3048 MS

HP 3048A Option 301 Phase Noise Measurement System

Reference Manual

Volumes 1 & 2

HEWLETT PACKARD

Reference Manual HP Part 03048-90040
Other Documents Available:
Operating Manual HP Part 03048-90042
Calibration Manual HP Part 03048-90041
Installation Guide HP Part 03048-90043
Microfiche Calibration Manual HP Part 03048-90045
Microfiche Operation Manual HP Part 03048-90046
Microfiche Reference Manual HP Part 03048-90047

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Notice

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Software Versions

This manual applies directly to instruments with software version numbers:

HP 3048A Option 301 Software Version: REV: A.00.00

Printing History

First Edition: 11/90 - Printed in U.S.A.

Volume 1 Contents

Chapter 1, General Information

Chapter 2, Measurement Definitions

Chapter 3, Graphics Functions

Chapter 4, Computed Outputs

Volume 2 Contents

Chapter 5, Special Functions

Chapter 6, System Configuration

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Chapter 8, Messages

General Information 1

Introduction

This *Reference Manual* helps you understand the measurement techniques and how to perform the advanced operating features of the HP 3048A Phase Noise Measurement System.

This chapter contains general information about the HP 3048A Option 301 -- a description, its options, and its specifications.

Software Operation

With the HP 3048A Option 301 Main Menu displayed on your computer, use the following operating instructions.

1. Select a Main Menu item using one of two methods:

   a. Press the first capitalized letter of the item you want.

   b. Use the △ or ▽ keys to move the inverse video box over the item you want, then press the **ENTER** key.

2. When a Main Menu item is selected, a pop-up window or diagram is superimposed over the Main Menu to provide you with further selections, or with entry fields or diagrams for input.

3. More pop-up windows may appear as you make selections. Press the **ESC** (escape) key to return to the previous window.

   To reduce keystrokes as you move between windows or diagrams, press and hold the **Alt** key, and then the first capitalized letter of the Main Menu item that you want.

4. To abort a measurement, press the **CNTL** and **BREAK** keys simultaneously. The measurement will stop and the software will return to the Main Menu.

5. To print a hard copy of a phase noise graph and the parameter summary, press **SHIFT** and **F4** simultaneously.

6. At the Main Menu level, you may press the **Q** key to exit the HP 3048A Option 301 software.

Software and Documentation Update Service

Software and documentation updates are available to provide the most current information about the HP 11838A Option 301.

Software Updates

The software supplied with your order is as accurate and up-to-date as possible at the time of shipment. However, new revisions are released periodically to correct software bugs and to enhance software operation. To keep you informed of the most current software status, Hewlett-Packard now offers a Software Status Bulletin. The Software Status Bulletin is free-of-charge and will provide you with current information on software bugs and fixes, software revision levels, and availability of software updates.

Documentation Updates

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NOTE

The update service applies only to the product referred to in this manual.

Software Notice

Use of the manuals and flexible disks supplied for this software product is strictly restricted to this product only. The software products are copyrighted with all rights reserved and may not be copied except for archive storage, to replace a defective copy, or for program error verification. The software may also be copied to other disk systems, such as a hard disk drive, for operating purposes.

Resale of the programs in their present form, or with alterations is expressly prohibited.

HP 3048A Description

The HP 3048A provides you with a standard process for measuring phase noise. It allows you to measure sources of many types with a flexible system configuration.

The HP 3048A Phase Noise Measurement System includes:

- **The HP 11848A Phase Noise Interface** is an interface specifically designed for high performance phase noise measurements. The HP 11848A supports several measurement techniques for phase noise and AM noise measurements. Built into the interface are the necessary phase detectors, amplifiers, filters, and switches to measure phase noise over a frequency range of 5 MHz to 18 GHz. An input for an external phase detector outside the above mentioned frequency range is also provided. Internal sources are provided to allow the test system to functionally check all of its signal handling circuits to ensure proper operation prior to making a measurement.

- **The HP 3561A Dynamic Signal Analyzer** is a Fast Fourier Transform analyzer with a wide frequency range (125 μHz to 100 kHz). The HP 3561A has built-in data averaging capabilities, large dynamic range, and fast measurement speed to make it ideal for quantifying demodulated phase noise (noise voltages).

- **Operator's Training,** an operator's training course that explains all of the operating modes and measurement techniques of the HP 3048A, when each technique is appropriate, and how to analyze the measured data.

The HP 3048A reduces the difficulty of making accurate phase noise measurements. The HP 3048A allows you to make phase noise measurements using a phase detector in a phase-locked loop configuration, a phase detector without a phase-locked loop, or with an FM discriminator.

Each method allows the measurement results to be plotted as phase noise ($\mathcal{L}(f)$ or $S_\phi(f)$), or frequency noise ($S_y(f)$ or $S_\nu(f)$) over an offset range of 1 mHz to 100 kHz (or to 40 MHz with a supported RF Analyzer).

By using an external crystal detector, the HP 3048A can automatically quantify the level of AM noise that could affect a phase noise measurement.

The HP 3048A allows you to measure and plot the results of noise voltage measurements.

The test system also allows you to calculate from measured data (from the *Manipulate Results* window):

- Sigma vs Tau (Allan Variance)
- Integrated Noise
- 2 or 3 Oscillator Comparisons
- Spur Listings

HP 3048A Configuration

The HP 3048A can be configured many different ways to optimize its operation for specific applications. All configurations of this test system must include the HP 3048A's basic components and a desktop computer. The following information helps you match your applications to the optimum test system configuration.

HP 3048A Reference Source Options

- **Option 001 adds the HP 8662A Opt. 003 Synthesized Signal Generator** as a 10 kHz to 1280 MHz reference source.

- **Option 002 adds the HP 8663A Opt. 003 Synthesized Signal Generator** as a 100 kHz to 2560 MHz reference source

- **Option 003 adds the HP 11729C Carrier Noise Test Set** as a 5 MHz to 18 GHz down converter to the test system (requires an HP 8662A Opt. 003 or HP 8663A Opt. 003 as its reference source).

- **Option 004 adds the HP 11729C Opt. 130 Carrier Noise Test Set** as a 5 MHz to 18 GHz down converter to the test system (requires an HP 8662A Opt. 003 or HP 8663A Opt. 003 as its reference source).

- **Option 005 adds the HP 8642A Opt. 001 Synthesized Signal Generator** as 100 kHz to 1057 MHz reference source.

- **Option 006 adds the HP 8642B Opt. 001 Synthesized Signal Generator** as 100 kHz to 2115 MHz reference source.

HP 3048A Spectrum Analyzer Options

- **Option 101 adds the HP 3585B Spectrum Analyzer** to extend the test system's offset measurement range from 100 kHz to 40 MHz. The HP 3585A/B is required to generate new HIGHDATA.CAL. HIGHDATA.CAL can be verified and corrected by any supported RF Analyzer by performing the Noise Flatness test in the *HP 3048A Option 301 System Calibration Manual*.

- **Option 110 deletes HP 3561A Dynamic Signal Analyzer** from the test system for replacement by the user. (The HP 3048A will not operate without the HP 3561A. Option 110 allows a customer-owned HP 3561A to be integrated into the HP 3048A. The HP 3561A must meet its specifications for the HP 3048A test system specifications to be warranted.)

HP 3048A System Options

- **Option 201 adds the 1.6 to 18 GHz Phase Detector to the HP 11848A Phase Noise Interface** for microwave phase noise measurements without a down converter.

- **Option 202 adds the System Rack** with built-in signal cabling, fan and power module (includes racking hardware and installation of the HP 11848A, HP 3561A, and any HP 3048A instrument options).

- **Option 301 deletes the BASIC system software** and adds the IBM$^{(R)}$ PC AT/XT compatible system software.

- **Option 910 adds an extra HP 3048A Manual Set** to the system. This includes the following manuals: HP 11848A Service Manual (11848-90004), HP 3048A Option 301 Operating Manual (03048-90042), HP 3048A Option 301 Calibration Manual (03048-90041), HP 3048A Option 301 Reference Manual (03048-90040), and HP 3048A Option 301 Installation Guide (03048-90043).

Desktop Computers

The HP 3048A Option 301 Software runs on any IBM PC-AT/XT compatible computer using the MS-DOS(R) 3.0 or later operating system. The software requires a minimum of 640 kilobytes of RAM, and a $5\frac{1}{4}$-inch 1.2 Mbyte floppy disk drive. An EGA compatible display is required.

Computer Accessories

A General Purpose Interface Bus (GPIB) drive card is required to control the instruments in the test system, and may be used to control the unit-under-test (UUT). The HP 3048A Option 301 software supports only two GPIB interface cards, the Hewlett-Packard 82335A and the National Instruments PC-II/IIA.

Printers/Plotters

- **Any GRAFPLUS™ supported printer** may be used for plotting graphs and documenting tests.

Spectrum Analyzers

The addition of any of the following Spectrum Analyzers extends the offset range to 40 MHz.

- **HP 3585A/B 20 Hz to 40 MHz Spectrum Analyzer** provides Tracking Generator output needed to generate HIGHDATA.CAL for calibration of the HP 3048A from 100 kHz to 40 MHz. (All supported spectrum analyzers can be used to verify or modify HIGHDATA.CAL.)
- **HP 8560A 50 Hz to 2.9 GHz Spectrum Analyzer**
- **HP 8561B 50 Hz to 6.5 GHz Spectrum Analyzer**
- **HP 8562A/B 1 kHz to 22 GHz Spectrum Analyzer**
- **HP 8568A/B 100 Hz to 1500 MHz Spectrum Analyzer**
- **HP 8567A 10 kHz to 1500 MHz Spectrum Analyzer**
- **HP 8566A/B 100 Hz to 22 GHz Spectrum Analyzer**
- **HP 71100A/C 100 Hz to 2.9 GHz Spectrum Analyzer**
- **HP 71210C 100 Hz to 22 GHz Spectrum Analyzer**

HP 3048A System and Option Specifications

The HP 3048A System specifications and Option specifications are listed in table 1-1 and table 1-2 respectively. Specifications describe the instrument's warranted performance. Supplemental characteristics are intended to provide information useful in applying the instrument by giving typical, but not warranted performance parameters. These supplemental characteristics are denoted as "typical," "nominal," or "approximate."

National Institute of Standards and Technology

Measurement of phase noise is a ratio measurement where both the numerator (the noise power) and the denominator (the carrier's power) of the ratio are measured by the same test system spectrum analyzer(s). The accuracy of this relative measurement depends on the amplitude linearity of the spectrum analyzer. The amplitude linearity calibration of the spectrum analyzer is be traceable to the National Institute of Standards and Technology (NIST) if the instruments used to perform the calibration are traceable to NIST.

Table 1-1. HP 3048A System Specifications (1 of 4)

HP 3048A System Specifications

PHASE DETECTOR PORTS

Frequency

Range: 5 MHz to 1.6 GHz (low-frequency inputs)
Additional Range with Option 201: 1.2 to 18 GHz (high-frequency inputs) (The frequency range can be extended with a customer-supplied phase detector or frequency discriminator.)

Amplitude

	Low-Frequency Inputs		High-Frequency Inputs	
	L in	R in	L in	R in
Maximum Signal (dBm)	+23	+23	+10	+5
Minimum Signal (dBm)	+15	0	+7	+0

Offset Frequency Range

0.01 Hz to 40 MHz for carriers from 95 MHz to 18 GHz
0.01 Hz to 2 MHz for carriers from 5 MHz to 95 MHz
(Assumes addition of 40 MHz spectrum analyzer to the system, otherwise offset range limited to 100 kHz.)

Accuracy (measurement of all noise and spurious present at the two inputs to the phase detector and system contribution):

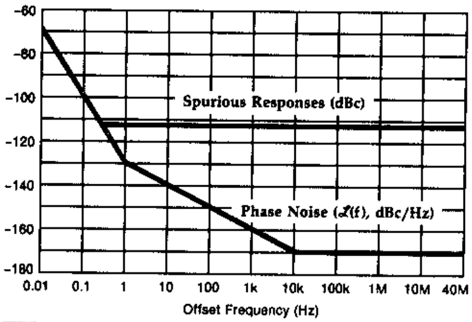
±2 dB for 0.01 Hz to 1 MHz offsets
±4 dB for 1 MHz to 40 MHz offsets

In order for the HP 3048A to meet its accuracy specifications, the following qualifications must be met:

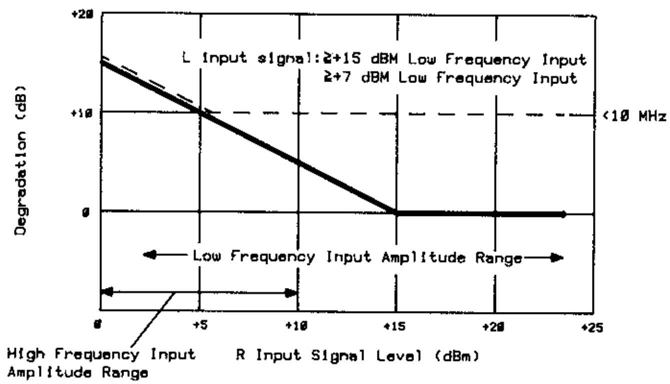
- Source return loss >9.5 dB (<2 : 1 SWR)
- Source harmonic distortion <−20 dB (or a square wave)
- Nonharmonic spurious, except for phase modulation close to the carrier, ≤−26 dBc

Table 1-1. HP 3048A System Specifications (2 of 4)

System Phase Noise and Spurious Responses
(Does not include phase noise and spurious signals from a reference source.)



System Noise and Spurious Response Increase with Input Level Decrease



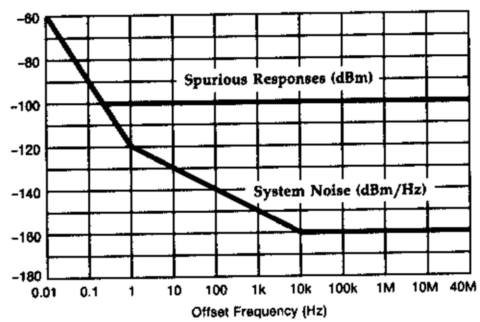
To determine system noise and spurious response levels, find the dB degradation at the signal input level from the lower graph and add to the curves of the upper graph. For example, if a +15 dBm signal is applied to the Low Frequency L Input and a +5 dBm signal to the R Input, the degradation is +10 dB. Therefore, the specified maximum spurious signal level increases from −112 to −102 dBc at all offset frequencies and the system's maximum noise level at >10 kHz offset frequencies increases from −170 to −160 dBc/Hz.

NOISE INPUT PORT

(For use with external phase detector or frequency discriminator)

Frequency: 0.01 Hz to 40 MHz
Amplitude: 1 Volt peak maximum
Typical Input Impedance: 50Ω; return loss >9.5 dB (<2:1 SWR)
Accuracy: External phase detector or frequency discriminator measurements calibrated with ±1 dB accurate signals.
±2 dB for 0.01 Hz to 1 MHz offsets
±4 dB for 1 MHz to 40 MHz offsets

System Noise and Spurious Responses



TUNING VOLTAGE OUTPUT

Voltage Range: ±10 volts
Current: ±20 mA maximum
Output Impedance: 50Ω nominal

SOURCE OUTPUT TYPICAL PERFORMANCE

10 MHz Source A
Amplitude: +15 dBm
Tuning: ±100 Hz

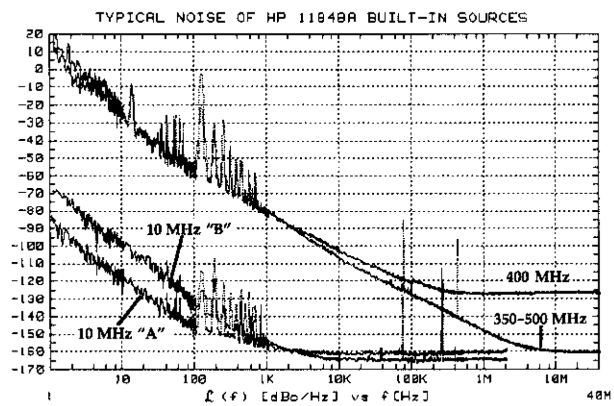
10 MHz Source B
Amplitude: +6 dBm
Tuning: ±1 kHz

350-500 MHz
Amplitude: +17 dBm

400 MHz
Amplitude: −5 dBm
Tuning: Fixed Frequency

Table 1-1. HP 3048A System Specifications (4 of 4)

Typical Noise and Spur Levels



Power Requirements: Between 190 and 900 VA depending on options included; 48 to 66 Hz; 100V, 110V, 220V, 240V (+5%, −10% of line voltage)

Operating Temperature Range: +0°C to +55°C

EMI: Satisfies level B of VDE specification 0871

General Considerations: The HP 3048A has low susceptibility to RFI and mechanical vibration. Care must be exercised however in making measurements in high RFI or mechanical vibration environments as spurious signals may be induced in the system.

Warm-up time: The HP 3048A will meet specification 20 minutes after turn-on.

Size: The HP 3048A system is composed of individual instruments that vary in size. Each instrument's individual specifications should be consulted for its dimensions. The HP 11848A Phase Noise Interface is approximately 146 H × 425 W × 593 D cm (5.7 × 16.8 × 23.3 inches).

Weight: Net weight varies from 31 to 275 kg (68 to 603 lbs) depending on the options ordered. Shipping weight varies from 42 to 347 kg (93 to 758 lbs).

HP 3048A Option Specifications

The HP 3048A can be ordered with any of several optional signal generators as a reference source for phase noise measurements. The following specifications address system operation with these signal generators. The data that follows is in addition to that given previously under the heading of HP 3048A System Specifications. Refer to the data sheet for each signal generator for more complete information on each model.

OPTIONS 001 OR 002: ADDING THE HP 8662A OR 8663A SIGNAL GENERATOR

The following data applies only if either the HP 8662A Opt. 003 or 8663A Opt. 003 is used as the reference source to demodulate the test signal.

Frequency

Range: 100 kHz to 1280 MHz (to 2560 MHz with HP 8663A).[1]

Resolution: 0.1 Hz, 0.2 Hz: 640 to 1280 MHz, 0.4 Hz above 1280 MHz.

Accuracy and Stability (internal 10 MHz quartz oscillator): Aging rate $<5 \times 10^{-10}$/day after 10-day warm-up (typically 24 hrs in normal operating environment).

EFC: Provides a drift tracking range of $\pm 10^{-8}$ with no degradation of phase noise or spurious.

[1] Measurements <5 MHz require external phase detector.

Table 1-2. HP 3048A System Option Specifications (2 of 9)

Spectral Purity[2]

Absolute Phase Noise

	Frequency Range (MHz)											
	0.01 to 119.9[1]		120 to 159.9[2]		160 to 319.9[2]		320 to 639.9[2]		640 to 1279.9[3]		1280 to 2559.9[4]	
	spec	typ	spec	typ	spec	typ	spec	typ	spec	typ	spec	typ
1 Hz	−68	−78	−66	−76	−60	−70	−54	−64	−48	−58	−42	−52
10 Hz	−98	−108	−96	−106	−90	−100	−84	−94	−78	−88	−72	−82
100 Hz	−116	−126	−115	−125	−109	−119	−103	−114	−97	−108	−92	−102
1 kHz	−126	−132	−129	−135	−124	−130	−118	−125	−112	−119	−106	−113
3 kHz	−126	−135	−129	−138	−124	−133	−118	−127	−112	−121	−106	−115
5 kHz	−128	−138	−131	−141	−126	−136	−120	−130	−114	−124	−108	−118
10 kHz	−132	−138	−142	−148	−136	−142	−131	−136	−124	−130	−118	−124
100 kHz	−132	−139	−142	−148	−136	−142	−131	−136	−124	−130	−118	−124

[1]*Specifications extend up to and including 119.9999999 MHz.*

[2]*Specifications extend up to and including 0.1 Hz less than the starting frequency of the next band.*

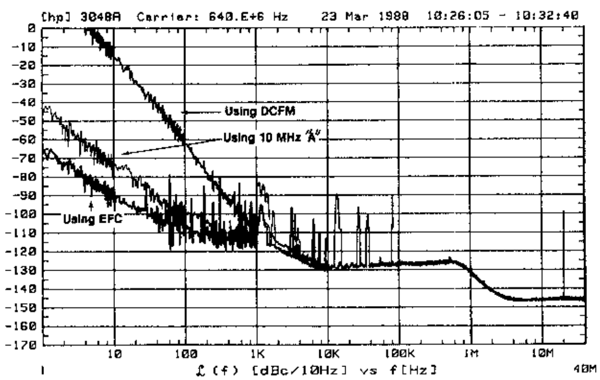
[3]*Specifications extend up to and including 1279.9999998 MHz.*

[4]*Specifications extend up to and including 2559.9999996 MHz.*

Typical HP 8662A/8663A Phase Noise

(With DCFM, 10 MHz "A" and EFC tuning)

The absolute phase noise of the HP 8662A and HP 8663A is dependent on the tuning mode used to control the PLL.



Spurious Signals

	Frequency Range (MHz)					
	0.1 to 120	120 to 160	160 to 320	320 to 640	640 to 1280	1280 to 2560
Spurious nonharmonically related[1]	−90 dBc	−100 dBc	−96 dBc	−90 dBc	−84 dBc	−78 dBc
Subharmonically related (1/2, 3f/2, etc.)	none	none	none	none	−70[2] dBc	−40 dBc
Power line (60 Hz) related to microphonically generated (within 300 Hz)[3]	−90 dBc	−85 dBc	−80 dBc	−75 dBc	−70 dBc	−65 dBc
Harmonics	≤30 dBc					

[1] In the remote mode it is possible to have microprocessor clock-related spurious signals spaced 3 MHz apart at an absolute level of typically less than −145 dBm.

[2] 3/2 spurs not specified for HP 8662A carrier frequencies above 850 MHz.

[3] At a 50 Hz line frequency, powerline or microphonically related spurious signals may be up to 3 dB higher and appear at offsets as high as 1 kHz from the carrier.

Amplitude

Typical Maximum Output Level: +16 dBm

Modulation

Modulation Types: FM, AM (Pulse with the HP 8663A)

FM Deviation

Center Frequency (MHz)	Maximum Peak Deviation dc FM (kHz)
0.1 – 120	100
120 – 160	25
160 – 320	50
320 – 640	100
640 – 1280	200
1280 – 2560*	400

*HP 8663A Option 003 only

Indicated FM Accuracy: ±8% (7% for HP 8663A) of reading plus 10 Hz (50 Hz to 20 kHz rates).

Input Impedance: HP 8662A: 1kΩ nominal, HP 8663A: 600Ω.

Maximum Input Level: 1V peak for specified accuracy.

Temperature Range: +15° to 35°C.

OPTIONS 003 OR 004: ADDING THE HP 11729C OR 11729C OPT 130 CARRIER NOISE TEST SET

The following data is applicable to using the HP 11729C to downconvert the test signal to an IF of between 5 MHz and 1280 MHz for subsequent demodulation using the Low Frequency phase detector of the HP 3048A system. The HP 8662A Opt. 003 or 8663A Opt. 003 Signal Generators provide a 640 MHz reference signal for this downcoversion process. These signal generators also provide a signal of between 5 MHz to 1280 MHz to demodulate the downconverted IF noise. The specifications that follow assume this measurement set-up is used.

Input Requirements

Frequency

Measurement Frequency Range: 5 MHz to 18 GHz in 8 bands, excluding ±5 MHz around band center frequencies.

Band Center Frequencies: 1.92 GHz, 4.48 GHz, 7.04 GHz, 9.60 GHz, 12.16 GHz, 14.72 GHz, 17.28 GHz.

Amplitude

For carrier frequencies <1.28 GHz: −5 dBm minimum to +23 dBm maximum.

For carrier frequencies >1.28 GHz: +7 dBm minimum to +20 dBm maximum.

Measurement Specifications

Offset Frequency Range

For carriers between 5 and 95 MHz from band centers: 0.01 Hz to 2 MHz.

For carriers >95 MHz from band center: 0.01 Hz to 40 MHz.

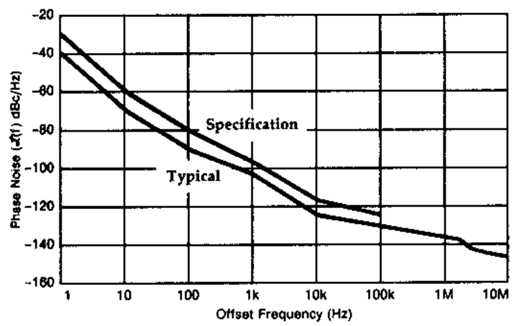
(Assumes addition of 40 MHz spectrum analyzer to the system, otherwise offset frequency range limited to 100 kHz.)

System Noise Floor[3]

Absolute System Noise Floor (dBc/Hz), when used with the HP 11729C and HP 8662A Option 003 or HP 8663A Option 003 as the reference source, phase locking via the signal generator's EFC.

[3] Specified only with FM off.

Table 1-2. HP 3048A System Option Specifications (5 of 9)



		Offset from Carrier (Hz)						
		1	**10**	**100**	**1k**	**10k**	**100k**	**1M**
0.1 to 1280 MHz		*See HP 3048A Option 001 or 002, Absolute Phase Noise table.*						
1280 to 3200 MHz	**Typ.**	-53	-83	-103	-115	-129	-130	-140
	Spec.	-43	-73	-93	-108	-124	-126	
3.2 to 5.76 GHz	**Typ.**	-47	-77	-97	-109	-127	-130	-138
	Spec.	-37	-67	-87	-104	-123	-126	
5.76 to 8.32 GHz	**Typ.**	-43	-73	-93	-105	-125	-129	-135
	Spec.	-33	-63	-83	-100	-121	-125	
8.32 to 10.88 GHz	**Typ.**	-40	-70	-90	-102	-123	-129	-134
	Spec.	-30	-60	-80	-97	-119	-125	
10.88 to 13.44 GHz	**Typ.**	-38	-68	-88	-100	-122	-128	-132
	Spec.	-28	-58	-78	-95	-118	-125	
13.44 to 16.0 GHz	**Typ.**	-37	-67	-87	-99	-121	-127	-131
	Spec.	-27	-57	-77	-94	-116	-124	
16.0 to 18.0 GHz	**Typ.**	-35	-65	-85	-97	-119	-127	-129
	Spec.	-25	-55	-75	-92	-115	-123	

System Spurious
System spurious signals in the HP 3048A Options 003 or 004 arise in three ways. First, from the detection and baseband signal processing, <−104 dBc for offsets greater than 0.2 Hz from the carrier. Second, any line-related or other spurious signals on the HP 8662A or 8663A outputs are translated to the noise spectrum output. Third, the downconversion process gives rise to system spurious signals whose frequency and level are determined by the relation between the test signal frequency and the band center frequency. The presence of system spurious signals does not affect the typical measurement of random noise.

AM Noise Detection
The HP 3048A can be used for AM noise measurements using either an external AM detector or the AM detector built-in to the HP 11729C Option 130 (ordered as Option 004 of the HP 3048A). AM measurements with the HP 11729C Option 130 can be made with a typical sensitivity of −165 dBc/Hz at a 1 MHz offset.

OPTION 005 OR 006: ADDING THE HP 8642A OPT. 001 OR 8642B OPT. 001 SIGNAL GENERATOR

The following data applies only if the HP 8642A Opt. 001 or 8642B Opt. 001 is used as the reference source

Frequency

Range: 100 kHz to 1057.5 MHz (to 2115 MHz with the HP 8642B)[4]
Opt. 001 Stability: $<10^{-9}$/day aging after 8 days warm-up.

[4] Measurements <5 MHz require external phase detector.

Spectral Purity

Absolute Phase Noise[5]

Carrier Frequency Band	SSB Phase Noise 20 kHz Offset dBc/Hz	SSB Phase Noise Floor 200 kHz Offset dBc/Hz
1057.5 – 2115*	−125	−134
528.7 – 1057.5	−134	−144
264.3 – 528.7	−137	−144
132.1 – 264.3	−141	−144
66.0 – 132.1	−144	−145
33.0 – 66.0	−145	−145
16.5 – 33.0	−146	−147
8.2 – 16.5	−147	−148
4.1 – 8.2	−148	−149
0.1 – 4.1	−137	−138
0.1 – 132.1 HET	−125	−137

* HP 8642B only.

Spurious

Type of Spurious	0.1 to 1052.5 MHz	1057.5 to 2115 MHz[1]
Harmonics Output Level ≤+10 dBm Output Level ≤+16 dBm	 −30 dBc −20 dBc	 −25 dBc −20 dBc
Subharmonics	none	−45 dBc
Nonharmonics, >10 kHz from the carrier	−100 dBc[2]	−94 dBc

[1] HP 8642B only. [2] Not specified in HET band.

Typical SSB AM Noise Floor at 200 kHz Offset, +16 dBm Output Power:

<−157 dBc/Hz, 4.13 to 1057 MHz
<−150 dBc/Hz, 1057 to 2115 MHz

[5] Specified only for dc FM <200 kHz.

Table 1-2. HP 3048A System Option Specifications (8 of 9)

Amplitude

Maximum Output Level:>16 dBm.

Modulation

Modulation Types: FM, AM, Phase, Pulse

FM Deviation

Carrier Frequency Band	Maximum Deviation dc Coupled
1057.5 - 2115[1]	3 MHz
528.7 - 1057.5	1.5 MHz
264.3 - 528.7	750 kHz
132.1 - 264.3	375 kHz
66.0 - 132.1[2]	187 kHz
33.0 - 66.0[2]	93.8 kHz
16.5 - 33.0[2]	46.9 kHz
8.2 - 16.5[2]	23.4 kHz
4.1 - 8.2[2]	11.7 kHz
0.1 - 4.1[2]	93.8 kHz
0.1 - 132.1 HET	1.5 MHz

[1] HP 8642B only.
[2] Maximum deviation may be increased up to that shown for the HET band (0.1 MHz to 132.1875 MHz carrier frequency) by selecting deviation larger than the value shown here. HET band can also be selected with the special function.

FM Accuracy, Rates <100 kHz: ±(5% of setting + 10 Hz).
Typical Input Impedance: 600Ω nominal.
Maximum Input Level: 1V peak.

OPTION 101: ADDING THE HP 3585A SPECTRUM ANALYZER

This option extends the offset measurement range of the HP 3048A from 100 kHz to 40 MHz. All of the HP 3048A specifications dependent on an offset measurement range from 100 kHz to 40 MHz are valid with this option.

OPTION 110: DELETING THE HP 3561A DYNAMIC SIGNAL ANALYZER

This option is provided to allow HP 3561A's already owned by the purchaser of the HP 3048A to be used in the system. A user-supplied HP 3561A included in the HP 3048A system must be operating properly and meet its specifications for the HP 3048A specifications to be valid. Note that the HP 3048A will not operate without an HP 3561A included in the system.

COMPATIBLE SPECTRUM ANALYZERS

The HP 3048A is designed to use several Hewlett-Packard spectrum analyzers to extend the offset range from 100 kHz to 40 MHz. Those spectrum analyzers include the HP 3585A (orderable as Option 101 to the HP 3048A), the HP 8562A/B, 8566A/B, 8567A, 8568A/B, 71100A, and 71200A. Automatic control of each of these spectrum analyzers is provided. The HP 3048A specifications apply fully when these compatible spectrum analyzers are included in the system as long as the spectrum analyzer is operating properly and meets its performance specifications.

OPTION 201: ADD HIGH FREQUENCY PHASE DETECTOR

This option adds a 1.2 to 18 GHz phase detector to the HP 3048A to extend the carrier frequency of the test signals that can be demodulated without prior downconversion by the system. All of the HP 3048A specifications dependent on a carrier frequency range from 1.6 to 18 GHz are valid with this option.

OPTION 202: ADD SYSTEM RACK

This option provides the HP 3048A system and its options installed in a full size instrument rack. Rack includes a power module, all necessary signal cabling, and a pull-out shelf to use as a work surface. Outside dimensions are approximately 163 H × 61 W × 81 D cm (64 × 24 × 32 inches). The net weight varies from 191 to 275 kg (418 to 603 lbs.) depending on the options installed. Shipping weight varies from 248 to 347 kg (543 to 758 lbs).

Measurement Definitions 2

Introduction

This chapter describes the process of defining a measurement. Details are given to describe the following Main Menu selections:

Also included under the Main Menu entry *File System,* is information about Parameter Files.

Type/Range of Measurements

Introduction

The *Type/Range of Measurements* window enables you to define:

- The type of measurement you want to make,
- The frequency offset span you want to measure, and
- The minimum number of measurements you want to have taken for averaging the noise in each segment of the offset span.

Measurement Type

To select the correct type of measurement, you need to determine the type of noise to be measured and then the technique that best suits the device and available hardware.

Noise measurements can be categorized as either:

- Phase Noise Measurements,
- AM Noise Measurements, or
- Baseband Noise Measurements.

Procedure

1. Select the *Type/Range of Measurement* window.
2. Press the F1 softkey to select the measurement type you want the test system to perform.
3. Enter start and stop frequencies, and the number of averages you want the test system to make.

NOTE

The measurement type that you select determines which entry fields appear in the *Parameters* window.

Phase Noise Measurements

Phase Noise Using a Phase Lock Loop. This measurement type is used to measure the Phase Noise of two sources, a Reference Source and the unit under test (UUT) source. A phase lock loop configuration is used to maintain quadrature during the measurement. This requires that one of the two sources is a VCO with an adequate tuning range to maintain phase lock between the sources.

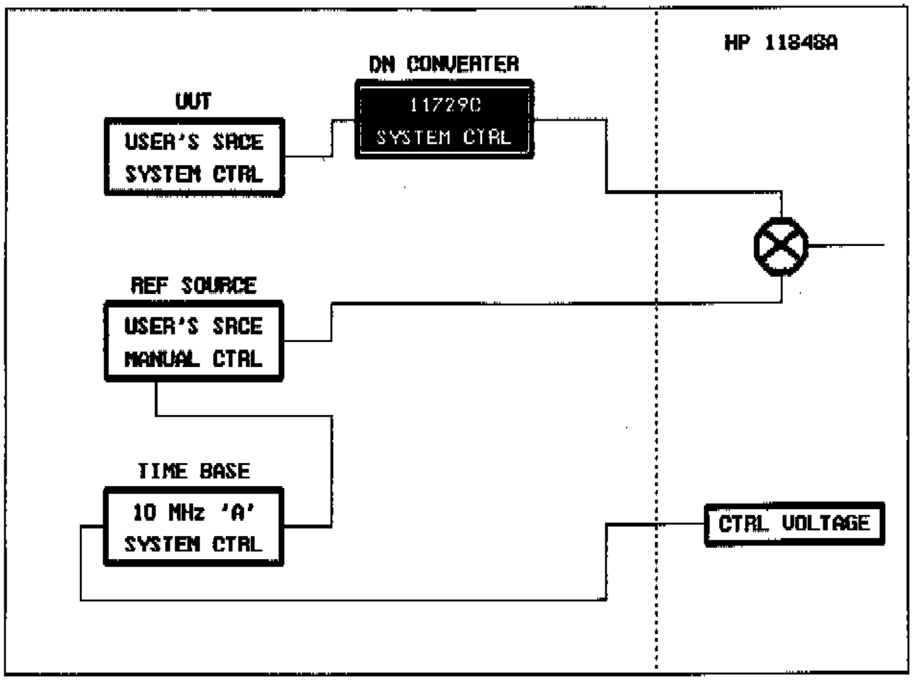


Figure 2-1. Block Diagram of the Phase Lock Loop Measurement Configuration

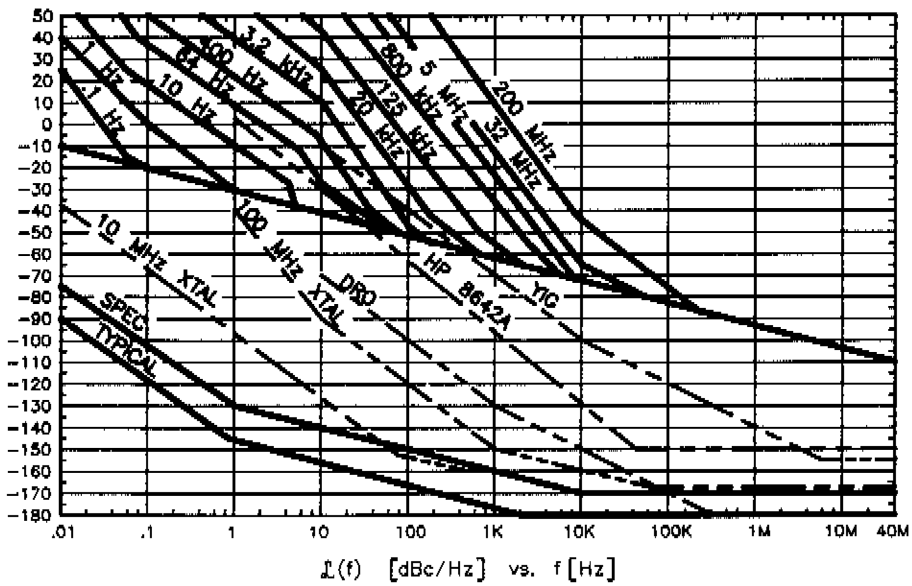


Figure 2-2. PTR Required to Phase Lock a Source.

Phase Noise Without Using a PLL. This measurement type is used to measure the residual phase noise of a Two Port (input/output) device. Two Port devices can be divided into two groups:

- Devices that translate the input frequency to a different output frequency, such as frequency multipliers and dividers. (The measurement setup for these types of devices requires that two similar devices be used.)

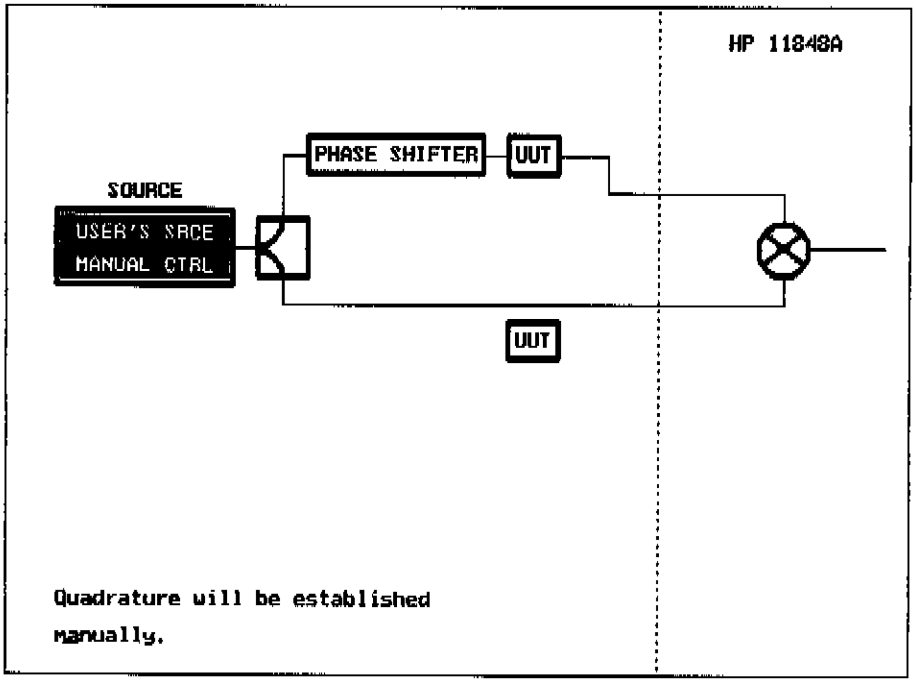


Figure 2-3. Phase Noise Without Using a Phase Lock Loop
Measurement Setup for Frequency Translator Devices

- Devices that do not translate the input frequency, such as amplifiers and filters. For these devices, quadrature can often be attained by introducing the appropriate delay in one of the input paths, as shown in figure 2-3, or by varying the source frequency. (Note that devices with large amounts of delay may require measurement of two similar devices, as shown for frequency translator devices.)

Phase Noise Using an FM Discriminator Setup This measurement type measures phase noise of a drifting source by using a frequency discriminator. A delay line of the proper electrical length allows measurements of noisy sources without needing a reference source.

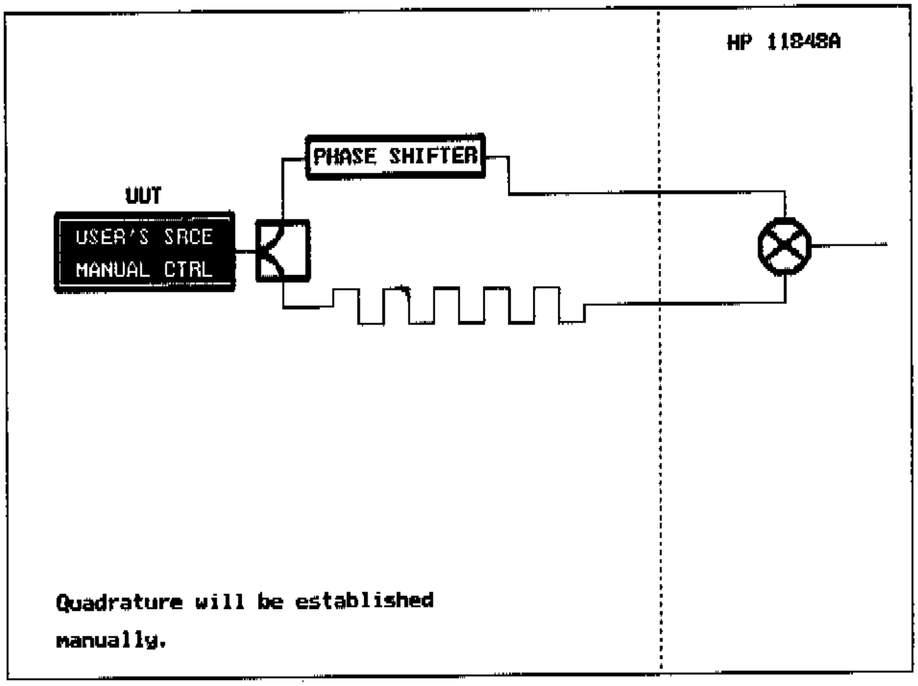


Figure 2-4. Phase Noise Using an FM Discriminator

AM Noise Measurements

AM Noise. This measurement type is used to measure the AM Noise on a signal, as shown in figure 2-5.

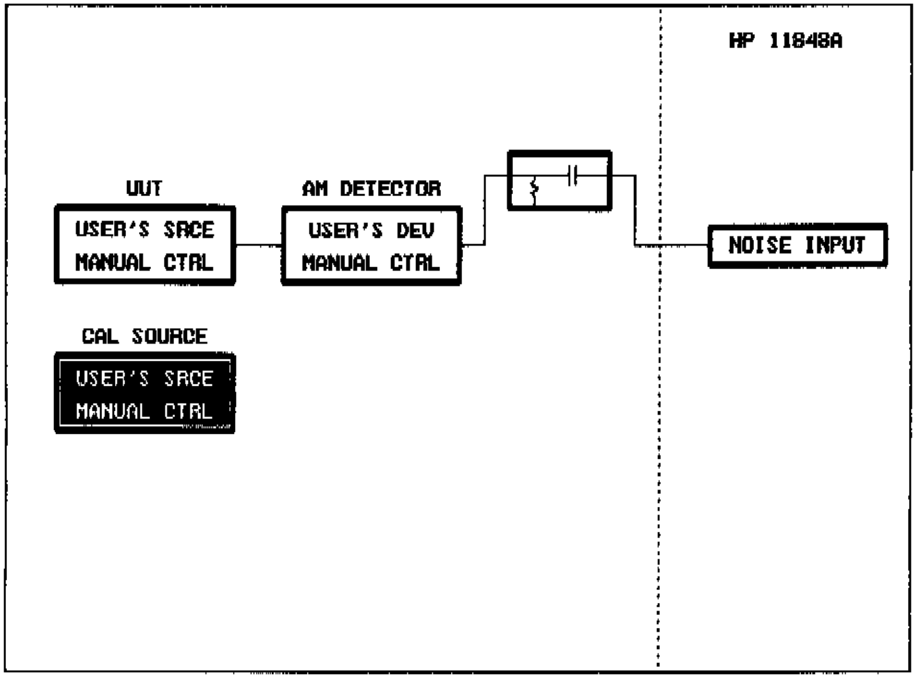


Figure 2-5. Block Diagram of the AM Noise Measurement Configuration

AM Noise can contribute to phase noise when a phase noise measurement is made. Phase detectors typically have 20 to 30 dB of AM rejection. Therefore, the AM Noise level should not exceed the level of the Phase Noise by more than 20 dB to insure that the AM Noise is not contributing to the phase noise measurement results. AM Noise affects the results of a Phase Noise measurement using an FM Discriminator much more strongly. An FM Discriminator implemented with a delay line and phase detector becomes increasingly sensitive to AM Noise at the rate of 20 dB/decade as the offset frequency decreases below $\frac{1}{2\pi\tau}$.

To make an AM Noise Measurement, an AM Detector is used to translate AM Noise to voltage fluctuations. A DC block (HP 3048A Option K21) is also required to eliminate any DC from overdriving the HP 11848A.

Baseband Measurements

Noise Measurement Using the HP 3561A Only. The baseband noise measurement measures the noise voltage of a device from .01 Hz to 100 kHz. This measurement type uses the HP 3561A Dynamic Signal Analyzer to measure the noise voltage directly.

Select the *New Measurement* window to begin the measurement. (This measurement type does not require any measurement calibration.)

NOTE

Connect the signal (noise) source to the HP 3561A INPUT as shown in figure 2-6. It may be necessary to use a DC block to enable the HP 3561A to have maximum dynamic range. The HP 3561A is DC coupled in order to have flat response below 1 Hz.

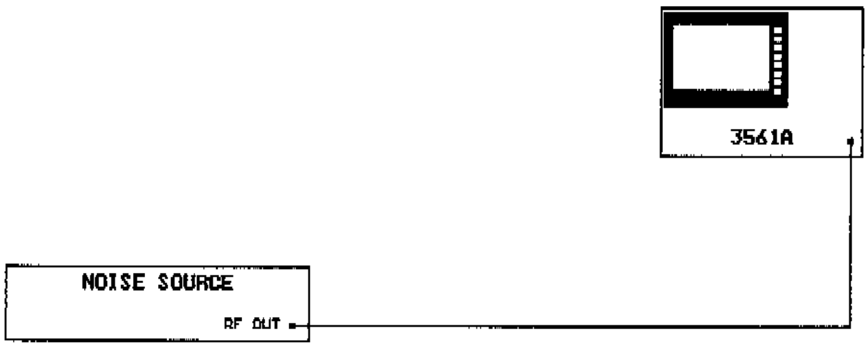


Figure 2-6. Block Diagram of the HP 3561A Baseband Noise Measurement

Baseband Noise Measurement measurement type uses the HP 11848A External Noise Input to direct the Noise Voltage to either the HP 3561A Dynamic Signal Analyzer or to a configured RF Analyzer, as shown in figure 2-7. The RF Analyzer extends the measurement range to 40 MHz. This measurement type also makes the internal LNA and High/Low Pass Filters within the HP 11848A available for the measurement.

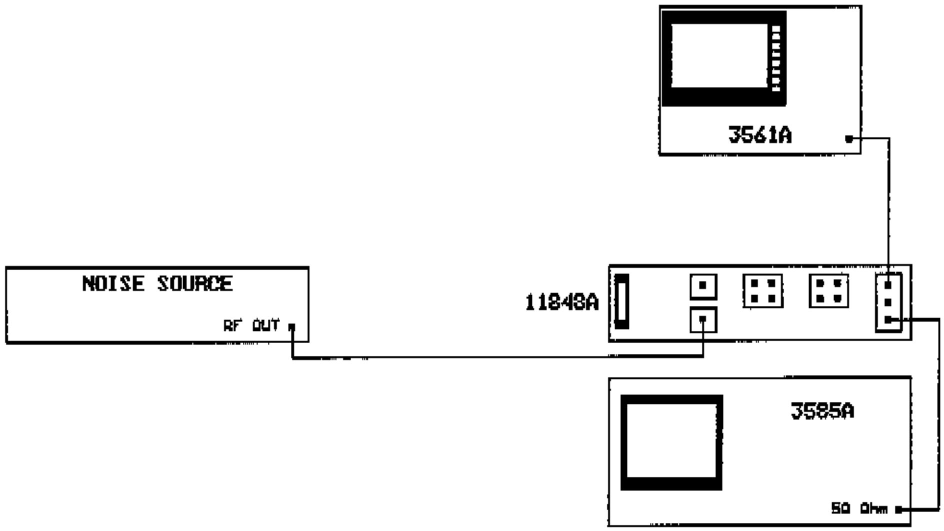


Figure 2-7. Block Diagram of the Baseband Noise Measurement

Range

The defined Start and Stop Frequencies specify the carrier-frequency offset range that is measured by the HP 3048A.

Averages

The minimum number of averages defined for the measurement determines the minimum number of noise level measurements the HP 3048A will make for each segment of the specified offset range. The HP 3048A actually takes more averages if the minimum number of averages specified in the Segment table is greater than the number of averages specified here. (Refer to *FFT Segment Table* in chapter 5, *Advanced Functions*, for further information about minimum averaging.)

Parameters

Introduction

The *Parameters* window allows you to define characteristics for the measurement setup. The defined parameters inform the test system about the following characteristics:

- **Frequency;** Carrier Frequency and Detector Input Frequency.
- **VCO Tune Port Parameters;** Phase lock loop measurements only.
- **Detector Selection;** the HP 11848A's Phase Detector Inputs.

The HP 3048A uses values from the *Parameters* window to determine hardware settings required for the measurement, and for calculations of various computed output functions (refer to chapter 4). The measurement type selected determines which parameters are required. (The *Noise Measurement Using HP 3561A Only* and the *Baseband Noise Measurement* types do not require definition of any parameters.)

Phase Noise Using a Phase Lock Loop

The parameters shown in figure 2-8 are available when you select the *Phase Noise Using a Phase Lock Loop* measurement type.

```
   ┌─ Main Menu ─────────────┐
══ Parameters ═══════════════════════════════════════════════════

 Carrier Frequency ......................[      10.E+06 ] Hz
 Detector Input Freq ....................[      10.E+06 ] Hz
 VCO Tune Constant ......................[          100 ] Hz/Volt
 Center Voltage of VCO Tune Curve ......[            0 ] Volts
 Tune Range of VCO ......................[±           2 ] Volts
 VCO Tune Port Input Resistance ........[      1.E+06 ] Ohms

── Press F1 to Select Detector ──────────────────────────────────

   Low  Freq Phase Detector (5 MHz to 1600 MHz)
   High Freq Phase Detector (1.2 GHz to 18 GHz)
   External  Phase/AM Detector
```

Figure 2-8. Parameters for Phase Noise Using A Phase Lock Loop

Frequency Parameters

Carrier Frequency is the fundamental (center) frequency of the device you are measuring. The HP 3048A uses the Carrier Frequency entry to:

- Label the Carrier Frequency on the Graph of Results .
- Select the correct bandpass filter for the HP 11729C, when it is configured in the test system as a Down Converter.
- Calculate Sigma vs. Tau and $S_y(f)$.

Detector Input Frequency is the frequency of the input signal connected to the HP 11848A's phase detector. The Detector Input Frequency is used to:

- Select the appropriate Low Pass Filter (LPF) in the HP 11848A Phase Noise Interface. For frequencies < 95 MHz, the test system enables the 2 MHz LPF to eliminate feedthrough of the fundamental signal and the additive products out of the phase detector. When the 2 MHz LPF is enabled, the maximum offset frequency the test system can measure is 2 MHz.
- Set the frequency of the Reference Source when the Reference Source is under system control.
- When using an HP 11729C under System Control, the HP 3048A will derive the correct Detector Input Frequency and enter it into the *Parameters* window. If the currently entered Detector Input Frequency is less than 95 MHz, and you are allowing the test system to input the correct Detector Input Frequency by computing the value from a System Controlled HP 11729C, then the measured offset range will be limited to 2 MHz. To eliminate this problem, set the Detect Input Frequency to a frequency greater than 95 MHz.

Frequency Parameter Considerations

- If the Carrier Frequency defined for the measurement is incorrect, the Manipulate Results calculations may be in error. Verify that the Carrier Frequency displayed on the Graph of Results is the correct frequency.

  Also, when using an HP 11729C under System Control, an incorrect Carrier Frequency entry can result in an incorrect filter selection.
- The HP 3048A changes the Detector Input Frequency and updates the *Parameters* window when a Source is under System Control and a frequency change is required to zero the beatnote. If the change in frequency changes other parameters such as Peak Deviation for DC FM, the HP 3048A informs you of the change and allow you to proceed with the new setting or abort the measurement.
- The HP 3048A does not allow a Detector Input Frequency of less than 5 MHz. If you are using an external Phase Detector at a frequency < 5MHz, enter the fundamental frequency as the carrier frequency and 5 MHz for the Detector frequency. (Note that when measuring frequency < 5 MHz you must filter out the fundamental carrier external to the HP 11848A.)

VCO Tune Port Parameters

VCO Tune Constant is the resulting frequency deviation of the Voltage Controlled Oscillator (VCO) for a 1 volt change at its tune port. This entry must be accurate to within $\pm 5\%$ when the HP 3048A is not going to measure the VCO Tune Constant. The entry must be accurate to within a factor of 2 when the VCO Tune Constant is going to be measured by the HP 3048A.

