectangles instead of a number. This is because the mixer is bypassed, and the input signal is passed through the input attenuator to the IF amplifier.

In mm mode, the **LO:** display shows the harmonic mixer's internally generated LO frequency.

**PATH**            *Freqs*  
  
                    *or,*  
  
                    *Amplitudes*  
  
                    *or,*  
  
                    *Ref Chain*

**HP-IB command**      DC:FREQ:LO?

Returns a real number. In mm mode the HP-IB command is:

DC:FREQ:YTF?



**Figure 10-53**    *HP 70427A*

## LO (tunable source)

This display shows the tunable source's LO frequency. The LO frequency is computed when an output frequency is entered, or you can enter it with the *LOFREQ* softkey.

**Path**            *Outout*  
  
                  *or*  
  
                  *Set Levels*  
  
                  *or,*  
  
                  *Ref Chain*

**HP-IB command**            TS:OUT:LO:FREQ?



**Figure 10-54** HP 70428A Option 002

---

## LO FREQ (downconverter)

This softkey allows entry of a downconverter LO frequency between 2.4 GHz and 26.4 GHz in 600 MHz steps.

When you enter an LO frequency, the **Input:** and the **IF:** displays will be blank requiring that you keep track of the input and IF frequencies.

The LO will tune to the comb line nearest the entered frequency and display its actual frequency.

**Path**                    *Freqs*    *LO FREQ*

**HP-IB command**            DC:FREQ:LO *frequency*

Where *frequency* is a real number.



**Figure 10-55**    *μW Mode HP 70427A*

## ***LO FREQ (tunable source)***

This softkey allows entry of a tunable source LO frequency between 2.4 GHz and 25.8 GHz in 600 MHz steps.

Normally, an output frequency is entered and the tunable source calculates the LO and RF source frequency. If you enter an LO frequency you must keep track of those frequencies yourself.

**Path**                    *Output*    *LO FREQ*

**HP-IB command**                    *TS:OUT:LO:FREQ frequency*

Where *frequency* is a real number.



***Figure 10-56***    ***HP 70428A Option 002***

---

## LO Power

This display shows the tunable source's LO power that was set with the *LO POWER* softkey.

**Path**            *Output*  
                  *or,*  
                  *Set Levels*  
                  *or,*  
                  *Ref Chain*

**HP-IB command**    TS:OUT:LO:POW?

Returns a real number.



*Figure 10-57 HP 70428A Option 002*

## **LO POWER (downconverter)**

This softkey allows entry of a downconverter LO power from 0.0 to 20.0 dBm. The actual power will depend on the frequency as shown in the module's specifications. An error message will be displayed if the power can't be set to the entered value, but it doesn't prevent the downconverter from operating.

**Path**                    *Freqs*    *LO POWER*

**HP-IB command**                    `DC:FREQ:LO:POW power`

Where *power* is a real number from 0.0 to 20.0 dBm.



**Figure 10-58**    *μW Mode HP 70427A*

---

## LO POWER (tunable source)

This softkey allows entry of a tunable source LO power from 0 dBm to +20 dBm in 0.1 dBm steps.

**Path**                    *Output*    *LO POWER*

**HP-IB command**        TS:OUT:LO:POW *power*

Where *power* is a real number.



**Figure 10-59**    *HP 70428A Option 002*

---

## LO Pwr Set

This display shows the default value of the tunable source's LO power that was set with the *LO PWR SET* softkey.

The LO power is set to this level each time the tunable source's output frequency is changed.

**Path**                    *Output*  
  
                              *or,*  
  
                              *Set Levels*  
  
                              *or,*  
  
                              *Ref Chain*

**HP-IB command**                    TS:LEV:LO:POW?

Returns a real number.



*Figure 10-60 HP 70428A Option 002*

---

## ***LO PWR SET***

This softkey allows entry of a default level for the tunable source's LO. The entered value is shown on the **LO Pwr Set:** display. It is not saved through instrument preset.

The LO will be set to this level each time the tunable source's output frequency is changed.

**Path**                    *Set Levels*    *LO PWR SET*

**HP-IB command**        *TS:LEV:LO:POW power*

Where *power* is a real number between 0.0 and 20.0.



***Figure 10-61***    ***HP 70428A Option 002***

## ***LOW NOISE***

This softkey puts the local oscillator or source in low-noise mode. In this mode the amplifiers at the output of the YIG-Tuned-Filter (YTF) are biased to saturation.

**Path**                    *Service Misc*    *Power Control*    *LOW NOISE*

**HP-IB command**                    None.



***Figure 10-62 Reference Chain***

---

## Main

This display shows the value of the YIG-Tuned-Filter's (YTF) frequency coarse-tune DAC during a YTF calibration.

**Path**                    *Service YTF Cal*

**HP-IB command**        None.

**See Also**                Chapter 15 - Adjustments.



**Figure 10-63** *Multiplier / YTF*

---

## **MISC**

This softkey displays a menu of softkeys for designating the power meter that will be used for YIG-Tuned-Filter (YTF) calibration.

It also displays the module's model, options, serial number, and ROM (firmware) version.

The following functions are also available in the HP 70428A Option 002:

- Optimum Range
- RF Source Selection

<b>Path</b>	<i>Service</i>	<i>Misc</i>
<b>HP-IB command</b>		None.

---

## MIXER BIAS

This softkey allows entry of a bias current for an external harmonic mixer. The range is  $-10.000$  mA to  $+10.000$  mA DC, with a resolution of  $0.0005$  mA.

The default is either 0 or 5 mA. The downconverter determines the default value from the external mixer's LO frequency. If it is an odd harmonic the default is 5 mA, and an **Adjust Bias** message will be displayed.

This softkey is disabled when the **BIAS ON/OFF** has **OFF** underlined.

The bias current will be present at the downconverter's **SIGNAL** input when it is in millimeter-wave (mm) mode and when the **BIAS ON/OFF** has **ON** underlined.

**Path**                    *Freqs*    *MIXER BIAS*

**HP-IB command**      DC:FREQ:MIX:BIAS *current*

Where *current* is a real number.



**Figure 10-64**    *HP 70427A*

---

## Mixer Low Power

This display shows the power of the downconverter's local oscillator.

Local oscillator power is set with the *LO Power* softkey.

**Path**            *Freqs*  
  
                  *or,*  
  
                  *Amplitudes*  
  
                  *or,*  
  
                  *Ref Chain*

**HP-IB command**            DC:FREQ:LO:POW?

Returns a real number.



**Figure 10-65**  $\mu$ W Mode HP 70427A

---

## Mixer Max Level

This display shows the downconverter's maximum mixer input level. This level is set with the *MIXERMAXLVL* softkey.

The downconverter uses this level when auto-ranging the input attenuator.

**Path**            *Freqs*  
                  or,  
                  *Amplitudes*  
                  or,  
                  *Ref Chain*

**HP-IB command**        DC:AMPL:MIX:MAXL?

Returns a real number.



**Figure 10-66** HP 70472A

---

## ***MIXER MAX LVL***

This softkey allows entry of a maximum level for the downconverter's mixer input. The range is  $-5$  dBm to  $+5$  dBm. The default is  $-5$  dBm.

The maximum level is used to set the input attenuation value when the *AUTO ATTEN* softkey is pressed.

**Path**                    *AMPLITUDES*    *more 1 of 2*    *MIXER MAX LVL*

**HP-IB command**                    *DC:AMPL:MIX:MAXL level*

Where *level* is a real number.



***Figure 10-67***    ***HP 70427A***

---

## *mm Band*

This softkey displays a menu of external harmonic mixer frequency bands. When the downconverter is in mm mode, the input frequency must be within selected band. Band A is the default.

The bands are as follows:

- K 18 to 26.5 GHz
- A 26.5 to 40 GHz
- Q 33 to 50 GHz
- U 40 to 60 GHz
- V 50 to 75 GHz
- W 75 to 110 GHz
- The downconverter accepts frequencies 100 MHz below or 100 MHz above each band.

**Path**                    *Freqs*    *mm Band*

This softkey is only available when the *MODE μW/mm* softkey has mm underlined.

**HP-IB commands**            DC:FREQ:MM:BAND *n*

Where *n* is as follows:

<b>Band</b>	<b>n</b>
K	0
A	1
Q	2
U	3
V	V
W	5

---

**mm LO**

This display shows the LO frequency of an external mm wave mixer. This frequency is derived in the external mixer by multiplying the signal from the downconverter's  $\mu W$  LO connector.

**Path**                    *Freqs*  
                              or,  
                              *Amplitudes*  
                              or,  
                              *Ref Chain*

The *MODE* $\mu W/mm$  must have mm underlined.

**HP-IB Command**                    DC:FREQ:LO?



*Figure 10-68 HP 70427A*

---

## **mm Mixer Bias**

This display shows the value of external mixer's bias current applied through the **SIGNAL** connector when the downconverter is in mm mode. The bias level is set with the *MIXER BIAS* softkey.

**Path**                    *Freqs*

This display is only present when the *MODE  $\mu$ W/mm* softkey has *mm* underlined.

**HP-IB command**        DC:FREQ:MIX:BIAS?

Returns a real number.



*Figure 10-69 HP 70427A*

**MODE  $\mu W$  | mm**

This softkey toggles the downconverter between microwave mode and millimeter-wave mode. In millimeter wave mode an external harmonic mixer is used to convert the signal to a frequency within the HP 70427A's IF range.

**Path**                      *Freqs*      *MODE  $\mu W$  | mm*

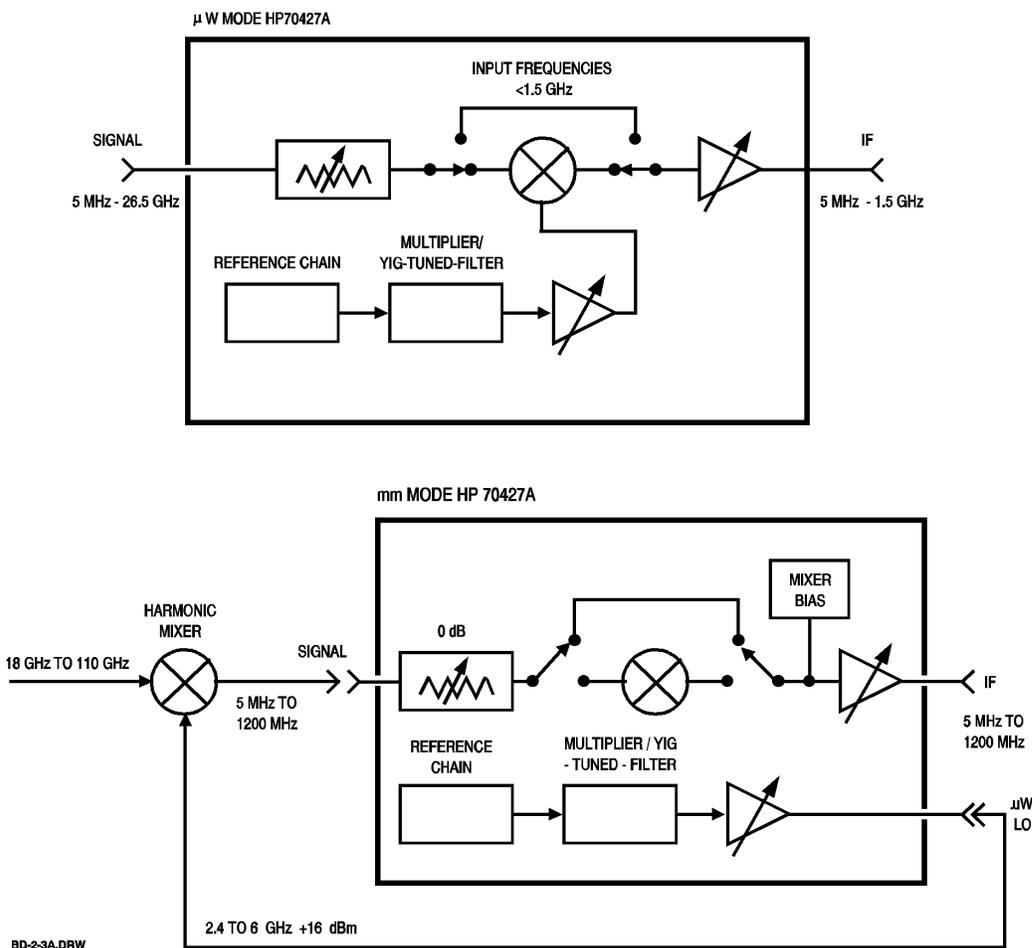
**HP-IB command**

DC:FREQ:MODE 0

*selects the microwave mode*

DC:FREQ:MODE 1

*selects the millimeter-wave mode*



**Figure 10-70**  $\mu W$  Mode HP 70427A

---

## model nr

This display shows the model number of the module  
(HP 70427A for example).

**Path**                    *Service*    *Misc*

**HP-IB command**        None.

## **Mux**

This display shows which measurement point is being monitored by the internal voltmeter. The measurement point is selected with the *VOLTMETER* softkey.

The voltage at the selected point is also routed to the rear-panel **MULTIPLEXER OUT** connector.

Measurement points are shown on the schematic diagrams in the Component Level Information Packet Set.

**Path**                    *Service*    *Hardwre Control*

**HP-IB command**                    DIAG:MUX?

Returns an integer.

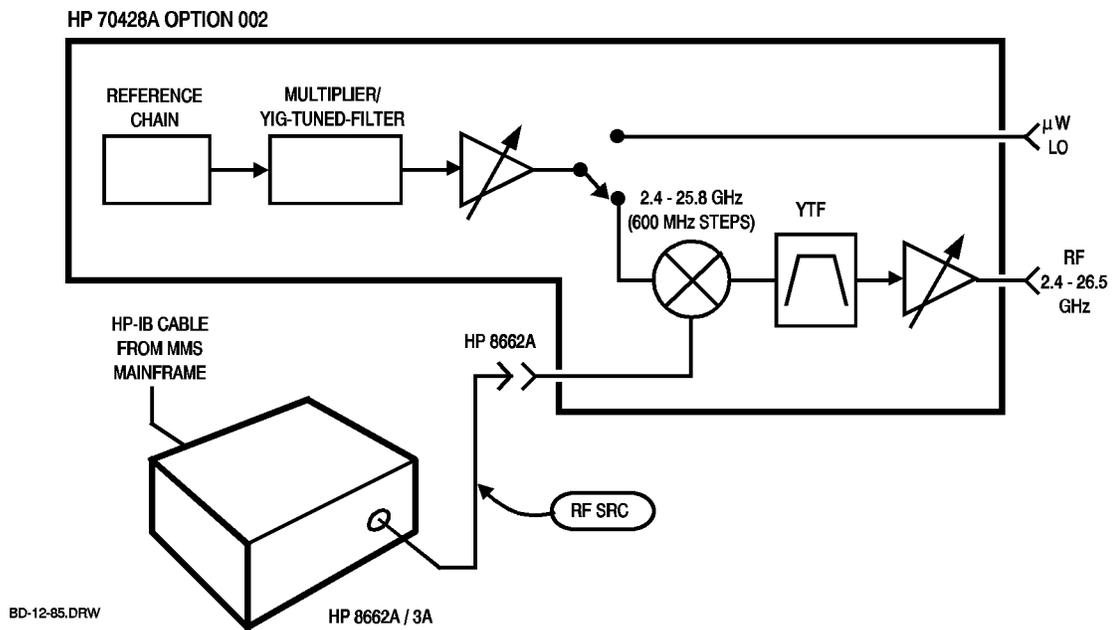
## Optimum Range

This softkey displays a menu of tuning ranges for the HP 70428A Option 002's external source.

**Path**                    *Service*    *Misc*    *Optimum Range*

**HP-IB command**        `TS:RANG:MODE n`

Where *n* is the range: 0= 300-600, 1= 120-300 and 480-600.



**Figure 10-71** *HP 70428A Option 002*

## Options

This display shows which options are installed in the module.

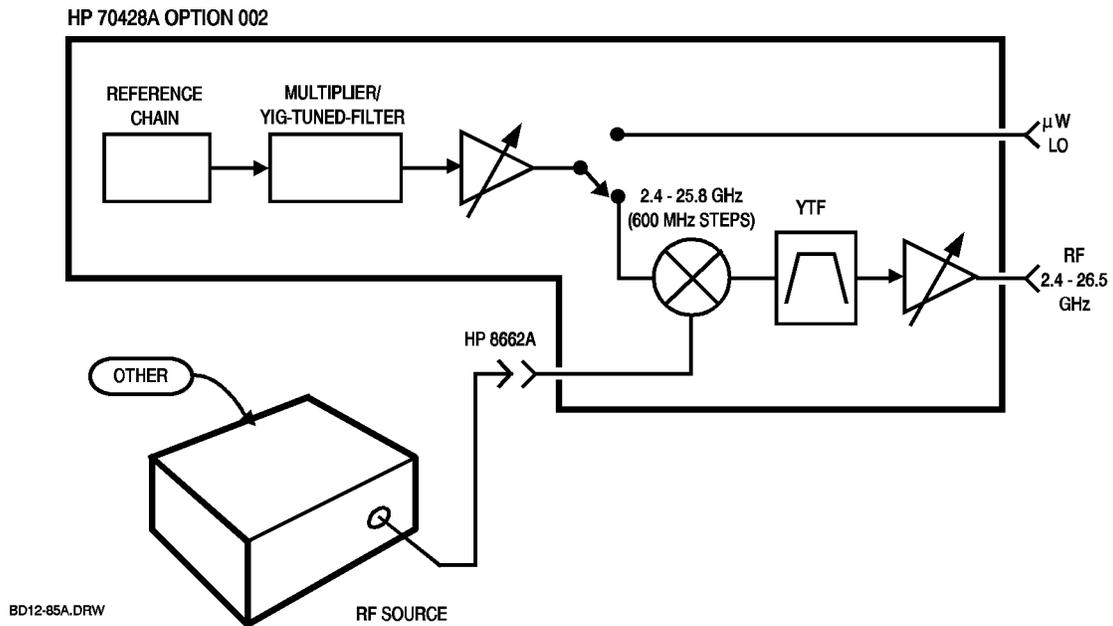
<b>Path</b>	<i>Service</i>	<i>Misc</i>
<b>HP-IB command</b>		None.

**OTHER**

This softkey designates an external RF source for the HP 70428A Option 002 as one other than an HP 8662A or HP 8663A.

**Path**                    *Service   Misc   RF Source   OTHER*

**HP-IB command**        None.



**Figure 10-72** HP 70428A Option 002

## ***Output***

This softkey displays a menu of softkeys for setting the source's output frequency and power.

**Path** This softkey is always present in the source mode and tunable source.

**HP-IB command** None.

---

## Ouput

This display shows the output frequency of the tunable source.

**Path**            *Output*

or,

*Set Levels*

or,

*Ref Chain*

**HP-IB command**    TS:OUT:FREQ?

Returns a real number.

## *OUTPUT dBm / mW*

This softkey allows selection of output power units for the source and the tunable source.

**Path**                    *Output*    *OUTPUT dBm/mW*

or,

*Set Levels Output dBm/mW* (Tunable source only)

**HP-IB command**                    None.

HP-IB power-levels are always in dB.

## OUTPUT FREQ

This softkey allows entry of a tunable source output frequency from 2.4 GHz to 26.5 GHz in 0.1 Hz steps.

When a valid frequency is entered, the LO YIG-Tuned-Filter (YTF) is tuned. Then, the external RF source is tuned to a frequency that will result in the entered output frequency. Finally, the output YIG-Tuned-Filter is tuned.

If the external RF source is an HP 8662A or HP 8663A it will be tuned automatically over HP-IB. If not, it must be tuned manually to the frequency displayed in the **RFsrc** field.

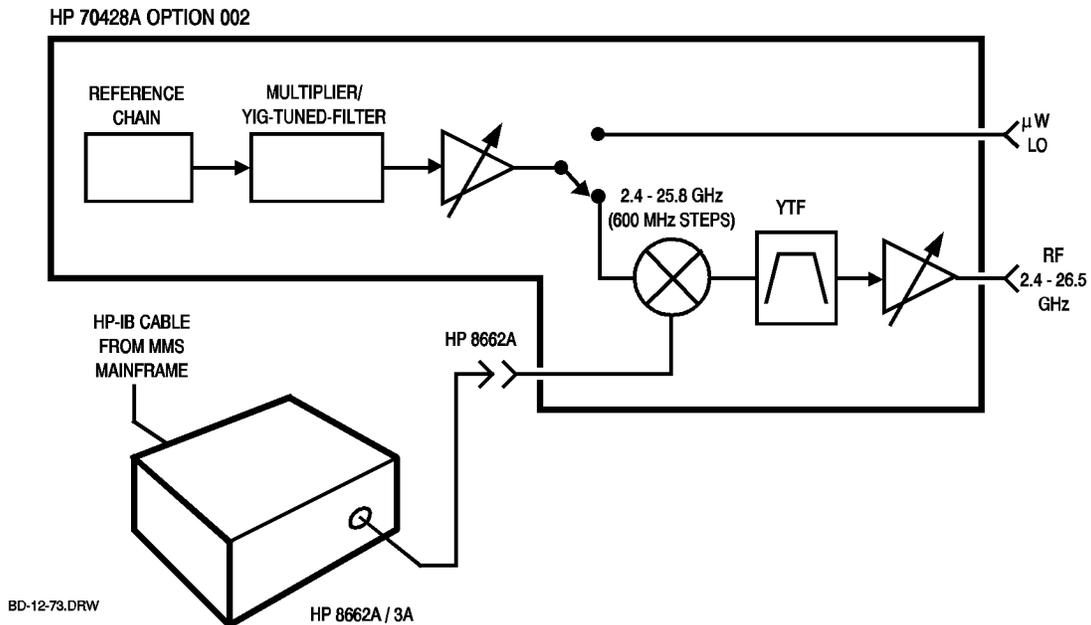
**Path**                    *Output*    *OUTPUT FREQ*

**HP-IB command**        *TS:OUT:FREQ frequency*

Where *frequency* is a real number.

This command does not generate the command to tune the :

HP 8662A or HP 8663A.



**Figure 10-73** *HP 70428A Option 002*

## Output Power

This display shows the output power of the tunable source.

**Path**            *Output*  
  
                    or,  
  
                    *Set Levels*  
  
                    or,  
  
                    *Ref Chain*

**HP-IB command**            TS:OUT:POW?

Returns a real number.

---

## ***OUTPUT POWER***

This softkey allows entry of the tunable source's output power. Power levels of 0.0 to 20.0 dBm (or 1 to 100 mW) can be entered. But, the actual output power is specified as follows:

- 2.4 GHz to 6.6 GHz: 0 dBm to +16 dBm
- >6.6 GHz to 26.5 GHz: 0 dBm to +10 dBm

**Path**                    *Output*    *OUTPUT POWER*

**HP-IB command**        TS:OUT:POW *power*

Where *power* is a real number.

---

## ***POWER***

This softkey allows entry of the source's output power from 0.0 dBm to +20.0 dBm (or 1 to 100 mW).

**Path**                    *Output*    *POWER*

**HP-IB command**                    *SRC:OUT:POW power*

Where *power* is a real number between 0.0 and 20.0.

---

## Power

This display shows the source's output power, as measured by the internal voltmeter.

**Path**            *Output*

or,

*Ref Chain*

**HP-IB command**      SRC:OUT:POW?

Returns a real number.

## Power

This display shows the YIG-Tuned-Filter (YTF) power as a YTF power calibration is running.

**Path**                    *Service*    *YTF Cal*

**HP-IB command**                    None.

**See Also**                    Chapter 15 - Adjustments.

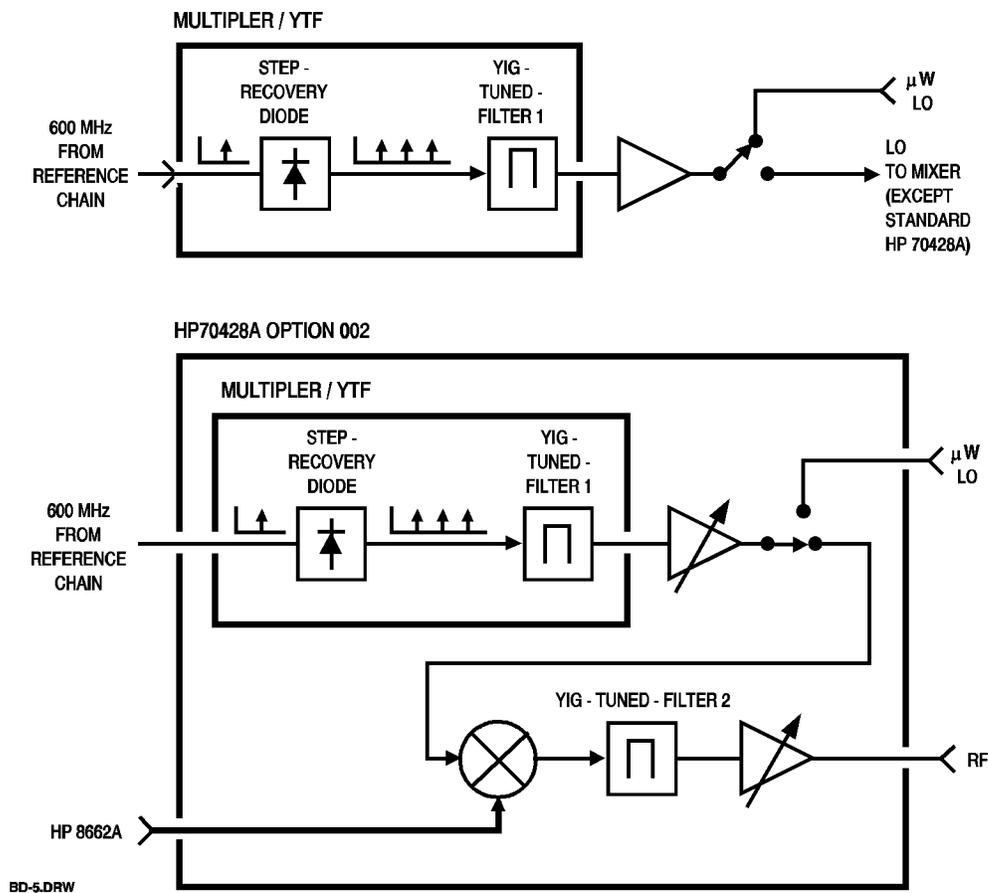


Figure 10-74 Multiplier / YTF

## Power Control

This softkey displays a menu of softkeys for selecting the noise performance of the local oscillator or source.

The choices are *Low Noise* and *Linear*.

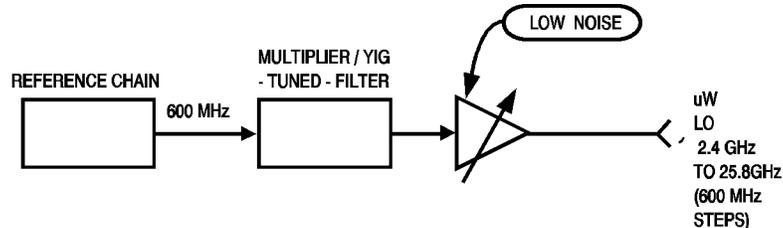
In the low-noise mode the amplifiers at the output of the YIG-Tuned-Filter (YTF) are biased into hard compression for low noise. But, because of the hard compression the waveform tends to have high order harmonics.

In the linear mode the amplifiers are biased linearly, which makes the higher order harmonics lower. Also, the output level will tend to be more accurate with the HP 70428A Option 002, AM on the external RF source's signal will be passed through.

The choice is stored in non-volatile memory.

**Path**                    *Service*    *Misc*    *Power Control*

**HP-IB command**        None.



BD-3-60.DRW

Figure 10-75 Reference Chain

---

## **Power Meter**

This display shows the model number of the power meter that will be used for YIG-Tuned-Filter (YTF) calibration. Power meter type is selected with the *Pwrmttr Type* softkey.

**Path**                    *Service*    *Misc*

**HP-IB command**                    None.

**See Also**                    Chapter 15 - Adjustments.

---

## *Pwrmttr Type*

This softkey displays a menu of power meter types for YIG-Tuned-Filter (YTF) calibration.

**Path**                    *Service Misc Pwrmttr Type*

**HP-IB command**        None.

**See Also**              Chapter 15 - Adjustments.

## Q band 33-50

This softkey allows entry of a frequency from 32.9 GHz to 50.1 GHz. This frequency is the input frequency of an external mmWave harmonic mixer.

The downconverter computes and displays the LO, IF, and comb line frequencies when an input frequency in this range is entered.

Attempts to enter input frequencies outside of this range are ignored.

**Path** This softkey is only displayed when the *MODE*  $\mu$ W/mm softkey has mm underlined.

Freqs mm Band Q band 33-50

**HP-IB command**

DC:FREQ:MM:BAND 2

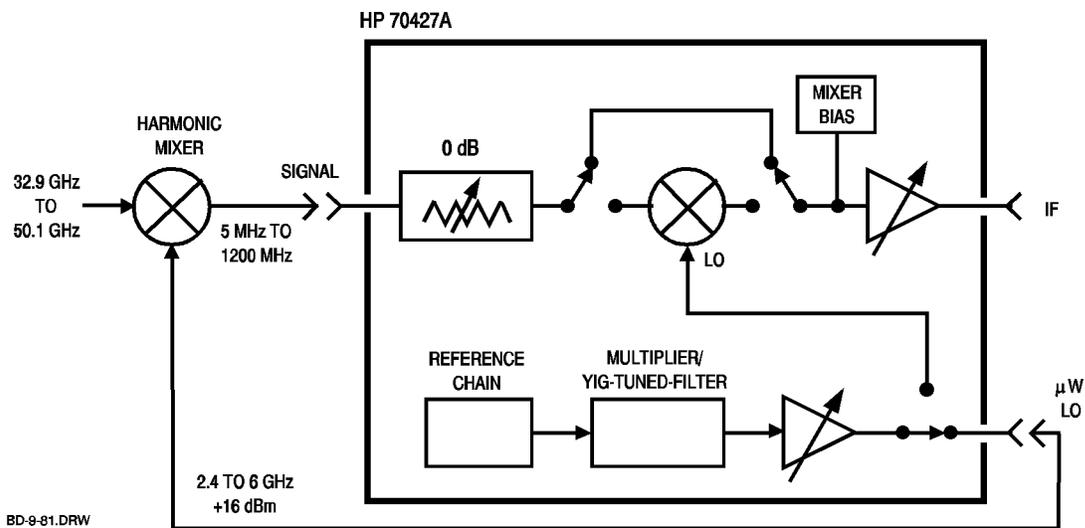


Figure 10-76 HP 70427A

## READ AM DET

This softkey triggers an AM detector voltage measurement and displays the result on the downconverter's **AM Det Voltage:** display.

**Path** *AM Noise* *READ AM DET*

**HP-IB command** DC:AMN:AMD?

Returns a real number.

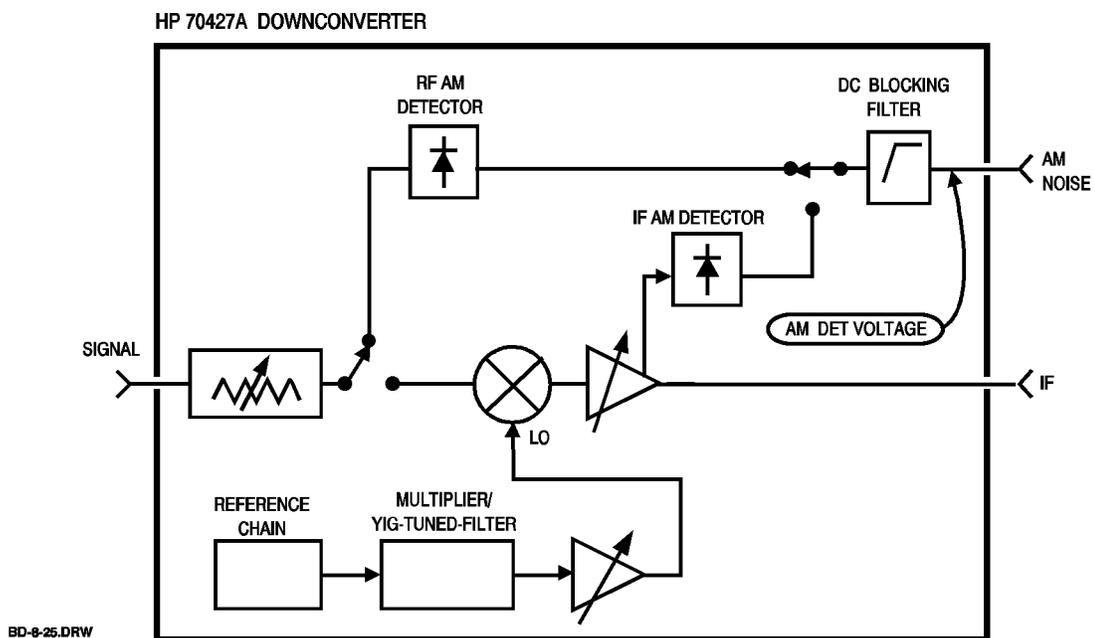


Figure 10-77 HP 70427A Downconverter

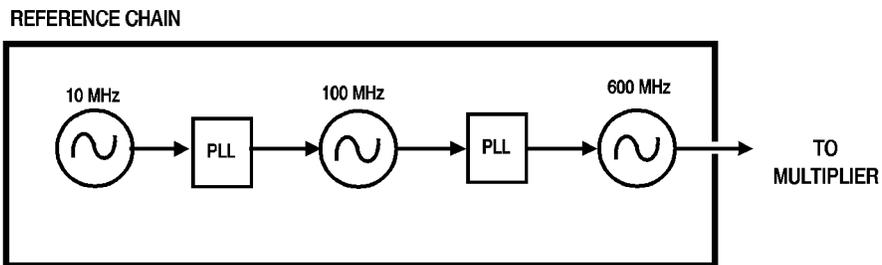
---

## Ref Chain

This softkey displays a menu of softkeys for setting the tuning range of the reference chain and the bandwidth of the phase-lock-loops.

**Path** This softkey is always present.

**HP-IB command** None, use the command for the desired range or bandwidth.



BD-11.DRW

*Figure 10-78 Reference Chain*

---

## Relay

This display shows which relay you can control with the *RELAY NUMBER* softkey.

**Path**            *Service    Hardwre Control*

**HP-IB command**        *DIAG:REL:NUMB*

Returns an integer from 0 to 15.

**See Also**            Chapter 8 - Advanced Hardware Control.

---

## ***RELAY NUMBER***

This softkey allows selection of a relay and then sets the relay's state with the *RELAY STATE* softkey.

The selected relay is shown on the **Relay:** display. The relay is in the hardware block shown on the **Block:** display.

**Path**                    *Service*    *Hardware Control*    *RELAY NUMBER*

**HP-IB command**                    *DIAG:REL:NUMB relay number*

Where *relay number* is an integer from 0 to 15.

**See Also**            Chapter 8 - Advanced Hardware Control.

---

## RELAY STATE

This softkey allows you to set the state of the relay shown on the **Relay :** display.

**Path**                    *Service    Hardware Control    RELAY STATE*

**HP-IB command**        *DIAG:REL:DATA 0*  
*sets the state to normal*

*DIAG:REL:DATA 1*  
*sets the state to out*

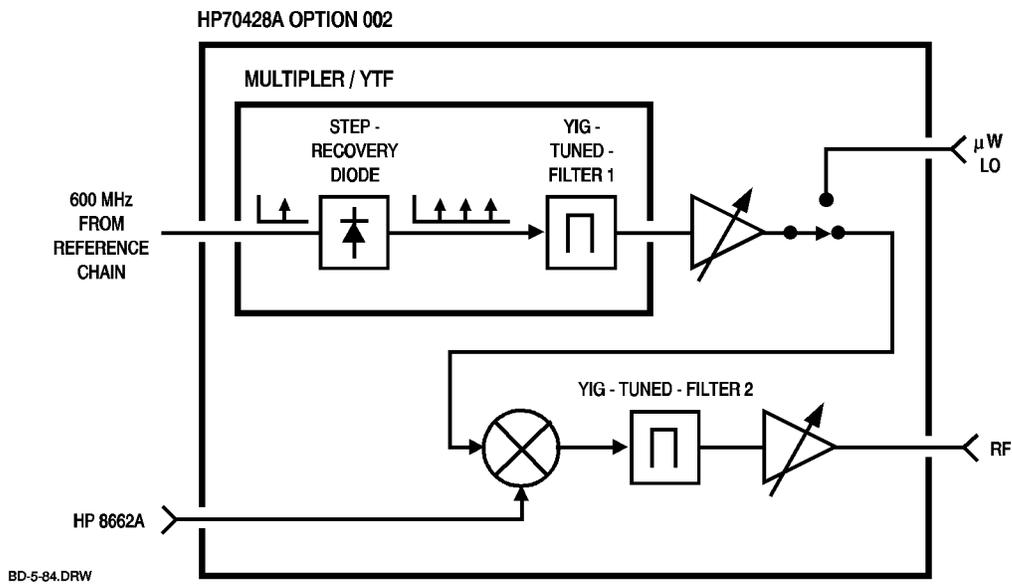
**See Also**              Chapter 8 - Advanced Hardware Control.

**RETUNE YTF**

This softkey triggers the tuned source to center the YIG-Tuned-Filter (YTF) on the appropriate comb line or mixing product for the current output frequency.

**Path** *Output Retune YTF*

**HP-IB command** None.



**Figure 10-79** HP 70428A Option 002

---

## ***RF SOURCE***

This softkey displays a menu of HP 70428A Option 002 external RF source choices. If you select *HP 8662A* or *HP 8663A* the microwave source will set the external RF source's frequency over HP-IB. If you select *OTHER* you must tune the external source manually.

**Path**                    *Service*    *Misc*    *RF Source*

**HP-IB command**        None.

---

## **RF Source**

This display shows the model number of the signal generator that will be used as the tunable source's external LO.

<b>Path</b>	<i>Service</i>	<i>Misc</i>
<b>HP-IB command</b>		None.

## RFScr

This display shows the output frequency of the signal generator used as the tunable source's external RF source.

**Path** This display is present when the HP 70428A Option 002 is in tunable source mode.

**HP-IB command** None.

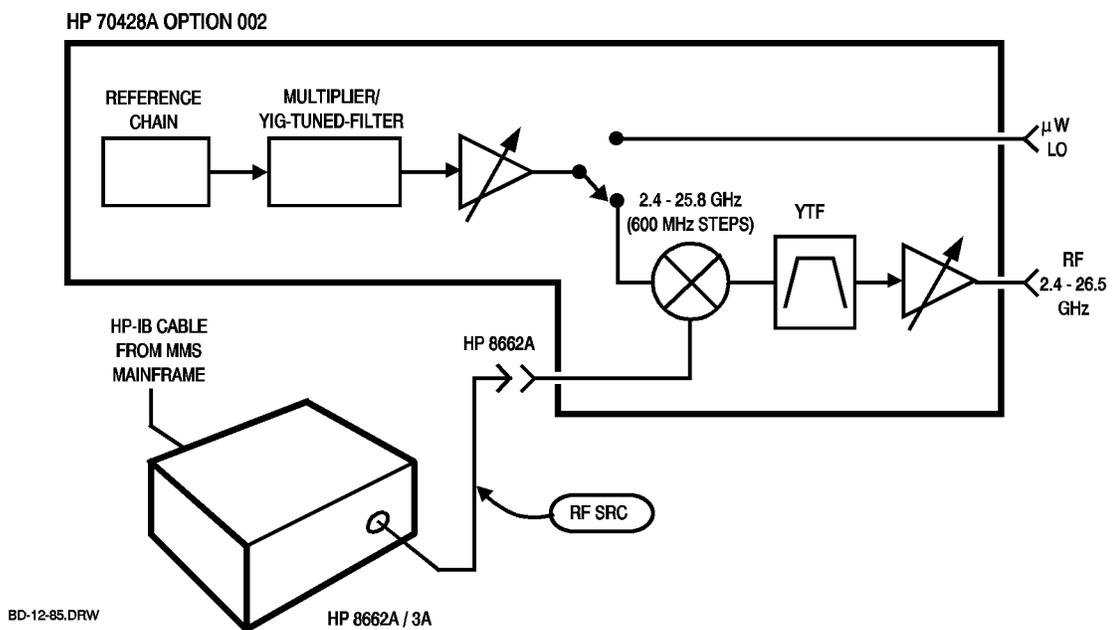


Figure 10-80 HP 70428A Option 002

## RF Src Pwr Set

This display shows the default output power setting that was entered with the *RF SRC PWR SET* softkey. The external RF source will be set to this value each time the tunable source's frequency is changed.

**Path**                    *Output*

                              or,

*Set Levels*

                              or,

*Ref Chain*

**HP-IB command**        TS:LEV:RFS?

Returns a real number.

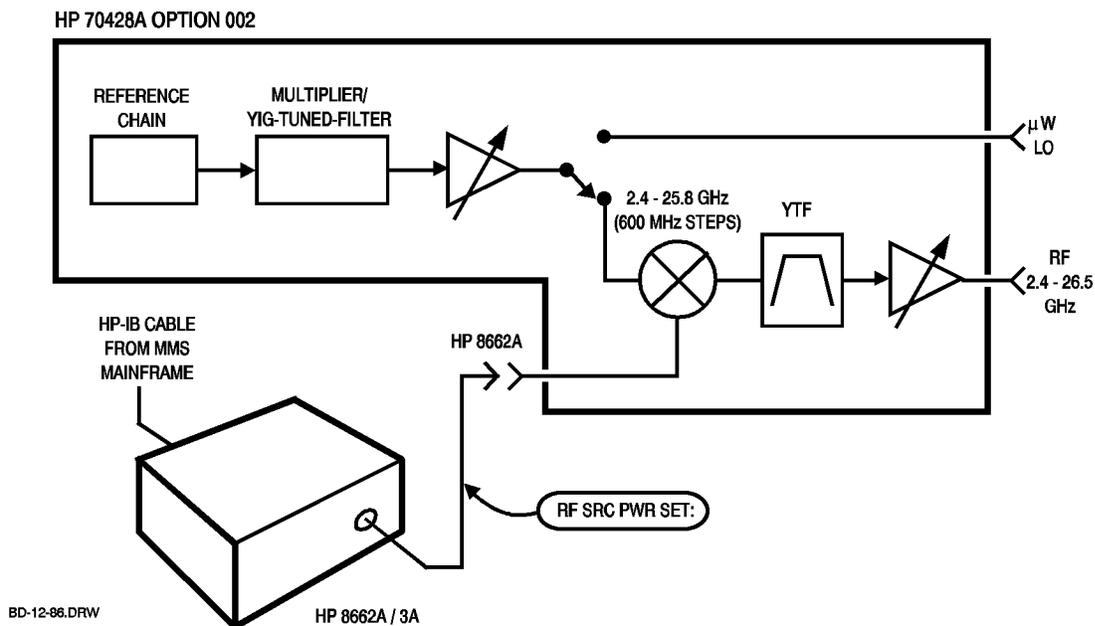


Figure 10-81 HP 70428A Option 002

## RF SRC PWR SET

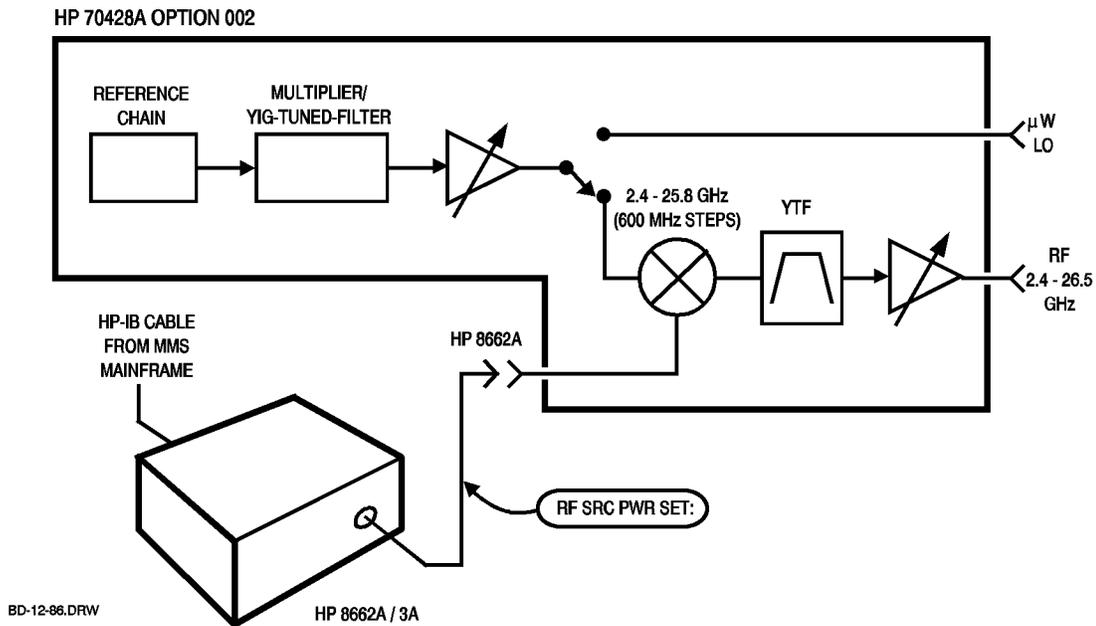
This softkey allows entry of a default level for the tunable source's external RF source from 0 to +13 dBm. The RF source level will be set to this value each time the tunable source's output frequency is changed.

The entered value is not saved through instrument preset. The power-on default is +5 dBm.

**Path**                    *Set Levels*    *RF SRC PWR SET*

**HP-IB command**        *TS:LEV:RFS level*

Where *level* is a real number between 0 and +13.0.



**Figure 10-82** *HP 70428A Option 002*

---

## ROM version

This display shows the module's firmware version.

<b>Path</b>	<i>Service</i>	<i>Misc</i>
<b>HP-IB command</b>		None

---

## serial nr

This display shows the module's serial number.

<b>Path</b>	<i>Service</i>	<i>Misc</i>
<b>HP-IB command</b>	None	

## *Service*

This softkey displays a menu of softkeys for YTF calibration, hardware control, and miscellaneous functions.

**Path** This softkey is always present.

**HP-IB command** None.

---

## *Set Levels*

This softkey displays a menu of softkeys for setting default levels for the tunable source's internal LO power and external RF source's input power. The module's firmware sets the LO and RF source to these levels each time the frequency is changed. These levels are not saved through instrument preset.

**Path**                    *Set Levels*

**HP-IB command**        None.

---

## *Source*

This softkey puts the HP 70427A or HP 70428A Option 002 in source mode. In source mode it has the capabilities of a standard HP 70428A Microwave Source Module.

**Path** This softkey is present when the HP 70427A is in downconverter mode or when the HP 70428A Option 002 is in tunable source mode.

**HP-IB command** INST 4

---

## State

This display shows the state of the relay shown on the **Relay:** display.

**NORMAL** means the relay is in its normal state.

**OUT** means the relay is not in its normal state.

Relay state is toggled by the *RELAY STATE* softkey.

**Path**                    *Service*    *Hardware Control*

**HP-IB command**            DIAG:REL?

Returns a 1 or 0 where 1=normal and 0=out.

**See Also**            Chapter 8 - Advanced Hardware Control.

## **Trim**

This display shows the value of the YIG-Tuned-Filter's (YTF) frequency fine-tune DAC.

**Path**                    *Service*    *YTF Cal*

**HP-IB command**                    None.

**See Also**                    Chapter 15 - Adjustments.

## Tune Sens

This softkey displays a menu of reference chain phase-lock-loop tuning sensitivities. The choices are:

- 0 ppm: Chain is phase-locked to the 10 MHz reference with no external tuning.
- 0.05 ppm/V: Chain is phase-locked to the 10 MHz reference and the 10 MHz reference can be tuned externally.
- 1.0 ppm/V: 600 MHz oscillator is phase-locked to the 100 MHz oscillator and the 100 MHz oscillator can be tuned externally.
- 20 ppm/V: 600 MHz oscillator is free-running and can be tuned externally.
- 100 MHz no tune: 600 MHz oscillator is phase-locked to the 100 MHz oscillator with no external tuning.
- 600 MHz no tune: 600 MHz oscillator is free-running with no external tuning.

**Path** *Ref Chain Tune Sens*

**HP-IB commands** REF:TS *n*

Where *n* is as follows:

Tuning Sensitivity	n
0 ppm	0
0.05 ppm/V	1
1.0 ppm/V	2
20 ppm/V	3
100 MHz no tune	4
600 MHz no tune	5

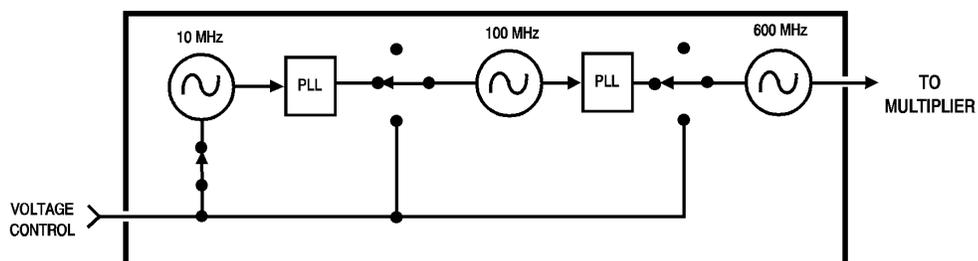


Figure 10-83 Reference Chain

## U band 40-60

This softkey allows entry of a frequency from 39.9 GHz to 60.1 GHz. This frequency is the input frequency of an external mmWave harmonic mixer.

The downconverter computes and displays the LO, IF, and comb line frequencies when an input frequency in this range is entered.

Attempts to enter input frequencies outside of this range are ignored.

**Path** This softkey is only displayed when the *MODE $\mu$ W/mm* softkey has mm underlined.

*Freqs mm Band U band 40-60*

**HP-IB command**

DC:FREQ:MM:BAND 3

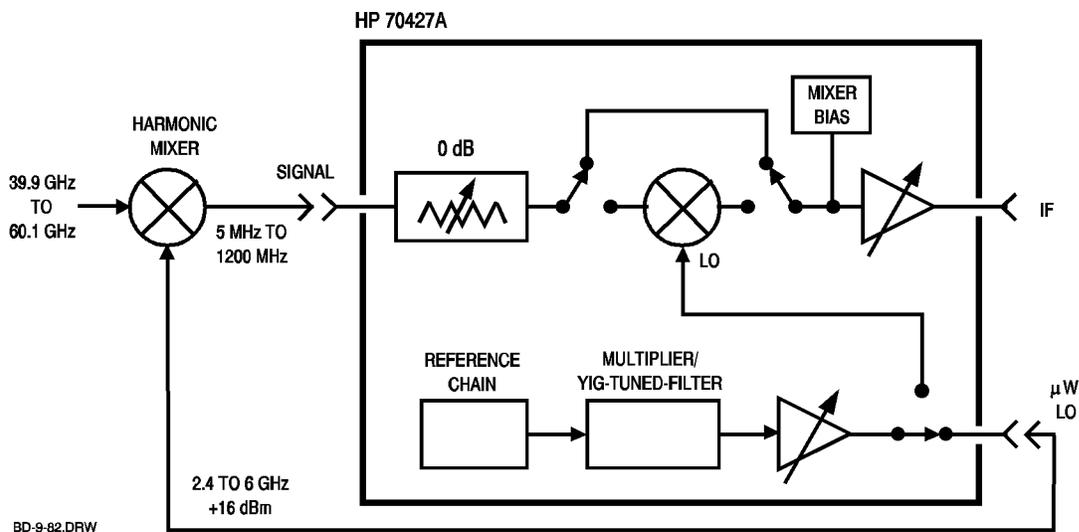


Figure 10-84 HP 70427A

---

## ***UPDATE DISPLAY***

This softkey updates the Hardware Control screen so that it shows the module's current hardware settings, and internal voltmeter reading.

**Path**                    *Service    Hardwre Control    UPDATE DISPLAY*

**HP-IB command**        *DIAG:VOLT?*

*DIAG:LATC:DATA*

**See Also**              Chapter 8 - Advanced Hardware Control.

## V band 50-75

This softkey allows you entry of a frequency from 49.9 GHz to 75.1 GHz. This frequency is the input frequency of an external mmWave harmonic mixer.

The downconverter computes and displays the LO, IF, and comb line frequencies when an input frequency in this range is entered.

Attempts to enter input frequencies outside of this range are ignored.

**Path** This softkey is only displayed when the *MODE*  $\mu$ W/mm softkey has mm underlined.

Freqs mm Band V band 50-75

**HP-IB command**

DC:FREQ:MM:BAND 4

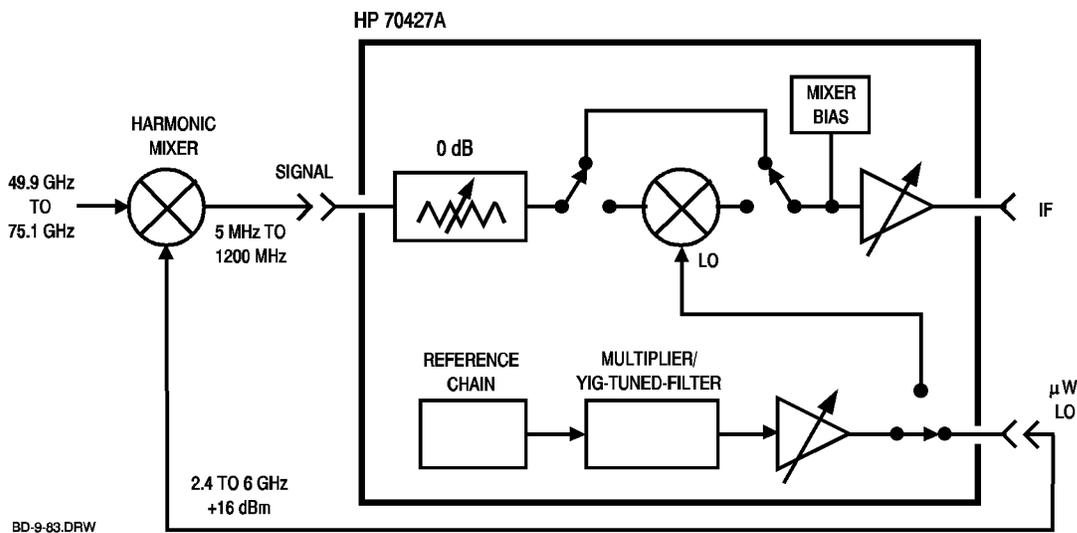


Figure 10-85 HP 70427A

## **VIEW IN | IF | -**

This softkey routes the downconverter's input signal to the front-panel **RF ANALYZER** connector.

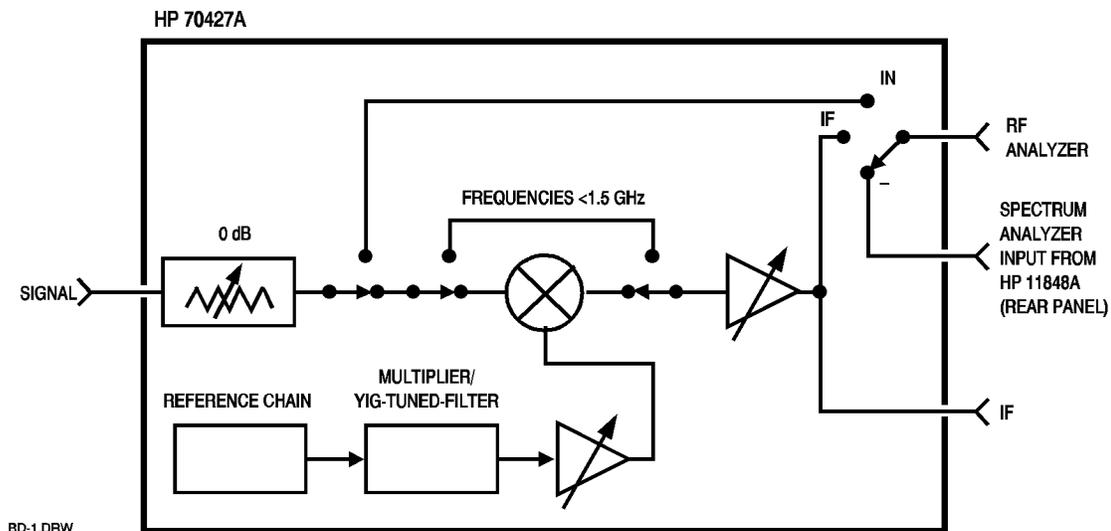
When IF is underlined, the signal is routed from the downconverter's IF amplifier to the **RF ANALYZER** connector. The IF output is simultaneously available at the front-panel IF output connectors.

When IN is underlined, the signal is routed from the downconverter's input attenuator to the **RF ANALYZER** connector. There will be no IF output.

When - is underlined, the **RF ANALYZER** connector is routed to the rear-panel **SPECTRUM ANALYZER INPUT FROM HP 11848A** connector. The downconverter's signal follows its normal path to the **IF** output connector.

**Path**                    *Amplitudes*    **VIEW IN|IF|-**  
 or  
*AM Noise View*    **IN|IF|-**

**HP-IB command**      DC:AMPL:VIEW 0 selects **IF**  
                               DC:AMPL:VIEW 1 selects **IN**  
                               DC:AMPL:VIEW 2 selects **-**



**Figure 10-86** HP 70427A

---

## Volt

This display shows the voltage measured by the internal voltmeter. The voltmeter is connected to internal points selected by the *VOLTMETER* softkey. The reading is in millivolts except for a few measurement points which are described in chapter 9 - *Block Diagram*. The display is only updated when the *UPDATE DISPLAY* softkey is pressed or when the `DIAG:VOLT?` command is received.

**Path**                    *Service*    *Hardware Control*

**HP-IB command**                    `DIAG:VOLT?`

Returns an integer.

**See Also**                    Chapter 8 - Advanced Hardware Control.

---

## ***VOLTMETER***

This softkey allows you to select a point for the internal voltmeter to monitor. The selected point is shown on the **mux:** display. The measured voltage is shown in the **volt:** display. This display is in millivolts with the exception of a few points which are described in chapter 9 - *Block Diagram*.

**Path**                    *Service    Hardware Control    VOLTMETER*

**HP-IB command**                    *DIAG:MUX integer*

Where *integer* is the mux number of the point to be monitored.

**See Also**                    Chapter 8 - Advanced Hardware Control.

## W band 75-100

This softkey allows entry of a frequency from 74.9 GHz to 110.1 GHz. This frequency is the input frequency of an external mmWave harmonic mixer.

The downconverter computes and displays the LO, IF, and comb line frequencies when an input frequency in this range is entered.

Attempts to enter input frequencies outside of this range are ignored.

**Path** This softkey is only displayed when the *MODE*  $\mu$ W/mm softkey has mm underlined.

*Freqs mm Band W band 75-100*

### HP-IB command

DC:FREQ:MM:BAND 5

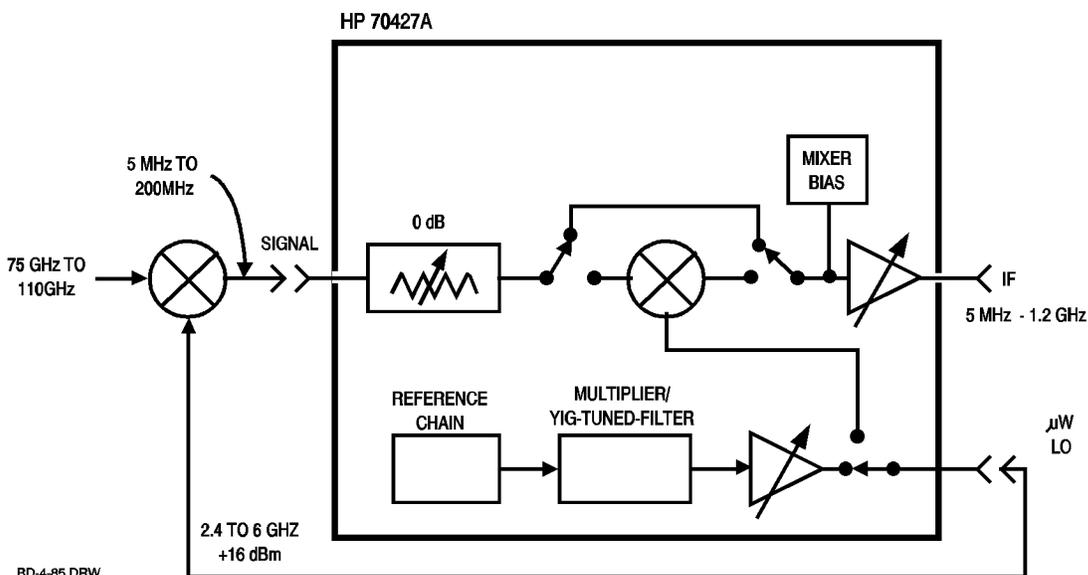


Figure 10-87 HP 70427A

## YTF 1 Freq

This softkey causes the module to run an internal YIG-Tuned-Filter (YTF) frequency calibration routine.

**Path** *Service YTF Cal YTF 1 Freq*

**HP-IB command** *SOUR:FREQ:CAL 1*

**See Also** Chapter 15 - Adjustments.

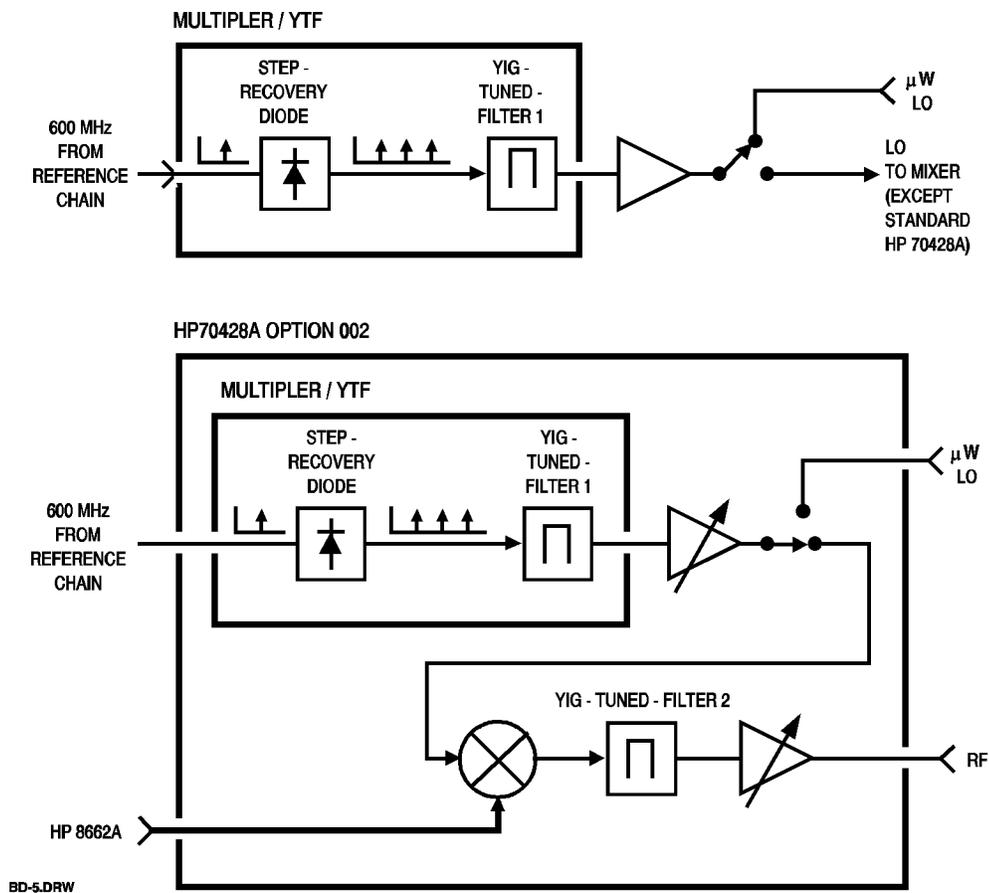


Figure 10-88 Multiplier / YTF

## YTF 2 Freq

This softkey causes the tunable source to run an internal YIG-Tuned-Filter (YTF) frequency calibration routine.

**Path Service**    *YTF Cal*    *YTF 2 Freq*

**HP-IB command**                      SOUR:FREQ:CAL 2

**See Also**                      Chapter 15 - Adjustments.

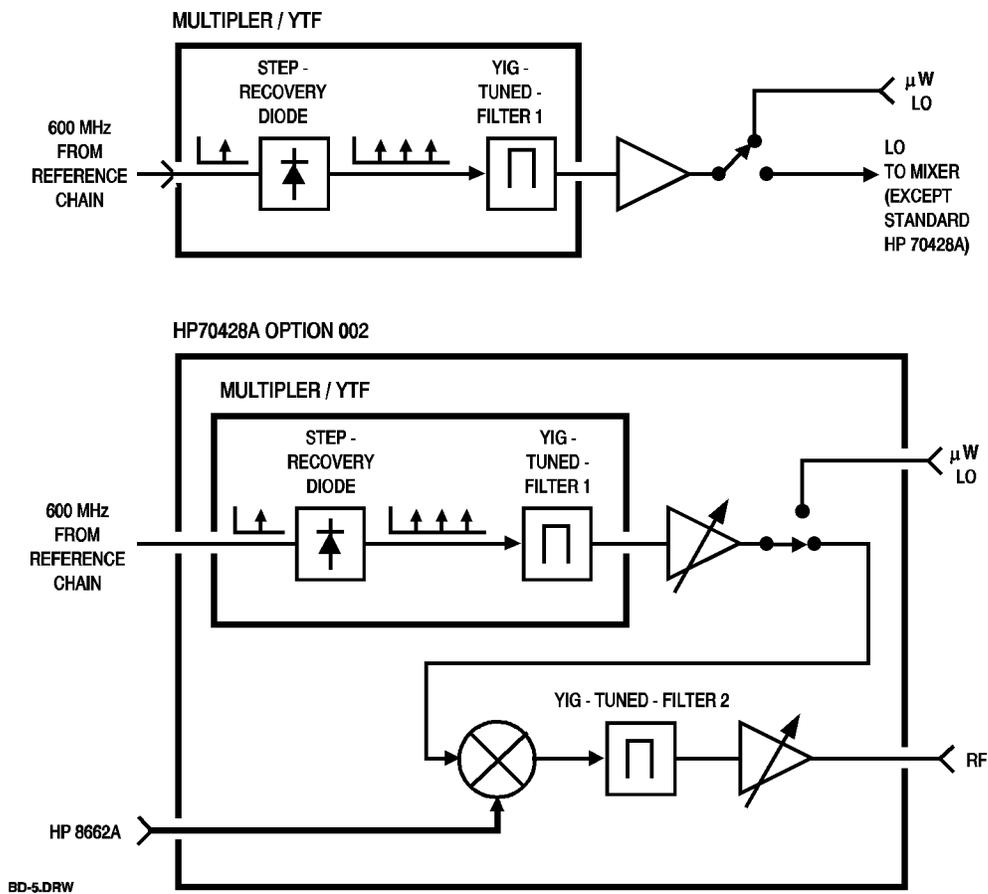


Figure 10-89 Multiplier / YTF

## YTF 1 Power

This softkey causes the module to run an internal YIG-Tuned-Filter (YTF) power calibration routine.

**Path**                    *Service*    *YTF Cal*    *YTF 1 Power*

**HP-IB command**        SOUR:POW:CAL 1

**See Also**              Chapter 15 - Adjustments.

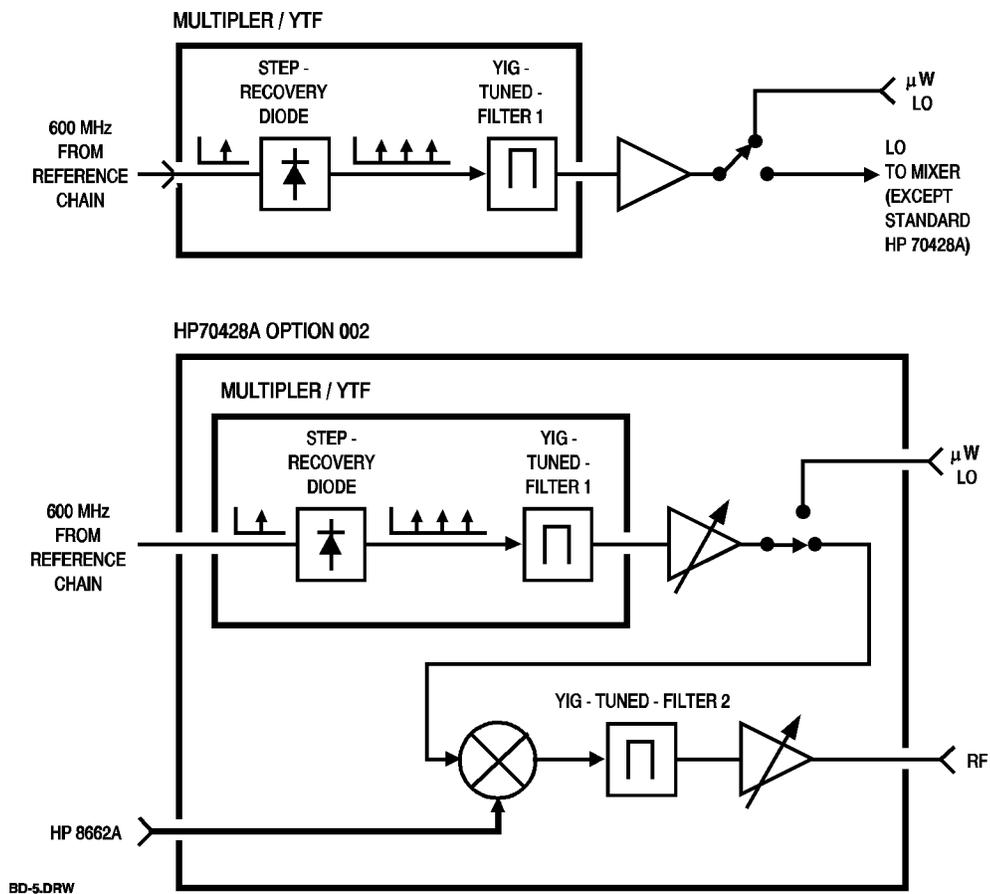


Figure 10-90 Multiplier / YTF

## YTF 2 Power

This softkey causes the tunable source to run an internal YIG-Tuned-Filter (YTF) power calibration routine.

**Path**                    *Service*    *YTF Cal*    *YTF 2 power*

**HP-IB command**                    SOUR:FREQ:CAL 2

**See Also**                    Chapter 15 - Adjustments.

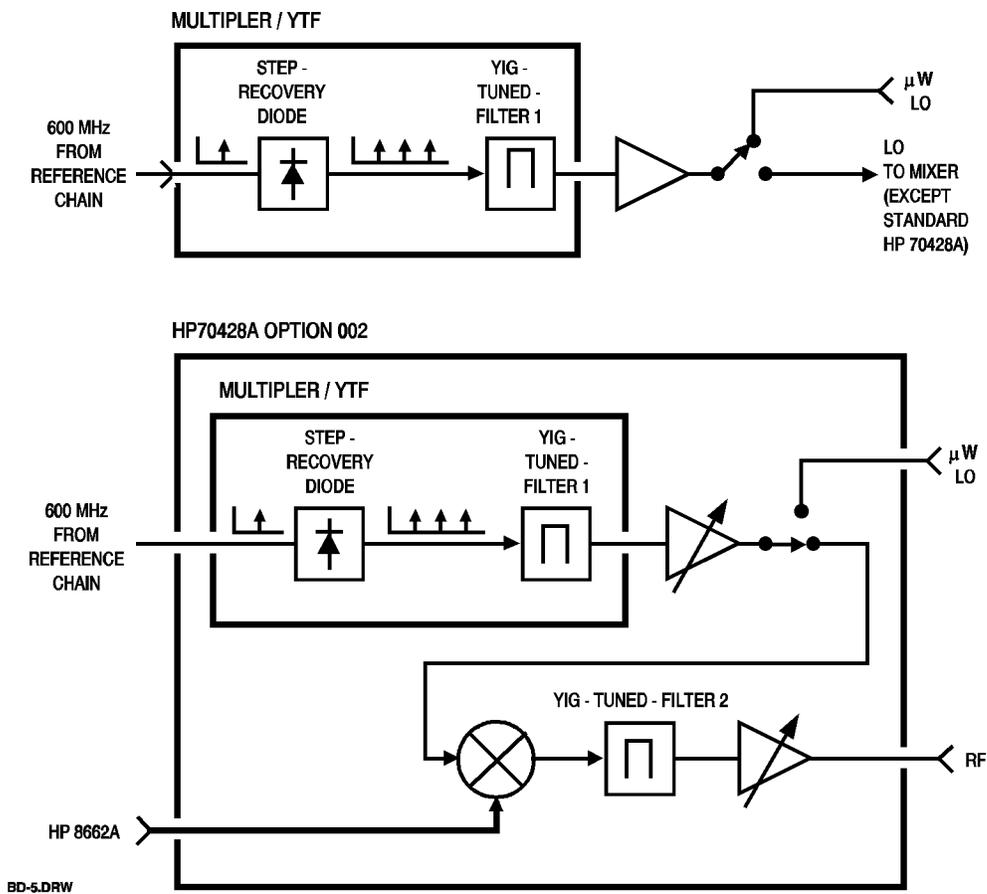


Figure 10-91 Multiplier / YTF

## YTF Cal

This softkey displays a menu of YIG-Tuned-Filter (YTF) calibration functions.

**Path**                    *Service*    *YTF Cal*

**HP-IB command**        None.

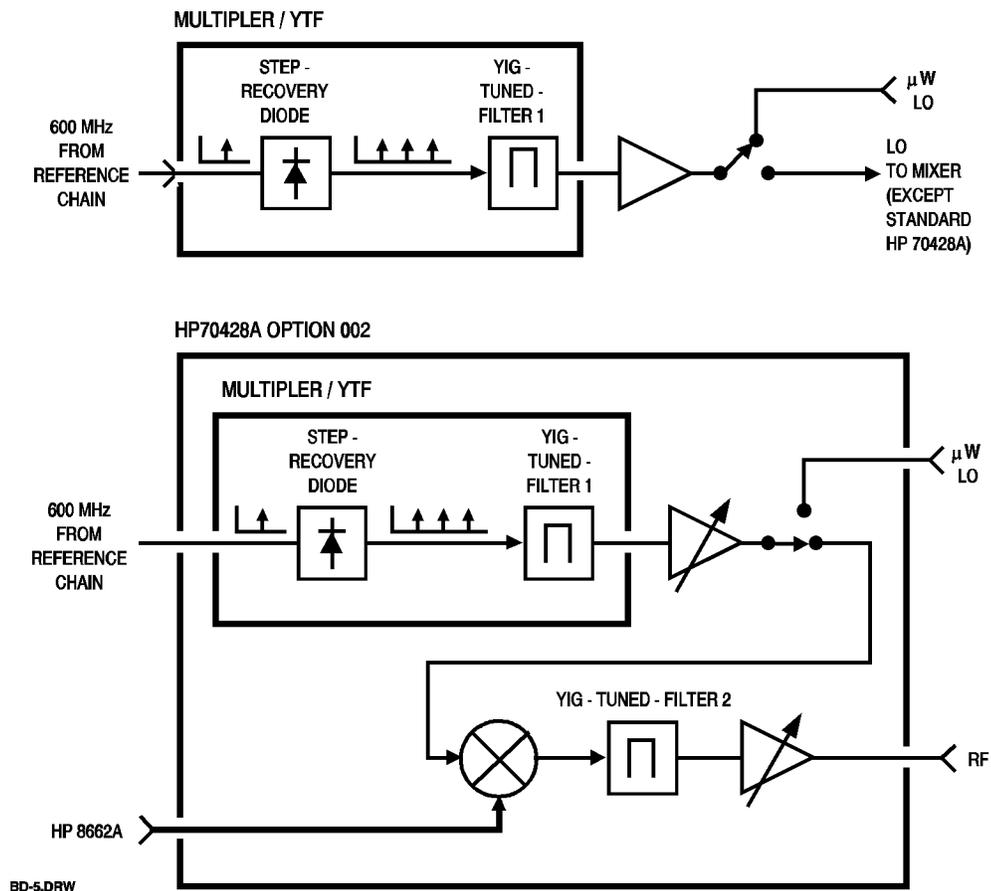


Figure 10-92 Multiplier / YTF

Softkeys and Displays  
**YTF Cal**

# 11

---

---

## Connectors and Indicators (Front- and Rear-Panel)

### Overview

This chapter describes the performance limits, impedances, and operating considerations of each front- and rear-panel connector and indicator. All HP 70427A , HP 70428A , and HP 70428A Option 002 connectors and indicators are listed alphabetically.

# Front Panel

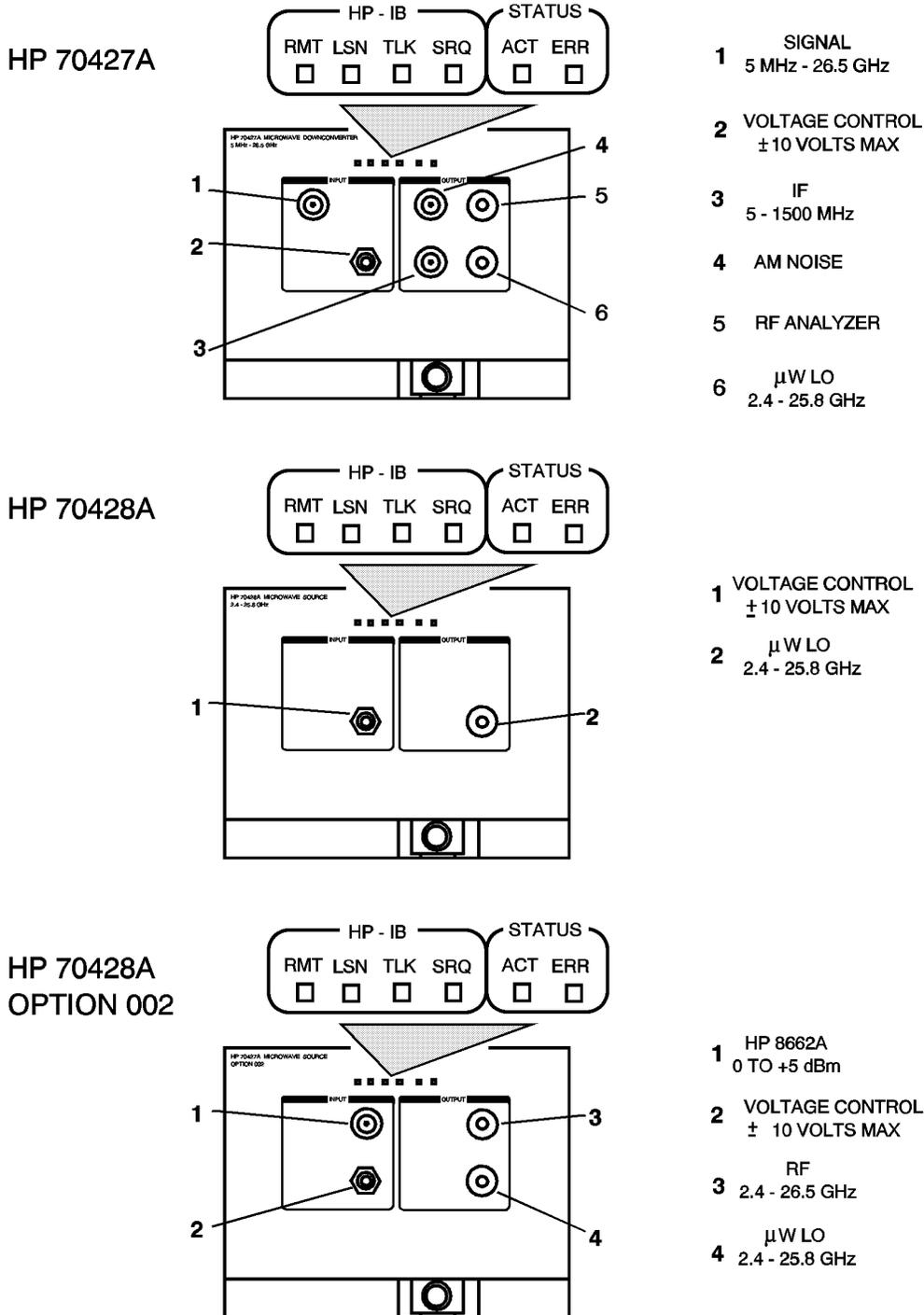


Figure 11-1 Front Panel Views HP 70427A, HP 70428A & HP 70428A Option 002

---

## ACT indicator

The active module indicator shows when the module can be controlled from the MMS mainframe.

### Changing active modules

Press the *DISPLAY* softkey then press the *NEXT INSTR* softkey, until the desired module's **ACT** indicator lights.

---

## **AM NOISE output**

The signal at this connector is the output of the down converter's RF AM detector or the IF AM detector.

---

### **NOTE**

---

AM noise specifications apply to the RF AM detector only.

### **Characteristics**

- Output impedance: Approximately 500  $\Omega$ , but it is designed to drive a 50  $\Omega$  load such as the 50  $\Omega$  noise input of an HP 11848.
- Output bandwidth: 1 Hz to 40 MHz into a 50 $\Omega$  load.

### **Operating Considerations**

#### **RF AM detector enabling**

Press the *AM Noise* softkey, then the *AMNSE* softkey so that *IN* is underlined.

#### **IF AM detector enabling**

This detector is normally enabled and its output is present at the **AM NOISE OUTPUT** connector. The *AMNSE* softkey must have the *IN* softkey underlined.

#### **RF AM detector input power adjusting**

The input to the RF AM detector must not exceed +20 dBm. The recommended operating range is +10 to +15 dBm.

Input power can be adjusted with the input attenuator (0 to 35 dB) in 5 dB steps. Press the *Amplitudes* softkey, the *more 1 of 2 softkey*, then the *INPUT ATTEN* softkey. Enter the desired attenuation.

#### **IF AM detector level adjusting**

See the **IF** connector description. The input attenuators and IF amplifier gain can be adjusted.

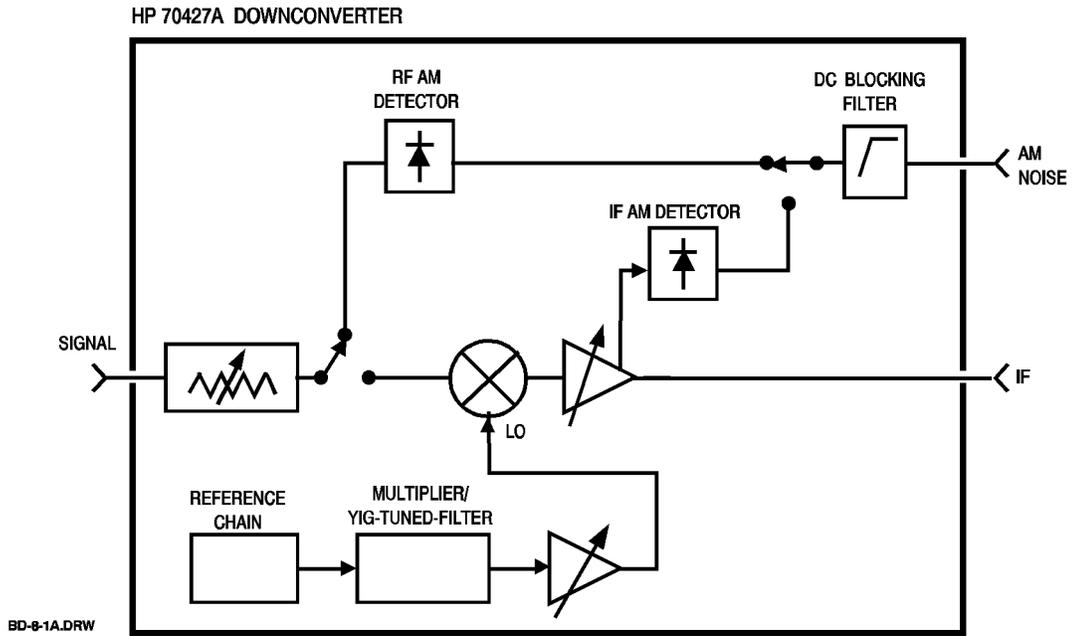


Figure 11-2 HP 70427A Downconverter Front Panel

---

## ERR indicator

The error message indicator shows when an error occurs and that an error message can be read.

### Operating considerations

To read error messages, press the **DISPLAY** key, then the **REPORT ERRORS** softkey. The error message(s) will be listed on the screen. Press the **REPORT ERRORS** repeatedly until "No Errors" is displayed.

Press **MENU** to return to the normal instrument display.

Error messages are erased as they are read. When all error messages are erased the error message indicator will go out. If an error condition still exists the message will re-appear. For example, if a phase-lock-loop is unlocked you will get an out-of-lock message. After you read the error message it will be cleared. If the loop is still unlocked, another out-of-lock message will be generated and the error message indicator will light.

Messages can also be read over the HP-IB.

## HP 8662A input

This connector accepts a 120 MHz to 900 MHz signal from an HP 8662A or HP 8663A. This signal is mixed with the internal microwave local oscillator. The result is a tunable microwave signal with a 0.1 Hz resolution over most of the frequency range.

### Limits

- Maximum input level: +10 dBm
- Recommended input level: -10 to +5 dBm
- Frequency: 120 MHz to 900 MHz

### Characteristics

- Input impedance: 50  $\Omega$

### Operating considerations

#### Setting frequency

The HP 70428A Option 002 is designed to work with an HP 8662A or HP 8663A signal generator. Normally an HP-IB cable is connected between the MMS mainframe and the HP 8662A or HP 8663A. The HP 70428A Option 002 acts as a controller and tells the HP 8662A or HP 8663A what frequency to set. In remote operation, the signal generator must be programmed separately. If another signal generator is used you must determine and set its frequency manually.

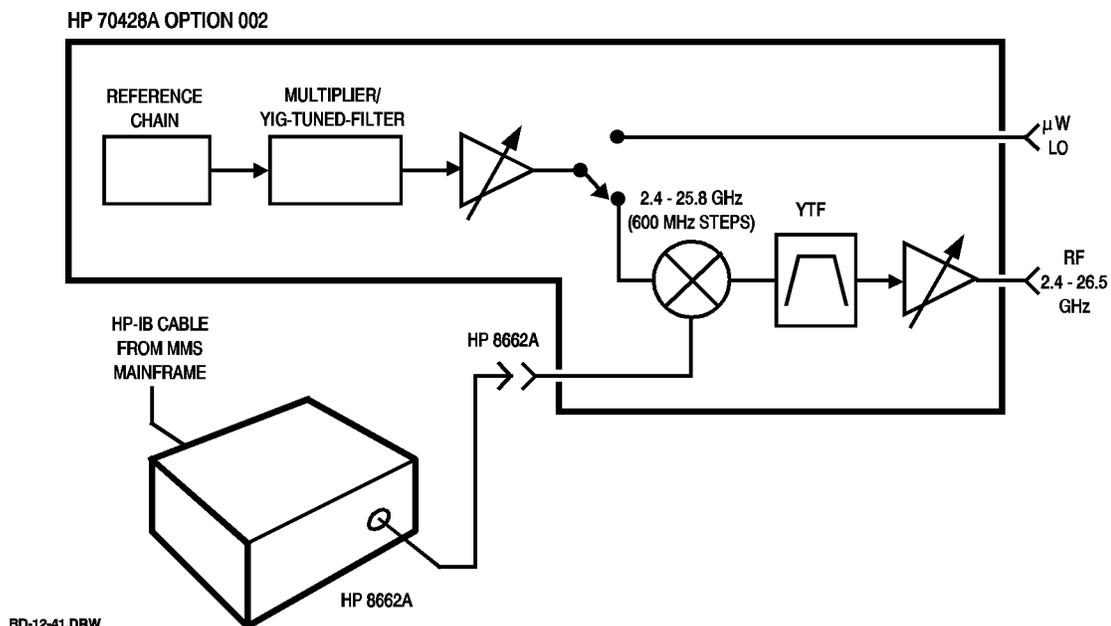


Figure 11-3 HP 70428A Option 002

## **HP-IB indicators**

See RMT, LSN, TLK, and SRQ.

## IF output

The signal at this connector is the downconverter's output.

### Limits

- Nominal output level: 0 to +5 dBm (input signal  $\geq -30$  dBm)
- Maximum output level: +15 dBm
- Frequency (RF input 5 to 1500 MHz): 5 to 1500 MHz
- Frequency (RF input 1.5 to 26.5 GHz): 300 to 900 MHz

The IF amplifiers frequency response starts rolling off above 1200 MHz. It is best to avoid using IF frequency between 1200 and 1500 MHz.

### Characteristics

- Output impedance: 50  $\Omega$

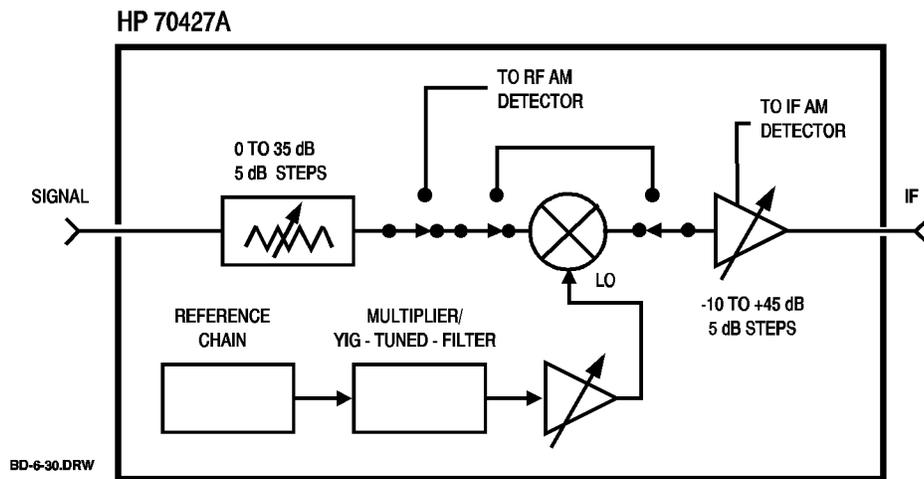


Figure 11-4 HP 70427A

---

## **LSN indicator**

The listen indicator shows when the module is addressed to listen over HP-IB.

---

## RF output

The signal at this connector is the output of the tunable source.

### Limits

- Frequency: 2.4 to 26.5 GHz
- Level(2.4 to 6.6 GHz): 0 to +16 dBm
- Level(>6.6 GHz to 25.8 GHz): 0 to +10 dBm
- Level(>25.8 GHz to 26.5 GHz): 0 to +7 dBm

### Characteristics

- Output impedance: 50  $\Omega$

### Operating considerations

#### Level setting

The level setting resolution is 0.1 dB, but the actual level change for a 0.1 dB change in the entered level can be as much as 0.2 dB.

#### Linear v. low-noise mode

Power accuracy, AM noise, and phase-noise performance depends on whether the module is in linear mode or low-noise mode. See the *LINEAR* softkey and *LOW NOISE* softkey descriptions.

#### AM on the HP 8662A signal

In low-noise mode AM is strongly compressed.

In linear mode, AM is passed through fairly well, but AM depth is not accurate.

The module's **RF** output can be varied by about +3 dB to -10 dB by varying the HP 8662A's carrier level.

RF output

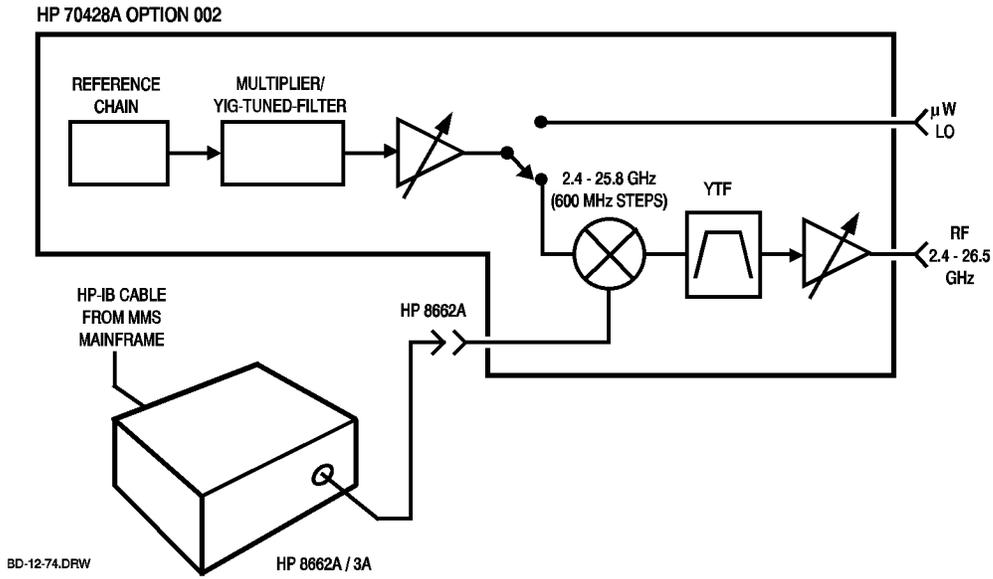


Figure 11-5 HP 70428A Option 002

## RF ANALYZER output

This connector provides a monitoring point for the downconverter's input, IF output, or for a signal connected to the rear-panel **SPECTRUM ANALYZER input from 11848** connector.

### Characteristics

- Output impedance: 50  $\Omega$

### Operating considerations

#### Signal routing

Press the *Amplitudes* softkey, then the *VIEW* softkey until the signal you want to monitor is underlined. The choices are *IF*, *IN*, and *-*. The last choice connects the rear-panel **SPECTRUM ANALYZER input from 11848** connector to the **RF ANALYZER** connector.

#### Terminating

Select the *-* choice if the connector is not used.

Terminate the **IF** output in 50 $\Omega$  when monitoring the input. Leaving it unterminated can cause frequency response ripples in the monitored input.

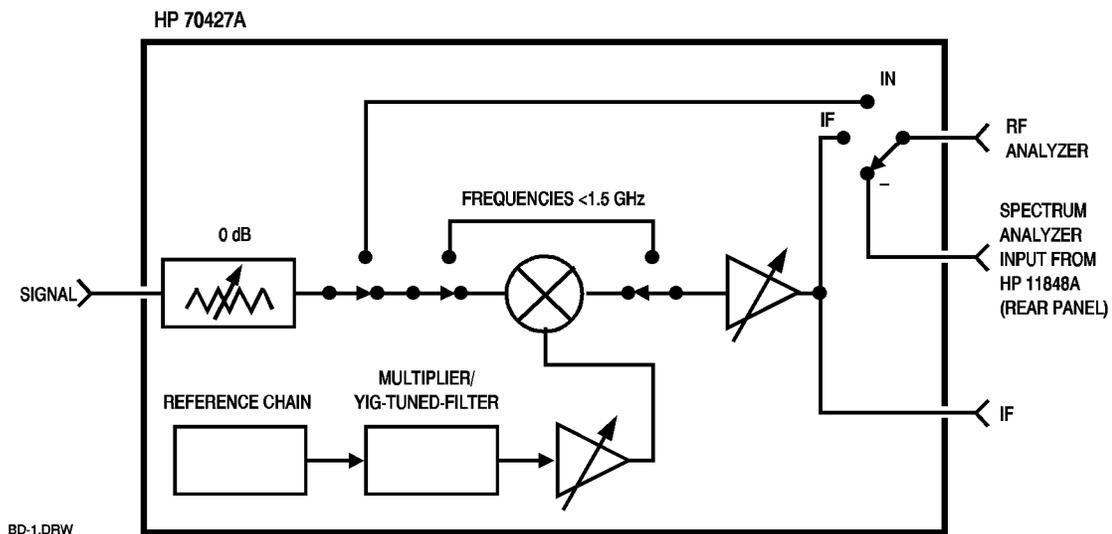


Figure 11-6 HP 70427A RF Analyzer

---

## **RMT indicator**

The remote indicator shows when the module is enabled for HP-IB control (lit) or front-panel control (not lit).

## SIGNAL input

This connector accepts the input signal for the downconverter.

### Limits

- Maximum level: +30 dBm
- Frequency: 5 MHz to 26.5 GHz

### Characteristics

- Input impedance: 50  $\Omega$
- Typical return loss: 10 dB
- Mixer compression point: -10 dBm

### Operating considerations

#### Input level

Optimum mixer input level depends on the application. Level is set by adjusting the input signal level and setting the internal input attenuators. For making noise measurements you want the highest level above the noise floor. For applications such as AM measurement where distortion is important the signal should be as far below the mixer compression point as possible.

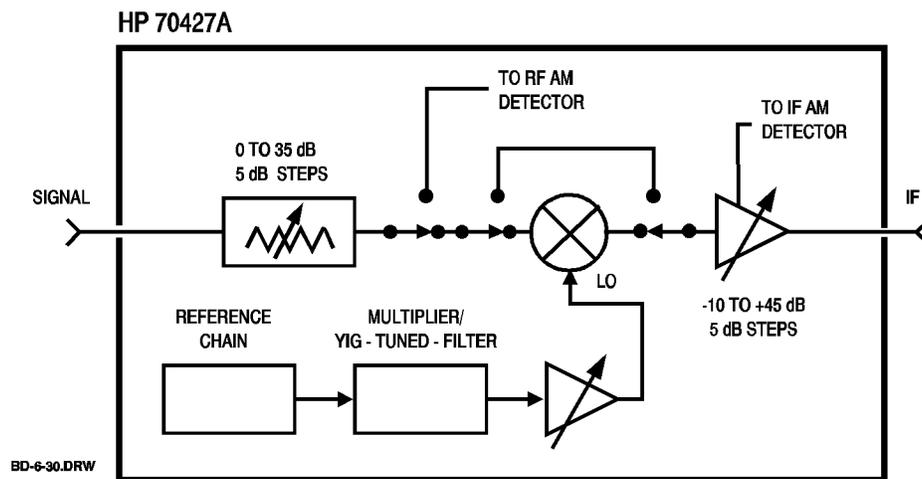


Figure 11-7 HP 70427A

---

## SRQ indicator

The service request indicator shows when the module has requested service over HP-IB.

---

## **STATUS indicators**

See ACT and ERR.

---

## **TLK indicator**

The talk indicator shows when the module is addressed to talk over HP-IB.

---

## $\mu$ W LO output (downconverter)

The signal at this connector on the downconverter can drive the comb generator of an external mmWave harmonic mixer.

When the downconverter is in source mode this connector is the output.

### Limits

- Frequency range: 2.4 to 6.8 GHz in 600 MHz steps
- Output power (2.4 to 6.6 GHz): 0 to +16 dBm
- Output power (7.2 to 25.8 GHz): 0 to +10 dBm

The frequency range is 2.4 to 25.8 GHz if the LO frequency is entered manually.

### Characteristics

- Output impedance: 50  $\Omega$

### Downconverter operating considerations

#### Enabling

Press the *Freqs* softkey, then the  $\mu$ W/mm softkey (mm must be underlined).

#### Entering mm band

Press the *mm Band* softkey, then the softkey for the band that includes the input frequency. This enables the downconverter to accept and input frequency entry within the selected band.

#### Entering LO frequencies

A LO frequency between 2.4 and 25.8 GHz can be entered with the *LO FREQ* softkey. If a LO Frequency is entered the down converter does not calculate and display Input, mm LO, or IF frequencies.

Connectors and Indicators (Front- and Rear-Panel)  
mW LO output (downconverter)

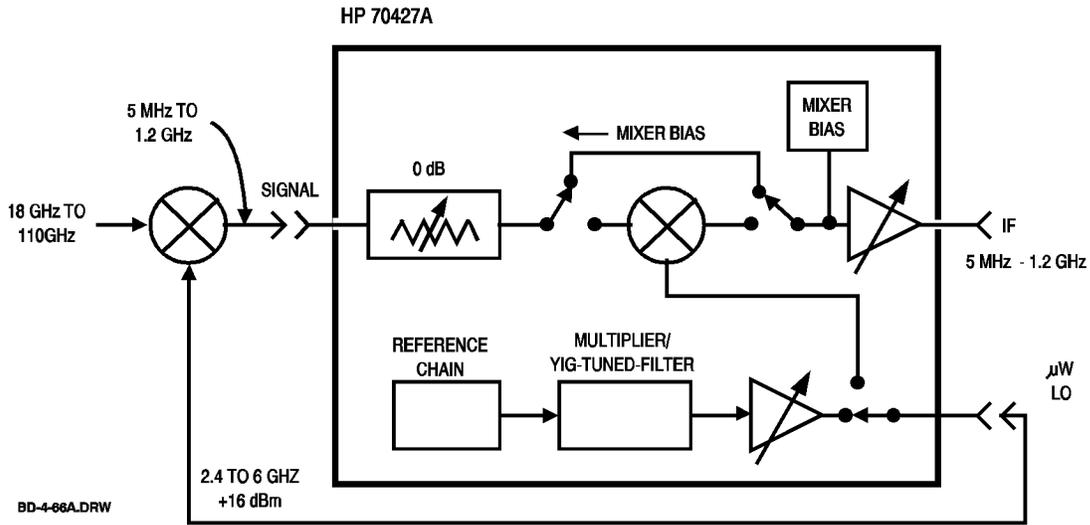


Figure 11-8 HP 70427A Connectors and Indicators

## VOLTAGE CONTROL input

This connector accepts an external tuning voltage for the 10 MHz, 100 MHz, or 600 MHz oscillators.

### Limits

- Maximum voltage:  $\pm 10$  Volts
- Maximum frequency shift (10 MHz):  $\pm 0.25$  ppm
- Maximum frequency shift (100 MHz):  $\pm 5$  ppm
- Maximum frequency shift (600 MHz):  $\pm 100$  ppm

### Characteristics

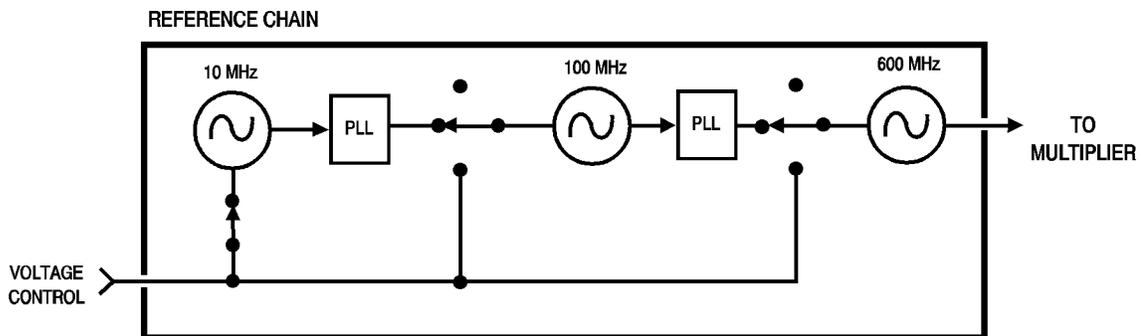
- Input impedance: 100 k $\Omega$

### Operating considerations

#### Oscillator selection

Press the *Ref Chain* softkey, then the *Tune Sens* softkey. Select the oscillator by choosing tuning sensitivity as follows:

- No external tuning: 0 ppm
- 10 MHz oscillator: 0.05 ppm/V
- 100 MHz oscillator: 1.0 ppm/V
- 600 MHz oscillator: 20 ppm/V
- 100 MHz No Tune: 0 ppm
- 600 MHz No Tune: 0 ppm



BD-10-20.DRW

Figure 11-9 Reference Chain

---

## $\mu$ W LO output (source)

The signal at this connector is the source's output.

### Limits

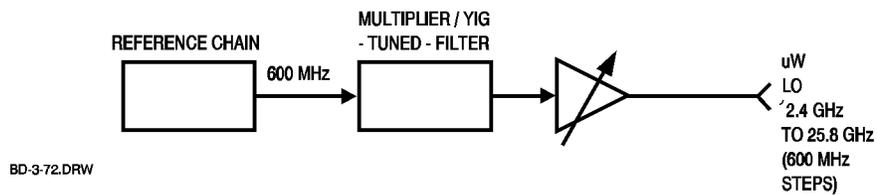
- Frequency range; 2.4 to 25.8 GHz in 600 MHz steps.
- Output power (2.4 to 6.6 GHz): 0 to +16 dBm.
- Output power (7.2 to 25.8 GHz): 0 to +10 dBm.