Center Voltage of VCO Tune Curve is the center voltage of the tuning curve of the VCO, that is, the voltage required at the tune port input to set the VCO to the desired carrier frequency for the measurement. A 0 volt entry allows the maximum Voltage Tune Range available from the HP 11848A. Entries other than zero restrict the Voltage Tune Range as described in table 2-1.

Table 2-1. Maximum Tune Range of VCO

Center Voltage	Maximum Tune Range of VCO
$\leq$2V	$\pm$10V
$>$2V	$\pm$12V $-$ Center Voltage

Tune Range of VCO is the $\pm$ peak voltage available to tune the VCO. This entry along with the VCO Tuning Constant determines the Peak Tuning Range available.

$$\textit{VCO Tune Constant} \times \textit{Tune Range} \approx \textit{Peak Tuning Range}$$

NOTE

Prior to initiating a New Measurement at the HP 11848A Tune Voltage Output port, an output voltage of as high as $\pm$12V may be present at the HP 11848A Tune Voltage output port from a previous measurement setting. It is recommended that you wait to connect the VCO's tune port to the Tune Voltage output until the connect diagram appears to avoid possible damage to your VCO.

The Tune Voltage Output port on the rear panel of the HP 11848A provides an inverted output of the tune voltage.

VCO Tune Port Input Resistance is the input impedance of the VCO's tune port. This entry must be accurate to within $\pm 5\%$ when the VCO Tune Constant is not going to be measured. When the Tune Constant is going to be measured by the HP 3048A, the actual value of the VCO Tune Port Input Resistance is not critical, and an entry of 1E+6 is recommended. (The HP 11848A drives the tune port through a 50Ω series resistor and is restricted to 20 mA of output current.)

The Peak Tuning Range

The Peak Tuning Range (PTR) is one half of the total (peak to peak) tuning range defined for the VCO in the *Parameters* window.

The parameters entry for the VCO Tune Constant, Tune Range of VCO, and Tune Port Input Resistance are used by the HP 3048A to determine the PTR for the PLL measurement.

$$PTR \approx VCO\ Tune\ Constant \times \left(\frac{(R_{load})}{R_{load} + 50} \right) \times Tune\ Range\ of\ VCO$$

There are three primary considerations for determining the Peak Tuning Range (PTR) required for your measurement.

- Adequate Drift Tracking
- Sufficient Phase Lock Loop Bandwidth, and
- Sufficient Noise Floor Level

These three considerations must be traded-off against one another to determine the optimum PTR for your measurement. That is to say, higher PTRs (recommended for initial measurements) ensure adequate drift tracking and Phase Lock Loop bandwidths (PLL BW) at the expense of higher noise floors.

The Peak Tuning Range determines the Drift Tracking Range (20% of PTR), and the PLL Capture Range (10% of PTR) for the measurement, as shown in figure 2-9.

Peak Tuning Range (PTR) ≈ Tune Range of VCO X VCO Tune Constant

Min. PTR = .1 Hz

Max. PTR = 500 kHz (200 MHz with an RF Analyzer).

Drift Tracking Range = Allowable Drift During Measurement.

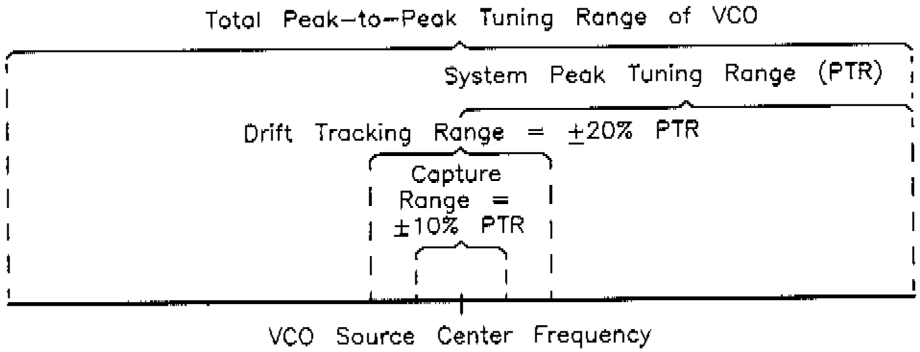


Figure 2-9. Typical Relationship of Capture Range and Drift Tracking Range to Tune Range of the VCO Source

Determining the PTR Required for Drift Tracking

The following procedure helps you determine the PTR required to provide adequate drift tracking.

1. Observe or estimate the combined drift range of the sources.

2. If the drift estimate is based on a period of 10 minutes to $\frac{1}{2}$ hour, use the drift estimate directly as the PTR required for the measurement.

   If the drift estimate is short term (10 seconds to 1 minute), multiply the drift estimate by 100 to determine the required PTR. A factor of 100 is recommended to ensure that the test system has sufficient Drift Tracking range to complete the initial noise measurement. (Refer to *Noise Floor Level* in this section for information about reducing the PTR for subsequent measurements to verify the measurement noise floor.)

3. Divide the required PTR by the Tune Range of VCO to determine the VCO Tune Constant required for the measurement.

NOTE

The PTR can also be modified by changing the Tune Range of VCO value defined for measurement.

Noise Floor Level

The noise floor available for the measurement can be limited by the presence of noise at the VCO control port. Narrowing the PTR can reduce the effect of the control port noise thereby reducing the measurement noise floor. Figure 2-10 shows the noise floor limits for various PTRs.

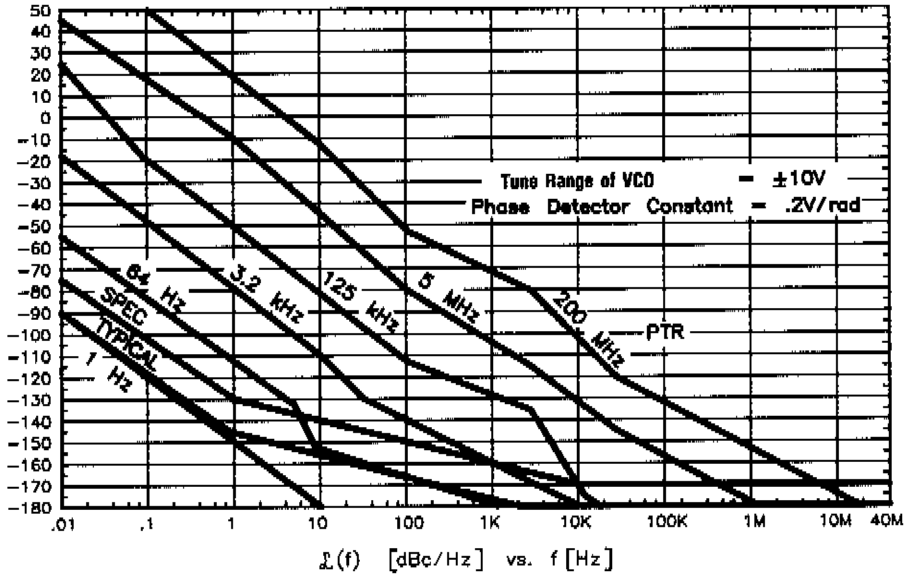


Figure 2-10. Noise Floor Level Limits for Various PTRs

If you maximized the PTR for your initial measurement to ensure that the HP 3048A has adequate drift tracking capability to complete the PLL measurement, it is recommended that you incrementally reduce the PTR and initiate a new measurement to verify that your Measurement Results are not being limited by the Noise Floor of the test system. Continue to lower the PTR (by reducing the Tune Constant or Tune Range of VCO) and make new measurements until there is no subsequent reduction in the measured noise floor, or until the HP 3048A is no longer able to acquire or maintain phase lock.

Phase Lock Loop Bandwidth

The PTR also determines the Phase Lock Loop Bandwidth (PLL BW) for the measurement as shown in figure 2-11.

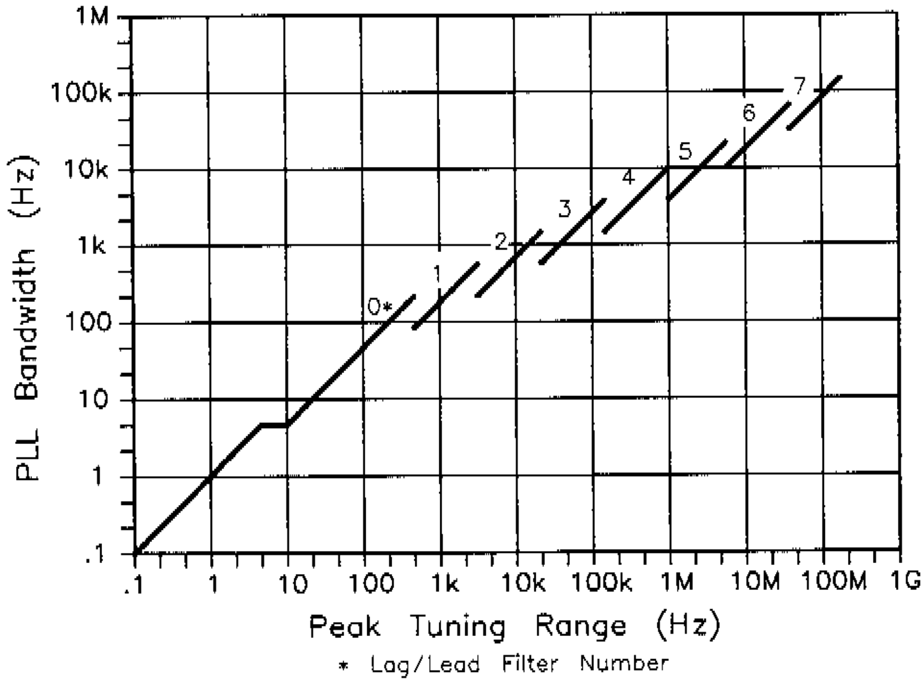


Figure 2-11. Phase Lock Loop Bandwidth as a Function of the Peak Tuning Range

The PLL BW requirement for the measurement is a function of the average noise level of the signal sources. If the average noise level on the input signals exceeds approximately 0.1 radians RMS outside of the Phase Lock Loop (PLL) bandwidth, it can prevent the HP 3048A from attaining phase lock. Figure 2-12 shows the PTR required to provide an adequate PLL BW for given average noise levels.

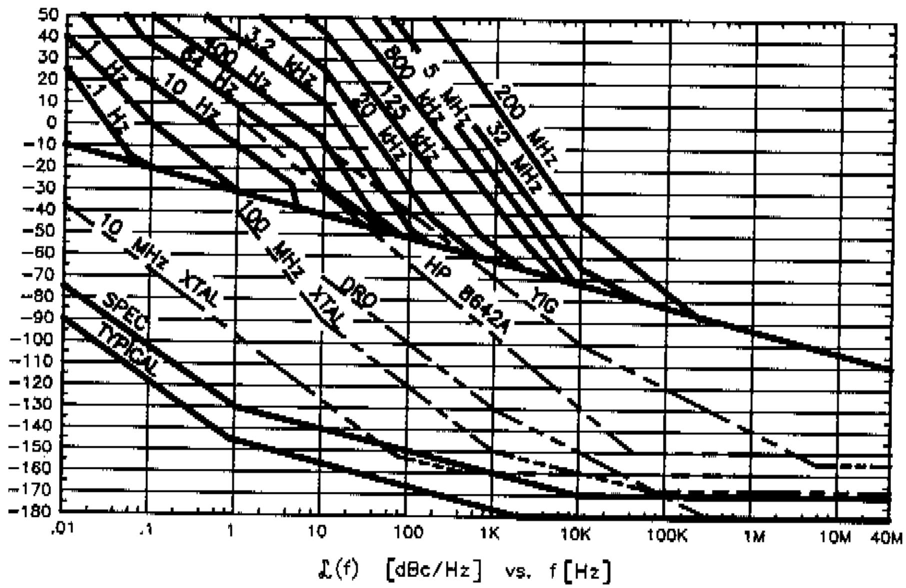


Figure 2-12. Graph Showing Peak Tuning Range Required to Provide an Adequate Phase Lock Loop Bandwidth for Given Average Noise Levels.

VCO Tuning Linearity

The HP 3048A requires the VCO's tuning curve nonlinearity to not exceed the limits shown in figure 2-13 out to ±45% of the center voltage defined for the measurement.

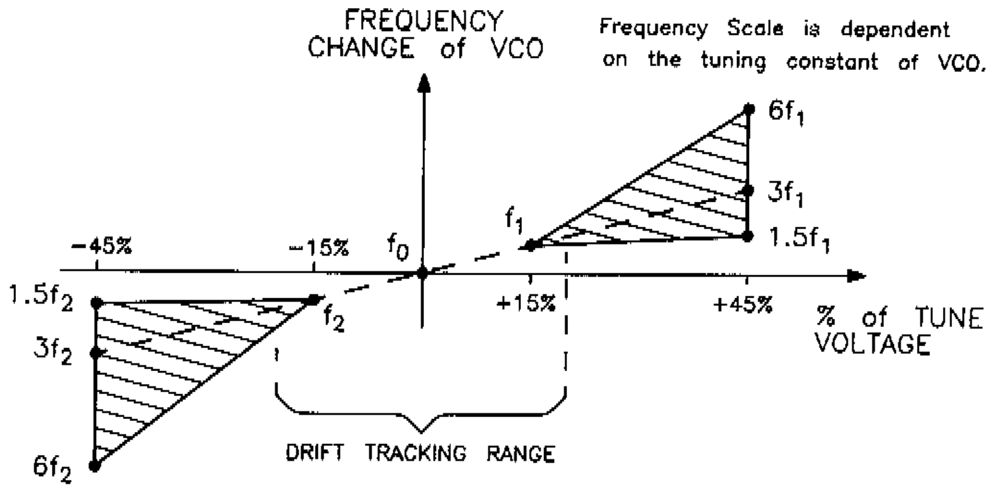


Figure 2-13. VCO Tuning Linearity Required for Phase Lock Loop Measurements

where: f_0 = The frequency of the beatnote at the Center Voltage.

and: f_1 = The + 15% point of the Voltage Tune Range.

f_2 = The − 15% point of the Voltage Tune Range.

($6f_1$ to $1.5f_1$) and ($6f_2$ $1.5f_2$) are the limits for the ± 45% points of the Voltage Tune Range.

Measuring the VCO Tune Constant

The following procedure describes the HP 3048A process for measuring the VCO Tune Constant.

1. The HP 3048A drives the VCO's tune port to −45%, −15%, +15%, +45% of the defined Tune Range of VCO and measures the frequency of the beatnote at each of these settings.
2. The ±15% frequencies are used to derive the limits for the ±45% frequencies. The HP 3048A requires that at ±45% of the Tune Range of VCO's tuning response must be within 1.5 to 6 times the frequency of the ±15% points.
3. The HP 3048A verifies that the frequencies measured at ±45% of the Tune Range of VCO are within these computed limits.

NOTE

The VCO Tune Constant must be monotonic and have a slope other than zero in addition to meeting the linearity requirements.

---

4. If the ±45% points are within the limits, the test system generates a curve fit using all 4 points and then determines the slope at the 0 frequency point (f_o) or lock point.

Center Frequencies not at Center Voltage

If the center frequency for the measurement (f_0) is not at the specified center voltage, then the f_1 and f_2 frequencies must be translated relative to the center frequency offset as well as the ±45% limits.

Detector Selection

The F1 softkey in the *Parameters* window provides selection between the HP 11848A Phase Detectors. Verify that the selected Phase Detector is:

- Within the frequency range of the Detector Input Frequency entered.
- Installed in the HP 11848A Phase Noise Interface. (Option 201 adds the 1.2 to 18 GHz Phase Detector to the HP 11848A).

Table 2-2. Detector Selection for Phase Noise Using a Phase Lock Loop

Detector Selection	Required Level (dBm)	
	L Port	R Port
Internal 5 MHz to 1.6 GHz	+15 to +23	0 to +23
Internal 1.2 GHz to 18 GHz	+7 to +10	0 to +5
External	As specified for the detector used	As specified for the detector used

External Detectors

Using an External Phase Detector to measure a device with fundamental frequency less than 5 MHz or greater than 18 GHz requires special considerations. The HP 3048A limits the Detector Input Frequency range to from 5 MHz to 18 GHz. If you are measuring a device that exceeds the limits of the Detector Input Frequency, enter a frequency of less than 95 MHz for a device with a frequency of less than 5 MHz to enable the 2 MHz LPF, or enter a frequency of greater than 95 MHz for a device with a frequency greater than 18 GHz to remove the 2 MHz LPF. Also when measuring frequencies less than 5 MHz you must filter out the fundamental feedthrough and additive product prior to the HP 11848A Noise Input. This is necessary to prevent overloading.

Enhanced Tuning Range Using a Calibrated DC FM Source

Enhanced Tuning Range is a method to increase the PTR by using the total available tuning range of the VCO. The VCO must have calibrated DC FM accurate within to 5% of the indicated deviation, and can accept input voltages exceeding the calibrated voltage range without damage.

The Enhanced Tuning Range can be used to decrease the test systems noise floor when using DC FM. By allowing a larger PTR with the minimum VCO Tune Constant (Peak Deviation) the test system can phase lock a drifty source without increasing the peak deviation. Enhanced Tuning Range increases the PTR thereby increasing the Drift Tracking Range and Capture Range without changing the VCO Tune Constant (Peak Deviation). This feature allows you to measure a noisy or drifty source, that would normally exceed the phase lock loops ability to maintain phase lock, without increasing the VCO's Tuning sensitivity. The noise floor is limited by sensitivity of the VCO Tune Port, (refer to *12 HP 3048A Noise Floor Limits Due to Peak Tuning Range* in chapter 7, *Quick Reference*, to see the graphic relationship of noise floor to PTR).

NOTE

You cannot use this feature on a VCO that does not have a known Tuning Constant (within ± 5%) or if the VCO could be damaged by applying voltages (Typically ± 10 volts) that exceed the Tune Port requirements.

How do You Enhance the Tuning Range?

The Enhanced Tuning Range allows the test system to use the total VCO Tuning Range available from a calibrated DC FM Source when defining the measurement:

- Enter the VCO Tune Constant and the VCO Tune Port Input Resistance in the *Parameters* window. These entries must be within ± 5% of their actual values for the measurement to be properly calibrated. The verification of the Loop Suppression verifies the entered accuracy of the VCO Tune Constant, VCO Tune Port Input Resistance, and Phase Detector Constant.
- Enter a Tune Range of VCO that is 5 to 10 times the maximum voltage required to achieve the peak deviation of the VCO. This artificially increases the PTR. (The HP 3048A allows the maximum Tune Range of VCO to be ± 10 volts).
- Choose "Calculate from Expected Tune Constant" in the *Calibration Technique* window. This restricts the test system from measuring the non-linear VCO Tune Constant.
- Verify the Beatnote is less than 10% of the PTR at the Connect Diagram. This insures that the test system can Zero-Beat the sources and measure the phase Detector Constant. (Phase Detector Constant must be entered in the *Calibration Technique* window if it cannot be measured by the test system).

Considerations with Enhancing the Tuning Range.

- The test system is instructed to use a tune range for the VCO that exceeds the calibrated Tune Port input voltage range of the VCO. Typically a tune range of 5 to 10 volts is entered from the *Parameters* window to artificially increase the PTR by 5 to 10 times. This increases the Drift Tracking Range allowed which is 20% of the PTR enabling the test system to use the total VCO tuning range available. For example an HP 8663A with 10 kHz DC FM and 1 volt peak deviation would normally result in a PTR of 10 kHz and a Drift Tracking Range of 2 kHz. Any drift greater than 2 kHz the test system would break lock because the HP 8663A was restricted to $\pm$ .2 volts at the tune port and could not track the drift. With Enhanced Tuning applied the test system would think that the same HP 8663A would have a PTR of 10 $\times$ the peak deviation of 10 kHz, or 100 kHz. This allows a Drift Tracking Range of 20 kHz and a Capture Range of 10 kHz. Even though the Enhance Drift Tracking Range exceeds the peak deviation of the HP 8663A the test system will track the sources until the tuning range exceeds 20% of the Tune Range of VCO or the VCO fails to compensate for the drift due to its capabilities. (non-linearity).

NOTE

The test system may apply the full voltage tune range to the VCO when phase lock is lost.

- When Enhanced Tuning Range is used the test system is unable to measure the VCO Tune Constant and you must select the "Calculate from Expected Tune Constant" in the *Calibration Technique* window, and enter the exact VCO Tune Constant and VCO Tune Port Input Resistance in the *Parameters* window. Normally the test system measures the VCO Tune Constant by applying $\pm$ 15 and 45% of the Tune Range of VCO to the tune port of the VCO. Enhanced Tuning Range increases the Tune Range of VCO to where 45% of the Tune Range of VCO would drive the tune port into its non-linear region. This would create a VCO non-linear error message and stop the measurement.
- The Verification of the Phase Lock Loop Suppression is recommended to ensure the validity of the entered VCO Tune Constant and the Phase Detector Constant.
- The beatnote must be within 10% of the PTR to insure that the test system can measure the Phase Detector Constant. The HP 3048A applies 10% of the Tune Range of VCO to create a beatnote to measure the Phase Detector Constant.

Phase Noise Without Using a PLL

The parameters shown in figure 2–14 are available when you select the *Phase Noise Without Using a PLL* measurement type.

```
   ┌─ Main Menu ────────────────┐
┌═ Parameters ════════════════════════════════════════════════════┐
│                                                                 │
│ Carrier Frequency .....................[      400.E+6 ] Hz     │
│ Detector Input Freq ...................[    414.05E+6 ] Hz     │
│                                                                 │
├── Press F1 to Select Detector ─────────────────────────────────┤
│                                                                 │
│   Low  Freq Phase Detector (5 MHz to 1600 MHz)                  │
│   High Freq Phase Detector (1.2 GHz to 18 GHz)                  │
│   External  Phase/AM Detector                                   │
│                                                                 │
└═════════════════════════════════════════════════════════════════┘
    │  Quit                        │
    └──────────────────────────────┘
```

Figure 2–14. Parameters for Phase Noise Without Using a PLL

Frequency Parameters

Carrier Frequency is the fundamental (center) frequency of the device you are measuring. The HP 3048A uses the Carrier Frequency entry to:

- Label the Carrier Frequency on the Graph of Results .
- Select the correct bandpass filter for the HP 11729C, when it is configured in the test system as a Down Converter.
- Calculate Sigma vs. Tau and $S_y(f)$.

Detector Input Frequency is the frequency of the input signal connected to the HP 11848A's phase detector. The *Detector Input Frequency* is used to:

- Select the appropriate Low Pass Filter (LPF) in the HP 11848A Phase Noise Interface. For frequencies $<$ 95 MHz, the test system enables the 2 MHz LPF to eliminate feedthrough of the fundamental signal and the additive products out of the phase detector. When the 2 MHz LPF is enabled, the maximum offset frequency the test system can measure is 2 MHz.

Frequency Parameter Considerations

- If the Carrier Frequency defined for the measurement is incorrect, the Manipulate Results calculations may be in error. Verify that the Carrier Frequency displayed on the Graph of Results is the correct frequency. When computing Sigma of Tau from a result file you must ensure that the Carrier Frequency in the *Parameters* window represents the carrier frequency of the result file.

  Also, when using an HP 11729C under system control, an incorrect Carrier Frequency entry can result in an incorrect filter selection.

Detector Selection

The [F1] softkey in the *Parameters* window provides selection between the HP 11848A Phase Detectors. Verify that the selected Phase Detector is:

- Within the frequency range of the Detector Input Frequency entered.
- Installed in the HP 11848A Phase Noise Interface. (Option 201 adds the 1.2 to 18 GHz Phase Detector to the HP 11848A).

Table 2-3. Detector Selection for Phase Noise Without Using a PLL

Detector Selection	Required Level (dBm)	
	L Port	R Port
Internal 5 MHz to 1.6 GHz	+15 to +23	0 to +23
Internal 1.2 GHz to 18 GHz	+7 to +10	0 to +5
External	As required for the detector used	As required for the detector used

External Detectors

Using an External Phase Detector to measure a device with fundamental frequency less than 5 MHz or greater than 18 GHz requires special considerations. The HP 3048A limits the Detector Input Frequency range to from 5 MHz to 18 GHz. If you are measuring a device that exceeds the limits of the Detector Input Frequency, enter a frequency of less than 95 MHz for a device with a frequency of less than 5 MHz to enable the 2 MHz LPF, or enter a frequency of greater than 95 MHz for a device with a frequency greater than 18 GHz to remove the 2 MHz LPF. Also when measuring frequencies less than 5 MHz you must filter out the fundamental feedthrough and additive product prior to the HP 11848A Noise Input. This is necessary to prevent overloading.

Phase Noise Using an FM Discriminator

Phase Noise Using an FM Discriminator

```
  ┌─ Main Menu ──────────────────┐
══ Parameters ══════════════════════════════════════════════════

  Carrier Frequency .....................[       10.E+6 ] Hz
  Detector Input Freq ...................[   10.0006E+6 ] Hz

── Press F1 to Select Detector ─────────────────────────────────

    Low  Freq Phase Detector (5 MHz to 1600 MHz)
    High Freq Phase Detector (1.2 GHz to 18 GHz)
    External  Phase Detector

════════════════════════════════════════════════════════════════
  │  Quit                        │
  └──────────────────────────────┘
```

Figure 2-15. Parameters for Phase Noise Using an FM Discriminator

Frequency Parameters

Carrier Frequency is the fundamental (center) frequency of the device you are measuring. The HP 3048A uses the Carrier Frequency entry to:

- Label the Carrier Frequency on the Graph of Results.
- Calculate Sigma vs. Tau and S_y (f).

NOTE

When loading a result file for calculating Sigma vs. Tau, the carrier frequency used for the measurement must be entered in the *Parameters* window in order to compute accurate values.

Detector Input Frequency is the frequency of the input signal connected to the HP 11848A's phase detector. The Detector Input Frequency is used to:

- Select the appropriate Low Pass Filter (LPF) in the HP 11848A Phase Noise Interface. For frequencies < 95 MHz, the test system enables the 2 MHz LPF to eliminate feedthrough of the fundamental signal and the additive products out of the phase detector. When the 2 MHz LPF is enabled, the maximum offset frequency the test system can measure is 2 MHz.
- Set the frequency of the Calibration Source when the Calibration Source is under system control.

Frequency Parameter Considerations

- If the Carrier Frequency defined for the measurement is incorrect, the Manipulate Results calculations may be in error. Verify that the Carrier Frequency displayed on the Graph of Results is the correct frequency. When computing Sigma of Tau from a result file you must ensure that the Carrier Frequency in the *Parameters* window represents the carrier frequency of the result file.

Detector Selection

The F1 softkey in the *Parameters* window provides selection between the HP 11848A Phase Detectors. Verify that the selected Phase Detector is:

- Within the frequency range of the Detector Input Frequency entered.
- Installed in the HP 11848A Phase Noise Interface. (Option 201 adds the 1.2 to 18 GHz Phase Detector to the HP 11848A).

Table 2-4. Detector Selection for Phase Noise Using an FM Discriminator

Detector Selection	Required Level (dBm)	
	L Port	R Port
Internal 5 MHz to 1.6 GHz	+15 to +23	0 to +23
Internal 1.2 GHz to 18 GHz	+7 to +10	0 to +5
External	As required for the detector used	As required for the detector used

External Detectors

Using an External Phase Detector to measure a device with fundamental frequency less than 5 MHz or greater than 18 GHz requires special considerations. The HP 3048A limits the Detector Input Frequency range to from 5 MHz to 18 GHz. If you are measuring a device that exceeds the limits of the Detector Input Frequency, enter a frequency of less than 95 MHz for a device with a frequency of less than 5 MHz to enable the 2 MHz LPF, or enter a frequency of greater than 95 MHz for a device with a frequency greater than 18 GHz to remove the 2 MHz LPF. Also when measuring frequencies less than 5 MHz you must filter out the fundamental feedthrough and additive product prior to the HP 11848A Noise Input. This is necessary to prevent overloading.

AM Noise

The parameters shown in figure 2-16 are available when you select the *AM Noise* measurement type.

```
  ┌─ Main Menu ──────────────────────┐
══ Parameters ═══════════════════════════════════════════════════════

  Carrier Frequency .....................[        10.E+6 ] Hz
  Detector Input Freq ...................[    10.0006E+6 ] Hz

─── Press F1 to Select Detector ─────────────────────────────────────

    Low  Freq Phase Detector (5 MHz to 1600 MHz)
    High Freq Phase Detector (1.2 GHz to 18 GHz)
    External  Phase Detector

═════════════════════════════════════════════════════════════════════
  │  Quit                            │
  └──────────────────────────────────┘
```

Figure 2-16. Parameters for AM Noise

Frequency Parameters

Carrier Frequency is the fundamental (center) frequency of the device you are measuring. The HP 3048A uses the Carrier Frequency entry label the Carrier Frequency on the Graph of Results.

Detector Input Frequency is the frequency of the input signal connected to the AM Detector. The Detector Input Frequency is used to:

- Select the appropriate Low Pass Filter (LPF) in the HP 11848A Phase Noise Interface. For frequencies < 95 MHz, the test system enables the 2 MHz LPF to eliminate feedthrough of the fundamental signal and the additive products out of the phase detector. When the 2 MHz LPF is enabled, the maximum offset frequency the test system can measure is 2 MHz.

Frequency Parameter Considerations

- If the Carrier Frequency defined for the measurement is incorrect, the Manipulate Results calculations may be in error. Verify that the Carrier Frequency displayed on the Graph of Results is the correct frequency. When computing Sigma of Tau from a result file you must ensure that the Carrier Frequency in the *Parameters* window represents the carrier frequency of the result file.

Detector Selection

For AM Noise measurement the "External Phase Detector" should be selected. Pressing the [F1] softkey allows you to change the selected phase detector. (The inverse video box indicates which HP 11848A phase detector is defined for the measurement.)

AM Detector Considerations

When using an AM Detector you should consider:

- The frequency range of the AM Detector.
- The power level the AM Detector can tolerate.
- The sensitivity (Detector Constant) of the AM Detector selected.
- The frequency range and flatness of the DC Block. (The HP 3048A Option K21 AM Detector is designed specifically for this purpose.)

Table 2-5. AM Detector Considerations

Connector	Frequency Range	Maximum Level
NOISE INPUT	DC to 40 MHz	1V Peak

Calibration Technique

Introduction

Select the *Calibration Technique* window to define how calibration will be done for the measurement. The measurement type you select in the *Type/Range of Measurement* window determines the calibration technique that will be used.

Calibration for the Phase Noise Using a Phase Lock Loop Measurement

The window shown in figure 2-17 is available when you select the *Phase Noise Using a Phase Lock Loop* measurement type.

```
┌─ Main Menu ──────────┐
═ Calibration Technique ══════════════════════════════════════════

─ Press F1 to Select Detector Constant Method ─────────────────

  Use Current Detector Constant .......[     277.7E-3 ] V/Rad
  Measure the Detector Constant.

─ Press F2 to Select VCO Tune Constant Method ─────────────────

  Use Current Tune Constant (       106.7 Hz/Volt).
  Measure the Tune Constant.
  Calculate from Expected Tune Constant (      99.995 Hz/Volt).

─ Press F3 to Toggle Verification of Loop Suppression ─────────

  The computed PLL suppression    WILL    be verified.
```

Figure 2-17. Calibration Technique for Phase Noise Using a Phase Lock Loop

Introduction

The calibration process for a phase lock loop measurement involves determining the phase Detector Constant, the VCO Tune Constant, and verifying the Loop Suppression. The phase Detector Constant is the sensitivity of the phase detector expressed in volts per radian (V/Rad). The VCO Tune Constant is the sensitivity of the tuning input of the Voltage Controlled Oscillator (VCO) expressed in Hertz per volt (Hz/V). The Loop Suppression verification characterizes the phase lock loop configured for the measurement and then compares the measured loop response with a theoretical loop suppression curve.

The Phase Detector Constant

Introduction

The phase detector translates relative phase fluctuations between the two phase detector inputs to voltage fluctuations. The amplitude of the phase detector's output voltage is proportional to the amount of relative phase fluctuation at its two inputs scaled by and the sensitivity of the detector. The phase detector's sensitivity is the phase Detector Constant. The phase Detector Constant determines the absolute noise floor of the test system. The accuracy of the Phase Lock Loop measurement is dependent on the accuracy of the phase Detector Constant.

Use the Current Detector Constant and *Measure the Detector Constant* are the two methods available for determining the phase Detector Constant. The HP 3048A uses the method displayed in inverse video. Press the [F1] softkey to select the desired method.

Table 2-6. Phase Detector Constant Considerations

Calibration Method	Considerations
Use the Current Detector Constant	Uses the displayed value (in memory from the last measurement or from user entry). This method saves measurement time by eliminating the phase Detector Calibration from the measurement process.
Measure the Detector Constant	Recommended method to ensure measurement accuracy.

Parameter Entry Descriptions

Use the Current Detector Constant

When measuring similar devices the *Use the Current Detector* method can be used to save calibration time. The HP 3048A assumes that the frequency and amplitude are identical to the previous measurement in which the phase Detector Constant was established. In most cases, the accuracy uncertainty is negligible as long as the power levels are very close (±0.3 dB) to the levels present when the phase Detector Constant was established.

User entry of the phase Detector Constant (within the range of Acceptable Values displayed) is possible when the sensitivity of the detector being used is known. Entering the phase Detector Constant can be helpful when the test system is unable to measure the phase Detector Constant. Keep in mind that the accuracy of the measurement is dependent on the accuracy of the phase Detector Constant. The HP 3048A verifies accuracy of the entered phase Detector Constant when it's configured to verify the Phase Lock Loop Suppression. An Accuracy Specification Degradation will be reported if the entered phase Detector Constant is in error.

The sensitivity of the phase detector is a function of the input level to the phase detector. You can estimate the phase Detector Constant directly from the input power level at the R port of the phase detector; providing the input level required for driving the L port of the phase detector has been met. A power meter or a spectrum analyzer can be used to measure the input level at the R port. Compare the measured R port level to graph below to estimate the phase Detector Constant, as shown in figures 2-18 and 2-19.

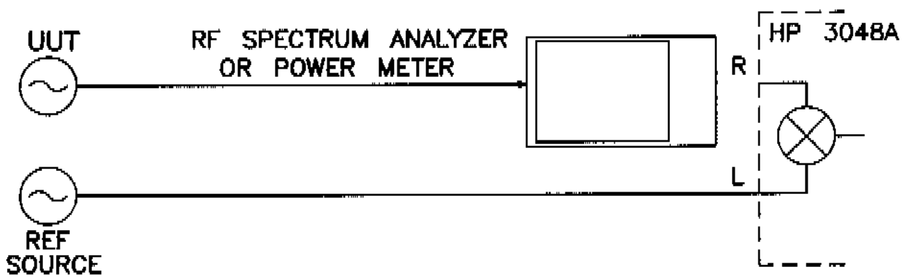
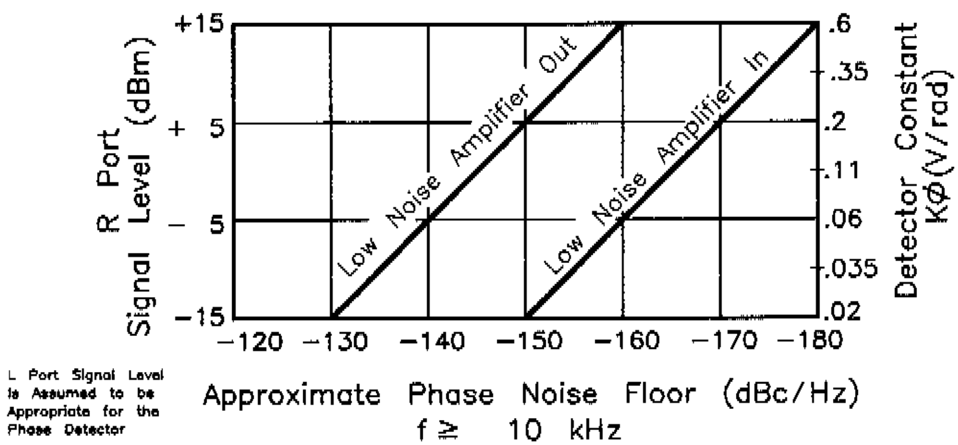


Figure 2-18. R Port Power Setup Diagram



Note: This relationship assumes a 9 dB conversion loss in the Phase Detector.

Figure 2-19. Estimate of Phase Detector Constant for a Given R Port Input Level

The AUX MONITOR port on the HP 11848A Phase Noise Interface provides an output for monitoring the beatnote, as shown in figure 2-20. Connecting an oscilloscope to this output port allows the phase Detector Constant to be estimated from the peak amplitude of the beatnote. The peak voltage of the sine wave equals the Phase Detector Constant in V/Rad.

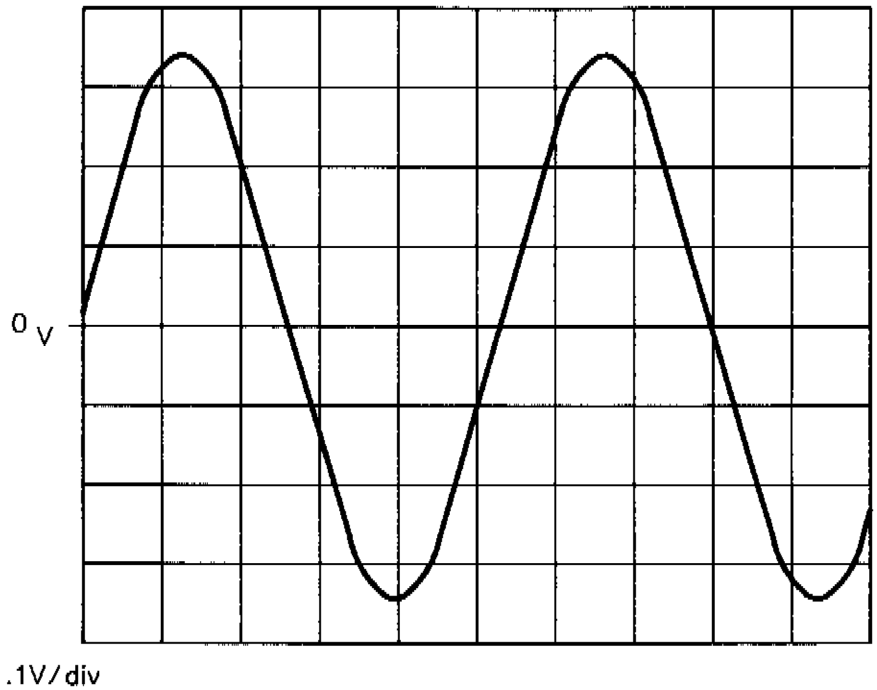


Figure 2-20. Oscilloscope Display of Beatnote out of the HP 11848A AUX MONITOR Port

Measure the Detector Constant

When *Measure the Detector Constant* is selected, the HP 3048A automatically measures the phase Detector Constant. Measuring the phase Detector Constant is the most accurate method for calibrating the detector. The test system calibrates the phase Detector Constant by generating a beatnote frequency at approximately 10% of the entered Peak Tuning Range. The maximum Peak Tuning Range the test system accepts is 500 kHz (or 200 MHz if a supported RF Analyzer is configured in the test system).

If the beatnote is less than 1 kHz, the test system measures slope of the zero crossings to determine the phase Detector Constant. If the beatnote is greater than or equal to 1 kHz, the test system measures the beatnote signal's amplitude of the fundamental and its odd harmonics to determine the phase Detector Constant, as follows:

$$Detector\ Constant_{<1\ kHz} = Slope_{Beatnote}$$
$$Detector\ Constant_{\geq 1\ kHz} = H_1 - 3H_3 + 5H_5 - 7H_7 \cdots$$

$$where\ H_1 = \ Peak\ amplitude\ of\ fundamental\ of\ beatnote$$
$$and\ H_n = \ Amplitude\ of\ harmonics\ of\ beatnote$$

Considerations for the Phase Detector Constant

The HP 11848A External Noise Input must be attenuated as needed to limit the phase Detector Constant to less than 1 Vpk to keep from overloading the HP 11848A. The beatnote must be DC coupled to the input for the Phase Lock Loop to operate.

Insufficient power at the L input port on the HP 11848A can cause excessive conversion loss through the phase detector. In addition, the beatnote may be compressed causing an incorrect calibration of the phase Detector Constant.

The input level at the R input port of the HP 11848A determines the test system's sensitivity. Amplification of the input signal to the R port will increase the phase Detector Constant thereby decreasing the test system's noise floor.

The Phase Detector Constant cannot be measured if the test system cannot generate a beatnote of less than 50 kHz (20 MHz for test systems with an RF Analyzer), or if the sources are injection locking. Also, the test system cannot measure the phase Detector Constant if the beatnote deviates too much from a sine wave, or is excessively noisy. In these cases, you may need to enter the phase Detector Constant using a power level estimate or from examination of the beatnote.

If the beatnote is less than 1 kHz, and the test system cannot locate three zero-crossings within the time record of the HP 3561A Dynamic Signal Analyzer, the test system cannot measure the phase Detector Constant. In this case, you should abort the measurement, verify all of the entered parameters and initiate a new measurement.

The recommended range for the Phase Detector Constant when making a phase lock loop measurement using the 5 MHz to 1.6 GHz Phase Detector is 20 mV to 1V. The recommended range when making a phase lock loop measurement using the 1.2 GHz to 18 GHz Phase Detector is 100 mV to 0.3V. Detector Constants down to 20 mV may work but, proper operation may be inhibited by dc offsets up to 50 mV.

Adequate isolation must be provided to insure that the injection locking range is much less than the Phase Lock Loop Bandwidth. Injection Locking removes or distorts the beatnote from which the phase Detector Constant is measured.

The sensitivity of the HP 11848A front panel meter depends on the gain and attenuation settings within the phase lock circuitry. When the test system is phase locked, 0 V (center scale) on the meter indicates that the sources are tuned to exactly the same frequency. The HP 3048A detects an out of lock indication when the meter moves off zero more than ± 2.5 divisions. The full scale meter voltage is determined from the sum of the Center Voltage of the VCO Tune Curve (CV) and the Tune Range of VCO (TRV) entered in the *Parameters* window and the configuration of the HP 11848A's internal attenuator. Table 2-7 shows four possible full-scale meter voltages.

Table 2-7. Full-scale Meter Voltages

Full Scale Meter Voltage	Center Voltage (CV) Tune Range of VCO (TRV)
1	$0.2V \leq CV + TRV \leq 1.2V$
2	$1.2V < CV + TRV \leq 2.4V$
5	$2.4V < CV + TRV \leq 6V$
10	$6V < CV + TRV \leq 12V$

Spurs on the input signals to the phase detector must be less than −26 dBc at offsets greater than the PLL BW. At offsets within the PLL BW, spurs may increase at 20 dB per decade starting at −26 dBc at the PLL BW.

Harmonics on the input signals to the phase detector must be less than −20 dBc or harmonics of a square wave.

Odd harmonics on the beatnote out of the phase detector must be less than −10 dBc and even harmonics must be less than −30 dBc.

Source Return Loss less than 9.5 dB (2:1 SWR) may degrade the performance of the HP 3048A system.

The VCO Tune Constant

Introduction

The VCO Tune Constant is the frequency sensitivity of the VCO source to voltage changes at its control voltage input. This constant is measured in Hz/V. The HP 3048A uses the VCO Tune Constant along with the defined Tune Range of VCO and the VCO's Tune Port Input Resistance to determine the Peak Tuning Range for the measurement. The Bandwidth of the Phase Lock Loop, the Lock Capture Range, and the Drift Tracking Range for the measurement are all derived from the Peak Tuning Range.

As shown previously in figure 2–17, three calibration techniques are available for determining the VCO Tune Constant for the measurement:

- Use Current Tune Constant
- Measure the Tune Constant
- Calculate from Expected Tune Constant

The test system uses the method displayed in inverse video on the computer. To change the method, press the [F2] softkey. Table 2-8 lists tuning characteristics of various VCO source options.

Table 2-8. Tuning Characteristics of Various VCO Source Options

VCO Source	Carrier Freq.	VCO Tune Constant (Hz/V)	Center Range (V)	Tune Range of VCO ($\pm$V)	Input Resistance (ohms)	Calibration Technique
HP 8662/3A						
EFC	v_o	$5\,E-9 \times v_o$	0	10	$1\,E+6$	Measure
DCFM		FM Deviation	0	10	1k (8662)	Calculate
					600 (8663)	Calculate
HP 8642A/B		FM Deviation	0	10	600	Calculate
HP 8640B		FM Deviation	0	10	600	Calculate
HP 8656B		FM Deviation	0	10	600	Calculate
Other Signal Generator DCFM Calibrated for $\pm$1V		FM Deviation	0	10	R_{in}	Calculate
10 MHz Source A						Measure
Direct		10	0	10	$1\,E+6$	
Multiplied	v_o	$1\,E-6 \times v_o$	0	10	$1\,E+6$	
As a Timebase:						
To HP 8662/3A	v_o	$1\,E-6 \times v_o$	0	$10\,E+9 \div v_o$	$1\,E+6$	
To other synthesized signal generators	v_o	$1\,E-6 \times v_o$	0	$1\,E+6 \times$ PTR* $\div v_o$	$1\,E+6$	
10 MHz Source B						Measure
Direct		100	0	10	$1\,E+6$	
Multiplied	v_o	$10\,E-6 \times v_o$	0	10	$1\,E+6$	
As a Timebase:						
To HP 8662/3A	v_o	$10\,E-6 \times v_o$	0	$1\,E+9 \div v_o$, (up to 2.5V max.)	$1\,E+6$	
To other synthesized signal generators	v_o	$10\,E-6 \times v_o$		$100\,E+3 \times$ PTR* $\div v_o$	$1\,E+6$	
350-500 MHz Source		$12\,E+6$	0	2	$1\,E+6$	Measure
Other User VCO Source		Estimated within a factor of 2	−10 to +10	See Graph 8	$1\,E+6$	Measure

* Limited PTR due to PLL BW limitations.

Parameter Entry Descriptions

Use the Current Tuning Constant

This calibration method uses the value of the VCO Tune Constant currently in memory. Selecting this method saves time for measuring the VCO Tune Constant without any degradation in accuracy, providing either the same VCO source is being used or a source with an identical tuning constant is being used (within ±5%).

Measure the VCO Tune Constant

Selecting this calibration method causes the test system to automatically measure the tuning sensitivity and tuning linearity of the VCO source. Measuring the VCO Tune Constant is the recommended method under most circumstances for ensuring measurement accuracy. (As noted below, the special case of extending the Tune Range of VCO requires selection of the Calculate from Expected Tune Constant calibration technique.) The test system cannot measure the VCO Tune Constant for an entered Peak Tuning Range greater than 500 kHz for test systems configured without an RF Analyzer, and 200 MHz for test systems configured with an RF Analyzer.

When measuring the VCO Tune Constant, the test system requires that the VCO Tune Constant defined in the *Parameters* window be within a factor of two of the VCO's actual sensitivity. This approximation is required in order for the HP 3048A to establish a beatnote. The frequency response of the VCO source must remain flat (±.3 dB) from dc to the phase lock loop bandwidth (PLL BW).

Extending the Tune Range of VCO value as defined on the *Parameters* window to 10V is a valid way to increase the Peak Tuning Range for the measurement. The VCO source being used in this case must be a signal generator with a calibrated DC FM input (such as the HP 8662A). When the tuning range has been extended, select the "Calculate from Expected Tune Constant" calibration technique for the measurement. Refer to the "Enhanced Tuning Range" description in the *Parameters* section of this chapter for complete details on extending the Tune Range of VCO.

Calculate from Expected Tune Constant

Selecting the Calculate from Expected Tune Constant method causes the test system to use the entered VCO Tune Constant and VCO Tune Port Input Resistance that have been entered in the *Parameters* window. This method requires that the entered VCO Tune Constant is within $\pm5\%$ of the VCO's actual sensitivity. If it is not, the test system reports an Accuracy Specification Degradation after verifying the Phase Lock Loop Suppression.

$$VCO\ Tuning\ Constant = Entered\ VCO\ Tuning\ Constant \times \frac{R_{in}}{R_{in} + 50}$$

$$Where: R_{in} = VCO\ Tune\ Port\ Input\ Resistance$$

Consideration for the VCO Tune Constant

The VCO's tuning curve must be within the parameters shown in figure 2-21.

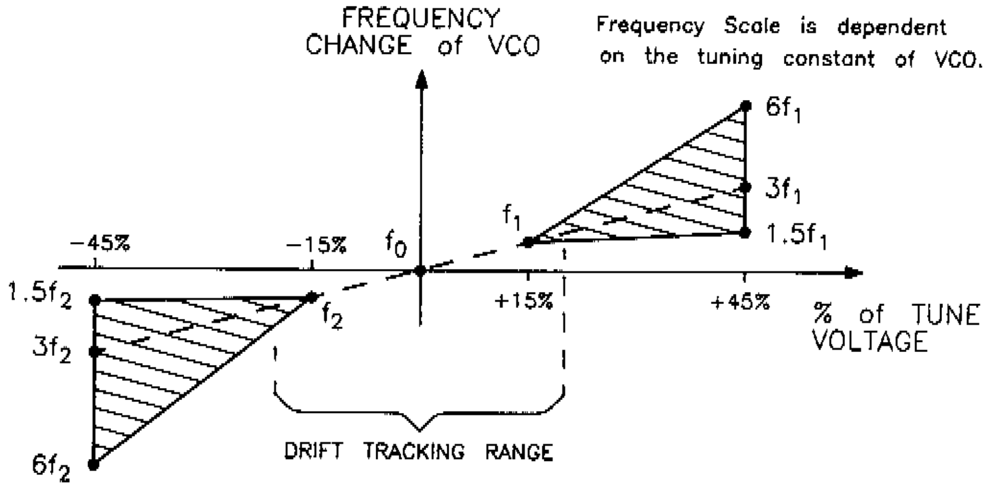


Figure 2-21. VCO Tuning Response Linearity Requirements of the HP 3048A

When the VCO Tuning Linearity does not meet the requirements of figure 2-21, an ERROR message is generated to inform you that the test system cannot continue. If this happens, you must do one of the following:

- Inspect the 4 points to determine the source of the non-linearity (disconnected tune line, drift, wrong DC FM sensitivity, wrong voltage tune range).
- Restrict the Tune Range of VCO to a portion of the Tuning Curve which is linear.
- Replace the VCO with one having a linear Tune Constant, or
- Instruct the test system not to measure the Tune Constant.

The Loop Suppression Verification

Introduction

Verification of the Phase Lock Loop Suppression insures that the Phase Lock Loop Bandwidth (PLL BW), the Phase Detector Constant, and the VCO Tune Constant are all accurate for the measurement. (Note that the HP 3048A always corrects for the loop suppression whether or not verification is selected.)

Description

The HP 3048A verifies Loop Suppression before beginning the measurement by closing the phase lock loop and injecting noise into the loop. The response of the loop is measured and recorded. The loop is then opened, and a measurement is made of the open loop response. The suppression of the PLL is the difference between the closed loop response and open loop response to the injected noise. The measured Loop Suppression curve is smoothed and then four points are selected along the curve including the peak and the −8 dB point. The measured curve is then compared to the theoretical curve at the four selected points. Figure 2-22 shows an example of a Loop Suppression curve measured by the HP 3048A. (For information about interpreting the curve, and using the *11848A Control* selection for troubleshooting this measurement refer to chapter 5, *Advanced Functions* under *Measurement Mode*).

The amount of adjustment required to fit the theoretical curve to the measured curve is recorded as the PLL GAIN CHANGE on the Suppression Graph and the frequency of the Assumed Pole. The Assumed Pole is a software controlled term used to fit the Adjusted Theoretical loop response to the smoothed measured response of the phase lock loop. The MAX ERROR is the final amount of error existing between the adjusted theoretical curve and the measured curve of the phase lock loop suppression. If the PLL GAIN CHANGE or MAX ERROR is greater than 1 dB, the test system indicates that an Accuracy Specification Degradation has been detected. (For information about the appropriate actions to take, refer to chapter 8 *Messages*.)