### Characteristics

- Output impedance: 50  $\Omega$

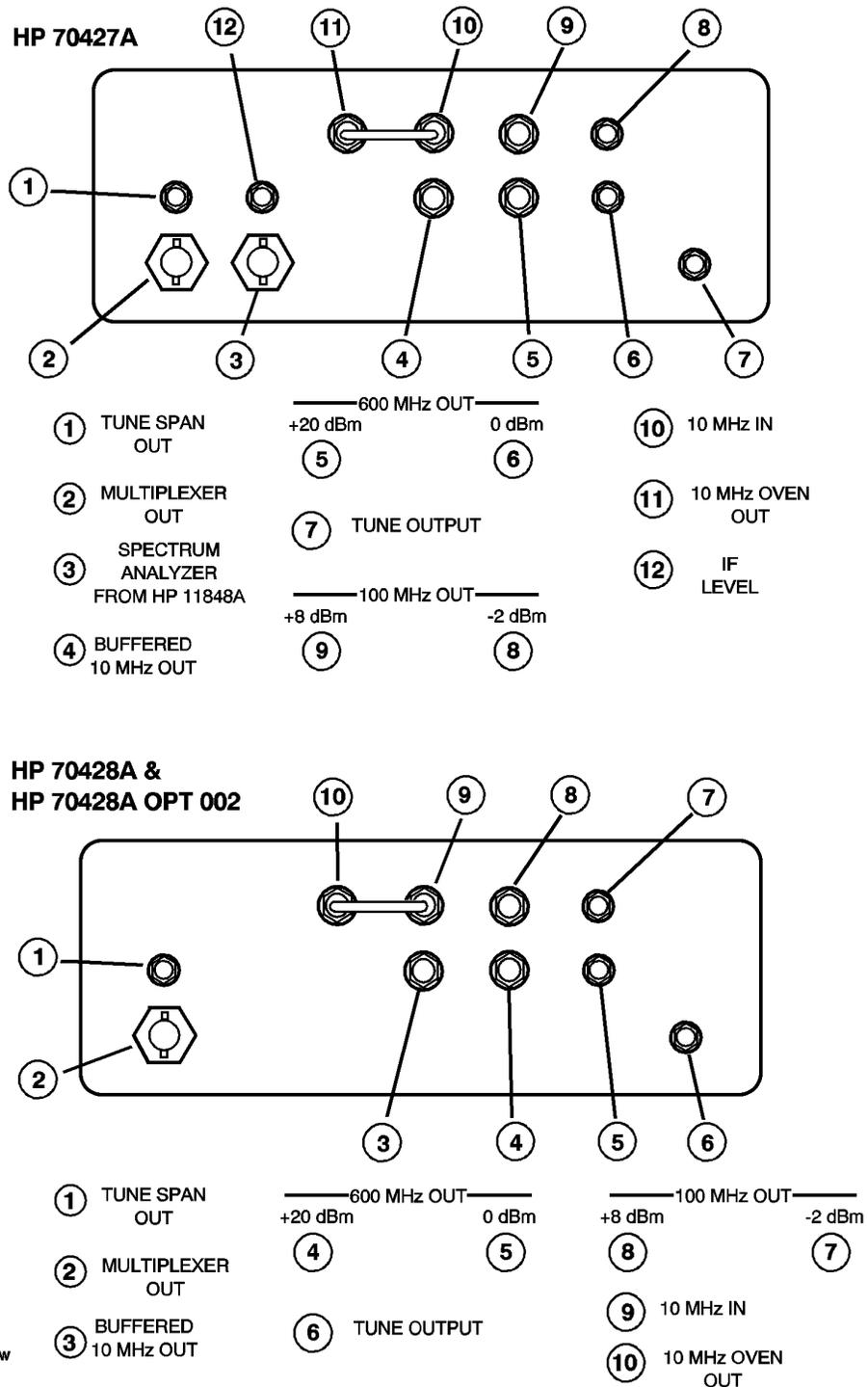
### Operating Considerations

The HP 70427A and HP 70428A Option 002 are switched into source mode with the *Source* softkey.



*Figure 11-10 Reference Chain*

## Rear Panel



REAR-PAN.DRW

Figure 11-11 Rear Panel Views HP 70472A, HP 70428A and 70428A Option 002

## 10 MHz IN

This connector accepts a 10 MHz reference signal for the module's phase-lock-loops. It is normally jumpered to the **10 MHz OVEN OUT** connector.

### Limits

- Level range: +7 to +13 dBm

### Characteristics

- Input impedance: 50  $\Omega$

### Operating considerations

Noise and other impurities on a signal applied to this input will show up on the output. The amount of noise and impurities passed through depends on the tuning sensitivity ( *Tune Sens* softkey setting).

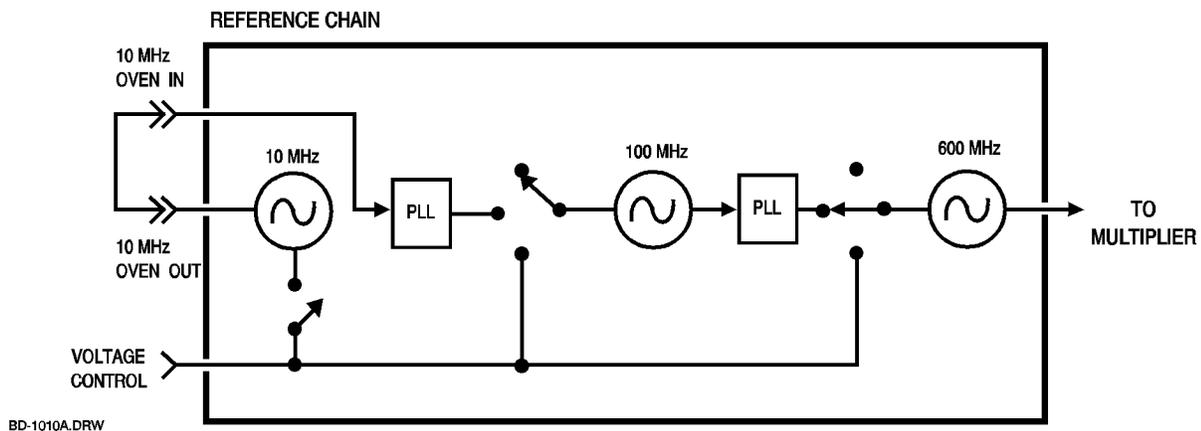


Figure 11-12 Reference Chain

## 10 MHz OVEN OUT

The signal at this connector is the output of the 10 MHz reference oscillator. It is normally jumpered to the **10 MHz IN** connector.

### Characteristics

- Typical output power: +13 dBm
- Output impedance: 50  $\Omega$
- Phase noise: See Specifications.

### Operating considerations

#### External tuning

This signal can be tuned by a voltage applied to the front-panel **VOLTAGE CONTROL** connector.

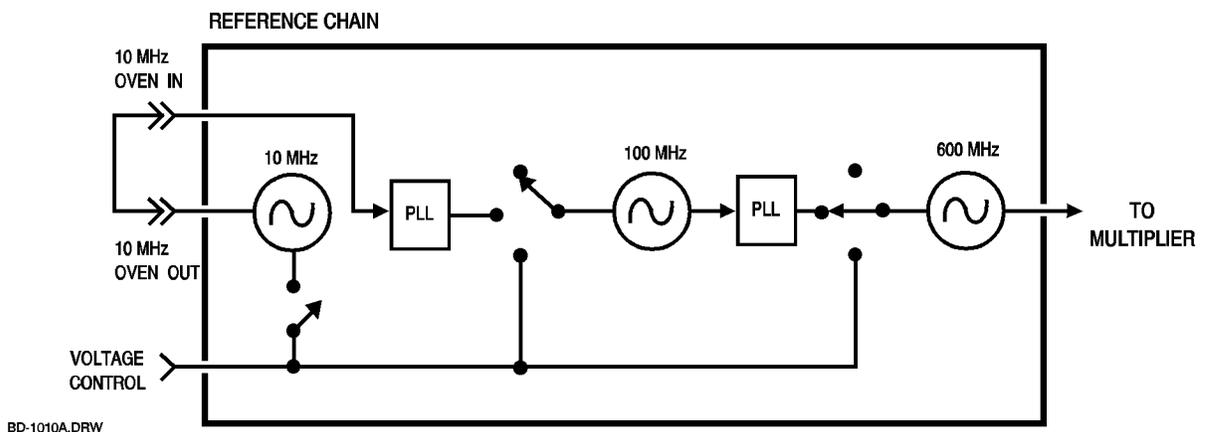


Figure 11-13 Reference Chain

## 100 MHz OUT-2 dBm

The signal at this connector is an output of the 100 MHz reference oscillator.

### Characteristics

- Output impedance: 50  $\Omega$
- Phase noise: See Specifications.
- Typical output power: -2 dBm

### Operating considerations

#### External tuning

This signal can be tuned by a voltage applied to the front-panel **VOLTAGE CONTROL** connector.

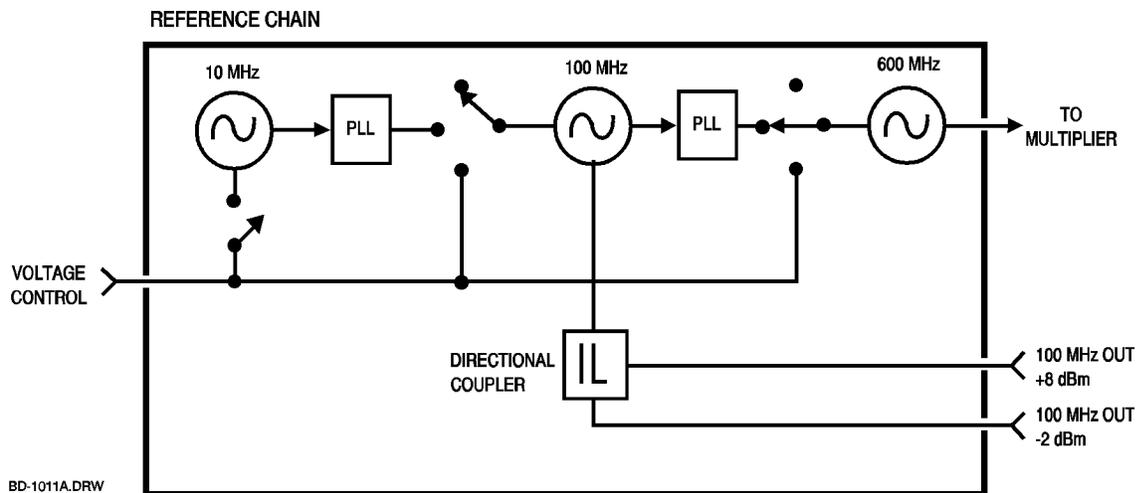


Figure 11-14 Reference Chain

## 100 MHz OUT+8 dBm

The signal at this connector is an output of the 100 MHz oscillator.

### Characteristics

- Output impedance: 50  $\Omega$
- Phase noise: See Specifications.
- Typical output power: +8 dBm

### Operating considerations

#### External tuning

This signal can be tuned by a voltage applied to the front-panel **VOLTAGE CONTROL** connector.

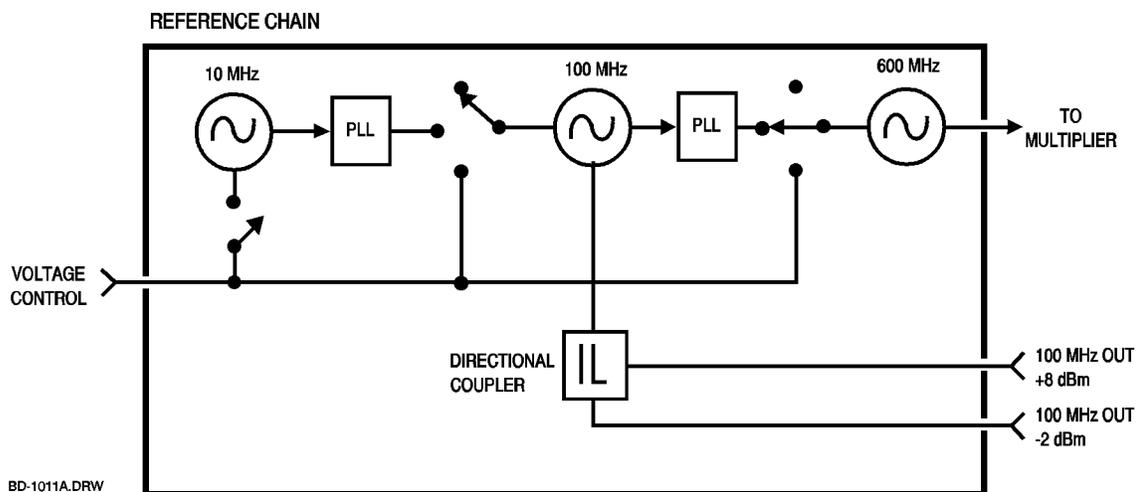


Figure 11-15 Reference Chain

## 600 MHz OUT 0 dBm

The signal at this connector is an output of the 600 MHz Output oscillator.

### Characteristics

- Output impedance: 50  $\Omega$
- Phase noise: See Specifications.
- Typical output power: 0 dBm

### Operating considerations

#### External tuning

This signal can be tuned by a voltage applied to the front-panel **VOLTAGE CONTROL** connector.

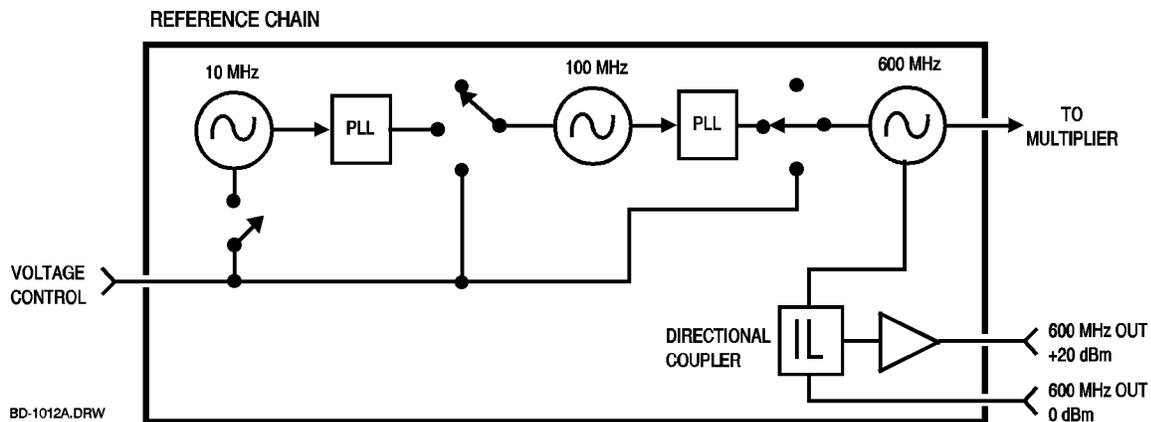


Figure 11-16 Reference Chain

## 600 MHz OUT+20 dBm

The signal at this connector is an output of the 600 MHz oscillator.

### Characteristics

- Output impedance: 50  $\Omega$
- Phase noise: See Specifications.
- Typical output power: +20 dBm

### Operating considerations

#### External tuning

This signal can be tuned by a voltage applied to the front-panel **VOLTAGE CONTROL** connector.

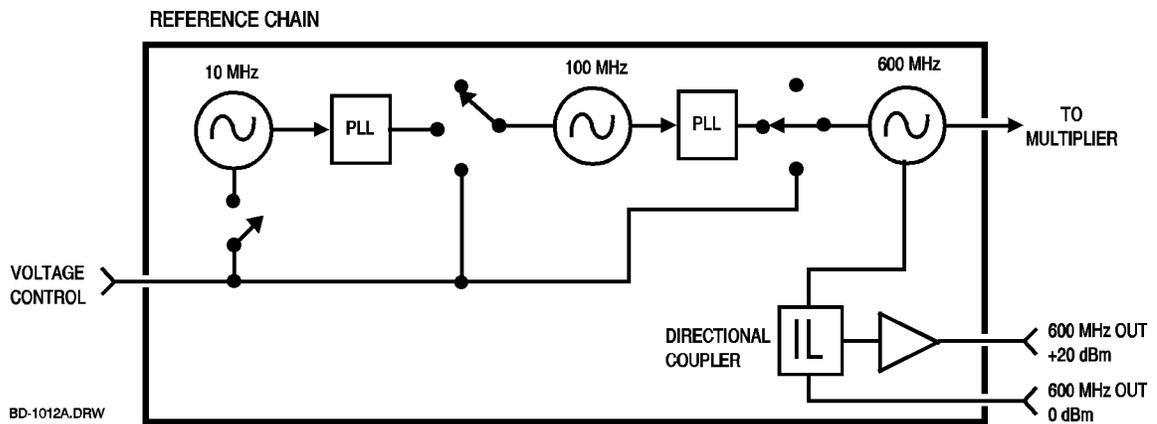


Figure 11-17 Reference Chain

## BUFFERED 10 MHz OUT

The signal at this connector is the signal at the rear-panel 10 MHz IN connector after it has been buffered by an amplifier.

### Characteristics

- Output impedance: 50  $\Omega$
- Typical output power: +7 dBm

### Operating Considerations

When the reference chain tuning sensitivity is set to 1.0 ppm/V this output is switched off.

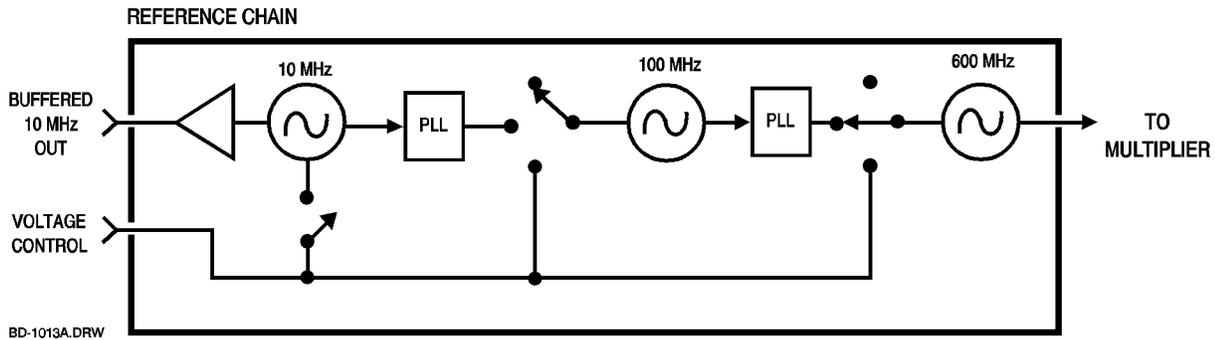


Figure 11-18 Reference Chain

---

## **IF LEVEL output**

Not used.

**MULTIPLEXER OUT**

---

## **MULTIPLEXER OUT**

The signal at this connector is the voltage that is measured by the internal voltmeter.

### **Characteristics**

- Output level range:  $\pm 10$  V
- Output impedance: 1 k $\Omega$
- Bandwidth: 100 kHz

## SPECTRUM ANALYZER Input From 11848

This connector is the input for the **SPECTRUM ANALYZER PHASE NOISE** output of the HP 11848A.

When the *VIEW* has -underlined, this connector is routed to the front-panel **RF ANALYZER** connector.

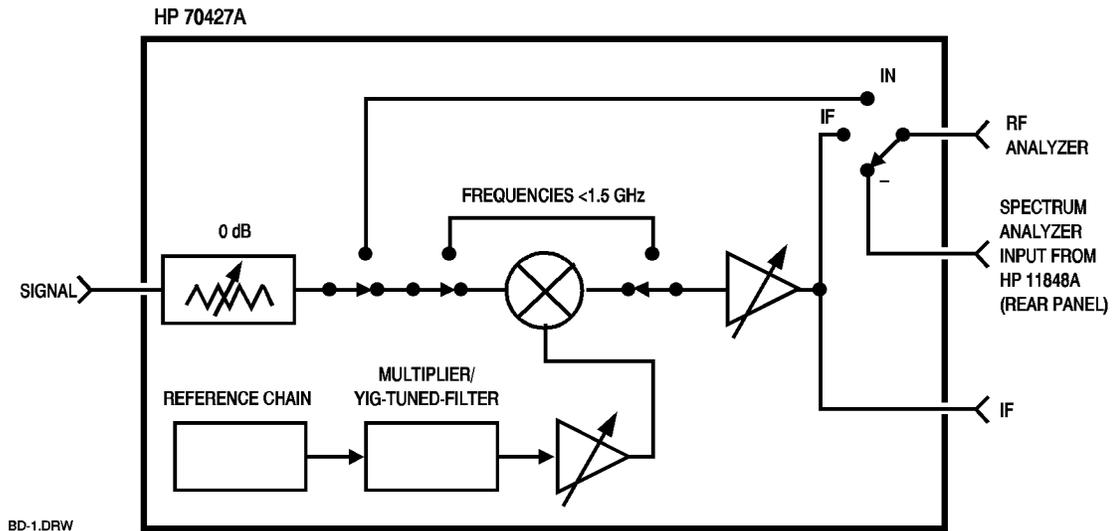


Figure 11-19 HP 70427A

**TUNE OUTPUT**

---

**TUNE OUTPUT**

Not used.

---

## **TUNE SPAN OUT**

Not used.

**TUNE SPAN OUT**

# 12

---

---

## Remote Programming Commands

### Overview

This chapter consists of a reference table of HP-IB commands for the HP 70427A , HP 70428A , and HP 70428A Option 002.

Most of the commands are non-overlapped. That is, when a series of commands is to be executed the controller sends one at a time. It sends a command then waits until the module executes it before sending the next one.

The commands for frequency and power calibration are the only overlapped commands.

**Table 12-1 Specific Instrument Commands Summary**

$\mu$ Wave Source	Tuneable Source	Downconverter
SRC	TS	DC
OUTput	:OUTput	:FREQs
:FREQuency	::[OUTput]	:IF
:FFRequency	:FREQuency	::[FREQuency]
:POWer	:FFRequency	:YTF
	:POWer	::[FREQuency]
	:OUTput	:INPut
	:LO	::[FREQuency]
	:FREQuency	:LO
	:FFRequency	::[FREQuency]
	:POWer	:POWer
	:LEVel	:MODE
	:LO	:MM
	::[POWer]	:BAND
	:RFSource	:MIXer
	::[POWer]	:BIAS
	:RANGE	:AMPLitudes
	:MODE	:AUTOrange
		:IF
		:AM
		:GAIN
		:INPut
		:ATTen
		:MIXer
		:MAXLevel
		:VIEW
		AMNoise
		:AMDetector
		::[READ]:
		: MAXLevel:
		:AMNoise
		:LNA
		:RFAnalyzer
		:IF
		:PEAK
		:INPut
		: PEAK

**Table 12-2 :General Instrument Command Summary**

Instrument	Reference Chain	Source	Status	System	Diagnostic	IEEE
:INST	:REF	:SOUR	:STAT	:SYST	:DIAG	:*CLS
: [SElect]	: BW	:ALC	:OPERation	:ERRor	:OPTIONS	:*ESE
	:PLL100		:CONDition		:SERIAL	:*ESR
	:PLL600		:[EVENT]		:SETup	:*IDN
			:PTRansition		:BLOCK	:*OPT
			:NTRansition		:LATCh	:*OPC
			:ENABLE		:NUMber	:*WAI
			:QUEStionable		:DATA	:*RST
			:CONDitionable		:MUX	:*SRE
			:[EVENT]		:VOLTmeter	:*STB
			:PTRansition		:RELay	:*TST
			:NTRansition		:NUMber	:*TRG
			:ENABLE		:DATA	:*SAV
			:CALibration			
			:CONDition			
			:[EVENT]			
			:PTRansition			
			:NTRansition			
			:ENABLE			

**Table 12-3 IEEE 488.2 COMMON COMMANDS**

COMMAND	Action
*CLS	Clears status and event registers.
*ESE	Sets the Standard Event Status Enable Register.
*ESE?	Queries the Standard Event Status Enable Register.
*ESER?	Queries the Standard Event Status Register.
*IDN?	Returns the module's identity.
*OPC?	Queries the Operation Complete bit of the Standard Event Status Register.
*OPT?	Returns the module's installed options.
*RST	Resets the module to its power-up state.
*SRE	Sets the Service Request Enable Register.
*SRE?	Queries the Service Request Enable Register.
*STB	Sets the Status Byte.
*STB?	Queries the Service Request Enable Register.
*WAI	Holds the bus until all previous commands or queries are completed.

**Table 12-4 INSTRUMENT SELECT COMMAND**

Command	Function	Equivalent Softkey
INST n	Configures the module as a downconverter, source, or tunable source. Values of n are: 3= Downconverter (HP 70427A only) 4= Microwave Source 5= Tunable Source (HP 70428A Option 002 only)	<i>Down Convert Source</i> <i>Tunable Source</i>

**Table 12-5 DOWNCONVERTER COMMANDS (HP 70427A only)**

Command	Function	Equivalent Softkey or Display
DC : AMN : AMD?	Returns AM detector voltage.	<b>READ AM DET</b>
DC : AMN : AMD : MAXL	Sets AM Detector Max Level	<b>AM DET MAX LVL</b>
DC : AMN : AMD : MAXL?	Returns AM Detector Max Level setting.	<b>AM Det Max Lvl :</b>
DC : AMN : AMN n	Turns AM noise mode to IN and IF... IF: n= 0 IN: n= 1	<b>AM NSE IN   IF</b>
DC : AMN : AMN?	Returns the AM noise mode setting: 0,1	
DC : AMPL : AUTO	Triggers one-time amplitude autorange.	<b>AUTO RANGE</b>
DC : AMPL : IF : AM n	Routes the IF AM detector output... rear-panel: n= 0 front-panel: n= 1	<b>IF AM Output</b>
DC : AMPL : IF : AM?	Returns the IF AM detector output setting: 0 or 1	
DC : AMPL : IF : GAIN n	Sets IF gain: n= -10 to +45, in 5 dB steps	<b>IF GAIN</b>
DC : AMPL : IF : GAIN AUTO	Triggers one time IF gain autorange.	<b>AUTO IF GAIN</b>
DC : AMPL : IF : GAIN?	Returns IF gain setting: -10 to +45	<b>IF GAIN :</b>
DC : AMPL : INP : ATT n	Sets input attenuator: n= 0 to 35, in 5 dB steps	<b>INPUT ATTEN</b>
DC : AMPL : INP : ATT?	Returns input attenuator setting: 0 to 35	<b>Atten :</b>
DC : AMPL : INP : ATT AUTO	Triggers one-time attenuator autorange.	<b>AUTO ATTEN</b>
DC : AMPL : MIX : MAXL n	Sets mixer maximum level: n= -5 to +5 in 1 dB steps	<b>MIXER MAX LVL</b>
DC : AMPL : MIX : MAXL?	Returns mixer maximum level setting: - 5.0 to +5.0	<b>Mixer Max Level :</b>
DC : AMPL : VIEW n	Selects the signal to route to the <b>RF ANALYZER</b> connector... IF: n= 0 input: n= 1 terminated: n= 2	<b>VIEW IN   IF   -</b>
DC : AMPL : VIEW?	Returns the view setting: 0,1,2	
DC : FREQ : BIAS n	Turns bias for an external mixer on and off.. off: 0 on: 1	<b>BIAS ON   OFF</b>
DC : FREQ : BIAS?	Returns the bias on   off status: 0,1	
DC : FREQ : YTF?	Returns the downconverter's YTF frequency. (mm mode only).	<b>LO :</b>

**Table 12-5 DOWNCONVERTER COMMANDS (HP 70427A only)**

Command	Function	Equivalent Softkey or Display
DC:FREQ:IF?	Returns the IF frequency.	<b>IF:</b>
DC:FREQ:INP n	Sets the input frequency: n= 4.9 MHz to 26.5 GHz (0.1 Hz resolution) or in mm mode, 17.9 GHz to 110.1 GHz	<b>INPUT FREQ</b>
DC:FREQ:INP?	Returns the input frequency setting.	<b>Input:</b>
DC:FREQ:LO n	Sets the LO frequency: n= 2.4 GHz to 26.4 GHz, in 600 MHz steps	<b>LO FREQ</b>
DC:FREQ:LO?	Returns the LO frequency setting.	<b>LO: or mm LO:</b>
DDC:FREQ:LO:POW n	Sets the LO power: n= real, 0.0 to 20.0 dBm	<b>LO POWER</b>
DC:FREQ:LO:POW?	Returns the LO power setting.	<b>Mixer LO Power:</b>
DC:FREQ:MIX:BIAS n	Sets the level of bias current supplied to an external mixer (mm mode only): n= real, -10 to +10 mA	<b>MIXER BIAS</b>
DC:FREQ:MIX:BIAS?	Returns the mixer bias current in setting in mA.	<b>mm Mixer Bias:</b>
DC:FREQ:MM:BAND n	Sets mm band (mm mode only)... K band: n= 0 A band: n= 1 Q band: n= 2 U band: n= 3 V band: n= 4 W band: n= 5	<b>mm Band</b>
DC:FREQ:MM:BAND?	Returns the mm band setting: 0,1,2,3,4,5	
DC:FREQ:MODE n	Switches the downconverter between mm mode and $\mu$ W mode... $\mu$ Wave mode: n= 0 mm wave mode: n= 1	<b>MODE <math>\mu</math>W/mm</b>
DC:FREQ:MODE?	Returns the above mode: 0,1	
DC:AMPL:MIX:MAXL?	Returns a real number	
DC:IF:PEAK?	Returns the peak voltage, in mV, from the peak detector at the IF amplifier's output.	

**Table 12-5 DOWNCONVERTER COMMANDS (HP 70427A only)**

Command	Function	Equivalent Softkey or Display
DC : INP : PEAK?	Returns the peak voltage, in mV, from the peak detector at the downconverter's input.	
DC : LNA : RFA n	Sets the path from the rear-panel <b>SPECTRUM ANALYZER</b> from HP 11848A to the front-panel <b>RF ANALYZER</b> connector... path enabled: n = 0 path disabled: n = 1	<b>IN  IF  VIEW</b>
DC : LNA : RFA?	Returns the above path setting: 0,1	

**Table 12-6 MICROWAVE SOURCE COMMANDS**

Command	Function	Equivalent Softkey or Display
SRC : OUT : FREQ n	Sets the output frequency: n= 2.4 to 26.4 GHz, in 600 MHz steps	<b>FREQ</b>
SRC : OUT : FREQ?	Returns the output frequency setting.	<b>Frequency:</b>
SRC : OUT : FFR n	Sets the output frequency quickly (without tuning the YTF trim DAC): n= 2.4 to 26.4 GHz, in 600 MHz steps	
SRC : OUT : POW n	Sets the output power: n= 0.0 to 20.0 dBm, in 0.1 dB steps	<b>POWER</b>
SRC : OUT : POW?	Returns the output power setting.	<b>Power:</b>

**Table 12-7 TUNABLE SOURCE COMMANDS (HP 70428A Option 002 Only)**

<b>Command</b>	<b>Function</b>	<b>Equivalent Softkey or Display</b>
TS:OUT:FREQ n	Sets the output frequency: n= 2.4 to 26.4 GHz, in 0.1 Hz steps	<b>OUTPUT FREQ</b>
TS:OUT:FREQ?	Returns the output frequency setting.	<b>Output:</b>
TS:OUT:FFR n	Sets the output frequency quickly (without tuning the YTF trim DAC): n= 2.4 to 26.4 GHz, in 0.1 Hz steps	
TS:OUT:POW n	Sets the output power: n= 0.0 to 20.0 dBm, in 0.1 dB steps	<b>OUTPUT POWER</b>
TS:OUT:POW?	Returns the output power setting.	<b>OUTPUT POWER:</b>
TS:OUT:LO:FREQ n	Sets the LO frequency n= 2.4 to 26.4 GHz, in 600 MHz steps	<b>LO FREQ</b>
TS:OUT:LO:FREQ?	Returns the LO frequency setting.	<b>LO:</b>
TS:OUT:LO:FFR n	Sets the LO frequency quickly (without tuning the LO YTF trim DAC): n= 2.4 to 26.4 GHz, in 600 MHz steps	
TS:OUT:LO:POW n	Sets the LO power: n= 0 to 20 dBm, in 1 dB steps	<b>LO POWER</b>
TS:OUT:LO:POW?	Returns the LO power setting.	<b>LO Power:</b>
TS:LEV:RFS n	Sets a default RF source output power: n= 0 to 13 dBm, in 1 db steps	<b>RF SRC PWR SET</b>
TS:LEV:RFS?	Returns the default RF source power setting.	<b>RF SRC PWR SET:</b>
TS:RANG:MODE n	Selects an external RF source range... 300-600 MHz: n= 0 120-300 and 480-600: n= 1	<b>Optimum Range</b>
TS:RANG:MODE?	Returns the above range setting: 0,1	

**Table 12-8 Microwave LO COMMANDS**

Command	Function	Equivalent Softkey or Display
REF:BW:PLL100 n	Selects the 100 MHz phase-lock-loop bandwidth: 25 Hz: n= 0 53 Hz: n= 1 126 Hz: n= 2 300 Hz: n= 3 650 Hz: n= 4 1.5 kHz: n= 5 3.6 kHz: n= 6 10 kHz: n= 7	<b>100 MHz PLL BW</b>
REF:BW:PLL100?	Returns the above bandwidth: 0,1,2,3,4,5,6,7	
REF:BW:PLL600n	Selects the 600 MHz phase-lock-loop bandwidth: 1 kHz: n= 0 10 kHz: n= 1 17 kHz: n= 2 30 kHz: n= 3	<b>600 MHz PLL BW</b>
REF:BW:PLL600?	Returns the above bandwidth.	
REF:TS n	Selects the reference chain tuning sensitivity: 0 ppm: n= 0 0.05 ppm/V: n= 1 1.0 ppm/V: n= 2 20 ppm/V: n= 3 100 MHz no tune: n= 4 600 MHz no tune: n= 5	<b>Tune Sens</b>
REF:TS?	Returns the tuning sensitivity: 0,1,2,3,4,5	
SOUR:POW:CONT n	Selects low noise or linear mode... low noise: n= 0 linear: n= 1	<b>Power Control</b>
SOUR:POW:CONT?	Returns the above mode setting: 0,1	
SOUR:ALC n	Selects ALC ON or OFF.. OFF: n= 0 ON: n= 1 ALC ON OFF	
SOUR:ALC?	Returns the above ALC setting: 0,1	

## HARDWARE CONTROL COMMANDS

These commands correspond to the *Hardware Control* softkeys. They are used to set relays and latches in the module's hardware. The setting of these relays and latches is normally invisible to the operator. See chapter 8 for a description of how to use these commands and the *Hardware Control* softkeys.

**Table 12-9** *HARDWARE CONTROL COMMANDS*

Command	Function	Equivalent Softkey or Display
DIAG:BLOCK n	Selects block n for control by the LATC and MUX commands.	<b>BLOCK</b>
DIAG:BLOCK?	Returns the selected block.	<b>Block:</b>
DIAG:LATC:DATA n	Writes n to the selected latch.	<b>LATCH DATA</b>
DIAG:LATC:DATA?	Reads from the selected latch.	<b>Data:</b>
DIAG:LATC:NUMB n	Selects latch n.	<b>LATCH NUMBER</b>
DIAG:LATC:NUMB?	Returns the number of the selected latch.	<b>Latch:</b>
DIAG:MUX n	Selects multiplexer n.	<b>VOLTMETER</b>
DIAG:MUX?	Returns the number of the selected multiplexer.	<b>Mux:</b>
DIAG:REL:DATA n	Sets the state of the selected relay (normal: n=0 out: n=1).	<b>RELAY STATE</b>
DIAG:REL:DATA?	Returns the state of the selected relay.	<b>State:</b>
DIAG:REL:NUMB n	Selects relay n.	<b>RELAY NUMBER</b>
DIAG:REL:NUMB?	Returns the number of the selected relay.	<b>Relay:</b>
DIAG:VOLT?	Returns the voltage measured by the internal voltmeter at the selected multiplexer point.	<b>Volt:</b>

**Table 12-10 Microwave LO COMMANDS**

Command	Function	Equivalent Softkey or Display
SOUR:FREQ:CAL 1	Triggers a YTF 1 frequency calibration.	<b>YTF 1 Freq</b>
SOUR:FREQ:CAL 2	Triggers a YTF 2 frequency calibration (HP 70428A Option 002 only). The RF source type must be set to <b>other</b> .	<b>YTF 2 Freq</b>
SOUR:POW:CAL 1	Triggers a YTF 1 power calibration.	<b>YTF 1 Power</b>
SOUR:POW:CAL 2	Triggers a YTF 2 power calibration (HP 70428A Option 002 only). The RF source type must be set to other and Pwrmt= HP 70100A	<b>YTF 2 Power</b>

**Table 12-11 STATUS REPORTING COMMANDS**

Command	Function
STAT:OPER:COND?	Returns the bit values of the Operation Status Condition Register.
STAT:OPER:ENAB n	Sets the Operation Status Event Enable register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:OPER:ENAB?	Returns the value of the Operation Status Event Enable register.
STAT:OPER?	Returns the value of the Operation Status Event register.
STAT:OPER:PTR n	Sets the Operation Status Positive Transition register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:OPER:PTR?	Returns the value of the Operation Status Positive Transition register.
STAT:OPER:NTR n	Sets the Operation Negative Transition register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:OPER:NTR?	Returns the value of the Operation Negative Transition register.
STAT:QUES:CAL:COND?	Returns the value of the Questionable Calibration Status Condition register.
STAT:QUES:CAL:ENAB n	Sets the Questionable Calibration Status Event Enable register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:QUES:CAL:ENAB?	Returns the value of the Questionable Calibration Status Event Enable register.
STAT:QUES:CAL?	Returns the value of the Questionable Calibration Status Event register.
STAT:QUES:CAL:PTR n	Sets the Questionable Calibration Status Positive Transition register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:QUES:CAL:PTR?	Returns the value of the Questionable Calibration Status Positive Transition register.
STAT:QUES:CAL:NTR n	Sets the Questionable Calibration Status Negative Transition register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:QUES:CAL:NTR?	Returns the value of the Questionable Calibration Status Negative Transition register.
STAT:QUES:COND?	Returns the value of the Questionable Status Condition register.
STAT:QUES:ENAB n	Sets the Questionable Status Event Enable register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:QUES:ENAB?	Returns the value of the Questionable Status Event Enable register.
STAT:QUES?	Returns the value of the Questionable Status Event register.

<b>Command</b>	<b>Function</b>
STAT:QUES:PTR n	Sets the Questionable Status Positive Transition register to n (n is the decimal value of the weighted sum of the register's bits).
STAT:QUES:PTR?	Returns the value of the Questionable Status Positive Transition register.
STAT:QUES:NTR n	Sets the Questionable Status Negative Transition register to n (n is the decimal value of the weighted sum of the register's bits)
STAT:QUES:NTR?	Returns the value of the Questionable Status Negative Transition register.
SYST:ERR?	Returns the most recent error message as a quoted unique number and a string of up to 50 characters.



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**General Theory of  
Operation: Microwave  
Deck Assemblies**

There are three versions of the Microwave Deck (Assembly A5) used in the HP 7042XA family of products. The simplest version is used in the HP 70428A Microwave Source. This assembly generates a low noise, microwave reference signal from 2.4 GHz to 25.8 GHz in 600 MHz steps, and will overrange to 26.4 GHz. The microwave signal is generated by frequency multiplication of the 600 MHz Reference Module output (Assembly A7).

The HP 70428A opt 002 Microwave Source uses the microwave step reference function generated by the HP 70428A's deck to frequency up-convert an external RF Source between 120 MHz and 700 MHz to produce continuous frequency coverage from 2.4 GHz to 26.5 GHz.

The HP 70427A Microwave downconverter fundamentally mixes external microwave signals between 2.4 GHz and 26.5 GHz with the microwave step reference function generated by the HP 70428A's deck to produce an Intermediate Frequency (IF) between 5 MHz and 1200 MHz.

The tuning sensitivity of the 600 MHz Reference is present on the microwave stepped reference. Tuning sensitivity of the 600 MHz Reference is adjustable in three steps, 0.05 ppm/V, 1 ppm/V and 20 ppm/V, plus the default mode of 0 ppm/V. Tuning is done by injecting the voltage control signal, from the front panel, into one of the three different oscillators in the 600 MHz Reference.

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**NOTE**

The tuning sensitivity must be adequate to acquire and maintain phase-lock with the device under test (DUT) during a phase noise measurement, without degrading the measurement of the DUT. The 600 MHz Reference phase noise, close to the carrier, degrades as the tuning sensitivity is increased above 0.05 ppm/V, but allows for a greater drift tracking range to be used with noisy DUTs.)

## General Theory of Operation: 600 MHz Reference Chain

### Overview

The 600 MHz Reference (Assembly A7) produces the low noise, tunable reference signal for the microwave multiplier. It also produces auxiliary output signals at 10, 100, and 600 MHz which are accessible from the rear panel of the module.

The 600 MHz output is produced by first multiplying the 10 MHz, oven-stabilized timebase to 100 MHz. This signal is the reference frequency for the 100 MHz noise clean-up phase-locked loop (PLL). The clean-up loop reduces the noise added to the signal by the 10 $\times$  multiplication process at carrier offsets greater than the loop's bandwidth (default=126 Hz).

The 100 MHz clean-up loop produces two auxiliary outputs available at the rear panel.

The main output of the 100 MHz clean-up loop drives the 10 $\times$  multiplier to produce 600 MHz. This signal is the reference frequency for the 600 MHz noise clean-up loop. This PLL reduces the noise added to the signal by the 6 $\times$  multiplier at carrier offsets greater than its loop bandwidth (default=10 kHz). The 600 MHz clean-up loop also produces two auxiliary outputs available at the rear panel. The main output of the 600 MHz clean-up loop is the 600 MHz Reference which drives the microwave multiplier.

Tuning sensitivity of the 600 MHz Reference is adjustable in three steps, 0.05 ppm/V, 1 ppm/V and 20 ppm/V, plus the default mode of 0 ppm/V. Tuning is done by injecting the voltage control signal, from the front panel, into one of the three different oscillators in the 600 MHz Reference.

The 0 ppm/V or CW mode is produced by grounding the tuning port of the 10 MHz timebase, while both the 10 $\times$  and the 6 $\times$  multipliers and their associated clean-up loops are operating and phase-locked back to the 10 MHz timebase.

The 0.05 ppm/V mode is the same as the 0 ppm/V mode, except the front panel voltage control signal is connected to the 10 MHz timebase frequency control port.

The 1 ppm/V mode is implemented by turning off the 10 MHz output and 10 $\times$  multiplier and reconfiguring the 100 MHz clean-up loop. The loop's 100 MHz voltage controlled crystal oscillator (VCXO) is now controlled by the front panel voltage control signal. The 6 $\times$  multiplier, and the 600 MHz clean-up loop are now locked only to the 100 MHz VCXO.

The 20 ppm/V mode is produced by turning off the 6 $\times$  multiplier and reconfiguring the 600 MHz clean-up loop. The loop's 600 MHz surface

transverse wave oscillator (STWO) is now controlled by the front panel voltage control. The 10 and 100 MHz auxiliary outputs are turned on, with the 100 MHz clean-up loop locked to the 10 MHz timebase. The timebase is set to 0 ppm/V.

**NOTE**

The tuning sensitivity must be adequate to acquire and maintain phase-lock with the device under test (DUT) during a phase noise measurement, without degrading the measurement of the DUT. The 600 MHz Reference phase noise, close to the carrier, degrades as the tuning sensitivity is increased above 0.05 ppm/V, but allows for a greater drift tracking range to be used with noisy DUTs.)

The module's noise performance is set by the 600 MHz Reference and its associated circuitry. The 10, 100, and 600 MHz oscillators contribute to the noise of the 600 MHz Reference output at different carrier offsets. The 10 MHz timebase is responsible for the noise close to the carrier, between 0.01 and 300 Hz. The 100 MHz VCXO contributes the noise between 50 Hz and 20 kHz carrier offsets. The 600 MHz STWO sets the noise performance between 5 kHz and 20 MHz offsets.

The phase noise performance of the 600 MHz Reference is specified for three conditions:

**Table 13-1** *1. The 600 MHz loop locked to the 100 MHz loop, with the 100 MHz loop locked to the 10 MHz timebase. (tuning sensitivity: 0.05 ppm/V)*

Frequency	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	40 MHz
Specified	-59	-89	-109	-137	-149	-159	-163	-163
Typical	-67	-97	-116	-142	-156	-170	-177	-177

**Table 13-2** *2. The 600 MHz loop locked to the 100 MHz VCXO (tuning sensitivity: 1 ppm/V)*

Frequency	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	40 MHz
Specified	-7	-57	-107	-137	-149	-159	-163	-163
Typical	-50	-88	-118	-143	-157	-170	-177	-177

**Table 13-3** 3. *The 600 MHz STWO. (tuning sensitivity: 20 ppm/V)*

Frequency	1 Hz	10 Hz	100 Hz	1 kHz	10 KHz	100 kHz	1 MHz	40 MHz
Specified	+6	-44	-84	-124	-149	-159	-163	-163
Typical	-37	-76	-106	-135	-162	-175	-177	-177

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**NOTE**

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The spec lines on the phase noise graphs in chapter 9 are for two units measured against each other. The data displayed is the typical performance of two units measured against each other.

## 10 MHz Timebase (A5Y1)

### Internal Operation

The internal timebase is a 10 MHz, low noise, oven-stabilized, third overtone SC-cut VCXO from Wenzel Associates, Inc.

The electronic frequency control (EFC) has a maximum input voltage range of  $\pm 5$  V, with a 0.05 ppm/V tuning sensitivity.

The internal timebase has two noise options, the standard unit, and the selected low noise special which improves the noise inside of 300 Hz carrier offsets.

**Table 13-4** 10 MHz Timebase (A5Y1)

Offset Frequency	Std. Unit	Low Noise Unit	Timebase Performance Requirements	
			Specified	Typical
1 Hz	-100	-110	-95	-100
10 Hz	-130	-140	-125	-130
100 Hz	-150	-160	-145	-150
1 kHz	-160	-165		

Phase noise is in dBc/Hz. The last two columns are the timebase noise requirements to meet the customer specification and the Typical standard noise performance.

The timebase is Mu-Metal shielded to minimize spurious pickup.

The signal kill (10 MHz\_CNTL) feature on the timebase allows the microprocessor to shut off the 10 MHz for diagnostic checks.

The oven temperature status can be monitored by the module via the oven monitor port.

The timebase output level is +10 to +13 dBm into 50 $\Omega$ . This signal is routed to the rear panel. A jumper cable must be connected between the 10 MHz OVEN OUT and the 10 MHz IN for internal timebase operation.

### External Operation

An external 10 MHz reference may be connected to the 10 MHz IN connector. The 10 MHz input requires a signal of 10 MHz,  $\pm 1$  ppm. The input level is +7 to +14 dBm.

## 100 MHz Reference Loop (A7A1)

### Overview

The 100 MHz Reference Loop multiplies the 10 MHz rear panel input to 100 MHz. This signal is the phase detector reference for the 100 MHz PLL. The 100 MHz PLL filters out spurs from the 10× multiplier, and optimizes the phase noise between the multiplied-up 10 MHz timebase and the loop's 100 MHz VCXO. The 100 MHz PLL's bandwidth is adjustable between 25 Hz and 10.4 kHz, in 8 steps. The default bandwidth is 126 Hz, which produces the best noise compromise. Also, the front-panel voltage control distribution switches for the 10, 100 and 600 MHz oscillators are also implemented on the A7A1 PC board.

### Looking at the Block Diagram

#### VCO Tuneline Control

The VCO tuneline control block provides the tuneline switching for the module, and controls the Internal timebase A5Y1. There are two inputs to this block. The primary input is the Voltage Control input from the front panel of the module which allows the user or an HP 3048A Phase Noise System to electronically tune the reference chain. The internal tuneline input is not currently used. These two inputs are combined in an SPDT relay to produce the CUST/INT TUNE which is selected by the 10, 100 and 600 MHz oscillators. The CUST/INT TUNE line also has a switchable, high current, buffered output which is available from the rear panel. The output impedance is 50Ω, with 100 mA current capability.

The input impedance is 100 kΩ on the front panel for the 1 ppm/V and 5 ppm/V tuning sensitivities. When the 0.05 ppm/V sensitivity is selected, the 10 MHz timebase's internal 38 kΩ tuneline resistor is placed in parallel with the module's 100 kΩ input impedance, reducing the input impedance to 27.5 kΩ.

The voltage control input range is specified to be ±5 V, and usable to ±10 V. The input is also clamped by diodes at ±15 V to prevent damage to the solid state switches by inputs exceeding the ±15 V supply voltage. The input impedance for signals greater than ±15 V is 250Ω.

**The VOLTAGE CONTROL MUST BE TERMINATED OR DRIVEN WITH AN IMPEDANCE OF 50Ω OR LESS** to prevent module noise performance degradation due to excess resistor thermal noise voltage, in all input tuning sensitivity modes except 0 ppm/V. The 50Ω termination also greatly improves tuneline input offset voltage frequency error.

Both the timebase 10 MHz output, and EFC source are controlled by the VCO tuneline control block. The 10 MHz output can be toggled on and off. The timebase EFC is selectable between ground, for 0 ppm/V tuning sensitivity, and the CUST/INT TUNE for 0.05 ppm/V tuning sensitivity.

## 10 MHz to 100 MHz Frequency Multiplier

The 10 to 100 MHz multiplier block multiplies the 10 MHz input to 100 MHz by doubling the signal to 20 MHz, then multiplying by 5. It also produces a switched, buffered 10 MHz rear-panel output.

The 10 MHz rear-panel signal is first amplified to about 18 dBm. This 10 dB gain amplifier with tuned output is designed to be operated in compression without adding significant noise to the 10 MHz input signal. The collector supply is regulated with a capacitance multiplier to reduce power supply noise that will be up-converted around the carrier. The RF amplifier is designed to be limited by collector current cutoff, not  $V_{ce}$  saturation voltage. The signal is then split.

The 10 MHz auxiliary output signal is picked off with a  $511\Omega$  resistor. The signal is then amplified in a differential amplifier, followed by an emitter follower, both for high isolation. The output is tuned to 10 MHz, via C42, C43, and L12, to reduce harmonics. The output impedance is  $50\Omega$  with a nominal power of +10 dBm.

The main signal from the input amplifier drives the 2x doubler. The doubler is implemented by splitting the 18 dBm, 10 MHz signal in a quadrature hybrid. The two outputs are about +14 dBm, and 90 degrees out of phase. The two signals are then mixed together in a doubly balanced mixer. The result is a small DC offset, due to phase errors, and a signal at twice the input frequency. The 20 MHz signal level is about +5 dBm. The 20 MHz signal's 10 MHz feedthrough is about -30 dBc.

The 20 MHz signal is amplified by the 20 MHz interstage amplifier. This 17 dB gain amplifier has a tuned output to eliminate subharmonics and is very similar to the 10 MHz input amplifier design, except for its gain and output frequency. Its output level is about +18 dBm into  $50\Omega$ .

The 20 MHz interstage amplifier drives the 5x multiplier. The 5x multiplier is based on the harmonic content of a square wave. Its theoretical efficiency is as follows:

$$\text{efficiency (dB)} = 20 \log (1/n)$$

where n = the desired harmonic

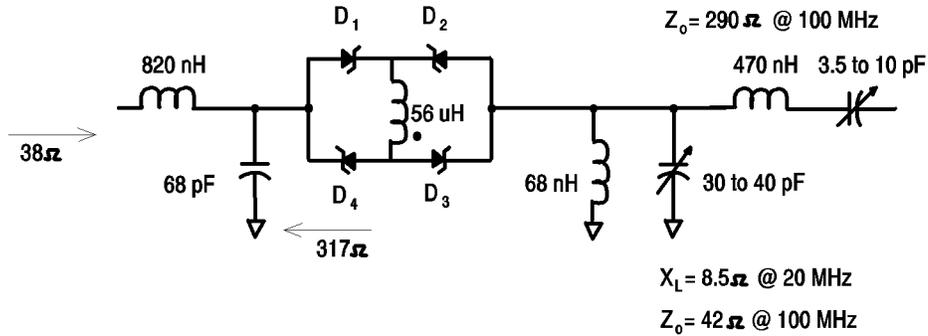
For example, If n=5, then efficiency=-14 dB.

The 5x multiplier works by first impedance transforming the 20 MHz input signal to about  $300\Omega$ . This is done so that the input voltage is large enough to switch the 20 V Schottky diodes. The impedance transformer output capacitor is also a low impedance for the desired fifth harmonic. The diodes are arranged as a full wave bridge rectifier, with an inductor across the "+ and - outputs". One of the "AC inputs" is connected to the input impedance transformer output. The other "AC input" is connected to the parallel resonator to ground and the series resonator output.

Block Diagram  
 100 MHz Reference Loop (A7A1)

During the positive part of the 20 MHz cycle, current flows from the impedance transformer, through D1, through the inductor across the bridge output, through D3, and then through the inductor in the parallel resonator to ground. The inductor in the parallel resonator has been chosen to be a low impedance at 20 MHz.

20 MHz to 100 MHz Multiplier



Diode Bridge Squaring Circuit

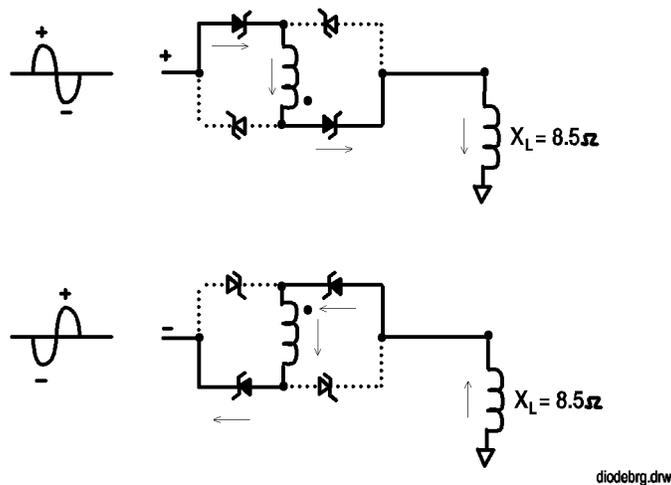


Figure 13-1 20 MHz to 100 MHz Multiplier

During the negative part of the 20 MHz cycle, current flows from ground, through the inductor in the parallel resonator, through D2, through the inductor across the bridge output, through D4, and then into the impedance transformer.

It is important to note that the current in the inductor across the bridge flows in the same direction in both cases. Since an inductor will not allow its

current flow to change instantaneously, the inductor supplies the voltage necessary to switch the diodes fast. The fast switching of the diodes produces a square wave very rich in odd harmonics. The fifth harmonic signal flows through the capacitor at the output of the impedance matching network, through the bridge rectifier squaring circuit and out the series resonant circuit at the multiplier output. The parallel resonant circuit to ground is resonant at the fifth harmonic so it does not short the 100 MHz signal to ground. The multiplier output level is about +3 dBm.

The 100 MHz signal is amplified by the 100 MHz multiplier output amplifier. This 17 dB gain amplifier is designed to remain low noise when driven into collector current cutoff. Its output level is about +11 to +15 dBm into 50Ω. This 100 MHz signal is the phase detector reference for the 100 MHz reference clean-up loop.

### **Phase Detector/2.3 MHz LPF/20 dB Amp**

The phase detector/amplifier block combines the 100 MHz reference output with the output of the 100 MHz VCXO, through the 80 dB isolation amplifier, to produce a phase error voltage. This phase error voltage will be integrated, and then fed back to the VCXO to phase-lock the oscillator.

The phase detector is a doubly balanced mixer. One input is the 100 MHz multiplier's output. The other input is a +5 to +7 dBm signal from the 80 dB isolation amplifier. The two signals are multiplied together which produces a sum and difference product. The 200 MHz sum product and the 100 MHz feedthrough are terminated in 50Ω by the 2.3 MHz low pass filter's diplexed input. The difference product is proportional to the phase error between the two inputs, where a 90 degree phase difference between the two inputs will produce 0 V output. The phase detector sensitivity is 0.3 V/rad.

The 2.3 MHz lowpass filter (LPF) performs two functions. First, it provides the termination of undesired 100 and 200 MHz signals produced in the phase detector. Second, it rejects the undesired harmonics of 10 MHz, produced in the 10 to 100 MHz Multiplier, by 70 dB. These 10 MHz harmonics will produce 10 MHz sidebands on the PLL output if allowed to reach the VCXO tuning port.

The filter was designed in two sections. The input is a 3 pole, 0.1 dB ripple, 3 MHz Chebyshev LPF, with a 50Ω resistor in series with the input capacitor. The 50Ω resistor terminates frequencies above the filter cutoff frequency. The majority of the stop band performance is from the 5 pole, 2 zero, 3 MHz elliptic filter section. Phase delay in the LPF must be minimized to prevent PLL peaking due to excess phase shift around the loop. The output of the filter is terminated in 50Ω to provide proper filter response.

The output of the LPF is amplified 20 dB by a low noise non-inverting operational amplifier. The input noise of the op-amp is about 1.2 nV/Hz. Given a 0.3 V/rad phase detector sensitivity, the signal-to-noise ratio of this

**100 MHz Reference Loop (A7A1)**

block is approximately 168 dB with a 3 V/rad phase detector sensitivity at the amplifier output.

The phase detector amplifier output primarily feeds the 100 MHz loop integrator. It is also connected to the module's diagnostic multiplexer system and the 100 MHz PLL phase detector beatnote out-of-lock detector. The beatnote detector is a window comparator. It monitors the phase detector amplifier output voltage. An output voltage greater than +2.1 V or less than -2.1 V indicates an out-of-lock condition which triggers the loop's integrator acquisition circuit. The out-of-lock condition is also reported to the module's microprocessor via a processor interrupt which activates an SRQ and ERR status indicator on the front panel.

The diagnostic multiplexer system is a series of 8-input analog multiplexers which allow the monitoring of key analog voltages and waveforms throughout the module by the module's internal volt meter and external test equipment connected to the MULTIPLEXER OUT on the module's rear panel.

**Loop Integrator/Search Acquisition**

The loop integrator/search acquisition block controls the loop bandwidth, monitors out-of-lock, causes the integrator to search and acquire lock, and configures the VCXO between being phase-locked to the 10 MHz reference and free running.

The 100 MHz reference clean-up loop is a second order PLL, with 8 selectable loop bandwidths. The multiple loop bandwidths are available to optimize the noise performance trade-off between the multiplied 10 MHz timebase noise and the 100 MHz VCXO.

Wider loop bandwidths track the multiplied 10 MHz signal more closely, allowing for a faster tuning response to changes in the 10 MHz timebase. This allows a phase noise measurement system to use a greater measurement PLL bandwidth without producing excessive measurement loop peaking. Excess measurement loop peaking is produced by the group delay caused by insufficient tuneline bandwidth (tuning through a PLL with insufficient bandwidth).

Narrower loop bandwidths take advantage of the 100 MHz VCXO noise performance. The 100 MHz VCXO noise performance is better than the 10 MHz timebase multiplied to 100 MHz for offsets greater than approximately 120 Hz. Inside the PLL bandwidth, the loop tracks the noise of the multiplied 10 MHz signal. Outside the PLL bandwidth, the noise performance is that of the free running 100 MHz VCXO. The best compromise from a noise standpoint is the default bandwidth of 126 Hz.

The noise at the edge of the loop bandwidth is actually the sum of the reference noise and the VCXO noise, plus any loop peaking due to excess phase shifts around the loop. The PLL bandwidth can be adjusted to

optimize the performance between 0.01 and 100 Hz by setting the bandwidth to 300 Hz or greater. The noise performance greater than 100 Hz is optimized by setting a narrow loop bandwidth (53 Hz or less) which still retains the frequency stability and noise performance of the 10 MHz timebase at very low carrier offsets. If noise performance less than 100 Hz is not important, the best noise performance is achieved by tuning the 100 MHz VCXO directly ( 1 ppm/V tuning sensitivity).

The selectable PLL bandwidths range from 25 Hz to 10.4 kHz, with a logarithmic distribution in an attempt to cover all required bandwidth contingencies. The final bandwidths are 25 Hz, 53 Hz, 126 Hz, 300 Hz, 650 Hz, 1.53 kHz, 3.63 kHz and 10.4 kHz after adjusting for component availability.

There are two primary assumptions that were made before the loop integrator design could begin:

1. The phase detector gain is 3 V/rad. This is held constant by the saturation output level of the phase detector mixer. Given that both inputs to the phase detector (+7 dBm level) mixer is +5 to +10 dBm, the saturated output is a 0.3 V/rad phase slope into a 50 $\Omega$  termination. The output is then amplified by 20 dB (10 $\times$ ) resulting in the 3 V/rad phase detector gain. The 20 dB gain, low-noise amplifier is necessary to insure that the signal levels out of the phase detector are large enough to maintain an adequate signal-to-noise ratio, despite the added noise from the integrator.
2. The VCXO tuning sensitivity is 155 Hz/V. This was determined experimentally after there was a stable 100 MHz VCXO design with adequate noise performance and tuning range. The original VCXO design goal was a 100 Hz/V tuning sensitivity.

The first order, closed loop bandwidth, equals phase detector gain times tuning sensitivity (3 V/rad \* 15 Hz/V= 465 Hz).

The eight different PLL bandwidths are produced by switching between eight different integrator networks. Each integrator network was designed as follows:

- a. Calculate the ratio between the first order closed loop bandwidth and the desired bandwidth. This ratio is the amount of gain the integrator must add to or subtract from the VCXO tuning sensitivity.

Block Diagram  
**100 MHz Reference Loop (A7A1)**

It is equal to the ratio of the integrator output resistor divided by the input resistor.

$$\frac{BW(\text{desired})}{BW(\text{first order loop})} = \frac{R_2}{R_1}$$

- b. Set the integrator zero at  $BW(\text{desired}) / 4$  to keep the loop peaking less than 2 dB due to the zero's phase shift. ....

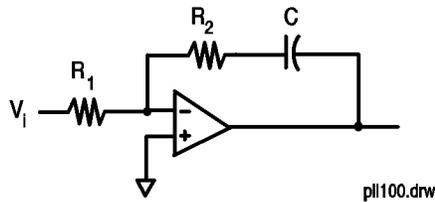
$$\frac{BW(\text{desired})}{4} = \frac{1}{(2\pi R_2 C)}$$

**100 MHz Phase Locked Loop Integrator**

$K_{VCO} = 155 \text{ Hz/V}$       Gain above F =  $-\frac{R_1}{R_2}$

$K_{\phi} = 3 \text{ V/rad}$       F Integrator Zero =  $\frac{1}{2\pi R_2 C}$

First order bandwidth =  $K_V * K_{\phi}$   
 = 465 Hz



**Figure 13-2 100 MHz Phase Locked Loop Integrator**

**Table 13-5 100 MHz Phase Locked Loop Integrator**

	25 Hz	53 Hz	126 Hz	300 Hz	650 Hz	1.53 kHz	3.63 kHz	10.4 kHz
R <sub>1</sub>	681 k	316 k	121 k	42.2 k	17.8 k	9.09 k	3.83 k	2.15 k
R <sub>2</sub>	26.1 k	26.1 k	23.7 k	21.5 k	21.5 k	23.7 k	23.7 k	34.8k
C	1 μF	0.47 μF	0.2 μF	0.1 μF	0.047 μF	0.015 μF	6800 pF	1800 pF
F <sub>z</sub>	6.10 Hz	13.0 Hz	33.6 Hz	74.0 Hz	157 Hz	448 Hz	988 Hz	2.54 kHz
BW Gain, Ratio	0.054	0.114	0.271	0.265	1.40	3.29	7.81	22.4
BW Gain, dB	-25.4 dB	-18.7 dB	-11.3 dB	-3.81 dB	2.91 dB	10.3 dB	17.8 dB	27.0 dB
BW Gain, Ratio	0.038	0.083	0.196	0.509	1.21	2.61	6.19	16.2
BW Gain, dB	-28.3 dB	-21.7 dB	-14.2 dB	-5.86 dB	1.64 dB	8.23 dB	15.8 dB	24.2 dB

The integrator op-amp's negative input, which is at virtual ground, is switched between the networks. All eight network inputs are in parallel and must be driven by the phase detector amplifier. All eight feedback paths are also in parallel and must be driven by the integrator op-amp. The component values of R<sub>1</sub> and R<sub>2</sub> are such that only the integrator network selected by the eight-input analog multiplexer used for switching may put a significant load on either op-amp. Stability in the integrator op-amp is maintained by adding the 10 pF capacitor between the op-amp's negative input and output. The 10 pF capacitor counteracts the excess phase shift added by the analog multiplexer.

The integrator op-amp output is connected to the 100 MHz VCXO tuning port select analog multiplexer. This multiplexer selects between connecting the integrator to the VCXO and closing the loop, grounding the tune line (100 MHz NO TUNE), or connecting the tune line to the CUST/INT tune line (1 ppm/V).

The tuning port select analog multiplexer is connected to five locations. The main output is the 100 MHz VCXO tune port. It is also connected to the diagnostic multiplexer system, the integrator out-of-lock detector, the search/acquisition circuit and an amplifier used for loop/VCXO noise diagnostics. The noise diagnostic amplifier is not used in normal module functions. The amplifier is an 80 dB AC coupled amplifier, connected to the diagnostic multiplexer system. It is for monitoring the tune line noise of the 100 MHz PLL inside the loop bandwidth, under closed loop conditions.

The integrator out-of-lock detector is a window comparator with its threshold set at ±10 V. If the tune line voltage goes outside the ±10 V range, an interrupt is generated in the microprocessor, and the search/acquisition speed-up circuit is activated.

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**NOTE**

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The 100 MHz PLL will remain phase-locked and on frequency with as much as  $\pm 12.5$  V on the tune line, but the noise and spur performance will be greatly impaired. This circuitry is always active and can also act as an over-voltage indicator for the 1 ppm/V tuning mode.

Search and acquisition is accomplished by ramping the integrator output voltage to that voltage required by the VCXO to be at the same frequency as the 100 MHz reference. The phase detector can then produce the phase-error voltage necessary to produce and maintain phase-lock.

The search is produced by a small amount of positive feedback placed around the loop's integrator. The positive feedback amplifier places an offset voltage at the integrator input of + or - 0.15 volts. This offset voltage forces the integrator's inverted output to ramp in voltage until it reaches a threshold of - or + 12 V. When the threshold voltage is reached, the offset voltage is reversed, forcing the integrator to ramp in voltage in the opposite direction. The integrator output continues to search until either the tune line voltage remains within the  $\pm 12$  V window, as in 100 MHz NO TUNE and 1 ppm/V modes, or there is enough negative feedback produced by the loop being phase-locked to overcome the positive feedback. The amount of phase detector offset required to overcome the positive feedback is 15 mV, about .25 degrees of offset.

The search speed-up circuit increases the PLL bandwidth to at least 1200 Hz when triggered by the out-of-lock detectors. This is done by placing a 10 k $\Omega$  resistor in parallel with all the integrator input resistors. The sweep speed is further increased by placing a 10 k $\Omega$  resistor in parallel with the positive feedback offset resistor, raising the integrator offset to  $\pm 0.22$  V.

The speed-up timer triggers for 100 ms, and is retriggered by the out-of-lock detectors if lock is not acquired in that time period.

### **100 MHz Oscillator**

The 100 MHz VCXO is a fifth overtone crystal oscillator designed for low noise performance and wide tuning range. The tuning sensitivity is typically 155 Hz/V at 100 MHz or approximately 1 ppm/V. It is designed to oscillate at 100 MHz, -1.125 kHz @ -10 V tune line voltage and +2.0 kHz @ + 10 V tune line voltage. The exact frequency of oscillation is not important for phase noise measurements, but the VCXO must be able to acquire and maintain phase-lock under all environmental conditions with an external 10 MHz timebase, tunable over a  $\pm 1$  ppm range, which is  $\pm 100$  Hz at 100 MHz.

**Table 13-6** *The phase noise performance is as follows:*

Offset Frequency	Typical Noise Performance	Oscillator Performance Requirements	
		Specified	Typical
1 Hz	-70 dBc	-28 dBc	-25 dBc
10 Hz	-100 dBc	-78 dBc	-75 dBc
100 Hz	-130 dBc	-128 dBc	-125 dBc
1 kHz	-160 dBc	-158 dBc	-155 dBc
>10 kHz	-175 dBc	-170 dBc	-167 dBc

The phase noise performance is achieved by using very high-Q crystal resonators with very small burst noise, a circuit topology that is inherently low noise, an active device which maintains good residual noise performance as an amplifier even while limiting, and by paying special attention to oscillator bias supply voltages. The capacitance multiplier regulators on both the oscillator's emitter and collector supplies greatly reduce the power supply noise which would be converted to phase noise in the oscillator. The 100 MHz output amplifier collector supply is also regulated to prevent noise degradation.

The regulators also improve 40 kHz spurs generated by the module's 40 kHz switching power supply. Vibrational spurs induced in the crystal resonator structure are reduced by vibration shock mounting of the 600 MHz Reference Assembly.

The 100 MHz output amplifier has four outputs. The main output is connected to the 600 MHz multiplier. The output level is +20 dBm,  $\pm 2$  dB. The outputs to the rear panel are +8 dBm and -2 dBm respectively, both  $\pm 2$  dB. The output to the 80 dB isolation amplifier is 0 dBm,  $\pm 2$  dB. The 100 MHz oscillator and outputs amplifier are always active during normal module operation. The main 100 MHz output to the 600 MHz multiplier/clean-up PLL must be turned off to prevent 100 MHz spurs in the 600 MHz NO TUNE and 5 ppm/V tuning sensitivity modes. Both these criteria are satisfied by adding a 100 MHz output relay. The output relay switches the main 100 MHz on, or terminates the amplifier output and the input to the 600 MHz multiplier in 50 $\Omega$ . The 50 $\Omega$  termination of the amplifier path is necessary for proper operation of the couplers between the amplifier output and the output relay.

### **80 dB Isolator**

The 80 dB isolation amplifier provides the isolation necessary to prevent multiplier spurs, from the 10 to 100 MHz multiplier, from leaking onto the 100 MHz clean-up loop main output. The leakage path being eliminated is

### 100 MHz Reference Loop (A7A1)

from the multiplier output, through the phase detector, through the 100 MHz phase detector amplifier, through the couplers and into the output amplifier's output.

The 80 dB isolation amplifier is a tuned three stage amplifier with attenuators placed between each stage. The attenuators are necessary to maintain the amplifier's stability and to provide an additional 26 dB of isolation. Each stage has a 17 dB gain with about 20 dB of reverse isolation in the amplifier passband. Outside the 40 MHz passband the reverse isolation increases at 6 dB/octave. Inside the passband the input and output return losses are about 10 dB. The output return loss drops to 0 dB outside the passband. The input level to the 80 dB isolator is 0 dBm,  $\pm 2$  dB. The output level is +5 to +7 dBm into the phase detector.

### Digital Control

The digital interface with the rest of the module is through a serial three line data bus. The interface is implemented using a custom I/O interface chip. The chip requires a bidirectional data line, a clock line and a chip enable/interrupt line from the microprocessor. The I/O chip generates 22 parallel outputs and controls all the functions on the A1A7 board. The I/O chip also latches and transfers the interrupt status of the out-of-lock detectors to the microprocessor.

## 600 MHz Reference Loop (A7A2)

### Overview

The 600 MHz reference Loop multiplies the 100 MHz reference loop's output to 600 MHz. This signal is the phase detector reference for the 600 MHz clean-up PLL. The 600 MHz PLL filters out spurs from the 6 $\times$  multiplier, and optimizes the phase noise between the multiplied-up 100 MHz Reference loop, and the loop's 600 MHz surface-transverse-wave-oscillator (STWO). The 600 MHz PLL's bandwidth is adjustable between 4 kHz and 30 kHz, in 4 steps. The default bandwidth is 10 kHz, which produces the best noise compromise at a 1 kHz offset. The 10 kHz noise is improved by 3 dB using the 4 kHz PLL bandwidth. The 600 MHz PLL output is the reference for the microwave comb line generator. The PLL also produces two auxiliary 600 MHz outputs available at the module's rear panel.

### Looking at the Block Diagram

#### 100 MHz to 600 MHz Frequency Multiplier

The 100 to 600 MHz Multiplier Block multiplies the 100 MHz input from the 100 MHz clean-up loop's main output by doubling the signal to 200 MHz, then multiplying by 3 to 600 MHz.

The signal from the 100 MHz PLL output drives the 2x doubler. The doubler is implemented by splitting the 20 dBm, 100 MHz signal in a quadrature hybrid. The two outputs are about +16 dBm, and 90 degrees out of phase. The two signals are then mixed together in a double-balanced mixer. The result is a small DC offset due to phase errors, and a signal at twice the input frequency. The 200 MHz signal level is about +7 dBm. The 200 MHz signal's 100 MHz feedthrough is about -30 dBc.

The 200 MHz signal is amplified by the 200 MHz interstage amplifier. This amplifier has 16 dB gain with tuned output. Its output level is about +18 dBm into 50 $\Omega$ . The amplifier must maintain good noise performance while operating in gain compression.

200 MHz Multiplier Amplifier Output Impedance Matching

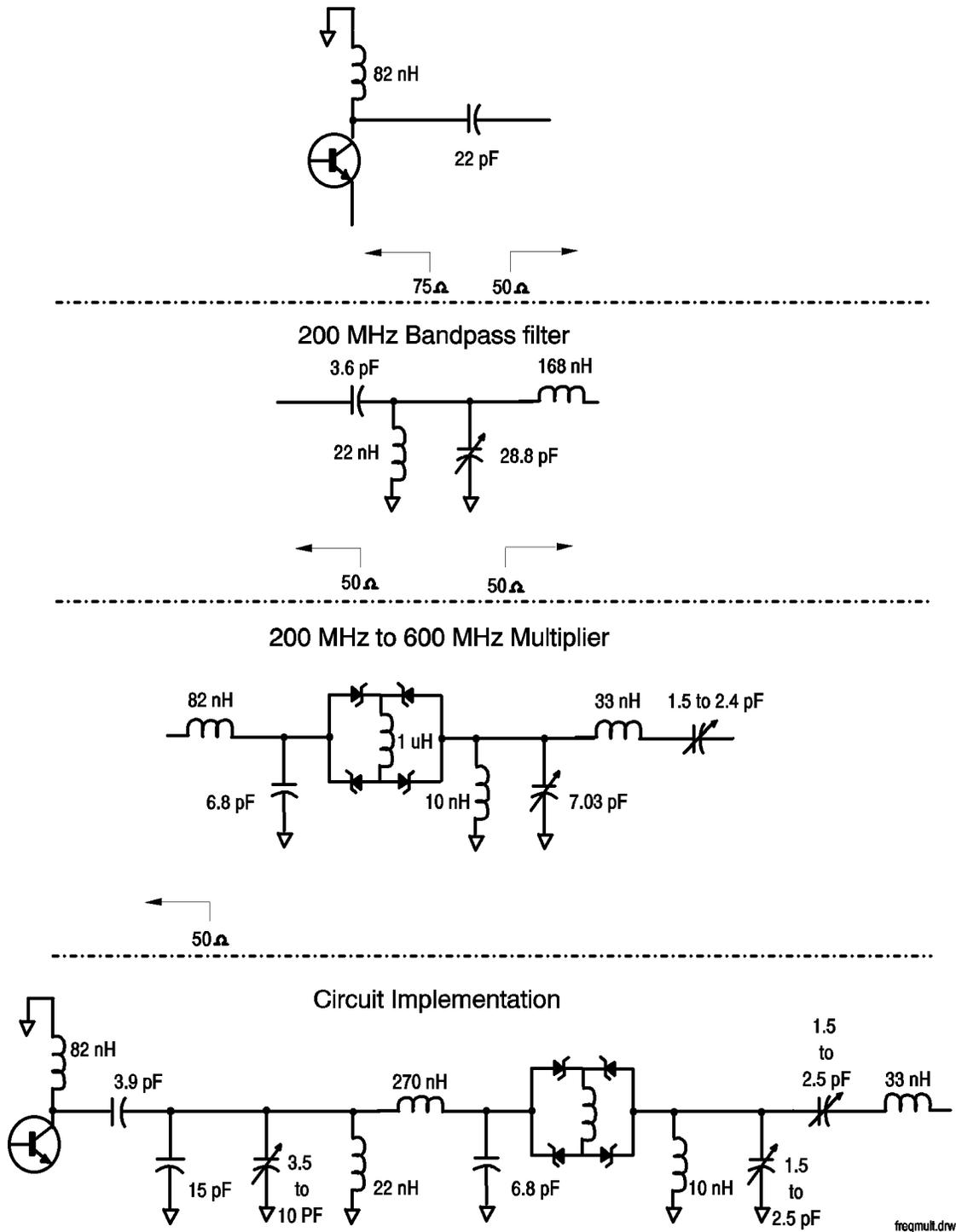


Figure 13-3 200 MHz Multiplier Amplifier Output Impedance Matching

The amplifier's output is filtered by a 200 MHz bandpass filter. The filter is a single resonator design, with a input capacitor to match the input impedance

up to the resonator impedance, and an output inductor to match the resonator impedance down to 50Ω. The amplifier's 22 pF output capacitor is combined with the filter's 3.6 pF input capacitor to produce a single component of 3.9 pF. Also, the filter's 168 nH output inductor is combined with the 3× multiplier's 82 nH input inductor to produce a single inductor of 270 nH.

The 200 MHz interstage amplifier drives the 3× multiplier through the 200 MHz output filter. The 3× multiplier is based on the harmonic content of a square wave. Its theoretical efficiency is as follows:

$$\text{efficiency (dB)} = 20 \log (1/n)$$

where n = the desired harmonic

For example, if n = 3, then efficiency = -9.5 dB.

The 3× multiplier works by first impedance transforming the 200 MHz input signal to about 300Ω. This is done so that the input voltage is large enough to switch the 20 V Schottky diodes. The impedance transformer output capacitor is also a low impedance for the desired third harmonic. The diodes are arranged as a full wave bridge rectifier, with an inductor across the "+ and - outputs". One of the "AC inputs" is connected to the input impedance transformer output. The other "AC input" is connected to the parallel resonator to ground and the series resonator output.

During the positive part of the 200 MHz cycle, current flows from the impedance transformer, through D1, through the inductor across the bridge output, through D3, and then through the inductor in the parallel resonator to ground. The inductor in the parallel resonator has been chosen to be a low impedance at 200 MHz.

During the negative part of the 200 MHz cycle, current flows from ground, through the inductor in the parallel resonator, through D2, through the inductor across the bridge output, through D4, and then into the impedance transformer.

It is important to note the current in the inductor across the bridge has current flow in the same direction in both cases. Since an inductor will not allow its current flow to change instantaneously, the inductor supplies the voltage necessary to switch the diodes fast. The fast switching of the diodes produces a square wave very rich in odd harmonics. The third harmonic signal flows through the capacitor at the output of the impedance matching network, through the bridge rectifier squaring circuit and out the series resonant circuit at the multiplier output. The parallel resonant circuit to ground is resonant at the third harmonic so it does not short the 600 MHz signal to ground. The multiplier output level is about +3 dBm.

The 600 MHz signal is amplified by the 600 MHz multiplier output amplifier. This 19 dB gain amplifier is designed to remain low noise when driven into collector current cutoff. Its output level is about +11 to +15 dBm

**600 MHz Reference Loop (A7A2)**

into 50 $\Omega$ . This 600 MHz signal is the phase detector reference for the 600 MHz Reference Clean-up loop.

**Phase Detector/2.3 MHz LPF/20 dB Amplifier**

The phase detector/amplifier block combines the 600 MHz reference output with the output of the 600 MHz STWO, through the 80 dB isolation amplifier, to produce a phase error voltage. This phase error voltage will be integrated, and then fed back to the STWO to phase-lock the oscillator.

The phase detector is a doubly balanced mixer. One input is the 600 MHz Multiplier output. The other input is a +11 to +16 dBm signal from the 80 dB isolation amplifier. The two signals are multiplied together which produces a sum and difference product. The 1200 MHz sum product, and the 600 MHz feedthrough is terminated in 50 $\Omega$  by the 2.3 MHz low pass filter's diplexed input. The difference product is proportional to the phase error between the two inputs, where a 90 degree phase difference between the two inputs will produce 0 V output. The phase detector sensitivity is 0.5 to 0.7 V/rad.

The 2.3 MHz lowpass filter (LPF) performs two functions. First, it provides the termination of the undesired 600 and 1200 MHz signals produced in the phase detector. Second, it rejects the undesired harmonics of 100 MHz, produced in the 100 to 600 MHz Multiplier, by 60 dB. These 100 MHz harmonics will produce 100 MHz sidebands on the PLL output if allowed to reach the VCXO tuning port. The filter was designed in two sections. The input is a 3 pole, 0.1 dB ripple, 3 MHz Chebyshev LPF, with a 50 $\Omega$  resistor in series with the input capacitor. The 50 $\Omega$  resistor terminates frequencies above the filter cutoff frequency. The majority of the stop band performance is from the 5 pole, 2 zero, 3 MHz elliptic filter section. Phase delay in the LPF must be minimized to prevent PLL peaking due to excess phase shift. The output of the filter is terminated in 100 $\Omega$ . The 100 $\Omega$  termination is a compromise between greater phase detector sensitivity over a 50 $\Omega$  termination and to provide proper filter response.

The output of the LPF is amplified by a variable gain low noise non-inverting operational amplifier. The gain of the amplifier is adjusted to produce an output phase slope of 4.25 V/rad. The input noise of the op-amp is about 1.2 nV/Hz. Given 0.5 V/rad minimum phase detector sensitivity, the signal-to-noise ratio of this block is approximately 172 dB with a 4.25 V/rad phase detector sensitivity at the amplifier output.

The phase detector amplifier output primarily feeds the 600 MHz loop integrator. It is also connected to the modules diagnostic multiplexer system and the 600 MHz PLL phase detector beatnote out-of-lock detector. The beatnote detector is a window comparator. It monitors the phase detector amplifier output voltage. An output voltage greater than +2.1 V or less than -2.1 V indicate an out-of-lock condition which triggers the loop's integrator

acquisition circuit. The out-of-lock condition is also reported to the module's microprocessor via a processor interrupt.

The diagnostic multiplexer system is a series of 8 input analog multiplexers which allow the monitoring of key analog voltages and waveforms throughout the module by the module's internal volt meter and external test equipment connected to the **MULTIPLEXER OUT** connector on the module's rear panel.

### **Loop Integrator**

The loop integrator block controls the loop bandwidth, monitors out-of-lock, and configures the STWO between being phase-locked to the 100 MHz reference and free running.

The 600 MHz reference clean-up loop is a second order PLL, with 4 selectable loop bandwidths. The multiple loop bandwidths are available to optimize the noise performance trade-off between the multiplied 100 MHz reference noise and the 600 MHz STWO.

Wider loop bandwidths track the multiplied 100 MHz more closely, allowing for a faster tuning response to changes in the 100 MHz reference. This allows a phase noise measurement system to use a greater measurement PLL bandwidth without producing excessive measurement loop peaking. Excess measurement loop peaking is produced by the group delay caused by insufficient tuneline bandwidth (tuning through a PLL with insufficient bandwidth).

Narrower loop bandwidths take advantage of the 600 MHz STWO noise performance. The 600 MHz STWO noise performance is better than the 100 MHz reference multiplied to 600 MHz for offsets greater than approximately 10 kHz. Inside the PLL bandwidth, the loop tracks the noise of the multiplied 100 MHz signal. Outside the PLL bandwidth, The noise performance is that of the free running 600 MHz STWO. The best compromise from a noise standpoint is the default bandwidth of 10 kHz.

The noise at the edge of the loop bandwidth is actually the sum of the 100 MHz reference noise multiplied to 600 MHz, the STWO noise and noise added by the amplifiers and integrator in the 600 MHz PLL, plus any loop peaking due to excess phase shifts around the loop. The PLL bandwidth can be adjusted to optimize the performance between 0.01 and 10 kHz by setting the bandwidth to 17 or 30 kHz. The noise performance greater than 10 kHz is optimized by setting the loop bandwidth to 4 kHz, which still retains the frequency stability and noise performance of the 100 MHz reference at low carrier offsets below 4 kHz. If noise performance less than 10 kHz is not important, the best noise performance is achieved by tuning the 600 MHz STWO directly ( 5 ppm/V tuning sensitivity).

**600 MHz Reference Loop (A7A2)**

The selectable PLL bandwidths range from 4 kHz to 30 kHz in an attempt to cover all required bandwidth contingencies. The bandwidths are 4 kHz, 10 kHz, 17 kHz and 30 kHz after adjusting for component availability.

There are two primary assumptions that were made before the loop integrator design could begin:

1. The phase detector gain is 4.25 V/rad. This is held constant by the saturation output level of the amplifiers driving the phase detector mixer. Given that both inputs to the phase detector (+17 dBm level) mixer is +11 to +16 dBm, the output is a 0.5 to 0.7 V/rad phase slope into a 100Ω termination. The output is then amplified by a variable gain amplifier. The amplifier gain is adjusted to produce the 4.25 V/rad phase detector gain. The low-noise amplifier is necessary to insure that the signal levels out of the phase detector are large enough to maintain an adequate signal-to-noise ratio, despite the added noise from the integrator and to adjust the phase detector gain to 4.25 V/rad.
2. The STWO tuning sensitivity is 10 kHz/V. This was determined experimentally after there was a stable 600 MHz STWO design with adequate noise performance and tuning range. The original STWO design goal was a 4 kHz/V tuning sensitivity.

The lead/lag filter is necessary to reduce integrator noise on the STWO's tuning port. The contribution to phase noise from noise on the oscillator's tuning port is:

$$L(f) = \frac{20 \log V_{\text{rms}} K_v}{\sqrt{2F_m}}$$

where:  $V_{\text{rms}}$  = noise voltage

$k_v$  = oscillator tuning sensitivity, and

$F_m$  = carrier frequency offset.

The first order, closed loop bandwidth is equal to the phase detector gain times the tuning sensitivity. For example:

$$\frac{4.25 \text{ V}}{\text{rad}} \times \frac{10 \text{ kHz}}{\text{V}} = 42.5 \text{ kHz}$$

The four different PLL bandwidths are produced by switching between four different integrator networks with four different lead/lag filters. The integrator and lead/lag networks are designed as matched pairs. The overall response of each pair is an integrator with a zero. This is accomplished by placing the integrator's zero and the lead/lag network's pole at the same

frequency. The two responses will then cancel. What remains is the integrator's response with the zero of the lead/lag network.

Each integrator-lead/lag network was designed as follows:

1. Calculate the ratio between the desired closed loop bandwidth and the first order loop bandwidth. This ratio is the amount of gain the integrator-lead/lag must add to or subtract from the STWO tuning sensitivity. It is equal to:

$$\frac{\text{BW}(\text{desired})}{\text{BW}(\text{first order loop})} = \text{Integrator gain} \times \text{Lead/Lag Gain}$$

2. Set the lead/lag zero at  $\frac{\text{BW}(\text{desired})}{4}$  or less to keep the loop peaking 2 dB or less due to the zero's phase shift.

$$\frac{\text{BW}(\text{desired})}{4} = \frac{1}{(2\pi R_4 C_2)}$$

3. Set the integrator's zero to the same frequency as the lead/lag's pole.

$$\frac{1}{2\pi C_1 (R_1 + R_2)} = \frac{1}{2\pi C_2 (R_3 + R_4)}$$

The 10 kHz bandwidth for the 600 MHz PLL was used as a design example. The noise design goal for the 10 kHz phase noise is -160 dBc/Hz at 600 MHz. The oscillator tuning sensitivity is 10 kHz/V.

The tuning port noise contribution is to be 0.1 dB, so its noise must be -180 dbc. Given that:

$$L(f) = \frac{20 \log V_{\text{rms}} K_v}{\sqrt{2F_m}}$$

and solving for  $V_{\text{rms}}$ , the noise on the tuning port must be 1.41 nV or less at 10 kHz. This is the equivalent of a 123 Ω resistor at room temperature. This is why R4 is of this magnitude.

The oscillator's 10 kHz performance is excellent, and loop peaking would not be tolerated, so the lead/lag zero was set at bandwidth ÷ 10. This eliminates loop peaking, but does not yield enough loop gain at 1 kHz offset to suppress the 1 kHz STWO noise to the multiplied 100 MHz reference noise performance.

A 2 dB improvement in the 10 kHz noise performance is made at the expense of a 2 dB degradation in the performance at 1 kHz.

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**NOTE**

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Using the 17 kHz bandwidth results in a 2 dB improvement in the 1 kHz noise for a 3 dB degradation in the 10 kHz performance. An additional 3 dB of improvement can be made to the 10 kHz noise performance using the 4 kHz bandwidth at the expense of 2 dB degradation to the 1 kHz noise.

Given the 10 kHz PLL bandwidth, and the lead/lag zero set to bandwidth ÷ 10, the zero is 1 kHz. The lead/lag capacitor  $C_2$  can now be calculated using:

$$\frac{\text{BW(desired)}}{10} = F_{\text{zero}} = \frac{1}{(2\pi R_4 C_2)}$$

assuming  $R_4$  is  $125\Omega$ , and solving for  $C_2$  yields  $C_2 = 1.27 \mu\text{F}$ .

Adjusting for standard component values:

$C_2 = 1 \mu\text{F}$  and

$R_4 = 162\Omega$ , with

$F_{\text{zero}} = 982 \text{ Hz}$ .

The lead/lag pole is set at 1/10 the lead/lag zero frequency to provide 20 dB of attenuation to the noise added by the integrator, approximately 100 Hz.

The lead/lag resistor  $R_3$  can be calculated using:

$$\frac{\text{BW(desired)}}{100} = F_{\text{zero}} = \frac{1}{2\pi C(R_3 + R_4)}$$

assuming  $R_4$  is  $162\Omega$  and  $C_2$  is  $1 \mu\text{F}$ , and solving for  $R_3$  yields  $R_3 = 1.43 \text{ k}\Omega$ .

Adjusting for standard component values:

$R_3 = 1.47 \text{ k}\Omega$ ,

$C_2 = 1 \mu\text{F}$  and

$R_4 = 162\Omega$ , with

$F_{\text{pole}} = 97.5 \text{ Hz}$

and a gain of 0.0993 beyond  $F_{\text{zero}}$ ,

where the lead/lag gain is:

$$\text{Lead/Lag Gain} = \frac{R_4}{(R_3 + R_4)}$$

well beyond  $F_{\text{zero}}$ .

Once the lead/lag pole frequency is determined, the integrator zero frequency is also set, where:

$$\frac{BW_{desired}}{100} = F_{zero} = F_{pole} = \frac{1}{2\pi C_1 (R_1 + R_2)}$$

The integrator gain at the PLL bandwidth is:

$$IntegratorGain = \frac{BW(\text{first order desired})}{Lead\backslash LagGain}$$

where:

$$Integratorgain = \frac{(R_1 + R_2)}{R_1} \text{ at the PLL bandwidth}$$

#### 600 MHz Phase Locked Loop Integrator

$$K_{VCO} = 10 \text{ kHz / V} \quad \text{Integrator Zero} = \frac{1}{2\pi C_1 (R_1 + R_2)}$$

$$K_{\phi} = 4.25 \text{ V / rad} \quad \text{Lead / Lag Pole} = \frac{1}{2\pi C_2 (R_3 + R_4)}$$

$$\text{Lead / Lag Zero} = \frac{1}{2\pi C_2 R_4}$$

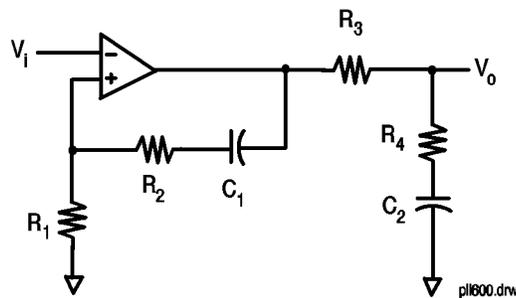


Figure 13-4 600 MHz Phase Locked Loop Integrator

Block Diagram  
600 MHz Reference Loop (A7A2)

**Table 13-7 Gain Yields**

	4 kHz BW	10 kHz BW	17kHz BW	30 kHz BW
R <sub>1</sub>	4.22 k	619Ω	1.1 k	562Ω
R <sub>2</sub>	6.19 k	909Ω	4.64 k	2.37 k
C <sub>1</sub>	1 μF	1 μF	0.1 μF	0.068 μF
R <sub>3</sub>	2.15 k	1.47 k	2.61 k	1.47 k
R <sub>4</sub>	82.5Ω	162Ω	215Ω	215Ω
C <sub>2</sub>	5 μF	1 μF	0.2 μF	0.1 μF
Integrator Zero	15.3 Hz	104 Hz	277 Hz	798 Hz
Lead/Lag Pole	14.3 Hz	97.5 Hz	282 Hz	944.5 Hz
Lead/Lag Pole	386 Hz	982 Hz	3.70 Hz	7.40 Hz

Solving for the integrator gain yields: Gain = 2.37. Assuming C<sub>1</sub> is 1 μF, and solving for R<sub>1</sub> and R<sub>2</sub> yields R<sub>1</sub> = 689Ω and R<sub>2</sub> = 944Ω

Adjusting for standard Component values:

$$C_1 = 1\text{mF}$$

$$R_1 = 619\Omega$$

$$R_2 = 909\Omega$$

Yields F<sub>zero</sub> = 104.2 Hz and a gain of 2.47 well beyond F<sub>zero</sub>. The actual bandwidth is 10.42 kHz.

Checking the tuning port noise performance, the input noise performance of the phase detector amplifier op-amp is about 2 nV/Hz in its circuit configuration. The maximum gain of the amplifier is 12.87, so the maximum output noise is 25.5 nV/Hz. The integrator multiplies the phase detector amplifier noise by 2.47, to produce 63 nV/Hz of noise at the integrator output. The integrator op-amp input noise is 4 nV/Hz.

The integrator input noise is also multiplied by the integrator gain of 2.47, to produce an output noise of 9.9 nV/Hz. The two noise mechanisms add as:

$$\text{TotalNoise} = \sqrt{(\text{noise1})^2 + (\text{noise2})^2}$$

The two mechanisms together produce 63.8 nV/Hz at the lead/lag network input. The lead/lag network attenuates the noise to 6.33 nV/Hz by multiplying the noise by its gain of 0.0993. The tuning port noise contribution at 10 kHz carrier offset can be calculated by:

$$L(f) = 20 \log \frac{V_{\text{rms}} K_v}{\sqrt{2F_m}}$$

where:  $V_{\text{rms}}$  = noise voltage

$k_v$  = oscillator tuning sensitivity, and

$F_m$  = carrier frequency offset.

The tuning port noise contribution is  $-167$  dBc/Hz. The typical STWO performance at 10 kHz offset is  $-163$  dBc/Hz. The tuning port noise degrades the performance to  $-161.5$  dBc/Hz under closed loop conditions.

Four different integrator feedback networks produce the integrator characteristics required for the four PLL bandwidths. All four feedback networks are in parallel, and must be driven by the integrator op-amp's output. An analog multiplexer selects which network is actually fed back to the integrator op-amp. Stability in the integrator op-amp is maintained by adding the 100 pF capacitor between the op-amp's negative input and output. The 100 pF capacitor counter-acts the excess phase shift added by the analog multiplexer.

The integrator's main output drives the four lead/lag networks required for the four PLL bandwidths. The integrator output is also connected to the diagnostic multiplexer system. A second analog multiplexer selects STWO tuning port input. The multiplexer selects between the four lead/lag networks, the CUST/INT tune line ( 20 ppm/V tuning sensitivity) and ground (600 MHz NO TUNE).

The two analog multiplexers' control inputs are connected together so that the first two bits of each multiplexer control the PLL bandwidths. The third bit on the integrator multiplexer is grounded. This forces this multiplexer to select only one of the four integrator feedback networks. The third bit of the tuning port select multiplexer selects between the phase-locked modes and the free running STWO modes.

The tuning port select analog multiplexer output is connected to four locations. The main output is the 600 MHz STWO tune port. It is also connected to the diagnostic multiplexer system, the integrator out-of-lock detector, and the search/acquisition lead/lag network speed-up circuit.

The 4 kHz PLL bandwidth lead/lag network has a pole at 14.3 Hz which sets the maximum rate at which the integrator may search to acquire phase-lock. The speed-up circuit places a  $511 \Omega$  resistor in parallel with the lead/lag network's input resistor whenever the voltage difference across the network exceeds  $\pm 0.4$  V. This  $511 \Omega$  resistor raises the pole frequency of the 4 kHz lead/lag network to 64 Hz. This greatly increases the maximum rate at which the integrator may search to acquire phase-lock.

Block Diagram  
**600 MHz Reference Loop (A7A2)**

The lead/lag speed-up circuit is engaged whenever the 600 MHz reference is set for phase-locked operation.

The integrator out-of-lock detector is a window comparator with its threshold set at  $\pm 10$  V. If the tune line voltage goes outside the  $\pm 10$  V range, an interrupt is generated in the microprocessor, and the search/acquisition circuit is activated.

---

**CAUTION**

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The 600 MHz PLL will remain phase-locked and on frequency with as much as  $\pm 12.5$  V on the tune line, but the noise and spur performance will be greatly impaired. This circuitry is always active and can also act as an over-voltage indicator for the 20 ppm/V tuning mode.

### **Sweep-to-Lock**

The sweep-to-lock circuit, when triggered by one of the out-of-lock indicators, sweeps the loop integrator in an attempt to acquire phase lock. The sweep in the voltage of the loop integrator sweeps the output frequency of the loop, which is fed back through the phase detector. When the loop output is at the same frequency as the 600 MHz reference, the phase detector will produce the phase-error voltage necessary to acquire and maintain phase-lock. When this occurs, the out-of-lock indicators will indicate a locked condition.

The sweep-to-lock circuit is microprocessor controlled. It is normally active whenever the 600 MHz reference is in a phase-locked mode. When active, the sweep-to-lock circuit will accept a trigger signal from the integrator or beat note out-of-lock indicators. The trigger signal from the out-of-lock indicators is a level sensitive input, where a logical "0" is the out-of-lock condition. The logical "0" trigger level activates a 9.4 kHz astable oscillator which is necessary to activate the edge triggered sweep-to-lock circuit.

The sweep-to-lock circuit consists of a pair of one-shot monostable multi-vibrator timers, each set for a 219 ms pulse. The first one-shot is triggered by the 9.4 kHz oscillator. The one-shot's output is connected to an analog switch which places an offset on the phase detector amplifier input, which places a large offset on the integrator input, forcing the integrator to ramp in voltage, in an attempt to acquire lock.

The end of the first time period triggers the second timer, which is also connected to an analog switch. This switch produces a voltage offset in the opposite direction forcing the integrator to ramp down in voltage, in a second attempt to acquire phase lock. At the end of the second time period, the out-of-lock indicator is checked for lock. If lock has not occurred, the cycle repeats. Lock will normally occur in 500 ms.

The sweep-to-lock signals injected into the phase detector amplifier are adjustable to two levels of integrator input offset. The normal level produces  $\pm 0.88$  V of integrator input offset. It is used in the 10 kHz, 17 kHz and 30

kHz bandwidth modes. This offset level is sufficient to ramp the integrator over its entire output range in less than 200 ms. The integrator response time in the 4 kHz bandwidth is much slower. It is necessary to increase the integrator offset to  $\pm 2.7$  V to insure the entire output range will be swept in less than 200 ms.

The maximum integrator sweep offset which can be tolerated by the PLL must be sufficiently less than the phase detector output phase slope that:

1. The phase detector output can override the sweep-to-lock offset and acquire phase lock.
2. The PLL must maintain phase lock through the phase transients generated by the sweep circuit turning off.

### 600 MHz STW Oscillator

The 600 MHz STWO is a transverse wave resonator oscillator designed for low noise performance and wide tuning range. The tuning sensitivity is typically 10 kHz/V at 600 MHz or approximately 20 ppm/V. It is designed to oscillate at 600 MHz, +160 kHz @ -9 V tune line voltage and -100 kHz at +12 V tune line voltage. The oscillator is offset +21.9 kHz with 0 V on the tune line to compensate for the temperature drift of the transverse wave resonator. The exact frequency of oscillation is not important for phase noise measurements, but the STWO must be able to acquire and maintain phase-lock under all environmental conditions with the internal 100 MHz VCXO, tunable over a  $\pm 10$  ppm range, which is  $\pm 6$  kHz at 600 MHz.

*Table 13-8 Phase Noise Performance*

Offset Frequency	Typical Noise Performance	Oscillator Performance Requirements	
		Specified	Typical
10 Hz	-70 dBc	-28 dBc	-25 dBc
100 Hz	-100 dBc	-78 dBc	-75 dBc
1 KHz	-130 dBc	-128 dBc	-125 dBc
10 kHz	-160 dBc	-158 dBc	-155 dBc
>100 kHz	-175 dBc	-170 dBc	-167 dBc

The phase noise performance is achieved by using very high-Q STW resonators with very small burst noise, a circuit topology that is inherently low noise, an active device which maintains good residual noise performance as an amplifier, even while limiting, and by paying special attention to oscillator bias supply voltages. The capacitance multiplier regulator on the oscillator's collector supply greatly reduces the power supply noise which would be converted to phase noise in the oscillator. The

Block Diagram  
**600 MHz Reference Loop (A7A2)**

600 MHz output amplifier's collector supply are also regulated to prevent noise degradation.

The regulators also improve 40 kHz spurs generated by the module's 40 kHz switching power supply. Vibrational spurs induced in the crystal resonator structure are reduced by vibration shock mounting of the 600 MHz Reference Assembly.

The 600 MHz oscillator output amplifier has four outputs. The main output is connected to the 600 MHz, 1 watt, power amplifier which drives the microwave multiplier. The output level is +20 dBm,  $\pm 2$  dB.

---

**CAUTION**

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The 600 MHz power amplifier output has a DC component of +13.6 V regulated output voltage, capable of supplying several amps of current. The DC voltage is to supply bias voltage to the 600 MHz power amplifier. Appropriate DC blocking must be used to prevent damage to test equipment when measuring this output.

The 600 MHz outputs to the rear panel are +7 dBm and +21 dBm respectively, both  $\pm 2$  dB. The output to the 80 dB isolation amplifier is 10 dBm,  $\pm 2$  dB.

The 600 MHz oscillator and output amplifier are always active during normal module operation. The rear-panel 600 MHz outputs are necessary for performance testing.

**80 dB Isolator**

The 80 dB isolation amplifier provides the isolation necessary to prevent multiplier spurs, from the 100 to 600 MHz multiplier, from leaking onto the 600 MHz clean-up loop's main output. The leakage path being eliminated is from the multiplier output, through the phase detector, through the 600 MHz phase detector amplifier, through the couplers and into the output amplifier's output.

The 80 dB isolation amplifier is a tuned three-stage amplifier with attenuators placed between each stage. The attenuators are necessary to maintain the amplifier's stability and to provide an additional 23 dB of isolation. Each stage has a 17 dB gain with about 20 dB of reverse isolation in the amplifier passband. Outside the 40 MHz passband the reverse isolation increases at 6 dB/octave. Inside the passband the input and output return losses are about 10 dB. The output return loss drops to 0 dB outside the passband. The input level to the 80 dB isolator is 10 dBm,  $\pm 2$  dB. The output level is +11 to +16 dBm into the phase detector.

## **Digital Control**

The digital interface with the rest of the module is through a serial three-line data bus. The interface is implemented using a custom I/O interface chip.

The chip requires a bidirectional data line, a clock line and a chip enable/interrupt line from the microprocessor. The I/O chip generates 22 parallel outputs and controls all the functions on the A2A7 board. The I/O chip also latches and transfers the interrupt status of the out-of-lock detectors to the microprocessor.

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## HP 70428A Microwave Deck Assembly

### Overview

The HP 70428A Microwave Deck (Assembly A5) generates a low-noise microwave reference signal from 2.4 GHz to 26.4 GHz in 600 MHz steps, with an adjustable output level of 0 dBm to +20 dBm. The reference signal generator is the basis of the HP 7042x family of products.

The microwave signal is generated by amplifying the 600 MHz Reference output to 1 watt, and then bandpass filtering the 600 MHz signal to remove noise sidebands and harmonics beyond a 20 MHz carrier offset. The 600 MHz signal is then frequency multiplied to microwave by a Step Recovery Diode (SRD) comb generator. The harmonic output level of the comb generator is enhanced by a GaAs edge-sharpening transmission line, which is terminated with a 3 dB attenuator. The desired comb frequency is now selected with a three resonator YIG-Tuned-Filter (YTF). With the undesired comb lines removed, the desired signal is amplified by a pre-amplifier and a power amplifier microcircuit to the required level.

### Looking at the Block Diagram

#### 600 MHz Power Amplifier

The 600 MHz power amplifier is a high gain, high efficiency, Class A, 1 Watt amplifier designed to provide broadband power in low noise power applications. This two stage hybrid amplifier uses silicon bipolar technology and incorporates input/output blocking capacitors, bias network, and is matched to 50Ω.

**Table 13-9** *Amplifier's Typical Residual Phase Noise Performance*

Carrier Offset (Hz)	1	10	100	1 k	10 k	>100 k
Residual Phase Noise	-123	-137	-153	-167	-175	-180

The amplifier's low-noise bias voltage is supplied by the A7A2 600 MHz assembly, and is connected to the amplifier's RF input cable.

---

### CAUTION

The 600 MHz coax cable between the 600 MHz reference output and the 600 MHz power amplifier input has a DC bias voltage of 13.6 V, capable of delivering several amps of current. Appropriate DC blocking must be in place when measuring the RF signal on this cable.

### 600 MHz Bandpass Filter

The 600 MHz power amplifier filter reduces the broadband reference noise down to the thermal noise floor at carrier offsets greater than 20 MHz. This is necessary to prevent 30 MHz noise sidebands from being induced on each of the microwave comb line frequencies by the SRD comb generator. The step-recovery-diode (SRD) comb generator has a bias network resonance at 30 MHz which will cause parametric amplification of any 30 MHz sideband energy present on the 600 MHz reference.

The filter is a four-section bandpass filter, with a center frequency of 600 MHz, and less than 1 dB of insertion loss. The stop-band loss relative to loss at the center frequency is 25 dB minimum from DC to 560 MHz and from 640 to 3000 MHz. The VSWR in the passband is 1.35:1 or better, input and output, at 600 MHz.