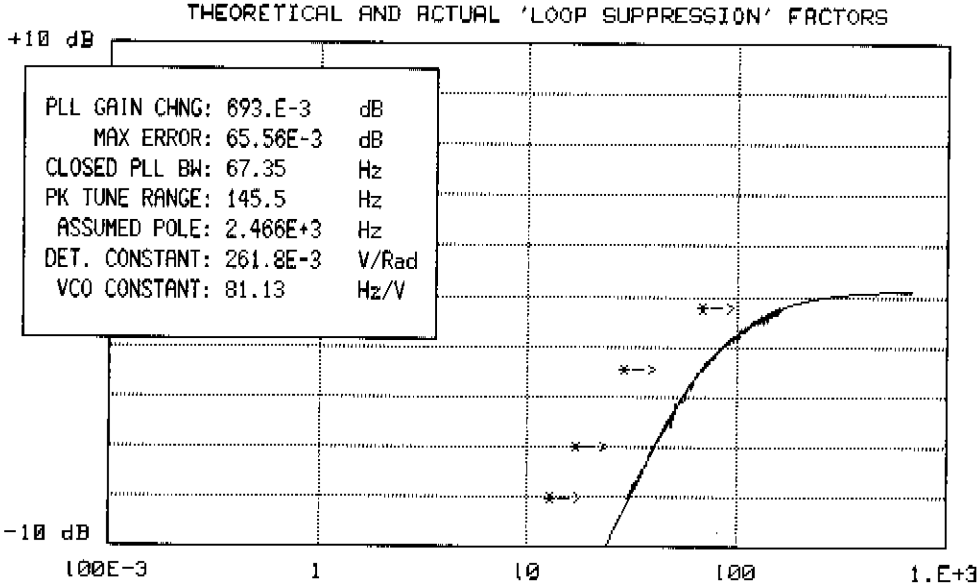


Figure 2-22. Example of Loop Suppression Graph

Considerations for the Loop Suppression Verification

Verification of the loop suppression may be prevented by excessive noise close to the carrier, by a large spur within the bandwidth of the PLL, or by injection locking.

It should be assumed that an indicated Accuracy Specification Degradation applies at all offset frequencies (both inside and outside of the loop bandwidth).

If the Detector Constant and VCO Tune Constant are known to be accurate, the PTR is less than 10 MHz, and the VCO tuning port bandwidth is greater than PLL BW $\times$ 10, then a measurement without Loop Suppression Verification will be accurate.

The amount of adjustment required to fit the theoretical curve to the measured curve is recorded as the PLL GAIN CHANGE on the Suppression Graph and the frequency of the Assumed Pole. The Assumed Pole is a software controlled term used to fit the Adjusted Theoretical loop response to the smoothed measured response of the phase lock loop. The MAX ERROR is the final amount of error existing between the adjusted theoretical curve and the measured curve of the phase lock loop suppression. If the PLL GAIN CHANGE or MAX ERROR is greater than 1 dB, the test system indicates that an Accuracy Specification Degradation has been detected. (For information about the appropriate actions to take, refer to chapter 8 *Messages*.)

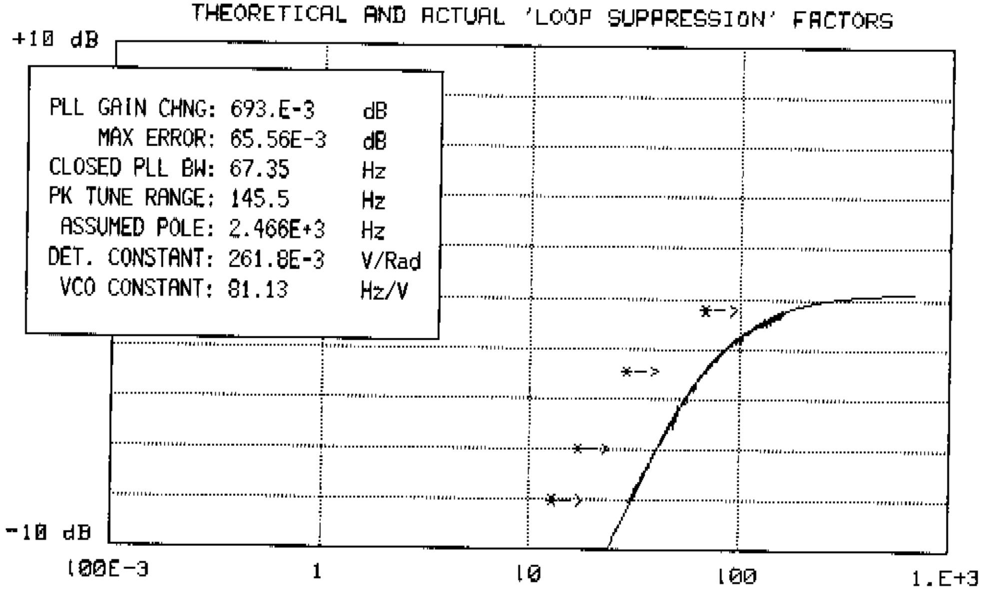


Figure 2-22. Example of Loop Suppression Graph

Considerations for the Loop Suppression Verification

Verification of the loop suppression may be prevented by excessive noise close to the carrier, by a large spur within the bandwidth of the PLL, or by injection locking.

It should be assumed that an indicated Accuracy Specification Degradation applies at all offset frequencies (both inside and outside of the loop bandwidth).

If the Detector Constant and VCO Tune Constant are known to be accurate, the PTR is less than 10 MHz, and the VCO tuning port bandwidth is greater than PLL BW $\times$ 10, then a measurement without Loop Suppression Verification will be accurate.

Calibration for the Phase Noise Without Using a PLL Measurement

The window shown in figure 2–23 is available when you select the *Phase Noise Without Using a PLL* measurement type.

```
    ┌─ Main Menu ──────────────────┐
    │                              │
    │ Type/Range of Measurement    │
    │ Parameters                   │
╒═══ Calibration Technique ══════════════════════════════════════════════╕
│                                                                        │
── Press F1 to Select Detector Constant Method ───────────────────────────
│                                                                        │
│   Use Current Detector Constant ........[      277.7E-3 ] V/Rad        │
│   Derive From Measured ± DC Peak                                       │
│   Derive From Measured Beat-note                                       │
│                                   ┌── Known Spur Parameters ──┐        │
│   Derive From Double-sided Spur   │ Ampl [           -30 ] dBc│        │
│   Derive From Single-sided Spur   │ Freq [        10.E+3 ] Hz │        │
│                                   └───────────────────────────┘        │
│                                                                        │
╘════════════════════════════════════════════════════════════════════════╛
```

Figure 2–23. Calibration Technique for Phase Noise Without Using a PLL

Introduction

Calibration of the "Phase Noise Without Using a PLL" measurement type involves calibration of the phase Detector Constant. The phase Detector Constant is the sensitivity of the phase detector expressed in V/Rad. The noise floor (or the maximum sensitivity of the test system) is set by the phase Detector Constant.

The phase detector translates phase fluctuations to voltage fluctuations. The amplitude of the phase detector's voltage output is proportional to the phase fluctuations at its input and its sensitivity. The detector's sensitivity is a function of the power levels at its input. The phase Detector Constant determines the absolute noise floor of the test system.

There are several methods available for calibrating the phase Detector Constant when phase noise measurements are made without using a phase lock loop. The primary considerations for selecting a calibration method are measurement accuracy and equipment availability as shown in table 2-9.

Table 2-9. Calibration and Measurement Accuracy Comparison

Technique	Additional Equipment Required	Accuracy
Use the Current Detector Constant	None	*
Derive From Measured +/— DC Peak	Phase Shifter or source with appropriate frequency resolution	Fair
Derive From Measured Beat-note	Second RF source	Good
Derive From Double Sided Spur	Phase Modulator, Audio Source, and RF Analyzer	Best
Derive From Single Sided Spur	Directional Coupler, RF Analyzer, and Second RF Source	Best

* Accuracy depends on which technique was used to determine the Detector Constant in memory.

Use the Current Detector Constant

Introduction

This calibration method configures the test system to use the phase Detector Constant currently in memory. This eliminates the time spent calibrating the phase Detector Constant. The phase Detector Constant in memory is the value that was determined by the last measurement made (unless a stored Parameter file has been loaded). The phase Detector Constant value appears in the *Calibration Technique* window.

The phase Detector Constant is valid for repeat measurements of similar devices as long as the input power levels remain the same (within ±0.3 dB).

Parameter Entry Descriptions

Entering a Detector Constant

The phase Detector Constant's value may be changed by keying in the desired value when "Use Current Detector Constant" is displayed in inverse video. (Keep in mind that absolute measurement accuracy depends on the accuracy of the phase Detector Constant.)

Estimating a Detector Constant

An estimate of the phase Detector Constant can be made directly from the R port input power level. (Providing the power level requirements for driving the L port of the phase detector are being met.) A power meter or a spectrum analyzer can be used to measure the power level. Compare the measured R port level to the following graph to determine the phase Detector Constant.

Z

Derive From Measured +/- DC Peak

Introduction

The Derive From Measured + /− DC Peak selection configures the test system to measure the positive and negative peak voltages out of the phase detector. The measured + /− DC Peak voltages out of the phase detector are averaged to determine the phase Detector Constant (Peak volts = Detector Constant in V/Rad.)

This method requires a phase shifter, or an RF source capable of tuning the phase detector through 360° of phase shift to achieve the maximum and minimum dc voltages. The HP 3048A prompts you to adjust the phase. One of the advantages of using this method of calibration is that the phase detector is calibrated using the same equipment used for the measurement. Manual operation of the equipment may be required.

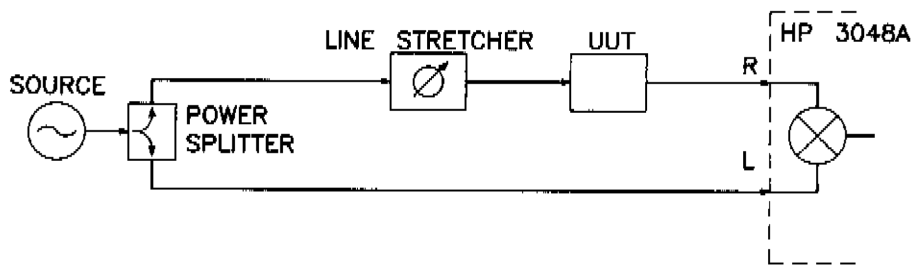


Figure 2-25. +/− DC Peak Setup Diagram

Considerations for the Derive From Measured +/- DC Peak Method

This method for determining the phase Detector Constant provides more accuracy than an estimated entry but less than the Beatnote, Double-sided Spur, or Single-sided Spur methods.

The accuracy of the phase Detector Constant using this method depends upon the power level driving the phase detector. The phase detector should be operated in its linear region for best accuracy. Very high input levels are often used to maximize the test system's noise floor at the expense of driving the Phase Detector in its non-linear region. The HP 3048A assumes the phase detector is operating in its linear region during calibration. If the Phase Detector is operating in its non-linear region, the phase Detector Constant could be slightly in error (maximum error is ≈ 1 dB).

Derive From Measured Beat-Note

Introduction

The beatnote method for calibrating the phase Detector Constant requires two signal sources. Usually one source is used only for calibration. The calibration source is connected to the phase detector in place of one of the input-signal paths. The output level of the calibration source must be adjusted to provide exactly the same signal level at the phase detector input port as will be present during the measurement. The disconnected signal path should be terminated in 50 ohms to maintain the power level at the other input port of the phase detector.

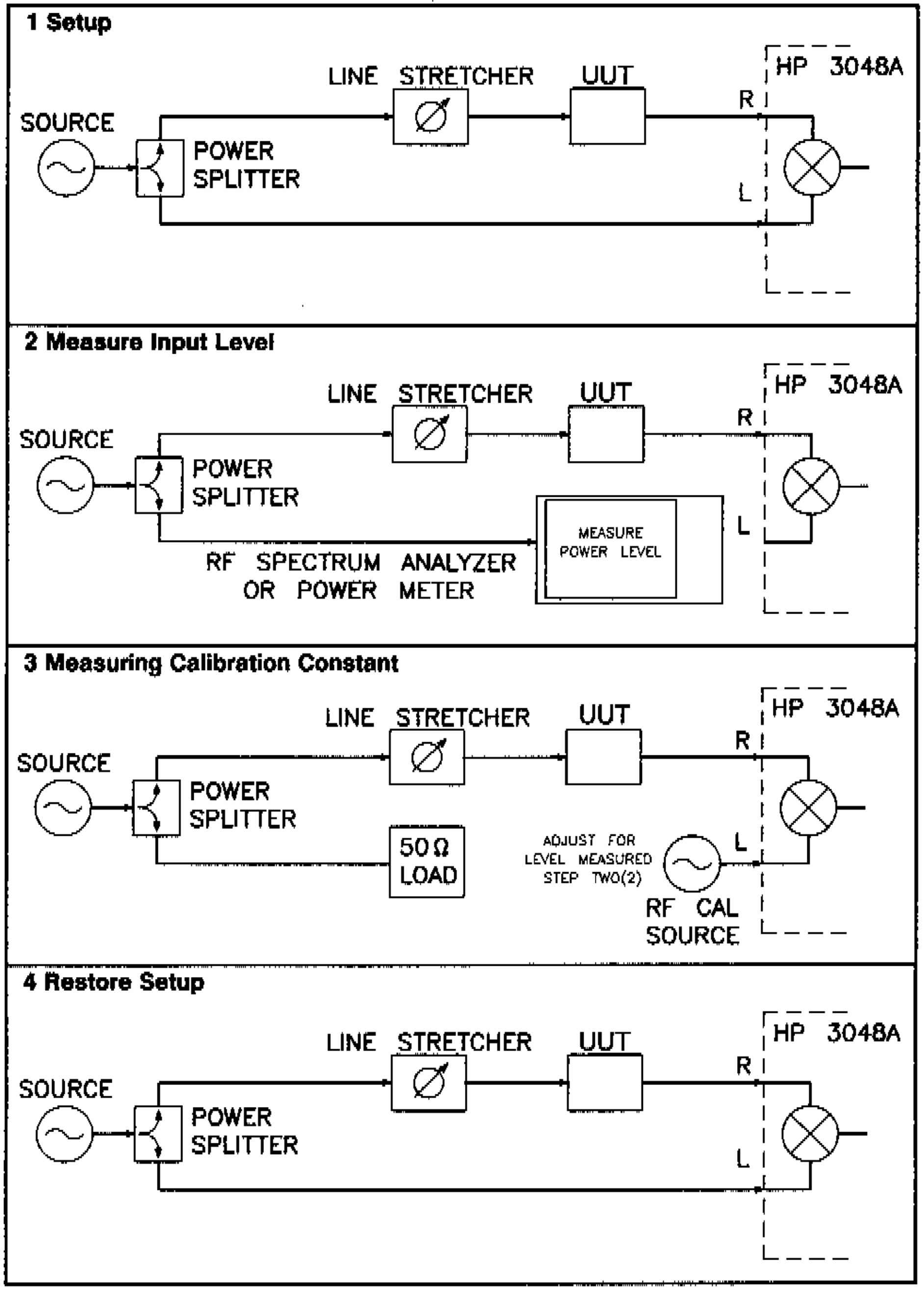


Figure 2-26. Setup Block Diagram for Beat-Note Calibration

Description of the Beatnote Calibration Method

Beatnote Frequencies Less Than 1 kHz

To determine the phase Detector Constant from a beatnote, the calibration source is adjusted to create a beatnote between the two sources. For beatnote frequencies less than 1 kHz the HP 3048A uses the slope of the beatnote waveform as it passes through the zero crossing as the phase Detector Constant (or sensitivity of the detector to variations in phase). If slope of the beatnote waveform differs by less than 10% on two consecutive zero crossings, as in a sine wave or a triangle wave, then the software's ability to determine the phase Detector Constant is very good. The phase Detector Constant is valid for variations in phase up to 0.2 radians (the small angle criteria).

Beatnote Frequencies Greater than 1 kHz

Beatnotes greater than 1 kHz require that the test system determine the phase Detector Constant by measuring the beatnote fundamental and its odd harmonics. The odd harmonics of the beatnote are measured to determine how much the beatnote departs from a sine wave. This measurement corrects the measured amplitude of the beatnote to determine an accurate phase Detector Constant for non-sinusoidal beatnotes.

If the first odd harmonic is less than −30 dBc, the HP 3048A assumes the beatnote is a sine wave. The phase Detector Constant is a function of the amplitude of the fundamental (a sine wave's peak amplitude is equal to the phase slope). If, however, the first odd harmonic of the beatnote is greater in amplitude than −30 dBc but beyond the range of the analyzer configured in the test system, the HP 3048A incorrectly assumes that the beatnote is a sine wave. In this case, a small error in the Detector Constant is introduced (maximum, worst case error is $\approx$ 1 dB). For this reason, the beatnote frequency should be less than one third of the full-scale frequency range of the test system analyzer. (As an example, the HP 3561A has a maximum frequency span of 100 kHz, therefore, a beatnote frequency of less than 30 kHz insures that the third harmonic (90 kHz) can be measured.)

Considerations for the Derive from Measured Beat-Note Method

This method is more accurate than the + /− DC Peak method but not as accurate as the Single or Double-sided Spur method. The level of the calibration source and the circuit it replaces must be exactly the same or the Detector Constant will be in error.

The HP 3048A displays messages to guide you through the manual steps required for the Beatnote Calibration method.

Since the peak voltage of a sine wave is equal to its slope, the peak voltage can be used as an approximation of the phase Detector Constant for sinusoidal beatnotes. The beatnote can be examined with an oscilloscope using the HP 11848A AUX MONITOR port. This is helpful to confirm that the phase Detector Constant measured by the test system is correct.

Derive From Double-Sided Spur

Introduction

The Derive From Double-sided Spur method is one of the most accurate Detector Constant Calibration methods available. However, it requires additional equipment and presents a high level of technical difficulty.

This calibration method requires the generation of modulation sidebands. The sideband (spur) level relative to the carrier level (dBc) and the spur offset frequency must be determined first using an RF spectrum analyzer or modulation analyzer. You will be required to define the relative level and offset frequency values in the *Calibration Technique* window either during the measurement definition or when you reach the connect diagram.

The test system measures the phase detector output for the known spur levels and calculates the phase Detector Constant.

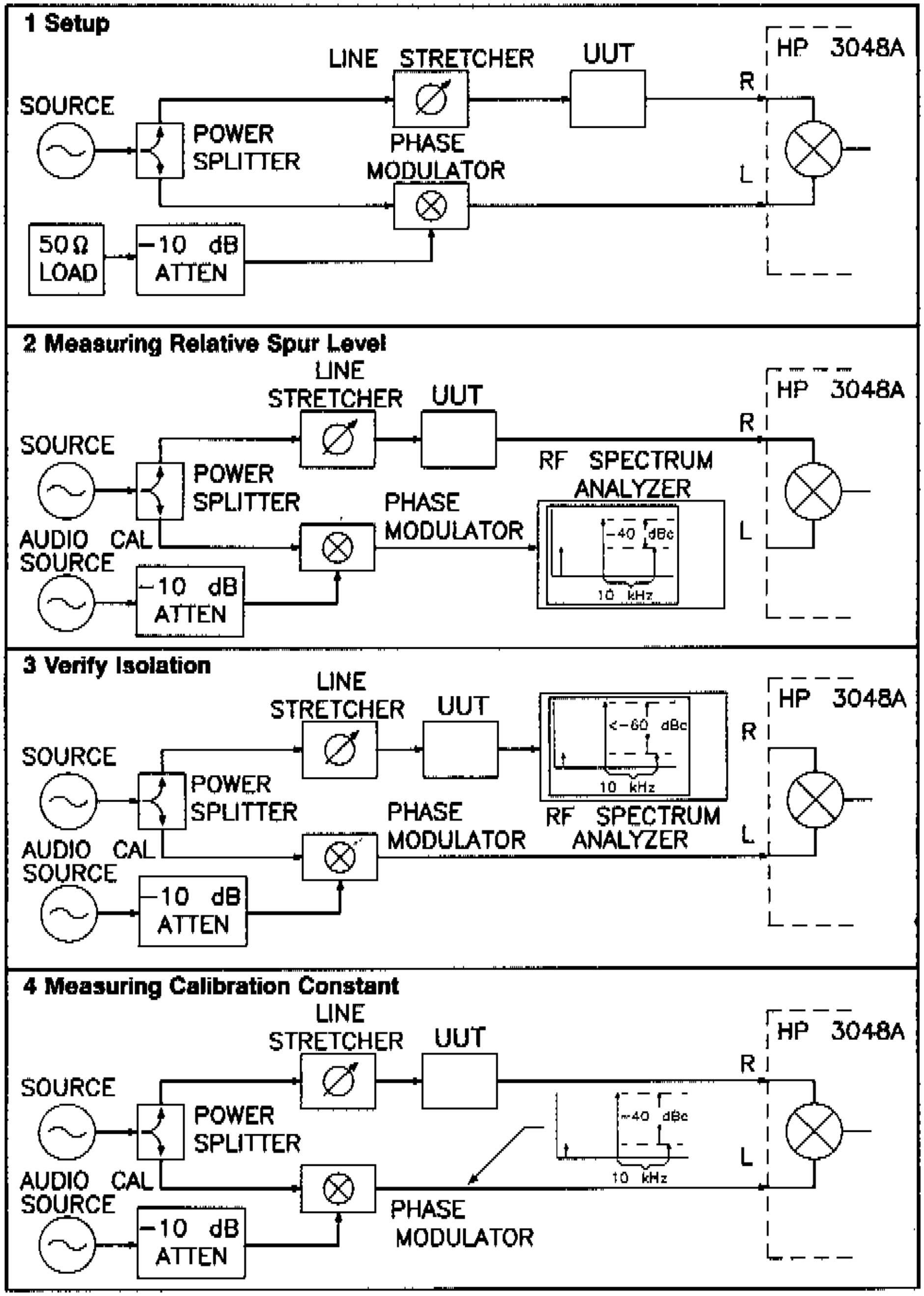


Figure 2-27. Setup Block Diagram for Double-Sided Spur Calibration

Description of the Double-Sided Spur Calibration Method

An RF spectrum analyzer is required to measure the relative difference between the fundamental signal and the spur. A spur level of −20 to −130 dBc is acceptable, however, levels within the range −26 to −60 dBc are optimum. The calibration spur can be set at a frequency offset of 1 Hz to 100 kHz (40 MHz with a supported RF analyzer) however 20 Hz to 50 kHz is recommended.

A modulation analyzer with phase demodulation capability can be used in place of the RF Analyzer. In this case the sideband levels can be determined with the following formula.

$$Sideband\ Level\ in\ dBc = 20\ log_{10} \frac{Peak\ Phase\ Deviation}{2}$$

NOTE

It is important to insure that the level of the calibration spurs are greater than the level of any other spurious signals present in the frequency spectrum. Also, you should evaluate both sideband calibration spurs to ensure that they are equal in amplitude. (Any deviation in the amplitude of the calibration spurs indicates the presence of AM in the phase modulator.) Modulation Analyzers reject the AM contribution to the sidebands thus removing any inaccuracies due to AM.

Ensure that there is at least 20 dB of isolation between the drive circuit to the R input port and the L input port of the Phase Detector by measuring the level of the spur at both input ports. (Less than 20 dB of isolation causes the calibration spur to be correlated out by the phase detector.)

K_VCO Method: This is the calibration method selected for determining the VCO Tune Constant. If "Measure the Tune Constant" is selected, the VCO Tune Constant is accurately measured by the test system. If the Tune Constant is not measured, then it is recommended that either the PLL Suppression is verified, the VCO is a calibrated source, or that the Tune Constant has been verified in a previous measurement.

K_vco: This is the VCO Tune Constant the test system uses for the measurement. The accuracy of the VCO Tune Constant determines the accuracy of the PLL noise measurement for offset frequencies greater than or equal to the phase lock loop bandwidth. The accuracy of the VCO Tune Constant is verified if the PLL Suppression is Verified. The VCO Tune Constant times the Tune Range of VCO determines the Peak Tune Range (PTR) value for the measurement. The PTR sets the drift tracking and close-in noise suppression capabilities of the test system.

Loop Suppr: This indicates whether or not the Phase Lock Loop (PLL) Suppression was verified. The PLL Suppression verification shows the accuracy of the phase Detector Constant and VCO Tune Constant.

For all PLL measurements, the test system generates a theoretical loop suppression correction and applies it to the measured noise data. When verification of the loop suppression is selected, the test system measures the suppression of the phase lock loop and compares the measured suppression to the theoretical suppression. By adjusting the PTR and the Assumed Pole, the theoretical suppression is fit to the measured loop suppression. If a significant modification is required, the HP 3048A notifies you of an Accuracy Specification Degradation.

Acc'y Spec Degrad: This parameter only appears when Verification of the Loop Suppression is selected and when the theoretical loop suppression must be modified beyond acceptable limits to match it to the measured loop suppression. If the indicated Accuracy Specification Degradation is greater than zero, the VCO Tune Constant or the phase Detector Constant is in error at an offset frequency near the PLL BW, or some other problem is effecting the PLL BW, such as injection locking.

Derive From Single-Sided Spur

Introduction

The Derive From Single-Sided Spur method is a very accurate method for calibrating the Detector Constant. However, it requires additional equipment and presents a high level of technical difficulty.

This calibration method requires that an additional signal (representing the spur) is applied to one of the phase detector inputs. The sideband (spur) level relative to the carrier level (dBc) and the spur offset frequency must first be determined using an RF spectrum analyzer. You will be required to enter the relative level and offset frequency values in the *Calibration Technique* window either during measurement definition or when you reach the connect diagram.

The test system measures the phase detector output for the known spur levels and calculates the phase Detector Constant.

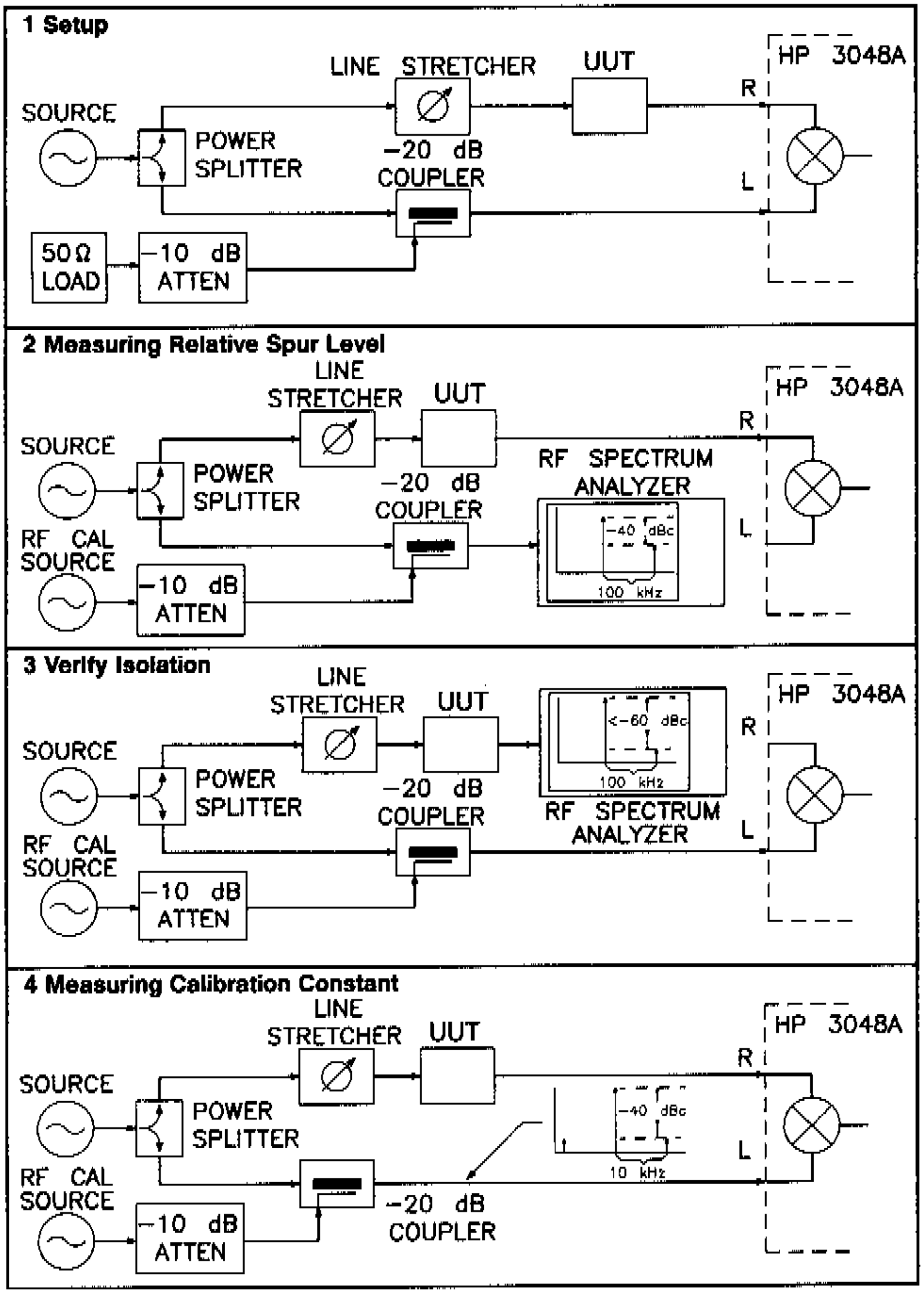


Figure 2-28. Setup Block Diagram for the Single-Sided Spur Calibration Method

Description of the Single-Sided Spur Calibration Method

A second RF signal generator and a directional coupler are required to inject the calibration spur. The calibration spur should be adjusted to approximately −40 dBc at an offset frequency that can be accurately measured with the RF analyzer. A spur level of −20 to −130 dBc is acceptable, however, levels within the range −26 to −60 dBc are optimum. The calibration spur can be set at a frequency offset of 1 Hz to 100 kHz (40 MHz with a supported RF analyzer) however 20 Hz to 50 kHz is recommended.

NOTE

It is important to insure that the level of the calibration spur is greater than any other spurious signals present in the frequency spectrum. When the test system measures the calibration spur, the analyzer does a peak search over a frequency span of two times the entered spur frequency.

Ensure that there is at least 20 dB of isolation between the drive circuit to the R input port and the L input port of the Phase Detector by measuring the level of the spur at both input ports. (Less than 20 dB of isolation causes the calibration spur to be correlated out by the phase detector.)

When the test system measures the calibration spur, the analyzer does a peak search over a frequency span of two times the entered spur offset frequency. Once the spur has been located, the level of the spur is measured and used to calculate the phase Detector Constant. This method compensates for both the non-linearity and harmonics of the phase detector. (The HP 3048A informs you when to remove the calibration spurs.)

Considerations for the Derive From Single-Sided Spur Method

Requires a RF spectrum analyzer capable of measuring the calibration spur at the desired carrier frequency.

Calibration is performed under actual measurement setup conditions.

The non-linearity and harmonics of the phase detector are calibrated out.

The relative level (dBc) of the calibration spur must remain the same when the test system measures the amplitude of the spur as when the reference measurement was made using the RF analyzer or modulation analyzer.

Calibration for Phase Noise Using an FM Discriminator Measurement

The window shown in figure 2-29 is available when you select the *Phase Noise Using an FM Discriminator* measurement type.

```
    ┌─ Main Menu ──────────────────┐
    │                              │
    │ Type/Range of Measurement    │
    │ Parameters                   │
╒═ Calibration Technique ══════════════════════════════════════════════╕
│                                                                      │
├─ Press F1 to Select Discriminator Constant Method ───────────────────┤
│                                                                      │
│  Use Current Discriminator Constant .......[      277.7E-3 ] V/Hz    │
│                                                                      │
│                                  ┌─── Known Spur Parameters ───┐     │
│  Derive From Double-sided Spur   │ Ampl     [           -30 ] dBc│   │
│  Derive From FM Rate & Deviation │ FM Rate  [        10.E+3 ] Hz │   │
│                                  └──────────────────────────────┘    │
│                                                                      │
╘══════════════════════════════════════════════════════════════════════╛
    └──────────────────────────────┘
```

Figure 2-29. Calibration Technique for Phase Noise Using an FM Discriminator

Introduction

The Phase Noise Using an FM Discriminator measurement requires calibration of the Discriminator Constant in V/Hz. The Discriminator Constant is the sensitivity of the discriminator to frequency fluctuations.

The HP 3048A offers three methods for determining the Discriminator Constant. The primary considerations for selecting a calibration method are measurement accuracy and equipment availability.

NOTE

The context of this calibration technique applies directly to a delay line FM discriminator. These calibration techniques also apply to other types of FM discriminators.

The FM Discriminator translates the phase fluctuations into frequency fluctuations. Adjustment of the input frequency or a phase shifter is required to achieve quadrature. The Discriminator Constant determines the system's absolute noise floor for the measurements. Refer to table 2-10 for a comparison of each calibration technique.

Table 2-10. Calibration Technique Comparison for FM Discriminator

Technique	Additional Equipment Required	Accuracy
Use the current Discriminator Constant	None	*
Derive From Double-Sided Spur	FM or phase modulation Generator set at the carrier frequency	Excellent
Derive From FM Rate and Deviation	FM Generator set at the carrier frequency (can be at the IF frequency if a Down Converter is being used)	Excellent

* The accuracy is dependent on which technique was used to determine the Detector Constant currently in memory or the constant being entered.

Use Current Discriminator Constant Method

Introduction

This calibration method configures the test system to use the Discriminator Constant currently in memory. This eliminates the time spent calibrating the Discriminator Constant. The Discriminator Constant in memory is the value that was determined by the last measurement made (unless a stored Parameter file has been loaded). The Discriminator Constant value appears in the *Calibration Technique* window.

The Discriminator Constant is valid for repeat measurements of similar devices as long as the delay and the input power levels remain the same (within ±0.3 dB).

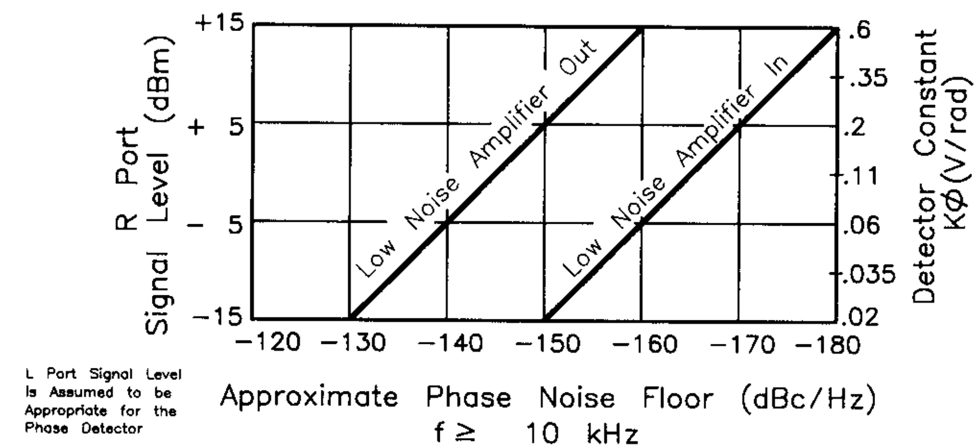
Parameter Entry Descriptions

Entering a Discriminator Constant Value

The Discriminator Constant's value may be changed by keying in the desired value. (Keep in mind that absolute measurement accuracy depends on the accuracy of the Discriminator Constant.)

Estimating the Discriminator Constant

The phase Detector Constant can be estimated directly from the R port input power level. (Providing the power level requirements for driving the L port of the phase detector are being met.) A power meter or a spectrum analyzer can be used to measure the power level. Compare the measured R port level to the following graph to determine the phase Detector Constant.



Note: This relationship assumes a 9 dB conversion loss in the Phase Detector.

Figure 2-30. Estimate of phase Detector Constant for a Given R Port Input Level

An estimate of the Discriminator Constant (K_D) can be derived from an estimate of the phase Detector Constant ($K\phi$).

The following equation converts the phase Detector Constant (K_ϕ) to a Discriminator Constant (K_D).

$$K_D = 2\pi\tau K_\phi$$

$$\begin{aligned} where\ K_\phi &= Detector\ Constant \\ K_D &= Discriminator\ Constant,\ and \\ \tau &= the\ delay\ of\ the\ discriminator \end{aligned}$$

Considerations when Using the Current Discriminator Constant

User entry is potentially the least accurate method for determining the Discriminator Constant.

This calibration method does not verify accuracy of the Discriminator Constant, but relies strictly on the user to ensure Discriminator Constant validity. (Keep in mind that Discriminator Constant accuracy relates directly to the accuracy of the measurement and accuracy to within ± 1 dB guarantees a measurement accuracy of ± 2 dB.)

An accuracy degradation may be acceptable when only the relative shape of a device's noise characteristics is important rather than the absolute noise level. In this case, only a crude approximation of the Discriminator Constant is necessary.

The Discriminator Constant calibration of the delay line discriminator is valid only to $\frac{1}{2\pi\tau}$.

Derive From Double-Sided Spur Method

Introduction

The Derive From Double-Sided Spur method is one of the most accurate Discriminator Constant calibration methods available. However, it requires additional equipment and presents a high level of technical difficulty.

This calibration method requires the generation of modulation sidebands. The sideband (spur) level relative to the carrier level (dBc) and the spur offset frequency must first be determined using an RF spectrum analyzer. You must enter the relative level and offset frequency values either in the *Calibration Technique* window or when the connect diagram appears.

The HP 3048A measures the spur level at the output of the discriminator (Phase Detector) and calculates the Discriminator Constant.

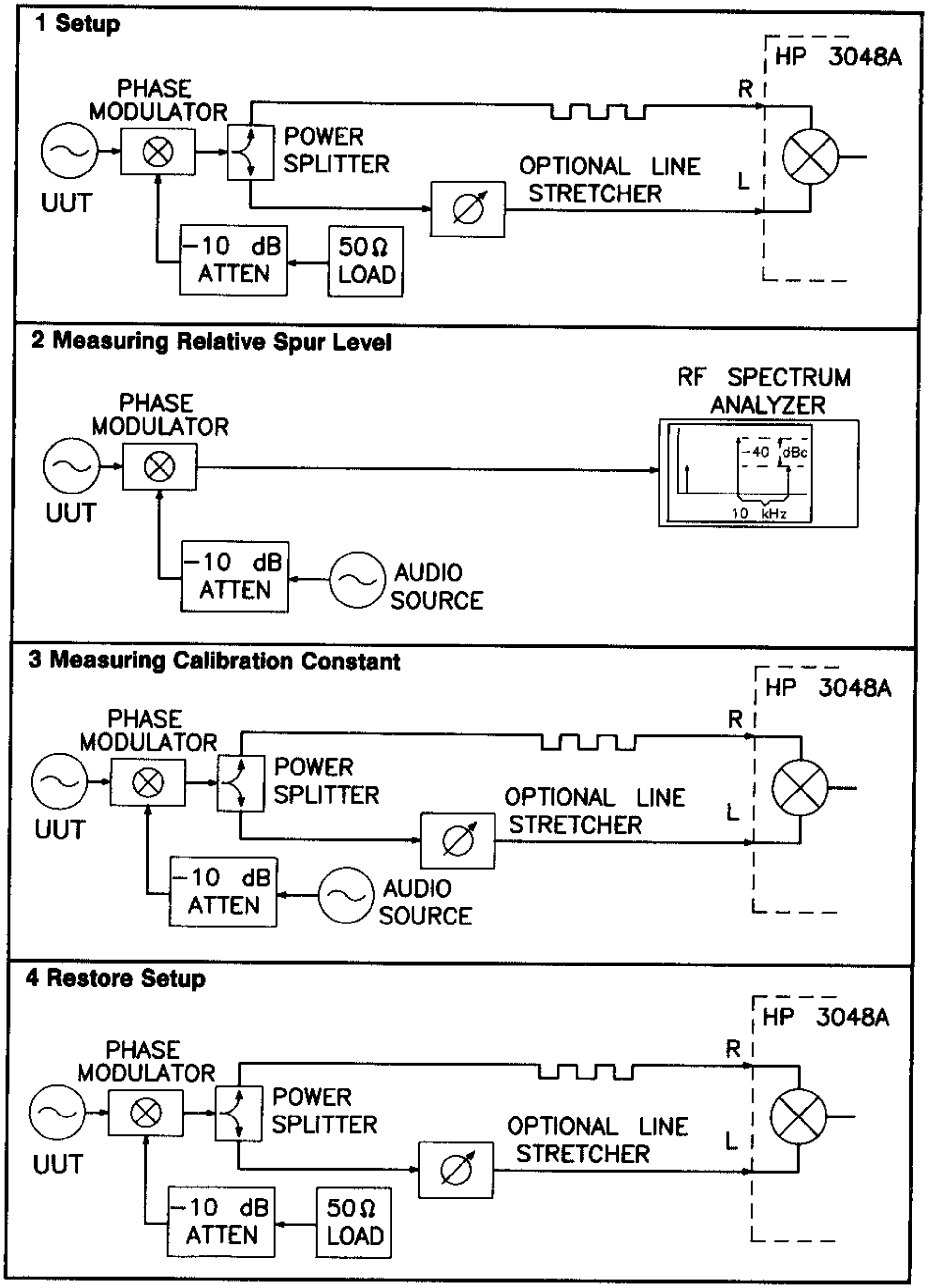


Figure 2-31. Setup Block Diagram for Double Sided Spur Calibration

Description of the Double Sided Spur Discriminator Constant Calibration Method

An RF spectrum analyzer is required to measure the relative difference between the fundamental signal and the spur. A spur level of −20 to −130 dBc is acceptable, however, levels within the range −26 to −60 dBc are optimum. The calibration spur should be adjusted to an offset frequency (FM rate) that can be accurately measured by the RF analyzer or modulation analyzer. A recommended rate of less than $\frac{1}{10\tau}$ will insure that the spur is within the flat response region of the discriminator's frequency response.

NOTE

It is important to insure that the level of the calibration spurs are greater than the level of any other spurious signals present in the frequency spectrum. Also, you should evaluate both sideband calibration spurs to ensure that they are equal in amplitude. (Any deviation in the amplitude of the calibration spurs indicates the presence of AM in the phase modulator.) Modulation analyzers reject the AM contribution to the sidebands thus removing any inaccuracies due to AM.

When the test system measures the calibration spur, the analyzer does a peak search over a frequency span of two times the entered spur offset frequency. Once the spur has been located, the level of the spur is measured and used to calculate the Discriminator Constant. This method compensates for both the non-linearity and harmonics of the phase detector.

Considerations for the Derive From Double-Sided Spur Method

This method requires an RF spectrum analyzer capable of measuring the carrier frequency and the modulation side bands or a modulation analyzer with phase demodulation capabilities.

This method requires a phase modulator capable of generating the calibration spurs at the desired carrier frequency.

Evaluation of the modulated spurs are necessary to insure good accuracy. Uneven sidebands denote amplitude modulation.

The HP 11848A's front-panel meter can be used as an aid for adjusting normal quadrature. The meter has a full scale sensitivity of 20 mV with a 2 mV/Div resolution. The meter reading setting must be within ± 1 division of center scale for starting a measurement and must remain within ± 2 divisions of the center during the measurement.

An FM rate that is greater than $\frac{1}{2\pi\tau}$ will result in a calibration spur that is beyond the flat region of the discriminator's frequency response.

Derive From FM Rate and Deviation Method

Introduction

The Derive from FM Rate and Deviation method is very accurate and is the only fully automated method for determining the Discriminator Constant. This calibration method requires the application of a frequency modulated signal to the measurement configuration. The FM rate and deviation must be determined. You are required to define FM rate and deviation values either in the *Calibration Technique* window or when the connect diagram appears.

The HP 3048A measures the spur level at the output of the discriminator (Phase Detector) and calculates the Discriminator Constant.

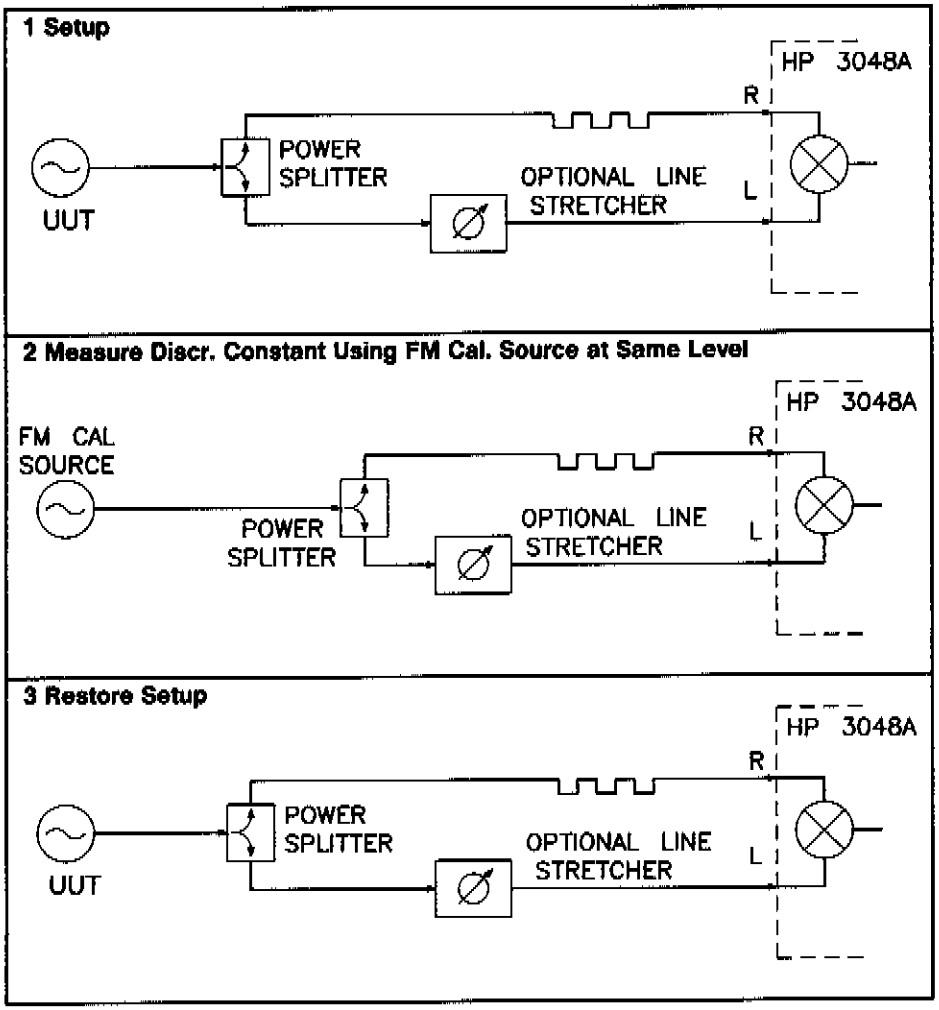


Figure 2-32. Setup Block Diagram for the
FM Rate and Deviation Spur Calibration Method

Description of the FM Rate and Deviation Spur Calibration Method

The calibration source must have a calibrated FM output. The FM accuracy of the calibration source must be within 10% to ensure the required Discriminator Constant accuracy of less than 1 dB. (If the UUT has a calibrated FM output it can be used as the calibration source.) In most cases, the UUT will be replaced by a calibration source for determining the Discriminator Constant. The calibration source output level must be adjusted to within ± 0.3 dB of the UUT's output level.

The FM Deviation must be less than $\frac{1}{100\tau}$ to maintain the small angle criteria. A recommended frequency rate of less than $\frac{1}{10\tau}$ will ensure that the calibration spur is within the linear region of the discriminator. (A rate of greater than $\frac{1}{2\pi\tau}$ is beyond the linear response region. A frequency of greater than $\frac{1}{2\pi\tau}$ violates the Small Angle Criteria and produces invalid results.)

The Derive from FM Rate and Deviation method can be performed either manually or with system control.

Manual control. If the calibration source is not under system control, you are required to connect the calibration source, adjust it to the appropriate settings (the parameters defined for the measurement), and then adjust its frequency to obtain quadrature when the connect diagram appears. The connect diagram appears again after the calibration process is complete to provide connection information for the UUT. The output level of the UUT must be within ± 0.3 dB of the calibration source level to ensure the validity of the Discriminator Constant.

System Control. The test system can control the calibration source if it is a supported RF source and has been configured in the *System Configuration*, Instrument Address table. The RF source to be used as the calibration source must also be configured in the *Instrument Control* diagram.

Calibration under system control require the entry of the FM Rate and Deviation in the *Calibration Technique* window. The connect diagram provides the connection information for the calibration source. Once the calibration source is connected to the test system, the HP 3048A sets the calibration source to the entered parameters, adjust the frequency to obtain quadrature, and measures the Discriminator Constant. After the calibration process is completed the connect diagram appears again showing the connections for the UUT. The output level of the UUT must be within ±0.3 dB of the calibration source level to ensure the validity of the Discriminator Constant.

Considerations for the Derive From FM Rate and Deviation Method

The HP 11848A's front-panel meter can be used as an aid for adjusting quadrature. The meter has a full scale sensitivity of 20 mV with a 2 mV/Div resolution. The meter reading must be within ±1 division of center scale for starting a measurement and must remain within ±2 divisions of the center during the measurement.

AM Noise Measurement

The window shown in figure 2-33 is available when you select the *AM Noise Measurement* type.

```
┌── Main Menu ──────────────────────┐
│                                   │
│  Type/Range of Measurement        │
│  Parameters                       │
│  Calibration Technique            │
│  Instrument Control               │
== Calibration Technique ================================================

— Press F1 to Select Detector Constant Method ———————————————————

  Use Current Detector Constant ........[     277.7E-3 ] V/Rad

                                      ┌─ Known Spur Parameters ─┐
  Derive From Double-sided Spur       │ Ampl [          -30 ] dBc
  Derive From Single-sided Spur       │ Freq [       10.E+3 ] Hz
                                      └─────────────────────────┘
```

Figure 2-33. Calibration Technique for AM Noise

Introduction

Calibration of the AM Noise measurement type involves calibration of the AM Detector Constant. The Detector Constant is the sensitivity of the AM detector being used for the measurement expressed in equivalent V/Rad. The noise floor (or maximum sensitivity of the test system) is set by the Detector Constant.

The amplitude of the AM detector's voltage output is proportional to the AM noise (modulation) fluctuations at its input and its sensitivity. The AM detector's sensitivity is a function of the power level at its input.

Calibration for an AM Noise measurement involves measuring the relationship between a known signal and the output of the AM detector being used. There are three methods available for calibrating the AM Detector Constant. The primary considerations for selecting a calibration method are measurement accuracy and equipment availability as shown in table 2-11.

Table 2-11. Calibration Technique Comparison for AM Noise Measurements

Technique	Equipment Required	Accuracy
Use Current Detector Constant	None	*
Derive From Double-sided Spur	Source with calibrated AM or calibrated amplitude modulator.	Very Good
Derive From Single-sided Spur	Directional coupler, RF analyzer, RF source.	Very Good

* Accuracy depends on which technique was used to determine the Detector Constant in memory.

Use the Current Detector Constant Method

Introduction

This calibration method configures the HP 3048A to use the Detector Constant currently in memory. This eliminates the time spent calibrating the AM Detector Constant. The AM Detector Constant in memory is the value that was determined by the last AM Noise measurement made (unless a stored Parameter file has been loaded). The Detector Constant value appears in the *Calibration Technique* window.

The Detector Constant is valid for repeat measurements of similar devices as long as the same detector is being used and the input-power levels remained the same (within ±0.3 dB).

Parameter Entry Descriptions

Entering a Detector Constant

The Detector Constant's value may be changed by keying in the desired value. (Keep in mind that absolute measurement accuracy depends on the accuracy of the Detector Constant.)

Estimating the Detector Constant

An estimate of the Detector Constant can be made directly from the detector's power level if the detector's sensitivity is known. A power meter or a spectrum analyzer can be used to measure the power level. The graph shown in figure 2-34 can be used to determine the Detector Constant for an HP 33330C Low Barrier Schottkey Diode Detector when used with the HP 3048A Option K21 AM Detector filter.

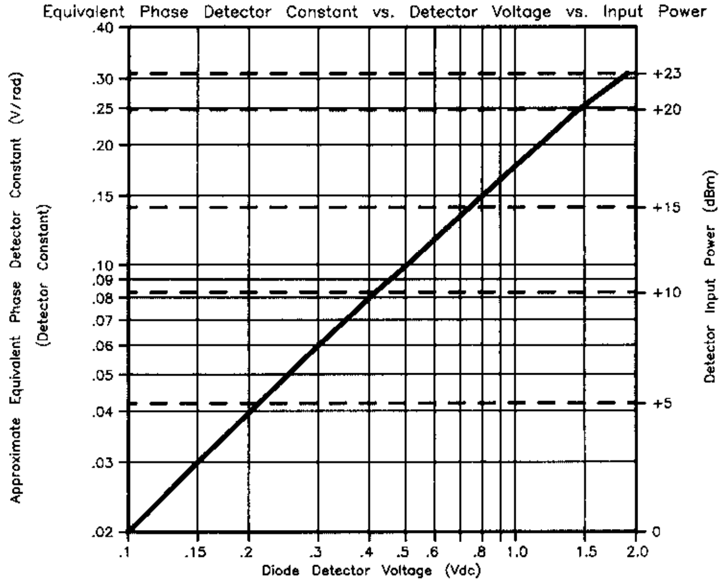


Figure 2-34. Relationship between Detector Constant and Input Power Level for the HP 33330C

Considerations when Using the Current Detector Constant

User entry is potentially the least accurate method for determine the Detector Constant.

This calibration method does not verify accuracy of the Detector Constant, but relies strictly on the user to ensure Detector Constant validity. (Keep in mind that Detector Constant accuracy relates directly to the accuracy of the measurement and accuracy to within ±1 dB guarantees a measurement accuracy of ±2 dB.)

An accuracy degradation may be acceptable when only the relative shape of a device's noise characteristics is important rather than the absolute noise level. In this case, only a crude approximation of the Detector Constant is necessary.