### Step Recovery Diode (SRD) Comb Generator

The SRD comb generator is a modified HP 33004A 500 MHz Comb Generator re-designed to operate at a 600 MHz input frequency, with an input level of +27 dBm to +30 dBm. The comb generator generates voltage impulses with rise times on the order of 65 ps. This fast rise time is rich in harmonic energy. The individual comb frequency power is distributed as a  $\frac{\sin x}{x}$  function, where x is proportional to the pulse rise time. The usable output frequency range is 600 MHz to 15.0 GHz. The usable output frequency range is defined as output levels greater than -20 dBm.

**Table 13-10 SRD's Typical Residual Phase Noise Performance**

Carrier Offset (Hz)	1	10	100	1 k	10 k	>100 k
Residual Phase Noise	-130	-140	-150	-160	-168	-176

---

#### NOTE

The noise is referred to the input frequency of a single SRD.

### GaAs Edge-sharpening Transmission Line

The edge-sharpener is a high-impedance coplanar-waveguide transmission line with varactor diodes spaced periodically along its length. The edge-sharpening nonlinear transmission line changes its characteristic impedance as a function of input voltage, which also changes its velocity factor.

The edge-sharpener sharpens the leading edge of SRD pulse sources by as much as 4:1 depending on the input pulse characteristics. When the input pulse voltage is low, the velocity factor is low. As the pulse voltage increases the velocity factor increases. This action causes the leading part of the

leading edge to slow down relative to the later part of the leading edge. The result is a faster pulse rise time.

Currently, the SRD/edge-sharpener combination has a rise time of about 13 ps, measured between 10% and 90% of the pulse amplitude. The result is a usable frequency range of 600 MHz to 25.8 GHz.

A 26.5 GHz, 3 dB attenuator has been integrated into the edge-sharpener's package to insure the SRD/edge-sharpener combination is terminated in a minimum of 6 dB return-loss for all usable output frequencies when connected to the YTF. This is necessary to prevent spurious oscillations in the SRD.

**YIG-Tuned-Filter (YTF)**

The YTF is a three resonator filter tunable from 2.4 to 26.5 GHz. The filter is used to select the desired comb frequency, and reject the undesired signals.

It is necessary to remove unwanted comb frequency before the desired signal is amplified to prevent amplifier output saturation. The power in all the comb line frequencies together is about +23 dBm to +27 dBm although any individual comb frequency is no more than +3 dBm.

The YTF filter performance is as follows:

**Table 13-11 Passband Performance**

	Band 1	Band 2	Band 3	Band 4
Frequency Range (GHz)	2.4 to 2.75	2.75 to 13.0	13.0 to 20	20 to 25.8
Insertion Loss (dB)	7.5	6.5	6.5	6.5
Frequency Range (dB <sub>p-p</sub> )	5.0	5.0	5.0	5.0
insertion Loss with Temperature (dB)	±1.5	±1.5	±2.0	±2.0
Input VSWR (max)	2.8:1	2.8:1	2.8:1	2.8:1
Output VSWR (max)	2.8:1	2.8:1	2.8:1	2.8:1
1 dB Compress dBm	>10	>10	>10	>10
Bandwidth min MHz	25	25	30	35

The rejection performance at 600 and 1200 MHz offsets referenced to passband insertion loss is as follows:

**Table 13-12 600 - 1200 MHz Offsets**

2.4 to 18.0 GHz	18.0 to 25.8 GHz
72 dBc	62 dBc

**Table 13-13** *YTF's typical residual phase noise performance at 9.6 GHz*

Carrier Offset (Hz)	1	10	100	1 k	10 k	>100 k
Residual Phase Noise	-92	-110	-125	-135	-143	-152

The tuning sensitivity of the YTF is about 75 MHz/mA, with a measured phase sensitivity of 10 rad/mA. This tuning sensitivity sets the noise current requirements on the YTF driver. Given a goal of only a 0.5 dB degradation or less due to YTF tune-current noise, the tune-current noise must be 10 dB less than the YTF phase noise. The noise current contribution to phase noise can be calculated by:

$$\frac{C}{sb} = 20 \log \frac{\beta}{2} \text{ where } \beta = \text{peak phase deviation}$$

$$\beta_{rms} = \text{noise current (rms)} \times$$

**Table 13-14** *YTF tune current noise goal*

Carrier Offset (Hz)	1	10	100	1 k	10 k	>100 k
Noise Current (pA)	1120	141	25.1	7.95	3.16	1.12

The YTF is equipped with an internal heater to help maintain frequency stability and tuning repeatability over the module's operating temperature range.

The tuning algorithm is designed to minimize magnetic hysteresis. The YTF is tuned to a frequency below all usable frequencies, before it is tuned to the desired frequency. This relaxes the magnetic hysteresis. The YTF is then tuned to the new frequency by increasing the magnetic field until the new frequency is reached.

Frequency calibration data is stored in the EE PROM on the microprocessor assembly. The calibration data contains DAC current settings for each comb line frequency, and an interpolation algorithm generates DAC settings for the second YTF in the HP 70428 opt 002. The module can measure its own frequency calibration data by accessing the YTF Calibration screen (see Chapter 15).

### **GaAs Amplifier Preamp & Power Amp**

The YTF output is amplified by the GaAs amplifiers. The amplifier input range is 2.4 to 26.4 GHz, with an input level of -25 dBm to 0 dBm.

The active devices used in the two amplifier microcircuits are monolithic-microwave-traveling-wave-amplifiers. These GaAs monolithic-microwave-integrated-circuits (MMIC) are designed for high gain and excellent input/output match to 50Ω over the full 2 GHz to 26.5 GHz band. The seven MESFET cascode stages provide a minimum  $S_{21}$  of 7 dB per MMIC, and remain relatively low noise even while operating in gain compression.

The pre-amplifier microcircuit and power amplifier microcircuit contain a total of six MMIC gain stages, with three stages in each package. The amplifier was packaged in two microcircuits to greatly reduce internal microcircuit shielding requirements, and to re-use existing package and substrate designs. The two microcircuits make up one six stage amplifier.

The microcircuits are designed for  $\pm 5$  dB gain flatness from 2.4 GHz to 26.5 GHz, with gain being rolled off below 2 GHz. The low frequency roll-off is accomplished by using small value coupling capacitors between MMIC stages. The low frequency gain roll-off is necessary to prevent noise below 1 GHz from being mixed up onto the microwave output for output frequencies above 20 GHz. The sloped gain attenuator between stage 2 and 3 greatly improves gain flatness.

The output power level is detected in the microcircuit at the output of the sixth stage using a low-loss GaAs directional bridge. The module's internal voltmeter is then used to measure the power level. The power level is then compared to the power level curve-fit data, and the power is then adjusted accordingly.

Amplitude calibration data is stored in the EE PROM on the microprocessor assembly. The calibration data contains polynomial curve-fit coefficients for power vs frequency at 10 dBm output, and power vs detector voltage at 9.6 GHz. Coefficients for the second set of GaAs amplifiers are also stored on the microprocessor assembly for the HP 70428 opt 002, when necessary. The module can measure its own frequency calibration data by connecting an external HP 70100A or HP 437B power meter to the instrument, and accessing the YTF Calibration screen (see chapter 15).

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**NOTE**

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The power meter must be manually calibrated and zeroed before calibration is started.

Output power and gain are controlled in two different modes which are selectable from the Miscellaneous screen.

Second-gate-control adjusts gain by controlling the gate bias of the second MESFET of each of the cascode stages in the MMIC. The second gate control ports of the second, third, and fourth MMIC amplifiers are connected together and can be controlled by the GaAs amplifier driver assembly. The

control range is  $-7$  dB to  $+8$  dB gain per MMIC, which allows an overall output level range of 0 to  $+20$  dBm.

Second-gate-control is used in the module whenever frequency switching or calibration is taking place. The advantage of second gate control is fast and repeatable power level setting. The disadvantage is a 20 dB degradation in AM noise over drain bias control.

Drain-bias-control adjusts the output level by controlling the drain voltage on each of the six MMIC amplifiers. The level adjustment range is  $-15$  dBm to  $+16$  dBm, but is only usable from 0 dBm to  $+16$  dBm. The level adjustment sensitivity increases rapidly at lower output levels.

Drain-bias-control is used in the module's normal low noise mode. AM noise is suppressed by drain voltage saturation limiting. The limiting occurs in the last several MMIC stages at lower microwave frequencies, and provides a 20 dB improvement in AM noise. The amount of limiting and noise suppression decreases with increasing frequency as the comb frequency power decreases, and the MMIC gain decreases. Optimum noise performance and level accuracy occur at  $+10$  dBm output level.

The disadvantage of drain bias control is in level accuracy and level switching speed. The level accuracy is about  $\pm 3$  db. The switching speed is slow because the output level is dependent on drain voltage driver transistor junction temperature and MMIC device temperature. In ALC ON mode, time is taken to allow the thermal transients to decay, while constantly re-adjusting the output level. The switching time from  $+20$  dBm to 0 dBm is as much as 5 seconds.

**Table 13-15 GaAs Amplifier's Typical Residual Phase Noise @ 9.6 GHz:**

Carrier Offset (Hz)	1	10	100	1 k	10 k	>1 M
Residual Phase Noise	-110	-120	-128	-137	-144	-158

**Table 13-16 GaAs Amp's Typical AM Noise @ 9.6 GHz (Second Gate control):**

Carrier Offset (Hz)	1	10	100	1 k	10 k	>40 M
AM Noise @ 10 dBm	-93	-103	-112	-123	-132	-155

**Table 13-17 GaAs Amp's Typical AM Noise @ 12 GHz (Drain Volt control):**

Carrier Offset (Hz)	1	10	100	1 k	10 k	>1 M
AM Noise @ 10 dBm	-105	-116	-126	-139	-150	-161

## HP 70428A opt 002 Microwave Deck Assembly

### Overview

The HP 70428A opt 002 Microwave Source has two microwave outputs, the microwave step reference function output generated by the HP 70428A deck circuitry, and the frequency up-converter output. The frequency up-converter mixes the microwave stepped reference with an external RF Source between 120 MHz and 900 MHz to produce continuous frequency coverage from 2.4 GHz to 26.5 GHz. The second YTF then selects the desired mixer sideband, and rejects the unwanted sideband, and the LO feedthrough. The filtered output is finally amplified to the desired output level by a second set of GaAs amplifiers.

### Looking at the Block Diagram

#### 2.4 GHz to 25.8 GHz Microwave Stepped Reference

The 2.4 GHz to 25.8 GHz step reference output is identical to the main output of a HP 70428A Stepped Source. The output is made available to the front panel via a DC to 26.5 GHz SPDT switch connecting it to the step reference output amplifier. The step reference output is necessary for calibration of the step reference output level into the up-conversion mixer LO port. This output has slightly lower noise than the upconverter's output, and is available at the  $\mu$ W LO connector when the module is in source mode.

#### Microwave Upconversion Mixer

The upconversion mixer multiplies the external RF input with the stepped microwave reference source to produce upper and lower sidebands at the RF input frequency rate on the microwave stepped reference.

The mixer LO port is connected to the step reference output amplifier via the SPDT, DC to 26.5 GHz switch connected to the step reference output amplifier. The reference output level into the mixer is +10 dBm.

The mixer is operated with the IF port being used for the RF signal input. It is specified for a frequency range of 120 MHz to 900 MHz, with an input module level of +5 dBm. A 10 dB attenuator is added to RF input path to protect the mixer diodes from burn-out caused by accidental DC voltage input or electrostatic discharge (ESD).

The mixer RF port is used for the microwave signal output. It is terminated with a 3 dB attenuator between the RF port output and the second YTF used to select the desired mixer sideband. It is necessary to terminate the RF port to prevent signals reflected by the YTF from causing mixer un-flatness and mixer spurs.

The tuning algorithm is designed to tune continuously over the 2.4 to 26.5 GHz frequency range, while minimizing both the number of microwave frequency steps required, and the frequency range of the RF source. In standard operation, the RF source will always be between 300 MHz and 600 MHz, except at an output frequency of 25.8 GHz to 26.1 GHz where the RF frequency must be extended from 600 MHz to 900 MHz, and at an output frequency of 26.4 GHz to 26.5 GHz where the RF frequency must be extended from 600 MHz to 700 MHz. This frequency range was chosen to minimize the noise from the HP 8662/3 RF signal generator used for the RF reference, and to insure that the LO feedthrough and the undesired sideband were far enough away from the desired signal to be filtered by the second YTF. A slightly lower noise tuning algorithm is also selectable which allows the HP 8662/3 to operate between 120 MHz and 600 MHz RF (reducing the RF generator noise by 6 dB), whenever the output frequency is at least 120 MHz from a comb line frequency (see description of *120-300, 480-600* softkey in Chapter 10). The disadvantage of this mode is that the undesired sideband and the LO feedthrough signal spurs are much greater due to insufficient YTF filtering at those frequency offsets.

**Table 13-18** *Standard Frequency Algorithm*

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
600 to 300	3.0	lower	2.4 to 2.7
300 to 600	2.4	upper	2.7 to 30
600 to 300	3.6	lower	3.0 to 3.3
300 to 600	3.0	upper	3.3 to 3.6
600 to 300	4.2	lower	3.6 to 3.9
300 to 600	3.6	upper	3.9 to 4.2
600 to 300	4.8	lower	4.2 to 4.5
300 to 600	4.2	upper	4.5 to 4.8
600 to 300	5.4	lower	4.8 to 5.1
300 to 600	4.8	upper	5.1 to 5.4
600 to 300	6.0	lower	5.4 to 5.7
300 to 600	5.4	upper	5.7 to 6.0
600 to 300	6.6	lower	6.0 to 6.3
300 to 600	6.0	upper	6.3 to 6.6
600 to 300	7.2	lower	6.6 to 6.9
300 to 600	6.6	upper	6.9 to 7.2
600 to 300	7.8	lower	7.2 to 7.5
300 to 600	7.2	upper	7.5 to 7.8
600 to 300	8.4	lower	78 to 8.1
300 to 600	7.8	upper	8.1 to 8.4
600 to 300	9.0	lower	8.4 to 8.7
300 to 600	8.4	upper	8.7 to 9.0
600 to 300	9.6	lower	9.0 to 9.3
300 to 600	9.0	upper	9.3 to 9.6
600 to 300	10.2	lower	9.6 to 9.9
300 to 600	9.6	upper	9.9 to 10.2
600 to 300	10.8	lower	10.2 to 10.5

**Table 13-18 Standard Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
300 to 600	10.2	upper	10.5 to 10.8
600 to 300	11.4	lower	10.8 to 11.1
300 to 600	10.8	upper	11.1 to 11.4
600 to 300	12.0	lower	11.4 to 11.7
300 to 600	11.4	upper	11.7 to 12.0
600 to 300	12.6	lower	12.0 to 12.3
300 to 600	12.0	upper	12.3 to 12.6
600 to 300	13.2	lower	12.6 to 12.9
300 to 600	12.6	upper	12.9 to 13.2
600 to 300	13.8	lower	13.2 to 13.5
300 to 600	13.2	upper	13.5 to 13.8
600 to 300	14.4	lower	13.8 to 14.1
300 to 600	13.8	upper	14.1 to 14.4
600 to 300	15.0	lower	14.4 to 14.7
300 to 600	14.4	upper	14.7 to 15.0
600 to 300	15.6	lower	15.0 to 15.3
300 to 600	15.0	upper	15.3 to 15.6
600 to 300	16.2	lower	15.6 to 15.9
300 to 600	15.6	upper	15.9 to 16.2
600 to 300	16.8	lower	16.2 to 16.5
300 to 600	16.2	upper	16.5 to 16.8
600 to 300	17.4	lower	16.8 to 17.1
300 to 600	16.8	upper	17.1 to 17.4
600 to 300	18.0	lower	17.4 to 17.7
300 to 600	17.4	upper	17.7 to 18.0
600 to 300	18.6	lower	18.0 to 18.3
300 to 600	18.0	upper	18.3 to 18.6

**Table 13-18** *Standard Frequency Algorithm*

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
600 to 300	19.2	lower	18.6 to 18.9
300 to 600	18.6	upper	18.9 to 19.2
600 to 300	19.8	lower	19.2 to 19.5
300 to 600	19.2	upper	19.5 to 19.8
600 to 300	20.4	lower	19.8 to 20.1
300 to 600	19.8	upper	20.1 to 20.4
600 to 300	21.0	lower	20.4 to 20.7
300 to 600	20.4	upper	20.7 to 21.0
600 to 300	21.6	lower	21.0 to 21.3
300 to 600	21.0	upper	21.3 to 21.6
600 to 300	22.2	lower	21.6 to 21.9
300 to 600	21.6	upper	21.9 to 22.2
600 to 300	22.8	lower	22.2 to 22.5
300 to 600	22.2	upper	22.5 to 22.8
600 to 300	23.4	lower	22.8 to 23.1
300 to 600	22.8	upper	23.1 to 23.4
600 to 300	24.0	lower	23.4 to 23.7
300 to 600	23.4	upper	23.7 to 24.0
600 to 300	24.6	lower	24.0 to 24.3
300 to 600	24.0	upper	24.3 to 24.6
600 to 300	25.2	lower	24.6 to 24.9
300 to 600	24.6	upper	24.9 to 25.2
600 to 300	25.8	lower	25.2 to 25.5
300 to 900	25.2	upper	25.5 to 26.1
600 to 700	25.8	lower	26.1 to 26.5

**Table 13-19 Low noise, High Spur Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
600 to 480	3.0	lower	2.40 to 2.52
120 to 300	2.4	upper	2.52 to 2.70
300 to 120	3.0	lower	2.70 to 2.88
480 to 600	2.4	upper	2.88 to 3.00
600 to 480	3.6	lower	3.00 to 3.12
120 to 300	3.0	upper	3.12 to 3.30
300 to 120	3.6	lower	3.30 to 3.48
480 to 600	3.0	upper	3.48 to 3.60
600 to 480	4.2	lower	3.60 to 3.72
120 to 300	3.6	upper	3.72 to 3.90
300 to 120	4.2	lower	3.90 to 4.08
480 to 600	3.6	upper	4.08 to 4.20
600 to 480	4.8	lower	4.20 to 4.32
120 to 300	4.2	upper	4.32 to 4.50
300 to 120	4.8	lower	4.50 to 4.68
480 to 600	4.2	upper	4.68 to 4.80
600 to 480	5.4	lower	4.80 to 4.92
120 to 300	4.8	upper	4.92 to 5.10
300 to 120	5.4	lower	5.10 to 5.28
480 to 600	4.8	upper	5.28 to 5.40
600 to 480	6.0	lower	5.40 to 5.52
120 to 300	5.4	upper	5.52 to 5.70
300 to 120	6.0	lower	5.70 to 5.88
480 to 600	5.4	upper	5.88 to 6.00
600 to 480	6.6	lower	6.00 to 6.12
120 to 300	6.0	upper	6.12 to 6.30

**Table 13-19** *Low noise, High Spur Frequency Algorithm*

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
300 to 120	6.6	lower	6.30 to 6.48
480 to 600	6.0	upper	6.48 to 6.60
600 to 480	7.2	lower	6.60 to 6.72
120 to 300	6.6	upper	6.72 to 6.90
300 to 120	7.2	lower	6.90 to 7.08
480 to 600	6.6	upper	7.08 to 7.20
600 to 480	7.8	lower	7.20 to 7.32
120 to 300	7.2	upper	7.32 to 7.50
300 to 120	7.8	lower	7.50 to 7.68
480 to 600	7.2	upper	7.68 to 7.80
600 to 480	8.4	lower	7.80 to 7.92
120 to 300	7.8	upper	7.92 to 8.10
300 to 120	8.4	lower	8.10 to 8.28
480 to 600	7.8	upper	8.28 to 8.40
600 to 480	9.0	lower	8.40 to 8.52
120 to 300	8.4	upper	8.52 to 8.70
300 to 120	9.0	lower	8.70 to 8.88
480 to 600	8.4	upper	8.88 to 9.00
600 to 480	9.6	lower	9.00 to 9.12
120 to 300	9.0	upper	9.12 to 9.30
300 to 120	9.6	lower	9.30 to 9.48
480 to 600	9.0	upper	9.48 to 9.60
600 to 480	10.2	lower	9.60 to 9.72
120 to 300	9.6	upper	9.72 to 9.90
300 to 120	10.2	lower	9.90 to 10.08
480 to 600	9.6	upper	10.08 to 10.20

**Table 13-19 Low noise, High Spur Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
600 to 480	10.8	lower	10.20 to 10.32
120 to 300	10.2	upper	10.32 to 10.50
300 to 120	10.8	lower	10.50 to 10.68
480 to 600	10.2	upper	10.68 to 10.80
600 to 480	11.4	lower	10.80 to 10.92
120 to 300	10.8	upper	10.92 to 11.10
300 to 120	11.4	lower	11.10 to 11.28
480 to 600	10.8	upper	11.28 to 11.40
600 to 480	12.0	lower	11.40 to 11.52
120 to 300	11.4	upper	11.52 to 11.70
300 to 120	12.0	lower	11.70 to 11.88
480 to 600	11.4	upper	11.88 to 12.00
600 to 480	12.6	lower	12.00 to 12.12
120 to 300	12.0	upper	12.12 to 12.30
300 to 120	12.6	lower	12.30 to 12.48
480 to 600	12.0	upper	12.48 to 12.60
600 to 480	13.2	lower	12.60 to 12.72
120 to 300	12.6	upper	12.72 to 12.90
300 to 120	13.2	lower	12.90 to 13.08
480 to 600	12.6	upper	13.08 to 13.20
600 to 480	13.8	lower	13.20 to 13.32
120 to 300	13.2	upper	13.32 to 13.50
300 to 120	13.8	lower	13.50 to 13.68
480 to 600	13.2	upper	13.68 to 13.80
600 to 480	14.4	lower	13.80 to 13.92

**Table 13-19 Low noise, High Spur Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
120 to 300	13.8	upper	13.92 to 14.10
300 to 120	14.4	lower	14.10 to 14.28
480 to 600	13.8	upper	14.28 to 14.40
600 to 480	15.0	lower	14.40 to 14.52
120 to 300	14.4	upper	14.52 to 14.70
300 to 120	15.0	lower	14.70 to 14.88
480 to 600	14.4	upper	14.88 to 15.00
600 to 480	15.6	lower	15.00 to 15.12
120 to 300	15.0	upper	15.12 to 15.30
300 to 120	15.6	lower	15.30 to 15.48
480 to 600	15.0	upper	15.48 to 15.60
600 to 480	16.2	lower	15.60 to 15.72
120 to 300	15.6	upper	15.72 to 15.90
300 to 120	16.2	lower	15.90 to 16.08
480 to 600	15.6	upper	16.08 to 16.20
600 to 480	16.8	lower	16.20 to 16.32
120 to 300	16.2	upper	16.32 to 16.50
300 to 120	16.8	lower	16.50 to 16.68
480 to 600	16.2	upper	16.68 to 16.80
600 to 480	17.4	lower	16.80 to 16.92
120 to 300	16.8	upper	16.92 to 17.10
300 to 120	17.4	lower	17.10 to 17.28
480 to 600	16.8	upper	17.28 to 17.40
600 to 480	18.0	lower	17.40 to 17.52
120 to 300	17.4	upper	17.52 to 17.70
300 to 120	18.0	lower	17.70 to 17.88

**Table 13-19 Low noise, High Spur Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
480 to 600	17.4	upper	17.88 to 18.00
600 to 480	18.6	lower	18.00 to 18.12
120 to 300	18.0	upper	18.12 to 18.30
300 to 120	18.6	lower	18.30 to 18.48
480 to 600	18.0	upper	18.48 to 18.60
600 to 480	19.2	lower	18.60 to 18.72
120 to 300	18.6	upper	18.72 to 18.90
300 to 120	19.2	lower	18.90 to 19.08
480 to 600	18.6	upper	19.08 to 19.20
600 to 480	19.8	lower	19.20 to 19.32
120 to 300	19.2	upper	19.32 to 19.50
300 to 120	19.8	lower	19.50 to 19.68
480 to 600	19.2	upper	19.68 to 19.80
600 to 480	20.4	lower	19.80 to 19.92
120 to 300	19.8	upper	19.92 to 20.10
300 to 120	20.4	lower	20.10 to 20.28
480 to 600	19.8	upper	20.28 to 20.40
600 to 480	21.0	lower	20.40 to 20.52
120 to 300	20.4	upper	20.52 to 20.70
300 to 120	21.0	lower	20.70 to 20.88
480 to 600	20.4	upper	20.88 to 21.00
600 to 480	21.6	lower	21.00 to 21.12
120 to 300	21.0	upper	21.12 to 21.30
300 to 120	21.6	lower	21.30 to 21.48
480 to 600	21.0	upper	21.48 to 21.60
600 to 480	22.2	lower	21.60 to 21.72

**Table 13-19 Low noise, High Spur Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
120 to 300	21.6	upper	21.72 to 21.90
300 to 120	22.2	lower	21.90 to 22.08
480 to 600	21.6	upper	22.08 to 22.20
600 to 480	22.8	lower	22.20 to 22.32
120 to 300	22.2	upper	22.32 to 22.50
300 to 120	22.8	lower	22.50 to 22.68
480 to 600	22.2	upper	22.68 to 22.80
600 to 480	23.4	lower	22.80 to 22.92
120 to 300	22.8	upper	22.92 to 23.10
300 to 120	23.4	lower	23.10 to 23.28
480 to 600	22.8	upper	23.28 to 23.40
600 to 480	24.0	lower	23.40 to 23.52
120 to 300	23.4	upper	23.52 to 23.70
300 to 120	24.0	lower	23.70 to 23.88
480 to 600	23.4	upper	23.88 to 24.00
600 to 480	24.6	lower	24.00 to 24.12
120 to 300	24.0	upper	24.12 to 24.30
300 to 120	24.6	lower	24.30 to 24.48
480 to 600	24.0	upper	24.48 to 24.60
600 to 480	25.6	lower	24.60 to 24.72
120 to 300	24.6	upper	24.72 to 24.90
300 to 120	25.6	lower	24.90 to 25.08
480 to 600	24.6	upper	25.08 to 25.20
600 to 480	25.8	lower	25.20 to 25.32
120 to 300	25.2	upper	25.32 to 25.50
300 to 120	25.8	lower	25.50 to 25.68

**Table 13-19** *Low noise, High Spur Frequency Algorithm*

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (GHz)
480 to 720	25.2	upper	25.68 to 25.92
120 to 700	25.8	upper	25.92 to 26.50

**YIG-Tuned-Filter (YTF)**

The YTF is a three resonator filter tunable from 2.4 to 26.5 GHz. The filter is used to select the desired comb frequency, and reject the undesired signals. It is identical to the YTF used in the step reference. See HP 70428A YIG-Tuned-Filter (YTF).

**GaAs Amplifier Preamp & Power Amp**

The YTF output is amplified by the output GaAs amplifiers. The amplifier input range is 2.4 to 26.5 GHz, with a input level of -27 dBm to -23 dBm. The output amplifier microcircuits are identical to the step reference output microcircuits. See HP 70428A GaAs Amplifier Preamp & Power Amp.

## HP 70427A Microwave Deck Assembly

### Overview

The HP 70427A Microwave Downconverter offers several functions dependent on input frequency and level. The input frequency range is 5 MHz to 26.5 GHz, with an input level range of  $-30$  to  $+30$  dBm. This range may be extended from 26.5 GHz to 110 GHz by using the HP 11970 family of millimeter harmonic mixers in external application.

Linear frequency downconversion is available for microwave signals between 1.5 GHz and 26.5 GHz. An input signal, between  $-30$  dBm and  $+30$  dBm is mixed with step reference function generated by the HP 70428A deck circuitry to produce an intermediate frequency (IF) between 300 MHz and 900 MHz. The IF signal is then amplified in a switched gain linear IF amplifier. The amplified signal can then be monitored (using the IF VIEW selection of the RF/microwave spectrum analyzer monitor port), AM detected (using the IF amplifier AM detector), or phase noise can be measured on the IF output (using an HP 3048A Phase Noise System).

Input signals between 5 MHz and 1.5 GHz can be amplified directly by the IF amplifier. The input range is  $-30$  dBm to  $+30$  dBm. The amplified signal can then be monitored (using the IF VIEW selection of the RF/microwave spectrum analyzer monitor port), AM detected between 50 MHz and 1.5 GHz (using the IF amplifier AM detector), or phase noise can be measured on the IF output (using an HP 3048A Phase Noise System).

AM Noise may be measured using the internal diode detector. The input frequency range is from 5 MHz to 26.5 GHz, with an input level requirement of 0 dBm to  $+30$  dBm.

The spectrum analyzer monitor switching allows one analyzer with adequate frequency range and performance to view the main input signal, view the IF amplifier output, and measure the RF frequency offset range in the HP 3048A Phase Noise System, without recabling the measurement setup. The frequency range of the input view function (VIEW IN) is DC to 26.5 GHz. The IF view function (VIEW IF) covers the IF frequency range, 5 MHz to 1.5 GHz. The HP 3048A RF analyzer function (VIEW  $-$ ) covers the HP 3048A requirement of 100 kHz to 40 MHz.

### Looking at the Block Diagram

#### 2.4 GHz to 25.8 GHz Microwave Stepped Reference

The 2.4 GHz to 25.8 GHz step reference output is identical to the main output of an HP 70428A Stepped Source. The output is made available to the front panel via a DC to 26.5 GHz SPDT switch connecting it to the step reference output amplifier. The step reference output is necessary for calibration of the step reference output level into the downconversion mixer

LO port, or to drive the LO port of one of the HP 11970 family of millimeter harmonic mixers.

### **External Application of Millimeter Harmonic Mixers**

The external harmonic mixer may be used to extend the frequency range from 26.5 GHz to 110 GHz. The mixer requires an LO frequency of 2.4 to 6.6 GHz at +16 dBm. The mixer multiplies input frequencies between 26.5 GHz and 110 GHz with the harmonics of the stepped microwave reference source to produce an IF between 5 MHz and 1500 MHz. If an odd harmonic is required to produce the desired IF frequency, a bias current between -10 mA and +10 mA must be added to the IF port of the mixer. If an even harmonic is required to produce the desired IF frequency, no mixer bias is necessary.

### **Microwave Downconversion Mixer**

The downconversion mixer multiplies microwave inputs between 1.5 GHz and 26.5 GHz with the stepped microwave reference source to produce an IF signal between 300 MHz and 900 MHz.

The mixer LO port is connected to the step reference output amplifier via the SPDT, DC to 26.5 GHz switch connected to the step reference output amplifier. The reference output level into the mixer is +10 dBm.

The microwave signal to be downconverted is connected to the mixer RF Port via the two DC to 26.5 GHz attenuator/switch assemblies. The input attenuator is used to attenuate input signals of -10 dBm to +30 dBm into the RF port input range of -5 dBm to -10 dBm. The downconverter is usable for signals between -10 dBm and -30 dBm, but the input attenuator must be manually set to 0 dB attenuation. The downconverter maximum RF port input level can be changed using the *MIXER MAX LVL* softkey, but will change back to the default value whenever the module is preset.

The tuning algorithm is designed to tune continuously over the 1.5 to 26.5 GHz frequency range, while minimizing the number of microwave frequency steps required, and the frequency range of the IF signal. In standard operation, the IF amplifier will be always be between 300 MHz and 600 MHz, except in the following cases:

at an input frequency of 1.5 GHz to 1.8 GHz, 2.1 GHz to 2.4 GHz and 25.8 GHz to 26.1 GHz, the IF frequency must be extended from 600 to 900 MHz, and

at an input frequency of 26.4 GHz to 26.5 GHz, the IF frequency must be extended from 600 to 700 MHz.

These constraints were chosen to minimize the noise from the HP 8662/3 RF signal generator used as the RF reference for phase noise measurements of the downconverted IF output.

**Table 13-20 Downconverter Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (MHz)
1.5 to 2.1	2.4	LO_RF	900 to 300
2.1 to 2.7	3.0	LO_RF	900 to 300
2.7 to 3.0	2.4	RF_LO	300 to 600
3.0 to 3.3	3.6	LO-RF	600 to 300
3.3 to 3.6	3.0	RF-LO	300 to 600
3.6 to 3.9	4.2	LO_RF	600 to 300
3.9 to 4.2	3.6	RF_LO	300 to 600
4.2 to 4.5	4.8	LO_RF	600 to 300
4.5 to 4.8	4.2	RF_LO	300 to 600
4.8 to 5.1	5.4	LO_RF	600 to 300
5.1 to 5.4	4.8	RF_LO	300 to 600
5.4 to 5.7	6.0	LO_RF	600 to 300
5.7 to 6.0	5.4	RF_LO	300 to 600
6.0 to 6.3	6.6	LO-RF	600 to 300
6.3 to 6.6	6.0	RF-LO	300 to 600
6.6 to 6.9	7.2	LO_RF	600 to 300
6.9 to 7.2	6.6	RF_LO	300 to 600
7.2 to 7.5	7.8	LO_RF	600 to 300
7.5 to 7.8	7.2	RF_LO	300 to 600
7.8 to 8.1	8.4	LO_RF	600 to 300
8.1 to 8.4	7.8	RF_LO	300 to 600
8.4 to 8.7	9.0	LO_RF	600 to 300
8.7 to 9.0	8.4	RF_LO	300 to 600
9.0 to 9.3	9.6	LO-RF	600 to 300
9.3 to 9.6	9.0	RF-LO	300 to 600
9.6 to 9.9	10.2	LO_RF	600 to 300
9.9 to 10.2	9.6	RF_LO	300 to 600

**Table 13-20 Downconverter Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (MHz)
10.2 to 10.5	10.8	LO_RF	600 to 300
10.5 to 10.8	10.2	RF_LO	300 to 600
10.8 to 11.1	11.4	LO_RF	600 to 300
11.1 to 11.4	10.8	RF_LO	300 to 600
11.4 to 11.7	12.0	LO_RF	600 to 300
11.7 to 12.0	11.4	RF_LO	300 to 600
12.0 to 12.3	12.6	LO-RF	600 to 300
12.3 to 12.6	12.0	RF-LO	300 to 600
12.6 to 12.9	13.2	LO_RF	600 to 300
12.9 to 13.2	12.6	RF_LO	300 to 600
13.2 to 13.5	13.8	LO_RF	600 to 300
13.5 to 13.8	13.2	RF_LO	300 to 600
13.8 to 14.1	14.4	LO_RF	600 to 300
14.1 to 14.4	13.8	RF_LO	300 to 600
14.4 to 14.7	15.0	LO_RF	600 to 300
14.7 to 15.0	14.4	RF_LO	300 to 600
15.0 to 15.3	15.6	LO-RF	600 to 300
15.3 to 15.6	15.0	RF-LO	300 to 600
15.6 to 15.9	16.2	LO_RF	600 to 300
15.9 to 16.2	15.6	RF_LO	300 to 600
16.2 to 16.5	16.8	LO_RF	600 to 300
16.5 to 16.8	16.2	RF_LO	300 to 600
16.8 to 17.1	17.4	LO_RF	600 to 300
17.1 to 17.4	16.8	RF_LO	300 to 600
17.4 to 17.7	18.0	LO_RF	600 to 300
17.7 to 18.0	17.4	RF_LO	300 to 600
18.0 to 18.3	18.6	LO-RF	600 to 300

Block Diagram  
**HP 70427A Microwave Deck Assembly**

**Table 13-20 Downconverter Frequency Algorithm**

Input Freq. (MHz)	LO Freq. (GHz)	Mixer SB	Output Freq. (MHz)
18.3 to 18.6	18.0	RF-LO	300 to 600
18.6 to 18.9	19.2	LO_RF	600 to 300
18.9 to 19.2	18.6	RF_LO	300 to 600
19.2 to 19.5	19.8	LO_RF	600 to 300
19.5 to 19.8	19.2	RF_LO	300 to 600
19.8 to 20.1	20.4	LO_RF	600 to 300
20.1 to 20.4	19.8	RF_LO	300 to 600
20.4 to 20.7	21.0	LO_RF	600 to 300
20.7 to 21.0	20.4	RF_LO	300 to 600
21.0 to 21.3	21.6	LO-RF	600 to 300
21.3 to 21.6	21.0	RF-LO	300 to 600
21.6 to 21.9	22.2	LO_RF	600 to 300
21.9 to 22.2	21.6	RF_LO	300 to 600
22.2 to 22.5	22.8	LO_RF	600 to 300
22.5 to 22.8	22.2	RF_LO	300 to 600
22.8 to 23.1	23.4	LO_RF	600 to 300
23.1 to 23.4	22.8	RF_LO	300 to 600
23.4 to 23.7	24.0	LO_RF	600 to 300
23.7 to 24.0	23.4	RF_LO	300 to 600
24.0 to 24.3	24.6	LO-RF	600 to 300
24.3 to 24.6	24.0	RF-LO	300 to 600
24.6 to 24.9	25.2	LO_RF	600 to 300
24.9 to 25.2	24.6	RF_LO	300 to 600
25.2 to 25.5	25.8	LO_RF	600 to 300
25.5 to 26.1	25.2	RF_LO	300 to 900
26.1 to 26.5	25.8	RF_LO	300 to 700

## HP 70427A Intermediate Frequency (IF) Amplifier

### Overview

The HP 70427A IF Amplifier (Assembly A4A1) is a linear,  $-10$  dB to  $+45$  dB, stepped gain, 1 MHz to 1.5 GHz amplifier, with a 1.5 GHz diplexed low-pass filter input. The mixer bias source provides up to  $\pm 10$  mA of bias current, necessary for odd harmonic mixing in HP 11970 series of external millimeter mixers.

The amplifier output signal can be monitored (using the IF VIEW selection of the RF/Microwave Spectrum analyzer monitor port), AM detected (using the IF amplifier AM detector), or phase noise can be measured on the main IF Output (using an HP 3048A Phase Noise System).

### Looking at the Block Diagram

#### 1.5 GHz Diplexed Low-Pass Filter

The IF amplifier input is filtered by a 1.5 GHz low-pass filter. The input filter limits the amount of LO feedthrough leakage entering the IF amplifier, and provides a broadband impedance match to reduce mixer spurs at the downconversion mixer IF port.

The diplexed filter design is actually two filter inputs in parallel, a high-pass maximally flat (Butterworth) filter and a low-pass maximally flat (Butterworth) filter, designed with the same cutoff frequency. The result is a diplexer with a constant input impedance. Signals below the cutoff frequency pass through the low-pass part of the filter. Signals above the cutoff frequency pass through the high pass part of the filter and are terminated in a  $50\Omega$  load resistor.

The filters were synthesized from 1.7 GHz, 6 pole designs, with 3 dB of attenuation at the cutoff frequency. The theoretical input return loss is better than  $-25$  dB at all frequencies. The actual filter provides a return loss better than  $-12$  dB to beyond 6 GHz, with a 1 dB cutoff frequency of 1.5 GHz.

#### External-Mixer Bias Source

The millimeter mixer bias source is connected to the filter input through the low-pass filter section. The mixer bias source provides up to  $\pm 10$  mA of bias current, necessary for odd harmonic mixing in HP 11970 series of millimeter mixers. The bias source is controlled with a 12-bit digital-to-analog converter (DAC), with  $5\ \mu\text{A}/\text{step}$  current resolution.

The DAC output voltage range is 0.000 to 4.096 volts, and is used between 0.000 and 4.000 volts. The DAC output is combined with the output of a precision 10.00 volt reference in a difference amplifier. The result is a

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precise  $\pm 10.00$  volt reference, where a DAC voltage of 2.000 volts corresponds to a DAC number of 2000, and a 0.00 volt amplifier output.

DAC and 10.00 volt reference noise are reduced by the filter capacitor across the feedback resistor in the difference amplifier. The capacitor introduces a pole in the DAC noise response at 15.9 Hz. The capacitor also produces a pole-zero response in the 10.00 volt reference noise at 15.9 Hz and 95.5 Hz respectively.

The DAC and the 10 V reference produce about 200 nV/Hz of noise, and contribute equally to the output noise until the amplifier zero stops the noise roll-off at 95.5 Hz. The output noise is then dominated by the 10 V reference beyond 100 Hz at 33 nV/Hz.

1 k $\Omega$  of resistance converts the  $\pm 10$  volt output into  $\pm 10$  mA of current with respect to ground. The bias source noise is filtered by two additional poles. The two poles are produced by breaking the 1 k $\Omega$  of resistance into three sections. The first two sections are about 250 $\Omega$  each, followed by 0.068  $\mu$ F capacitors to ground after each section. The result are two additional poles at about 9 kHz. The final resistor section is 500 $\Omega$  which is coupled to the 1.5 GHz low-pass filter section output through a 2.5  $\mu$ H RF choke.

The millimeter mixer diodes must be protected against high current capacitive discharges. A 1  $\mu$ Joule energy discharge may damage or destroy the mixer diodes. The diodes are protected by limiting the maximum bias voltage to less than 2 volts with clamping diodes and minimizing the coupling capacitor values.

**Switched Gain Amplifiers**

There are five switchable gain stages, with an overall gain of 10 dB per stage. Each stage consists of a DPDT relay which can bypass or select the amplifier. The thin film cascaded amplifiers have typically greater than 13 dB of gain, with a bandwidth of 0.1 MHz to 1.5 GHz. Each amplifier is biased through a 3 dB sloped gain attenuator. The attenuators adjust for gain roll-off at the upper frequencies, and improve the impedance match between gain stages. The attenuators also provide a method of biasing the amplifiers without introducing excessive loading at the upper frequencies.

The bias voltage is switched off on bypassed amplifier stages to prevent spurious oscillations and noise peaking due to unterminated amplifiers.

Adequate bias supply bypassing is essential. There is over 60 dB of gain available between the input of the first amplifier and the output of the last amplifiers before the signal is split off to the various outputs. Any extraneous feedback paths will cause gain unflatness and oscillations. The power supply is distributed through a series of L-C low-pass networks with a cut-off frequency of less than 800 kHz. Following the power MOS FET bias supply switches, R-L-C low-pass networks are used to filter each of the individual

amplifier bias/control lines. The amplifier bias lines have a one pole roll-off at 10 kHz, followed by two more poles at about 1 MHz.

The five dB gain steps are provided by a switchable 5 dB attenuator. The attenuator is located between stages 4 and 5.

The 6 dB sloped gain attenuator is also located between stages 4 and 5. The attenuator provides 6 dB of attenuation from DC to 100 MHz, and decreases to less than 0.5 dB of attenuation at 2.0 GHz.

The step gain amplifier selection is designed to provide minimum amplifier noise figure and maximum dynamic range without gain compression. The noise figure is typically 4.3 dB for a gain of +20 dB or greater and 5.0 dB noise figure for a gain of +10 dB or +15 dB, which are the lowest gain settings used in normal downconverter operation. The amplifier vs gain settings are as follows.

**Table 13-21 Step Gain Amplifier Selection**

GAIN	-5dB Attn	Stage 5 Amp	Stage 2 Amp	Stage 1 Amp	Stage 3 Amp	Stage 4 Amp
-10 dB	IN	OUT	OUT	OUT	OUT	OUT
-5 dB	OUT	OUT	OUT	OUT	OUT	OUT
-0 dB	IN	IN	OUT	OUT	OUT	OUT
+5 dB	OUT	IN	OUT	OUT	OUT	OUT
+10 dB	IN	IN	IN	OUT	OUT	OUT
+15 dB	OUT	IN	IN	OUT	OUT	OUT
+20 dB	IN	IN	IN	IN	OUT	OUT
+25 dB	OUT	IN	IN	IN	OUT	OUT
+30 dB	IN	IN	IN	IN	IN	OUT
+35 dB	OUT	IN	IN	IN	IN	OUT
+40 dB	IN	IN	IN	IN	IN	IN
+45 dB	OUT	IN	IN	IN	IN	IN

### IF Output Amplifiers

The step gain amplifier selection output is split into two output paths. Each path is amplified by a 12 dB gain, +16 dBm output, thin film amplifier. One output amplifier drives the AM detector and IF output peak detector. The other amplifier drives the IF Output Switching.

The RF output must be well isolated from the +15 volt power supply. The amplifier bias networks are made from several L-C and R-C sections, producing a pole at 100 kHz, and several poles at 800 kHz.

## IF Output Switching

The IF output amplifier drives the IF Output available on the module's front panel and the RF Analyzer Output, IF monitor selection. The IF Output is always active, and should be terminated in 50 $\Omega$  when not in use. Both outputs may be used simultaneously.

The IF monitor path also has an auxiliary input which allows the RF ANALYZER OUTPUT on the HP 11848A Phase Noise Test Set to be connected through the rear panel of the HP 70427A to the HP 70427A Analyzer Output.

## IF AM and Peak Detector

The AM detector output amplifier drives the IF level peak detector, and the AM detector path. The AM detector path can be further switched between the AM noise measurement output, and the IF peak level output.

The AM detector employs a diplexed 40 MHz high pass filter to remove base band noise and provide a constant input impedance.

The diplexed filter design is actually two filter inputs in parallel, a high-pass maximally flat (Butterworth) filter and a low-pass maximally flat (Butterworth) filter, designed with the same cutoff frequency. The result is a diplexer with a constant input impedance. Signals above the cutoff frequency pass through the high-pass part of the filter. Signals below the cutoff frequency pass through the low-pass part of the filter and are terminated in a 50 $\Omega$  load resistor.

The filters were synthesized from 35 MHz, 4 pole designs, with 3 dB of attenuation at the cutoff frequency. The theoretical input return loss is better than -18 dB at all frequencies. The actual filter provides a return loss better than -15 dB to beyond 1.5 GHz, with a 1 dB cutoff frequency of 40 MHz.

The output of the high pass section is also terminated in two 100 $\Omega$  resistors in parallel which provide a good low inductance 50 $\Omega$  load for the diode detector. The detector is a surface mounted 20 volt Schottky diode. The 20 volt version is chosen because it has the best noise performance of the Schottky diodes. The detector capacitor is 3.3 pF, which is the same capacitance used in the input AM detector.

The detector output is then switched between the AM noise output which is connected to the AM Detector Filter, and the IF level amplifier.

The baseband bandwidth of the IF AM detector has been experimentally adjusted to beyond 40 MHz. It is dependent on the input impedance match of the HP 11848A noise input, the amount of coax between the two modules, the compensation elements in the AM Detector Filter, and the stray capacitance in the AM Detector Filter.

The IF Level output is a DC coupled voltage proportional to the IF carrier level. The response time of this output is on the order of 20 to 30 ns, and may be used as a pulse trigger output for pulsed noise measurements.

The IF Level amplifier is a 175 MHz, 2300 V/ $\mu$ s, trans-impedance Op Amp, set for a gain of 11, and back-matched with a 50 $\Omega$  resistor. The detector is terminated in 100 $\Omega$ , with an additional 5 pF of capacitance at the input of the level Amplifier, with a detector time constant of 830 ps.

The maximum output level for linear operation of the IF level amplifier is about +3 dBm. Operation above this level greatly decreases the op-amp rise time and compresses the output level. Also, IF frequencies less than 300 MHz will produce excessive video feedthrough of the IF carrier at the IF Level Output.

The level peak detector consists of a diode peak detector on the input to the AM detector input filter. The detector rise time is about 50 ns for full output from a single pulse, which will decay with a 33  $\mu$ s time constant. The detector output is buffered through a 7.19 gain non-inverting FET-input operational amplifier, which is followed by a monolithic peak-hold detector. The peak-hold detector stores the fast diode detector output until the level can be read by the module's internal volt meter. The acquisition time of the peak-hold detector is 2.5  $\mu$ s/V. The droop rate is 15 mV/s at room temperature.

The internal microprocessor uses the peak-hold level to set the IF gain for an output level of 0 dBm to +6 dBm. The IF gain setting routine is initiated by the user with the *AUTO RANGE* softkey or the *AUTO IF GAIN* softkey. The auto gain setting command, initiated after a signal is present, first sets the IF gain to minimum, and then steps the gain up in 5 dB steps until the desired output range is achieved. The IF gain is set back to minimum if the output level of 0 dBm to +6 dBm cannot be set. The gain can be set manually using the *IF GAIN* softkey.

The peak-hold output is also monitored by an internal comparator. The comparator threshold corresponds to an IF output level of about 13 dBm. If the threshold level is exceeded, the comparator output will be set 'low'. The comparator may be read through the Diagnostic Multiplexer System.

## Digital Control

The digital interface with the rest of the module is through a serial three-line data bus. The interface is implemented using a custom I/O chip. The chip requires a bi-directional data line, a clock line and a chip enable/interrupt line from the microprocessor. The I/O chip generates 22 parallel outputs and controls all the functions on the assembly. The I/O chip also latches and transfers the interrupt status of the overload detector to the microprocessor.

## HP 70427A AM Detector Filter

### Overview

The HP 70427A AM Detector filter (Assembly A3) prevents the DC voltage component of the demodulated signal from saturating the measurement system's low noise amplifier(LNA) in the HP 11848A Phase Noise Interface. The AM detector assembly also measures the peak input carrier level to set the input attenuation level on CW and pulsed signals.

### Looking at the Block Diagram

#### AM Detector Filter

The IF AM detector and microwave peak detector (Input AM Detector) outputs are connected together at the input of the detector filter block. Detector selection is made by the presence of an RF carrier on the detector's input. The diode detector is best modeled as a current source which produces a current proportional to the carrier level. If the carrier signal is removed, the detector acts like an open circuit. The switching is therefore accomplished by selecting which detector is connected to an RF signal.

The combined input signal is switched between two paths. The AM Detector Filter path removes the DC component from the detector output for AM noise measurement. The level detector path measures the peak DC component which is proportional to carrier level.

The AM Detector Filter is a 0.1 Hz, one pole, high pass filter with a flat frequency response to beyond 40 MHz. The filter is implemented as a 3,000  $\mu$ F blocking capacitor. The value of this capacitor sets the lower frequency limit of the demodulated output. The cutoff frequency can be decreased by increasing the value of the DC blocking capacitor.

The 511 $\Omega$  resistor in the AM detector filter sets the DC bias current in the diode detector. The AC load is 50 $\Omega$ , set by the input impedance of the HP 11848A noise input. The 50 $\Omega$  load increases the detector bandwidth to greater than 40 MHz.

The detector output high frequency roll-off is greatly reduced by compensation inductors. The inductors compensate for excess capacitance to ground by peaking the response. The result is a low pass filter network with a cutoff frequency greater than 40 MHz.

The output voltage of the AM detector filter is limited to  $\pm 1$  volt maximum. Silicon protection diodes are in parallel with the filter output. The protection diodes prevent possible destructive discharges from the DC blocking capacitor from overloading the HP 11848A's Noise Input.

Carrier feedthrough in the detectors may be excessive for frequencies below a few hundred megahertz. The measurement system's LNA in the HP 11848A interface is protected from saturation by its internal filters used to

absorb phase detector feedthrough and unwanted mixer products. This limits the maximum carrier offset frequency to 2 MHz, for input frequencies of less than 95 MHz, and 40 MHz for carriers above 95 MHz.

### **Detector Bias Amplifier**

The detector bias amplifier is a DC coupled, 12 dB gain amplifier with a 26 Meg- $\Omega$  input impedance. The ratio of amplifier input impedance to the 511 $\Omega$  detector DC bias resistor results in 94 dB attenuation of noise coming from the amplifier's input into the AM detector signal path. The amplifier allows the measurement of the DC voltage component of the demodulated signal without degrading the noise measurement. This feature is only used for diagnostics.

### **Level Detector Amplifier**

The diode detector outputs are amplified by the level detector amplifier during the input attenuator setting operation. The amplifier provides a 100 $\Omega$  load for the detector outputs, and adequate gain and frequency response to operate the peak-hold detector under pulsed conditions.

The level detector amplifier is a 165 MHz, 3000 V/ $\mu$ s, trans-impedance op-amp, set for a gain of 10, and back-matched with a 50 $\Omega$  resistor. The output voltage range is  $\pm 11$  V. An auxiliary output is provided through a 500 $\Omega$  resistor which connects the DC-coupled AM signal to the diagnostic multiplexer system.

### **Peak-Hold Detector**

The peak-hold detector is a buffered diode peak detector followed by a monolithic peak-hold circuit. The peak-hold detector measures and stores the peak amplitude of the microwave detector diode until it can be read by the diagnostic multiplexer system.

The diode peak detector rise time is about 50 ns for full output from a single pulse, which will decay with a 33  $\mu$ s time constant. The detector output is buffered through a unity gain non-inverting FET-input op-amp amplifier, which is followed by a monolithic peak-hold detector. The peak-hold detector stores the fast diode detector output until the level can be read by the module's internal volt meter. The acquisition time of the peak-hold detector is 2.5  $\mu$ s/V. The droop rate is 15 mV/s at room temperature.

The internal microprocessor uses the peak-hold level to set the input attenuator for an output level of -5 dBm to -10 dBm. The input attenuation setting routine is initiated by the *AUTO RANGE* softkey or the *AUTO ATTEN* softkey. The auto attenuator setting command, initiated after a signal is present, first sets the input attenuator to maximum, and then steps the gain up in 5 dB steps until the desired output range is achieved. The input attenuator is set back to maximum if the output level of -5 dBm to -10 dBm

Block Diagram  
**HP 70427A AM Detector Filter**

cannot be set. The input attenuation can be set manually using the *INPUT ATTN* softkey.

The attenuator output level range can be changed using the *MIXER MAX LEV* softkey, but will change back to the default value whenever the module is preset.

The peak-hold output is also monitored by an internal comparator. The comparator threshold corresponds to an attenuator output level of about 10 dBm. If the threshold level is exceeded, the comparator output will be set 'low'. The comparator may be read through the diagnostic multiplexer system.

## YIG-Tuned-Filter (YTF) and GaAs FET Amplifier Driver Assembly

### Overview

The YTF and GaAs FET amplifier driver assembly is common to all modules in the HP 7042x family. This assembly provides the bias necessary to operate one 2.4 GHz to 26.5 GHz YTF, one three-stage 2.4 GHz to 26.5 GHz GaAs FET pre-amplifier microcircuit, and one three-stage 2.4 GHz to 26.5 GHz GaAs FET power amplifier microcircuit.

The YTF assembly uses a 6-bit parallel data bus to transfer data into the four 12-bit Digital-to-Analog converters (DAC). The DACs control YTF main tuning, YTF fine tuning, output amplifier level, and the auxiliary **TUNE-SPAN** output.

### Looking at the Block Diagram and Schematics

#### Digital Control

The digital interface into the YIG/GaAs amplifier driver assembly is a high-speed parallel interface to accommodate the large amount of data necessary to set frequency and amplitude. It consists of a 6-bit parallel data bus, a 3-bit address bus (which is used to select where data is to be transferred) and an enable transfer line.

The data transfer occurs in several steps. First, the 6-bit data word is stored in one of three 6-bit data latches. Data latch 0 and data latch 1 are used to reconstruct the 12-bit parallel word required for the 12-bit DACs. Finally, the reconstructed 12-bit word is transferred into the 12-bit DACs. Data latch 7 stores the 4-bit diagnostic multiplexer control, the amplitude mode control, and the noise filter enable control.

Data is stored in each latch by placing the data on the data bus, addressing the latch in which the data is to be stored, and enabling the transfer. The data is then transferred into the desired 12-Bit DAC once both halves of the 12-bit word are present in Latch 0 and Latch 1. The data is transferred by addressing the desired DAC, and then enabling the transfer.

#### YTF and GaAs Amplifier Power-On Control

The address bus also enables the +10.00 volt reference after the DACs have been initialized at module turn-on to prevent possible main frame current overload shutdown. The four DACs contain random data at module power-up. This data often sets all four DACs to the maximum output setting. This combined with the capacitor inrush current in the module's power supply allows the module to exceed its maximum current consumption limits for an MMS {4}over{8}-module. If two HP 7042x modules are in the same HP 70001 Main Frame, and both exceed the maximum current consumption

limit, the Main Frame will current-overload, and shut down. This problem is eliminated by turning off the 10.00 volt reference to the DACs.

The 10.00 V precision reference must be present for the DACs to output a signal. Removing the 10.00 volt reference sets the output to zero, regardless of the data latched in the DAC at power-up. After the microprocessor initializes the DAC data to zero, it turns on the 10 volt reference. This process also protects the YTF and GaAs FETs from being held at maximum power dissipation indefinitely during an MSIB power-on failure, which will prevent the microprocessor from initializing the module.

The power-on control is implemented using a supply voltage supervisor (U25) to monitor the +5 V supply. The supply voltage supervisor produces a 200  $\mu$ s pulse as soon as the supply voltage rises to the minimum 3.5 V level. The pulse sets the R-S flip-flop made from U24, which turns on the control switch U21A in the +10 volt reference, which shorts out the 10 volt reference signal. The +10 volt reference will remain off until the flip-flop is reset by addressing to latch 4.

### **+10 Volt Precision Reference**

The +10 volt reference (U12) is a monolithic, low drift (less than 1.5 ppm/ $^{\circ}$ C), low initial error (less than 1.0 mV) reference. It offers 12-bit absolute accuracy without any user adjustment. This performance is obtained by an ion-implanted buried zener diode reference cell and laser-wafer-drift-trimming of the high stability thin-film resistors.

The reference also contains two low temperature drift op-amps. The first amplifier is used to buffer the reference cell's +10 volt output. The buffered output drives a 300 Hz one pole R-C filter, which is followed by the second op-amp configured as a voltage follower. The noise filter reduces the noise beyond 300 Hz, and provides shunt switching access. The voltage follower input bias current is typically 20 nA which corresponds to 100  $\mu$ V voltage drop across the filter. The +10 volt reference is turned off by shorting the filter output to ground with a FET switch (U21d). The shunt switch is used to minimize the voltage drop when the reference is on. The output voltage is reduced to less than 0.07 volts due to internal switch resistance when the reference is off.

### **Tune-Span Generator**

The tune-span generator and output level control are both controlled by a dual 12-bit DAC (U7). Each 12-bit DAC section uses the +10.0 volt reference to produce an output from 0.0 volts to -10.0 volts. The output is then shifted and gain adjusted to produce the desired output.

The tune-span generator drives an auxiliary rear panel output (not currently used). The output voltage range is from +4.33 V to +9.95 V. This is the same range covered by the Tune-Span Output on the HP 70900 A/B Spectrum

Analyzer LO module. The spectrum analyzer uses this output to control the HP 70601A Preselector Microwave Filter.

### **Output Level Control**

The output level control sets the output level on the 2.4 GHz to 26.5 GHz GaAs amplifiers. Level setting can be done in two ways, depending on the noise performance vs level stability requirements.

### **Second Gate Control**

Second gate control adjusts gain by controlling the gate bias of the second MESFET of each of the cascode stages in the MMIC. The second, third, and fourth amplifier MMIC's second gate control ports are connected together and can be controlled by the GaAs amplifier driver assembly. The control range is  $-7$  dB to  $+8$  dB gain per MMIC, which allows an overall output level range of 0 to  $+20$  dBm.

Second gate control is used in the module whenever frequency switching or calibration is taking place. The advantage of second gate control is fast and repeatable power level setting. The disadvantage is a 20 dB degradation in AM noise over drain bias control.

The second gate control is produced by forcing the MMICs' second-gate bias network from its nominal  $+2.5$  V operating point ( $@$  7.0 V drain voltage) over the range of  $-2.5$  V to  $+2.5$  V. The drive current required is 17 mA/MMIC (50 mA total). The second gate control voltage is generated by offsetting the  $-10$  V to 0 V DAC output and adjusting the gain. The drive current is supplied by an emitter follower placed on the offset/gain adjust amplifier output (U13), but still connected inside the amplifier's feedback loop. Four sections of a quad FET switch (U26) are used to connect the Second Gate Control driver to the microcircuits. A 2.3 kHz L-C filter follows the FET switch output to reduce control line noise.

The second gate control requires the drain voltage be set to  $+7.0$  V.

### **Drain Bias Control**

Drain bias control adjusts the output level by controlling the drain voltage on each of the six MMIC amplifiers. The level adjustment range is  $-15$  dBm to  $+16$  dBm, but is only usable from 0 dBm to  $+16$  dBm. The level adjustment sensitivity increases rapidly at lower output levels.

Drain bias control is used in the module's normal low noise mode. AM noise is suppressed by drain voltage saturation limiting. The limiting occurs in the last several MMIC stages at lower microwave frequencies, and provides a 20 dB improvement in AM noise. The amount of limiting and noise suppression decreases with increasing frequency as the comb frequency power decreases, and the MMIC gain decreases. Optimum noise performance and level accuracy occurs at  $+10$  dBm output level.

The disadvantage of drain bias control is in level accuracy and level switching speed. The level accuracy is about  $\pm 3$  db. The switching speed is slow because the output level is dependent on drain voltage driver transistor junction temperature and MMIC device temperature. In ALC ON mode, time is taken to allow the thermal transients to decay, while constantly re-adjusting the output level. The switching time from +20 dBm to 0 dBm is as much as 5 seconds.

The output level control DAC (U7) also controls the drain bias control mode. In drain bias control mode, the second gate control switch (U26) is opened, which allows the second gates of the MMICs to float to their normal internal bias levels.

### **GaAs FET Amplifier Drain Bias Supply**

The drain bias supply regulates and controls the bias voltage for the six MMIC GaAs FET amplifiers. Its output voltage range is 0.0 V to +7.0 V. Each of the MMIC amplifier stages has an output designed for its nominal current requirement, with individual current monitoring capability. Stages 1 to 4 are set to 100 mA of bias current. Stages 5 and 6 are set to 150 mA.

The drain voltage shutdown circuit protects the MMICs against over-currenting due to loss of 1st gate bias.

The drain bias supply has two modes of operation: second gate control mode which requires a fixed 7.0 V output, and drain bias control which has a variable voltage output of 0.0 V to +7.0 V.

The reference for the fixed +7.0 V output operation is derived from the +10.0 volt reference. A resistive voltage divider consisting of R116 and R117 is buffered by the emitter follower transistor Q22 to produce a +7.8 V reference voltage.

The variable voltage output reference is supplied by amplifying the output level control DAC (U7) by a gain of  $-0.75$  in op-amp U29. This produces a 0 V to 7.5 V reference.

A quad-FET switch (U28) is used to switch between modes. The FET switch output is then filtered by an 0.18 Hz adaptive noise filter. The noise filter reduces the 100 nV/Hz reference noise to less than 3 nV/Hz at 6 Hz. The adaptive filter is buffered by a voltage follower (U27). The voltage follower input noise sets the noise at 3 nV/Hz beyond 60 Hz.

The adaptive noise filter is switched out during level setting. The switching is done by shunting the 100 k $\Omega$  filter input resistor with 50 $\Omega$ , which increases the cutoff frequency to 215 Hz.

The drain voltage shutdown circuit monitors the  $-10$  V supply used to bias the 1st gate in the MMICs. Loss of the gate bias will force the MMICs to operate at  $I_{dss}$  which may exceed their absolute maximum power dissipation limit. Damage is prevented by clamping the noise filter voltage to less than

+2 V, which corresponds to 1.3 V at the MMIC drains, if the -10 V supply is more positive than -7.5 V.

The output of the noise filter voltage follower (U27) drives the output transistor for each of the six drain supply outputs. Each output uses 2 or 3 parallel output transistors depending on the required output current. Each set of output transistors uses both base and emitter resistors. The base resistors prevent oscillation instability, the emitter resistors force equal current sharing between devices.

Drain supply noise and spurs are reduced beyond 4.5 kHz by the R-L-C filter at the output of each of the drain supplies. The series 55  $\mu\text{H}$  inductors and their corresponding  $0.5\Omega$  winding resistance are located at the output of each of the drain supplies on the YIG-tuned-filter (YTF) and GaAs FET amplifier driver assembly. The 22  $\mu\text{F}$  shunt capacitors are located on the GaAs amplifier connector assemblies. The inductors are designed to be low "Q". The internal resistance keeps the noise from peaking near the filter corner frequency of 4.5 kHz. Distributing the filter between the two printed circuit board assemblies, minimizes the amount of 40 kHz spur energy induced on the inter-connecting cables by the 40 kHz switching power supply.

The resistors between the output transistors' collector and the +10 V supply are used to measure the drain current of the MMICs, and help reduce power dissipation in the output transistors. Current is measured in a two step process. First, the voltage is measured at the output transistor collectors by the internal volt meter, and then the +10 V supply voltage is measured.

It is important to keep the change in junction temperature of the drain supply output transistors to a minimum. The MMIC drain voltage is set by the reference voltage at the noise filter output, minus the base-emitter voltage drop of the drain supply output transistors. The base-emitter voltage is typically 0.7 V, with a  $-2 \text{ mV}/^\circ\text{C}$  temperature sensitivity.

A small change in drain voltage will produce several tenths of a dB change in output power when operating in drain bias control mode, especially at low output levels.

The sensitivity of output level to drain bias voltage also makes minimizing drain voltage noise crucial in producing good AM noise performance.

### **GaAs FET Amplifier Gate #1 Bias Supply**

The gate #1 voltage controls the bias current through the MMIC amplifiers. The voltage range is -2.5 V (Drain current pinch-off) to 0.0 V ( $I_{\text{dss}}$ ). The gate #1 noise voltage must be kept to a minimum to prevent drain current modulation, which produces AM noise.

The Gate #1 voltage is supplied by the -10 V supply. The supply is monitored by the drain voltage shutdown circuit, which protects the MMICs in case of -10 V supply shutdown.

**YIG-Tuned-Filter (YTF) and GaAs FET Amplifier Driver Assembly**

The gate #1 bias supply is implemented by first filtering the  $-10\text{ V}$  supply with a capacitance multiplier. The capacitance multiplier corner frequency is  $7.2\text{ Hz}$ . The output of the capacitance multiplier is then fed to the six gate #1 output controls.

$22\text{ }\mu\text{F}$  shunt capacitors are located on the GaAs amplifier connector assemblies. The capacitors form a low-pass filter with the output resistance of the gate #1 controls. Distributing the filter between the assemblies, minimizes the amount of  $40\text{ kHz}$  spur energy induced on the inter-connecting cables by the  $40\text{ kHz}$  switching power supply. GaAs FET Amplifier Drain Current Adjustment

The drain current must be checked and adjusted whenever the YIG-tuned-filter (YTF) and GaAs FET amplifier driver assembly or the GaAs FET amplifier assemblies are altered.

The current in MMIC stages #1 to #4 must be set for  $100\text{ mA}$ ,  $\pm 2\text{ mA}$ . Stages #5 and #6 are set to  $150\text{ mA}$ ,  $\pm 2\text{ mA}$ .

The current is measured without RF signal present (Main DAC 100), and the Output Level DAC set to maximum (DAC= 4095). The module may be in either second gate control or drain voltage control modes. The current may be read using the diagnostic multiplexer system in service mode (see chapter 15).

**GaAs FET Amplifier Level Detector Amplifier**

The  $470\text{ pF}$  peak-hold capacitor at the detector amplifier input filters the detector output. The parallel  $10\text{ k}\Omega$  resistor across the capacitor produces a  $4.7\text{ }\mu\text{s}$  discharge time constant.

The detector amplifier (U20A) is a non-inverting high input impedance amplifier with a gain of 20.6. The amplifier output is connected into the diagnostic multiplexer system.

**YIG-Tuned-Filter (YTF) Current Driver**

The YTF Current Driver is a precision current sink which controls the YTF frequency. Frequency is set by the dual 12-bit DAC U6. One section of the DAC adjusts the main frequency tuning. The main DAC tune sensitivity is  $7.32\text{ MHz/step}$ . Fine tune adjustments are made by the other DAC section. The Fine tune DAC sensitivity is  $85.2\text{ kHz/step}$ .

Each 12-bit DAC section uses the  $+10.0\text{ volt}$  reference to produce an output from  $0.0\text{ volts}$  to  $-10.0\text{ volts}$ . The output is then shifted and gain adjusted to produce the desired output.

The main tune DAC output is first inverted by the unity gain amplifier U16 to produce an output between  $0.0$  and  $+10.0\text{ V}$ . The reference and DAC noise is then removed with an adaptive noise filter.

The adaptive filter cut-off frequency is switchable between 0.03 Hz for normal operation and 550 Hz when changing frequency. The adaptive filter reduces the 110 nV/Hz reference and DAC noise to less than 10 nV/Hz at 0.3 Hz.

The filtered output is the reference for a precision voltage-to-current converter. The voltage-to-current gain is 40 mA/V, with an output range of 0 to 400 mA. The conversion reference for the converter is a precision 25 $\Omega$ , 25 W resistor. The resistors temperature stability is 2 ppm/ $^{\circ}$ C. This corresponds to a 20 kHz/ $^{\circ}$ C frequency drift at 10 GHz. The resistor is mounted to the microwave deck plate heatsink to reduce its thermal rise due to power dissipation.

The voltage-to-current conversion is produced by comparing the voltage across the conversion reference resistor with the input voltage from the adaptive filter. Since the gate current of an NMOS transistor is essentially 0 (less than 100 nA), the drain current is equal to the source current measured across the conversion reference.

The OP-77 op-amp (U22) used in the voltage-to-current converter dominates its low frequency noise. The OP-77 has a typical input noise of 10.5 nV/Hz. This amplifier was selected mainly for its very low input bias current, typically less than 1.2 nA. The 1.2 nA bias current produces a 615  $\mu$ V voltage drop across the, 511 k $\Omega$  (R48), adaptive filter's input resistor when ever the noise filter is in. This voltage drop corresponds to a 1.84 MHz shift in frequency.

The noise degradation caused by U22 is controlled at higher frequencies by controlling the loop bandwidth of the voltage- to-current converter. A pole at 0 Hz, in the response of U22, sets the converter's loop bandwidth to 1.5 kHz. This integrator limits the noise degradation to 11.5 nV/Hz (462 pA/Hz at the output) beyond 1.5 kHz.

The converter output current is controlled by an N-Channel Enhancement Mode Power MOS FET (Q7), driven by the op-amp U22. The MOS FET will dissipate up to 75 W, with  $V_{dss}$ = 120 V, and  $I_d$ = 10 A. The gate threshold voltage is 4  $V_{max}$ .

The advantage of a power MOS FET is the low drive current requirement. The gate leakage current is 100 nA max. The disadvantage is that its gate capacitance is 850 pF, and the drive voltage must be at least 4 volts greater than the source for current to flow.

The voltage-to-current converter op-amp (U22) is unstable driving the capacitive gate of the MOS FET directly. Amplifier stability is insured by driving the MOS FET through the 562 $\Omega$  resistor (R51). This insures the op-amp stability, but an additional pole is added to the voltage-to-current converter loop response at 333 kHz. This pole will reduce all conversion noise at 6 dB/octave beyond 333 kHz, but in order to maintain loop stability this pole must be compensated for. The 562 $\Omega$  resistor also allows a clamping

diode to be used to prevent the MOS FET gate from going negative, without overloading the op-amp output.

The phase shift produced by the pole formed by R51 and the gate of MOS FET (Q7) is compensated for by adding a zero in the integrator's response at 15 kHz. This zero also sets the loop gain to  $-20$  dB to prevent loop peaking due to the 333 kHz pole.

The fine tune DAC output is amplified and level shifted to produce an output range of  $-10$  V to  $+10$  V. The output is then summed into the source of MOS FET (Q7) through a 2.15 k resistor (R16). The fine tune DAC will add or subtract up to 4.65 mA into the voltage-to-current converter output.

The voltage-to-current converter output is further filtered at its output by the two 100  $\mu$ F capacitors (C35 & C36) placed in parallel with the YTF tuning coil. The combination of the 200  $\mu$ F in parallel with the 1 H of inductance in the tuning coil produces a pole at 15 Hz, which greatly reduces noise and spurs. A rectifier diode (CR7) is also placed in parallel with the capacitors to eliminate the possibility of reverse biasing.

The balun (T1) placed between the capacitors C35 & C36, and the YTF tuning coil greatly reduces spurious pickup from the 40 kHz switching power supply. T1 is a bifilar wound inductor which acts as a balanced isolator with 8 mH of inductance. It allows the YTF tuning coil to float with respect to the YTF driver assembly, reducing common mode induced spurs, while remaining a low impedance with respect to C35 & C36. A 10  $\mu$ F capacitor is placed directly across the YTF coil to eliminate any induced 40 kHz currents.

The  $+50$  V supply is inter-locked through connectors J4 & J5. This was added as a protection feature for the voltage-to-current converter. If the sense resistor (J5), or the YTF tuning coil (J4) are disconnected, the  $+50$  V supply is also disconnected to prevent damage to the MOS FET (Q7). Unfortunately, the protection diode VR1 may not survive removal of the sense resistor connector J5 while power is on.

### **YTF Heater Current Limiter**

The YTF filter employs a thermistor-type ceramic heater to maintain constant YIG sphere temperature over the operating temperature range and over the range of power being dissipated by the tuning coil. This minimizes thermal frequency drift.

The heater material resistance is designed to be low at low temperature, and high resistance when hot. The result is a simple heater/thermostat. The operating voltage is 28 V nominal, with a 32 V maximum. The operating current varies between 10 mA and 175 mA. Current must be limited to 2 A at turn-on to prevent damage.

**YIG-Tuned-Filter (YTF) and GaAs FET Amplifier Driver Assembly**

The YTF current limiter acts as a current controlled switch. At turn-on, when the heater resistance is very low, Q5 acts as a 200 mA current source which limits the surge current. When the heater resistance rises, and the current becomes less than 200 mA, Q5 saturates, and the limiter appears as a 10 $\Omega$  resistance to ground.

## Controller, I/O Interface and Power Supply Assembly A6

### Overview

The A6 assembly is composed of two printed circuit boards (PCBs). The controller board contains the microprocessor, HP-IB interface and the MS-IB interface. The I/O and power supply board contains the digital control chip drivers, the drivers for two YTF assemblies, the internal voltmeter, the module's eight power supplies and the power supply/digital control distribution which supply all the other assemblies.

### Looking at the Block Diagram

#### Digital Controller

The digital control unit (DCU) uses a Motorola MC68HC000R8 microprocessor IC running at an 8 MHz clock rate. 1 Mbyte of erasable programmable read-only-memory (EPROM) and 128 kbytes of random-access-memory (RAM) are provided, along with HP-IB and MS-IB interfaces. A Motorola MC68901 Multi-function Peripheral IC provides timers, a serial port (not used in the firmware), and an interrupt controller. In addition, two 8-bit DIP switches, a number of LED drivers and parallel I/O interfacing to the I/O interface/power supply assembly are provided. The microprocessor also has 2048 bytes of electronically erasable programmable read only memory (EE- PROM) for calibration data storage.

The firmware for the entire HP 7042x family of modules is resident in the EPROMS on the controller PCB. The firmware is written as a series of virtual modules allowing the user to access all the functions built into his module. Example: the HP 70427A will function as an HP 70427A downconverter or as an HP 70428A source, since the HP 70428A function is needed for the downconverter function. Also, the HP 70428A Option 002 will function as an HP 70428A Option 002 upconverter or an HP 70428A source. A softkey on the MMS display, or an HP-IB command is used to switch between the virtual modules available.

The module's hardware configuration is stored in the EE-PROM at the factory along with the required calibration data needed for proper module operation.

#### I/O Interface

The I/O interface converts parallel I/O information to and from the controller board into the serial data needed to drive the serial interfaces throughout the module. It also converts the 6-bit parallel information needed to drive two YTF driver assemblies.

The I/O interface also multiplexes between and measures the analog voltages returned through the diagnostic multiplexer system. This system provides the voltage measurements needed for power and frequency setting, and allows for module trouble shooting and monitoring without disassembling the module. The DC voltmeter has 12-bit resolution, and has an input range of  $\pm 10$  V. AC measurements of the diagnostic multiplexer system are possible through the buffered output on the rear panel of the module. The bandwidth of the rear-panel output is DC to 100 kHz.

### Power Supply

The power supply provides six regulated low-noise output voltages, and two unregulated voltages. The regulated outputs are  $\pm 5$  V,  $\pm 10$  V and  $\pm 15$  V. The unregulated supplies are +25 V and +50 V.

The input voltage to the supply is 24.3 VAVG  $\pm 1\%$  at 40 kHz.

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**NOTE**

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24.3 VAVG is approximately  $27 V_{\text{rms}}$ . The worst case power dissipation is about 90 watts, drawn by an HP 70428A Option 002 at 26.5 GHz.

The power supply's input is fused by two 2.5 amp fast-blow fuses, one fuse for each of the 40 kHz power transformers.

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**NOTE**

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The fuses must be removed from their pin socket holders to be tested.

The power supply input circuitry is designed to minimize 40 kHz radiation into the rest of the module. The transformer inputs are isolated from the MMS mainframe's 40 kHz switching supply by two bifilar wound isolation chokes. All 40 kHz signals on the PCB are routed using co-planar transmission lines to minimize 40 kHz radiation induced spurs. The transformers are also built with a 40 kHz hum shield to reduce spurs. Inductors in the power supply are built either as pot core inductors or toroid inductors, both of which are self-shielding.

The voltage reference for all of the regulated supply output is produced by a precision +10 V monolithic voltage reference (U101) which is adjusted, by R165, to +10.0 V,  $\pm 0.002$  V. The output noise of the +10 V reference is about 100 nV/Hz. The reference output is followed by a 0.3 Hz noise filter which reduces the reference noise to less than 10 nV/Hz at 3 Hz. During power-up, the noise filter is bypassed by back to back silicon diodes (CR101 & CR102) which allow the power supplies to rise to 90% of their final value very quickly, and then drift into the final value over the next 30 seconds. The noise filter output is buffered by an OP-77 op-amp (U102) which provides the current necessary to provide voltage reference for the negative power supplies. The +10 V reference is inverted by a second OP-77 (U109) to produce the -10 V reference which drives the positive regulated supplies.

**Controller, I/O Interface and Power Supply Assembly A6**

Power supply efficiency is maximized by minimizing the voltage drop across the output regulators. This can only be accomplished if the voltage supplied to the output regulators is reasonably constant. There are several design considerations which help make this possible. First the power supplied by the MMS mainframe is regulated to within  $\pm 1\%$ . The mainframe supply operates at 40 kHz output. This is done to make power transformers and filter capacitors small enough to mount on PCBs.

The design of the custom power transformers makes allowances for the following design considerations:

1. resistive voltage drop in the transformer's winding
2. voltage loss in the rectifier diodes
3. waveform of the voltage supplied by the MMS mainframe
4. effect of the voltage transit snubber circuits on the transformer and rectifier outputs
5. value and efficiency of the output filter capacitors
6. the amount of the expected load

The result is an unregulated supply voltage which can be predicted and will remain within 0.1 to 0.3 volts at maximum load, and will only rise 2 to 3 volts under minimum load for each of the eight supply voltages.

The un-regulated +50 V and +25 V supplies operate from a single center-taped winding on power transformer T100. The 30.7 V clamp produced by VR2 and Q111 limits the maximum voltage for the two supplies to +61.4 V and +30.7 V with no load. The inductors L9 and L8 help to reduce 40 kHz spurs. The +50 V supply provides power for the YTF tuning coil. The +25 V supply provides power to the YTF heater and the YTF voltage to current converter.

The six regulated supplies are all very similar in circuit topology. They are all low noise, high current, DC coupled inverting amplifiers. Each supply also has over-current protection, and an output current monitor which can be read through the diagnostic multiplexer system.

The OP-77s U102 and U109 used in the power supply reference dominates the noise of the power supplies at frequencies less than 10 Hz. The supply output noise is set by the supply voltage gain times the noise of the reference. The DC voltage gains are  $-1.5$  for the  $\pm 15$  V supplies,  $-1.0$  for the  $\pm 10$  V supplies, and  $-0.516$  for the  $\pm 5.15$  V supplies.

The OP-27 op-amp used in the power supply regulators dominates their noise performance at frequencies greater than 10 Hz. The regulators are designed as a high current inverting amplifier, with a  $10\mu\text{F}$  capacitor placed across the feedback resistor in each of the supplies. This capacitor places a pole in the frequency response of the regulator between 1 Hz and 3 Hz. As frequency increases, the regulator's rejection to reference noise increases at

6 dB/octave, and the noise becomes equivalent to a unity gain inverting buffer. The typical noise of an OP-27 in this configuration is 4.5 nV/Hz.

The regulator's output voltage is controlled by enhancement mode power MOS FETs. The P-Channel MOS FETs used in the negative supplies will dissipate up to 74 W, with  $V_{dss}$  50 V, and  $I_d=$  18 A. The ON resistance is  $0.14\Omega$  at 9.3 A. The N-Channel MOS FETs used in the positive supplies will dissipate up to 125 W, with  $V_{dss}=$  50 V, and  $I_d=$  35 A. The ON resistance is  $0.028\Omega$  at 29 A. The gate threshold voltages are each  $4 V_{max}$ .

The advantage of a power MOS FET is the low drive current requirement, and as little as 0.5 V to 0.8 V voltage drop across the drain and source. The gate leakage current is 250  $\mu$ A maximum. The disadvantage is that its gate capacitance is 3000 pF, and the drive voltage must be at least 4 volts greater than the source for current to flow.

The regulator op-amps are unstable driving the capacitive gate of the MOS FETs directly. Amplifier stability is insured by driving the MOS FET through the  $100\Omega$  gate resistors. This insures the op-amp stability, but an additional pole is added to the regulator's loop response at 530 kHz. In order to maintain loop stability when the op-amp gain cross-over occurs, this pole must be compensated for.

The phase shift produced by the pole formed by the gate resistors and the gate of the MOS FET is compensated for by adding a pole/zero pair around the regulator op-amps. The pole is at DC, which produces an integrator response until the zero at 457 kHz. This zero also sets the loop gain to  $-6$  dB to prevent loop peaking due to the 530 kHz pole.

The regulator op-amp power is supplied by the un-regulated  $\pm 15$  V supplies. This provides  $\pm 16.5$  V under normal load conditions, and never drops below  $\pm 15.5$  V at maximum current. This provides ample voltage to supply the op-amps which drive the MOS FET pass transistors on the  $\pm 10$  V and  $\pm 5$  V supplies directly. The regulator op-amp output on the  $\pm 15$  V supplies must be level shifted to provide the required gate threshold voltage.

Level shifting is accomplished by rectifying the peak voltage off the 15 V winding of transformer T107, to produce  $\pm 26$  V.  $+26$  V is connected to the pass transistor (Q105) in the  $+15$  V regulator through a 3.9 mA constant current diode (CR103). The 3.9 mA drawn through R120 (2.61 k) produces a constant level shift of 10.2 V. The 10  $\mu$ F capacitor (C119) provides an AC short across R120 at frequencies above 10 kHz.

Similarly, the  $-26$  V is connected to the pass transistor (Q109) in the  $-15$  V regulator through a 3.9 mA constant current diode (CR126). The 3.9 mA drawn through R134 (2.61 k) produces a constant level shift of  $-10.2$  V. The 10  $\mu$ F capacitor (C46) provides an AC short across R134 at frequencies above 10 kHz.

The over-current protection on each of the six regulated supplies is designed to shut off the affected supplies without causing damage to the supply or

**Controller, I/O Interface and Power Supply Assembly A6**

blowing out fuses. At module power-up, a pulse of current is generated in each of the six supplies to force the output enable op-amps into the "normal" power supply "on" condition. These op-amps are configured as bi-stable flip-flops, using positive feedback. They will remain in the "normal" state until an over-current fault occurs. If the maximum current is exceeded, the flip-flop will go to the "overload" state, and shut down the supply. The supply will remain off until a new start-up pulse resets the flip-flop. Power must be cycled on the module for power to be restored.

The over-current protection circuit generates an analog voltage which is proportional to the output current, and used to compare with the over-current trip point. This voltage is equal to 5 A/volt, and is available via the diagnostic multiplexer system.

The power supply output voltage is monitored for each of the eight power supplies. The comparator thresholds are set to 0.66 of the nominal output voltage. If any one of the eight supplies falls below the comparator threshold, the "voltage good" flag is set low, and the microprocessor turns on all of the front-panel status lights.

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**Overview**

This chapter contains performance tests for the HP 70427A Downconverter Module, HP 70428A Microwave Source Module, and the HP 70428A Option 002 Microwave Source Module (Tunable Source) MMS modules. The performance tests verify that the module meets the specifications listed in chapter 9.

**Tests**

Performance tests 1 through 4 are common to all three modules. Tests 5 through 7 are for the downconverter, and tests 8 and 9 are for the tunable source (HP 70428A Option 002).

**Common tests**

The following tests verify performance of the microwave source. They are done on all three modules: HP 70427A, HP 70428A, and HP 70428A Option 002.

Test 1 - Maximum Output Power ( **$\mu$ W LO**)

Test 2 - Phase Noise and Spurs ( **$\mu$ W LO**)

Test 3 - AM Noise and Spurs ( **$\mu$ W LO**)

Test 4 - Comb line Spurs ( **$\mu$ W LO**)

**Downconverter tests**

The HP 70427A is tested by doing the four common tests and the following tests:

Test 5 - Mixer Compression (**IF**)

Test 6 - Phase Noise and Spurs (**IF**)

Test 7 - AM Detector Noise Floor (**AM NOISE**)

**Tunable source tests**

The HP 70428A Option 002 is tested by doing the four common tests and the following tests:

Test 8 - Phase Noise and Spurs (**RF**)

Test 9 - AM Noise and Spurs (**RF**)

## Equipment Required

Table 14-1 shows the test equipment required and their critical specifications.

**Table 14-1 Equipment Required**

Instrument Type	Critical Specifications	Recommended Model
Measuring Receiver and Sensor Module	Frequency Range: 2.4 GHz to 25.8 GHz Power Range: +10 to +16 dBm Accuracy: $\pm 0.5$ dB AM Measurement: Depth to 40% AM Accuracy: 1% of reading	HP 8902A HP 11792A
Phase Noise Measurement System with Spectrum Analyzer	The Performance Tests for SSB Phase Noise and AM Noise are complex and the procedure has been written specifically using the HP 3048A, no substitutions are recommended.	HP 3048A/201/H26 HP 3585B HP 5316B (optional)
Reference Source	Frequency Range: 2.4 to 25.8 GHz $\phi$ Noise $\leq$ Device under test.	HP 70428A
Tune Voltage Supply Balun Filter	These accessories are especially designed and shielded for $\phi$ Noise and AM Noise measurements. No substitutions are recommended.	HP 70428A K01 HP 70427A K02 HP 3048A K21
Spectrum Analyzer	Frequency Range: 100 kHz to 22 GHz	HP 8562A HP 8566B HP 70XXX series
$\mu$ Wave AM Source	Frequency: 18 GHz AM Depth: 40% Output Power: -5 dBm	HP 83640A
Pulse Generator	Square Wave to 10 kHz: Level Adjustable to 1 Vpk.	HP 8116A
Coaxial Detector	Frequency Range to 25.8 GHz	HP 33330C
1 dB Step Attenuator	0 -12 dB; 1 dB steps	HP 355C

## Accessories Required

Table 14-2. shows the accessories available for various models.

**Table 14-2** *Test Accessories*

Accessories	Model Number
10 dB Pad	HP 8491A-10
50 $\Omega$ BNC Termination	HP 11652-60001
SMC(m) to SMC(m)	HP 1250-0827
SMC(f) to SMC(f)	HP 1250-1113
SMC(f) to N (m)	HP 1250-1152
SMC tee	HP 1250-0670
High Frequency Cable SMC(m) to SMC(m)	HP 5061-5458

## Calibration Cycle

Performance tests should be done every 12 months. They should also be done after the module is repaired.

## Warmup time

Allow a 30 minute warmup time before performing the tests.

---

## Test 1 - Maximum Output Power ( $\mu$ W LO)

### Overview

This test measures the source's ability to put out its specified power. It does this by measuring output power at several frequencies with a measuring receiver's power meter function.

### Specification

Output power:

2.4 to 6.6 GHz .....	$\geq +16$ dBm
7.2 to 25.8 GHz .....	$\geq +10$ dBm

### Equipment

HP 8902A Measuring Receiver (or equivalent power meter).

HP 11792A Sensor Module

### Test Setup

Minimize the number of connector adapters. Normally, it's best to leave the adaptor on the  $\mu$ W LO connector to prevent damage to the connector. If you remove the adaptor for this test take care not to damage the center conductor.

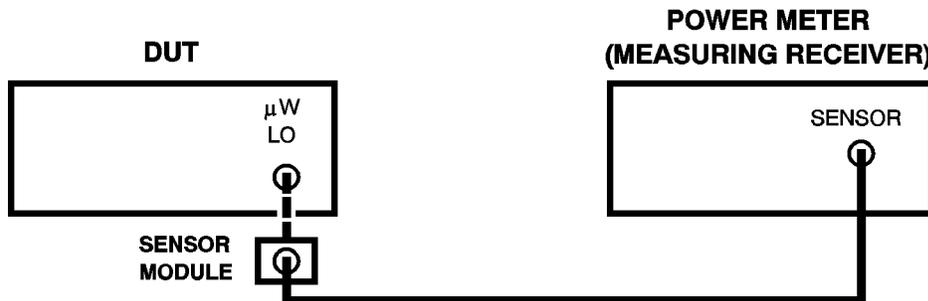


Figure 14-1 Maximum Output Power Test Setup

### Procedure

#### Step 1 -Set up the measuring receiver

Make sure the measuring receiver's calibration factors match the sensor module. Zero the power sensor and calibrate the power measurement using the measuring receiver's built-in power reference.

Press the **RF POWER** key to configure the HP 8902A as a power meter.

## Step 2 -Access the module's source screen

1. Press the **INSTR PRESET** key.
2. Press the **Source** softkey if necessary.  
HP 70428A: go to step 3.  
HP 70427A: press the **Source** softkey.  
HP 70428A Option 002: press the **Source** softkey.

## Step 3 - Enter the first test frequency (2.4 GHz)

1. Press the **Output** softkey.
2. Press the **FREQ** softkey.
3. Enter the frequency with the numeric keypad.
4. Complete the entry by pressing the **GHz** softkey.

The module's firmware won't accept an output power entry until a frequency is entered.

## Step 4 -Enter the output power (+20 dBm)

1. Press the **Output** softkey.
2. Press the **POWER** softkey.
3. Enter the output power with the numeric keypad.
4. Complete the entry by pressing the **dB** softkey.

The power you entered will be displayed in the lower left corner of the screen. But, the module's actual output power, as measured by the internal voltmeter, will be displayed on the **Power:** display. The actual output power will be somewhere between the specified value and +20 dBm. You will probably notice a difference between power shown on the **Power:** display and the power measured by the measuring receiver. This is because the measuring receiver is more accurate than the module's internal diode detector.

## Step 5 -Measure power at each frequency in the table

1. Press the **Output** softkey.
2. Press the **FREQ** softkey.
3. Enter the frequency with the numeric keypad.
4. Complete the entry by pressing the **GHz** softkey.
5. Enter frequency into measuring receiver to invoke proper calibration factors.

Performance Tests

Test 1 - Maximum Output Power (mW LO)

6. Wait for the module to complete tuning and read the power on the measuring receiver.

**Table 14-3 Results Table Test 1**

Test No. & Description	Output level	Frequency (GHz)	Max. Specs. (dBm)	Actual	Measurement Uncertainty ( $\pm$ dB)
<b>Maximum Output Power</b>					
	20 dBm	2.4	16		0.42
	20 dBm	3.6	16		0.42
	20 dBm	4.8	16		0.42
	20 dBm	6.6	16		0.44
	20 dBm	7.2	10		0.44
	20 dBm	8.4	10		0.44
	20 dBm	9.6	10		0.44
	20 dBm	10.8	10		0.47
	20 dBm	12.0	10		0.47
	20 dBm	13.2	10		0.53
	20 dBm	15.0	10		0.54
	20 dBm	16.8	10		0.54
	20 dBm	18.6	10		.0.64
	20 dBm	20.4	10		0.64
	20 dBm	22.2	10		.0.65
	20 dBm	24.6	10		0.65
	20 dBm	25.8	10		0.65

---

## Test 2 - Phase Noise and Spurs ( $\mu$ W LO)

### Overview

This test measures the source's phase noise and spurs at several carrier frequencies and reference chain tuning sensitivities. First, the tuning sensitivity is set to 0.05 ppm/V which makes the 10 MHz oscillator the reference with the 100 MHz oscillator locked to it and the 600 MHz oscillator locked to the 100 MHz oscillator. Phase noise and spurs are measured at 12.6 GHz. Then, tuning sensitivity is set to 1 ppm/V which makes the 100 MHz oscillator the reference with the 600 MHz oscillator locked to it. Phase noise and spurs are measured at 12.6 GHz. Finally, tuning sensitivity is set to 20 ppm/V which means the 600 MHz oscillator is free-running. Phase noise and spurs are measured at 2.4 GHz, 12.6 GHz, and 25.8 GHz.

### Specification

Refer to the specification table for Microwave source RF output spectral purity:

0.05 ppm/V (10 MHz oscillator): .....	Configuration 1
1.0 ppm/V (100 MHz oscillator): .....	Configuration 2
20 ppm/V (600 MHz oscillator): .....	Configuration 3

### Equipment

HP 70428A Microwave Source Module (with MMS mainframe and display).

HP 3048A Phase Noise Measurement System with Options 201, H26.

HP 8562A Spectrum Analyzer

HP 70428A Option K01 Tune Voltage Supply.

HP 8491A-10 10 dB Pad.

50  $\Omega$  BNC termination.

### Test Setup

Set up the HP 3048A according to the HP 3048A Installation Guide. Connect the reference source and the DUT as shown on the following diagram:

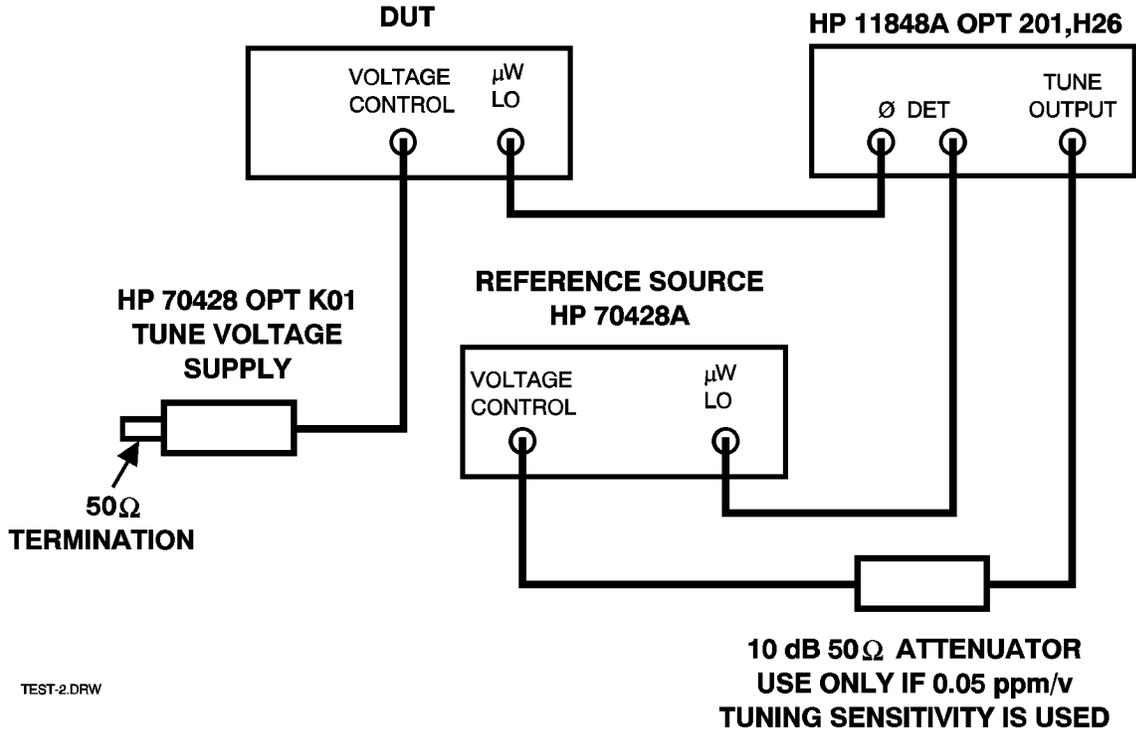


Figure 14-2 Phase Noise and Spurs Test Setup

## Procedure

The following procedure assumes familiarity with HP 3048A operation. Initial configuration of the test system and DUT is done in steps 1 to 3. A phase noise measurement is made 5 times with various DUT tuning sensitivities and carrier frequencies. The software configuration changes, DUT tuning sensitivities and frequencies are listed for each measurement in steps 4 through 8.

### Step 1 - Initial HP 3048A measurement definition

1. Specify measurement type and frequency range
  - Measurement type: Phase Noise Using a Phase Lock Loop
  - Start freq: *To be entered later.*
  - Stop freq: 40 MHz
  - Averages: 4
2. Enter source and interface parameters
  - Carrier frequency: *To be entered later.*
  - Detector/discr input frequency: *To be entered later.*
  - VCO Tuning constant: *To be entered later.*
  - Center voltage of VCO tuning curve: 0 V.

- Voltage tuning range of VCO: *To be entered later.*
  - VCO tune-port input resistance: 1E6  $\Omega$
  - Phase detector: Internal Phase Detector, 1.2 GHz to 18 GHz.
3. Specify a calibration process
    - Method for determining phase detector constant: Measure the detector constant.
    - Method for determining the VCO tuning constant: Measure the VCO tuning constant.
    - PLL suppression: Will be verified.
  4. Specify the control of signal sources
    - DUT: User's source, manual control.
    - DN CONV: Not in use.
    - REF SOURCE: User's source, manual control.
    - TIMEBASE: Not in use.
    - TUNE VOLTAGE: Ref source.
  5. Define the graph of results
    - Title: *To be entered later.*
    - Minimum X coordinate: 1 Hz
    - Maximum X coordinate: 40 MHz
    - Minimum Y coordinate: -170
    - Maximum Y coordinate: 0
    - Horizontal portion of display to be used: 100%
    - Vertical portion of display to be used: 100%
    - Graph type: Single sideband phase noise (dBc/Hz)
  6. Enter the spec lines

*To be entered later*

## Step 2 - Reference source initial configuration

1. Make the reference source the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the reference source's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.
3. Access the Source screen: if the module is an HP 70427A or HP 70428A Option 002 press the **Source** softkey.

**Test 2 - Phase Noise and Spurs (mW LO)**

4. Set the frequency to 3.0 GHz (this frequency is not tested, the only reason for entering it is that the source must have a frequency entered before it will accept a power level):
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 3 with the numeric keypad.
  - d. Press the *GHz* softkey.
5. Set the output power to +10 dBm:
  - a. Press the *Output* softkey.
  - b. Press the *POWER* softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the *dBm* softkey.

---

**NOTE**

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Turn the HP 70428A K01 on now.

**Step 3 - DUT initial configuration**

1. Make the DUT the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the *NEXT INSTR* softkey until the reference source's **ACT** indicator lights.
  - c. Press the **INSTR PRESET** key.
2. Access the Source screen: if the module is an HP 70427A or HP 70428A Option 002 press the *Source* softkey.
3. Set the frequency to 3.0 GHz (this frequency is not tested, the only reason for entering it is that the source must have a frequency entered before it will accept a power level):
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 3 with the numeric keypad.
  - d. Press the *GHz* softkey.
4. Set the output power to +10 dBm:
  - a. Press the *Output* softkey.
  - b. Press the *POWER* softkey.
  - c. Enter 10 with the numeric keypad.

d. Press the *dBm* softkey.

This completes the setup. Measurements are made in steps 4 through 8.

**Step 4 - Measure Phase Noise at 12.6 GHz (0.05 ppm/V)**

1. Specify measurement type and frequency range
  - Start freq: 1 Hz
2. Enter source and interface parameters
  - Carrier frequency: 12.6 GHz
  - Detector/discr input frequency: 12.6 GHz
  - VCO Tuning constant: 200 Hz/Volt
  - Voltage tuning range of VCO: 0.2 V
3. Define graph of results
  - Title: Source at 12.6 GHz, .05 ppm/V tune sensitivity.
  - Minimum X coordinate: 1 Hz
4. Enter spec lines

**Table 14-4 Spec Lines: 12.6 GHZ Phase Noise (Test 2)**

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+33
2	10	-63
3	100	-83
4	1E3	-111
5	10E3	-123
6	100E3	-135
7	1E6	-138
8	40E6	-138
9	40E6	-70
10	10E6	-70
11	1E3	-40
12	100	-40

Test 2 - Phase Noise and Spurs (mW LO)

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

5. Set tuning sensitivity to 0.05 ppm/V
  - a. Do this on the reference source and the DUT.
  - b. Press the *Ref Chain* softkey.
  - c. Press the *Tune Sens* softkey.
  - d. Press the *0.05 ppm/V* softkey.
  - e. If necessary, make the other module active by pressing the **DISPLAY** key followed by the *NEXT INSTR* softkey. Press the **MENU** key to display the module's softkeys.
6. Set the reference source and DUT frequency to 12.6 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 12.6 with the numeric keypad.
  - d. Press the *GHz* softkey.
  - e. If necessary, make the other module active by pressing the **DISPLAY** key followed by the *NEXT INSTR* softkey. Press the **MENU** key to display the module's softkeys.
7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Make sure that the HP 70428A Option K01 is turned ON.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 2 Hz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
  - c. Press *Proceed* to make the phase noise measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

### Step 5 - Measure Phase Noise at 12.6 GHz (1 ppm/V)

---

**NOTE**

---

Remove the 10 dB attenuator and connect the HP 11848A **TUNE OUTPUT** directly to the reference source's **VOLTAGE CONTROL** input.

1. Specify measurement type and frequency range
  - Start freq: 10 Hz
2. Enter source and interface parameters
  - Carrier frequency: 12.6 GHz
  - Detector/discr input frequency: 12.6 GHz
  - VCO Tuning constant: 12.6 kHz/Volt
  - Voltage tuning range of VCO: 2.0 V
3. Define graph of results
  - Title: 12.6 GHz carrier with 1.0 ppm tuning.
  - Minimum X coordinate: 1 Hz.
4. Enter spec lines

**Table 14-5** *Spec Lines: 12.6 GHz Phase Noise and Spurs (Test 2)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+19
2	10	-31
3	100	-81
4	1E3	-111
5	10E3	-123
6	100E3	-135
7	1E6	-138
8	40E6	-138
9	40E6	-70
10	1E3	-70
11	100	-40

**Test 2 - Phase Noise and Spurs (mW LO)**

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

5. Set tuning sensitivities to 1.0 ppm/V
  - a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *1.0 ppm/V* softkey.
  - d. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey.
6. Set the reference source and DUT frequency to 12.6 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 12.6 with the numeric keypad.
  - d. Press the *GHz* softkey.
  - e. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press, the *MENU* key to display the module's softkeys.
7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Turn the HP 70428A Option K01 on.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 1200 Hz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
  - c. Press *Proceed* to continue with the measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the *SHIFT* key and the *Hard Copy* softkey.

**Step 6 - Measure Phase Noise at 2.4 GHz (20 ppm/V)**

1. Specify measurement type and frequency range
  - Start freq: 10 Hz

2. Enter source and interface parameters
  - Carrier frequency: 2.4 GHz
  - Detector/discr input frequency: 2.4 GHz
  - VCO Tuning constant: 48 kHz/Volt
  - Voltage tuning range of VCO: 2.0 V
3. Define graph of results
  - Title: 2.4 GHz carrier with 20 ppm tuning.
4. Enter spec lines

**Table 14-6** *Spec Lines: 2.4 GHz Phase Noise and Spurs (Test 2)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+20
2	10	-30
3	100	-70
4	1E3	-108
5	10E3	-133
6	100E3	-143
7	1E6	-147
8	40E6	-147
9	40E6	-70
10	10E6	-70
11	1E3	-70
12	100	-30

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

**Test 2 - Phase Noise and Spurs (mW LO)**

5. Set tuning sensitivities to 20 ppm/V

Do this on the reference source and the DUT.

- a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *20 ppm/V* softkey.
  - d. If necessary, make the other module active by pressing the **DISPLAY** key followed by the *NEXT INSTR* softkey. Press the **MENU** key to display the module's softkeys.
6. Set the reference source and DUT frequency to 2.4 GHz
    - a. Press the *Output* softkey.
    - b. Press the *FREQ* softkey.
    - c. Enter 2.4 with the numeric keypad.
    - d. Press the *GHz* softkey.
    - e. If necessary, make the other module active by pressing the **DISPLAY** key followed by the *NEXT INSTR* softkey. Press the **MENU** key to display the module's softkeys.

7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Turn the HP 70428A Option K01 on.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat with 4 kHz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
  - c. Press *Proceed* to continue with measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

**Step 7 - Measure Phase Noise at 12.6 GHz (20 ppm/V)**

1. Specify measurement type and frequency range
  - Start freq: 10 Hz
2. Enter source and interface parameters
  - Carrier frequency: 12.6 GHz
  - Detector/discr input frequency: 12.6 GHz
  - VCO Tuning constant: 252 kHz/Volt
  - Voltage tuning range of VCO: 2.0 V

3. Define graph of results
  - Title: 12.6 GHz carrier with 20 ppm/V tuning.
4. Enter spec lines

**Table 14-7 Spec Lines: 12.6 GHz Phase Noise and Spurs (Test 2)**

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+32
2	10	-18
3	100	-58
4	1E3	-98
5	10E3	-123
6	100E3	-135
7	1E6	-138
8	40E6	-138
9	40E6	-70
10	10E3	-70
11	1E3	-60
12	100	-20

The *Spec Lines* is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

5. Set tuning sensitivities to 20 ppm/V
- Do this on the reference source and the DUT.
- a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *20 ppm/V* softkey.
  - d. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* key to display the module's softkeys.