Derive From Double-Sided Spur

Introduction

The Derive From Double-Sided Spur method is one of the most accurate Detector Constant calibration methods available. However, it requires additional equipment and presents a high level of technical difficulty.

This calibration method requires the generation of modulation sidebands (AM). The sideband (spur) level relative to the carrier level (dBc) and the spur offset frequency must first be determined using an RF spectrum analyzer or modulation analyzer. You are required to define the relative level and offset frequency values in the *Calibration Technique* window either during the measurement definition or when you reach the connect diagram.

The test system measures the spur level at the output of the detector and calculates the Detector Constant.

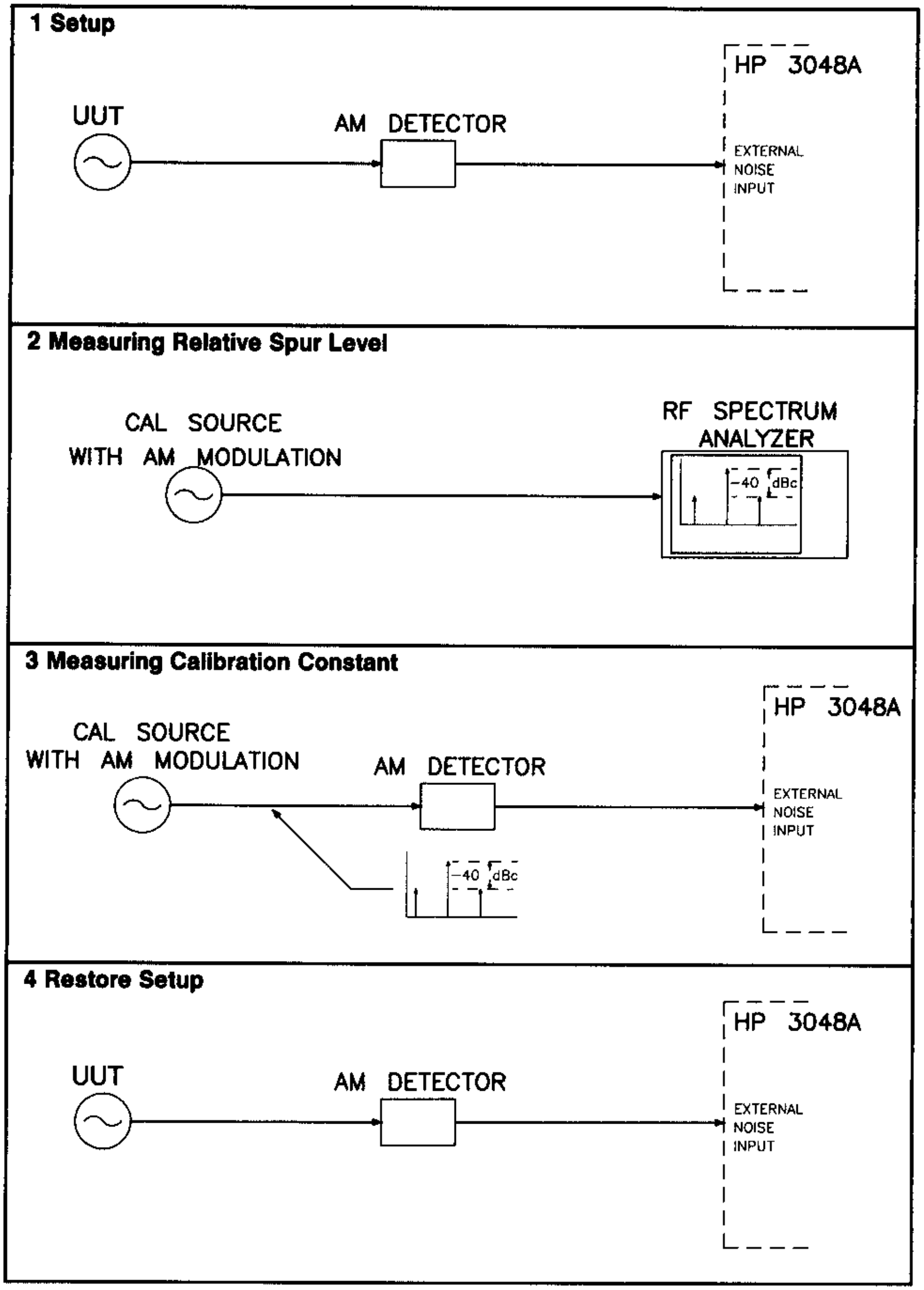


Figure 2-35. Setup Block Diagram for the Double-Sided Spur Calibration Method

Description of the Double-Sided Spur AM Detector Calibration Techinque

An RF spectrum analyzer or modulation analyzer is required to measure the fundamental signal and the spur. A spur level of −30 to −60 dBc is recommended. (If you are using a supported source that is under system control to generate the calibration spur, you will be required to enter the relative amplitude of the spur. An entry of −40 dBc is recommended; 2% AM produces a −40 dBc sideband.) The calibration spur can be set at a frequency offset of 1 Hz to 100 kHz (20 MHz with a supported RF analyzer).

NOTE

The HP 3048A expects the UUT to be set to the same power level as the calibration source prior to beginning the measurement.

It is important to insure that the level of the calibration spurs is greater than the level of any other spurious signals present in the frequency spectrum. Also, you should evaluate both sideband calibration spurs to ensure that they are equal in amplitude. (Any deviation in the amplitude of the calibration spurs indicates the presence of phase modulation in the measurement circuit. The HP 3048A's specified measurement accuracy is maintained as long as the difference in the sideband levels is less than 2 dB, and the average value of the levels is used.)

When the test system measures the calibration spur, the analyzer does a peak search over a frequency span of two times the entered spur offset frequency. Once the spur has been located, the level of the spur is measured and used to calculate the Detector Constant.

Considerations for the Derive From Double-Sided Spur Method

This method requires an RF spectrum analyzer or modulation analyzer capable of measuring the carrier frequency and the modulation sidebands unless a calibrated AM source is being used.

For optimum results, an input power level of +10 dBm is recommended for the HP 33330C AM Detector.

Unequal sidebands on the carrier potentially indicate a ΦM component is present. The presence of ΦM does not affect the operation of the AM detector. However, it does make it difficult to measure the amount of AM by looking at sideband levels. If the amount of AM is known from some other measurement technique, then the presence of ΦM is unimportant. If the sidebands are greater than 2 dB a different calibration source should be used. Variations greater than 2 dB can effect the certainty of the Detector Constant.

When under system control, the calibration source is set for an output level of +10 dBm. If this level setting is not possible on the source you are using, return to the *Instrument Control* diagram and select manual control for the calibration source. This allows you to control the source level output.

The amplitude value entered in the *Calibration Technique* window is used to derive the percentage of modulation at which to set the calibration source. If the calibration source does not provide the necessary resolution for setting the exact percentage derived from the entered amplitude, the Detector Constant will be in error. It is therefore recommended that −40 dBc be entered as the amplitude; this value corresponds to a two percent modulation which is available in all of the supported RF sources.

Derive From Single-Sided Spur

Introduction

The Derive From Single-sided Spur method is a very accurate method for calibrating the Detector Constant. However, it requires additional equipment and presents a high level of technical difficulty.

This calibration method requires that an additional signal (representing the spur) is applied to the input of the AM Detector being used. The AM sideband (spur) level relative to the carrier level (dBc) and the spur offset frequency must be determined using an RF spectrum analyzer. You are required to define the relative level and offset frequency values in the *Calibration Technique* window during the measurement definition.

The test system measures the spur level at the output of the detector and calculates the Detector Constant.

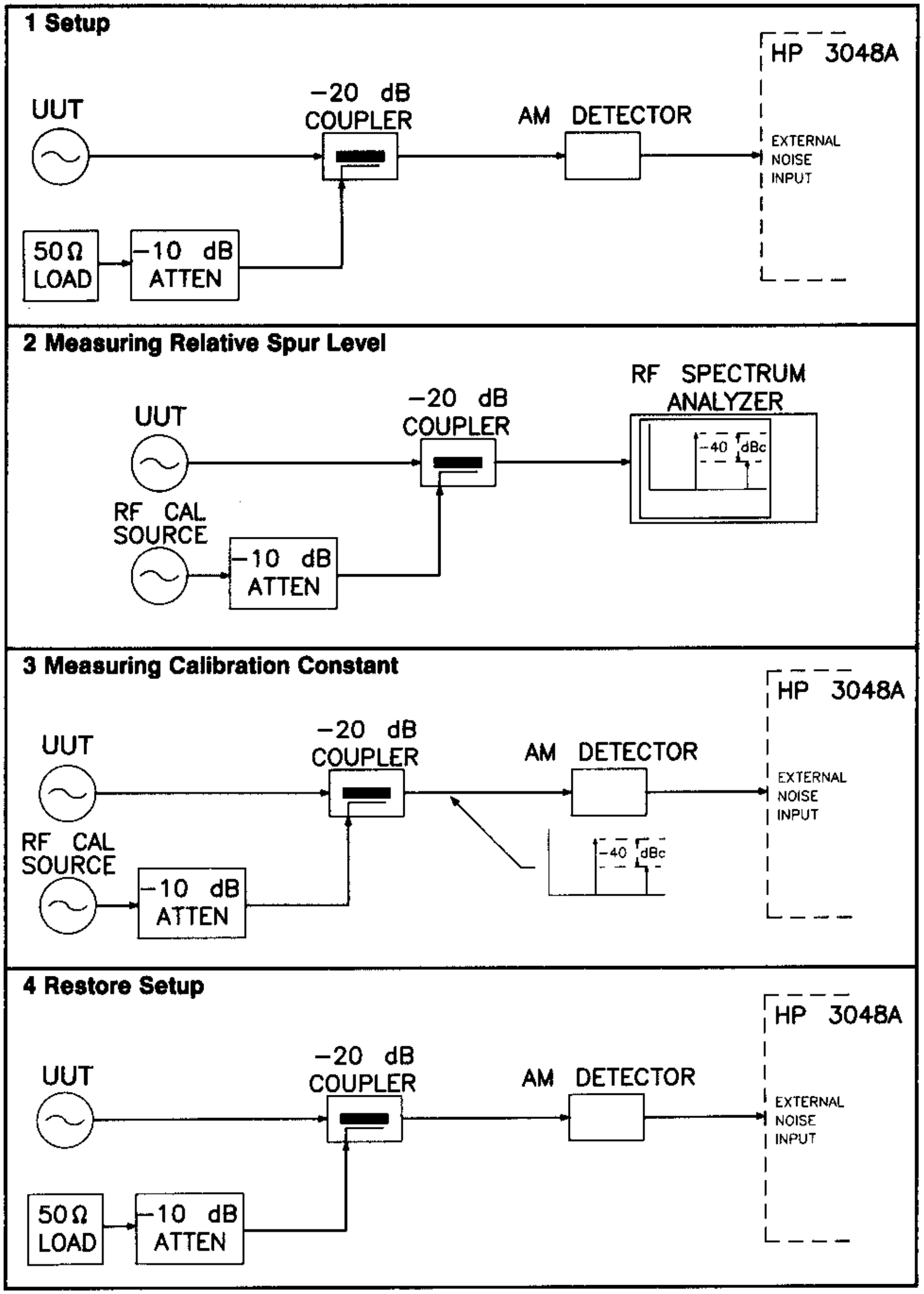


Figure 2-36. Setup Block Diagram for the Single-Sided Spur Calibration Method

Description of the Single-Sided Spur AM Detector Calibration Method

A second RF signal generator and a directional coupler are required to inject the calibration spur. The calibration spur should be adjusted to approximately −40 dBc at an offset frequency that can be accurately measured with the RF analyzer.

NOTE

The HP 3048A expects the UUT to be set to the same power level as the calibration source prior to beginning the measurement.

It is important to insure that the level of the calibration spur is greater than any other spurious signals present in the frequency spectrum.

When the test system measures the calibration spur, the analyzer does a peak search over a frequency span of two times the entered spur offset frequency. Once the spur has been located, the level of the spur is measured and used to calculate the Detector Constant. (The HP 3048A informs you when to remove the calibration spur.)

Considerations for the Derive From Single-Sided Spur Method

The power level at the AM detector input must remain the same for both calibration measurements and the noise measurements. For optimum results, a power level of +10 dBm is recommended when using the HP 33330C AM Detector.

This method requires an RF spectrum analyzer capable of measuring the calibration spur at the desired carrier frequency. Requires a second RF generator that can be set to an offset frequency of from 1 Hz to 100 kHz (or 20 MHz if an RF Analyzer is configured in the test system).

Calibration is performed under actual measurement setup conditions.

The non-linearity and harmonics of the AM detector are calibrated out.

Noise Measurement Using HP 3561A Only

The window shown in figure 2-37 is available when you select the *Noise Measurement Using HP 3561A Only* measurement type.

```
┌── Main Menu ──────────────────┐
│                               │
│  Type/Range of Measurement    │
│  Parameters                   │
═══ Calibration Technique ══════════════════════════════════════

  Adjust For Amplifier Gain by Subtracting [          20 ] dB

════════════════════════════════════════════════════════════════
│  Graph of Results             │
│  Manipulate Results           │
│  System Configuration         │
│  Advanced Functions           │
│  File System                  │
│  Quit                         │
│                               │
└───────────────────────────────┘
```

Figure 2-37. Calibration Technique for Noise Measurement Using HP 3561A Only

This function is used to offset the plotted measurement data. It compensates for any additional amplifiers or attenuators being used when making the measurement.

Offsets >0 compensate for known gains.

Offsets <0 compensate for known losses.

Baseband Noise Measurement

The window shown in figure 2-38 is available when you select the *Baseband Noise Measurement* type.

```
 ┌── Main Menu ──────────────────────┐
 │                                   │
 │   Type/Range of Measurement       │
 │   Parameters                      │
╒═ Calibration Technique ═══════════════════════════════════════╕
│                                                               │
│  Adjust For Amplifier Gain by Subtracting [          20 ] dB  │
│                                                               │
╘═══════════════════════════════════════════════════════════════╛
 │   Graph of Results                │
 │   Manipulate Results              │
 │   System Configuration            │
 │   Advanced Functions              │
 │   File System                     │
 │   Quit                            │
 │                                   │
 └───────────────────────────────────┘
```

Figure 2-38. Calibration Technique for Baseband Noise Measurement

This function is used to offset the plotted measurement data. It compensates for any additional amplifiers or attenuators being used when making the measurement.

Offsets >0 compensate for known gains.

Offsets <0 compensate for known losses.

Instrument Control

Introduction

The *Instrument Control* diagram specifies what devices are to be used in the measurement and which devices are to be controlled by the HP 3048A through the HP-IB. The measurement type selected in the *Type/Range of Measurement* window determines which measurement configuration appears in the *Instrument Control* diagram. The *Instrument Control* diagram determines what is displayed in the connect diagram at the beginning of the measurement.

Refer to the *HP 3048A Option 301 Operating Manual* for directions to change the configuration to represent the desired measurement setup. Reference Sources (other than those internal to the HP 11848A) must be configured in the *System Configuration* table to appear in the *Instrument Control* diagram.) Press the F1 softkey to allow selection of either Manual or System (HP-IB) control.

Phase Noise Using a Phase Lock Loop

The diagram shown in figure 2–39 is available when you select the *Phase Noise Using a Phase Lock Loop* measurement type.

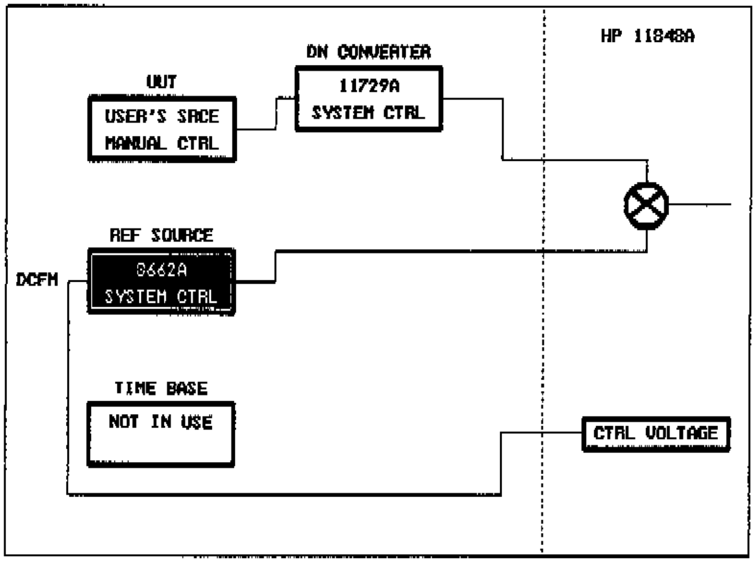


Figure 2–39. Instrument Control Diagram for Phase Noise Using a PLL

Instrument Control Block Description

When configuring the *Instrument Control* diagram, it is important that the correct connections are made and that the appropriate device is shown in each block being used. For the Phase Noise Using a Phase Lock Loop measurement type, the following blocks will appear in the diagram:

REF. SOURCE: Any of the HP 11848A Internal Sources or any RF sources defined in the *System Configuration,* Instrument Address table can be placed under System Control. Reference Sources other than HP 11848A Internal Sources must be defined in the Instrument Address table as RF Source, RF Source1, or RF Source2. If the Reference Source is the VCO for the measurement, it can be tuned by either the Control Voltage or via the Time Base.

CTRL VOLTAGE: The Control Voltage can be configured to tune the VCO Source directly (Reference Source or UUT), or to tune the Time Base when it has been configured to tune the Reference Source. One of the two sources being measured must be a VCO, either directly or through the Time Base.

TIME BASE: The Time Base connects directly to the Reference Source. The Time Base can be either an HP 11848A Internal 10 MHz A or the 10 MHz B Source, or a Users VCO Source under Manual Control.

UUT (Unit Under Test): The test system allows you to specify a USER's Source, or any of the HP 11848A Internal Sources as a System Controlled UUT. A UUT can be placed under System Control when the HP-IB character-string statements are set up in the Instrument Address table, under the *Option* column.

DN CONVERTER: The Down Converter is used to down convert the UUT frequency to a frequency within the frequency range of the Reference Source. The Down Converter can be either a Users device under Manual Control or an HP 11729C under either System or Manual Control. (The HP 11729C must be listed in the Instrument Address table to be under System Control.)

Considerations for – Phase Noise Using a Phase Lock Loop Measurement

When a Parameter file is loaded from the *File System*, it is possible that the *Instrument Control* diagram would subsequently be configured incorrectly. This occurs if the Instrument Address table does not contain an instrument required by the Parameter file. The HP 3048A then specifies another instrument currently listed in the Instrument Address table, or the User's Source if an appropriate instrument is not listed. (The Instrument Address table is not stored with the Parameter file.)

Changing the *Type/Range of Measurement* can change the *Instrument Control* diagram as well as other measurement definitions. It is recommended that you verify all measurement definition screens after selecting a new type of measurement.

Phase Noise Without Using a PLL

The diagram shown in figure 2-40 is available when you select the *Phase Noise Without Using a PLL* measurement type.

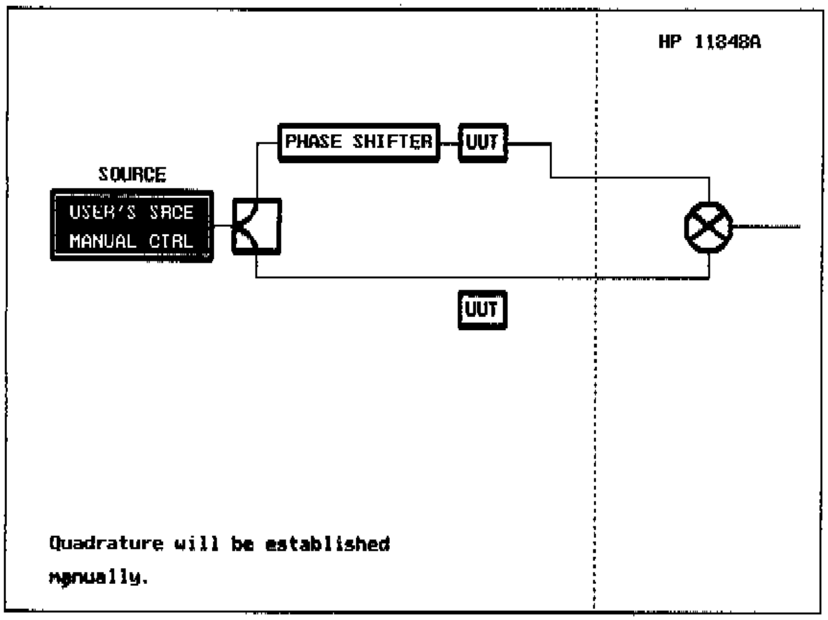


Figure 2-40. Instrument Control Diagram for Phase Noise Without Using a PLL

Instrument Control Block Description

When configuring the *Instrument Control* diagram, it is important that the correct connections are made and that the appropriate device is shown in each block being used. For the Phase Noise Without Using a PLL measurement type, the following blocks appear in the diagram:

Source: This block defines the signal source to be used for the measurement. Either an HP 11848A Internal Source, a USER's Source, or any RF source defined in the *System Configuration*, Instrument Address table can be selected.

NOTE

When measuring a two-port device, the AM noise contribution of the source can affect the measurement. It is recommended that a source with low AM noise be used to ensure good results.

Phase Shifter: When the source frequency cannot be adjusted, a Phase Shifter is required for achieving quadrature for the residual two port measurement.

UUT: The UUT blocks allow for either one or two devices to be configured in the measurement paths. The UUT blocks are positioned by pressing the [U] keyboard key. You must configure a device in both measurement paths when measuring devices that translate frequency or add large amounts of phase delay. The physical connection of where the UUT is placed with respect to the Phase Shifter is not important (unless the two port device to be measured translates the frequency). In this case, the frequency range of the Phase Shifter needs to be considered.

UUT placement is done only to help visualize the measurement configuration and specify a correct connect diagram including UUT's. UUT placement has no affect on any facet of system operation.

Quadrature: The test system allows you to specify how quadrature (90°phase shift) will be set. Pressing the [Q] or [P] key toggles the quadrature selection between adjustment of the source frequency and the manual method. (If the source is under System Control and entered in the Instrument Address table, the frequency adjustment will be automatic.) The manual method requires a phase shifter (or adjustable line stretcher) to achieve quadrature.

Considerations for – Phase Noise Without Using a PLL Measurement

When a Parameter file is loaded from the *File System,* it is possible that the *Instrument Control* diagram would subsequently be configured incorrectly. This occurs if the Instrument Address table does not contain an instrument required by the Parameter file. The HP 3048A then specifies another instrument currently listed in the Instrument Address table, or the User's Source if an appropriate instrument is not listed. (The Instrument Address table is not stored with the Parameter file.)

Changing the *Type/Range of Measurement* can change the *Instrument Control* diagram as well as other measurement definitions. It is recommended that you verify all measurement definition screens after selecting a new measurement type.

Phase Noise Using an FM Discriminator

The diagram shown in figure 2–41 is available when you select the *Phase Noise Using an FM Discriminator* measurement type.

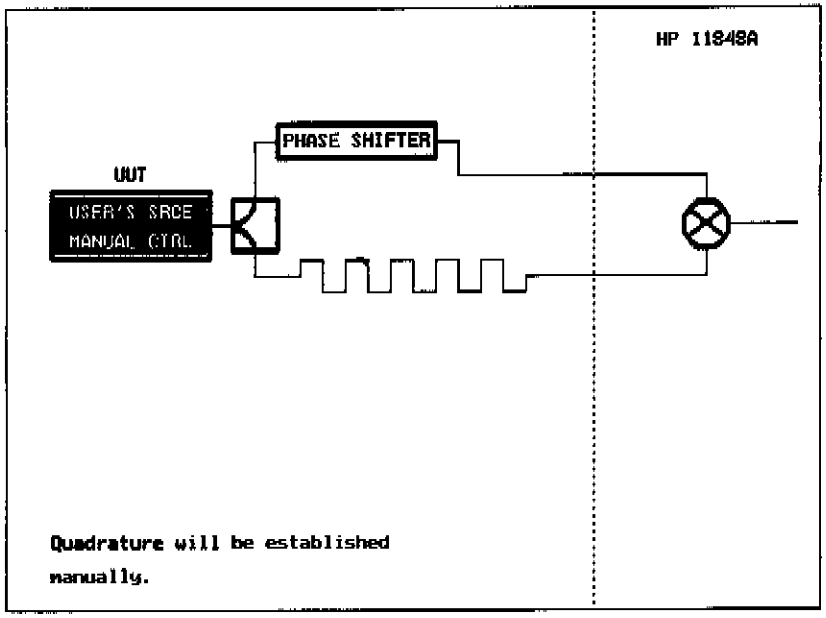


Figure 2–41. Instrument Control Diagram for Phase Noise Using an FM Discriminator

Instrument Control Block Description

When configuring the *Instrument Control* diagram, it is important that the correct connections are made and that the appropriate device is shown in each block being used. For the Phase Noise Using an FM Discriminator measurement type, the following blocks appear in the diagram:

UUT: This block defines the signal source to be measured. In most cases the UUT source will be a USER's Source under manual control. One of the HP 11848A internal sources, or an RF source defined in the *System Configuration*, Instrument Address table.

Phase Shifter: A Phase Shifter is required to achieve quadrature for the FM Discriminator measurement when the source frequency cannot be adjusted. Depending on the Quadrature Method selected, the HP 3048A responds differently. For example, if you specify "Quadrature will be established by adjusting the source frequency", you will have to adjust the frequency of the source to obtain quadrature, (unless the source is under System Control). If "Quadrature will be established manually" is selected, the HP 3048A expects to acquire quadrature by having you adjust the phase shift of one path.

Cal Source: This block appears on the *Instrument Control* diagram when "Derive from Rate and Deviation" Calibration Process is selected. Either a users Cal Source under Manual Control or a supported RF Source under System Control can be selected for the Calibration Source. The Calibration Source must have a calibrated FM output. Under Manual Control, the HP 3048A prompts you to connect the Cal Source and apply modulation, as well as to disconnect it after the calculation process is complete.

Delay Line: The Delay Line is represented by ℸ⌊ in the diagram. A Delay Line is required to decorrelate the UUT's Phase Noise (FM Discriminator).

(Refer to graph 5 *Approximate Sensitivity of Delay Line Discriminator* in chapter 7, *Quick Reference* for details on required delay lines.)

Considerations for – Phase Noise Using an FM Discriminator Measurement

When a Parameter file is loaded from the *File System*, it is possible that the *Instrument Control* diagram would subsequently be configured incorrectly. This occurs if the Instrument Address table does not contain an instrument required by the Parameter file. The HP 3048A then specifies another instrument currently listed in the Instrument Address table, or the User's Source if an appropriate instrument is not listed. (The Instrument Address table is not stored with the Parameter file.)

Changing the *Type/Range of Measurement* can change the *Instrument Control* diagram as well as other measurement definitions. It is recommended that you verify all measurement definitions after selecting a new measurement type.

AM Noise

The diagram shown in figure 2-42 is available when you select the *AM Noise* measurement type.

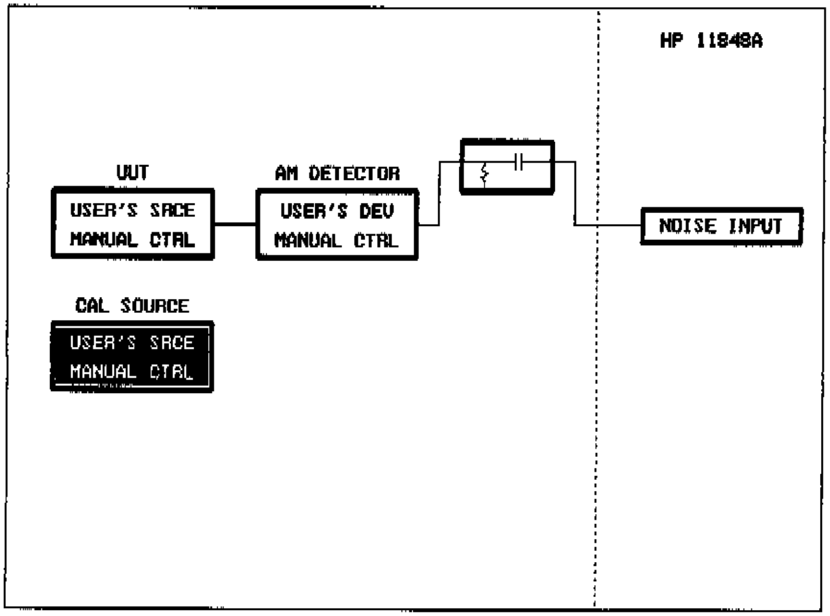


Figure 2-42. Instrument Control Diagram for AM Noise

Instrument Control Block Description

When configuring the *Instrument Control* diagram, it is important that the correct connections are made and that the appropriate device is shown in each block being used. For the AM Noise measurement type, the following blocks appear in the diagram:

UUT: This block defines the signal source to be measured. In most cases, the UUT source will be a USER's Source under manual control. The HP 3048A also allows you to specify one of the HP 11848A internal sources, or an RF source defined in the *System Configuration*, Instrument Address table.

AM Detector: This block specifies the Amplitude Modulation Detector. In most cases, the AM Detector will be a USER's device under manual control (although the test system allows you to specify the HP 11729C Option 130 as an AM Detector). The HP 11729C Option 130 includes an Internal AM Detector. The HP 11729C can be controlled manually, or it can be under System Control when it has been entered in the Instrument Address table. (The HP 11729C should be entered as a Down Converter in the Instrument Address table.)

Cal Source: This block appears on the *Instrument Control* diagram when "Derive from Double Sided Spur" Calibration Process is selected. Either a users Cal Source under Manual Control or a supported RF source under System Control can be selected for the Calibration Source. The Calibration Source must have a calibrated AM output. Under Manual Control the test system prompts you to connect the Cal Source and apply modulation as well as disconnect it after the calculation process is complete.

DC Block:

The HP 11848A Phase Noise Interface must be dc-blocked when using its NOISE INPUT. The Interface will not tolerate more than ±2 mv DC Input without overloading the LNA. A DC block must be connected in series after the AM Detector to remove the dc component. A blocking circuit is not provided with the HP 3048A. A dc block can either be constructed or purchased. The HP 3048A Option K21 is designed specifically for this purpose.

Considerations for – AM Noise Measurement

When a Parameter file is loaded from the *File System,* it is possible that the *Instrument Control* diagram would subsequently be configured incorrectly. This occurs if the Instrument Address table does not contain an instrument required by the Parameter file. The HP 3048A then specifies another instrument currently listed in the Instrument Address table, or the User's Source if an appropriate instrument is not listed. (The Instrument Address table is not stored with the Parameter file.)

Changing the *Type/Range of Measurement* can change the *Instrument Control* diagram as well as other measurement definitions. It is recommended that you verify all measurement definitions after selecting a new measurement type.

Define Graph

The window shown in figure 2-43 is available when you select *Define Graph*.

```
     ┌── Main Menu ─────────────────┐
═ Define Graph ══════════════════════════════════════════════════════

  Title [HP3048A DEMO: 10 MHz "A" vs. 10 MHz "B"                     ]
  Minimum X Coordinate ............................[              10 ]
  Maximum X Coordinate ............................[        100.E+03 ]
  Maximum Y Coordinate ............................[               0 ]
  Minimum Y Coordinate ............................[            -170 ]

── Press F1 to Select Graph Type ────────────────────────────────────

    Single Sideband Phase Noise (dBc/Hz)
    Phase Modulation Spectral Density (dB/Hz)
    FM Spectral Density (Hz/Sqrt(Hz))
    Spectral Density of Fract. Freq. Fluctuations (1/Sqrt(Hz))
    Noise Figure For 2-Port Devices
═════════════════════════════════════════════════════════════════════
```

Figure 2-43. Define Graph Characteristics

Introduction

The *Define Graph* window allows you to specify the characteristics shown in the *Graph of Results*. The graph title, X axis range, Y axis range, and graph type are defined in this window.

Figure 2-44 shows an example graph plotted from the *Graph of Results* (demo results were loaded).

Parameter Entry Descriptions

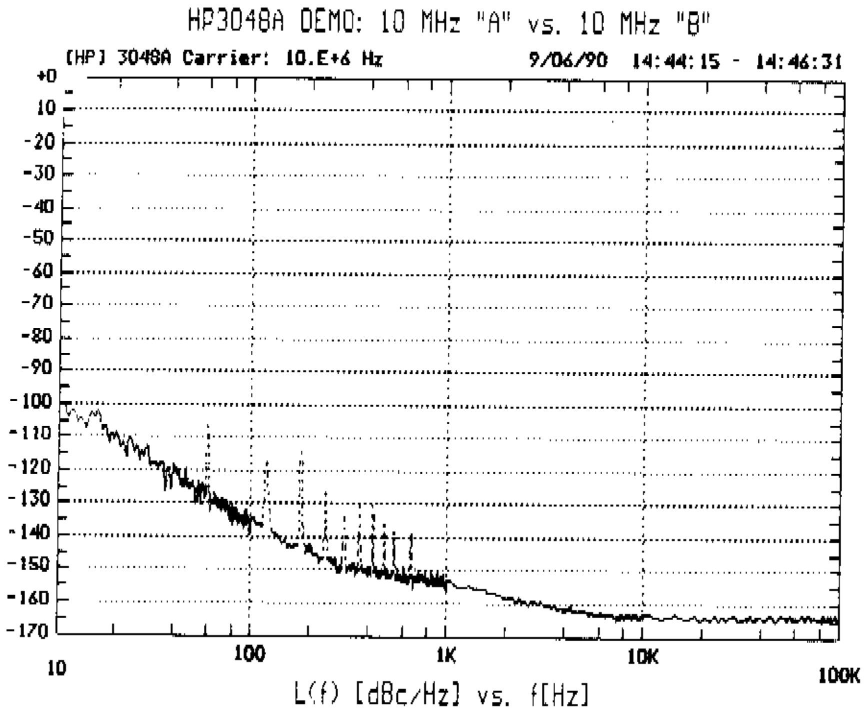


Figure 2-44. Graph of Results Demo Example

Title: This parameter allows you to enter a title for the Results Graph (up to 56 characters long).

Minimum X Coordinate: This parameter specifies the start value (frequency) for the X axis on the graph. The acceptable limits are 1.E−3 Hz. to 10.E+9 Hz. This value must be less than the Maximum X coordinate.

Maximum X Coordinate: This parameter specifies the stop frequency for the X axis on the graph. The acceptable limits are 1.E−3 Hz. to 10.E+9 Hz. This value must be greater than the Minimum X coordinate.

Minimum Y Coordinate: This parameter specifies the upper limit of the Y axis. Units for the Y axis are determined by the Graph Type selected. This value must be less than the Maximum Y coordinate.

Maximum Y Coordinate: This parameter specifies the lower limit of the Y axis. Units for the Y axis are determined by the Graph Type selected. This entry must be greater than the Minimum Y coordinate.

Graph Type Other than AM or Baseband Noise: This parameter specifies the data type in which the measurement results are displayed.

- **Single-sideband phase noise (dBc/Hz).** The HP 3048A calculates: $\mathcal{L}(f) = \frac{S_\phi(f)}{2}$, and plots the results in dBc.

- **Phase Modulation Spectral Density (dB/Hz).** The HP 3048A calculates: $S_\phi(f)$, and plots the results in dB with respect to 1 radian (Radians, and Degrees).

- **FM Spectral Density ($Hz/\sqrt{Hz}$).** The HP 3048A calculates: $S_\nu(f) = S_\phi(f) \times f^2$, and plots the results in Hz (Residual FM).

- **Spectral Density of Fractional Frequency Fluctuations ($1/\sqrt{Hz}$).** The HP 3048A calculates: $S_y(f) = S_\phi(f) \times (\frac{f}{\nu_o})^2$ (where ν_o = carrier frequency), and plots the results without units.

- **Noise Figure for 2-Port Devices.** The HP 3048A calculates the noise figure (NF) $= S_\Phi(f) + 174 + Pin$, and plots the results as dB/Hz. Pin is the input power listed in *Manipulate Results,* under the *Input Pwr (Noise Figure)* field.

Parameter Files

An example of Parameter files that are loaded after you select the *File System* menu and *Load File* *.PRM is shown in figure 2-45.

```
        ┌─ Main Menu ──────────────┐
        │ Type/Range of Measurement│
═ Load  File ═══════════════════════════════════════════ ▼
LASTPRMS.PRM │ 11/01/90 │ HP3048A DEMO: 10 MHz "A" vs. 10 MHz "B"
HPTEST21.PRM │ 10/23/90 │ HP TEST 8662/63 VS  8662/63 ABSOLUTE NOISE @ 1270
HPTEST20.PRM │ 10/23/90 │ HP TEST 8662/63 VS 8662/63 ABSOLUTE 640 MHZ REF NO
HPTEST19.PRM │ 10/23/90 │ HP TEST 8662/63 VS 10MHZ REF OUTPUT DCFM 10KHZ PEA
HPTEST18.PRM │ 10/23/90 │ HP TEST 8642A/B VS 8662/63 ABS NOISE @ 640 MHz
HPTEST17.PRM │ 10/23/90 │ HP TEST 11729C/8662/63 VS 11729C/8662/63 ABS NSE
HPTEST16.PRM │ 10/23/90 │ HP TEST 11729C RESIDUAL NOISE
HPTEST15.PRM │ 10/23/90 │ HP TEST 10 MHZ B VS 8662/63 10 MHZ REF OUTPUT
HPTEST14.PRM │ 10/23/90 │ HP TEST 10 MHZ A VS 8662/63 10 MHZ REF OUTPUT
HPTEST13.PRM │ 10/23/90 │ HP 8447E NOISE FLOOR USING AN 8642B
HPTEST12.PRM │ 10/23/90 │ STABLE RF OSCILLATOR VS SIMILAR REFERENCE SOURCE
HPTEST11.PRM │ 10/23/90 │ RF SYNTHESIZER VS HP 8662/3A USING EFC
HPTEST10.PRM │ 10/23/90 │ RF SYNTHESIZER VS HP 8662/3A USING DCFM
HPTEST09.PRM │ 10/23/90 │ RF SYNTHESIZER VS HP 8662/3A AND 10 MHZ B
```

Figure 2-1. Example Parameter Files

Introduction

Storing and Loading a Parameter file ensures that the parameter entries are identical each time a particular measurement is made. Also, it may be helpful to load and modify an existing Parameter file for making a new measurement for a similar type of device.

Description of the Parameter Files

Parameter File Contents

Parameter files contain the calibration constants created in the last measurement made by the HP 3048A as well as information from the following menus.

- Type/Range of Measurement
- Parameters
- Calibration Technique
- Instrument Control
- Define Graph
- Manipulate Results
- Advanced Functions

The File System

Each stored file has a *name* and a corresponding *title*.

- The file *name* is used to store, load, or delete files. File names are limited to eight characters and must have the extension `.PRM`. An example name is `DEFAULT.PRM`.
- The file *title* allows you to provide a description of a file's contents. The title is entered in the *Define Graph* menu, and appears at the top of the Graph of Results. Titles are limited to 55 characters. An example title is *HP3048A DEMO: 10 MHz "A" vs. 10 MHz "B"*.

Parameter Files Shipped with the HP 3048A Option 301

When the HP 3048A Option 301 is shipped, it includes the following predefined parameter files.

- *DEFAULT.PRM* sets up the HP 3048A to measure the HP 11848A's internal 10 MHz sources, 10 MHz "A" vs. 10 MHz "B". This measurement provides a quick verification of the HP 3048A's ability to complete a phase noise measurement. (Refer to the HP 3048A Option 301 System Calibration Manual for additional information.)

- *SPURACCY.PRM, FLATNESS.PRM, and NOISEFLR.PRM* are used to verify the performance of the HP 3048A. These parameter files are accessed from the Advanced Functions Menu. (Refer to the HP 3048A Option 301 System Calibration Manual for additional information.)

- *HPTESTXX.PRM* files contain predefined parameters used to verify some HP 3048A options. These files also contain example tests used for measuring the device indicated in the title of the file. The example tests are provided to aid you in setting up your own measurements. (Refer to the HP 3048A Option 301 System Calibration, and Operating manuals for additional information.)

- *LASTMEAS.PRM* contains the parameters from the last successfully completed measurement. It is automatically updated after each successful measurement and is automatically loaded each time the HP 3048A Option 301 software is booted-up. (If this file is not present, the HP 3048A will load the file named *DEFAULT.PRM*.)

Considerations for Parameter Files

The *System Configuration*, Instrument Address table is not stored with the Parameter file; this may cause the *Instrument Control* diagram to be configured incorrectly. If the control diagram stored in a Parameter file specifies an instrument not currently listed in the address table, the *Instrument Control* diagram will not include the specified instrument .

Instead, the HP 3048A specifies a similar instrument listed in the current Instrument Address table, or if an appropriate instrument is not currently listed, the USER's Source is selected.

How to Manage Parameter Files

Loading a Parameter File

1. From the Main Menu, select **File System.**
2. Select **Load File.**
3. Define the path by typing `*.PRM`.

NOTE

To load a file from a disk drive or subdirectory other than the one from which the software is being run, precede the path definition with the drive designation and/or the directory, for example, `A:\FILES\*.PRM`.

---

4. Use the △ ▽ keys to select the desired Parameter file and press **ENTER.**

Storing a Parameter File

It is recommended that you complete a measurement before storing the Parameter file. Completing the measurement ensures that all of the entered parameters are correct. Also, storing the Parameter file after the measurement has been completed ensures that the correct calibration constants are stored as well.

1. From the Main Menu, select **File System.**
2. Select **Store File.**
3. Type the file name and the extension .PRM.

NOTE

To store a file from a disk drive or subdirectory other than the one from which the software is being run, precede the file name with the drive designation and/or the directory, for example, A:\FILES\DEFAULT.PRM.

---

4. Press **ENTER.**

Deleting a Parameter File

1. From the Main Menu, select **File System.**
2. Select **Remove File.**
3. Type the name of the file to be deleted and the extension .PRM.

NOTE

To delete a file from a disk drive or subdirectory other than the one from which the software is being run, precede the path definition with the drive designation and/or the directory, for example, A:\FILES\DEFAULT.PRM.

---

4. Press **ENTER**.

The system will ask you if you want to delete the file.

5. Press **Y** to delete it.

NOTE

For additional information about managing files, refer to your MS-DOS(R) Manuals.

Graphic Functions 3

Introduction

The HP 3048A has a number of graphic functions that allow you to manipulate the results of your phase noise measurements. Each graphic function and its limitations are described in the following pages. (Also, refer to chapter 4, *Manipulate Results* for further information on how to modify phase-noise measurement results.)

Define Graph

The *Define Graph* window with example data is shown in figure 3-2.

```
     ┌── Main Menu ──────────────┐
═══ Define Graph ═════════════════════════════════════════════════════

  Title [HP3048A DEMO: 10 MHz "A" vs. 10 MHz "B"                      ]
  Minimum X Coordinate ............................[             10 ]
  Maximum X Coordinate ............................[       100.E+03 ]
  Maximum Y Coordinate ............................[              0 ]
  Minimum Y Coordinate ............................[           -170 ]

─── Press F1 to Select Graph Type ────────────────────────────────────

    Single Sideband Phase Noise (dBc/Hz)
    Phase Modulation Spectral Density (dB/Hz)
    FM Spectral Density (Hz/Sqrt(Hz))
    Spectral Density of Fract. Freq. Fluctuations (1/Sqrt(Hz))
    Noise Figure For 2-Port Devices
```

Figure 3–1. Define Graph Window

Introduction

The *Define Graph* window allows you to specify characteristics for the *Graph of Results*. Graph title, minimum/maximum X and Y-axis range, and graph type are defined in this window.

Define Graph Characteristics

Title: You may enter a title for the Graph of Results (up to 58 characters long).

Minimum X Coordinate: This specifies the start value (frequency) for the X axis on the graph. The acceptable limits are 1.E−3 Hz. to 1.E+9 Hz. This value must be less than the Maximum X coordinate.

Maximum X Coordinate: This specifies the stop frequency for the X axis on the graph. The acceptable limits are 1.E−3 Hz. to 1.E+9 Hz. This value must be greater than the Minimum X coordinate.

Minimum Y Coordinate: This specifies the upper limit of the Y axis. Units for the Y axis are determined by the Graph Type selected. This value must be less than the Maximum Y coordinate.

Maximum Y Coordinate: This specifies the lower limit of the Y axis. Units for the Y axis are determined by the Graph Type selected. This entry must be greater than the Minimum Y coordinate.

Graph Type (Other than AM Baseband Noise): You may specify the data type in which the measurement results are displayed.

- **Single-sideband phase noise (dBc/Hz).** The HP 3048A calculates $\mathcal{L}(f) = \frac{S_\phi(f)}{2}$, and plots the results in dBc.
- **Phase Modulation Spectral Density (dB/Hz).** The HP 3048A calculates $S_\phi(f) = S_\phi(f)$, and plots the results in dB with respect to 1 radian (Radians, and Degrees).
- **FM Spectral Density ($Hz/\sqrt{Hz}$).** The HP 3048A calculates $S_\nu(f) = S_\phi(f) \times f^2$, and plots the results in Hz (Residual FM).
- **Spectral Density of Fractional Frequency Fluctuations ($1/\sqrt{Hz}$).** The HP 3048A calculates $S_y(f) = S_\phi(f) \times (\frac{f}{v_o})^2$ (where v_o = carrier frequency), and plots the results without units.
- **Noise Figure for 2-Port Devices.** The HP 3048A calculates the noise figure (NF) $= S_\phi(f) + 174 + Pin$, and plots the results as dB/Hz. Pin is the input power listed in the *Manipulate Results* display under *Input Pwr (Noise Figure)*.

NOTE

Graph characteristics can be changed to display all or part of the measurement results by modifying the X and Y coordinates entered in the *Define Graph* window.

Graph of Results

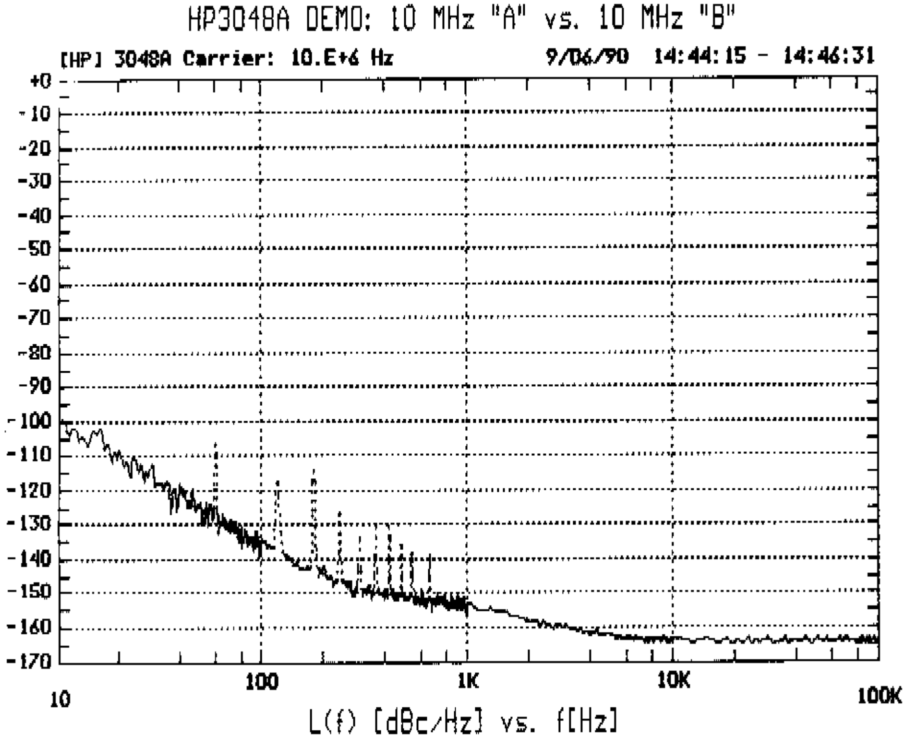


Figure 3-2. Example Graph of Results

Introduction

Select *Graph of Results* to display measurement results on the computer. Displayed results may then be printed by pressing the F4 softkey, or modified by selecting the *Define Graph* window.

Other modifications to the *Graph of Results* can be made by selecting the *Graph* window. Press the M (menu) key to access four graph functions:

- Marker
- New Graticule
- Plot Data
- Omit Spurs

Marker

This function allows you to read frequency and amplitude of the displayed noise or spur level at a discrete point. Access this function as follows:

1. After measurement results are plotted on the *Graph of Results* display, press the [M] key to reveal the *Graph* window.
2. Select *Marker*.
3. The marker "+" appears at the upper-left slope of the measurement results. Use the following keys to move the marker:
   a. Left/right arrow keys move the marker in 1 point increments.
   b. Up/down arrow keys move the marker in $\frac{1}{4}$ segments.
   c. Page up/down keys move the marker in whole segments.

NOTE

Segments are defined in the *Advanced Functions* window.

---

4. Frequency and amplitude of the marker is monitored at the bottom of the display. (To remove the marker, press the [ESC] key.)

Marker Resolution

Marker's resolution is a function of the measurement span defined in the *Advanced Functions* window by selecting the *FFT Segments* and *HF Segments* tables. Because each span for a particular analyzer contains the same number of data points, narrower spans provide better resolution than do wider spans. Table 3-1 lists the number of data points per span for supported analyzers.

Table 3-1. Data Points for Determining Marker Resolution

Model	Data Points Per Frequency Span
HP 3561A	401
HP 3585A/B	1001
HP 8566A/B	1001
HP 8568A/B	1001
HP 71000	1001

New Graticule

This function draws a new graticule on the computer according to the coordinates set up in the *Define Graph* window. If any *Noise Spec Lines* have been defined, they will appear on the new graticule. Access this function as follows:

1. Select *Graph of Results*.
2. Press the [M] key to reveal the *Graph* window.

NOTE

Any displayed measurement results are deleted when the *New Graticule* function is used.

3. Select the *New Graticule* entry. New measurement results may then be plotted on the computer screen.

Plot Data

This function plots measurement-result data onto the *Graph of Results* display. (A hardcopy of the measurement results is printed when you press the [F4] softkey.) More than one set of measurement results may be plotted on the display. Access this function as follows:

1. Select *Graph of Results*.
2. Press the [M] key to reveal the *Graph* window.
3. Select the *Plot Data* entry. The measurement results are plotted onto the *Graph of Results* display.
4. Multiple noise traces may be plotted on the same graticule by repeatedly loading measurement results from the disk and invoking the *Plot Data* function, or by selecting a new graph type in the *Define Graph* window.

Table 8-5. Status Messages (8 of 11)

Selecting the LNA... The HP 3048A is determining if the Low Noise Amplifier is required.
Setting up measurement configuration... The HP 3048A is configuring the instruments and/or the HP 11848A internal paths for the measurement.
Solving for (Osc unknown)... The HP 3048A is computing the noise of a source.
Solving for Osc_A,B,or C... The HP 3048A is computing the noise of each of the sources.
Span too narrow. Cannot integrate... The specified Range of Integration is not great enough to span a bin of the noise trace. **Action:** Increase the specified Range of Integration.

Manipulate Results 4

Introduction

The HP 3048A has a number of functions to help you interpret your phase noise measurements. These functions are derived from the data currently in memory. (Refer to *Chapter 3, Graphic Functions* for further information about modifying phase noise results.

Result Files

An example listing of result files is shown in figure 4-1.

```
        ┌─ Main Menu ─────────────────────┐
        │                                 │
        │ Type/Range of Measurement       │
══ Directory ════════════════════════════════════════════════════════════════

 HPTEST21.RES  | 11/02/90 | HP TEST 8662/63 VS  8662/63 ABSOLUTE NOISE @ 1270
 3561ONLY.RES  | 11/02/90 | HP 3561A Only Open Input
 FMDISCR.RES   | 11/02/90 | FM Discriminator Measurement of HP 8663A
 AM.RES        | 11/02/90 | AM Detector Measurement of HP 8663A
 62AVSUTC.RES  | 11/02/90 | HP8663A 2645A02301 VS HP8662C 2603A01829 TEST103
 62BVSUUT.RES  | 11/02/90 | HP8662A 2645A02301 VS HP8663A 2603A01829 TEST102
 62BVS62A.RES  | 11/02/90 | HP8662A 2645A02301 VS HP8662A 2603A01829 TEST101
 DEFAULT.RES   | 11/02/90 | HP3048A DEMO: 10 MHz "A" vs. 10 MHz "B"
```

Figure 4-1. Example Result Files

Introduction to Result Files

Result files contain data from a completed noise measurement or computation, and the associated *Parameter Summary*. Result files are accessed from the *File System* menu.

Description of the Result Files

Always store Result files whenever a permanent record of the results of a measurement is required, for example, when verifying of performance tests during calibration, or when performing a "3 Oscillator Comparison."

The File System

Each file that is stored has a *name* and a corresponding *title*.

- The file *name* is used to store, load, or delete files. File names are limited to eight characters and must have the extension .RES. An example name is DEFAULT.RES.
- The file *title* allows you to provide a description of a file's contents. The title is entered in the *Define Graph* menu, and appears at the top of the Graph of Results. Titles are limited to 55 characters. An example title is *HP3048A DEMO: 10 MHz "A" vs. 10 MHz "B"*.