**Test 2 - Phase Noise and Spurs (mW LO)**

6. Set the reference source and DUT frequency to 12.6 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 12.6 with the numeric keypad.
  - d. Press the *GHz* softkey.
  - e. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* to display the module's softkeys.

7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Turn the HP 70428A Option K01 on.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 25 kHz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
  - c. Press *Proceed* softkey to continue measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the *SHIFT* key and the *Hard Copy* softkey.

**Step 8 - Measure Phase Noise at 25.8 GHz (20 ppm/V)**

1. Specify measurement type and frequency range
  - Start freq: 10 Hz
2. Enter source and interface parameters
  - Carrier frequency: 25.8 GHz
  - Detector/discr input frequency: 25.8 GHz
  - VCO Tuning constant: 500 kHz/Volt
  - Voltage tuning range of VCO: 2.0 V
3. Define graph of results
  - Title: 25.8 GHz carrier, 20 ppm/V tuning.
4. Enter spec lines

**Table 14-8 Spec Lines: 25.8 GHz Phase Noise and Spurs**

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+38
2	10	-12
3	100	-52
4	1E3	-92
5	10E3	-117
6	100E3	-129
7	1E6	-131
8	40E6	-131
9	40E6	-60
10	10E3	-60
11	1E3	-54
12	100	-14

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

5. Set tuning sensitivities to 20 ppm/V
  - a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *20 ppm/V* softkey.
  - d. If necessary, make the other module active by pressing the **DISPLAY** key followed by the *NEXT INSTR* softkey. Press the **MENU** key to display the module's softkeys.
6. Set the reference source and DUT frequency to 25.8 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 25.8 with the numeric keypad.
  - d. Press the *GHz* softkey.

**Test 2 - Phase Noise and Spurs (mW LO)**

- e. If necessary, make the other module active by pressing the **DISPLAY** key followed by the **NEXT INSTR** softkey. Press the **MENU** to display the module's softkeys.

7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Turn the HP 70428A Option K01 on.
- b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 50 kHz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
- c. Press *Proceed* to continue measurement.

8. Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** and the *Hard Copy* softkey. Press the **MENU** to display the module's softkeys.

**Table 14-9 Test 2 Results Phase Noise and Spurs (mW LO)**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>2. Phase Noise and Spurs</b>					
<b>0.05 ppm/V tuningPhase Noise</b>					
	12.6	1 Hz	-33		2
	12.6	10 Hz	-63		2
	12.6	100 Hz	-83		2
	12.6	1 kHz	-111		2
	12.6	10 kHz	-123		2
	12.6	100 kHz	-135		2
	12.6	1 MHz	-138		2
	12.6	40 MHz	-1138		4
<b>Spurious</b>					
	12.6	10 Hz	-40		2
	12.6	100 Hz	-40		2
	12.6	1kHz	-70		2 or 4 <sup>1</sup>
<b>1.0 ppm/ V tuning Phase Noise</b>					
	12.6	10 Hz	-31		2
	12.6	100 Hz	-81		2
	12.6	1 kHz	-111		2
	12.6	10 kHz	-123		2
	12.6	100 kHz	-135		2
	12.6	1 MHz	-138		2
	12.6	40 MHz	-138		4
<b>Spurious</b>					
	12.6	100 Hz	-40		2
	12.6	100 Hz	-40		2
	12.6	$\geq$ 1kHz	-70		2 or 4 <sup>1</sup>

## Performance Tests

## Test 2 - Phase Noise and Spurs (mW LO)

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>20. ppm/V tuning</b>					
<b>Phase Noise</b>					
	2.4	10 Hz	-30		2
	2.4	100 Hz	-70		2
	2.4	1k Hz	-108		2
	2.4	10k Hz	-133		2
	2.4	100 kHz	-143		2
	2.4	1M Hz	-147		2
	2.4	40 MHz	-147		4
<b>Spurious</b>					
	2.4	100 Hz	-30		2
	2.4	1 kHz	-70		2
	2.4	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>
<b>Phase Noise</b>					
	12.6	10 Hz	-18		2
	12.6	100 Hz	-58		2
	12.6	1k Hz	-98		2
	12.6	10k Hz	-123		2
	12.6	100 kHz	-135		2
	12.6	1M Hz	-138		2
	12.6	40 MHz	-138		4
<b>Spurious</b>					
	.6	100 Hz	-20		2
	.6	1 kHz	-60		2
	.6	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>
<b>20 ppm/ V tuning</b>					
<b>Phase Noise</b>					
	25.8	10 Hz	-12		2
	25.8	100 Hz	-52		2
	25.8	1 kHz	-92		2
	25.8	10 kHz	-117		2
	25.8	100 kHz	-129		2

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
	25.8	1 MHz	-131		2
	25.8	40 MHz	-131		4
<b>Spurious</b>					
	25.8	100 Hz	-14		2
	25.8	1 kHz	-54		2
	25.8	$\geq$ 10 kHz	-60		2 or 4 <sup>1</sup>

1. Uncertainty 4dB at offsets >1 MHz

---

## Test 3 - AM Noise and Spurs ( $\mu$ W LO)

### Overview

This test measures the source's AM noise and spurs at 12.6 GHz.

### Specification

Refer to the specification table for Microwave Source AM Noise.

### Equipment

HP 3048A Phase Noise Measurement System with Options 201, H26.

HP 8562A Spectrum Analyzer

HP 33330C Coaxial Detector

HP 3048A K21 AM Detector Filter

HP 8662/3A Synthesized Signal Generator

HP 70427A K02 Balun

HP 8902A Measuring Receiver (Power Meter)

HP 11792A sensor Module

### Test Setup

Set up the HP 3048A according to the HP 3048A Installation Guide. The diagram below shows the test setup as it will be in step 6 when the AM Noise measurement is made.

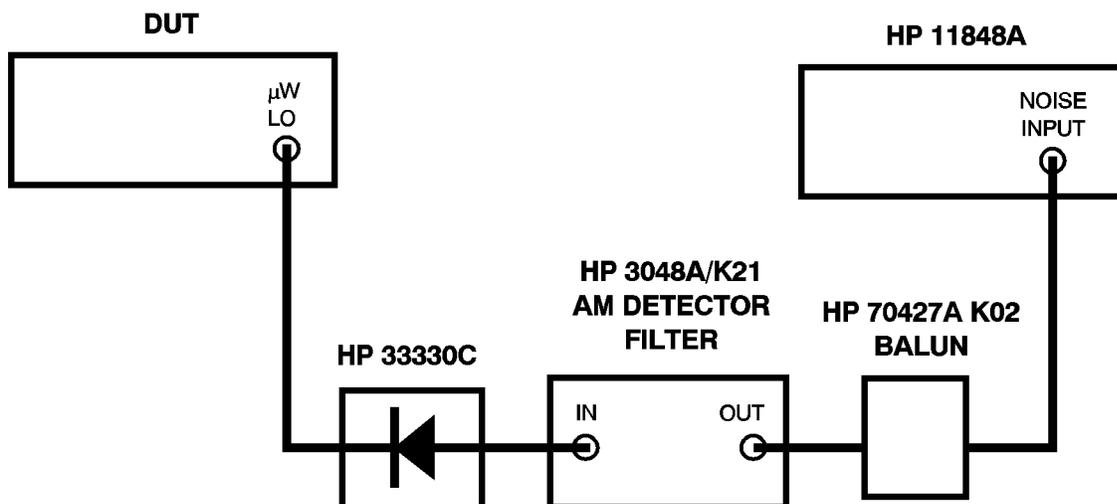


Figure 14-3 AM Noise and Spurs Test Setup

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**NOTE**

---

Set the **DETECTOR POLARITY** switch on the HP 3048A Option K21 to match the polarity of the detector.

## Procedure

The following procedure assumes familiarity with HP 3048A operation. Initial configuration of the test system and DUT is done in steps 1 to 4. Calibration is done in step 5, and an AM noise measurement is made in step 6.

### Step 1 - Define the measurement

1. Specify measurement type and frequency range
  - Measurement type: AM Noise
  - Start freq: 1 Hz
  - Stop freq: 40 MHz
  - Averages: 4
2. Enter source and interface parameters
  - Carrier frequency: 12.6 GHz
  - Detector/discr input frequency: 12.6 GHz
  - Phase detector: External Phase/AM Detector
3. Specify a calibration process
  - Calibration technique: Derive from Double Sided Spur.
  - Spur Amplitude: -40 dBc
  - Spur Frequency: 1 kHz
4. Specify the control of signal sources
  - DUT SOURCE: USER'S SRCE, MANUAL CONTROL
  - AM DETECTOR: USER'S DEV., MANUAL CONTROL
  - CAL SOURCE: USER'S SRCE, MANUAL CONTROL
5. Define the graph of results

Title: Test 3 - Source AM Noise and Spurs at 12.6 GHz

  - Minimum X coordinate: 1 Hz
  - Maximum X coordinate: 40 MHz
  - Minimum Y coordinate: -170
  - Maximum Y coordinate: 0
  - Horizontal portion of display to be used: 100%
  - Vertical portion of display to be used: 100%
  - Graph type: AM Noise (dBc/Hz)
6. Enter the spec lines

**Table 14-10** *Spec Lines: AM Noise of Source (Test 3)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	-95
2	10	-105
3	100	-112
4	1E3	-128
5	10E3	-138
6	100E3	-148
7	1E6	-150
8	40E6	-150
9	40E6	-70
10	1E3	-70
11	10	-50

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. AM noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

## Step 2 - Configure the DUT

1. Make sure the DUT is the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the DUT's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.
3. Access the Source screen: if the module is an HP 70427A or HP 70428A Option 002 press the **Source** softkey.
4. Set the frequency to 12.6 GHz
  - a. Press the **Output** softkey.
  - b. Press the **FREQ** softkey.
  - c. Enter 12.6 with the numeric keypad.
  - d. Press the **GHz** softkey.

5. Set the output power to +10 dBm:
  - a. Press the *Output* softkey.
  - b. Press the *POWER* softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the *dBm* softkey.
6. Measure the DUT output with a power meter and if necessary, adjust the DUT power for the +10 dBm  $\pm 0.5$  dB.
7. Disconnect the DUT end of the HP 33330C detector.
8. Connect a power meter to the DUT output, at the point where the HP 33330C was connected. That is, if the HP 33330C was connected to a cable from the DUT's output, connect the power meter to the end of the cable.
9. If necessary adjust the DUT's output power for +10 dBm  $\pm 0.5$  dB.
  - a. Press the *Output* softkey.
  - b. Press the *POWER* softkey.
  - c. Adjust the power with the knob (0.1 dB steps) or the Up/Down arrow keys (1 dB steps).

---

**NOTE**

---

When entering 0.1 dB steps the actual power may change as much as 0.2 dB.

### Step 3 - Set calibration source power to equal DUT power

Power is measured by bridging the HP 3561A across the output of the AM detector and making a DC voltage measurement.

1. Set up the HP 3561A for DC voltage measurement

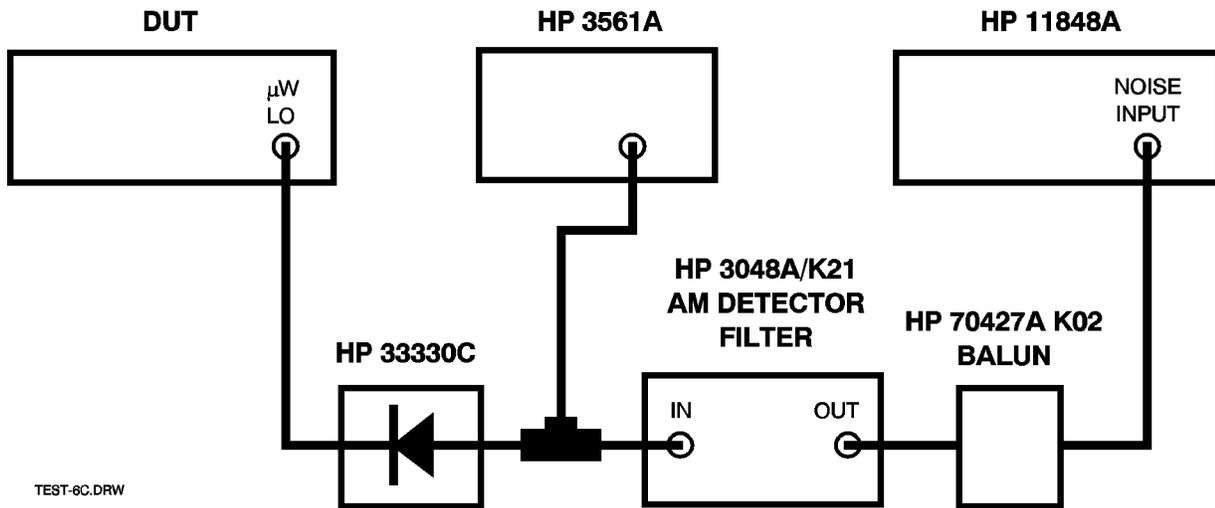
Press the following HP 3561A keys:

- **VERT SCALE** in the **DISPLAY** key group then the *LINEAR* softkey.
- **RANGE** in the **INPUT** key group then the *AUTO RNG* softkey so that *ON* is underlined.
- **DEFINE TRACE** in the **DISPLAY** key group then the *TIME* softkey.
- **MKR** in the **MARKER** key group then the *MKR* softkey so that *ON* is underlined.

The Y value of the marker will indicate the dc voltage across the AM detector. This voltage is proportional to RF output power.

Performance Tests  
Test 3 - AM Noise and Spurs (mW LO)

2. Measure and record the DUT power



*Figure 14-4 DUT Power Measure and Record*

Make sure the AM detector is connected to the DUT's output, and that the HP 3561A is connected to the detector's output via a Tee connector.

Record the DC voltage measured across the AM detector's output with the HP 3561A as described in 1 above.

3. Set up the calibration source

- Frequency: 1.2 GHz
- Power: +10 dBm
- Modulation: OFF

4. Measure and adjust the calibration source power

Connect the AM detector to the calibration source's output. Adjust the calibration source's output power until the voltage measured on the HP 3561A is within  $\pm 5\%$  of the DC voltage measured with the detector connected to the DUT.

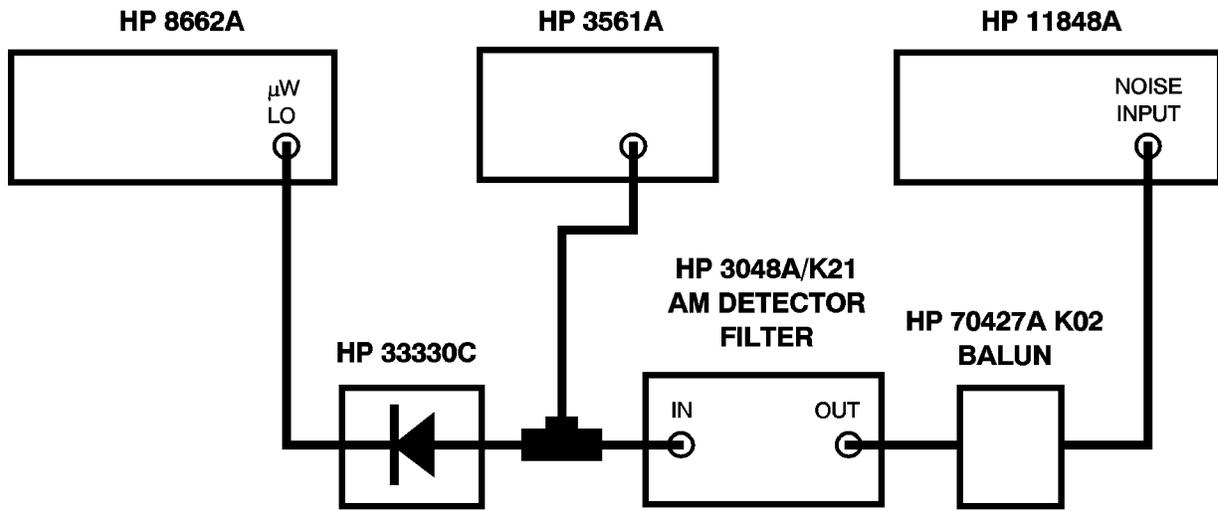


Figure 14-5 Calibration Source Modulation

**Step 4 - Modulate the calibration source**

- Type: Internal AM
- Frequency: 1 kHz
- Depth: 2%

**Step 5 - Calibrate for AM Noise measurement**

Select *New Measurement* and follow the HP 3048A software screen prompts, but use the connection below.

When prompted to Apply calibration spur to carrier, connect the AM detector to the RF output of the calibration source and press the *Proceed* softkey.

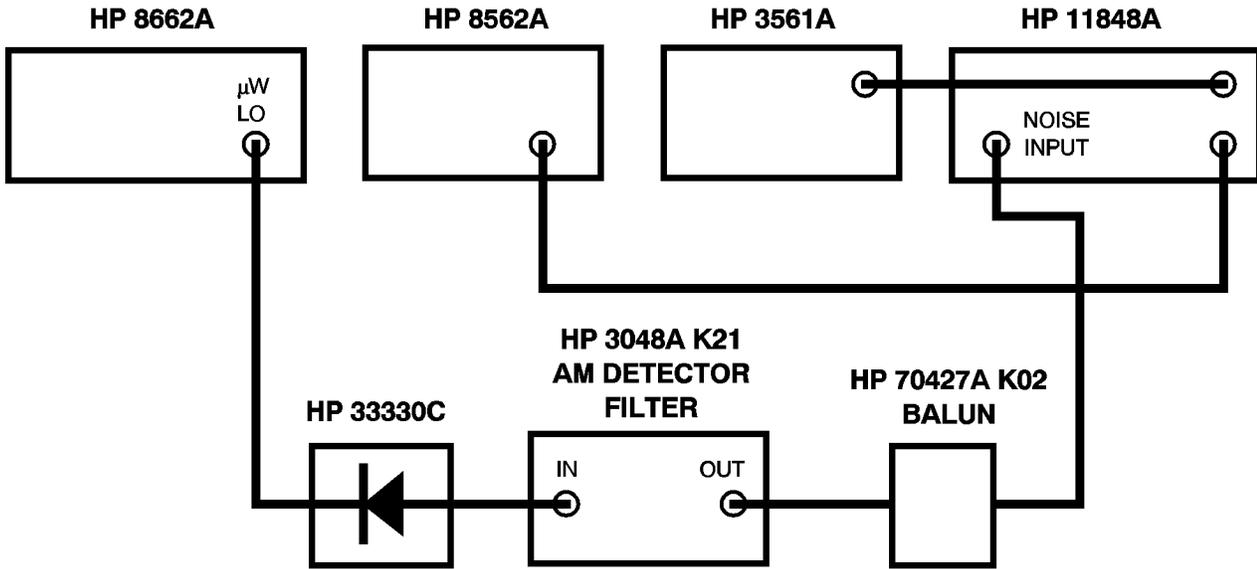


Figure 14-6 AM Noise Measurement

### Step 6 - Measure AM Noise

When prompted to Remove the calibration spur, connect the AM detector to the output of the DUT and press the *Proceed* softkey.

### Step 7 - Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

Table 14-11 Result Table Test 3

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach AM Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>3. Am Noise and Spurs</b>					
<b>AM Noise</b>					
	12.6	10 Hz	-105		2
	12.6	100 Hz	-112		2
	12.6	1 kHz	-128		2
	12.6	10 kHz	-138		2
	12.6	100 kHz	-148		2
	12.6	1 MHz	-150		2
	12.6	40 MHz	-150		4

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach AM Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>Spurious</b>					
	12.6	10 Hz	-50		2
	12.6	$\geq 1$ kHz	-70		2 or 4 <sup>1</sup>

---

## Test 4 - Comb line Spurs ( $\mu$ W LO)

### Overview

This test measures the ability of the Yig-Tuned-Filter (YTF) to reject adjacent comb line frequencies. It does this by measuring the filter feed-through relative to the source's output frequency. The filter feed-through is measured at 600 MHz and 1200 MHz intervals from the output frequency.

### Specification

Spectral Purity (Configuration 3 - 600 MHz free-running oscillator):

2.4 GHz to 12.6 GHz: .....	-70 dBc
13.2 GHz to 25.8 GHz: .....	-60 dBc

### Equipment

HP 8562A Spectrum Analyzer

### Test Setup

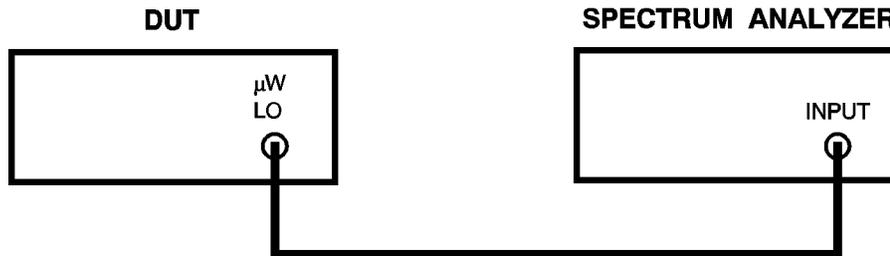


Figure 14-7 Comb Line Spurs Set Up Diagram

### Procedure

#### Step 1 - Set up the spectrum analyzer

You will be setting a reference level for each source output frequency in the table. Then for each frequency you will measure the level of the spur frequencies in dB down from the carrier (dBc).

### **Step 2 - Access the module's source screen**

1. Press the **INSTR PRESET** key.
2. Press the **Source** softkey if necessary.
  - HP 70428A: proceed to step 3.
  - HP 70427A: press the **Source** softkey.
  - HP 70428A Option 002: press the **Source** softkey.

### **Step 3 - Enter the first frequency (2.4 GHz)**

1. Press the **Output** softkey.
2. Press the **FREQ** softkey.
3. Enter the frequency with the numeric keypad.
4. Complete the entry by pressing the **GHz** softkey.

### **Step 4 - Enter an output power of +10 dBm**

1. Press the **Output** softkey.
2. Press the **POWER** softkey.
3. Enter the output power with the numeric keypad.
4. Complete the entry by pressing the **dB** softkey.

### **Step 5 - Measure the spur level in dBc**

For each source output frequency in the table do the following:

1. Tune the spectrum analyzer to the output frequency and mark its level as the reference level. Use spectrum analyzer settings of 300 Hz resolution bandwidth and 1 kHz video bandwidth. These settings should lower the noise floor and allow accurate spurious level measurements.
2. Measure the level of the spur frequencies in the table.

Performance Tests  
 Test 4 - Comb line Spurs (mW LO)

**Table 14-12 Spur Frequencies Level Results**

Test No. & Description	Carrier Frequency (GHz)	Spur Frequency (GHz)	Max. Specs. (dBc)	Results	Measurement Uncertainty ( $\pm$ dB)
<b>4. Comb Line Spurs</b>					
	2.4	3.0	-70		1.89
	2.4	1.8	-70		1.89
	18.0	18.6	-60		5.14
	18.0	19.2	-60		5.14
	21.0	21.6	-60		4.15

---

## Test 5 - Mixer Linearity (IF)

### Overview

This test measures the downconverter's mixer linearity at an input level of  $-5$  dBm. It does this by measuring an amplitude modulated signal at the IF output at two carrier levels. Percent AM is measured at each level with a measuring receiver. Mixer linearity is read from a table by looking up the difference between the two AM percentage readings.

This test is based on a mixer compression measurement technique described in Hewlett-Packard Application Note 286-2.

### Specification

Mixer linearity: .....  $\pm 0.4$  dB, mixer input  $\leq -5$  dBm

### Equipment

HP 8902A Measuring Receiver

HP 83640A Sweep Oscillator ( $\mu$  wave Sig Gen)

HP 8116A Pulse/Function Generator Test Setup

### Test Setup

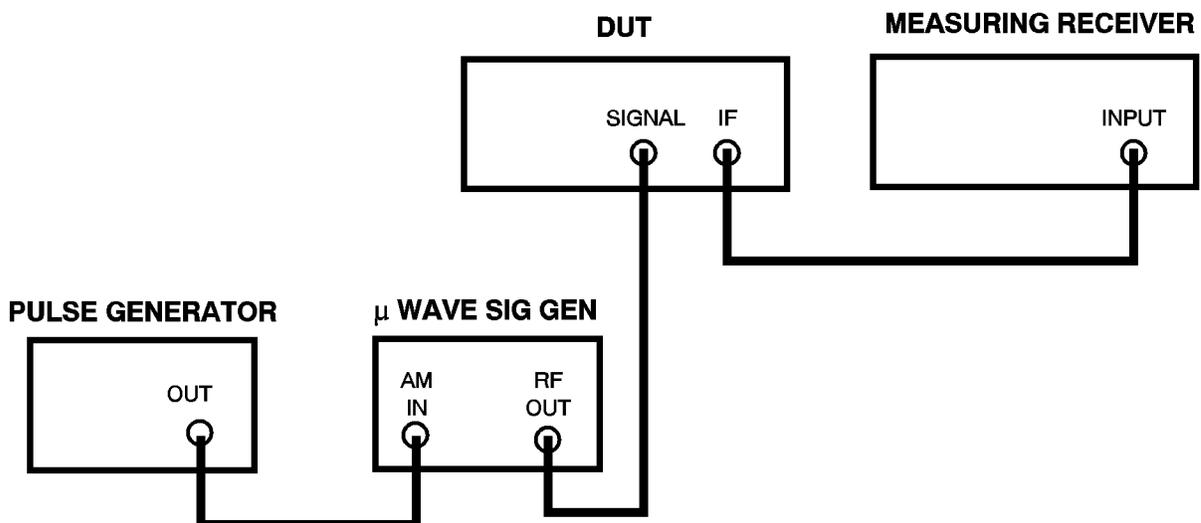


Figure 14-8 Measuring Receiver Set Up

## Procedure

### Step 1 - Set up the measuring receiver

- Frequency: 600 MHz manual tune
- AM mode
- Average detector
- 20 kHz low-pass filter
- 2.1 SPCL (selects 40% AM range)
- 6.1 SPCL (selects fast AM ALC)

### Step 2 - Initialize the HP 70427A

Press the **INSTR PRESET** key.

### Step 3 - Set the HP 70427A input frequency to 18 GHz

1. Press the *Output* softkey.
2. Press the *FREQ* softkey.
3. Enter 18 with the numeric keypad.
4. Complete the entry by pressing the *GHz* softkey.

### Step 4 - Set the HP 70427A input attenuator to 10 dB

1. Press the *Amplitudes* softkey.
2. Press the *more 1 of 2* softkey.
3. Press the *INPUT ATTEN* softkey.
4. Enter the 10 with the numeric keypad.
5. Complete the entry by pressing the *dB* softkey.

### Step 5 - Set up the sweep oscillator

- Frequency: 18 GHz
- Power: -2.5 dBm
- Modulation: External AM

### Step 6 - Set up the pulse/function generator

- Frequency: 10 kHz
- Waveshape: Square
- Level: Adjust for about 33%  $\pm$  0.5% AM measured on the measuring receiver.

**Step 7 - Record the AM% reading**

**Step 8 - Set the HP 70427A attenuation to 0 dB**

1. Press the *Amplitudes* softkey.
2. Press the *more 1 of 2* softkey.
3. Press the *INPUT ATTEN* softkey.
4. Enter 0 with the numeric keypad.
5. Complete the entry by pressing the *dB* softkey.

**Step 9 - Record the AM% reading again**

**Step 10 - Subtract the two AM% readings**

**Step 11 - Look up the mixer non-linearity**

*Table 14-13 Mixer Non-Linearity*

AM % Difference (From Step 10)	Non-Linearity (dB)	AM % Difference (From Step 10)	Non-Linearity (dB)
0.000	0.00	0.021	0.36
0.001	0.02	0.022	0.38
0.002	0.03	0.023	0.39
0.003	0.05	0.024	0.41
0.004	0.07	0.025	0.43
0.005	0.09	0.026	0.44
0.006	0.10	0.027	0.46
0.007	0.12	0.028	0.48
0.008	0.14	0.028	0.49
0.009	0.15	0.029	0.51
0.010	0.17	0.030	0.53
0.011	0.19	0.031	0.53
0.012	0.21	0.032	0.54
0.013	0.22	0.033	0.56
0.014	0.24	0.034	0.58
0.015	0.26	0.035	0.59
0.016	0.27	0.036	0.61
0.017	0.29	0.037	0.63

Performance Tests  
 Test 5 - Mixer Linearity (IF)

*Table 14-13 Mixer Non-Linearity*

AM % Difference (From Step 10)	Non-Linearity (dB)	AM % Difference (From Step 10)	Non-Linearity (dB)
0.018	0.31	0.038	0.65
0.019	0.32	0.039	0.65
0.020	0.34	0.40	0.68

*Table 14-14 Mixer Linearity Results Table*

Test No. & Description	Max. Specs. (dB)	Results	Measurement Uncertainty (±dB)
5. Mixer Linearity	0.4		0.24

---

## Test 6 - Phase Noise and Spurs of Downconverter

### Overview

This test measures the HP 70427A Downconverter Module's phase noise and spurs at several carrier frequencies.

### Specification

Refer to the specification table for Microwave Downconverter RF input spectral purity:

- 20 ppm/V (600 MHz oscillator): Configuration 1

### Equipment

HP 70428A Microwave Source Module (with MMS mainframe and display).

HP 3048A Phase Noise Measurement System with Options 201, H26.

HP 8562A Spectrum Analyzer

HP 8902A Measuring Receiver (Power Meter)

HP 70428A Option K01 Tune Voltage Supply.

HP 11792A Sensor Module

HP 8491A-10 10 dB Pad.

50  $\Omega$  BNC termination.



- Carrier frequency: *will be entered later.*
  - Detector/discr input frequency: 600 MHz.
  - VCO Tuning constant: *will be entered later.*
  - Center voltage of VCO tuning curve: 0 V.
  - Voltage tuning range of VCO: 2 V.
  - VCO tune-port input resistance: 1E6  $\Omega$
  - Phase detector: Internal Phase Detector, 5 MHz to 1600 MHz.
3. Specify a calibration process
- Method for determining phase detector constant: Measure the detector constant.
  - Method for determining the VCO tuning constant: Measure the VCO tuning constant.
  - PLL suppression: Will be verified.
4. Specify the control of signal sources
- DUT: User's source, manual control.
  - REF SOURCE: User's source, manual control.
  - TUNE VOLTAGE: Ref source.
5. Define the graph of results
- Title: *will be entered later.*
- Minimum X coordinate: 1 Hz.
  - Maximum X coordinate: 40 MHz
  - Minimum Y coordinate: -170
  - Maximum Y coordinate: 0
  - Horizontal portion of display to be used: 100%
  - Vertical portion of display to be used: 100%
  - Graph type: Single sideband phase noise (dBc/Hz)
6. Enter the spec lines
- Will be entered later.*

## Step 2 - Reference source initial configuration

1. Make the reference source the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the reference source's **ACT** indicator lights.

**Test 6 - Phase Noise and Spurs of Downconverter**

2. Press the **INSTR PRESET** key.
3. Access the Source screen: if the module is an HP 70427A or HP 70428A Option 002 press the **Source** softkey.
4. Set the frequency to 3.0 GHz (this frequency is not tested, the only reason for entering it is that the source must have a frequency entered before it will accept a power level):
  - a. Press the **Output** softkey.
  - b. Press the **FREQ** softkey.
  - c. Enter 3 with the numeric keypad.
  - d. Press the **GHz** softkey.
5. Set the output power to +10 dBm:
  - a. Press the **Output** softkey.
  - b. Press the **POWER** softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the **dBm** softkey.

---

**NOTE**

---

Turn the HP 70428A Option K01 on now.

**Step 3 - DUT initial configuration**

1. Make the DUT the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the reference source's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.
3. Set the DUT's input attenuation to 20 db.
  - a. Press the **Amplitudes** softkey.
  - b. Press the **More 1 of 2** softkey.
  - c. Press the **INPUT ATTEN** softkey.
  - d. Enter 20 with the numeric keypad.
  - e. Press the **dB** softkey.

This completes the setup. Measurements are made in steps 4 through 6.

### Step 4 - Measure Downconverter phase noise at 2.4 GHz

1. Enter source and interface parameters

Carrier frequency : 2.4 GHz

- VCO Tuning constant: 48 kHz/Volt
- Voltage tuning range of VCO: 2.0 V

2. Define graph of results

- Title: Downconverter at 2.4 GHz, 20 ppm/V tuning.

3. Enter spec lines

**Table 14-15** *Spec Lines: Downconverter at 2.4 GHz (Test 6)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+20
2	10	-30
3	100	-70
4	1E3	-108
5	10E3	-133
6	100E3	-143
7	1E6	-147
8	40E6	-147
9	40E6	-70
10	10E6	-70
11	1E3	-70
12	100	-30

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

4. Set the reference source and DUT tuning sensitivity to 20 ppm/V
  - a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *20 ppm/V* softkey.
  - d. If necessary, make the other module active by pressing the **DISPLAY** key followed by the *NEXT INSTR* softkey. Press the **MENU** to display the module's softkeys.

**Test 6 - Phase Noise and Spurs of Downconverter**

5. Set the reference source output frequency to 2.4 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 2.4 with the numeric keypad.
  - d. Press the *GHz* softkey.

Measure the reference source output with a power meter and if necessary, adjust it to +10 dBm  $\pm$ 0.5 dB. Disconnect the cable at the DUT's input connector and connect the power meter to the end of the cable.

Adjust the DUT's output power for +10 dBm,  $\pm$  0.5 dB.

- a. Press the *Output* softkey.
  - b. Press the *POWER* softkey.
  - c. Adjust the power with the knob (0.1 dB steps) or the  $\uparrow$   $\downarrow$  keys (1 dB steps). Note that when entering 0.1 dB steps the actual power may change as much as 0.2 dB.
  - d. If necessary, make the DUT module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* key to display the module's softkeys.
6. Set the DUT input frequency to 2.4 GHz
  - a. Press the *Freqs* softkey.
  - b. Press the *INPUT FREQ* softkey.
  - c. Enter 2.4 with the numeric keypad.
  - d. Press the *GHz* softkey.
7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Make sure the HP 70428A Option K01 is turned ON.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 4.8 KHz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
  - c. Press *Proceed* to continue measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the *SHIFT* key and the *Hard Copy* softkey.

### Step 5 - Measure Downconverter phase noise at 9.6 GHz.

1. Enter source and interface parameters
  - Carrier frequency: 9.6 GHz
  - VCO Tuning constant: 190 kHz/Volt
  - Voltage tuning range of VCO: 2.0 V
2. Define graph of results
  - Title: Downconverter at 9.6 GHz.
3. Enter spec lines

**Table 14-16** *Spec Lines: Downconverter at 9.6 GHz (Test 6)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+30
2	10	-20
3	100	-60
4	1E3	-100
5	10E3	-125
6	100E3	-136
7	1E6	-140
8	40E6	-140
9	40E6	-70
10	10E6	-70
11	1E3	-60
12	100	-20

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

4. Set the tuning sensitivity to 20 ppm/V
  - a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *20 ppm/V* softkey.

## Test 6 - Phase Noise and Spurs of Downconverter

If necessary, make the other module active by pressing the **DISPLAY** key followed by the **NEXT INSTR** softkey. Press the **MENU** key to display the module's softkeys.

5. Set the reference source output frequency to 9.6 GHz
  - a. Press the **Output** softkey.
  - b. Press the **FREQ** softkey.
  - c. Enter 9.6 with the numeric keypad.
  - d. Press the **GHz** softkey.
  - e. If necessary, make the DUT module active by pressing the **DISPLAY** key followed by the **NEXT INSTR** softkey. Press the **MENU** key to display the module's softkeys.
6. Set the DUT input frequency to 9.6 GHz
  - a. Press the **Freqs** softkey.
  - b. Press the **INPUT FREQ** softkey.
  - c. Enter 9.6 with the numeric keypad.
  - d. Press the **GHz** softkey.
7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Make sure the HP 70428A Option K01 is turned ON.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 19 kHz. If necessary, switch the **NORMAL/REVERSE** switch and turn the pot in the other direction.
  - c. Press **Proceed** softkey to continue measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the **Hard Copy** softkey.

### Step 6 - Measure Downconverter phase noise at 25.8

1. Enter source and interface parameters
  - Carrier frequency: 28.5 GHz
  - VCO Tuning constant: 500 kHz/Volt
  - Voltage tuning range of VCO: 2.0 V
2. Define graph of results
  - Title: Downconverter at 25.8 GHz.
3. Enter spec lines

**Table 14-17 Spec Lines: Downconverter at 25.8 GHz (Test 6)**

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	+38
2	10	-12
3	100	-52
4	1E3	-92
5	10E3	-117
6	100E3	-129
7	1E6	-131
8	40E6	-131
9	40E6	-60
10	10E6	-60
11	1E3	-54
12	100	-14

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

4. Set the tuning sensitivity to 20 ppm/V
  - a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *20 ppm/V* softkey.
  - d. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* key to display the module's softkeys.
5. Set the reference source output frequency to 28.5 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 28.5 with the numeric keypad.
  - d. Press the *GHz* softkey.

**Test 6 - Phase Noise and Spurs of Downconverter**

Measure the reference source output with a power meter and if necessary, adjust it to  $+10 \text{ dBm} \pm 0.5 \text{ dB}$ . Disconnect the cable at the DUT's input connector and connect the power meter to the end of the cable.

Adjust the DUT's output power for  $+10 \text{ dBm}, \pm 0.5 \text{ dB}$ .

- a. Press the *Output* softkey.
- b. Press the *Power* softkey.
- c. 3. Adjust the power with the knob (0.1 dB steps) or the Up/Down arrow keys (1 db steps).

---

**NOTE**

---

When entering 0.1 dB steps the actual power may change as much as 0.2 dB.

- d. If necessary, make the DUT module active by pressing the *Display* key followed by the *NEXT INSTR* softkey. Press the *MENU* key to display the module's softkeys.
6. Set the DUT input frequency to 25.8 GHz
    - a. Press the *Freqs* softkey.
    - b. Press the *INPUT FREQ* softkey.
    - c. Enter 25.8 with the numeric keypad.
    - d. Press the *GHz* softkey.
  7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Make sure the HP 70428A Option K01 is turned ON.
- b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 50 kHz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
- c. Press *Proceed* softkey to continue measurement.

On the HP 3048A controller press the *SHIFT* and the *Hard Copy* softkey.

**Table 14-18 Phase Noise Measurement**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>6. Phase Noise and Spurs</b>					
<b>Downconverter Phase Noise</b>					
	2.4	10 Hz	-30		2
	2.4	100 Hz	-70		2
	2.4	1 kHz	-108		2
	2.4	10 kHz	-133		2
	2.4	100 kHz	-143		2
	2.4	1 MHz	-147		2
	2.4	40 MHz	-147		4
<b>Spurious</b>					
	2.4	100 Hz	-30		2
	2.4	1kHz	-70		2
	2.4	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>
<b>Phase Noise</b>					
	9.6	10 Hz	-20		2
	9.6	100 Hz	-60		2
	9.6	1 kHz	-100		2
	9.6	10 kHz	-125		2
	9.6	100 kHz	-136		2
	9.6	1 MHz	-140		2
	9.6	40 MHz	-140		4
<b>Spurious</b>					
	9.6	100 Hz	-20		2
	9.6	1 kHz	-60		2
	9.6	10 kHz	$\geq -70$		2 or 4 <sup>1</sup>
<b>600 MHz Oscillator Phase Noise</b>					
	25.8	10 Hz	-12		2
	25.8	100 Hz	-52		2
	25.8	1k Hz	-92		2
	25.8	10k Hz	-117		2
	25.8	100 kHz	-129		2
	25.8	1M Hz	-131		2

**Table 14-18** *Phase Noise Measurement*

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
	25.8	40 MHz	-131		2
<b>Spurious</b>					
	25.8	100 Hz	-14		2
	25.8	1 kHz	-54		2
	25.8	$\geq 10$ kHz	-60		2 or 4 <sup>1</sup>

1. Uncertainty 4 dB at offsets  $>1$  MHz

## Test 7 - AM Detector Noise Floor (AM NOISE)

### Overview

This test measures the noise floor of the downconverter's input AM detector. A 600 MHz carrier is applied to the downconverter's AM detector. The detected noise is routed from the downconverter's AM NOISE output to the NOISE INPUT of the HP 3048A phase noise measurement system and an AM noise measurement is made.

### Specification

Refer to the specification table for AM detector noise floor.

### Equipment

HP 3048A Phase Noise Measurement System with Options 201, H26.

HP 8562A Spectrum Analyzer

HP 8662/3A Synthesized Signal Generator

HP 70427A K02 Spur Rejection Balun

HP 8902A Measuring Receiver (power meter)

HP 11792A Sensor Module

HP 355C 1 dB Step Attenuator

### Test Setup

Set up the HP 3048A according to the HP 3048A Installation Guide. The following diagram shows the test setup as it will be in step 6 when the AM noise measurement is made.

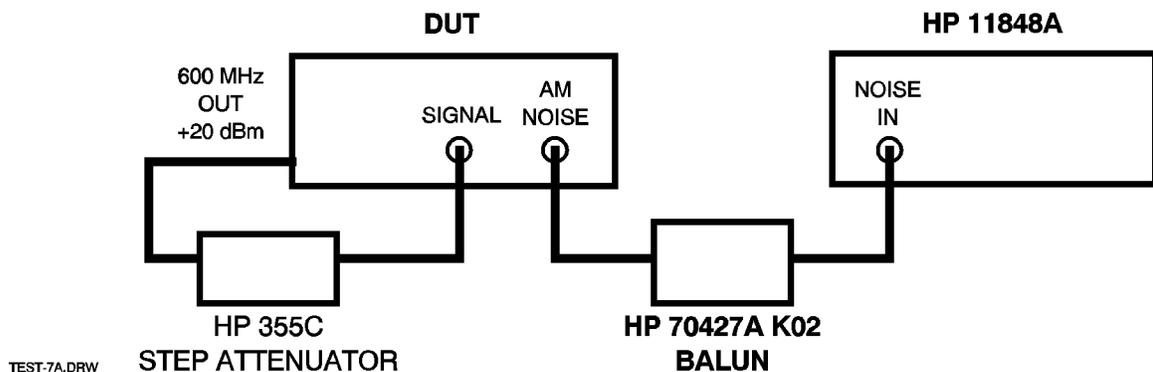


Figure 14-10 Step 6 Test Set Up Am Noise Measurement

## Procedure

The following procedure assumes familiarity with HP 3048A operation. Initial configuration of the test system and DUT is done in steps 1 to 4. Calibration is done in step 5, and an AM noise measurement is made in step 6.

### Step 1 - Define the measurement

Specify measurement type and frequency range

- Measurement type: AM Noise
- Start freq: 1 Hz
- Stop freq: 40 MHz
- Averages: 4

Enter source and interface parameters

- Carrier frequency: 600 MHz
- Detector/discr input frequency: 600 MHz
- Phase detector: External Phase/AM Detector

Specify a calibration process

- Calibration technique: Derive from Double Sided Spur.
- Spur Amplitude: -40 dBc
- Spur Frequency: 1 kHz

Specify the control of signal sources

- DUT SOURCE: USER'S SRCE, MANUAL CONTROL
- AM DETECTOR: USER'S DEV., MANUAL CONTROL
- CAL SOURCE: USER'S SRCE, MANUAL CONTROL

Define the graph of results

- Title: Test 3 - Downconverter AM Detector Noise Floor
- Minimum X coordinate: 10 Hz
- Maximum X coordinate: 40 MHz
- Minimum Y coordinate: -170
- Maximum Y coordinate: 0
- Horizontal portion of display to be used: 100%
- Vertical portion of display to be used: 100%
- Graph type: AM Noise (dBc/Hz)

Enter the spec lines

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude.

## Step 2 - Configure the DUT

1. Make sure the DUT is the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the DUT's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.
3. Put the downconverter in input AM noise mode.
  - a. Press the **AM Noise** softkey.
  - b. Press the **AMNSE IN/IF** softkey until **IN** is underlined.
4. Set input power to +10 dBm.
  - a. Disconnect the cable from the downconverter's **SIGNAL** input and connect it to the power sensor.

---

### NOTE

---

Make sure the measuring receiver has the sensor modules cal factors entered and that the 600 MHz test frequency has been entered.

- b. Adjust the 1 dB step attenuator for a power meter reading of +10 dBm,  $\pm 0.5$  dB.
- c. Re-connect the cable from the step attenuator to the downconverter's **SIGNAL** input.
- d. Autorange the downconverter's input attenuator: Press the **AUTO ATTEN** softkey.

## Step 3 - Set calibration source power to equal DUT input power

The calibration source power and the DUT input power are compared by measuring the DC voltage at the AM detector's output with the downconverter's internal voltmeter.

- 1) Measure and record the DUT input power
  - a. Read the AM Det Voltage: display.
  - b. Press the **Read AM Det** softkey
  - c. Repeat from "2." above until the reading on the AM Det Voltage display doesn't change from one reading to the next.
- 2) Set up the calibration source
  - a. Frequency: 600 MHz
  - b. Power: +10 dBm
  - c. Modulation: OFF

**Test 7 - AM Detector Noise Floor (AM NOISE)**

3) Measure and adjust the calibration source power

Connect the calibration source's output to the downconverter's **SIGNAL** input.

Adjust the calibration source's output power until the voltage measured by the internal voltmeter is within  $\pm 5\%$  of the DC voltage measured in "1" above. This is done as follows:

- a. Read the **AM Det Voltage** display.
- b. Press the *Read AM Det* softkey
- c. Repeat from "2." above until the reading on the **AM Det Voltage** display doesn't change from one reading to the next.
- d. If necessary, increment / decrement the calibration source's output power.
- e. Repeat "1." through "3." to read new power.
- f. Repeat "1." through "4." above until the calibration source's output power is within  $\pm 5\%$  of the DUT's input power.

---

**NOTE**

---

Leave the calibration source connected to the downconverter until prompted to remove the calibration spur in step 6 below.

**Step 4 - Modulate the calibration source**

- Type: Internal AM
- Frequency: 1 kHz
- Depth: 2%

### Step 5 - Calibrate for AM Noise measurement

Select *New Measurement* and follow the HP 3048A software screen prompts, but use the connection diagrams below.

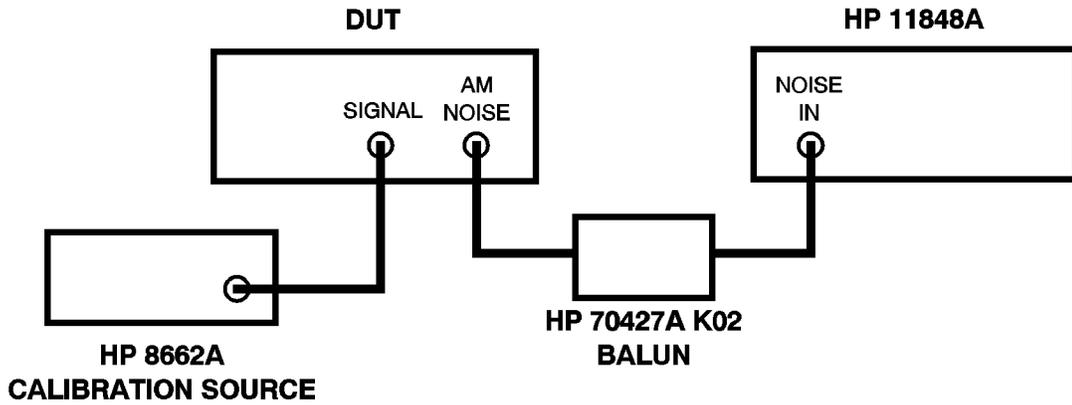


Figure 14-11 AM Noise Measurement Calibration Diagram

### Step 6 - Measure AM Noise

When prompted to **Remove the calibration spur**, connect the output of the 1 dB step attenuator to the downconverter’s **SIGNAL** input and press the *Proceed* softkey.

### Step 7 - Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

Table 14-19 Result Table Test 7

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach AM-Noise Plot	Measurement Uncertainty (±dB)
<b>7. AM Detector Noise Floor</b>					
	600	1 Hz	-108		2
	600	10 Hz	-118		2
	600	100 Hz	-128		2
	600	1 kHz	-138		2
	600	10 kHz	-145		2
	600	100kHz	-155		2
	600	40 MHz	-155		4

## Test 8 - Phase Noise and Spurs (RF)

### Overview

This test measures the HP 70428A Option 002's phase noise and spurs at three carrier frequencies.

### Specification

Refer to the specification table for Option 002 RF output spectral purity:

- 0.05 ppm/V (10 MHz oscillator): Configuration 1

### Equipment

HP 70428A Microwave Source Module (with MMS mainframe and display).

HP 3048A Phase Noise Measurement System with Options 201, H26.

HP 8562A Spectrum Analyzer.

HP 8662/3A Signal Generator.

HP 70428A Option K01 Tune Voltage Supply.

HP 8491A-10 10 dB Pad.

50  $\Omega$  BNC termination.

## Test Setup

Set up the HP 3048A according to the HP 3048A Installation Guide. Connect the reference source and the DUT as shown on the following diagram:

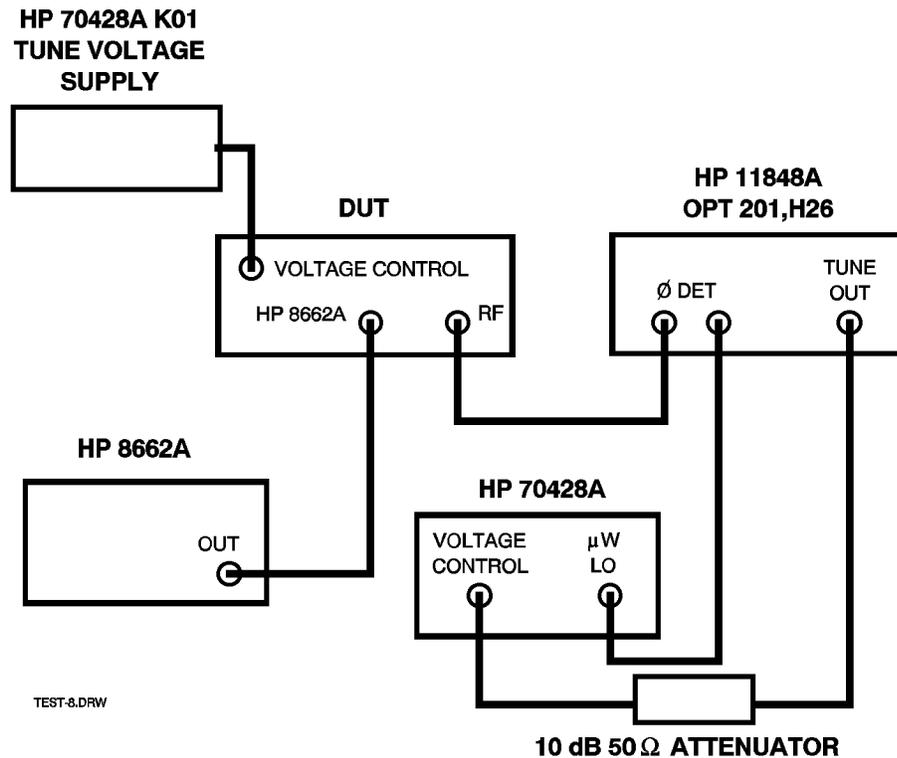


Figure 14-12 Reference Source and DUT Connection Diagram

## Procedure

The following procedure assumes familiarity with HP 3048A operation. Initial configuration of the test system and DUT is done in steps 1 to 3. A phase noise measurement is made 3 times at difference carrier frequencies. The software configurations and frequencies are listed for each measurement in steps 4 through 6.

### Step 1 - Initial HP 3048A measurement definition

#### Specify measurement type and frequency range

- Measurement type: Phase Noise Using a Phase-Lock-Loop
- Start freq: *will be entered later.*
- Stop freq: 40 MHz
- Averages: 4

### Enter source and interface parameters

- Carrier frequency: *will be entered later.*
- Detector/discr input frequency: *will be entered later.*
- VCO Tuning constant: *will be entered later.*
- Center voltage of VCO tuning curve: 0 V.
- Voltage tuning range of VCO: 0.2 V
- VCO tune-port input resistance: 1E6  $\Omega$
- Phase detector: Internal Phase Detector, 1.2 GHz to 18 GHz.

### Specify a calibration process

- Method for determining phase detector constant: Measure the detector constant.
- Method for determining the VCO tuning constant: Measure the VCO tuning constant.
- PLL suppression: Will be verified.

### Specify the control of signal sources

- DUT: User's source, manual control.
- REF SOURCE: User's source, manual control.
- Tune voltage: Ref source.