Result Files Shipped with the HP 3048A Option 301

When the HP 3048A Option 301 is shipped, it includes the following result files.

- *DEFAULT.RES* contains phase noise measurement data for the internal 10 MHz sources of the HP 11848A, 10 MHz "A" vs. 10 MHz "B". This file provides data for experimentation with the *Manipulate Results* functions.
- *LASTMEAS.RES* contains the results from the last successfully completed measurement. It is automatically updated after each successful measurement and is automatically loaded each time the HP 3048A Option 301 software is booted-up. (If this file is not present, the HP 3048A will load the file named *DEFAULT.RES*.)

How to Manage Result Files

Loading a Result File

1. From the Main Menu, select **File System.**
2. Select **Load File.**
3. Define the path by typing `*.RES`.

NOTE

To load a file from a disk drive or subdirectory other than the one from which the software is being run, precede the path definition with the drive designation and/or the directory, for example, `A:\FILES\*.RES`.

---

4. Use the △ ▽ keys to select the desired Result file and press **ENTER.**

Storing a Result File

1. From the Main Menu, select **File System.**
2. Select **Store File.**
3. Type the file name and the extension `.RES`, and press **ENTER.**

NOTE

To store a file from a disk drive or subdirectory other than the one from which the software is being run, precede the file name with the drive designation and/or the directory, for example, `A:\FILES\DEFAULT.RES`.

Deleting a Result File

1. From the Main Menu, select **File System.**
2. Select **Remove File.**
3. Type the name of the file to be deleted and the extension .RES.

NOTE

To delete a file from a disk drive or subdirectory other than the one from which the software is being run, precede the path definition with the drive designation and/or the directory, for example, A:\FILES\DEFAULT.RES.

---

4. Press **ENTER**.

The system will ask you if you want to delete the file.

5. Press **Y** to delete it.

NOTE

For additional information about managing files, refer to your MS-DOS(R) Manuals.

Noise Spec Lines

The *Noise Spec Lines* window is shown in figure 4–2. This window allows you to place up to 15 specification limit-lines on the *Graph of Results* for visual reference.

Noise Spec Lines

	x1 (Hz)	y1 (dBc/Hz)	x2 (Hz)	y2 (dBc/Hz)
1.	10	-30	100.E+3	-80
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

Figure 4–2. Noise Spec Lines Window

Placing Specification Lines on the Graph of Results

For example, to draw a line on the *Graph of Results* that starts −30 dBc at 10 Hz, and ends −80 dBc at 1 kHz, you would enter the parameters shown in figure 4–2.

List of Spurs

The *List of Spurs* window with example test Result data is shown in figure 4-3. Notice the frequency and amplitude of each identified spur.

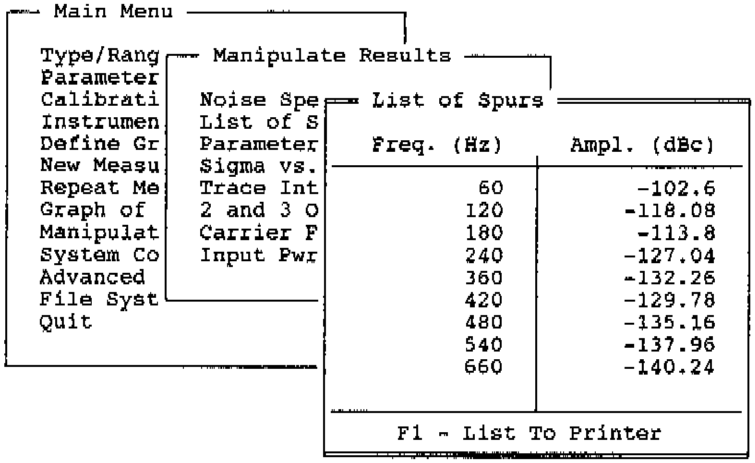


Figure 4-3. List of Spurs Window

The List of Spurs contains the frequency and amplitude values of up to 200 spurs which can be listed to a printer by pressing the F1 softkey. The HP 3048A marks all detected spurs (which can be re-defined to appear on the computer screen in another color by using the *Plotter Pens* window under *System Configuration*).

The criteria for marking spurs is a function of the measurement BW and how much the spur projects out of the noise. For offset frequencies ≤100 kHz, the amount a spur must project above the noise level to be marked as a spur is a function of the number of averages taken. All marked spurs are displayed at their true level. Only the marked spurs are shown in the List of Spurs. Table 4-1 shows how much a spur must project out of the noise to be marked.

Table 4-1. HP 3048A Spur Marking Criteria

Offset Frequency	Number of Averages	Required Amount Spur Must Project Out of Noise to be Marked
.01 Hz to 100 kHz	<4	30 dB
	4 to <8	17 dB
	8 to <30	12 dB
	≥30	6 dB
>100 kHz to 40 MHz	NA	4 dB

Considerations for the List of Spurs

There can be a maximum of 200 spurs listed, all are between the start and stop measurement range. If more than 200 spurs occur within this range, the measurement should be reduced to a subset of the initial measurement range.

Parameter Summary

```
     ┌─ Main Menu ──────────────┐
══ Parameter Summary ═══════════════════════════════════════════════════

 Meas. Type   : PHASE LOCK LOOP      K_VCO Method: MEASURED
 Start Freq   : 10 Hz
 Stop  Freq   : 100.E+3 Hz           K_vco       : 114.8 Hz/Volt
 Min.  Aves   : 4                    Loop Suppr. : VERIFIED

 Carrier Freq: 10.E+6 Hz             Closd PLL BW: 123.5 Hz
 Det. In Freq: 10.0005E+6 Hz         Pk Tune Rnge: 222.3 Hz
 Entered Kvco: 100 Hz                Assumed Pole: 1.821E+3 Hz
 Center Voltg: 0 Volts               UUT         : 10 MHz 'A', SYS, VCO
 Tune Range  : 2 Volts               Ref. Srce   : 10 MHz 'B', SYS
 Ph. Detector: 5 TO 1600 MHz         Ext. Tmbase : NOT IN USE
 K_phi Method: MEASURED              Dn Converter: NOT IN USE
 K_phi       : 269.5E-3 V/Rad        HP11848A LNA: IN
────────────────────────────────────────────────────────────────────────
                          F1- List To Printer
```

Figure 4–4. Parameter Summary Window

Introduction

The *Parameter Summary* window shown in figure 4–4 lists parameters defined for a measurement.

The Parameter Summary is automatically stored and recalled with the Result file. It is recommended that you include a hard copy of the Parameter Summary with every graph that you output to help evaluate the measurement results; press the [F1] softkey to list the Parameter Summary to the printer.

Parameter Entry Descriptions

The following pages give a brief description of each entry in the *Parameter Summary* window.

Meas. Type: This parameter identifies the Measurement Type defined in the *Type/Range of Measurement* window. The Measurement Type determines which calibration methods are available and the parameters that are required.

Start Freq: This parameter is the minimum offset frequency defined for the measurement in the *Type/Range of Measurement* window. This frequency is not necessarily the minimum frequency that is plotted on the *Graph of Results*. The minimum plotted frequency is set in the *Define Graph* window.

Stop Freq: This parameter is the maximum offset frequency defined for the measurement in the *Type/Range of Measurement* window. This frequency is not necessarily the maximum frequency that is plotted on the *Graph of Results*. The maximum plotted frequency is set in the *Define Graph* window.

Min. Aves: This is the minimum number of measurement averages used for the FFT Segments during the measurement. The smoothing of measured data within the FFT Segments is proportional to the square root of the number of averages. For instance, increasing the number of averages by a factor of 4 causes the results displayed on the graph to be smoothed by a factor of 2.

The FFT Segment table also specifies the minimum number of averages for each segment based on measurement time vs. computation time and plot time. The number of averages used by the system for a particular segment is the greater of the two specified minimum average values. (Smoothing for RF Analyzer segments is a function of the Video BW specified in the HF Segment table.)

Carrier Freq: The Carrier Frequency is used only for labeling the *Graph of Results,* and for the calculation of $S_y(f)$ and $\sigma_y(\tau)$ when the HP 11729C Down Converter is not being used.

If the Down Converter is defined to be under System Control in the Instrument Control Diagram, the Carrier Frequency is used to select the proper HP 11729C band as specified in the *System Configuration,* Instrument Address table. The HP 3048A also determines the correct IF frequency out of the Down Converter as determined by the Carrier Frequency and HP 11729C band setting.

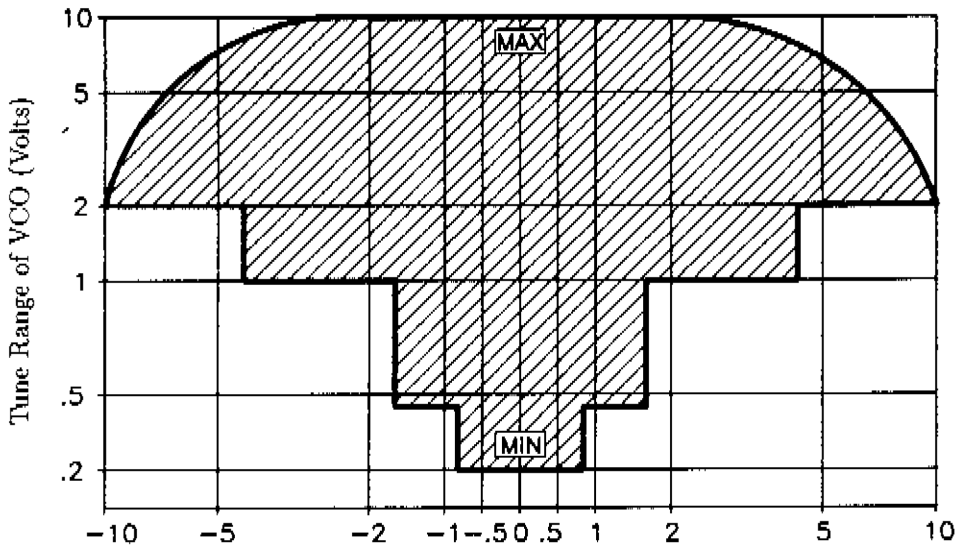
Det. In Freq: This is the input frequency to the phase detector as defined for the measurement. It is normally the same value as the Carrier Frequency when a Down Converter is not being used.

If a Down Converter is being used for the measurement, the Detector Input Frequency is the IF output frequency from the Down Converter. The Detector Input Frequency determines which phase detector can be used. At frequencies between 1.2 and 1.6 GHz, either of the internal phase detectors can be used. If the Detector Input Frequency is <95 MHz, then the 2 MHz LPF is enabled after the phase detector and the maximum offset frequency that can be measured is 2 MHz.

Entered Kvco: This is the VCO Tune Constant defined for the measurement in the *Parameters* window. The tune constant must be estimated to within a factor of 2 of the actual value to optimize the measurement when the HP 3048A is configured to measure the VCO Tune Constant.

If the *Calibration Technique,* Calculate from Expected Tune Constant is selected, the entry must be accurate to within $\pm$ 5% (with respect to the voltage applied to the tune port of the VCO). The VCO tune port input resistance is accounted for in a separate entry.

Center Voltg: This is the voltage defined for tuning the VCO to the center of its tuning curve, or to the carrier frequency desired for the measurement. The value of the Center Voltage determines the range of the Tune Voltage possible.



Center Voltage of VCO Tune Curve (Volts)

$|\text{Center Voltage}| + |\text{Tune Range of VCO}| \leq 12V$

Figure 4-5. HP 3048A Tune Range of VCO Limits Relative to the Center Voltage of the VCO Tune Curve.

Tune Range: This is the defined Tune Range of VCO through which the test system may tune the VCO around the Center Voltage. The VCO output must not change in amplitude by greater than 1 dB, show any reversal in frequency tuning, or be susceptible to damage within the defined Tune Range around the Center Voltage.

For the HP 3048A to measure the VCO Tune Constant accurately, the VCO must tune monotonically across ± 45% of the Tune Range of VCO around the Center Voltage, and the slope must not go to zero. If the VCO Tune Constant is not measured by the test system, the VCO must tune to within ± 10% of the Tune Range of VCO around the Center Voltage using the defined VCO Tune Constant.

To protect the VCO from possible damage, the Tune Voltage output port should not be connected to the VCO's input port until the *Instrument Control* diagram is displayed.

Ph. Detector: This is the Phase Detector that was selected for the measurement. (For AM and Baseband Noise measurements, the External Phase/AM Detector must be selected in the *Parameters* window.)

K_phi Method: This is the calibration method selected for determining the phase Detector Constant. (For descriptions of each method for determining the phase Detector Constant, refer to *Calibration Technique* in chapter 2 *Measurement Definitions*.)

K_phi: This is the phase Detector Constant (sensitivity of the phase detector) used for the measurement. The accuracy of the phase Detector Constant is verified if the PLL suppression is verified. The accuracy of the phase Detector Constant determines the accuracy of the noise measurement.

The phase Detector Constant value, along with the Low Noise Amplifier (LNA) In/Out parameter, determines the HP 3048A System noise floor exclusive of the reference source. The phase Detector Constant can be used to approximate the phase detector's R port input level (refer to graph 1 *Approximate HP 3048A Phase Noise Floor vs. R Port Signal Level* in chapter 7, *Quick Reference*).

K_VCO Method: This is the calibration method selected for determining the VCO Tune Constant. If "Measure the Tune Constant" is selected, the VCO Tune Constant is accurately measured by the test system. If the Tune Constant is not measured, then it is recommended that either the PLL Suppression is verified, the VCO is a calibrated source, or that the Tune Constant has been verified in a previous measurement.

K_vco: This is the VCO Tune Constant the test system uses for the measurement. The accuracy of the VCO Tune Constant determines the accuracy of the PLL noise measurement for offset frequencies greater than or equal to the phase lock loop bandwidth. The accuracy of the VCO Tune Constant is verified if the PLL Suppression is Verified. The VCO Tune Constant times the Tune Range of VCO determines the Peak Tune Range (PTR) value for the measurement. The PTR sets the drift tracking and close-in noise suppression capabilities of the test system.

Loop Suppr: This indicates whether or not the Phase Lock Loop (PLL) Suppression was verified. The PLL Suppression verification shows the accuracy of the phase Detector Constant and VCO Tune Constant.

For all PLL measurements, the test system generates a theoretical loop suppression correction and applies it to the measured noise data. When verification of the loop suppression is selected, the test system measures the suppression of the phase lock loop and compares the measured suppression to the theoretical suppression. By adjusting the PTR and the Assumed Pole, the theoretical suppression is fit to the measured loop suppression. If a significant modification is required, the HP 3048A notifies you of an Accuracy Specification Degradation.

Acc'y Spec Degrad: This parameter only appears when Verification of the Loop Suppression is selected and when the theoretical loop suppression must be modified beyond acceptable limits to match it to the measured loop suppression. If the indicated Accuracy Specification Degradation is greater than zero, the VCO Tune Constant or the phase Detector Constant is in error at an offset frequency near the PLL BW, or some other problem is effecting the PLL BW, such as injection locking.

Without specific information about the source of the problem, it should be assumed that the accuracy specification for the Graph of Results at all offsets has been degraded by the Accuracy Specification Degradation value. That is to say, the specified accuracy of the HP 3048A becomes ±(2 dB + the Accuracy Specification Degradation) for frequencies of 0.001 Hz to 1 MHz, and ±(4 dB + Accuracy Specification Degradation) for frequencies from greater than 1 MHz to 40 MHz. To minimize an Accuracy Specification Degradation, identify and eliminate the probable cause, then initiate a *New Measurement* with Loop Suppression Verification selected.

Closd PLL BW: This is the predicted Phase Lock Loop Bandwidth (PLL BW) for the measurement. The predicted PLL BW is based on the predicted Peak Tuning Range (PTR) as shown in figure 4-6. (Note that the predicted PLL BW value is not adjusted when the PTR is adjusted as a result of an Accuracy Specification Degradation.)

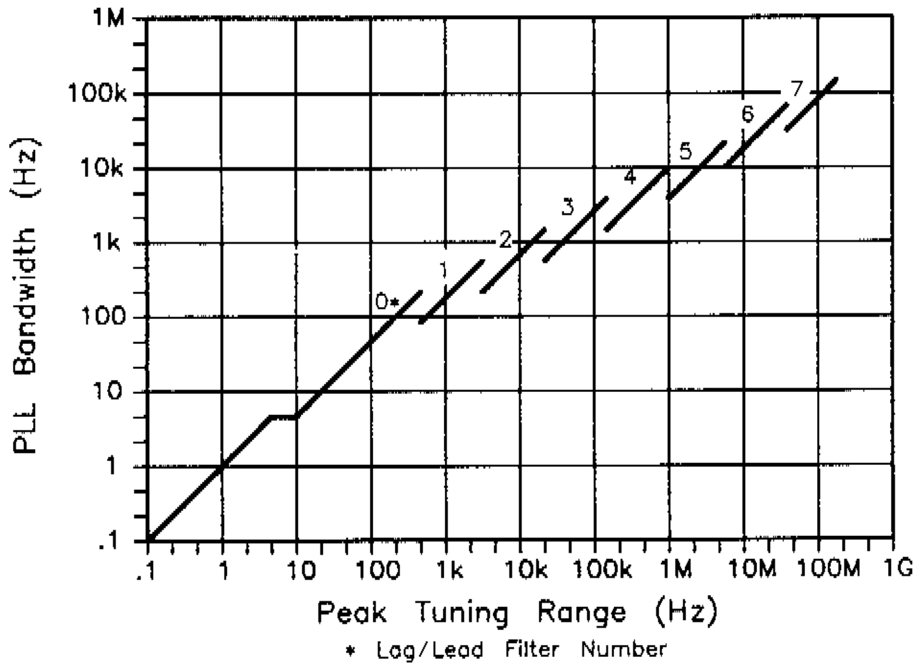


Figure 4-6. Phase Lock Loop Bandwidth Relative to the Peak Tuning Range.

Pk Tune Rnge: This is the Peak Tuning Range (PTR) for the measurement determined from the VCO Tune Constant and the Tune Range of VCO. This is the key parameter in determining the PLL properties, the Drift Tracking Range, and the ability to phase lock sources with high close in noise.

The PTR value displayed should be approximately equal to the product of the VCO Tune Constant times the Tune Range of VCO. This will not be the case when a significant Accuracy Specification Degradation is detected ($>$ 4 dB) by the Loop Suppression Verification. For Accuracy Specification Degradations of $>$4 dB, the PTR and Assumed Pole are adjusted when the theoretical loop suppression is fit to the smoothed measured Loop Suppression. In these cases, the test system displays the adjusted PTR.

Any time the PTR must be adjusted by more than 1 dB (as indicated by an Accuracy Specification Degradation of greater than 0 dB) it is an indication that the phase Detector Constant or the VCO Tune Constant will be in error at frequency offsets near the PLL BW, or that the PLL BW is being affected by some other problem such as injection locking.

Assumed Pole: This is the frequency of the Assumed Pole required to adjust the theoretical loop suppression to match the smoothed measured Loop Suppression. The Assumed Pole frequency is normally much greater than the PLL BW.

If the Assumed Pole is adjusted to a frequency of less than 10 $\times$ PLL BW, peaking in the PLL suppression is indicated. For PLL BWs less than 20 kHz, an Assumed Pole of less than 10 $\times$ PLL BW indicates a delay or phase shift in the VCO Tune Port. For PLL BWs greater than 20 kHz, the Assumed Pole may be adjusted to less than 10 $\times$ PLL BW to account for phase shifts in the HP 11848A.

UUT: This indicates the device defined as the UUT for the measurement, and how it is being controlled. The UUT cannot be one of the sources listed in the Instrument Address table. You may, however, select one of the HP 11848A internal sources as the UUT.

Ref. Srce: This indicates the device defined as the Reference Source for the measurement, whether or not it is the VCO, and how it is being controlled.

Ext. Tmbase: This indicates whether or not an External Timebase is being used, and whether it is the VCO for the measurement. (Note that the HP 11848A 10 MHz A and 10 MHz B internal sources can only be operated under system control.)

Dn Converter: This indicates whether or not a Down Converter is being used in the measurement. If the Down Converter being used is an HP 11729C, an indication is made as to whether it is under system or manual control.

HP11848A LNA: This indicates the state of the Low Noise Amplifier (LNA) on the HP 11848A Phase Noise Interface. The LNA is configured either In or Out depending on the output-power level of the phase detector. Along with the phase Detector Constant, the LNA configuration (In or Out) determines the HP 3048A System Noise Floor, exclusive of the reference source.

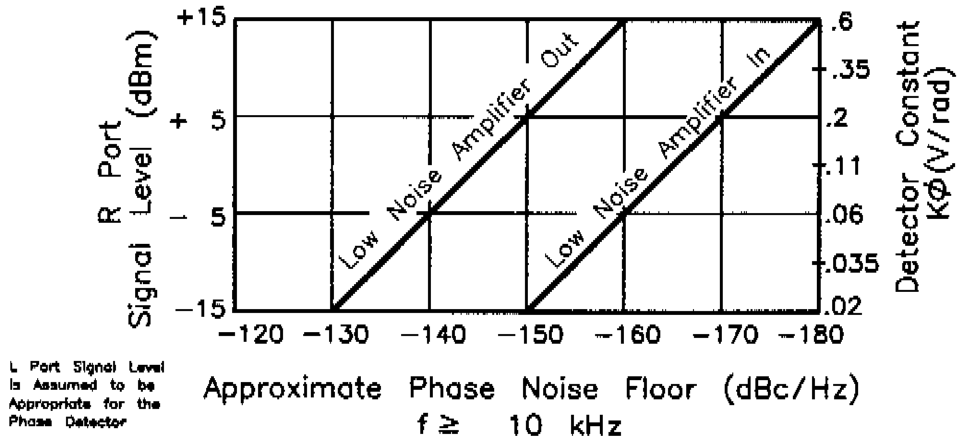


Figure 4–7. HP 3048A Noise Floor Relative to the Phase Detector Constant and LNA Configuration

Sigma vs. Tau

Main Menu

Sigma vs. Tau (σ vs. τ)

	τ (Sec.)	Cutoff Fr. (Hz)	N	T (Sec.)	σ (Sigma)	Jitter
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

F1-List To Printer F3-√(Allan Var) F5-*Omit Spurs F7-Plot

Figure 4-8. Sigma vs. Tau Window

Introduction

The Sigma vs. Tau function calculates fractional frequency deviation (σ) as a function of averaging time or measurement time (τ) over the range of τ permitted by the available phase noise data. This function also calculates the time jitter over the time interval (τ). These calculations require that parameters N, T, and f_h (cutoff frequency) be specified.

- **N** is the number of frequency averages used to compute the mean frequency for the calculation of σ.
- **T** is the total time period (dwell plus samples).
- τ (tau) is the averaging time selected (sample time, measurement time).
- **Cutoff Fr.** (f_h) is the measurement system bandwidth.

Allan Variance is the fractional frequency deviation versus the averaging time when $N = 2$ and $T = \tau$. This section describes the process used by the HP 3048A to calculate the Allan Variance.

Softkey Descriptions

List to Printer: Press the F1 softkey to print a hard copy of the results.

$\sqrt{}$(Allan Var): Press the F3 softkey to calculate $\sqrt{Allan\ Var}$ when τ and f_h are specified. N is set equal to 2 and T is set equal to τ automatically.

***Omit Spurs:** Press the F5 softkey to calculate $\sqrt{Allan\ Var}$ excluding the spur contributions for the specified entries.

Plot: Press the F7 softkey to plot the calculated $\sqrt{Allan\ Var}$ on a Sigma versus Tau graph. While the graph is displayed, press the F7 softkey again to plot the time jitter versus Tau graph. The softeky can be used to switch between the two graphs. Press ESC to return to the Sigma vs. Tau window.

Description of Sigma vs. Tau and Time Jitter

The following equations define fractional frequency deviation versus averaging time.

$$\sigma_y{}^2(N,T,\tau,f_h) = \left\langle \frac{1}{N-1}\sum_{h=1}^{N}(\overline{Y}_h - \frac{1}{N}\sum_{k=1}^{N}\overline{Y}_k)^2 \right\rangle$$

$f_h = noise\ bandwidth$

$y = \Delta\nu/\nu_o \equiv\ fractional\ frequency\ deviation$

$\Big\langle\ \Big\rangle \equiv infinite\ time\ average$

$\overline{Y}_k \equiv average\ frequency\ over\ Kth\ time\ interval\ of\ length\ \tau$ $(as\ would\ be\ determined\ by\ a\ high\ resolution\ counter) = \frac{1}{\tau}\int_{t_k}^{t_k+\tau} Y(t)dt = \frac{\Phi(t_k+\tau)-\Phi(t_k)}{2\pi\nu_0\tau}$

The following equation defines Time Jitter.

$$Time\ jitter = \sqrt{AllanVariance} \times \tau$$

Allan Variance [1]

David Allan of the National Bureau of Standards (now the National Institute of Standards and Technology) recognized that ${\sigma_y}^2(\tau)$ is also a function of N and T for some noise processes. Therefore, he proposed the following:

$$Let\ N = 2,\ T = \tau, Allan\ Variance = \sigma_y^2(2,\tau,\tau,f_h) = \sigma_y^2(\tau,f_h)$$

$$\langle \sigma_y^2(\tau,f_h) \rangle = \left\langle \frac{\left(\overline{Y}_{k+1} - Y_k\right)^2}{2} \right\rangle$$

Cutler[2] has shown that:

$$\langle {\sigma_y}^2(N,T,\tau,f_h) \rangle = \frac{N}{N-1} \int_0^{f_h} S_y(f) \frac{sin^2(\pi f \tau)}{(\pi f \tau)^2} \left[1 - \frac{sin^2(\pi N f T)}{N^2 sin^2(\pi f T)} \right] df$$

$$where:\ S_y(f) = \frac{f^2}{{v_0}^2} S_\Phi(f)$$

[1] D. W. Allan, "Statistics of atomic frequency standards," Proc. IEEE, vol. 54, pp. 221-230, February 1966.

[2] L. Cutler and C. Searle, "Some aspects of the theory and measurement of frequency fluctuations in frequency standards," Proc. IEEE, vol. 54, pp. 135–154, February 1966.

This equation is numerically integrated in the HP 3048A software. The lower limit of integration, 0, is replaced by the minimum offset frequency for which there is data in memory (f_{min}). Because arbitrarily low frequency data is not available, the maximum possible τ for which $\sigma(\tau, f_h)$ can be computed is $\tau_{max} = \frac{1}{5f_{min}}$.

The upper limit of integration (f_h) is specified by the user based on the actual bandwidth of the system in which he tests or uses the particular device for which $\sigma_y(\tau)$ is being calculated.

Depending on the dominant slope of the phase noise at offsets 1 decade above and below $\frac{1}{2\tau}$, the maximum value of τ for which an accurate computation of σ can be made and can be chosen as shown in table 4-2.

Table 4-2. Slope versus Maximum Tau

Description	Slope of $\mathcal{L}(f)$ or $S_\Phi(f)$	Maximum τ for data to f_{min}	f_h***
	−50 dB/decade	*	*
Random Walk Freq.	−40 dB/decade	$\tau \leq \frac{1}{10f_{min}}$	$\frac{10}{\tau}$
Flicker Frequency	−30 dB/decade	$\tau \leq \frac{1}{5f_{min}}$ **	$\frac{10}{\tau}$
White Frequency	−20 dB/decade	$\tau \leq \frac{1}{5f_{min}}$ **	$\frac{10}{\tau}$
Flicker Phase	−10 dB/decade	$\tau \leq \frac{1}{5f_{min}}$ **	As appropriate***
White Phase	0 dB/decade	$\tau \leq \frac{1}{5f_{min}}$ **	As appropriate***

* Calculation not recommended. Will not be accurate unless there is a region of shallower slope below the 50 dB/decade region.

** System Default.

*** For White Phase and Flicker Phase which depend on f_h, the user must specify the graph output value.

NOTE

Frequency f_h is specified as the measurement system bandwidth to minimize computation time. You may wish to determine the smallest f_h for a given τ that will provide accurate results.

Confidence Check on an HP 3048A Calculation of $\sigma_y(\tau)$

Table 4–3 shows the relationship of $\mathcal{L}(f)$ to Allan Variance for a power low-noise process. Using this table, an estimate of $\sigma_y(\tau)$ can be made directly from a phase noise plot.

Table 4–3. Relation of $\mathcal{L}(f)$ to Allan Variance

Description	Slope of $\mathcal{L}(f)$ (dB/decade)	$\sigma_y(\tau) =$
White Phase	0	$\frac{\sqrt{\mathcal{L}(f)f_h}}{2.565\nu_o}\ \tau^{-1}$
Flicker Phase	−10	$\frac{\sqrt{\mathcal{L}(f)f\left(2.184+\ \ \ell n(f_h\tau)\right)}}{2.565\nu_o}\ \tau^{-1}$
White Frequency	−20	$\frac{\sqrt{\mathcal{L}(f)f^2}}{\nu_o}\ \tau^{-\frac{1}{2}}$
Flicker Frequency	−30	$\frac{1.665\sqrt{\mathcal{L}(f)f^3}}{\nu_o}\ \tau^0$
Random Walk Freq.	−40	$\frac{3.63\sqrt{\mathcal{L}(f)f^4}}{\nu_o}\ \tau^{\frac{1}{2}}$

τ =measurement time, $y = \Delta\nu/\nu_o$, $\nu_o =$ carrier frequency, $f =$ modulation rate or offset frequency, $f_h =$ noise bandwidth.

Trace Integration

Trace Integration

	Data Type	Start Freq (Hz)	Stop Freq (Hz)	Value of Definite Integral
1.	L(f)			
2.	L(f)			
3.	L(f)			
4.	L(f)			
5.	L(f)			
6.	L(f)			
7.	L(f)			
8.	L(f)			
9.	L(f)			
10.	L(f)			

F1-List To Printer   F3-Evaluate   F5-*Omit Spurs   F7-Data Type

Figure 4-9. Trace Integration

Introduction

The Trace Integration function integrates the selected noise type between specified start and stop frequencies resulting in the Integrated Noise or the rms modulation in a frequency band.

The HP 3048A computes the value of the definite integral between two specified frequencies provided continuous data exists between those frequencies. The integration is computed on the noise data currently in memory. The computation is only as accurate as the measurement data being evaluated. (The *Evaluating the Results* chapter of the HP 3048A Option 301 Operating Manual provides help in verifying your measurement results.

The Trace Integration function allows you to include or omit the detected spurs in the calculation. Detected spurs are not integrated as noise, but they are included in the calculation as discrete power additions.

Softkey Descriptions

List to Printer: Press the [F1] softkey to print a hard copy of the Definite Integral Results.

Evaluate: Press the [F3] softkey to initiate the Definite Integral solution.

***Omit Spurs:** Press the [F5] softkey to initiate the Definite Integral solution without the addition of the spurs. This will solve for noise power and will not include the contribution of marked spurs. The results will be preceded by an asterisk (*).

Data Type: Press the [F7] softkey to select the result type for the Definite Integral.

Parameter Entry Descriptions

Data Type

Data types depend on the Measurement Type defined in the *Type/Range of Measurement* menu.

Phase Noise

$\mathcal{L}(f)$: Single-sideband phase noise. Selecting $\mathcal{L}(f)$ instructs the system to solve $\int_{f_1}^{f_2} \frac{S_\phi(f)}{2}\, df$ in dBc.

$S_\phi(f)$: Spectral density of phase fluctuations. Selecting $S_\phi(f)$ instructs the system to solve $\int_{f_1}^{f_2} S_\phi(f)\, df$ in dB with respect to 1 radian, radians, and degrees.

$S_\nu(f)$: Spectral density of frequency fluctuations. Selecting $S_\nu(f)$ instructs the system to solve $\int_{f_1}^{f_2} S_\phi(f) \times f^2 \, df$ in Hz (Residual FM).

$S_y(f)$: Spectral density of fractional frequency fluctuations. Selecting $S_y(f)$ instructs the system to solve $\int_{f_1}^{f_2} S_\phi(f) \times (\frac{f}{\nu_0})^2 \, df$ (without units), where ν_0 is the carrier frequency.

AM Noise

$M(f)$: Single-sideband AM noise. Selecting $M(f)$ instructs the system to solve $\int_{f_1}^{f_2} M(f) \, df$ in dBc.

Baseband Noise

$S_v(f)$: Spectral density of noise voltage in dB with respect to 1 Volt. Selecting $S_v(f)$ instructs the system to solve $\int_{f_1}^{f_2} S_v(f) \, df$ in dBv.

Start Freq. (in Hz)

The system allows you to enter a start frequency within the range of the measured data.

Stop Freq. (in (Hz)

The system allows you to enter a stop frequency within the range of the measured data.

Description

How Does the HP 3048A Compute Integrated Noise?

The software routine begins by storing the marked spurs within the specified start and stop frequency range. The marked spurs are then removed from the noise data. (A linear connection is made between the data points in the area where each spur was removed.) The remaining measured noise data is converted to noise power and integrated between the specified start and stop frequencies. When the integration is complete, the marked spurs are added to the integrated noise as discrete powers. The Definite Integral solution is then displayed for the Data Type selected.

The Definite Integral Value is computed by the HP 3048A using the following summation:

$$\sum_{i=a}^{b} G_{power(f_i)} \times \ Hz/Bin$$

$where:$

$$f_i = frequency\ from\ `a'\ (start)\ to\ `b'\ (stop)$$
$$Bin = Analyzer\ span\ resolution.$$

$and:$

$$G_{power(f_i)} = \left[\frac{10^{\frac{S_\phi(f_i)}{10}}}{2}\right]\ for\ \mathcal{L}(f).$$

$$= \left[10^{\frac{S_\phi(f_i)}{10}}\right]\ for\ S_\Phi(f).$$

$$= \left[10^{\frac{S_\phi(f_i)}{10}} \times f_i^2\right]\ for\ S_\nu(f).$$

$$= \left[10^{\frac{S_\phi(f_i)}{10}} \times \left(\frac{f_i}{carrier\ freq.}\right)^2\right]\ for\ S_y(f).$$

$$= \left[10^{\frac{M(f)}{10}}\right]\ for\ M(f).$$

$$= \left[10^{\frac{S_v(f)}{10}}\right]\ for\ S_v(f).$$

Considerations for Trace Integration

If the following contitions are not met, the system will display the message `Unable to calculate`.

- There must be measurement result data in memory for the system to solve the Definite Integral.
- Any gaps (missing data) between the specified start and stop frequencies will prevent the system from solving the Definite Integral. The system cannot solve the Definite Integral over non-contiguous data.
- The start and stop frequencies must both be entered and within the measurement data's range.
- The stop frequency must be at greater than the start frequency.

3 and 2 Oscillator Comparison

```
┌─ Main Menu ──────────────────┐
│                              │
│  Type/Rang┌─ Manipulate Results ─────┐
│  Parameter│                          │
│  Calibrati│ Noise Spec Lines         │
│  Instrumen│ List of Spurs            │
│  Define Gr│ Parameter Summary        │
│  New Measu│ Sig┌─ 3 and 2 Osc. Comparisons ─────┐
│  Repeat Me│ Tra│                                 │
│  Graph of │ 3 a│ Source Files for Computation    │
│  Manipulat│ Car│ Destination Files for Results   │
│  System Co│ Inp│ 3 Oscillator Comparison         │
│  Advanced │    │ 2 Oscillator Comparison         │
│  File Syst└────│                                 │
│  Quit          └─────────────────────────────────┘
│                              │
└──────────────────────────────┘
```

Figure 4-10. 3 and 2 Oscillator Comparison Window

3 Oscillator Comparison

The *3 Oscillator Comparison* determines noise level for each of three similar sources or devices. This comparison is useful when a reference source with a known lower noise level is not available for a direct comparison and is the only practical way to determine the exact noise level of state-of-the-art sources.

Description

The 3 *Oscillator Comparison* computes the noise level of three separate devices by measuring them in pairs (A vs. B, A vs. C, and then B vs. C). To achieve accurate results, each of the three measurements must be performed under the same conditions (frequency, measurement range, and segment definition). The test system computes the noise level of each device by comparing and analyzing the measurement results for each of the three noise measurements. The HP 3048A stores the computed noise level for each of the three devices in separate Result files.

The following expressions are used to evaluate the three devices.

A vs. B = X	X = *The results of device A vs. B without spurs.*
A vs. C = Y	Y = *The results of device A vs. C without spurs.*
B vs. C = Z	Z = *The results of device B vs. C without spurs.*

Therefore:

A = (X + Y - Z)/2	Noise of Osc A = *The result of device A only.*
B = (X + Z - Y)/2	Noise of Osc B = *The result of device B only.*
C = (Y + Z - X)/2	Noise of Osc C = *The result of device C only.*

Measurement Uncertainty

To insure accurate results, the noise levels of the three devices should be within 3 to 6 dB of each other at the frequency offsets of interest. Computation uncertainty increases when the phase noise differs by more than 3 dB between the three devices. A minimum of 20 averages, defined in the *Type/Range of Measurement* menu, is recommended when making the noise measurements. A good test to use for verifying the validity of the noise measurements before performing the 3 Oscillator Comparison is to check that the combined level of the two lowest measurements is greater than or equal to the level of the highest measurement.

Parameter Entry Descriptions

Source Files for Computation

```
          ┌── Main Menu ──────────────────┐
          │                               │
          │ Type/Rang┌── Manipulate Results ──────┐
          │ Parameter│                            │
          │ Calibrati│  Noise Spec Lines          │
          │ Instrumen│  List of Spurs             │
          │ Define Gr│  Parameter Summary         │
          │ New Measu│  Sig┌── 3 and 2 Osc. Comparisons ───┐
          │ Repeat Me│  Tra│                               │
╒═ Source Files for Computation ═══════════════════════════════════════╕
│                                                                      │
│  Known noise of Osc A [                                           ]* │
│  Noise of A vs. B . . [                                           ]  │
│  Noise of A vs. C . . [                                           ]**│
│  Noise of B vs. C . . [                                           ]**│
│                                                                      │
│                 * Used only for 2 Oscillator comparison.             │
│                ** Used only for 3 Oscillator comparison.             │
│                                                                      │
╘══════════════════════════════════════════════════════════════════════╛
```

Figure 4-11. Source Files for Computation Window

Known noise of Osc A: This parameter is not used for 3 Oscillator Comparison.
Noise of A vs. B . . .: Filename of the A device vs. B device Result file.
Noise of A vs. C . . .: Filename of the A device vs. C device Result file.
Noise of B vs. C . . .: Filename of the B device vs. C device Result file.

When `*.RES` is entered, a window with the list of Result files appears for your selection. To load a file from a disk drive or sub-directory other than the one from which the software is being run, precede the file name with the drive designation and/or the directory. An example of this is `A:\Files\*.RES`.

Destination Files for Results

```
  ┌─ Main Menu ──────────────┐
  │                          │
  │  Type/Rang┌─ Manipulate Results ───┐
  │  Parameter│                        │
  │  Calibrati│  Noise Spec Lines      │
  │  Instrumen│  List of Spurs         │
  │  Define Gr│  Parameter Summary     │
  │  New Measu│  Sig┌─ 3 and 2 Osc. Comparisons ─┐
  │  Repeat Me│  Tra│                            │
┌─ Destination Files for Results ──────────────────────────────────┐
│                                                                  │
│ Noise of Osc A . . [                                           ] │
│ Noise of Osc B . . [                                           ]*│
│ Noise of Osc C . . [                                           ] │
│                                                                  │
│              * Used for 2 Oscillator comparison.                 │
│                                                                  │
└──────────────────────────────────────────────────────────────────┘
```

Figure 4–12. Destination Files for Results Window

Noise of Osc A: Filename of the Result file to be created for calculated noise of the A device.
Noise of Osc B: Filename of the Result file to be created for calculated noise of the B device.
Noise of Osc C: Filename of the Result file to be created for calculated noise of the C device.

If a duplicate filename exists, you are given the option of overwriting that file. To store a file to a disk drive or sub-directory other than the one from which the software is being run, precede the file name with the drive designation and/or the directory. An example of this is `A:\Files\*.RES`.

How to Make a 3 Oscillator Comparison

1. Measure the noise of the three devices. Measure them in pairs and store the results in three separate files: A vs. B, A vs. C, and B vs. C. (Refer to the *Result Files* section in this chapter for information about storing result files.)

NOTE

Each of the three noise measurements MUST BE made with identical measurement parameters (frequency, measurement range, segment definition, and so forth). The calculation cannot be made if the measurement parameters differ.

---

2. Select the 3 and 2 Oscillator Comparisons functions from the *Manipulate Results* menu.
3. Select *Source Files for Computation.*
4. Enter the Result filename for each pair of devices measured. When entering the filenames, be sure that device "A" in "A vs. B" is the same device "A" as in "A vs. C" and so on.
5. Press *ESC* to return to the previous window.
6. Select *Destination Files for Results.*
7. Enter the filenames of the Result files to be created for the calculated noise of each device.

NOTE

The filename is limited to eight characters and the extension `.RES`. It is helpful to associate the device with the result file name using the serial number; for example, `SER#0001.RES`.

8. Press *ESC* to return to the previous window.
9. Select *3 Oscillator Comparison*.
10. The HP 3048A will now display a message indicating it is performing the computations.
11. When the computations are complete, select the *File Functions* menu to access the Result files.
12. Load the appropriate Result file.
13. Select the *Graph of Results* menu to display the calculated noise.

Considerations for the 3 Oscillator Comparison

Unmarked spurs can cause erroneous results for the 3 Oscillator Comparison. Marked spurs are automatically stripped out during the computation, unmarked spurs are not. Unmarked spurs prevent the test system from performing a proper subtraction since spurs cannot be subtracted on a power basis. Observe the measurement results to insure that a minimum of unmarked spurs are present around the offsets of interest.

The number of unmarked spurs within the measurement can be reduced by either reducing the measurement bandwidth, or by increasing the number of averages specified in the *Type/Range of Measurement* menu and in the FFT and RF Segment tables.

2 Oscillator Comparison

The 2 *Oscillator Comparison* determines the actual noise level of the unit under test (UUT) by subtracting the known noise level of the reference device. (This procedure is nearly identical to the 3 *Oscillator Comparison,* except that only one measurement from a pair of devices is necessary.)

Description

The 3 *Oscillator Comparison* must first be done to determine the noise level of the reference device. Once a known reference level is established, the HP 3048A subtracts the reference noise from the measurement results. The 2 *Oscillator Comparison* is valid only if the Measurement Definition parameters and the segment table parameters are kept the same for the Reference device versus the UUT noise measurement as they were when the Reference device was measured using the 3 Oscillator Comparison.

Measurement Uncertainty

The noise level of the two devices should be within 3 to 6 dB of each other at the frequency offset of interest. The amount of uncertainty increases when the phase noise differs by more than 3 dB. Also, a minimum of 20 averages defined in the *Type/Range of Measurement* menu is recommended when measuring the devices.

Parameter Entry Descriptions

Source Files for Computation

```
         ┌─ Main Menu ─────────────────┐
         │                              │
         │ Type/Rang┌─ Manipulate Results ───────┐
         │ Parameter│                            │
         │ Calibrati│ Noise Spec Lines           │
         │ Instrumen│ List of Spurs              │
         │ Define Gr│ Parameter Summary          │
         │ New Measu│ Sig┌─ 3 and 2 Osc. Comparisons ───┐
         │ Repeat Me│ Tra│                               │
╒═ Source Files for Computation ═══════════════════════════════════════╕
│                                                                       │
│ Known noise of Osc A [                                             ]* │
│ Noise of A vs. B . . [                                             ]  │
│ Noise of A vs. C . . [                                             ]**│
│ Noise of B vs. C . . [                                             ]**│
│                                                                       │
│             * Used only for 2 Oscillator comparison.                  │
│            ** Used only for 3 Oscillator comparison.                  │
│                                                                       │
╘═══════════════════════════════════════════════════════════════════════╛
```

Figure 4-13. Source Files for Computation Window

Known noise of Osc A: Filename of the Result file for the Reference device with known noise.
Noise of A vs. B . . .: Filename of the Reference device with known noise versus the Unit-Under-Test (UUT)
Noise of A vs. C . . .: This parameter is not used for 2 Oscillator Comparison
Noise of B vs. C . . .: This parameter is not used for 2 Oscillator Comparison

When `*.RES` is entered, a window with the list of Result files appears for your selection. To load a file from a disk drive or sub-directory other than the one from which the software is being run, precede the file name with the drive designation and/or the directory. An example of this is `A:\Files\*.RES`.

Destination Files for Results

```
     ┌─ Main Menu ─────────────────┐
     │                             │
     │   Type/Rang┌─ Manipulate Results ──┐
     │   Parameter│                       │
     │   Calibrati│  Noise Spec Lines     │
     │   Instrumen│  List of Spurs        │
     │   Define Gr│  Parameter Summary    │
     │   New Measu│  Sig┌─ 3 and 2 Osc. Comparisons ──┐
     │   Repeat Me│  Tra│                             │
╒═ Destination Files for Results ═══════════════════════════════╕
│                                                               │
│  Noise of Osc A . . [                                       ] │
│  Noise of Osc B . . [                                       ]*│
│  Noise of Osc C . . [                                       ] │
│                                                               │
│                * Used for 2 Oscillator comparison.            │
│                                                               │
╘═══════════════════════════════════════════════════════════════╛
```

Figure 4–14. Destination Files for Results Window

Noise of Osc A: This parameter is not used for 2 Oscillator Comparison
Noise of Osc B: Filename of the Result file to be created for calculated noise of the Unit-Under-Test (UUT).
Noise of Osc C: This parameter is not used for 2 Oscillator Comparison

If a duplicate filename exists, you are given the option of overwriting that file. To store a file to a disk drive or sub-directory other than the one from which the software is being run, precede the file name with the drive designation and/or the directory. An example of this is `A:\Files\*.RES`.

How to Make a 2 Oscillator Comparison

1. Measure the Reference device, with known noise, against the UUT and store the results. (Refer to the *Result Files* section in this chapter for information about storing result files.)

NOTE

This noise comparison MUST BE made with identical measurement parameters (frequency, measurement range, segment definition, and so forth) used in the measurements to determine the Reference device. The calculation cannot be made if the measurement parameters differ.

---

2. Select the 3 and 2 Oscillator Comparisons functions from the *Manipulate Results* menu.
3. Select *Source Files for Computation*.
4. Enter the Result filename for the Reference device and for the Reference device versus the UUT.
5. Press *ESC* to return to the previous window.
6. Select *Destination Files for Results*.
7. Enter the filenames of the Result file to be created for the calculated noise of the UUT.

NOTE

The filename is limited to eight characters and the extension `.RES`. It is helpful to associate the device with the result file name using the serial number; for example, `SER#0001.RES`.

---

8. Press *ESC* to return to the previous window.
9. Select *2 Oscillator Comparison*.
10. The HP 3048A will now display a message indicating it is performing the computations.
11. When the computations are complete, select the *File Functions* menu to access the Result files.
12. Load the appropriate Result file.
13. Select the *Graph of Results* menu to display the calculated noise.

Considerations for Making a 2 Oscillator Comparison

Unmarked spurs can cause erroneous results for the 2 Oscillator Comparison. Marked spurs are automatically stripped out during the computation, unmarked spurs are not. Unmarked spurs prevent the test system from performing a proper subtraction since spurs cannot be subtracted on a power basis. Observe the measurement results to insure that a minimum of unmarked spurs are present around the offsets of interest.

The number of unmarked spurs within the measurement is lowered by reducing the measurement bandwidth, or by increasing the number of averages specified in the *Type/Range of Measurement* menu and the FFT or HF Segment tables.

Carrier Frequency Scaling

```
    ┌─ Main Menu ──────────────────┐
    │                              │
    │  Type/Rang┌─ Manipulate Results ───┐
    │  Parameter│                        │
    │  Calibrati│ Noise Spec Lines       │
    │  Instrumen│ List of Spurs          │
╔═ Carrier Freq. Scaling ══════════════════════════════════════════╗
║ Scale data to new carrier freq defined as:     10.E+6 Hz * [        1 ] ║
╚══════════════════════════════════════════════════════════════════╝
    │  System Co│ Input Pwr (Noise Figure)│
    │  Advanced │                        │
    │  File Syst└────────────────────────┘
    │  Quit                        │
    │                              │
    └──────────────────────────────┘
```

Figure 4–15. Carrier Frequency Scaling Window

As shown in figure 4-15, you may enter a value to *Scale data to new carrier freq defined as:* The carrier frequency scaling function allows you to plot results based on frequency changes in the carrier, and to plot the noise of the measured source to a translated frequency. The carrier frequency "10.E+6 Hz", in this example, is the defined carrier frequency from the *Parameters* menu and is shown on the same line opposite the field for entering the scale factor. The scale factor can be any number greater than zero. Entering a factor-of-2 doubles the frequency, a factor-of-3 triples the frequency, and so on. A number less than one corresponds to a scaling to a lower carrier frequency.

Plots made after the scale factor has been entered indicate noise for the scaled frequency. Noise levels increase for scale factors > 1 and decrease for factors < 1.

Input Power (Noise Figure)

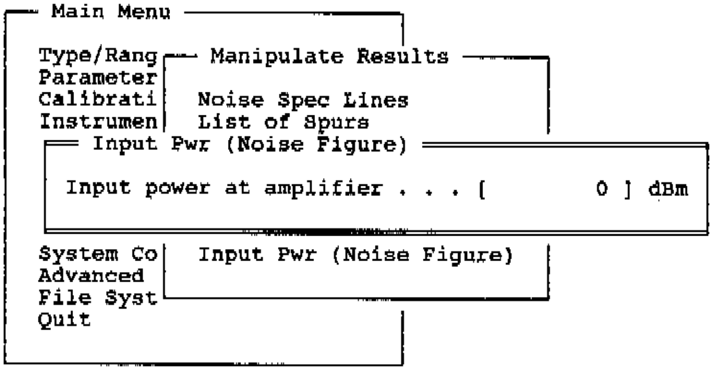


Figure 4–16. Input Power (Noise Figure) Window

As shown in figure 4–16, you may enter a value for the *Input power at amplifier*. This value is used to create Noise Figure for 2-Port Device plots. Enter the power level of the signal entering the unit under test (UUT).

You may need to change the graph scaling in the *Define Graph* window to accommodate for the Noise Figure data. The Noise Figure data is calculated as follows:

$$Noise\ Figure = S_\phi + 174\ dB + Input\ Power\ at\ Amplifier$$

OR

$$Noise\ Figure = \mathcal{L}(f) + 177\ dB + Input\ Power\ at\ Amplifier$$

(Where S_ϕ is the standard data type stored/maintained by the HP 3048A.)

Advanced Functions 5

Introduction

The *Advanced Functions* window allows you to manipulate the test system or to customize a measurement using the extended capabilities provided by the HP 3048A. These functions are recommended to be used only by those who understand how the measurement and the test system are affected. Refer to the following pages for details:

FFT Segments

FFT Segments

Plotted Range (Hz)	Measured Range (Hz)	Min Aves	BW (Hz)	Time Rec. (sec)
10.E-03 - 1	0 - 1	1	0.010	400.000
1 - 10	0 - 10	1	0.095	40.000
10 - 100	0 - 100	5	0.955	4.000
100 - 500	100 - 500	30	3.819	1.000
500 - 1.E+03	500 - 1.E+03	30	4.774	0.800
1.E+03 - 10.E+03	0 - 10.E+03	100	95.485	0.040
10.E+03 - 100.E+03	0 - 100.E+03	100	954.850	0.004
-	-			
-	-			
-	-			
-	-			
-	-			
-	-			
-	-			
-	-			

Figure 5-1. FFT Segments Window

Introduction

Measurement frequency spans or segments for the HP 3561A Dynamic Signal Analyzer are defined in the *FFT (Fast Fourier Transform) Segment* window, as shown in figure 5-1. The HP 3048A makes measurements by analyzing one segment of frequency data at a time. Up to 15 segments can be defined in the segment table. Use the FFT Segment table for frequencies up to 100 kHz, and use the RF Segment table for frequencies above 100 kHz.

Description

The Default FFT Segment Table Values

The default FFT Segment table shown if figure 5–1 provides an optimum set of values for most noise measurements. These values should be used the first time a new measurement is made to guarantee that any measurement problems are not due to a re-defined FFT Segment table.

Storing the FFT Segment Table

FFT Segment table data is stored whenever a Parameter file is stored. Consequently, whenever a Parameter file is loaded, FFT Segment table data is set to the values previously stored.

Modifying the FFT Segment Table

Changes made to the FFT Segment table do not affect measurement accuracy, but may cause gaps in the Graph of Results if the segments do not cover a continuous frequency range. Also, changes can result in measurement times that are longer than necessary. Whenever the FFT Segment table is modified, a *New Measurement* is recommended.

Directions

1. Move the inverse-video box to the entry area you want to change.
2. Type in the FFT Segment data and press the ENTER key.
3. When any entry area is deleted and the inverse-video box moved, the whole row of data is also deleted.
4. *BW* (bandwidth) and *Time Rec* (time record) are automatically calculated when the *Measured Range* data is entered.