### Define the graph of results

- Title: *will be entered later.*
- Minimum X coordinate: 1 Hz.
- Maximum X coordinate: 40 MHz
- Minimum Y coordinate: -170
- Maximum Y coordinate: 0
- Horizontal portion of display to be used: 100%
- Vertical portion of display to be used: 100%
- Graph type: Single sideband phase noise (dBc/Hz)

### Enter the spec lines

*Changes each measurement.*

### Step 2 - HP 8662A initial configuration

1. Set HP 8662A RF frequency to 600 MHz.
2. Set HP 8662A output power to +5 dBm.

### Step 3 - Reference source initial configuration

1. Make the reference source the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the reference source's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.
3. Access the Source screen: if the module is an HP 70427A or HP 70428A Option 002 press the **Source** softkey.
4. Set the frequency to 3.0 GHz (this frequency is not tested, the only reason for entering it is that the source must have a frequency entered before it will accept a power level):
  - a. Press the **Output** softkey.
  - b. Press the **FREQ** softkey.
  - c. Enter 3 with the numeric keypad.
  - d. Press the **GHz** softkey.
5. Set the output power to +10 dBm:
  - a. Press the **Output** softkey.
  - b. Press the **POWER** softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the **dBm** softkey.
6. Set the tuning sensitivity to 0.05 ppm/V
  - a. Press the **Ref Chain** softkey.
  - b. Press the **Tune Sens** softkey.
  - c. Press the **0.05 ppm/V** softkey.

---

**NOTE**

---

Turn the HP 70428A K01 on now.

### Step 4 - DUT initial configuration

1. Make the DUT the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the reference source's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.

**Test 8 - Phase Noise and Spurs (RF)**

3. Select the RF source
  - a. Press the *Service* softkey.
  - b. Press the *Misc* softkey.
  - c. Press the *RF Source* softkey.
  - d. Press the *OTHER* softkey.
4. Set the frequency to 3.0 GHz (this frequency is not tested, the only reason for entering it is that the source must have a frequency entered before it will accept a power level):
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT FREQ* softkey.
  - c. Enter 3 with the numeric keypad.
  - d. Press the *GHz* softkey.
5. Set the output power to +10 dBm:
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT POWER* softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the *dBm* softkey.
6. Set the tuning sensitivity to 0.05 ppm/V
  - a. Press the *Ref Chain* softkey.
  - b. Press the *Tune Sens* softkey.
  - c. Press the *0.05 ppm/V* softkey.

This completes the setup. Measurements are made in steps 4 through 6 below.

**Step 5 - Measure phase-noise at 2.4 GHz with .05 ppm/V tuning**

1. Specify measurement type and frequency range

Start freq: 1 Hz

2. Enter source and interface parameters
  - Carrier frequency: 2.4 GHz
  - Detector/discr input frequency: 2.4 GHz
  - VCO Tuning Constant: 40 Hz/V
3. Define graph of results
  - Title: HP 70428A Opt. 002, 2.4 GHz with 0.05 ppm/V Tuning

4. Enter spec lines

**Table 14-20** *Spec Lines: 2.4 GHz (Test 8)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	- 43
2	10	- 73
3	100	- 92
4	1E3	- 112
5	3E3	- 112
6	5E3	- 114
7	10E3	- 124
8	100E3	- 124
9	1E6	- 130
10	10E6	- 142
11	40E6	- 142

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude.

5. Set the reference source frequency to 2.4 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 2.4 with the numeric keypad.
  - d. Press the *GHz* softkey.
  - e. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* key to display the module's softkeys.
6. Set the DUT output frequency to 2.4 GHz
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT FREQ* softkey.
  - c. Enter 2.4 with the numeric keypad.
  - d. Press the *GHz* softkey.
7. Run the phase-noise measurement

**Test 8 - Phase Noise and Spurs (RF)**

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Make sure that the HP 70428A Option K01 is turned ON.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 0.4 Hz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction. A procedure is described in the HP 3048A operating manual page 3-25 that will help set the beat frequency using the time record displayed on the HP 3561A.
  - c. Please *Proceed* softkey to continue measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

**Step 6 - Measure phase-noise at 9.6 GHz**

1. Specify measurement type and frequency range
  - Start freq: 10 Hz
2. Enter source and interface parameters
  - Carrier frequency: 9.6 GHz
  - Detector/discr input frequency: 9.6 GHz
  - VCO tuning constant: 160 Hz
3. Define graph of results
  - Title: HP 70428A/002, 9.6 GHz with .05 ppm/V tuning.
4. Enter spec lines

**Table 14-21** *Spec Lines: 9.6 GHz (Test 8)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	-35
2	10	- 65
3	100	- 85
4	1E3	- 112
5	3E3	- 115
6	5E3	- 117
7	10E3	- 124
8	100E3	- 130
9	1E6	- 134

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
10	10E6	- 140
11	40E6	- 140
12	40E6	- 70
13	10E3	- 70
14	1E3	- 40
15	100	- 40

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

5. Set the reference source frequency to 9.6 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 9.6 with the numeric keypad.
  - d. Press the *GHz* softkey.
  - e. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* to display the module's softkeys.
6. Set the DUT output frequency to 9.6 GHz
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT FREQ* softkey.
  - c. Enter 9.6 with the numeric keypad.
  - d. Press the *GHz* softkey.
7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Turn the HP 70428A Option K01 on.
- b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 2 Hz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
- c. Press *Proceed* softkey to continue measurement.

**Test 8 - Phase Noise and Spurs (RF)**

8. Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

**Step 7 - Measure phase-noise at 25.8 GHz**

1. Specify measurement type and frequency range

- Start freq: 10 Hz

2. Enter source and interface parameters

- Carrier frequency: 25.8 GHz
- Detector/discr input frequency: 25.8 GHz
- VCO Tuning constant: 400 Hz/V

3. Define graph of results

- Title: HP 70428A/002, 25.8 GHz with 0.05 ppm/V tuning.

4. Enter spec lines

**Table 14-22** *Spec Lines: 25.8 GHz (Test 8)*

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	- 27
2	10	- 57
3	100	- 77
4	1E3	- 105
5	3E3	- 108
6	5E3	- 110
7	10E3	- 117
8	100E3	- 123
9	1E6	- 127
10	10E6	- 131
11	40E6	- 131
12	40E6	- 60
13	10E6	- 60
14	1E3	- 34
15	100	- 34

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. Phase noise specs are entered in order, but

the spurious specs must be entered in reverse order with an extra point at 40 MHz.

5. Set the reference source frequency to 25.8 GHz
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 25.8 with the numeric keypad.
  - d. Press the *GHz* softkey.
  - e. If necessary, make the other module active by pressing the *DISPLAY* key followed by the *NEXT INSTR* softkey. Press the *MENU* key to display the module's softkeys.
6. Set the DUT output frequency to 25.8 GHz
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT FREQ* softkey.
  - c. Enter 25.8 with the numeric keypad.
  - d. Press the *GHz* softkey.
7. Run the phase-noise measurement

When the phase-noise measurement program stops to prompt a zero-beat adjustment, do the following:

- a. Turn the HP 70428A Option K01 on.
  - b. Adjust the pot on the HP 70428A Option K01 for a zero beat within 4 Hz. If necessary, switch the NORMAL/REVERSE switch and turn the pot in the other direction.
  - c. Press *Proceed* softkey to continue measurement.
8. Print a graph and parameter summary

On the HP 3048A controller press the *SHIFT* key and the *Hard Copy* softkey.

Performance Tests  
**Test 8 - Phase Noise and Spurs (RF)**

**Table 14-23 Result Table Test 8**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>8. Phase Noise and Spurs</b>					
HP 70428A/ 002					
0.05ppm/Mtuning					
Phase Noise					
	2.4	10 Hz	-73		2
	2.4	100 Hz	-922		2
	2.4	1 kHz	-112		2
	2.4	3 kHz	-112		2
	2.4	5 kHz	-114		2
	2.4	10 kHz	-124		2
	2.4	100 kHz	-124		2
	2.4	1 MHz	-130		2
	2.4	10 MHz	-142		2
	2.4	40 MHz	-142		4
<b>Spurious</b>					
	2.4	All	N/A		N/A
<b>Phase Noise</b>					
	9.6	10 Hz	-65		2
	9.6	100 Hz	-85		2
	9.6	1 kHz	-112		2
	9.6	3 kHz	-115		2
	9.6	5 kHz	-117		2
	9.6	10 kHz	-124		2
	9.6	100 kHz	-130		2
	9.6	1 MHz	-134		2
	9.6	10 MHz	-140		2
	9.6	40 MHz	-140		4
<b>Spurious</b>					
	9.6	100 Hz	-40		2
	9.6	1 kHz	-40		2

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
	9.6	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>
<b>. Phase Noise and Spurs</b>					
HP 70428A/002					
0.05 ppm/V tuning					
Phase Noise					
	25.8	10 Hz	-57		2
	25.8	100 Hz	-77		2
	25.8	1 kHz	-105		2
	25.8	3 kHz	-108		2
	25.8	5 kHz	-110		2
	25.8	10 kHz	-117		2
	25.8	100 kHz	-123		2
	25.8	1 MHz	-127		2
	25.8	10 MHz	-131		2
	25.8	40 MHz	-131		4
<b>Spurious</b>					
	25.8	100 Hz	-34		2
	25.8	1 kHz	-34		2
	25.8	$\geq 10$ kHz	-60		2 or 4 <sup>1</sup>

---

## Test 9 - AM Noise and Spurs (RF)

### Overview

This test measures the HP 70428A Option 002's (tunable source) AM noise and spurs at 12.6 GHz.

### Specification

Refer to the specification table for AM Noise of Option 002.

### Equipment

HP 3048A Phase Noise Measurement System with Options 201, H26.

HP 8562A Spectrum Analyzer

HP 33330C Coaxial Detector

HP 3048A K21 AM Detector Filter

HP 8662/3A Synthesized Signal Generator

HP 70427A K02 Balun

### Test Setup

Set up the HP 3048A according to the HP 3048A Installation Guide. The following diagram shows the test setup as it will be in step 7 when the AM Noise measurements are made.

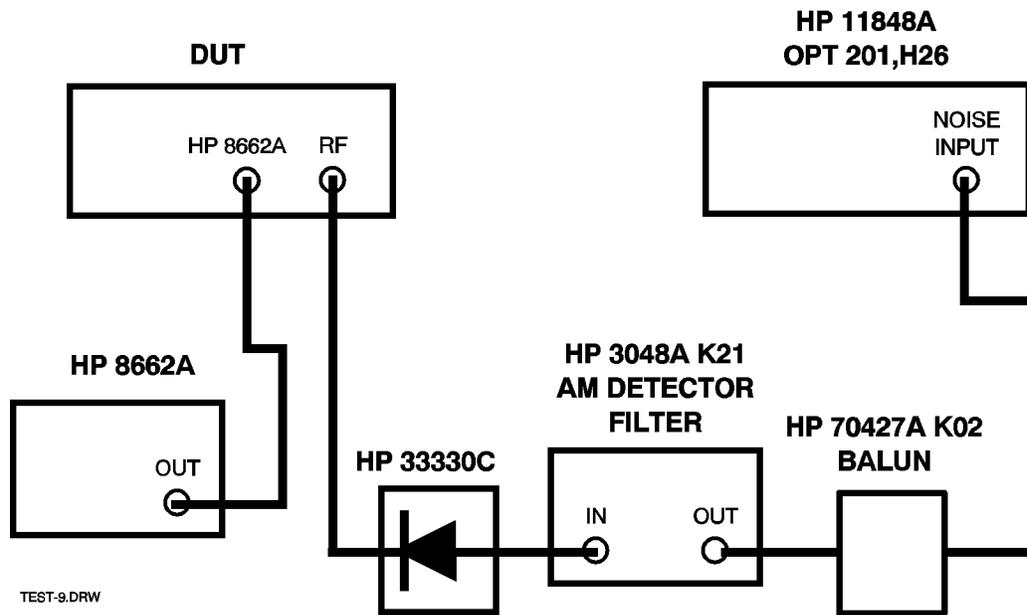


Figure 14-13 Step 7 Test Diagram

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**NOTE**

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Set the **DETECTOR POLARITY** switch on the HP 3048A Option K21 to match the polarity of the detector.

## Procedure

The following procedure assumes familiarity with HP 3048A operation. Initial configuration of the test system and DUT is done in steps 1 to 5. Calibration is done in step 6, and an AM noise measurement is made in step 7.

### Step 1 - Define the measurement

#### Specify measurement type and frequency range

- Measurement type: AM Noise
- Start freq: 1 Hz
- Stop freq: 40 MHz
- Averages: 4

#### Enter source and interface parameters

- Carrier frequency: 12.6 GHz
- Detector/discr input frequency: 12.6 GHz
- Phase detector: External Phase/AM Detector

#### Specify a calibration process

- Calibration technique: Derive from Double Sided Spur.
- Spur Amplitude: -40 dBc
- Spur Frequency: 1 kHz

#### Specify the control of signal sources

- DUT SOURCE: USER'S SRCE, MANUAL CONTROL
- AM DETECTOR: USER'S DEV., MANUAL CONTROL
- CAL SOURCE: USER'S SRCE, MANUAL CONTROL

#### Define the graph of results

- Title: Test 9 - Tunable Source AM Noise and Spurs at 12.6 GHz
- Minimum X coordinate: 1 Hz
- Maximum X coordinate: 40 MHz

**Test 9 - AM Noise and Spurs (RF)**

- Minimum Y coordinate: -170
- Maximum Y coordinate: 0
- Horizontal portion of display to be used: 100%
- Vertical portion of display to be used: 100%
- Graph type: AM Noise (dBc/Hz)

**Enter the spec lines****Table 14-24 Spec Lines: 12.6 GHz (Test 9)**

Point	Offset Frequency (Hz)	Amplitude (dBc/Hz)
1	1	- 92
2	10	- 102
3	100	- 109
4	1E3	- 125
7	10E3	- 135
8	100E3	- 145
7	1E6	- 147
8	40E6	- 147
9	40E6	- 70
10	1E3	- 70
11	100	- 50

The *Spec Lines* softkey is under the results graph definition menu. Use the offsets from the result table for the offset frequency and the max spec from the result table for the amplitude. AM noise specs are entered in order, but the spurious specs must be entered in reverse order with an extra point at 40 MHz.

**Step 2 - Configure the DUT**

1. Make sure the DUT is the active MMS module (**ACT** indicator lit):
  - a. Press the **DISPLAY** key.
  - b. Press the **NEXT INSTR** softkey until the DUT's **ACT** indicator lights.
2. Press the **INSTR PRESET** key.

3. Set RF source to OTHER:
  - a. Press the *Service* softkey.
  - b. Press the *Misc* softkey.
  - c. Press the *RF Source* softkey.
  - d. Press the *OTHER* softkey.
4. Set the frequency to 12.6 GHz:
  - a. Press the *Output* softkey.
  - b. Press the *FREQ* softkey.
  - c. Enter 12.6 with the numeric keypad.
  - d. Press the *GHz* softkey.
5. Set the output power to +10 dBm:
  - a. Press the *Output* softkey.
  - b. Press the *OUTPUT POWER* softkey.
  - c. Enter 10 with the numeric keypad.
  - d. Press the *dBm* softkey.

### Step 3 - Set HP 8662A Power and Frequency

1. Set HP 8662A output frequency to 600 MHz.
2. Set HP 8662A output power to +5 dBm.

### Step 4 - Set calibration source power to equal DUT power

Power is measured by bridging the HP 3561A across the output of the AM detector and making a DC voltage measurement.

1. Set up the HP 3561A for DC voltage measurement

Press the following HP 3561A keys:

- **VERT SCALE** in the **DISPLAY** key group then the *LINEAR* softkey.
- **RANGE** in the **INPUT** key group then the *AUTO RNG* softkey so that *ON* is underlined.
- **DEFINE TRACE** in the **DISPLAY** key group then the *TIME* softkey.
- **MKR** in the **MARKER** key group then the *MKR* softkey so that *ON* is underlined.

The Y value of the marker will indicate the dc voltage across the AM detector. This voltage is proportional to RF output power.

2. Measure and record the DUT power

Make sure the AM detector is connected to the DUT's output, and that the HP 3561A is connected to the detector's output via a Tee connector.

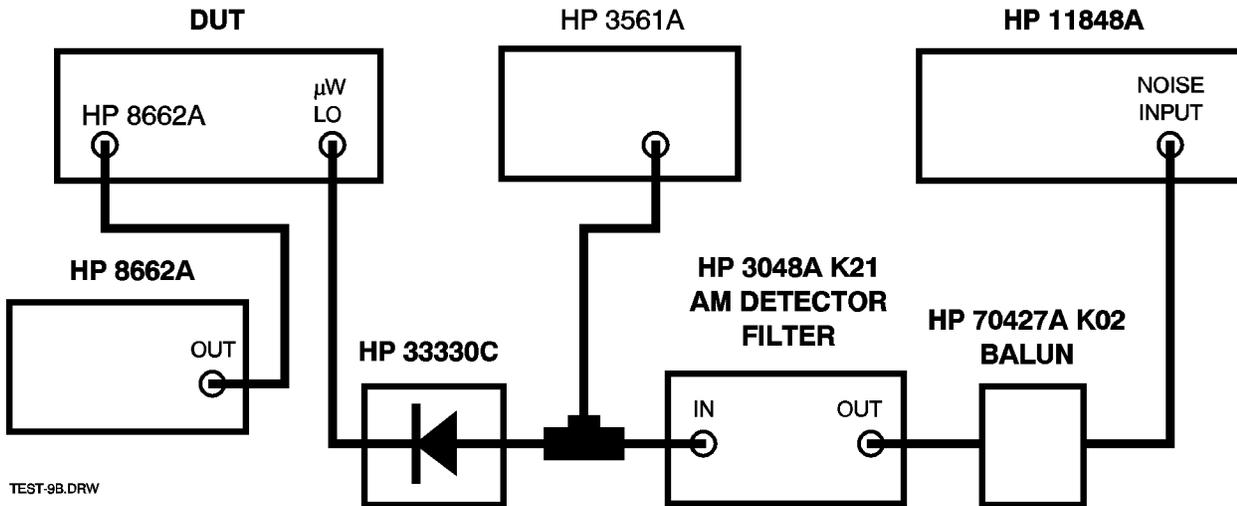


Figure 14-14 Tee Connector Diagram for HP 3561A

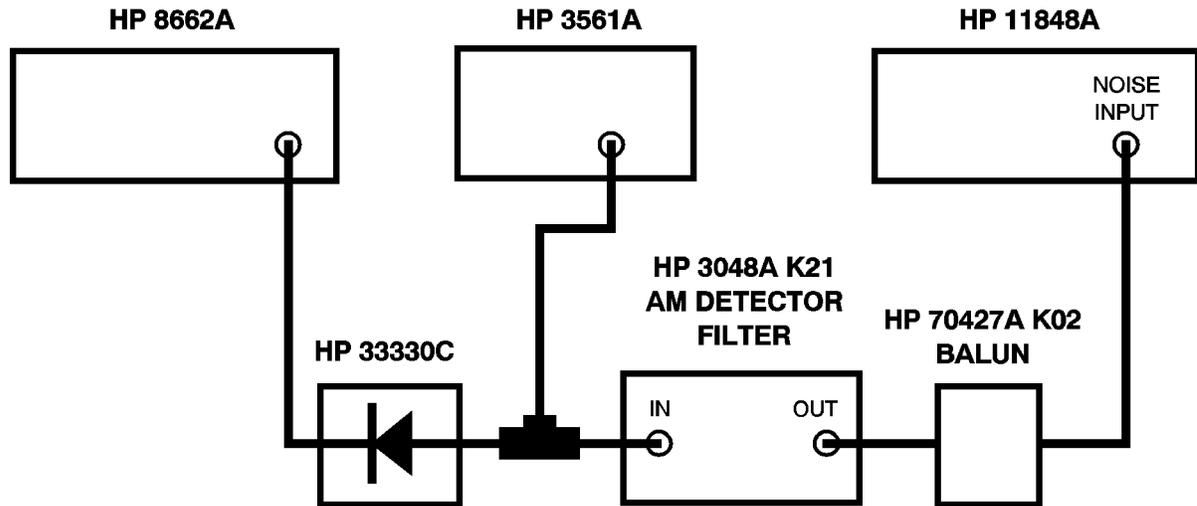
Record the DC voltage measured across the AM detector's output with the HP 3561A as described in 1 on the previous page.

3. Set up the calibration source

- Frequency: 1.2 GHz
- Power: +10 dBm
- Modulation: OFF

4. Measure and adjust the calibration source power

Connect the AM detector to the calibration source's output. Adjust the calibration source's output power until the voltage measured on the HP 3561A is within  $\pm 5\%$  of the DC voltage measured with the detector connected to the DUT.



*Figure 14-15 AM Detector to Sources Output Diagram*

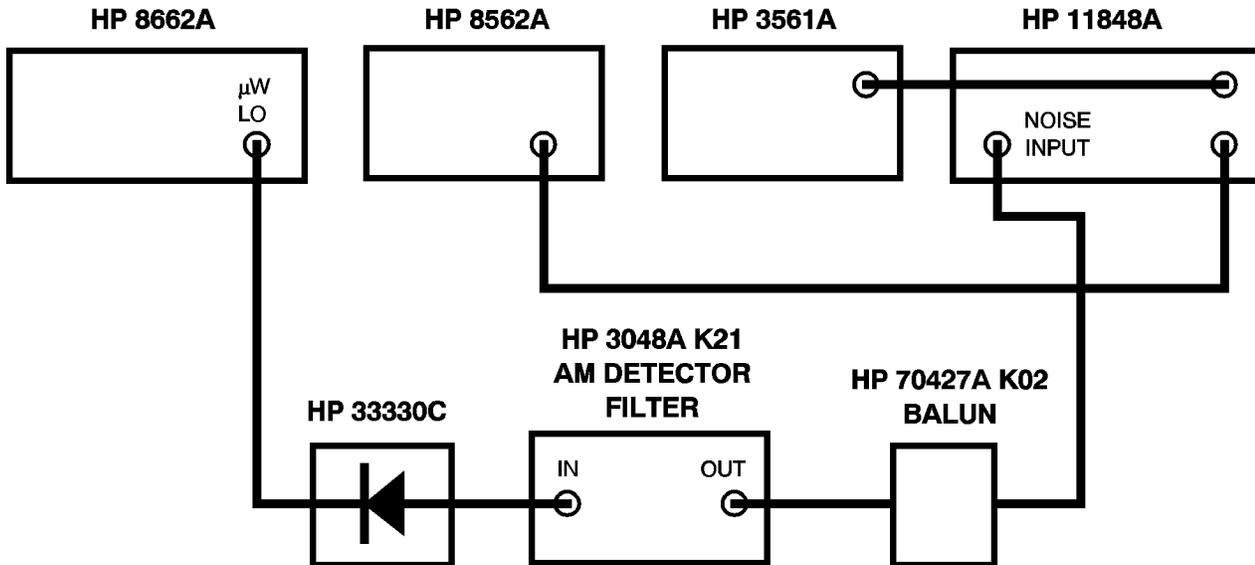
#### Step 5 - Modulate the calibration source

- Type: Internal AM
- Frequency: 1 kHz
- Depth: 2%

#### Step 6 - Calibrate for AM Noise measurement

Select *New Measurement* and follow the HP 3048A software screen prompts, but use the connection diagrams below.

When prompted to **Apply calibration spur to carrier**, connect the AM detector to the RF output of the calibration source and press the *Proceed* softkey.



*Figure 14-16 AM Detector and RF Output to Source Connection Diagram*

### Step 7 - Measure AM Noise

When prompted to "Remove the calibration spur";

1. Re-connect the HP 8662A output to the DUT HP 8662A input.
2. Set HP 8662A AM off, Power to +5 dBm, and Frequency to 600 MHz. Connect AM Detector to the output of the DUT.
3. Press *Proceed* softkey to continue.

### Step 8 - Print a graph and parameter summary

On the HP 3048A controller press the **SHIFT** key and the *Hard Copy* softkey.

*Table 14-25 Result Table Test 9*

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach AM-Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>9. Am Noise and Spurs</b>					
<b>AM Noise</b>					
	12.6	1 Hz	-92		2
	12.6	10 Hz	-102		2
	12.6	100 Hz	-109		2
	12.6	1 kHz	-125		2
	12.6	10 kHz	-135		2
	12.6	100 kHz	-145		2
	12.6	1 MHz	-147		2
	12.6	40 MHz	-147		4
<b>Spurious</b>					
	12.6	100 Hz	-50		2
	12.6	$\geq$ 1Khz	-70		2 or 4 <sup>1</sup>

## Test Record

Model Number \_\_\_\_\_

Serial Number \_\_\_\_\_

**Table 14-26 Test Record Maximum Output Power**

Test No. & Description	Output level	Frequency (GHz)	Max. Specs. (dBm)	Actual	Measurement Uncertainty ( $\pm$ dB)
<b>Maximum Output Power</b>					
	20 dBm	2.4	16		0.42
	20 dBm	3.6	16		0.42
	20 dBm	4.8	16		0.42
	20 dBm	6.6	16		0.44

## Test 9 - AM Noise and Spurs (RF)

Test No. & Description	Output level	Frequency (GHz)	Max. Specs. (dBm)	Actual	Measurement Uncertainty ( $\pm$ dB)
	20 dBm	7.2	10		0.44
	20 dBm	8.4	10		0.44
	20 dBm	9.6	10		0.44
	20 dBm	10.8	10		0.47
	20 dBm	12.0	10		0.47
	20 dBm	13.2	10		0.53
	20 dBm	15.0	10		0.54
	20 dBm	16.8	10		0.54
	20 dBm	18.6	10		.0.64
	20 dBm	20.4	10		0..64
	20 dBm	22.2	10		.0.65
	20 dBm	24.6	10		0..65
	20 dBm	25.8	10		0..65

Table 14-27 Phase Noise and Spurs .05ppm/V Tuning

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>2. Phase Noise and Spurs 05ppm/V tuning</b>					
<b>Phase Noise</b>					
	12.6	1 Hz	-33		2
	12.6	10 Hz	-63		2
	12.6	100 Hz	-83		2
	12.6	1 kHz	-111		2
	12.6	10 kHz	-123		2
	12.6	100 kHz	-135		2
	12.6	1 MHz	-138		2
	12.6	40 MHz	-138		4

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>Spurious</b>					
	12.6	10 Hz	-40		2
	12.6	100Hz	-40		2
	12.6	$\geq 1$ kHz	-70		2 or 4 <sup>1</sup>
<b>1.0 ppm/V Tuning Phase Noise</b>					
	12.6	10 Hz	-31		2
	12.6	100 Hz	-81		2
	12.6	1 kHz	-111		2
	12.6	10 kHz	-123		2
	12.6	100 kHz	-135		2
	12.6	1 MHz	-138		2
	12.6	40 MHz	-138		4
<b>Spurious</b>					
	12.6	10 Hz	-40		2
	12.6	100Hz	-40		2
	12.6	$\geq 1$ kHz	-70		2 or 4 <sup>1</sup>

**Table 14-28 Phase Noise and Spurs 20ppm/V tuning**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>2. Phase Noise and Spurs (cont.) 20ppm/V tuning Phase Noise</b>					
	2.4	10 Hz	-30		2
	2.4	100 Hz	-70		2
	2.4	1 kHz	-108		2

## Performance Tests

## Test 9 - AM Noise and Spurs (RF)

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
	2.4	10 kHz	-133		2
	2.4	100 kHz	-143		2
	2.4	1 MHz	-147		2
	2.4	40 MHz	-147		4
<b>Spurious</b>					
	2.4	10 Hz	-30		2
	2.4	100Hz	-70		2
	2.4	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>
<b>1.0 ppm/V Tuning Phase Noise</b>					
	12.6	10 Hz	-18		2
	12.6	100 Hz	-58		2
	12.6	1 kHz	-98		2
	12.6	10 kHz	-123		2
	12.6	100 kHz	-135		2
	12.6	1 MHz	-138		2
	12.6	40 MHz	-138		4
<b>Spurious</b>					
	12.6	10 Hz	-20		2
	12.6	100Hz	-60		2
	12.6	$\geq 1$ kHz	-70		2 or 4 <sup>1</sup>
<b>Phase Noise</b>					
	25.8	10 Hz	-12		2
	25.8	100 Hz	-52		2
	25.8	1 kHz	-92		2
	25.8	10 kHz	-117		2
	25.8	100 kHz	-129		2
	25.8	1 MHz	-131		2
	25.8	40 MHz	-131		4
<b>Spurious</b>					

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
	25.8	100 Hz	-14		2
	25.8	1 kHz	-54		2
	25.8	$\geq 10$ kHz	-60		2 or 4 <sup>1</sup>

**Table 14-29** *AM Noise and Spurs*

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach AM-Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>3. AM Noise and Spurs</b>					
<b>AM Noise</b>					
	12.6	10 Hz	-105		2
	12.6	100 Hz	-112		2
	12.6	1 kHz	-128		2
	12.6	10 kHz	-138		2
	12.6	100 kHz	-148		2
	12.6	1 MHz	-150		2
	12.6	40 MHz	-150		4
<b>Spurious</b>					
	12.6	10 Hz	-50		2
	12.6	$\geq 1$ kHz	-70		2 or 4 <sup>1</sup>

**Table 14-30** *Comb Line Spurs*

Performance Tests

Test 9 - AM Noise and Spurs (RF)

Test No. & Description	Carrier Frequency (GHz)	Spur Frequency (GHz)	Max. Specs. (dBc)	Results	Measurement Uncertainty ( $\pm$ dB)
<b>4. Comb Line Spurs</b>					
	2.4	3.0	-70		1.89
	2.4	1.8	-70		1.89
	18.0	18.6	-60		5.14
	18.0	19.2	-60		5.14
	21.0	21.6	-60		4.15

**Table 14-31 Mixer Linearity**

Test No. & Description	Max. Specs. (dBc)	Results	Measurement Uncertainty ( $\pm$ dB)
<b>5. Mixer Linearity</b>			
	0.4		0.24

**Table 14-32 Phase Noise and Spurs Downconverter**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>8. Phase Noise and Spurs</b>					
<b>Downconverter</b>					
<b>Phase Noise</b>					
	2.4	10 Hz	-30		2
	2.4	100 Hz	-70		2
	2.4	1 kHz	-108		2
	2.4	10 kHz	-133		2
	2.4	100 kHz	-143		2
	2.4	1 MHz	-147		2
	2.4	40 MHz	-147		4
<b>Spurious</b>					
	2.4	100 Hz	-30		2
	2.4	1 kHz	-70		2
	2.4	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>
<b>Phase Noise</b>					
	9.6	10 Hz	-20		2
	9.6	100 Hz	-60		2
	9.6	1 kHz	-100		2
	9.6	10 kHz	-125		2
	9.6	100 kHz	-136		2
	9.6	1 MHz	-140		2
	9.6	40 MHz	-140		4
<b>Spurious</b>					
	9.6	100 Hz	-20		2
	9.6	1 kHz	-20		2
	9.6	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>

Performance Tests  
**Test 9 - AM Noise and Spurs (RF)**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>8. Phase Noise and Spurs (cont.)</b>					
<b>Downconverter</b>					
<b>Phase Noise</b>					
	25.8	10 Hz	-12		2
	25.8	100 Hz	-52		2
	25.8	1 kHz	-92		2
	25.8	10 kHz	-117		2
	25.8	100 kHz	-129		2
	25.8	1 MHz	-131		2
	25.8	40 MHz	-131		4
<b>Spurious</b>					
	25.8	100 Hz	-14		2
	25.8	1 kHz	-54		2
	25.8	$\geq$ 10 kHz	-60		2 or 4 <sup>1</sup>

**Table 14-33** *Am Detector Noise Floor*

Test No. & Description	Carrier Frequency (MHz)	Offset	Max. Specs. (dBc)	Results Attach AM-Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>7. AM Detector Noise Floor</b>					
	600	1 Hz	-108		2
	600	10 Hz	-118		2
	600	100 Hz	-128		2
	600	1 kHz	-138		2
	600	10 kHz	-145		2
	600	100 kHz	-155		2
	600	40 MHz	-155		4

Performance Tests  
 Test 9 - AM Noise and Spurs (RF)

**Table 14-34 HP 70428/002 .05ppm/V Tuning**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>8. Phase Noise and Spurs</b>					
HP70428/002					
.05ppm/V tuning					
<b>Phase Noise</b>					
	2.4	10 Hz	-73		2
	2.4	100 Hz	-92		2
	2.4	1 kHz	-112		2
	2.4	3 kHz	-112		2
	2.4	5 kHz	-114		2
	2.4	10 kHz	-124		2
	2.4	100 kHz	-124		2
	2.4	1 MHz	-130		2
	2.4	10 MHz	-142		2
	2.4	40 MHz	-142		4
<b>Spurious</b>					
	2.4	All	N/A		N/A
<b>Phase Noise</b>					
	9.6	10 Hz	-65		2
	9.6	100 Hz	-85		2
	9.6	1 kHz	-112		2
	9.6	3 kHz	-115		2
	9.6	5 kHz	-117		2
	9.6	10 kHz	-124		2
	9.6	100 kHz	-130		2
	9.6	1 MHz	-134		2
	9.6	10 MHz	-140		2
	9.6	40 MHz	-140		4

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>Spurious</b>					
	9.6	100 Hz	-40		2
	9.6	1 kHz	-40		2
	9.6	$\geq 10$ kHz	-70		2 or 4 <sup>1</sup>

**Table 14-35 HP 70428A/002.05ppm/V Tuning**

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach $\phi$ -Noise Plot	Measurement Uncertainty ( $\pm$ dB)
<b>8. Phase Noise and Spurs HP 70428/002.05ppm/V tuning</b>					
<b>Phase Noise</b>					
	25.8	10 Hz	-57		2
	25.8	100 Hz	-77		2
	25.8	1 kHz	-105		2
	25.8	3 kHz	-108		2
	25.8	5 kHz	-110		2
	25.8	10 kHz	-117		2
	25.8	100 kHz	-123		2
	25.8	1 MHz	-127		2
	25.8	10 MHz	-131		2
	25.8	40 MHz	-131		4
<b>Spurious</b>					
	25.8	100 Hz	-34		2
	25.8	1 kHz	-34		2
	25.8	$\geq 10$ kHz	-60		2 or 4 <sup>1</sup>

Performance Tests  
 Test 9 - AM Noise and Spurs (RF)

**Table 14-36** *AM Noise And Spurs*

Test No. & Description	Carrier Frequency (GHz)	Offset	Max. Specs. (dBc)	Results Attach AM-Noise Plot	Measurement Uncertainty (±dB)
<b>9. AM Noise and Spurs</b>					
<b>AM Noise</b>					
	12.6	1 Hz	-92		2
	12.6	10 Hz	-102		2
	12.6	100 Hz	-109		2
	12.6	1 kHz	-125		2
	12.6	10 kHz	-135		2
	12.6	100 kHz	-145		2
	12.6	1 MHz	-147		2
	12.6	40 MHz	-147		4
<b>Spurious</b>					
	12.6	100 Hz	-50		2
	12.6	≥ 1 kHz	-70		2 or 4 <sup>1</sup>

## Adjustments

---

### NOTE

---

(To be done at the Periodic Maintenance interval or when the LO Power Amplifier, Preamplifier or harmonic generator has been replaced.)

### Introduction

#### Equipment

The following equipment is required for the YTF Power Calibration.

Sensor..... HP 8485A

Power Meter..... HP 70100A or HP 437A/B

Source..... HP 8662A or HP 8663A\*

\*(Used for Option 002 Calibration Only)

#### Check "Power Meter" type and address:

Before beginning the internal power calibration(s) insure the Device Under Test (DUT) is set properly to control the Power Meter to be used. Use the following softkey sequence to do this:

*Service*

*Misc*

*Pwrmttr Type*

*HP437A/B or HP70100A*

---

### NOTE

---

If you selected HP437A/B, continue by selecting the HP-IB address with the key sequence below. If you selected HP 70100A, you are done setting up the Power Meter.

*HP-IB ADDRESS*

NN (address of the Power Meter. Range= 1 to 30)

*ENTER*

#### Check "RF Source" type and address:

This section maybe skipped if the DUT does not have Opt 002 installed. Otherwise insure that the DUT is configured properly to control the RF Source during the Opt 002 Power Cal. First set the DUT to "Tunable Source"

mode. Then configure the DUT for the RF Source by using the following softkey sequence:

*Service*

*Misc*

*RF Source*

*HP 8662A or HP 8663A or Other*

---

**NOTE**

If you selected HP 8662A or HP 8663A, continue by selecting the HP-IB address with the key sequence below. If you selected Other, the RF Source is not controlled over HP-IB, so you may skip the remaining soft key sequence listed below. However, you must manually setup the RF Source. Set frequency to 600 MHz, power to +5.0 dBm, and turn off all modulation. Verify that the RF Source is within 1 dB of the desire level by using a power meter.

*HP-IB ADDRESS*

NN (address of the RF Source. Range= 1 to 30)

*ENTER*

**Frequency Cal:**

1. Begin the self calibration of the YTF, by pressing the following softkeys:

*Service*

*YTF Cal*

*YTF1 Freq*

2. The process takes approximately 10 minutes to complete. Once complete, the unit will have accurately determined the tuning of the YTF to select any comb line between 2.4 GHz and 26.4 GHz.

**Power Cal:**

1. Connect the equipment as shown:

---

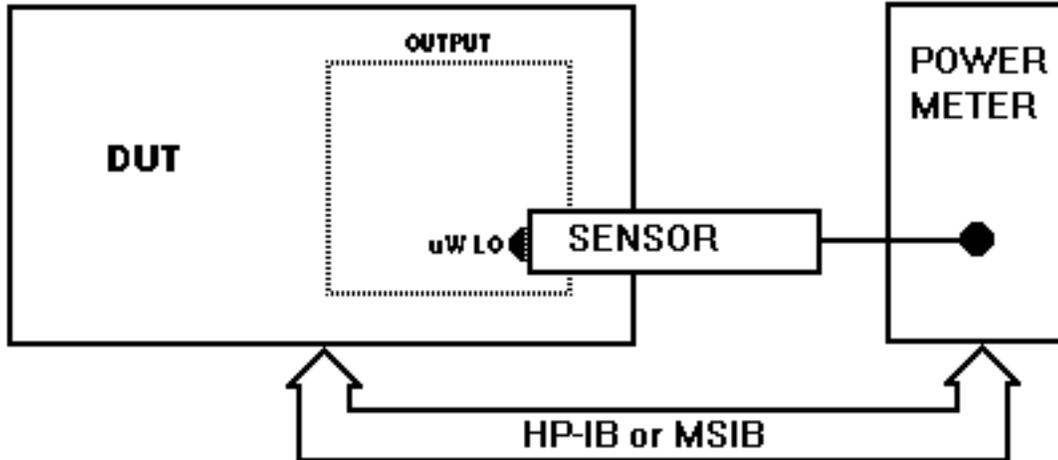
**NOTE**

a: The UUT is connected to the Power Meter via the MSIB for the HP 70100A or via HP-IB for the HP 437A/B.

---

**NOTE**

b: The sensor is connected to the  $\mu$ W LO Output with only the f-f adapter, HP part number 5061-5311 or equivalent.



*Figure 15-1 Power Meter to DUT Connection*

2. Begin the self calibration of the YTF, by pressing the following softkeys:

*Service*

*YTF Cal*

*YTF1 Power*

3. The process takes about 15 minutes. Once complete, the unit will have accurately determined the detector calibration to set output power.

### **Option 002 Frequency Cal:**

1. Begin the self calibration of YTF2, by pressing the following softkeys:

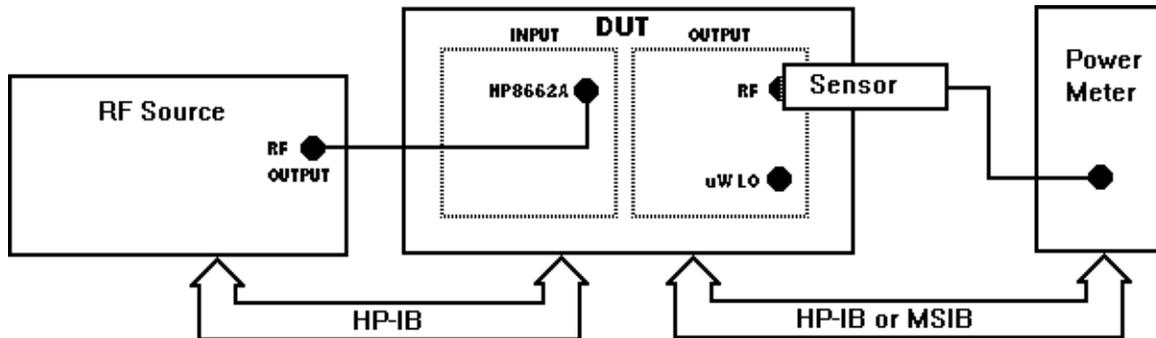
*Service*

*YTF Cal*

*YTF2 Freq*

2. The process takes approximately 10 minutes to complete. Once complete, the unit will have accurately determined the current settings of the YTF to select any frequency between 2.4 GHz and 26.5 GHz.

**Option 002 Power Cal:** 1. Connect the equipment as shown:



*Figure 15-2 Option 002 Power Call Connection*

---

**NOTE**

---

The DUT is connected to the Power Meter via the MSIB for the HP 70100A but via HP-IB if the HP 437A/B is used.

---

**NOTE**

---

The sensor is connected to the RF Output if the HP 70428A Option 002 Option 002 with only the F-F adapter, HP part number 5061-5311 or equivalent.

2. Begin the power calibration of YTF2, by pressing the following softkeys:

*Service*

*YTF Cal*

*YTF2 Power*

3. The process takes approximately 15 minutes to complete. Once complete, the unit will have accurately determined the detector calibration to set output power.

---

## Lo Amplifier Bias Adjustments

---

### NOTE

---

(To be done when the LO Power Amplifier, LO Pre Amplifier or YIG Driver Assembly have been changed)

### Description

Bias Adjustments for the LO Power Amplifier and LO Pre Amplifier reside on the YIG Driver assembly. If these adjustments are done because of a repair, they should be done prior to any Internal Power Calibrations. In addition, if these adjustments are performed as a result of replacing the LO Power Amplifier, or LO Pre Amplifier, the Internal Power Calibrations must be done afterward to assure that the instrument can set power correctly. For a unit with Option 002 there are two YIG Driver assemblies and two sets of Amplifiers. In this case A9 should be adjusted first and A8 second. Note that no external voltmeter is need for these adjustments. The instrument uses it's own internal voltmeter to display readings made during adjustment of each of the six amplifier stages.

### Procedure

1. Before performing adjustments, press the green [INSTR PRESET] key.
2. Go to the Latch Control Screen by pressing the following screen keys:  
*Service*  
*Hardware Control*
3. Set the Hardware Control screen to allow control of the YIG driver assembly as follows: Press **BLOCK** until **YIG Tuned Filter** appears. Or if you have an Option 002 equipped unit determine if you are adjusting YIG1 (right most) or YIG2 (left most) and press **BLOCK** until **YIG Tuned Filtr1** or **YIG Tuned Filtr2** appear.
4. Now set the LO Amplifiers to maximum gain with the following key sequence:  
*LATCH NUMBER 6 ENTER*  
*LATCH DATA 4095 ENTER*
5. Locate the six adjustments on the YIG Tuned Filter Driver assembly according to the following figure. Push W56 to the side to allow access but do not disconnect W56 as this will cause the adjustments to be off slightly.

Adjustments  
 Lo Amplifier Bias Adjustments

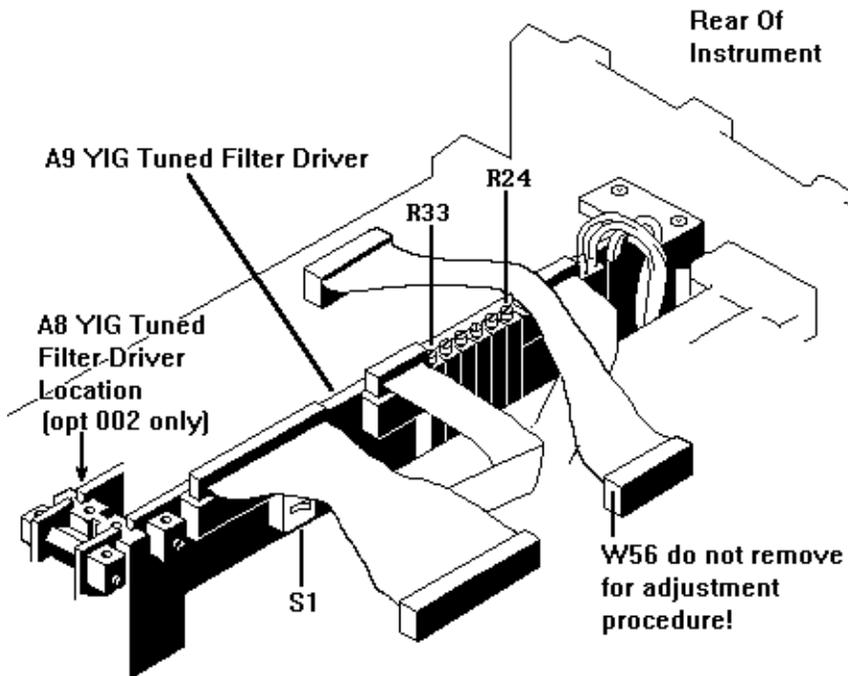


Figure 15-3 YIG Tuned Filter Driver Assembly

- Adjust each of the 6 stages of the LO Amplifiers as follows: Press the VOLT-METER key followed by the Key Sequence in the table below for each LO Amp Stage to be adjusted. Adjust the Pot listed, for the corresponding voltage shown in the VOLT column for each LO Amp Stage. As the Pot is adjusted it will be necessary to repeatedly press UPDATE DISPLAY to update the VOLT field of the display. The VOLT reading represents amplifier bias current in mA.

Table 15-1 Bias Current in MA

LO Amp Stage	Key Sequence	Pot	VOLT:
6th	12 ENTER	R24	150
5th	4 ENTER	R27	150
4th	8 ENTER	R29	100
3rd	0 ENTER	R34	100
2nd	14 ENTER	R32	100
1st	6 ENTER	R33	100

7. If it appears that the YIG Tuned Filter assembly voltages are not responding to adjustment, check the switch settings on the assembly for current positions. The assembly in the A9 slot should have S1 set to STD. The additional opt 002 assembly, the A8, should have S1 set to ALT. (Note the location of S1 in the previous figure.)

---

## 10 MHz Oscillator Adjustment

---

### NOTE

(To be done when the 10 MHz Oscillator is replaced or during periodic calibration.)

### Description

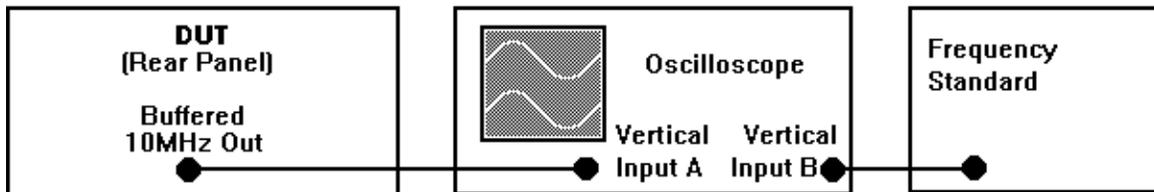
The rear panel 10 MHz output from the Device Under Test is compared against a frequency standard with a frequency error less than  $1 \times 10^{-8}$ . The frequency of the reference oscillator is fine tuned for a frequency error of less than  $1 \times 10^{-8}$  using the adjustment screw provide on the 10 MHz Reference Oscillator.

### Equipment

Oscilloscope..... HP 54600A  
Frequency Standard..... HP 5065A

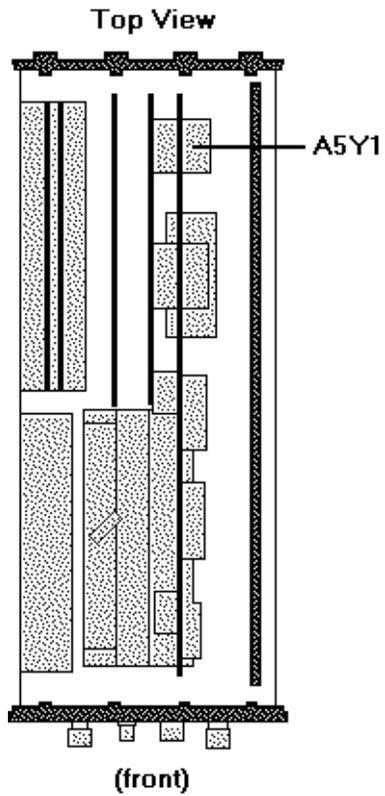
### Procedure

1. Let the instrument warm up for 30 minutes.
2. Connect the Test Setup below.



*Figure 15-4 10 MHz Oscillator Test Set UP*

3. Set up the oscilloscope as follows:
  - a. 10 ns/div
  - b. 0.25 V/div
  - c. Adjust the trigger level on the oscilloscope for reliable triggering of the vertical input B signal.



*Figure 15-5 Frequency Adjustment Access*

4. Remove cover.
5. Remove the adjustment cover screw on top of A5Y1 to allow access to frequency adjustment.
6. Adjust A5Y1 with a (non-metallic adjustment tool) so that the signal on "Input A" of the oscilloscope moves less than one cycle in 10 seconds.

Adjustments  
**10 MHz Oscillator Adjustment**

### Overview

This chapter tells how to install and operate the HP 7042X Service Manual-on-a-Disk.

The Service-Manual-on-a-Disk is a program that runs under Microsoft Windows® versions 3.0 or 3.1. See chapter 1 for the part numbers of the program disks.

---

### NOTE

The following discussion uses the HP 70427A in its examples. For the standard HP 70428A or the Option 002, substitute for "HP 70427A" the following:

For a standard HP 70428A substitute "HP 70428A".

For an Option 002 HP 70428A substitute "HP 70428T".

---

### Procedure

The program simulates an assembly-level repair manual in a Microsoft Windows® environment. Specifically, the manual includes:

- General Information (description, HP offices, warranty, etc.)
- Block Diagrams (including theory of operation)
- Troubleshooting (an expert system program)
- Service Helps (procedures for further troubleshooting)
- Disassembly (general service information, procedures, and drawings)
- Replaceable Parts (list and ordering instructions)

### System Requirements

- IBM PC running Microsoft Windows 3.0 or 3.1
- 7 MBytes hard drive space available
- 1.44 MByte 3.5 inch floppy drive
- Mouse or trackball
- VGA display (works best with 640 × 480 × 16 color VGA)

## Installing the Application

1. Run MS-DOS.
2. Change the source drive directory to the floppy disk drive (usually drive A or B). (For example, if you will be using floppy drive B, key in **B:** )
3. Insert the setup disk in the floppy disk drive.

4. Key in

```
SETUP <source drive>: <target drive>: \<target subdirectories>
```

- and press the **Enter** key. The "target directories" path is optional. (For example, if the source is floppy disk drive B and the target drive is C, key in `SETUP B: C:` and press the **Enter** key. If the source is floppy disk drive B and the target is subdirectory **MANUALS** on hard drive C, key in `SETUP B: C:\MANUALS` and press the **Enter key**.)

The setup program creates a directory **HP70427A** on the specified target drive (if needed), expands (or "melts") the compressed ("frozen") files on the source floppy disk, and copies or updates the files on the target drive.

If the target drive already contains an earlier version of this application, it is best to delete all the files in the application then run the Setup program.

Since the application occupies considerable space on the hard drive (7 MBytes), you may wish to delete the application from the hard drive and re-install it only when needed.

## Running the Application

1. Start Windows.
2. From the Program Manager, select **File** and **Run**
3. Key in full path name *<hard driv>* : `\HP70427A\HP70427A` and press the **Enter** key.

---

### NOTE

---

Alternatively, you can set up a program item in a program group for the application. (The icon file name is "HP70427A.ICO".)

The first screen that appears when this application is run is the Front Cover. To open the cover, move the pointer with the mouse to the button labeled **Open Manual** and click the left mouse button. The Table of Contents will appear from which other selections can be made using the mouse.

As with a paper-based manual, the application does not actually require the presence of the instrument it documents.

## Tips On Running the Application

If you are familiar with "navigating" around Window-based applications, this application should be intuitive. If you are not familiar with Windows, consult the documentation that came with Windows, or simply experiment. The following comments may also be helpful.

The application can be run without using the keyboard. This is the preferred method. Thus, a mouse or trackball is required.

In situations when the keyboard can be used, two methods apply.

When the desired function has an underlined letter, hold down the **Alt** key and press the corresponding letter on the keyboard.

Tab to the function, which will be faintly highlighted, and press the **Enter** key.

Most of the time there is a command button labeled *T of C*; it returns you to the Table of Contents screen. The button labeled *Back* returns you to the previous screen level.

On a few of the screens, boxes containing text will obliterate the view of the object the text is describing. To move the box, place the mouse pointer to the text box's title bar, press the left button on the mouse, move (or "drag") the box to a better location, and release the mouse button.

---

**NOTE**

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Windows is a trademark of Microsoft Corporation



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+10 Volt Precision Reference, 13-64

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