Considerations for Modifying the FFT Segment Table

There is a trade-off between measurement resolution and time. To increase measurement resolution in either frequency or amplitude, you must be willing to accept longer measurement times. It may be possible, however, to minimize the increase in measurement time and still get the increased measurement resolution over a specific portion of the graph by decreasing the resolution for other portions of the graph.

Plotted and Measured Ranges

The *Measured Range* entries in the FFT Segment table defines the measurement bandwidth (*BW*) of each segment. The spacing of the data points for a measured range is determines by the number of data points per frequency span. Refer to table 5-1 to determine the HP 3561A data point spacing.

Table 5-1. Table of Data Points for HP 3561A

Data Points Per Frequency Span	Intervals Per Frequency Span	Data Point Spacing
401	400	Freq. Span ÷ 400

The *Plotted Range* entries define what portion of the measured data will be plotted on the Graph of Results. The Plotted Range can be the same as or can be a subrange of the Measured Range within the following limitation:

$$\text{Minimum Plotted Frequency} \geq \frac{\text{Measured Range}}{100}$$

Considerations for Changing the Measured Range

Due to the possible steepness of the slope of the phase noise curve, spurs are not marked for offset frequencies less than 10% of the Measured Range.

$$For\ f < \frac{\text{Measured Range}}{10}\ Spurs\ are\ not\ marked.$$

Minimum Averaging

The Minimum Average value designates the minimum number of measurements the HP 3048A makes for a given Measured Range. The values entered in the FFT Segment table may or may not be used depending on the number of averages specified in the measurement definition. (Refer to *Type/Range of Measurement* in chapter 2 for further information about defining the minimum number of averages for the measurement.) The actual number of averages used is the larger of the two averages specified.

For example, if the measurement definition specifies 4 as the number of averages, and the FFT Segment table specifies 30 as the minimum number of averages for a given Measured Range; the HP 3048A uses 30 averages as the number of averages for that range.

Considerations for Changing the Minimum Number of Averages

The default Minimum Average values have been selected so that the measurement time for each Measured Range is approximately equal to the time it takes to process and plot the data taken during the previous measurement.

Increasing the number of Minimum Averages reduces the scatter of points around the true noise; however, it may also increase the time it takes to complete the measurement.

The following equations are used to calculate measurement time using the number of averages.

For HP 3561A Spans $\leq$ 5 kHz:

$$\text{Measurement Time} = (1+\text{Number of Avg}) \times \frac{\text{Time Record Length}}{2}$$

For HP 3561A Spans $>$ 5 kHz:

$$\text{Measurement Time} = \text{Num. of Avg.} \times 60\text{msec}$$

Bandwidth

The Bandwidth (*BW*) is automatically set by the HP 3048A to the appropriate value for each Measured Range. Bandwidth is determined by the Frequency Span setting of the HP 3561A, and is approximately equal to 1% of that setting. (Note, this value is not the same as display resolution which is 0.25% of the span setting).

Time Record Length

The Time Record length (*Time Rec*) is also determined by the HP 3561A Frequency Span and cannot be set independently. Time Record length is the approximate time it takes the analyzer to measure and record data for one measurement of the Measured Range. Table 5-1 shows the relationship between span, record lengths, and display resolution for the HP 3561A.

Table 5-2. Frequency Spans, Time Record Lengths, and Display Resolution for the HP 3561A

Frequency Span (Hz)	Time Record Length (Sec.)	Display Resolution (Hz)	Frequency Span (Hz)	Time Record Length (Sec.)	Display Resolution (Hz)
100 000	0.004	250	32	12.5	0.08
50 000	0.008	125	25	16.0	0.0625
25 000	0.016	62.5	20	20.0	0.05
20 000	0.020	50	16	25.0	0.04
12 500	0.032	31.25	10.0	40.0	0.025
10 000	0.040	25	8	50.0	0.02
6 250	0.064	15.625	6.4	62.5	0.016
5 000	0.080	12.5	5	80.0	0.0125
4 000	0.100	10	4	100.0	0.01
3 125	0.128	7.8125	3.2	125.0	0.008
2 500	0.160	6.25	2.5*	160.0	0.00625
2 000	0.200	5	2	200.0	0.005
1 250	0.320	3.125	1.6	250.	0.004
1 000	0.400	2.5	1.28	312.5	0.0032
800	0.500	2	1*	400.	0.0025
625	0.640	1.5625	0.8	500.	0.0020
500	0.8	1.25	0.62	625.	0.0016
400	1.0	1	0.4*	1000.	0.001
250	1.6	0.625	0.32	1250.	0.0008
200	2.0	0.5	0.256	1562.5	0.00064
160	2.5	0.4	0.16	2500.	0.0004
125	3.2	0.3125	0.128*	3125.	0.00032
100	4.0	0.25	0.064*	6250.	0.00064
80	5.0	0.2	0.0512*	7812.5	0.000128
50	8.0	0.125	0.0256*	15625.	0.000064
40	10.0	0.1	0.01024*	39062.5	0.0000256

* Zero start only

NOTE

Time Record length is only the time used for the actual data recording and does not include time needed by the frequency analyzer for processing the acquired data. The processing time for the HP 3561A is constant (approximately 60 milliseconds) regardless of the data recording time. Since the HP 3561A processes data from the previous measurement during the time it is recording new data, the constant processing time (60 milliseconds) sets the minimum cycle time for each measurement.

Display Modes

Approximately 100 milliseconds of additional time is required if the HP 3561A is in the Normal Display mode. The Display mode is changed by the HP 3048A as the sweep time is lengthened. Table 5-2 shows frequency spans where the Display mode changes:

Table 5-3. Display Modes

HP 3561A Span	Display Mode	Comments
$\leq$ 1kHz	Normal Display Mode	HP 3561A displays new data in time and frequency domain after every FFT.
> 1 kHz	Fast Display Mode	HP 3561A displays averaged FFT and last time record after all data is taken.
$\leq$ 5 kHz	50% Overlap Mode	Data recording time is reduced by a factor of 2 after the first time record.

Changing the FFT Segment Table

Example for Decreasing Measurement Time

The default FFT Segment table can be modified to speed-up the measurement by performing the following procedure.

1. Delete the first two lines in the default FFT Segment table.

2. Change the first entry under *Plotted Range* to 1.

The resulting FFT Segment table shown below decreases measurement time by 2 minutes and still provides measurements to 1 Hz minimum frequency offset.

Plotted Range (Hz)			Measured Range (Hz)			Minimum Averages	BW (Hz)	Time Record (Sec.)
1	-	100	0	-	100	5	.955	4.000
100	-	500	100	-	500	30	3.819	1.000
500	-	1E+3	500	-	1E+3	30	4.774	.800
1E+3	-	10E+3	0	-	10E+3	100	95.485	.040
10E+3	-	100E+3	0	-	100E+3	100	954.850	.004

NOTE

A drawback when using this technique is the limit placed on marking spurs. For this example, spurs below 10 Hz are not marked. The HP 3048A does not mark spurs within the first 10% of the measurement span.

Decreasing Measurement Time for Measuring .1 Hz Offsets

The entries shown in the following FFT Segment table provides a decrease in measurement time for measuring down to .1 Hz minimum offsets. In this example, spurs < 1 Hz are not marked.

Plotted Range (Hz)			Measured Range (Hz)			Minimum Averages	BW (Hz)	Time Record (Sec.)
10E-3	-	100E-3	0	-	100E-3	1	.010	400.000
.1	-	10	0	-	10	1	.095	40.000
10	-	100	0	-	100	5	.955	4.000
100	-	500	100	-	500	30	3.819	1.000
500	-	1E+3	500	-	1E+3	30	4.774	.800
1E+3	-	10E+3	0	-	10E+3	100	95.485	.040
10E+3	-	100E+3	0	-	100E+3	100	954.850	.004

Example for Measuring .001 Hz Offsets

The FFT Segment table shown below demonstrates how the frequency offset range can be extended down to 0.001 Hz. These changes increase the measurement time to approximately 5 hours for a measurement using 4 averages.

Plotted Range (Hz)			Measured Range (Hz)			Minimum Averages	BW (Hz)	Time Record (Sec.)
.001	-	.064	0	-	.064	1	.001	6250.000
.064	-	1	.064	-	1	1	.010	400.000
1	-	10	0	-	10	1	.095	40.000
10	-	100	0	-	100	5	.955	4.000
100	-	500	100	-	500	30	3.819	1.000
500	-	1E+3	500	-	1E+3	30	4.774	.800
1E+3	-	10E+3	0	-	10E+3	100	95.485	.040
10E+3	-	100E+3	0	-	100E+3	100	954.850	.004

Example for Increasing Measurement Resolution

The FFT Segment table shown below demonstrates how measurement resolution can be increased by dividing a Measured Range into several parts. In this example, the default Measured Range (0 to 10E+3 Hz) is divided into three ranges (1E+3 to 2E+3, 2E+3 to 3E+3, and 0 to 10E+3). This changes the bandwidth from 95.485 to 9.548 Hz over this range up to 3 kHz. Since the new bandwidth is less than 60 Hz, the 60 Hz spurs become visible on the plot. (The default Measured Range will not resolve spurs spaced less than 96 Hz apart in this band.)

Plotted Range (Hz)			Measured Range (Hz)			Minimum Averages	BW (Hz)	Time Record (Sec.)
10E-3	-	1	0	-	1	1	.010	400.000
1	-	10	0	-	10	1	.095	40.000
10	-	100	0	-	100	5	.955	4.000
100	-	500	100	-	500	30	3.819	1.000
500	-	1E+3	500	-	1E+3	30	4.774	.800
1E+3	-	2E+3	1E+3	-	2E+3	30	9.548	.400
2E+3	-	3E+3	2E+3	-	3E+3	30	9.548	.400
3E+3	-	10E+3	0	-	10E+3	100	95.485	.040
10E+3	-	100E+3	0	-	100E+3	100	954.850	.004

NOTE

The consequence of using changes shown in this example is an increase in measurement time of approximately 30 seconds.

Example for Increasing Measurement Resolution at Specific Frequencies

The FFT Segment table shown below is configured to cause the HP 3048A to measure and plot the phase noise of a signal at specific offsets from the carrier frequency. This technique generally gives better resolution for each unique point analyzed, but the measurement may take longer due to the smaller bandwidth at each offset frequency. The segments can be either continuous, or separated into isolated segments.

Plotted Range (Hz)			Measured Range (Hz)			Minimum Averages	BW (Hz)	Time Record (Sec.)
500E-3	-	1.5	500E-3	-	1.5	1	.010	400.000
5	-	15	5	-	15	1	.095	40.000
50	-	150	50	-	150	5	.955	4.000
500	-	1.5E+3	500	-	1.5E3	20	9.548	.400
5E+3	-	15E+3	5E+3	-	15E+3	100	95.485	.040
90E+3	-	100E+3	90E+3	-	100E+3	100	95.485	.040

NOTE

The maximum number of Measured Ranges that can be defined for the FFT Segment table is 15.

The maximum offset frequency that can be specified in the FFT Segment table is 100 kHz.

HF Segments

Main Menu

Type/Range of Measurement

HF Segments

Plotted Range (Hz)	Measured Range (Hz)	Min Aves	BW (Hz)	VBW (Hz)	Swp Time
100.E+3 - 500.E+3	0 - 500.E+3	1	3.E+3	10	20
500.E+3 - 5.E+6	0 - 5.E+6	1	10.E+3	30	20
5.E+6 - 40.E+6	0 - 40.E+6	1	30.E+3	100	20
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				

Figure 5-2. HF Segment Window

Introduction

The HP 3048A measures one segment of frequency data at a time. Each segment is defined in a segment table. There are two segment tables. Use the Fast Fourier Transform (FFT) table for frequencies from .001 Hz to 100 kHz, and use the HF Segment table for frequencies above 100 kHz. Up to 10 segments can be defined in the HF Segment table.

Description

The Default HF Segment Table Values

The default HF Segment table shown in figure 5–2 provides an optimum set of values for most noise measurements from 100 kHz to 40 MHz. The default HF Segment table values should be used the first time a new measurement is made. This guarantees that any measurement problems are not due to a re-defined HF Segment table.

Storing the HF Segment Table

HF Segment table data is stored whenever a Parameter file is stored. Consequently, whenever a Parameter file is loaded, the HF Segment table data is set to the values previously stored.

Modifying the HF Segment Table

All fields in the HF Segment table can be user defined however, all values entered must reflect available settings for the particular RF analyzer you are using. The accuracy of the measurement results is dependent on the values defined in the HF Segment table.

Changing the HF Segment table can cause gaps in the Graph of Results if the segments do not cover a continuous frequency range. Also, changes can result in a longer than necessary measurement time. Whenever the HF Segment table is modified, a *New Measurement* is recommended.

Directions

1. Move the inverse-video box to the entry area you want to change.
2. Type in the HF Segment data and press the $\boxed{\text{ENTER}}$ key.
3. When any entry area is deleted and the inverse-video box moved, the whole row of data is also deleted.

Considerations for Modifying the Segment Table

There is a trade-off between the measurement resolution and time. To increase measurement resolution in either frequency or amplitude, you must be willing to accept longer measurement times. It may be possible, however, to minimize the increase in measurement time and still get the increased measurement resolution you need over a specific portion of the graph by decreasing the resolution for other portions of the graph.

Plotted and Measured Ranges

The *Measured Range* entries in the HF Segment table define the frequency range that the spectrum analyzer actually sweeps for each segment. The spacing of the data points for a measured range is determines by the number of data points per frequency span. Refer to table 5-4 for a list of supported RF analyzers and their data point spacing.

Table 5-4. Table of Data Points for Supported RF Analyzers

Analyzer Model	Data Points Per Frequency Span	Intervals Per Frequency Span	Minimum Range of Integration
HP 3585A/B	1001	1000	Freq. Span ÷ 1000
HP 8562A	601	600	Freq. Span ÷ 600
HP 8566A/B	1001	1000	Freq. Span ÷ 1000
HP 8568A/B	1001	1000	Freq. Span ÷ 1000
HP 71000	801	800	Freq. Span ÷ 800

The *Plotted Range* entry defines what portion of the measured data will be plotted on the Graph of Results. The Plotted Range can be the same as or can be a subrange of the Measured Range within the following limitation:

$$\text{Minimum Plotted Frequency} \geq \frac{\text{Measured Range}}{100}$$

Considerations for Changing Measured Ranges

Due to the possible steepness of the slope of the phase noise curve slope, spurs are not marked in the first 10% of the Measured Range.

$$For\ f < \frac{\text{Measured Range}}{10}\ spurs\ are\ not\ marked.$$

Bandwidth

The Bandwidth (*BW*) sets the appropriate value for each Measured Range. Bandwidths defined in the HF Segment table should not exceed those specified in the default HF Segment table, but the bandwidths can be of finer resolution if desired. Bandwidths should typically be 1 kHz, 3 kHz, 10 kHz, 30 kHz, and so forth. These bandwidths are available on all supported RF analyzers. However, if your particular RF analyzer supports other bandwidths, they can be used. (Refer to your RF Spectrum Analyzer's Operating and Service manual for a list of the available bandwidths.)

NOTE

A Bandwidth greater than 3 kHz should not be used in a segment including 100 kHz.

Video Bandwidth

For accurate noise measurements, the Video Bandwidth entry (*VBW*) should be defined using the following equation. Remember that a smaller video bandwidth provides more smoothing of the noise but requires increased sweep time to maintain full accuracy on spurs.

$$\text{Video Bandwidth} \leq \frac{\text{Resolution Bandwidth}}{300}$$

Sweep Time

The defined Sweep Time value (*Swp Time*) for each segment affects the accuracy of the measurement results more than any other parameter in the HF Segment table. The following procedure can be used to decrease the Sweep Time below the spectrum analyzer's normal setting for the specified frequency span, resolution bandwidth, and video bandwidth and maintain measurement accuracy.

1. Connect a CW signal to the RF analyzer input.

2. Set the RF analyzer to the Measured Range (span), Bandwidth, Center Frequency to CW, and Video Bandwidth specified for the segment. (The RF analyzer will select an appropriate default Sweep Time setting.)

3. Position the marker to the peak of the input signal and note the level of the signal.

4. Begin decreasing the Sweep Time and note the change in the signal level for each change from the level in step 3. To maintain adequate measurement accuracy, the signal level should not change by more than 0.3 dB. Enter the resulting value in the HF Segment table. Typically, the sweep time can be reduced by a factor of 2 or more from the value set by the analyzer.

NOTE

The HP 3048A makes accurate measurements even though the RF analyzer may be indicating that it is being operated in an uncalibrated condition, as long as the above procedure has been used to verify the response.

11848A Control

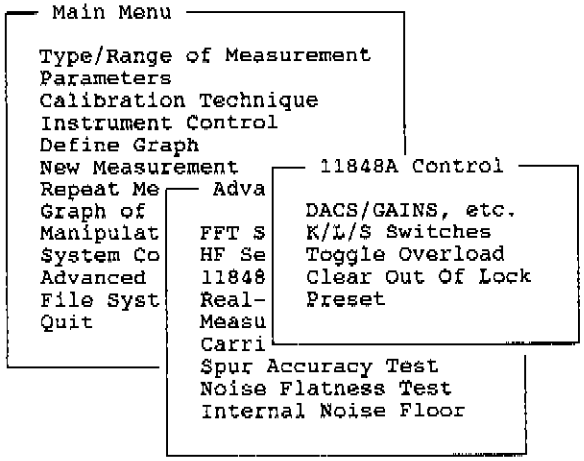


Figure 5-3. 11848A Control Window

Introduction

As shown in figure 5-3, the *11848A Control* function gives the user direct and arbitrary control of the programmable circuits and switches in the HP 11848A Phase Noise Interface through the computer and over HP-IB. Refer to the following pages for details:

NOTE

If HP 11848A settings are changed by the user, it is possible for the measurement results to not be valid until a *New Measurement* is performed.

Also, it may be possible to damage external equipment connected to the HP 11848A as a result of changing the settings within it.

The 11848A Control function is useful for setting up special measurement conditions to assist in diagnosing a suspected interface problem, and to show the signal path configuration. It is also used during System Calibration. (Refer to the *HP 3048A Option 301 System Calibration Manual* for the System Calibration procedures.)

The operation of this function is coupled to the block diagram of the HP 11848A. The block diagram with accompanying notes is presented on a foldout in the back of this section. (The theory of operation for the block diagram of the HP 11848A, as well as a description of the HP 11848A's role in making a phase noise measurement, can be found in the *HP 11848A Service Manual*.)

DACS/GAINS, etc.

```
┌─ Main Menu ──────────────────────┐
│                                  │
│  Type/Range of Measurement ╔═ DACS/GAINS, etc. ══════════════╗
│  Parameters                ║                                 ║
│  Calibration Technique     ║    DAC1:        1.000 Volts     ║
│  Instrument Control        ║    DAC2:        5.100 Volts     ║
│  Define Graph              ║    DAC3:        0.005 Volts     ║
│  New Measurement    ┌─ 1184║   GAIN1:            8 dB        ║
│  Repeat Me┌─ Adva   │      ║   GAIN2:           18 dB        ║
│  Graph of │         │DACS/ ║   GAIN3: x         20           ║
│  Manipulat│ FFT S   │K/L/S ║  ATTEN1: x        0.2           ║
│  System Co│ HF Se   │Toggl ║  ATTEN2: x        1.0           ║
│  Advanced │ 11848   │Clear ║  ATTEN3: x        0.2           ║
│  File Syst│ Real-   │Prese ║ HPF (H):            6           ║
│  Quit     │ Measu   │      ║ LPF (F):            5           ║
│           │ Carri   └──────║ LAGLEAD:            0           ║
└───────────│ Spur Accuracy  ║                                 ║
            │ Noise Flatnes  ╚═════════════════════════════════╝
            │ Internal Noise Floor   │
            │                        │
            └────────────────────────┘
```

Figure 5-4. DACS/GAINS, etc. Window

Introduction

As shown in figure 5-4, the *DACS/GAINS, etc.* window allows you to control various settings in the HP 11848A Interface. Use the block diagram foldout at the end of this section as you make entries into the *DACS/GAINS, etc.* window. Also, refer to table 5-3 for a description of each circuit control.

Manipulating Rotary Switches HPF and LPF

The *HPF (H)* and *LPF (F)* switches are rotary switches. (These switches are located at the bottom center of the block diagram). Only one position can be selected at a time for each switch. To move the rotor to a position, type in the desired position in the *DACS/GAINS, etc.* window.

Table 5-5. List of Circuit Controls for the HP 11848A (1 of 2)

Control	Description	Acceptable Values
DAC1	Digital to analog converter summed into the summing amplifier for PLL Tune Voltage and Center Voltage.	−12.75 to 12.75V in 50 mV steps.
DAC2	Digital to analog converter that controls *coarse* Frequency Set voltage for the HP 11848A internal VCOs.	0 to 12.75V in 50 mV steps.
DAC3	Digital to analog converter that controls *fine* Frequency Set voltage for the HP 11848A internal VCOs.	0 to 255 mV in 1 mV steps.
GAIN1	First programmable amplifier in the PLL circuit path of the HP 11848A.	0 to 28 dB in 4 dB steps.
GAIN2	Second programmable amplifier in the PLL circuit path of the HP 11848A.	6 to 20 dB in 2 dB steps.
GAIN3	Programmable amplifier in the $\leq$ 100 kHz path prior to the selectable Low Pass Filters.	$\times$ (2,4,10,20)*
ATTEN1	Programmable attenuator at the output of the HP 11848A rear-panel Tune Voltage Output port.	$\times$ (1,0.5,0.2,0.1)*
ATTEN2	Programmable attenuator within the PLL circuit path of the HP 11848A prior to the Summing Junction.	$\times$ (1,0.5)*
ATTEN3	Programmable attenuator at the output of the HP 11848A front-panel Tune Voltage Output port.	$\times$ (1,0.5,0.2,0.1)*

* These values are the multipliers for the available gain and attenuation settings.

Table 5-3. List of Circuit Controls for the HP 11848A (2 of 2)

Control	Description	Acceptable Values
H SWITCH NUMBER:	Programmable rotary switch that switches in the High Pass Filter paths.	0 through 7
F SWITCH NUMBER:	Programmable rotary switch that switches the Low Pass Filter paths.	0 through 6
LAG-LEAD FILTER:	Programmable filter that selects the poles and zeros of the PLL circuit path.	0 through 7
SELECTED 'K' SWITCHES:	Programmable switches represented by a K and shown in Preset state on the Block Diagram. Entry of a switch number causes that switch to toggle to the opposite state from that shown in Block Diagram.	N/A
SELECTED 'L' SWITCHES:	Programmable switches represented by an L and shown in Preset state on the Block Diagram. Entry of a switch number causes that switch to toggle to the opposite state from that shown in Block Diagram.	N/A
SELECTED 'S' SWITCHES:	Programmable switches represented by a S on the Block Diagram. Entry of a switch number causes that switch to toggle to the opposite state from that shown in Block Diagram.	N/A

K/L/S Switches

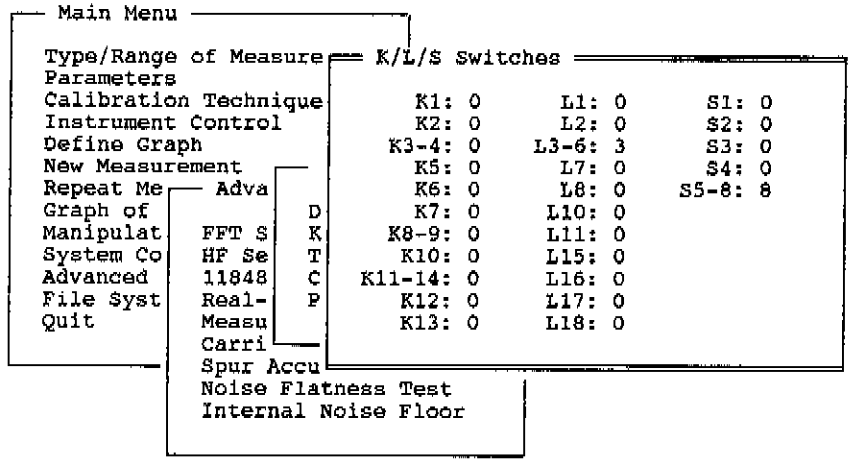


Figure 5-5. K/L/S Switches Window

Introduction

As shown in figure 5-5, the *K/L/S Switches* window allows you to control the K, L, and S switches in the HP 11848A Interface. The K, L, and S switches will either toggle to an opposite position, or toggle to another position in the ganged array, or toggle to another position in the rotary switch.

K Switches

All K switches are set according to the position shown in the block diagram, which is indicated by a preset state of "0" in the *K/L/S Switches* window. Enter a switch setting of "1" to cause the switch to toggle to the opposite position from that shown in the block diagram. Switches K8 and K9 toggle together, and switches K11 through K14 toggle together.

L Switches

All L switches are set according to the position shown in the block diagram, which is indicated by a preset state of "0" in the *K/L/S Switches* window except for switches L3 through L6, which is a ganged array set to L3, as indicated by the preset state of "3". Enter a switch setting of "1" to cause the switch to toggle to the opposite position from that shown in the block diagram.

S Switches

All S switches are set according to the position shown in the block diagram, which is indicated by a preset state of "0" in the *K/L/S Switches* window except for switches S5 through S8, which is a ganged array set to S8, as indicated by the preset state of "8". Enter a switch setting of "1" to cause the switch to toggle to the opposite position from that shown in the block diagram.

Toggle Overload, Clear Out of Lock, and Preset

The *Toggle Overload* and *Clear Out of Lock* functions clear the Overload and Out-of-Lock Flip-Flops as indicated by the respective front-panel annunciators (assuming, of course, that the overloading or lock-breaking condition has been removed).

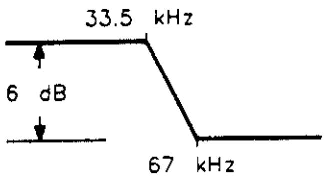
The *Preset* function sets all circuits in the HP 11848A to their preset condition, as shown in the block diagram.

Block Diag. Sht 1 of 5

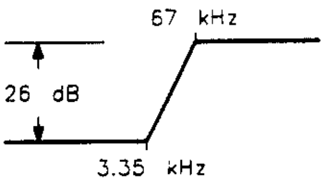
Block Diagram Notes

1. Switches on the Block Diagram are shown in their HP-IB preset state. At Interface turn-on with no controller connected, the power-up state is the same as the HP-IB preset state except:
   a. ATTEN 1 is set to an open-circuit (non-programmable) state, and
   b. the switches of cluster S5 through S8 are all open.

2. The transfer function of GAIN 2 also has a lead-lag response as follows:



3. The transfer function of Lag-Lead Network 1 is as follows:

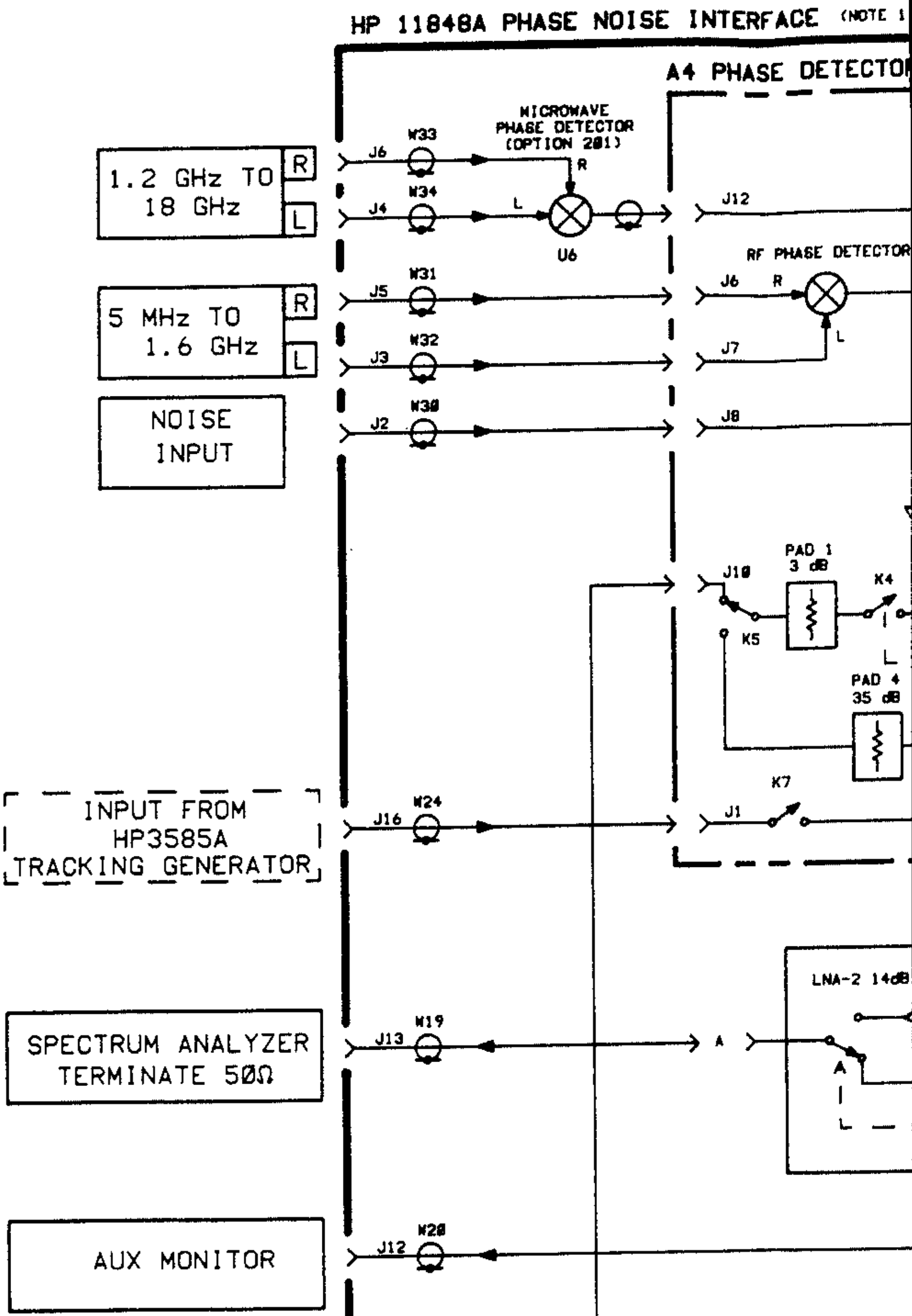


To this transfer function is added a programmable lag-lead with the following poles and zeros:

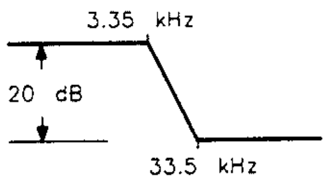
Lag-Lead Number	Pole Frequency	Zero Frequency	Attenuation
0	4.82 Hz	9.95 Hz	6 dB
1	8.01 Hz	40.1 Hz	14 dB
2	9.17 Hz	115.9 Hz	22 dB
3	9.68 Hz	306 Hz	30 dB
4	9.95 Hz	784 Hz	38 dB
5	9.95 Hz	1.985 kHz	46 dB
6	9.95 Hz	5.00 kHz	54 dB
7	9.95 Hz	12.58 kHz	62 dB

4. Assemblies A6, A8, and A9 are controlled as follows:

Control Line	State A6	State A8	State A9
L17	Off	On	On
L18	Off	On	Off
L17, L18	On	Off	Off

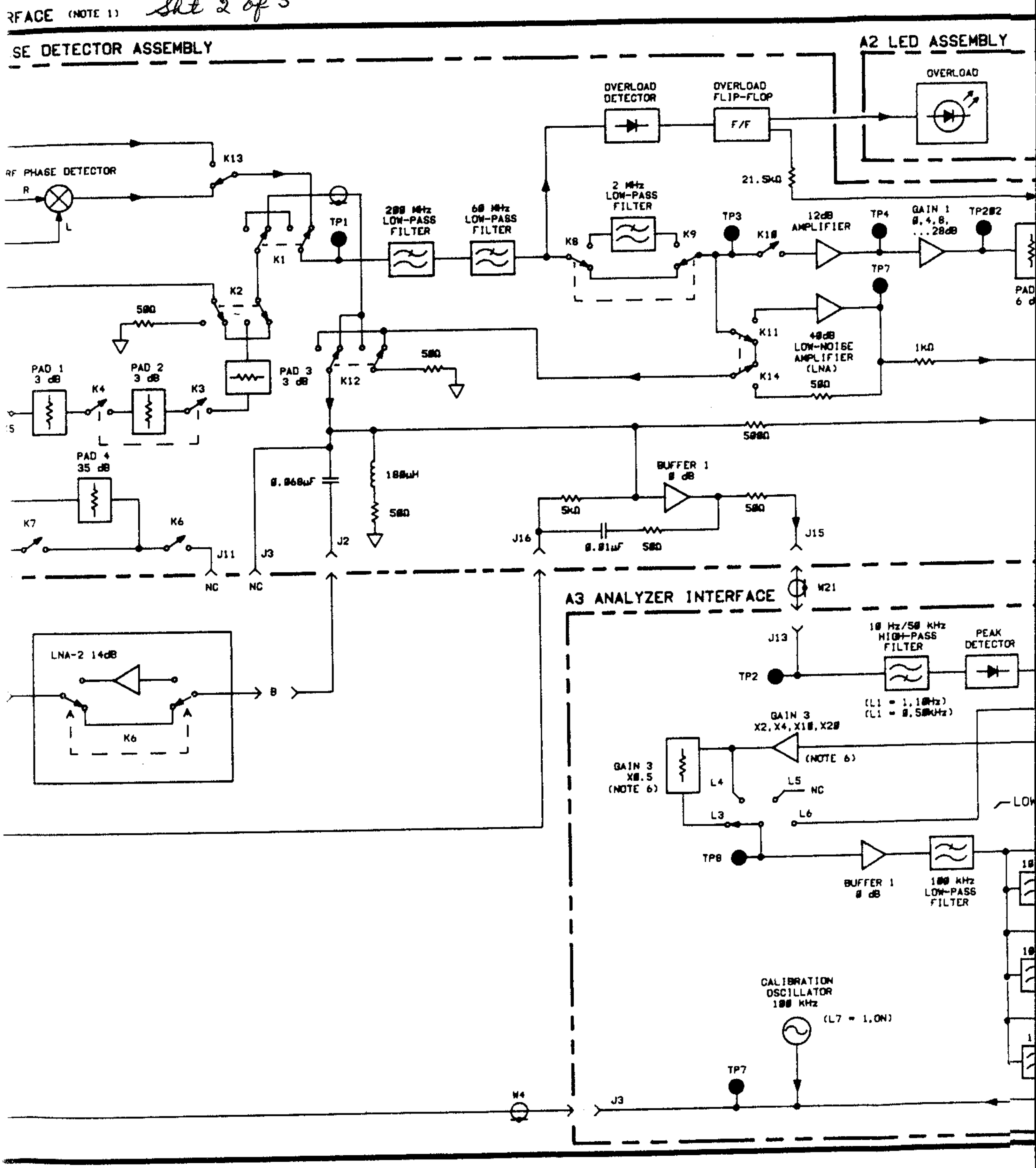


5. The transfer functions of Lag-Lead Network 2 on A4 and the Lag-Lead Network on A3 are both as follows:

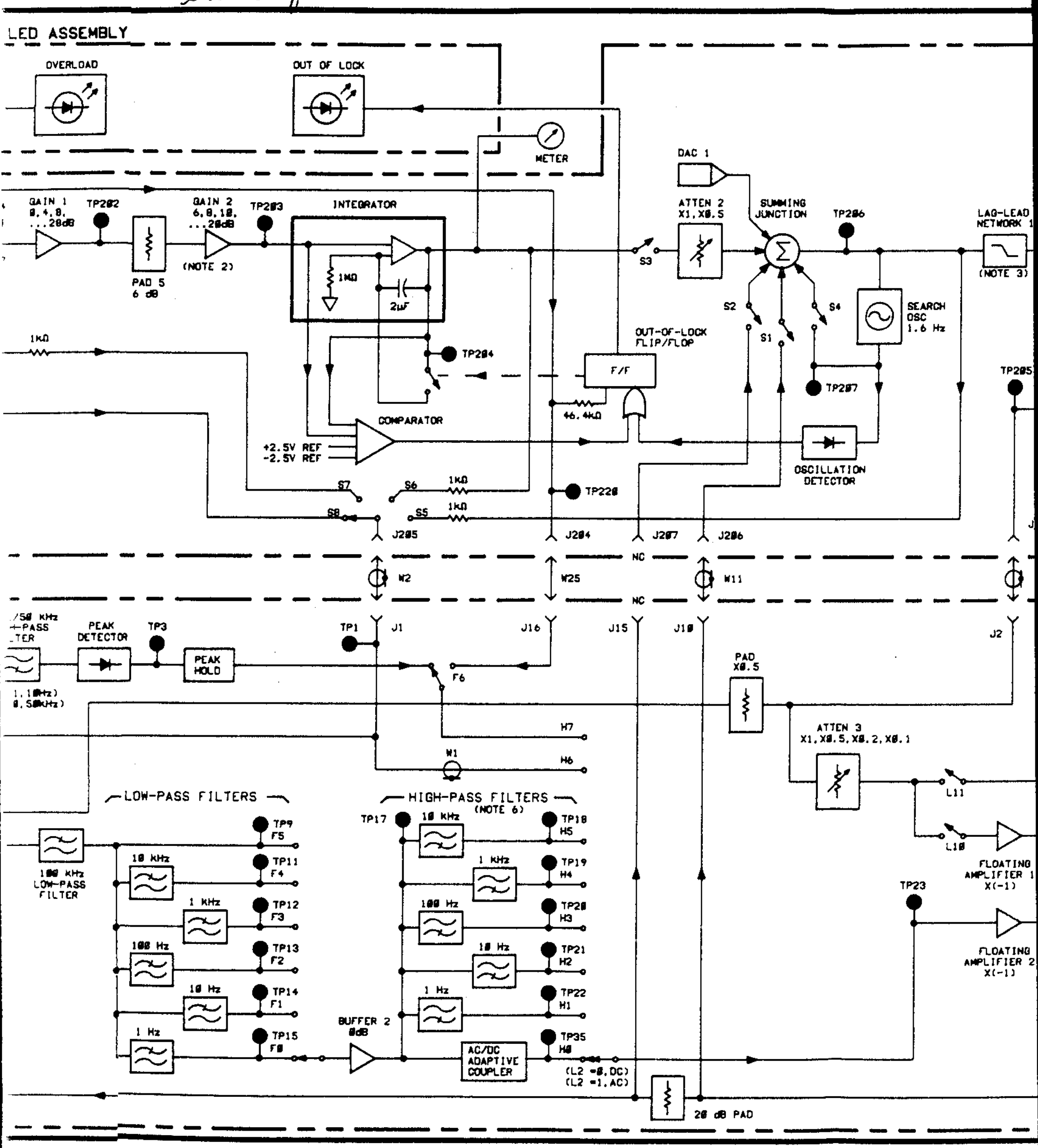


6. The passband gain of the High-Pass Filters is 2 (as measured from TP17 to the respective filter output). The gain settings of the GAIN 3 amplifier and attenuator include the passband gain of the High-Pass Filters.

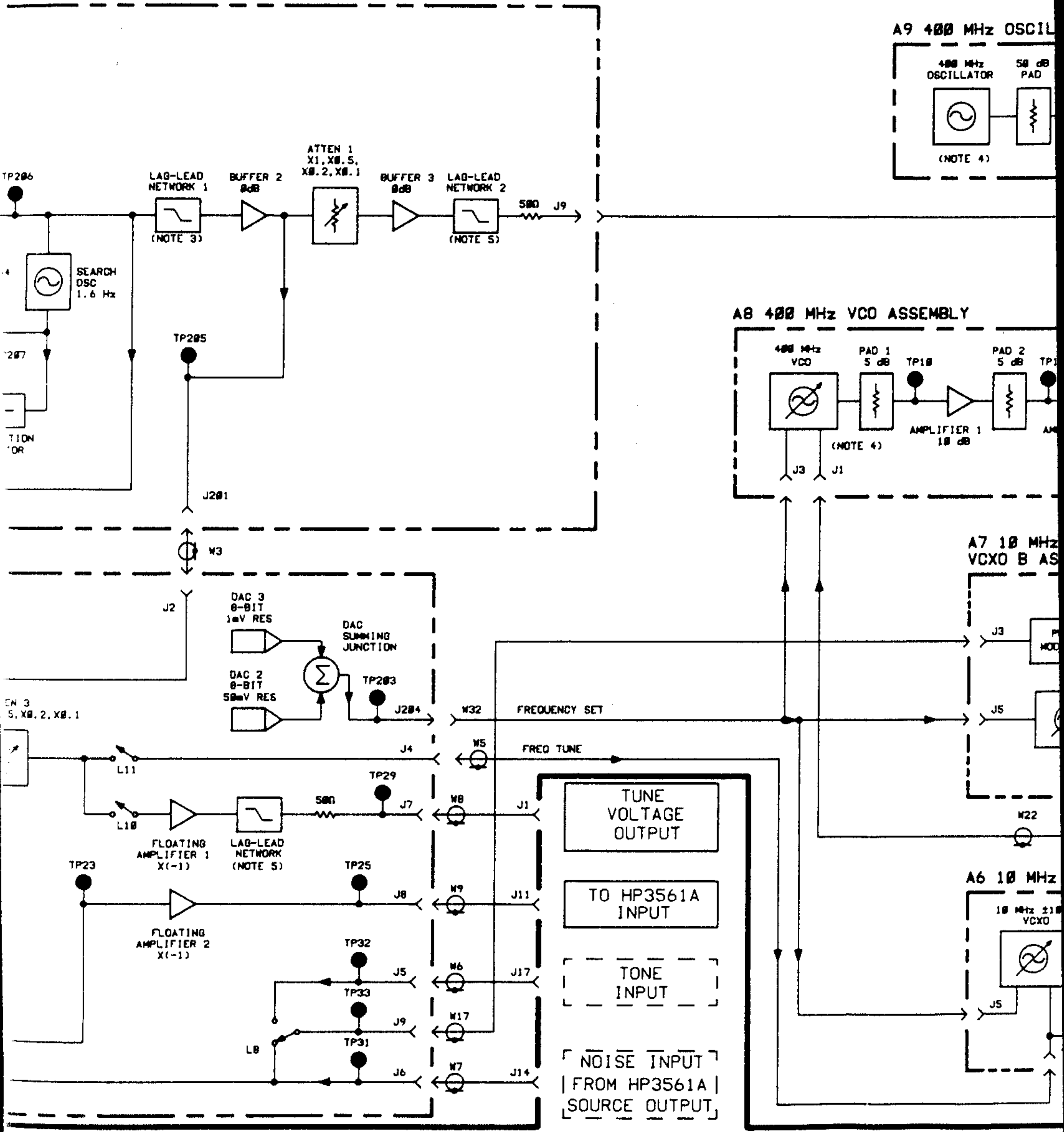
Block Diag.
Sht 2 of 5



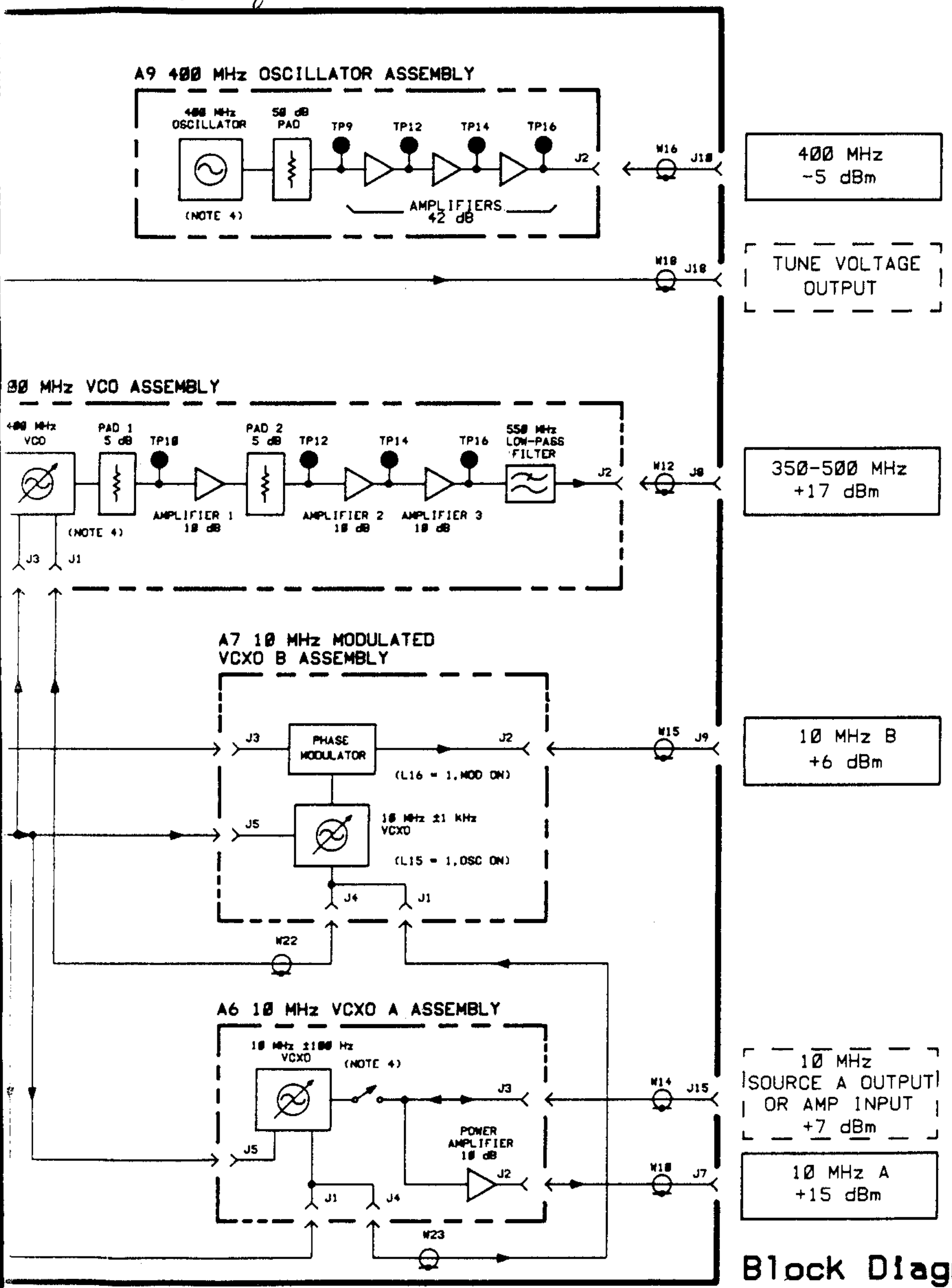
Block Diag.
Sht 3 of 5



Block Diag.
Sht 4 of 5



Block Diag.
Sht 5 of 5



Block Diagram

Real-time Monitor

```
 ┌─ Main Menu ─────────────────────┐
 │   Type/Range of Measurement      │
 │   Parameters                     │
 │   Calibration Technique          │
 │   Instrument Control             │
═ Real-time Monitor ═══════════════════════════════════════════
  HPF Cutoff:     10.E+3 Hz            LPF Cutoff:    100.E+3 Hz
  Start Freq:     10.E+3 Hz            Stop  Freq:    100.E+3 Hz
───────────────────────────────────────────────────────────────
                  Marker Freq:    42.5E+3 Hz
                   Noise Ampl:       -164 dBc/Hz
                    Spur Ampl:     -134.2 dBc
───────────────────────────────────────────────────────────────
 F1-Read Marker    F4-Select Segment   F5-Close PLL   F8-Take Sweep
═══════════════════════════════════════════════════════════════
                    │  Noise Flatness Test      │
                    │  Internal Noise Floor     │
                    └───────────────────────────┘
```

Figure 5–6. Real-time Monitor

Introduction

The Real-time Monitor function allows you to perform single-point and real-time evaluations of the measured noise. This function allows you to select specific spans and filters for the analyzers and the HP 11848A Interface to more closely evaluate the noise spectrum. Using the analyzer's marker function, the HP 3048A reads the frequency and amplitude of a single point and returns the value normalized to a 1 Hz bandwidth for $L(f)$, $S_\phi(f)$, $S_\nu(f)$, $S_y(f)$ and an unnormalized spur value. (The type of noise being measured is determined in the Define Graph menu.)

Softkey Descriptions

Read Marker: Press the [F1] softkey to display the frequency and corrected amplitude of the point indicated by the marker on the FFT or RF Analyzer. (The analyzer on which the marker is being read is defined by the frequency segment being used.)

Select Setment: Press the [F4] softkey to increment, or the [SHIFT] key and the [F4] softkey to decrement the frequency segment to be measured as defined in the current FFT or HF Segment tables.

Close PLL: Press the [F5] softkey to perform all of the system checks that ensure phase lock of the source.

Take Sweep: press the [F8] softkey to perform a sweep of the selected frequency segment as defined in the current FFT or HF Segment Table. The measurement will be taken exactly as a regular swept measurement but only for the frequency range of the selected segment.

High and Low Pass Cutoff

The High-pass and Low-pass cutoff frequencies are selected as follows.

HPF Cutoff: Press the [H] key to increase or the [SHIFT] key and the [H] key to decrease the High-Pass Filter in the HP 11848A Phase Noise Interface. These HPFs are in decade steps and are designed to permit increased sensitivity of the HP 3561A Dynamic Signal Analyzer by filtering out undesired regions of the broadband noise.

LPF Cutoff: Press the [L] key to increase or the [SHIFT] key and the [L] key to decrease the Low-Pass Filter in the HP 11848A Phase Noise Interface. These LPFs are in decade steps and are designed to permit increased sensitivity of the HP 3561A Dynamic Signal Analyzer by filtering out undesired regions of the broadband noise.

NOTE

When the Take Sweep softkey is pressed, the High-pass and Low-pass filters are reset to correctly correspond to the defined frequency segment.

How to Use Real-time Monitor

Evaluating a Single Offset Frequency

1. Press the [F4] softkey to increment or the [SHIFT] key and the [F4] softkey to decrement the frequency segment. The segments are those currently defined in the FFT and HF segment tables.

2. Press the [F8] softkey to take a sweep. This will set up the HP 11848A Interface, autorange the analyzer, measure the frequency segment, hold the averaged display, and place the analyzer in local.

NOTE

Real-time Monitor allows the user to manipulate the front panel controls of the analyzer. After the HP 11848A is set up, the analyzer's bandwidthe is changed to other than the one set up bye the Take Sweep softkey, the Read Marker function WILL NOT return accurate data.

3. Place the analyzer's marker at the desired frequency.

4. Press the [F1] softkey to read and display the value of the marker.

Evaluating Phase Fluctuations as a Function of Time

Real-time noise measurements can be useful for evaluating noise transients or device sensitivity to mechanical or electrical stimulation. Continuous Real-time display of the noise measurement can be made by turning off the averaging function of the analyzer or by setting the analyzer for repeat display or continuous sweep.

NOTE

The user is responsible for setting the front-panel controls on the analyzer for Real-time Noise measurements. If the analyzer's bandwidth is changed to other than the one set up by the Take Sweep softkey, the Read Marker function WILL NOT return accurate data.

---

1. Press the [F4] softkey to increment or the [SHIFT] key and the [F4] softkey to decrement the frequency segment. The segments are those currently defined in the FFT and HF segment tables.

2. Press the [F8] softkey to take a sweep. This will set up the HP 11848A Interface, autorange the analyzer, measure the frequency segment, hold the averaged display, and place the analyzer in local.

For a Continuous Display

On the HP 3561A, press [AVG] and [OFF].

For a Repeat, Averaged Display

On the HP 3561A, press [AVG], [RMS], [DEFINE NUM AVGS], key in the number of averages and press [ENTER]. Again on the HP 3561A, press [SELECT SETUP] and [REPEAT DISPLAY], this will set up the HP 3561A for a continuous display with the entered number of averages. RF analyzers can be set up for continuous display using a similar process.

NOTE

When the Read Marker function is used in an RF analyzer segment, the marker should be within the frequency ranges defined in the Plot Ranges of the RF Segment Table. If the RF analyzer's marker is not within the correct range, it is necessary to use Select Segment to re-define the segment and the Take Sweep function to correctly set the RF Analyzer.

To Display the Noise in the Time Domain on the HP 3561A

1. Press the [F4] softkey to increment or the [SHIFT] key and the [F4] softkey to decrement the frequency segment. The segments are those currently defined in the FFT and HF segment tables.

2. Press the [F8] softkey to take a sweep. This will set up the HP 11848A Interface, autorange the analyzer, measure the frequency segment, hold the averaged display, and place the analyzer in local.

3. On the HP 3561A, press [AVG], [OFF], [NEXT TRACE], [FORMAT], and [SINGLE]. This will display the time record on the HP 3561A display.

Measurement Mode

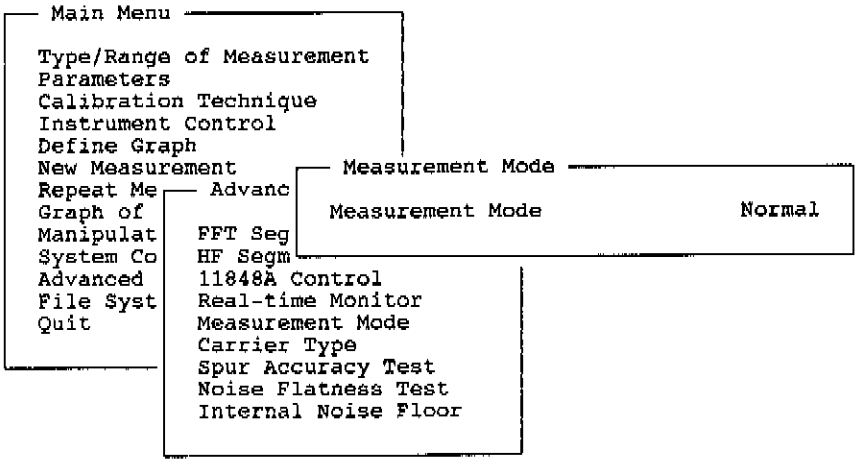


Figure 5-7. Measurement Mode Window

Introduction

The *Measurement Mode* window, as shown in figure 5-7, allows you to select between three operating modes for making measurements:

- Normal
- Trouble Shoot
- Ignore Out Of Lock

Description

Normal Test Mode

The Normal test mode is the default operating condition for the HP 3048A. The Normal test mode configures the test system to perform each measurement in the minimum time and with the minimum amount of operator assistance.

Trouble Shoot Mode

The Trouble Shoot test mode is helpful for trouble shooting the measurement but it does require more operator assistance than the Normal test mode. For example, the test operator is shown the phase lock loop suppression curve and is required to verify the curve during the measurement

Phase Lock Loop Suppression

Configuring the HP 3048A in the Trouble Shoot Mode causes the software to display the PLL Suppression Curve plot, as shown in figure 5-8, when it is verified during measurement calibration. The plot appears whether or not an accuracy degradation occurs. The error message `ACCY. DEGRADED` appears below the `VCO CONSTANT` value, shown in figure 5-8, if an accuracy degradation occurs.

The PLL Suppression verification must be selected in the *Calibration Technique* window prior to the measurement in order for verification to occur. (Refer to *Calibration Technique* in chapter 2, *Measurement Definitions* and *Parameter Summary* in chapter 4, *Manipulate Results* for details about the PLL Suppression verification.)

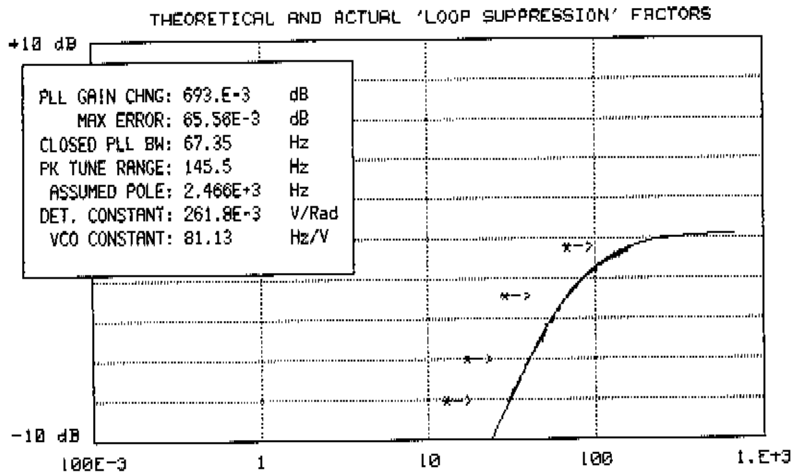


Figure 5-8. HP 3048A Example Display of the Phase Lock Loop Suppression Curve.

PLL Suppression Parameters

The following measurement parameters are displayed along with the PLL Suppression Curve.

PLL GAIN CHANGE: This is the amount of gain change required to fit the Theoretical Loop Suppression curve to the measured loop suppression. A PLL Gain Change of greater than 1 dB creates an accuracy degradation (ACCY. DEGRADED) error. If an accuracy degradation is detected, the amount of error is determined from either the PLL Gain Change or the Maximum Error, which ever is larger. The degradation itself is 1 dB less than the greater of these.

MAX ERROR: This is the measured error that still exists between the the measured Loop Suppression and the Adjusted Theoretical Loop Suppression. The four points on the Loop Suppression graph marked with arrows (ranging from the peak down to approximately −8 dB) are the points over which the Maximum Error is determined. An error of greater than 1 dB results in an accuracy degradation.

CLOSED PLL BW: This is the predicted Phase Lock Loop Bandwidth for the measurement. The predicted PLL BW is based on the predicted PTR. The Closed PLL BW will not be adjusted as a result of an accuracy degradation. If an accuracy degradation is detected, the amount of error is determined from either the PLL Gain Change or the Maximum Error, which ever is larger. The degradation itself is 1 dB less than the greater of these.

PEAK TUNE RANGE: This is the Peak Tuning Range (PTR) for the measurement determined from the VCO Tune Constant and the Tune Range of VCO. This is the key parameter in determining the PLL properties, the Drift Tracking Range, and the ability to phase lock sources with high close in noise.

The PTR displayed should be approximately equal to the product of the VCO Tune Constant times the Tune Range of VCO. This is not the case when a significant accuracy degradation is detected ($>$ 4 dB) by the Loop Suppression Verification. In this case, the PTR and Assumed Pole are adjusted when fitting the Theoretical Loop Suppression to the smoothed measured Loop Suppression, and the test system will display the adjusted PTR. If the PTR must be adjusted by more than 1 dB, as indicated by an accuracy degradation of greater than 0 dB, the Phase Detector Constant or the VCO Tune Constant is in error at frequency offsets near the PLL BW, or the PLL BW is being affected by some other problem such as injection locking.

ASSUMED POLE: This is the frequency of the Assumed Pole required to adjust the Theoretical Loop suppression to match the smoothed measured Loop suppression. The Assumed Pole frequency is normally much greater than the Closed PLL BW. An Assumed Pole frequency of less than 10 $\times$ PLL BW is an indication of peaking on the PLL Suppression curve. For PLL BWs less than 20 kHz, an Assumed Pole of less than 10 $\times$ PLL BW indicates a delay or phase shift in the VCO Tune Port. For PLL BWs greater than 20 kHz, the Assumed Pole may be adjusted to less than 10 $\times$ PLL BW to account for phase shifts in the HP 11848A.

DET. CONSTANT: This is the phase Detector Constant (sensitivity of the phase detector) used for the measurement. The accuracy of the Phase Detector Constant is verified if the PLL suppression is verified. The accuracy of the phase Detector Constant determines the accuracy of the noise measurement.

The phase Detector Constant value, along with the LNA In/Out parameter, determines the HP 3048A System noise floor exclusive of the reference source.

VCO CONSTANT: This is the VCO Tune Constant used for the measurement. The accuracy of the VCO Tune Constant determines the accuracy of the PLL noise measurement for offset frequencies in segments where the entire plotted frequency range is less than the PLL BW ÷ 4. The accuracy of the VCO Tune Constant is verified if the PLL Suppression is Verified. The VCO Tune Constant times the Tune Range of VCO determines the Peak Tune Range (PTR) value for the measurement. The PTR sets the drift tracking and close-in noise suppression capabilities of the test system.

Ignore Out Of Lock Mode

The *Ignore Out Of Lock* test mode enables all of the troubleshoot mode functions, plus it causes the HP 3048A to not check for an out-of-lock condition before or during a measurement. This allows you to measure sources with high close-in noise that normally would cause an out-of-lock condition and stop the measurement. When *Ignore Out Of Lock* is selected, the user is responsible for monitoring phase lock. This can be accomplished using an oscilloscope connected to the HP 11848A AUX. MONITOR port to verify the absence of a beatnote and monitor the dc output level.

Defining Measurement Mode

- From the *Advanced Functions* menu, select Measurement Mode.
- Use the △ ▽ keys to step through the choices until the desired Measurement Mode is displayed in the window.
- Press the [ESC] key to return to the *Advanced Functions* menu.

Considerations for the Measurement Mode Function

The *Measurement Mode* functions, like use of all *Advanced Functions* can change the outcome of the measurement. It is sometimes left to the user to ensure measurement validity when changes to the default functions have been made. Remember the following:

- When *Ignore Out Of Lock* is selected, the test system does not verify the phase lock of the measurement. The user must ensure that the measurement maintains phase lock during the measurement.
- Any changes entered into the 11848A Control screen can effect the measurement results or even the ability of the test system to complete the measurement.

Carrier Type

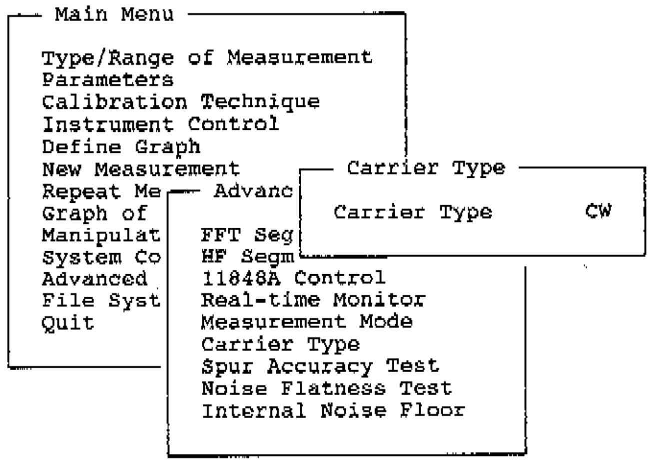


Figure 5-9. Carrier Type Window

Introduction

The *Carrier Type* function configures the HP 3048A to measure a Continuous Wave (CW) carrier or a Pulsed carrier. The *CW* selection is the default Carrier Type. All measurements except pulse modulated measurements and some special cases should be made using the CW mode. The Pulsed mode is frequently useful in special cases for measurements on CW Carriers when the user wants to control the Low Noise Amplifier (LNA) selection.

Description

Pulse Modulated Carriers

When a pulse modulated carrier is input to the phase detector, the *Pulsed* Carrier Type should be selected to configure the test system to display the LNA Toggle window each time the decision to switch the Low Noise Amplifier in or out must be made. The user is responsible for choosing the correct state for the Low Noise Amplifier (LNA). To determine if the LNA should be in or out, connect an oscilloscope to the AUX. MONITOR port on the HP 11848A when the Connect Diagram appears. If the AUX. MONITOR port output level is less than 0.5 Vpk with the LNA In, leave the LNA switched in and proceed with the measurement. If the AUX. MONITOR port output is greater than 0.5 Vpk and there is significant clipping of the noise waveform with the LNA In, toggle LNA Out then proceed with the measurement. (In the case of pulsed measurements, clipping of narrow spikes at each edge of the pulse is acceptable (Refer to Figure 5-10.) Note that the HP 3048A's sensitivity (noise floor) is degraded by 20 dB when the LNA is out.

Defining Carrier Type

- From the *Advanced Functions* menu, select Carrier Type.
- Use the △ ▽ keys to step through the choices until the desired Carrier Type is displayed in the window.
- Press the [ESC] key to return to the *Advanced Functions* menu.

Consideration for the Pulsed Carrier Function

When the Pulsed carrier function is selected and a phase noise measurement is being made, other than the phase lock loop type, the user is responsible for zero beating the sources and maintaining quadrature during the measurement. Zero beat is accomplished by manually adjusting the frequency of one of the sources so the beatnote frequency falls within the capture range for the system (< 10% of PTR). For quadrature, monitor the dc level out of the HP 11848A AUX. MONITOR port with an oscilloscope. If the LNA is switched out, the dc level seen on the scope must be less than or equal to 20% of the Detector Constant value. If the LNA is switched in, quadrature must be maintained so that the LNA does not cause severe clipping.

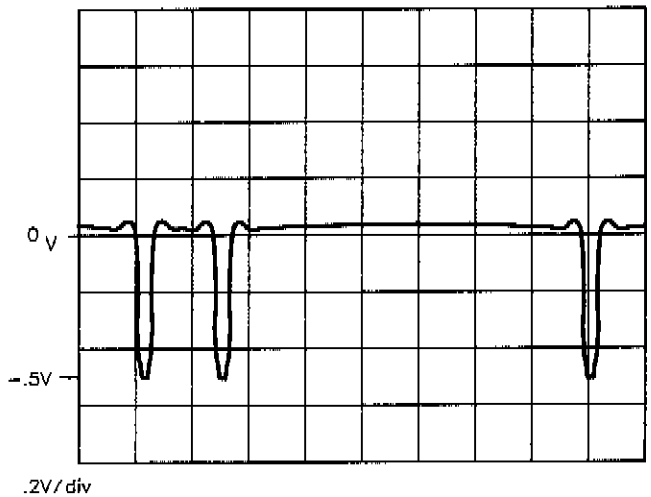


Figure 5-10. Oscilloscope Display of Maximum Acceptable Clipping

Spur Accuracy and Noise Flatness Test, and Internal Noise Floor

Refer to the *HP 3048A Option 301 Phase Noise Measurement System – System Calibration Manual* for detailed information about these tests.

System Configuration 6

```
   Main Menu
     Type/Range of Measurement
     Parameters
     Calibration Technique
     Instrument Control
     Define Graph
     New Measurement
     Repeat Measurement
 System Configuration
   Instrument Addresses
   11729C Filter Specs
   Plotter Pens
   Text  Colors
   Load  Config
   Store Config
```

Figure 6-1. System Configuration Window

Introduction

The *System Configuration* window, as shown in figure 6-1, allows you to modify the Instrument Address table, enter HP 11729A filter specifications, modify the plotter pens, Load or Store the Configuration file, and change the computer screen colors. Refer to the following pages for details:

Instrument Addresses

```
  ┌── Main Menu ──────────────┐
  │ ╒═ Instrument Addresses ══╧══════════════════════════════════════╕
  │ │ Instrument        Model  Address   Serial # / Option           │
  │ │ ─────────────────┬──────┬────────┬──────────────────────────── │
  │ │ FFT Analyzer     │ 3561A│    712 │                             │
  │ │ RF  Analyzer     │      │        │                             │
  │ │ Interface        │11848A│    720 │                  2924A00450 │
┌─ Sys│ Signal Srce 1    │ 8662A│    719 │                             │
│   │ Signal Srce 2    │USER'S│    707 │ FR10MZ;AP15.5DM;FM;M4       │
│ Inst│ Down Converter   │11729C│    706 │                         H33 │
│ 1172│ Freq Counter     │      │        │                             │
│ Plot│ DVM              │      │        │                             │
│ Text│ Function Gen.    │      │        │                             │
│ Load│                                                                │
│ Stor╘════════════════════════════════════════════════════════════════╛
└──────────────────────────┘
```

Figure 6–2. Instrument Address Table

Introduction

The *Instrument Addresses* window, as shown in figure 6–2, allows you to set up a table of supported test system equipment to be controlled by the computer over HP-IB (GPIB). The table verifies which instruments are on the bus and whether or not their HP-IB addresses are responding. Option information and HP-IB mnemonic commands may also be entered into the Instrument Address table.

Test system equipment must be configured into the Instrument Address table for it to appear in the Instrument Control diagram. Also, the maximum offset frequency the test system measures is determined by the presence of an RF analyzer configured into the Instrument Address table.

Table 6-1 shows a list of instruments that are supported by the HP 3048A software. Refer to the following pages for details:

Table 6-1. Supported Instruments

Name	Model
FFT Analyzer	HP 3561A
RF Analyzer	HP 3585A/B, 8560A, 8561B, 8562A HP 8566A/B, 8567A, 8568A/B, 71000
Interface	HP 11848A
Signal Source	HP 8662A, 8663A, 8642A/B, 8656B, 8657A/B
Down Converter	HP 11729C
Frequency Counter	HP 5343A, 5384A, 5385A, 5386A, 5316A/B
Digital Voltmeter	HP 3478A
Function Generator	HP 3325A/B, HP 8904A

FFT Analyzer

The HP 3561A Dynamic Signal Analyzer is the only Fast Fourier Transform (FFT) analyzer that can be used with the HP 3048A. No measurement can be made without the HP 3561A.

RF Analyzers

Using an RF analyzer extends the test system's measurement offset range to 40 MHz. RF analyzers also allow the use of a wider Peak Tuning Range, up to 200 MHz maximum. Most free-running sources (RF or microwave) require an RF analyzer.

The basic consideration for choosing an RF analyzer is the frequency range for secondary uses. The HP 3048A supports the RF analyzers listed in table 6–2.

Description

Configure an RF analyzer by entering its model number and HP-IB address into the Instrument Address table in the `RF Analyzer` entry area. The instrument's option number may also be entered.

Connect the RF analyzer's 50 Ω Input to the **SPECTRUM ANALYZER** port of the HP 11848A Phase Noise Interface.

NOTE

If an RF analyzer is not connected to the HP 11848A, the spectrum analyzer output must be terminated in 50 Ω .

The test system generates a 100 kHz calibration tone to calibrate the RF analyzer to match the HP 3561A prior to a new measurement. An error message is displayed if the calibration factor measured during RF analyzer Calibration is $>$ 5 dB.

Table 6-2. Supported RF Analyzers

Model	Frequency Range	Other Considerations
HP 3585A/B	20 Hz to 40 MHz	Allows complete generation of calibration files, Synthesized LO, Tracking Generator
HP 8560A, HP 8561B, HP 8562A, HP 8566A/B, HP 8567A, HP 8568A/B, HP 71000	Varies with model	Must verify calibration data by performing the Noise Flatness Performance Test. Synthesized LOs. Although these analyzers cannot generate New HIGHDATA.CAL $>$ 100 kHz, the Cal Data is verified and/or corrected by performing the Noise Flatness Test.

Considerations When Using an RF Analyzer

Entries into the HF Segment table may need to be changed depending upon the RF analyzer configured to the test system. Refer to chapter 5, *Advanced Functions* for information about the HF Segment table.

The test system is limited to a Peak Tuning Range of less than 500 kHz without an RF analyzer configured. Sources with high rates of drift and microwave sources may be difficult to measure without an RF analyzer.

Calibration tones required for Single-Sided Spur and Double-Sided Spur calibration of the phase Detector Constant are limited to less than 100 kHz without an RF analyzer.

Performance Tests are limited to 100 kHz offset without an RF analyzer. The Noise Flatness performance test is only required when a supported RF analyzer is used.

The HP 11848A spectrum analyzer output must be terminated with a 50 Ω impedance. When an RF analyzer is not used, this port must be terminated into 50 Ω .

To optimize sweep time, the standard RF Segment Table sets the RF analyzer to a faster sweep speed than it would set for itself forcing the UNCAL light on. This will not affect the test system accuracy. The user can modify the RF Segment Table to use sweep speeds that will not cause the UNCAL condition, but measurement times will be substantially longer with no improvement in noise measurement accuracy and only a slight, $\approx$0.3 dB, improvement in spur measurement accuracy.

Interface

The HP 11848A Phase Noise Interface is the only interface that works with the HP 3048A.

NOTE

Any HP 11848A Phase Noise Interface with a serial prefix of 2380A or below must have –BA entered in the Instrument Address table's Serial#/Option column.

Signal Sources

Introduction

Signal sources are supported by the HP 3048A to automate the measurements. The sources can be configured to set the output frequency, amplitude, and modulation over HP-IB. The type of measurement to be made, the carrier frequency, output level, source drift, and noise level to be measured determine which signal source best suits the application.

This section describes the signal sources supported by the HP 3048A, the required parameter entries for configuring them, and their performance.

Description

Configure a signal source by entering its model number and HP-IB Address into the Instrument Address table in the `Signal Source 1` entry area. (If more than one signal source is needed, use the `Signal Source 2` entry area.) The instrument's serial and/or option number may also be entered.

The configured signal source may then be set up in the Instrument Control diagram. The signal source may be under Manual or System Control.

The test system controls a User's Source after you enter the appropriate HP-IB string output statement into the Instrument Address table under the `Serial#/Option` column; `USER` must be entered into the `Model` column. This allows the test system to set the source's frequency, output level, and modulation (if any). Any HP-IB controlled source can be set up under System Control. (For example, if an HP 8642B was designated as "User's," the following command string would be used to preset the instrument and set it to 100 MHz at 16 dBm: `PP;FR100MZ;AP16DBM`. Refer to the operating manual provided for the signal source being used to get the appropriate HP-IB commands.)

Verify that the Detector Input Frequency is correctly entered in the *Parameters* window. This entry sets the output frequency of a supported system controlled signal source.

Verify that the correct Parameters are entered for the signal source, when the signal source is also the VCO for a PLL measurement.

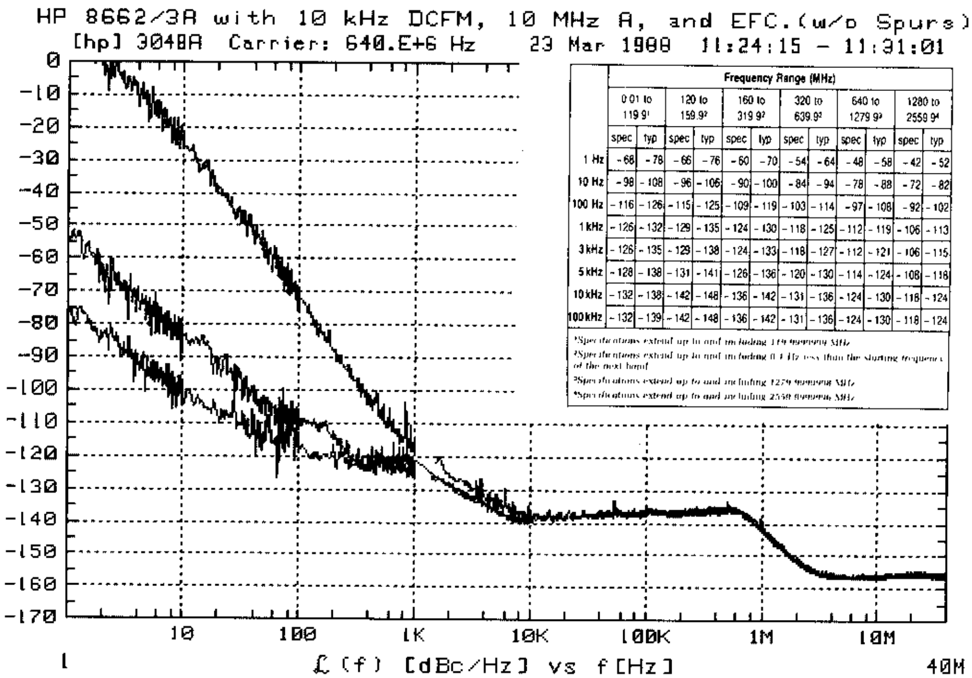
The application and the performance of the device being measured determines the selection of the signal source. Each of the signal sources supported by the HP 3048A has different qualities, as shown in table 6-3. For example, the HP 8662A has better phase noise performance close to the carrier than the HP 8642A, yet the HP 8642A has greater DC FM capabilities and a lower noise floor at offsets greater than 20 kHz from the carrier.

Table 6-3. Supported Signal Sources

Model	Frequency Range	Maximum Output Level	Maximum FM Peak Deviation	Comments
HP 8662A	10 kHz to 1280 MHz	> +13 dBm (typ. +16 dBm)	200 kHz at 640 to 1280 MHz	Tuning with DC FM EFC, or 10 MHz A/B
HP 8663A	100 kHz to 2560 MHz	> +16 dBm (typ. +19 dBm)	400 kHz at 1280 to 2560 MHz	Tuning with DC FM EFC, or 10 MHz A/B
HP 8642A	100 kHz to 1057.5 MHz	> +16 dBm (typ. +19 dBm)	1.5 MHz at 528.7 MHz to 1057.5 MHz	Tuning with DC FM
HP 8642B	100 kHz to 2115 MHz	> +16 dBm (typ. +19 dBm)	3 MHz at 1057.5 to 2115 MHz	Tuning with DC FM
HP 8656B	100 kHz to 990 MHz	> +13 dBm (typ. +15 dBm)	99 kHz	Tuning with DC FM
HP 8657A	100 kHz to 1040 MHz	> +13 dBm (typ. +15 dBm)	99 kHz	Tuning with DC FM
HP 8657B	100 kHz to 2060 MHz	> +13 dBm (typ. +15 dBm)	99 kHz	Tuning with DC FM
HP 11729C with HP 8662/3	5 MHz in HP 3048A to 18 GHz	> +7 dBm (typ. +13 dBm)	$0.5 \times \frac{f}{10^7}$ at ±10V	Tuned by HP 8663A HP 8662A, EFC, 10 MHz A or DC FM

Considerations When Choosing a Signal Source

HP 8662A/HP 8663A Performance



	Frequency Range (MHz)											
	0.01 to 119.9[1]		120 to 159.9[2]		160 to 319.9[2]		320 to 639.9[2]		640 to 1279.9[3]		1280 to 2559.9[4]	
	spec	typ	spec	typ	spec	typ	spec	typ	spec	typ	spec	typ
1 Hz	-68	-78	-66	-76	-60	-70	-54	-64	-48	-58	-42	-52
10 Hz	-98	-108	-96	-106	-90	-100	-84	-94	-78	-88	-72	-82
100 Hz	-116	-126	-115	-125	-109	-119	-103	-114	-97	-108	-92	-102
1 kHz	-126	-132	-129	-135	-124	-130	-118	-125	-112	-119	-106	-113
3 kHz	-126	-135	-129	-138	-124	-133	-118	-127	-112	-121	-106	-115
5 kHz	-128	-138	-131	-141	-126	-136	-120	-130	-114	-124	-108	-118
10 kHz	-132	-138	-142	-148	-136	-142	-131	-136	-124	-130	-118	-124
100 kHz	-132	-139	-142	-148	-136	-142	-131	-136	-124	-130	-118	-124

[1]Specifications extend up to and including [illegible] MHz

[2]Specifications extend up to and including 0.1 Hz less than the starting frequency of the next band

[3]Specifications extend up to and including [illegible] MHz

[4]Specifications extend up to and including [illegible] MHz

Figure 6-3. Graph of HP 8662A/8663A with EFC, DC FM, and 10 MHz A

Tuning the HP 8662A or HP 8663A

The HP 8662A or HP 8663A can be used as the VCO in a phase lock loop using three different configurations. These configurations have different tuning characteristics and different levels of noise performance. The HP 8662A and HP 8663A have the best noise performance when tuned with EFC (electronic frequency control).

EFC, shown in figures 6–4 and 6–5, tunes the internal HP 8662A/63A internal 10 MHz Reference Time Base. The internal time base tunes approximately 0.05 Hz/V over ± 10 V at 10 MHz. To calculate the VCO Tune Constant using EFC, multiply 0.05 Hz by the 10 MHz multiple of the output frequency. For example, if the output is set to 900 MHz the VCO Tune Constant would be:

$$90 \times 0.05\ Hz = 4.5\ Hz/V$$

Using the full Tune Range of VCO ± 10V would result in a Peak Tuning Range of 45 Hz. (The internal time base typically has a tune constant greater than 0.05 Hz/V.) Tuning with the EFC input will not degrade the noise performance of the HP 8662A/63A. The noise performance is specified for this mode.

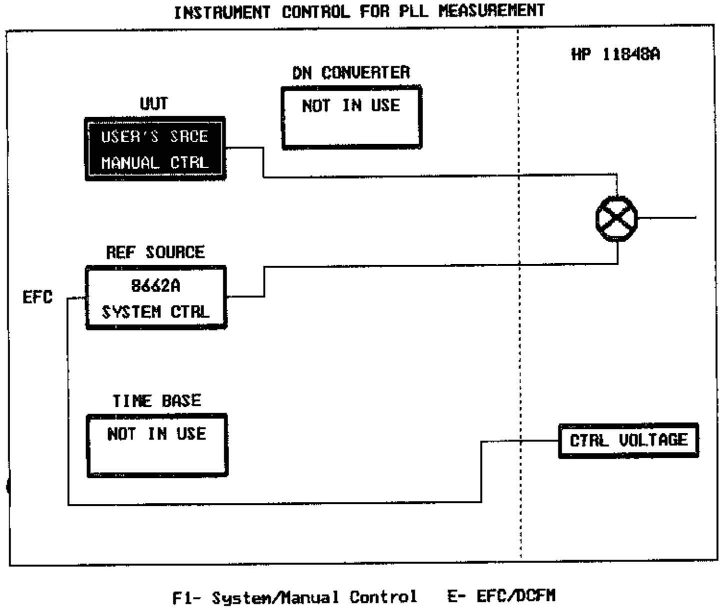


Figure 6-4. EFC Control Voltage

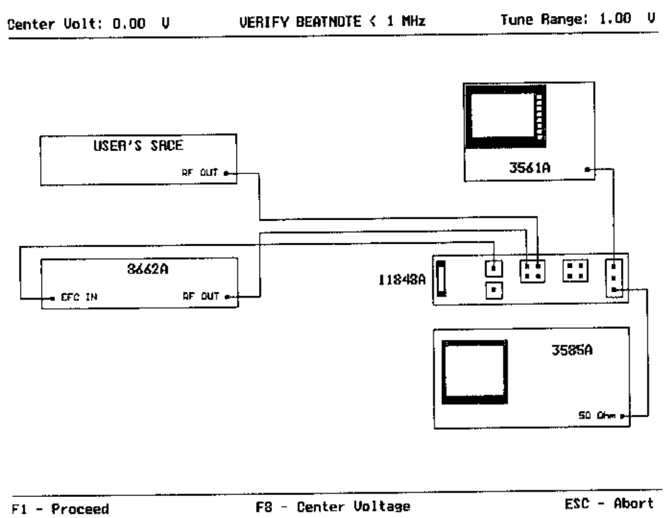


Figure 6-5. EFC Connect Diagram

DC FM, shown in figures 6-6 and 6-7, can also be used to tune the HP 8662A/63A. DC FM provides wide peak tuning range for measuring sources that have high close-in noise or spurs, or that drift. DC FM degrades the noise performance of the HP 8662A/63A. The noise performance of the HP8662A/63A is unspecified in DC FM mode. The graph in figure 6-3 shows typical performance.

Table 6-4. Maximum Peak Deviation for the HP 8662/63A

Center Frequency (MHz)	Maximum Peak Deviation DC Mode (kHz)	Center Frequency (MHz)	Maximum Peak Deviation DC Mode (kHz)
0.1 to 120	100	320 to 640	100
120 to 160	25	640 to 1280	200
160 to 320	50	1280 to 2560	400

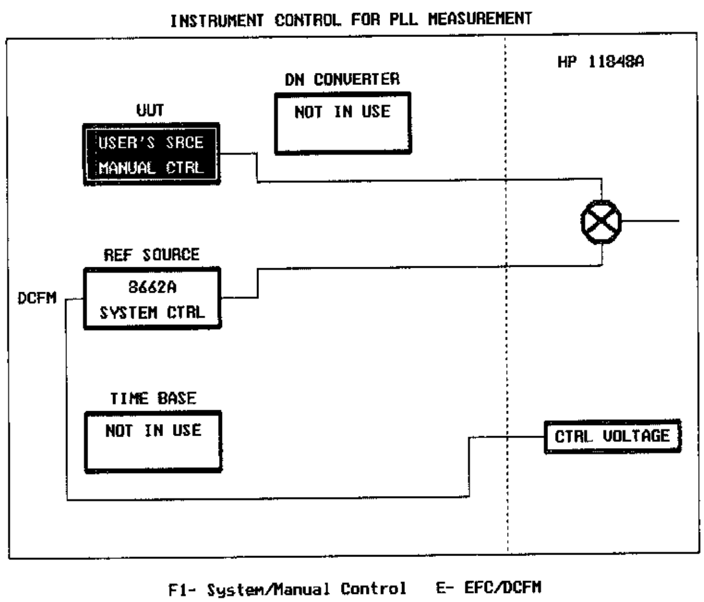


Figure 6-6. DC FM Control Voltage

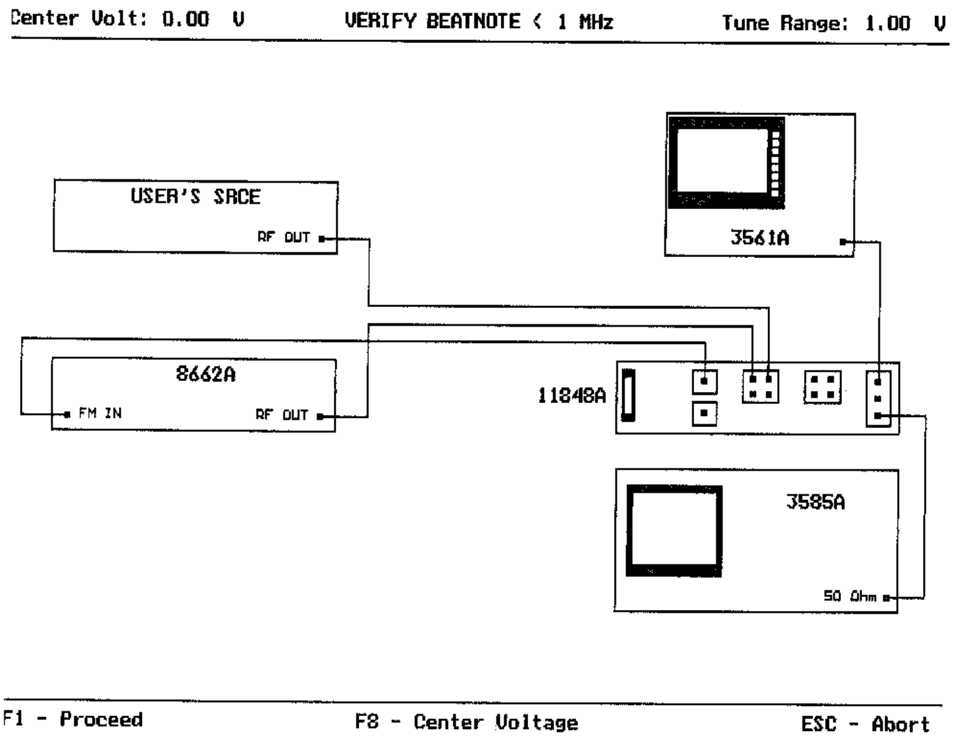


Figure 6-7. DC FM Connect Diagram

10 MHz A, shown in figures 6-9 and 6-10, can be used as an external time base for the HP 8662A/63A to increase the tuning capability. The phase noise performance of the HP 11848A 10 MHz A is better than DC FM yet slightly worse than the internal reference for the HP 8662A/63A. 10 MHz A has a 10 Hz/V tuning constant and can be tuned over $\pm$10V. To calculate the VCO Tune Constant at the output frequency multiply 10 Hz by the 10 MHz multiple of the output frequency. For example, if the output is set to 900 MHz, the VCO Tune Constant would be:

$$90 \times 10\ Hz = 900\ Hz/V$$

Using the full Tune Range of VCO $\pm$10V would result in a Peak Tuning Range (PTR) of 9 kHz.

The amount of tuning allowed at the external reference input to the HP 8662/63A is restricted to a ± 25 ppm deviation and by the HP 3048A PLL bandwidth. 10 kHz is the maximum PTR allowed when tuning the external reference. Using the maximum tuning graph shown in figure 6-8, determine the maximum PTR allowed at the time base and restrict the Voltage Tune Range so it will not exceed that range. The PTR is the Tune Constant of the reference time base multiplied up to the carrier frequency times the Tune Range of VCO.

For example, 10 MHz B VCO Tune Constant:

$$\frac{100\ Hz}{V} \times \frac{2\ GHz}{10\ MHz} = \frac{100\ Hz}{V} \times 200 = \frac{20\ kHz}{V}$$

Peak Tuning Range:

$$\frac{20\ kHz}{V} \times 0.5V = 10\ kHz = Max\ PTR$$

(The graph in figure 6-8 only applies to the HP 8662A/63A. Similar graphs must be determined for other signal sources when tuning their references.)

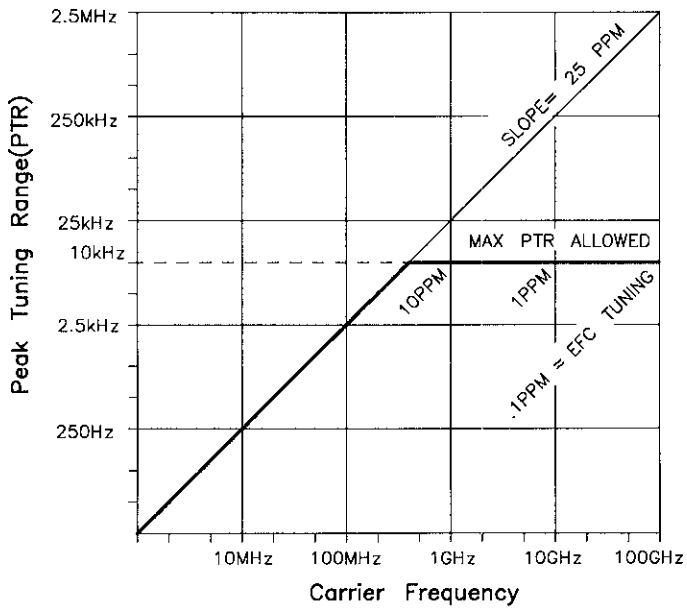


Figure 6-8. Graph of Maximum External Reference Tuning

NOTE

The diagrams in figures 6-9 and 6-10 show the 10 MHz A front-panel output connected to the Time Base input of the HP 8662A/63A. This output is at +16 dBm and over drives the Time Base input if not attenuated. The correct input level to the HP 8662A/63A external Time Base is 7 to 10 dBm. The HP 11848A provides a rear-panel 10 MHz A output of +7 dBm designed to be used for this application.

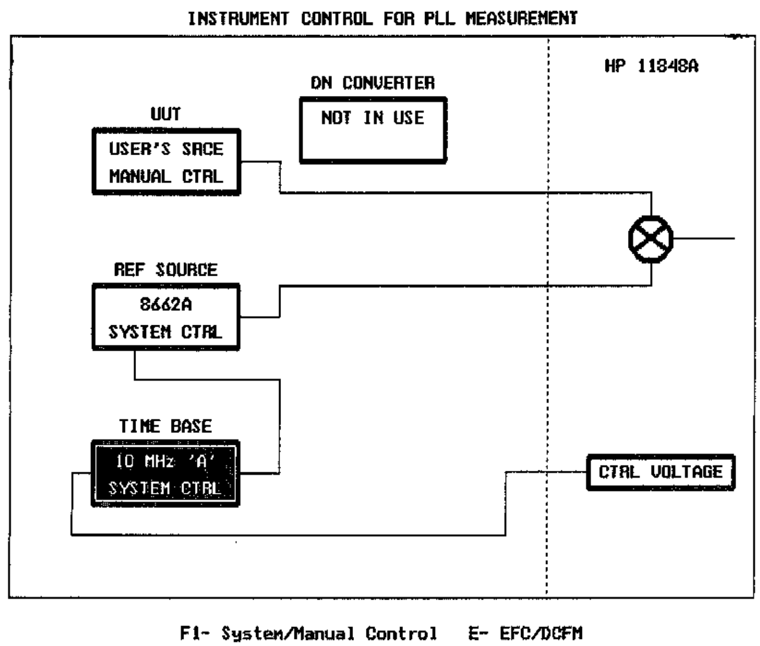


Figure 6-9. Time Base Control Voltage Using 10 MHz A

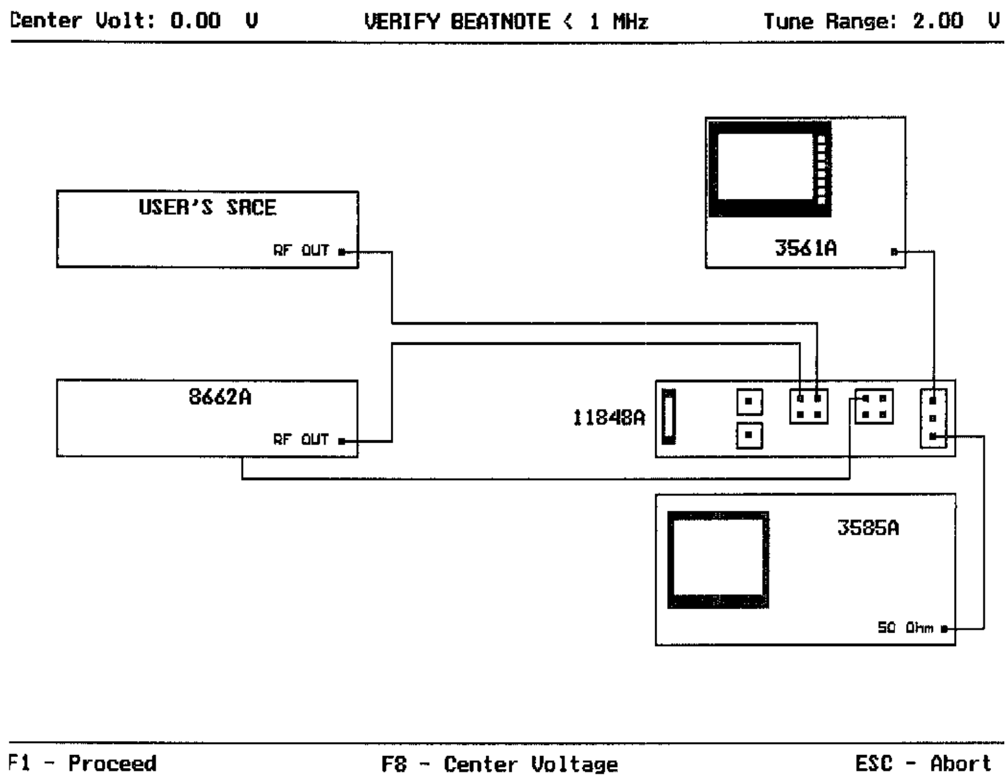


Figure 6-10. 10 MHz A Time Base Connect Diagram

10 MHz B, shown in figures 6-11 and 6-12, has a tuning constant of 100 Hz/V and can be used as an external time base. However, 10 MHz B has little advantage over 10 MHz A due to the restriction for maximum PTR discussed previously. Because 10 MHz B has a wider tuning range, it also has a higher noise level.

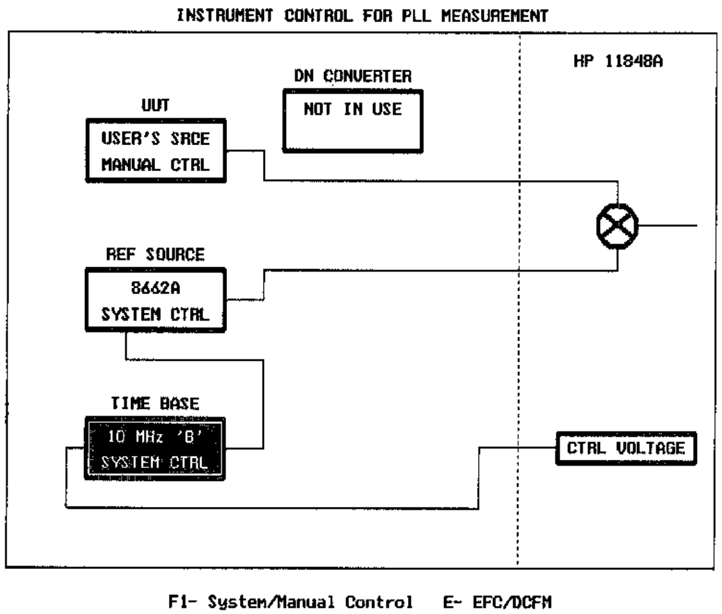


Figure 6-11. Time Base Control Voltage Using 10 MHz B

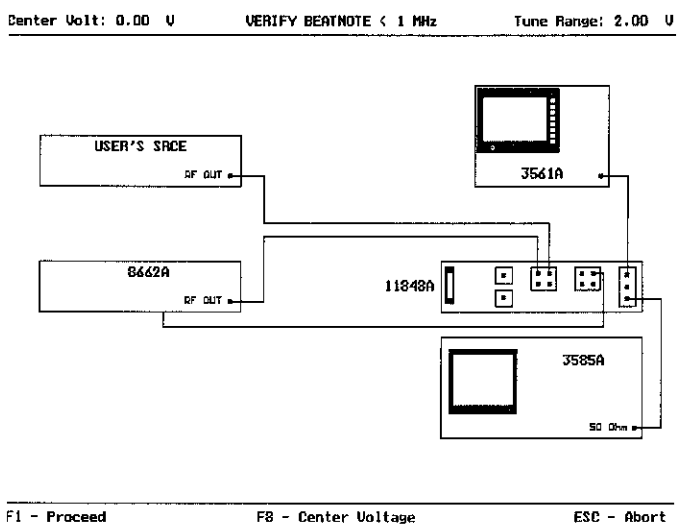
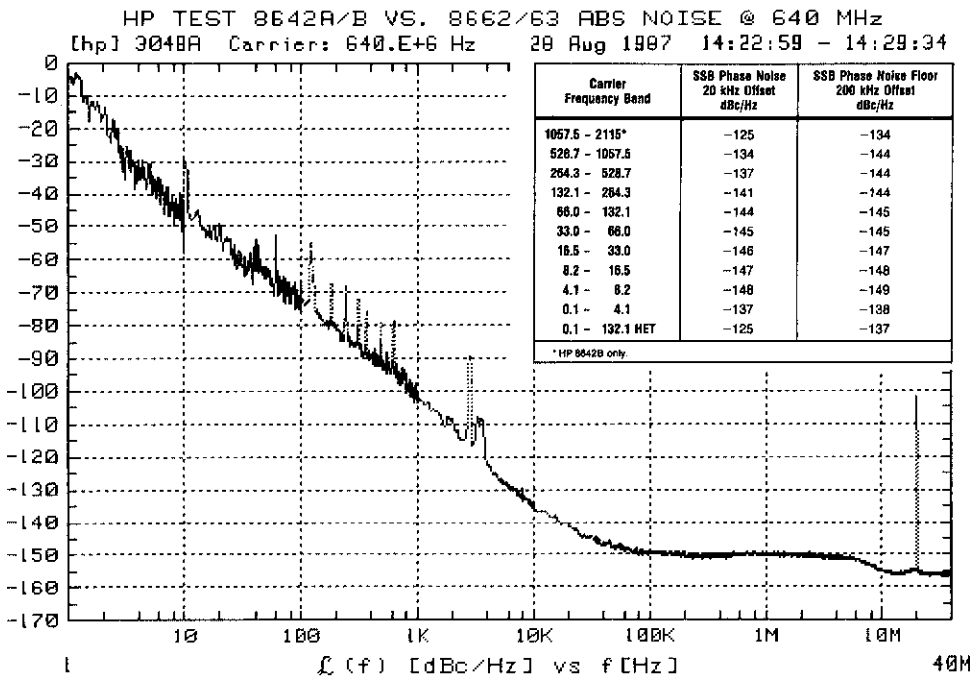


Figure 6-12. 10 MHz B Time Base Connect Diagram

HP 8642A Performance



Carrier Frequency Band	SSB Phase Noise 20 kHz Offset dBc/Hz	SSB Phase Noise Floor 200 kHz Offset dBc/Hz
1057.5 – 2115*	−125	−134
528.7 – 1057.5	−134	−144
264.3 – 528.7	−137	−144
132.1 – 264.3	−141	−144
66.0 – 132.1	−144	−145
33.0 – 66.0	−145	−145
16.5 – 33.0	−146	−147
8.2 – 16.5	−147	−148
4.1 – 8.2	−148	−149
0.1 – 4.1	−137	−138
0.1 – 132.1 HET	−125	−137

* HP 8642B only.

Figure 6-13. Graph of HP 8642A Noise Performance

Tuning the HP 8642A/B

Table 6–5. Maximum Peak Deviation for the HP 8642A/B

Carrier Frequency (MHz)	Maximum Deviation DC Coupled
0.1 to 132.1875 (HET)*	1.5 MHz
0.1 to 4.130859	93.8 kHz
4.130860 to 8.261718	11.7 kHz
8.261719 to 16.523437	23.4 kHz
16.523438 to 33.046875	46.9 kHz
33.046876 to 66.09375	93.8 kHz
66.093751 to 132.1875	187 kHz
132.187501 to 264.375	375 kHz
264.375001 to 528.75	750 kHz
528.750001 to 1057.5	1.5 MHz
1057.500001 to 2115 (8642B)	3 MHz

* HET band will not be set under system control. It must be manually set by the user. Manually enter a deviation larger than that shown in the table above to instruct the HP 8642 to use the HET band.

HP 8656B Performance

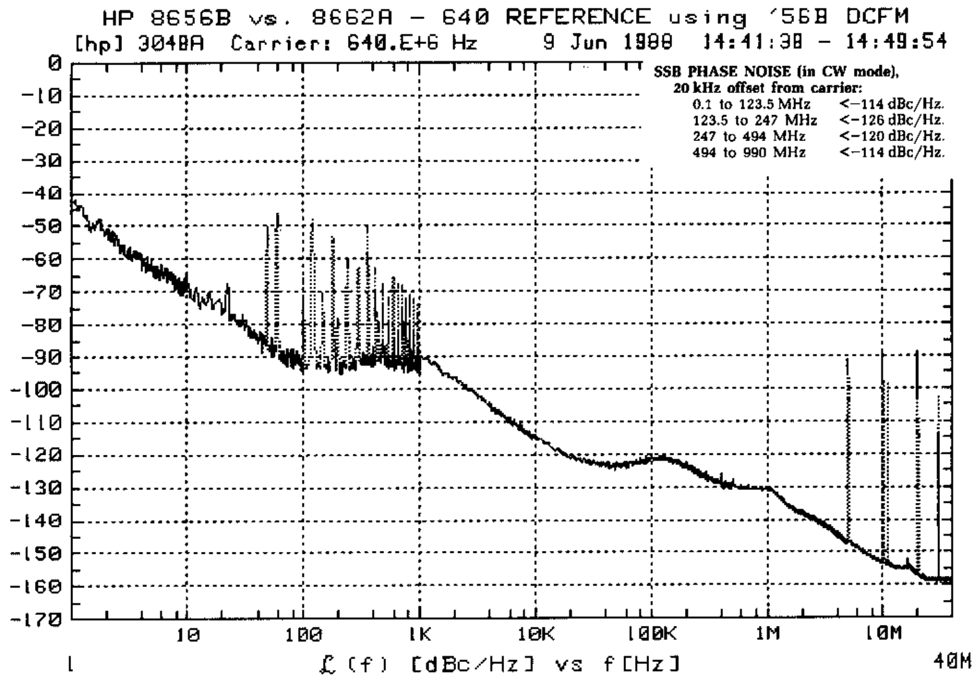


Figure 6-14. Graph of HP 8656B Noise Performance

Tuning the HP 8656B

Table 6-6. Maximum Peak Deviation for the HP 8656B

Center Frequency (MHz)	Maximum Peak Deviation DC Mode (kHz)
0.1 to 123.5	99
123.5 to 247	50
247 to 494	99
494 to 990	99

HP 8657A Performance

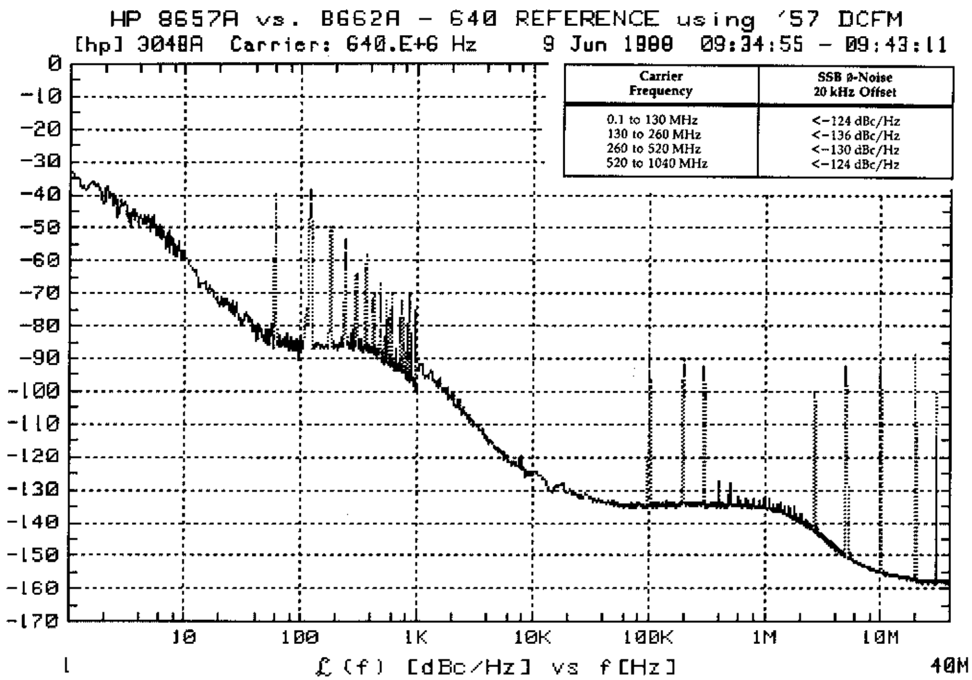


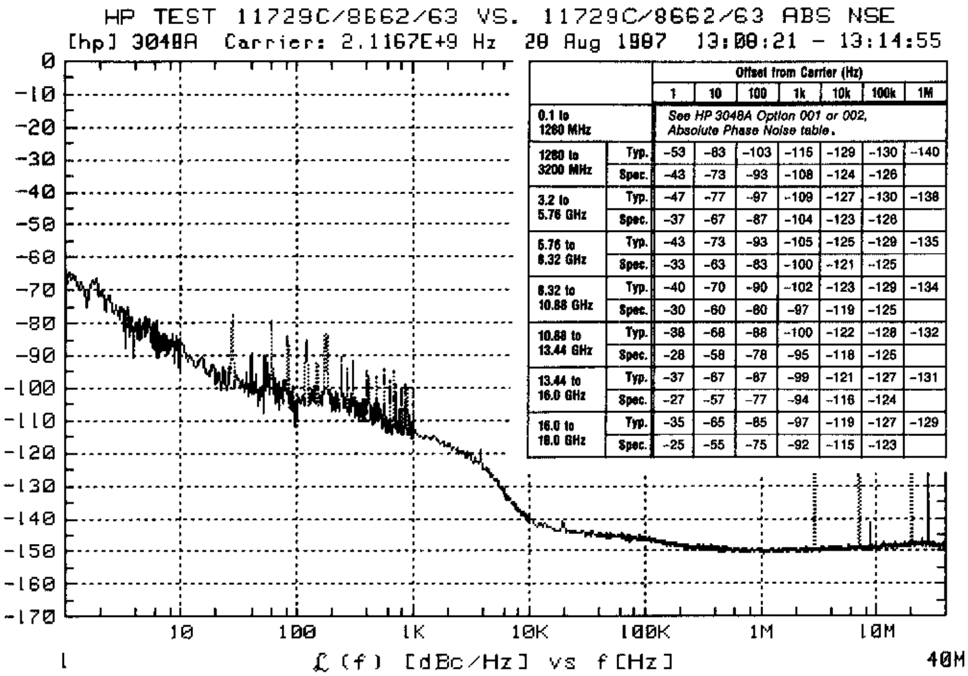
Figure 6-15. Graph of HP 8657A Noise Performance

Tuning the HP 8657A

Table 6-7. Maximum Peak Deviation for the HP 8657A

Center Frequency (MHz)	Maximum Peak Deviation DC Mode (kHz)
0.1 to 130	99
130 to 260	50
260 to 520	99
520 to 1040	99

HP 11729C Performance



		Offset from Carrier (Hz)						
		1	10	100	1k	10k	100k	1M
0.1 to 1280 MHz		See HP 3048A Option 001 or 002, Absolute Phase Noise table.						
1280 to 3200 MHz	Typ.	-53	-83	-103	-115	-129	-130	-140
	Spec.	-43	-73	-93	-108	-124	-126	
3.2 to 5.76 GHz	Typ.	-47	-77	-97	-109	-127	-130	-138
	Spec.	-37	-67	-87	-104	-123	-126	
5.76 to 8.32 GHz	Typ.	-43	-73	-93	-105	-125	-129	-135
	Spec.	-33	-63	-83	-100	-121	-125	
8.32 to 10.88 GHz	Typ.	-40	-70	-90	-102	-123	-129	-134
	Spec.	-30	-60	-80	-97	-119	-125	
10.88 to 13.44 GHz	Typ.	-38	-68	-88	-100	-122	-128	-132
	Spec.	-28	-58	-78	-95	-118	-125	
13.44 to 16.0 GHz	Typ.	-37	-67	-87	-99	-121	-127	-131
	Spec.	-27	-57	-77	-94	-116	-124	
16.0 to 18.0 GHz	Typ.	-35	-65	-85	-97	-119	-127	-129
	Spec.	-25	-55	-75	-92	-115	-123	

Figure 6-16. Graph of HP 11729C Noise Performance

The HP 11729C Carrier Noise Set shown in figures 6-17 and 6-18, when used with an HP 8662A or HP 8663A, is a very good reference source with a frequency range of 100 kHz to 18 GHz. For a complete description of the HP 11729C, refer to *Down Converters* later on in this chapter.

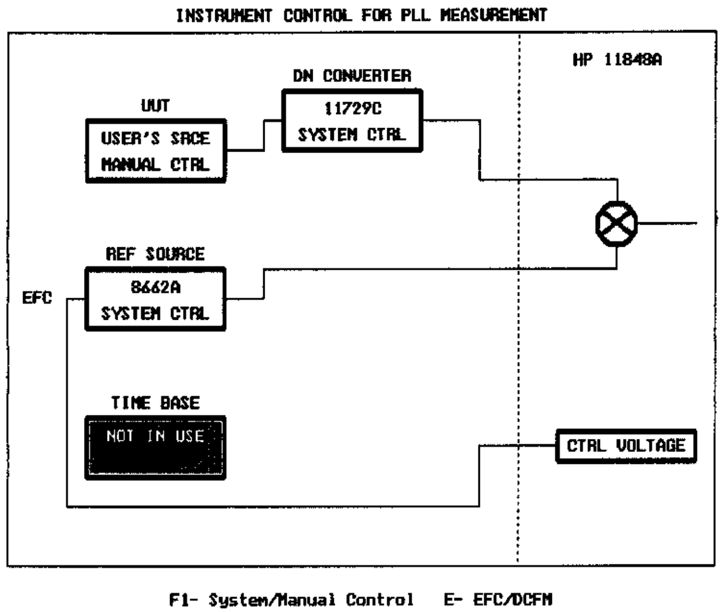


Figure 6-17. HP 11729C/HP 8662A with EFC Control Voltage

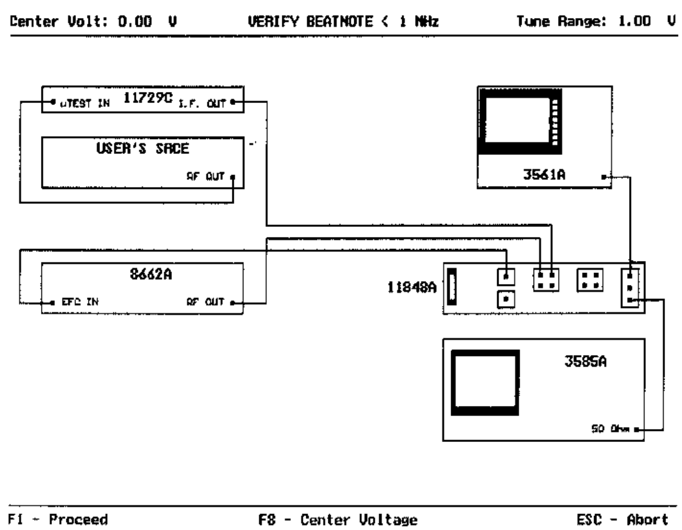


Figure 6-18. HP 11729C/HP 8662A Connect Diagram

Down Converters

Down Converters are used to translate the frequency of a source to a lower frequency that is compatible with tuneable low noise reference sources. The HP 3048A supports any manually controlled down converter, including the HP 11729C which is also supported under System Control.

This section describes how to configure a down converter into the test system, specifically the HP 11729C.

Description

The HP 3048A can be configured to operate with a down converter under Manual or System Control. Typically down converters translate the frequency of the UUT to a lower frequency. The critical parameter to the HP 3048A test system is phase detector input frequency. Since down conversion is done prior to the phase detector, the test system is essentially measuring a lower frequency source. When downconverting a signal by mixing against a local oscillator, the noise of the UUT is translated to the IF without any change in the noise level except for added noise due to the LO. When manually controlling the down converter, you must input the down converted frequency (IF) as the Detector Input Frequency in the *Parameters* window. If the Detector Input Frequency is less than 95 MHz, the test system automatically enables the 2 MHz Low Pass Filter internal to the HP 11848A Interface. With the 2 MHz LPF enabled, the measured offset range is limited to 2 MHz.

The Carrier Frequency entered in the *Parameters* window should reflect the correct UUT frequency so the graphic display of the Carrier Frequency is correct. The entered Carrier Frequency is used:

- To label the graph, and
- To derive the correct frequency band selection and Detector Input Frequency for a system controlled HP 11729C.

HP 11729C Carrier Noise Test Set

The HP 11729C is the only down converter fully supported under System Control. When configured under System Control the system automatically selects the correct comb line filter on the HP 11729C and determines the correct Detector Input Frequency from the entered Carrier Frequency.

$$Detector\ Input\ Frequency = |Carrier\ Frequency - Center\ Frequency\ of\ Comb\ Line|$$

The HP 11729C creates a series of comb line frequencies based on a 640 MHz reference. These comb lines have specified band-pass filters centered on multiples of 640 MHz up to a 17.28 GHz comb line. If non-standard filters are configured in the HP 11729C, they can be specified in the *System Configuration* window under *11729C Filter Specs*. The 640 MHz reference can be provided externally or internally (self oscillation). Self oscillation mode is an unspecified reference source without voltage control. Typically the HP 11729C uses the specified 640 MHz output of the HP 8662A Option 003 or the HP 8663A Option 003 as a reference for the comb line generator. The HP 8662A/63A used with the HP 11729C provides a low noise, specified microwave VCO reference.

HP-IB address switches are located on the rear of the HP 11729C and are typically set to 06.

To configure the HP 11729C into the *Instrument Address* table enter:

- "`11729C`" into the `Model` column.
- "`706`" (if appropriate) into the `Address` column.
- "`130`" into the `Option` column, if the HP 11729C includes option 130, the AM Detector.
- Return to the System Configuration menu and select the *11729C Filter Specs* window to define optional special filters for the HP 11729C. The default filters shown in figure 6-19 correspond to the standard HP 11729C.

```
┌── Main Menu ──────────────────────┐
│                                   │
│  Type/Range of Measurement        │
│  Parameters                       │
│  Calibration Tec══ 11729C Filter Specs ══════════════╗
│  Instrument Cont                                     ║
│  Define Graph   [   2 ] X 640 MHz =     1.28E+09 Hz  ║
│  New Measurement[   3 ] X 640 MHz =     1.92E+09 Hz  ║
│  Repeat Measurem[   7 ] X 640 MHz =     4.48E+09 Hz  ║
┌── System Configurati[  11 ] X 640 MHz =     7.04E+09 Hz  ║
│                 [  15 ] X 640 MHz =      9.6E+09 Hz  ║
│ Instrument Addresse[  19 ] X 640 MHz =    12.16E+09 Hz  ║
│ 11729C Filter Specs[  23 ] X 640 MHz =    14.72E+09 Hz  ║
│ Plotter Pens    [  27 ] X 640 MHz =    17.28E+09 Hz  ║
│ Text  Colors                                         ║
│ Load  Config    ═════════════════════════════════════╝
│ Store Config          │────┘
│                       │
└───────────────────────┘
```

Figure 6-19. HP 11729C Filter Specifications Window, Standard Bands (Comb Lines)

System Control is established for the HP 11729C in the *Instrument Control* diagram after the HP 11729C has been properly defined in the Instrument Address table. Press the [D] key until the configured down converter is displayed in the *Instrument Control* diagram. Then press the [F1] key to activate System Control.

Parameters enter the correct Carrier Frequency into the *Parameters* window to enable the test system to select the correct band filter and to determine the appropriate Detector Input Frequency.

Considerations When Using a Down Converter

Absolute System Noise Floor

The HP 11729C measurement system noise floor is dependent on the signal source(s) used as a reference. System noise for the phase detector method is a composite of the noise on the multiplied 640 MHz reference, the residual noise of the down converter, and the noise of the RF tunable source at the phase detector input (front-panel noise of the HP 8662A/8663A). For the frequency discriminator method, system noise is a composite of the noise on the multiplied 640 MHz signal plus the noise of the HP 11729C and the discriminator circuit noise. System noise can be described by:

$$\mathcal{L}_{system} = 10\ log[(N^2 \times 10^{\frac{\mathcal{L}_1}{10}}) + (10^{\frac{\mathcal{L}_2}{10}}) + (10^{\frac{\mathcal{L}_3}{10}})]$$

This equation is valid to 100 kHz offsets. At 1 MHz and above, the first term does not contribute due to the SAW filter in the HP 11729C.

$$\begin{aligned}
where\ N &= center\ frequency\ of\ selected\ filter/640\ MHz \\
\mathcal{L}_1 &= absolute\ SSB\ phase\ noise\ of\ 640\ MHz\ ref.\ signal\ (dBc/Hz) \\
\mathcal{L}_2 &= absolute\ SSB\ phase\ noise\ of\ 5\ to\ 1280\ MHz\ ref.\ signal\ (dBc/Hz) \\
\mathcal{L}_3 &= residual\ noise\ of\ the\ HP\ 11729C\ (dBc/Hz)
\end{aligned}$$

Specified Noise

The HP 11729C, when used with the HP 8662A/63A Option 003, provides a specified 640 MHz reference with EFC. Although the HP 11729C can be used in the self-oscillation mode the phase noise performance is not guaranteed. Refer to figure 6–20.

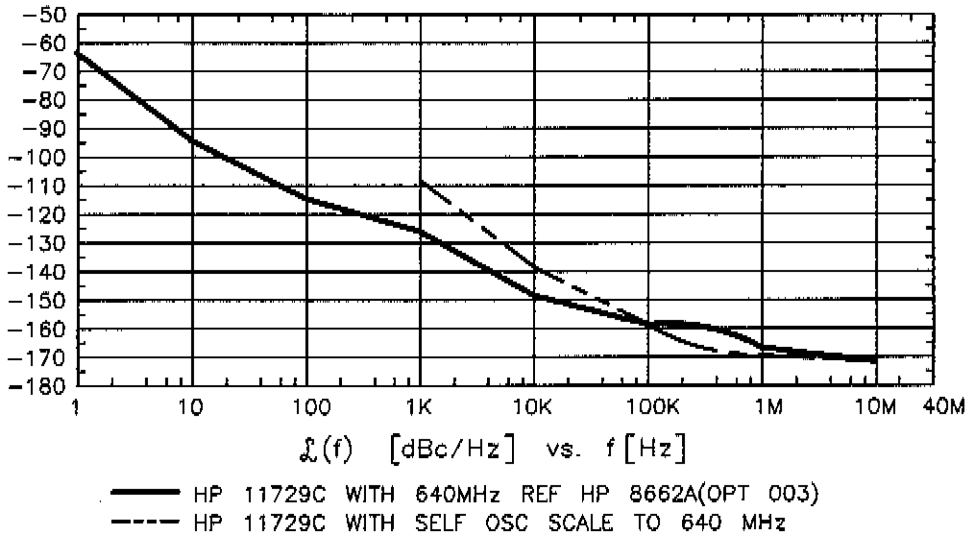


Figure 6-20. 640 MHz Noise Floor of HP 11729C/8662A vs. 11729C Self Oscillation

DC FM vs. EFC or 10 MHz A/B

Making measurements using a PLL requires that one of the sources being measured is a VCO. A VCO can be used to track or tune at the Carrier Frequency or at the down converted (IF) frequency. In both cases a variety of block diagrams can be used.

Tuning the UUT can be done directly to phase lock the UUT to the reference source, as shown in figures 6-21 and 6-22. Although this technique is acceptable it is not common due to hardware constraints at high frequencies.

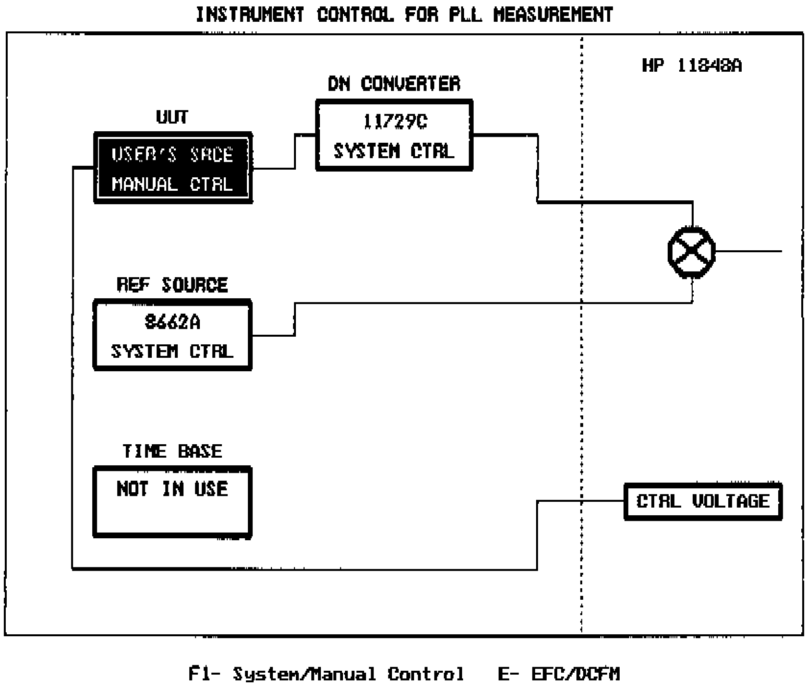


Figure 6-21. UUT Control Voltage

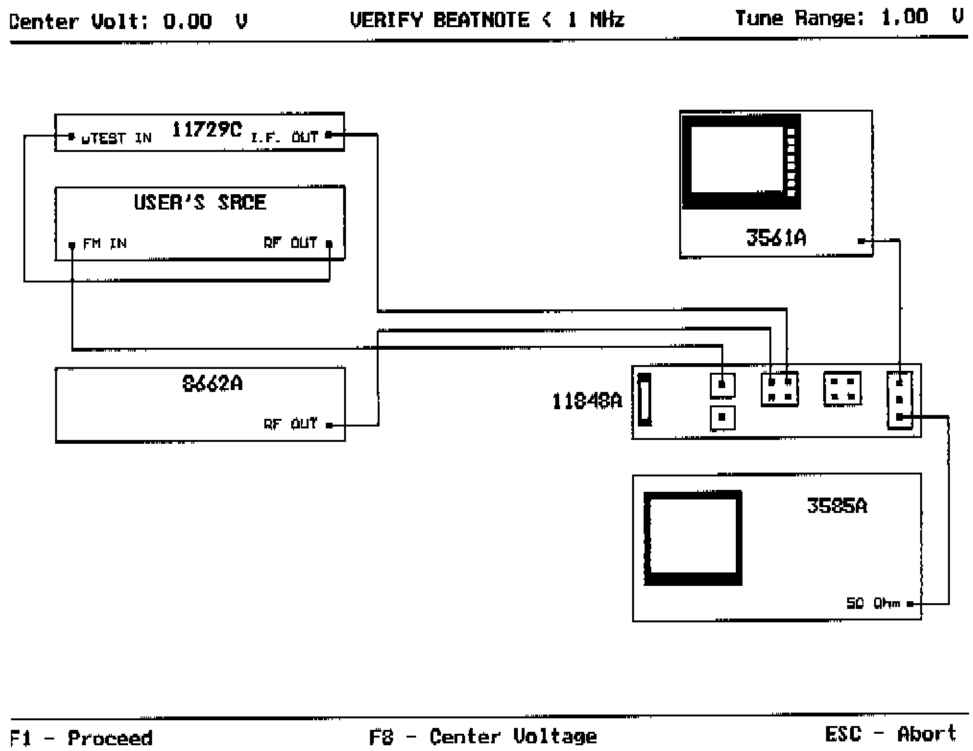


Figure 6-22. Tuning the UUT Connect Diagram

Tuning the down converter reference (HP 11729C 640 MHz input) also tunes the Carrier Frequency. You must scale the VCO Tune Constant directly to the Carrier Frequency. The HP 11729C, when used with the HP 8662A with EFC control to measure a 10 GHz source, will tune the comb line about ±500 Hz.

$$\frac{10\ GHz}{10\ MHz} \times \frac{0.05\ Hz}{V} \times 10V = 500\ Hz$$

$$where: \frac{10\ GHz}{10\ MHz} = Ratio\ of\ Carrier\ Frequency\ to\ Time\ Base$$

$$\frac{0.05\ Hz}{V} = Estimated\ Tune\ Constant\ of\ Time\ Base$$

$$10V = Tune\ Range\ of\ VCO$$

$$500\ Hz = Peak\ Tuning\ Range$$

Using the HP 11848A internal 10 MHz A source as the time base for the HP 8662A (as shown in figures 6–23 and 6–24) extends the tuning of the 640 MHz reference, thereby increasing the amount of tuning at the carrier frequency. Refer to the *Tuning Characteristics* table in chapter 7, Quick Reference for guidelines when tuning with 10 MHz A.

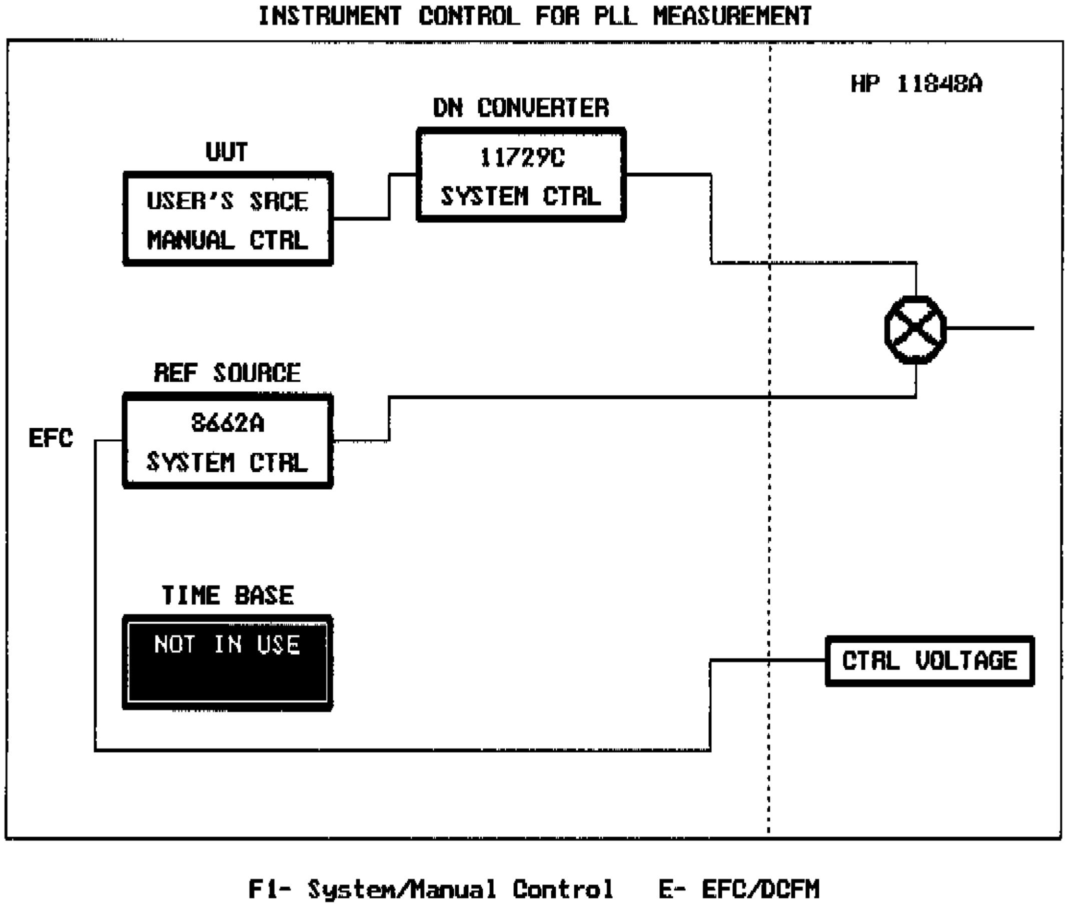


Figure 6-23. EFC Control Voltage Tuning with HP 8662A 640 MHz Reference

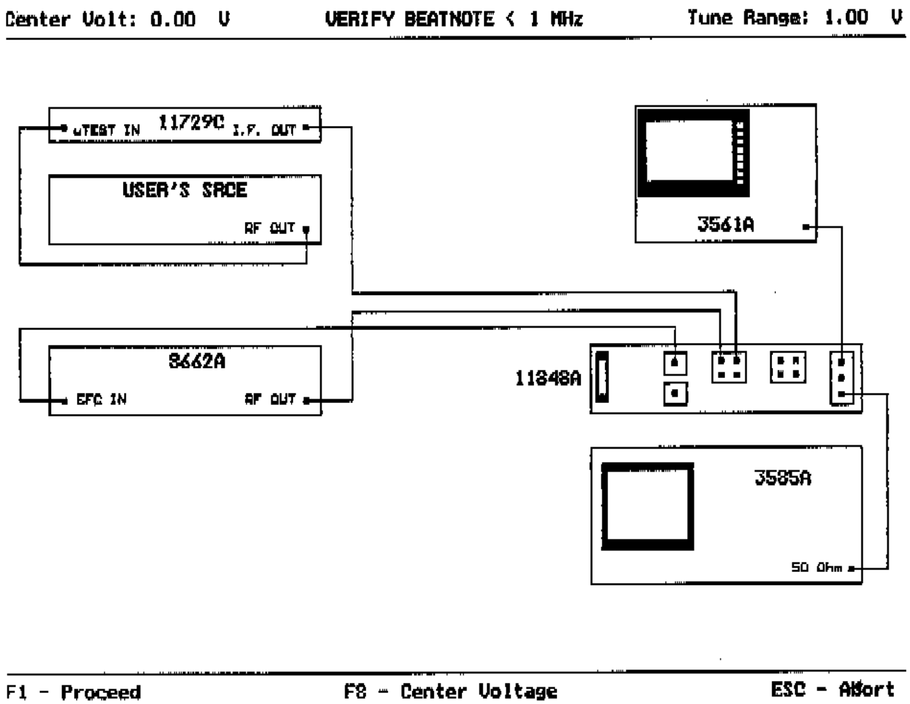


Figure 6-24. EFC Tuned 640 MHz Reference Connect Diagram

Tuning the Reference HP 8662A or HP 8663A using the EFC or an external tunable reference oscillator such as 10 MHz A or 10 MHz B has a maximum allowable PTR. If the PTR exceeds this limit, then DC FM must be used to tune the reference source. The maximum PTR allowed with EFC or an external reference oscillator is shown in figure 6-25. Figures 6-26 and 6-27 show the DC FM method of tuning the reference source.

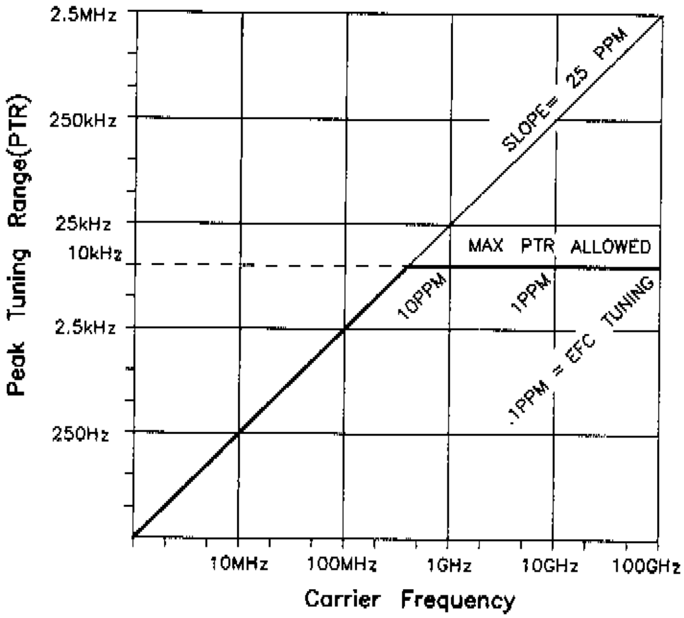


Figure 6-25. Graph of Limits for Maximum Peak Tuning Range Using EFC

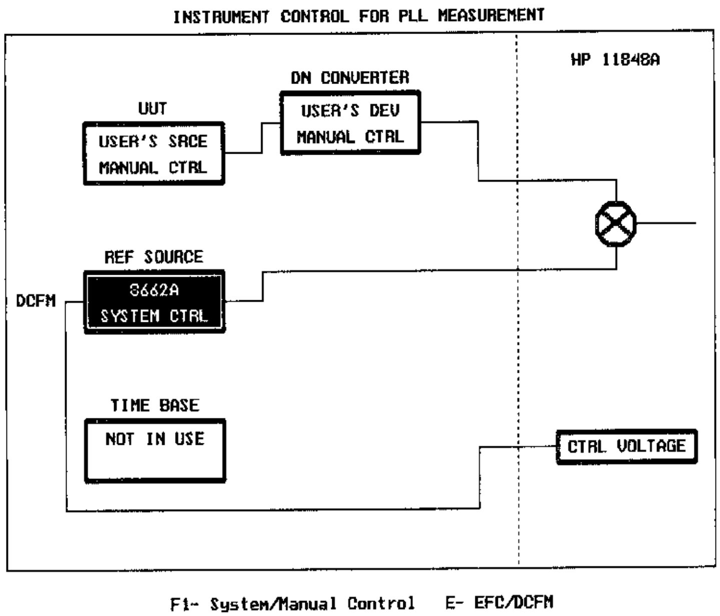


Figure 6-26. DC FM Reference Source Control Voltage

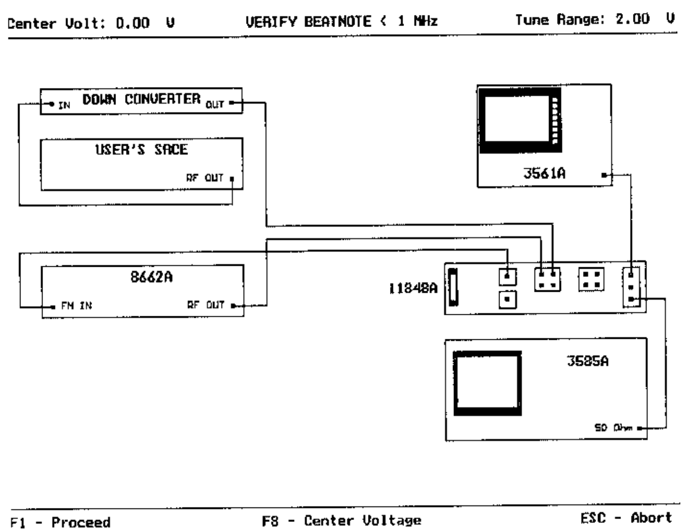


Figure 6-27. Reference Source Tuning Connect Diagram

AM Measurements Using the HP 11729C Option 130

For AM Noise measurements, refer to chapter 3 in the *HP 3048A Option 301 Operating Manual* to the section titled "AM Noise Using an HP 11729C".

Considerations When Using the HP 11729C

The HP 11729C configured in the HP 3048A cannot measure frequencies within 5 MHz of the selected comb line frequency.

The HP 11729C typically causes the measured noise to tip up close to 40 MHz offset. This is due to the parametric amplification of noise by the step recovery diode.

Spurs are not specified for the HP 11729C.

Frequency Counters

The HP 3048A supports several frequency counters. A frequency counter can be used to zero-beat the sources and measure the VCO Tune Constant. Using a frequency counter decreases the time the test system takes to find the beatnote, determine the VCO Tune Constant, and zero-beat the signal sources.

The following frequency counters are supported:

- HP 5343A
- HP 5384A
- HP 5385A
- HP 5386A
- HP 5316A
- HP 5316B

Description

The frequency counter is not shown in the *Instrument Control* diagram or in the Connect Diagram.

Connect the frequency counter to the HP 11848A Aux Monitor port. If you also want to use an oscilloscope to monitor the Phase Detector Output, use a tee adapter to connect both the oscilloscope and the frequency counter to the HP 11848A Aux. Monitor port.

Connect the test system's HP-IB to the Frequency Counter and verify that the test system recognizes it in the *Instrument Address* table.

Considerations when using a Frequency Counter.

Counters cannot tolerate signal sources with large amounts of drift or erratic noise. If an error message occurs indicating that the system cannot zero the beatnote or measure the VCO Tune Constant, remove the frequency counter from the Instrument Address table.

Digital Voltmeters

The HP 3048A supports only the HP 3478A Multimeter (DVM) for making the DC voltage measurements normally done by the HP 3561A Dynamic Signal Analyzer. A supported digital voltmeter reduces measurement time.

Description

The time required for making a measurement is reduced by using a DVM in place of the voltage measuring capability of the HP 3561A. Measurements such as the ±DC Peak (Phase Detector) calibration and verify beatnote, Out of Lock, and Overload can be done more quickly with the DVM.

Connect the DVM to the HP 11848A Phase Detector Output through a BNC tee adapter at the To 3561A Input. The HP 3561A and the HP 3478A are connected in parallel and both have high-impedance inputs. The measurement results are not affected by having the DVM connected at this point.

Connect the DVM to the HP-IB.

Considerations When Using a Digital Voltmeter

Using a common ground on the DVM (not isolated) may cause a ground loop, thereby increasing line spurs.

Function Generator

The HP 3325A/B Function Generator, and the HP 8904A Multifunction Synthesizer are the only function generators supported by the HP 3048A.

Additional Equipment

The following is a list of additional equipment that may be useful with the test system.

Modulation Analyzers

HP 8901A/B	150 kHz to 1300 MHz
HP 8902A	150 kHz to 1300 MHz

Accessory Kits

HP 11826A	RF Phase Noise Accessory Kit
HP 11826B	Microwave Phase Noise Accessory Kit
HP 11826A	RF and Microwave Phase Noise Accessory Kit

Power Meters

HP 436 or HP 438	Limits depend on power sensor used with power meter.

Power Meter Sensors

Various HP Models	Frequency ranges depend on model.

AM Detector

HP 33330D	10 MHz to 26 GHz, P max = +23 dBm Low Barrier Schottkey Diode

AM Detector Filter

HP 3048A Option K21	1 Hz to 40 MHz Positive and Negative Detector Polarity

Attenuators

HP 8493	Series of fixed attenuators
HP 8494	1 dB step attenuator
HP 8495	10 dB step

Amplifiers

HP 3048A Option K22	Specified Phase Noise 9 dB gain, NF Typically < 7 dB
Dual RF Amplifier	5 to 1500 MHz Output Power > 15 dBm
HP 8447A Preamp	20 dB gain 0.1 to 400 MHz NF < 5 dB, output power > 6 dBm
HP 8447D Preamp	26 dB gain 0.1 to 1300 MHz NF < 8.5 dB, output power > 7 dBm
HP 8447E Amplifier	22 dB gain 0.1 to 1300 MHz NF < 11 dB, output power > 15 dBm

Phase Shifter

HP 11609A Option K08	Packaged line stretcher 2.5 to 3.4 ns variable delay

0° Power Splitters

MCL ZFSC-2-5	10 to 1500 MHz
MCL ZAPD-21	500 MHz to 2 GHz
Merrimac PDM-27-10G	1.5 to 18 GHz

Couplers

MCL ZFDC-20-5	0.1 to 2000 MHz, 19.5 dB coupler
MCL ZFDC-10-2	10 to 1000 MHz, 10.75 dB coupler
NARDA 4227-16	1.7 to 26.5 GHz, 16 dB coupler

DC Blocks

HP 3048A Option K23	DC blocking filter for noise measurements on power supplies
NARDA 4563	Inside/Outside DC block 500 MHz to 18 GHz
NARDA 562	Noise Suppressor 10 MHz to 12.4 GHz

Load and Store System Configuration File

Changes made to any *System Configuration* function are not stored on disk memory unless you select *Store Config.* All System Configuration data resides in the file `DEFAULT.CFG`. If you want to load the last stored *System Configuration* file, select *Load Config.*

Text Colors

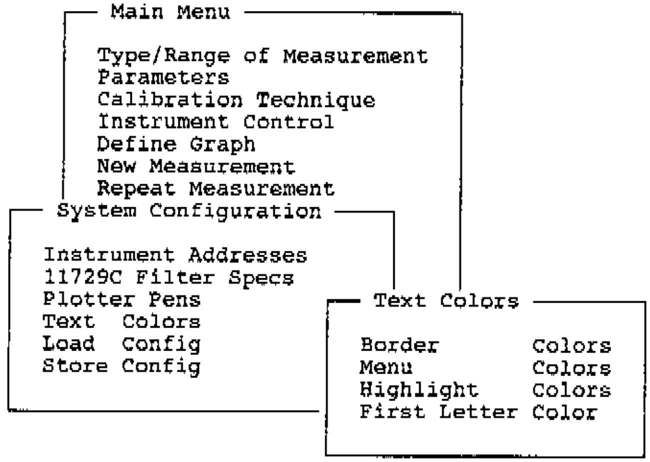
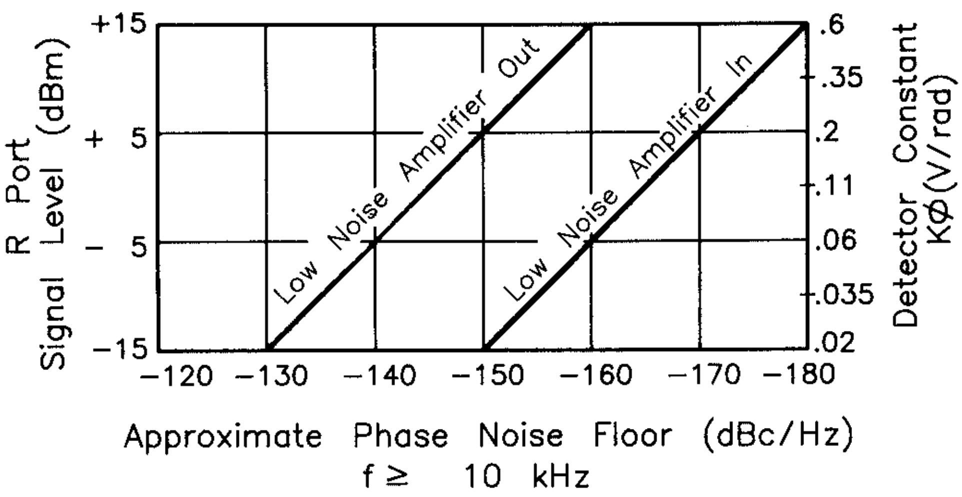


Figure 6-28. Text Colors Window

Select the *Text Colors* function you want to change and then press the [Enter] key until the color displayed on the monitor is to your satisfaction. As with other *System Configuration* functions, the modified *Text Colors* must be stored in order to have them appear when the computer is booted.

Quick Reference 7

1 Approximate HP 3048A Phase Noise Floor vs. R Port Signal Level



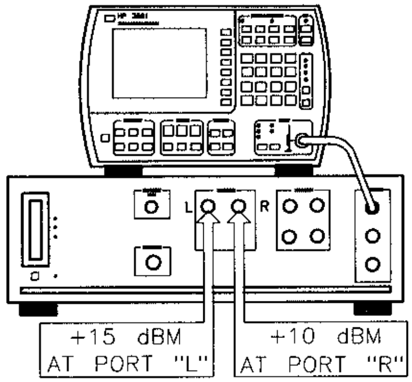
L Port Signal Level Is Assumed to be Appropriate for the Phase Detector

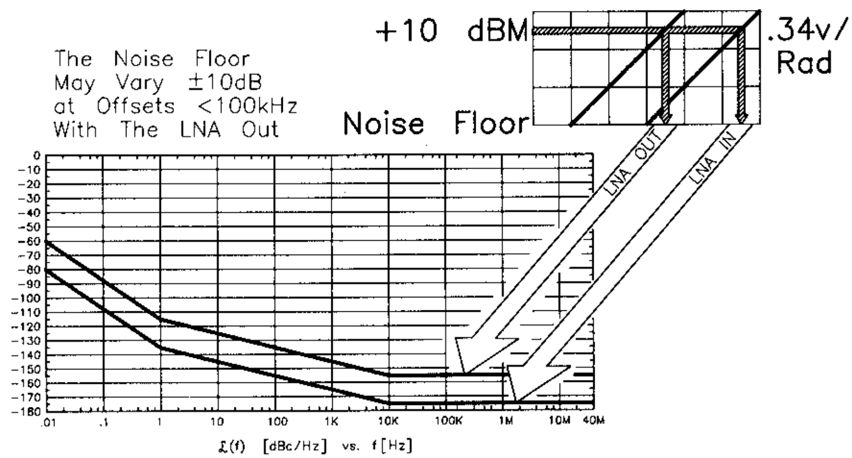
Description

The sensitivity of the HP 3048A Phase Noise Measurement System can be improved by increasing the signal power at the R input port of the Phase Detector in the HP 11848A. The graph shown above illustrates the approximate noise floor of the test system for a range of R input port signal levels from −15 dBm to +15 dBm. The diagonal line on the left side indicates the approximate sensitivity for offsets greater than 10 kHz without the test system's low noise amplifier out of the signal path. The right diagonal line indicates the sensitivity with the amplifier in the signal path. These estimates of sensitivity assume the signal level at the L port is appropriate for either the microwave or the RF mixer that is used (+7 dBm or +15 dBm, respectively). The approximate phase Detector calibration Constant K_Φ that results from the input signal level at the R port is shown on the right side of the graph. (Refer to *Calibration Technique* in chapter 2, *Measurement Definitions* for more information about calibration of the phase Detector Constant.)

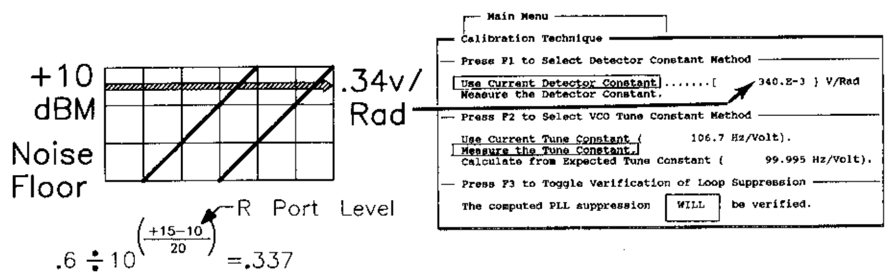
EXAMPLE

Estimating The Phase Noise Floor

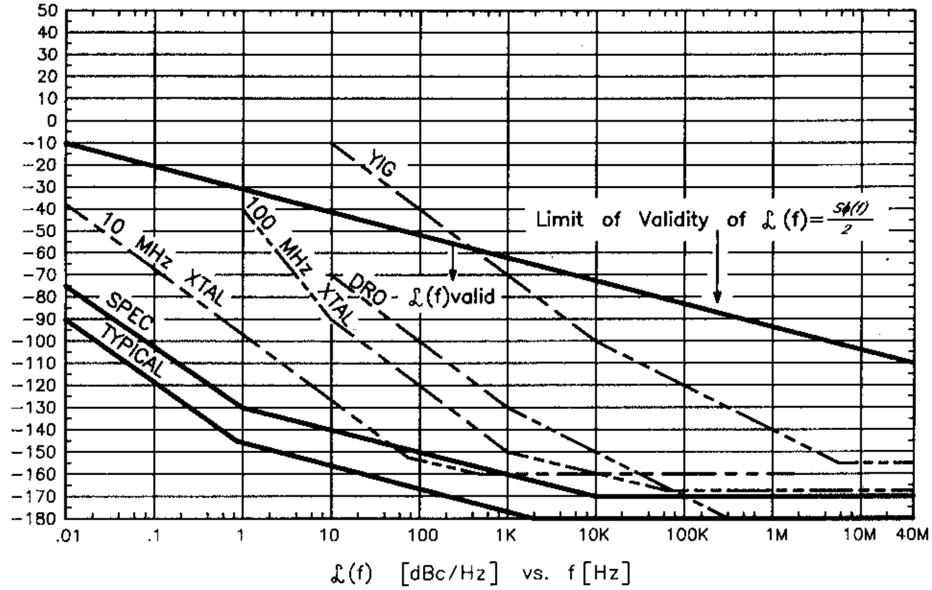




Estimating The Phase Detector Constant



2 HP 3048A Phase Noise Floor and Region of Validity of $\mathcal{L}(f) = \frac{S_\phi(f)}{2}$

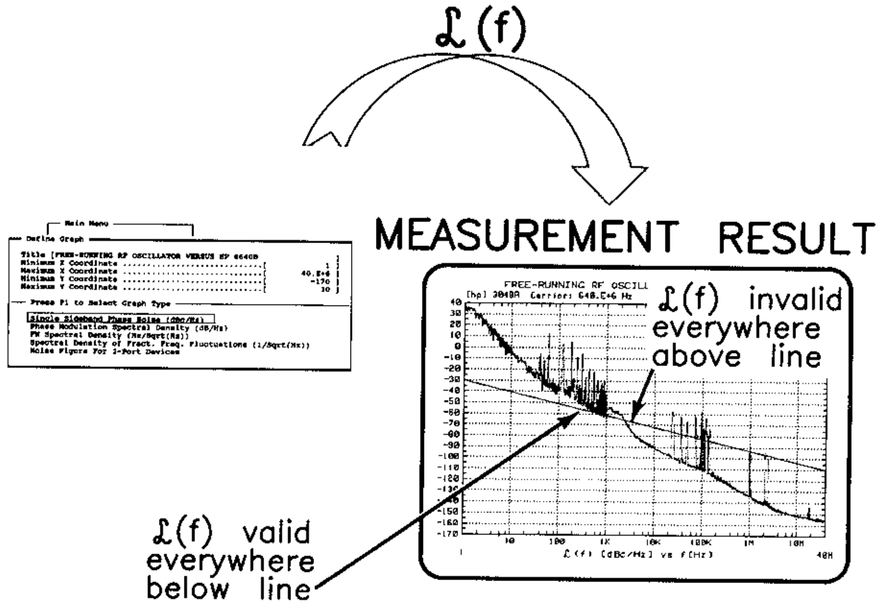


Description

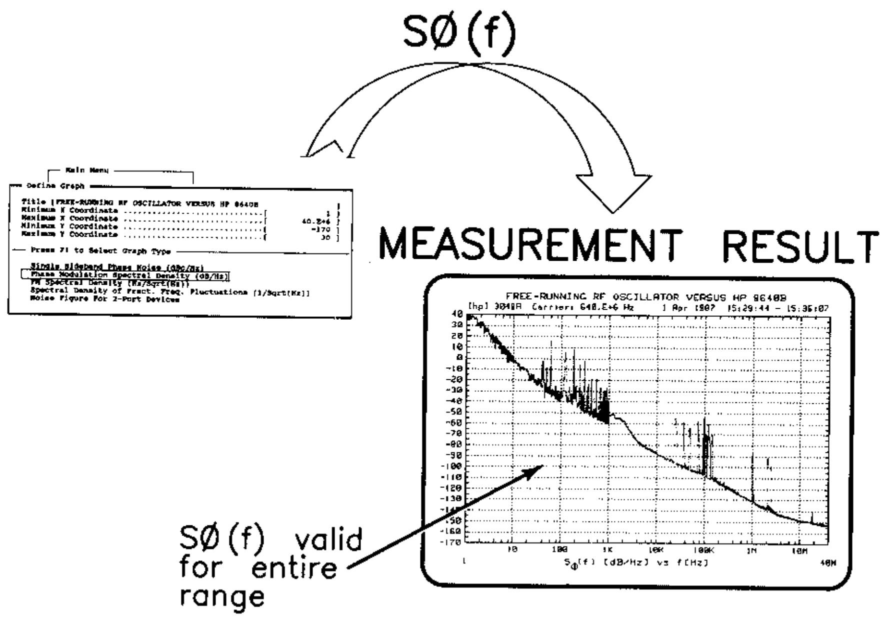
Caution must be exercised when $\mathcal{L}$(f) is calculated from the spectral density of the phase fluctuations, S_ϕ(f), because of the small angle criterion. The −10 dB/decade line is drawn on the plot for an instantaneous phase deviation of 0.2 radians integrated over any one decade of offset frequency. At approximately 0.2 radians, the power in the higher order sidebands of the phase modulation is still insignificant compared to the power in the first order sideband which ensures the calculation of $\mathcal{L}$(f) is still valid. As show in the graph above, below the line, the plot of $\mathcal{L}$(f) is correct; above the line, $\mathcal{L}$(f) is increasingly invalid and S_ϕ(f) must be used to represent the phase noise of the signal. (S_ϕ(f) is valid both above and below the line.) When using the $\mathcal{L}$(f) graph to compute S_ϕ(f), add 3 dB to the offset Level.

$$S_\Phi(f) = 2(\mathcal{L}(f))$$

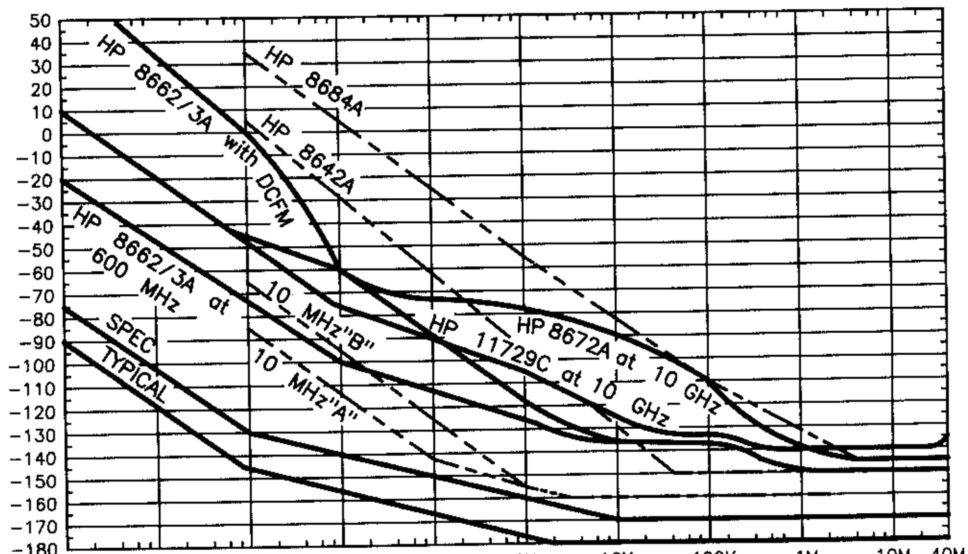
EXAMPLE



ℒ(f)
MEASUREMENT RESULT
FREE-RUNNING RF OSCILL
ℒ(f) invalid everywhere above line
ℒ(f) valid everywhere below line



SØ(f)
MEASUREMENT RESULT
FREE-RUNNING RF OSCILLATOR VERSUS HP 8640B
SØ(f) valid for entire range

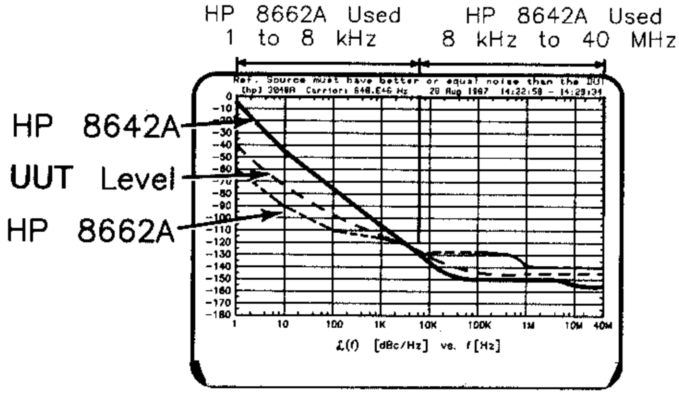


$\mathcal{L}(f)$ [dBc/Hz] vs. f [Hz]

Description

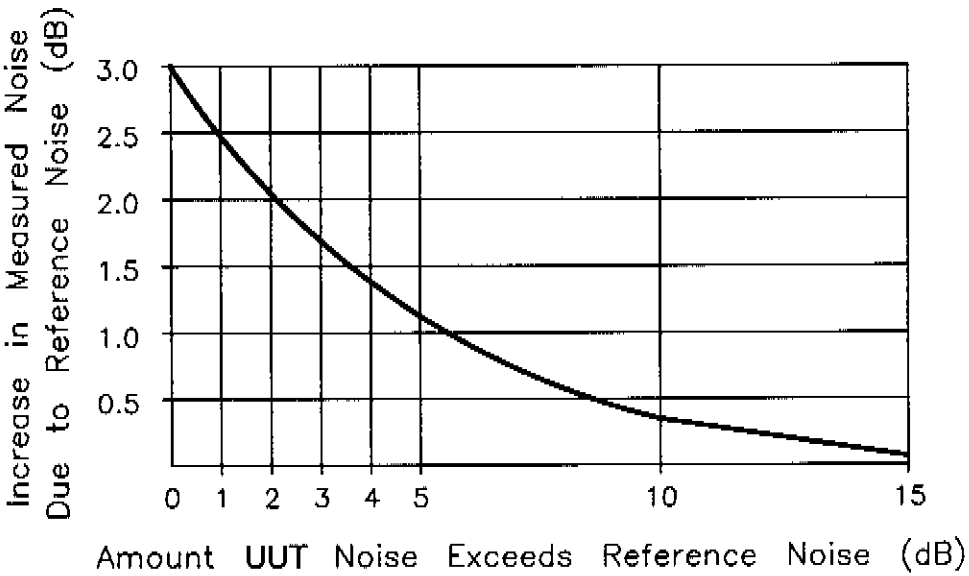
The graph shown above indicates the level of phase noise that has been measured for several potential reference sources. Depending on the sensitivity that is required at the offset to be measured, a single reference source may suffice or several different references may be needed to achieve the necessary sensitivity at different offsets. (Refer to *Signal Sources* in chapter 6 *System Configuration* for complete specifications of HP 3048A supported sources.)

EXAMPLE



MEASUREMENT
RESULT

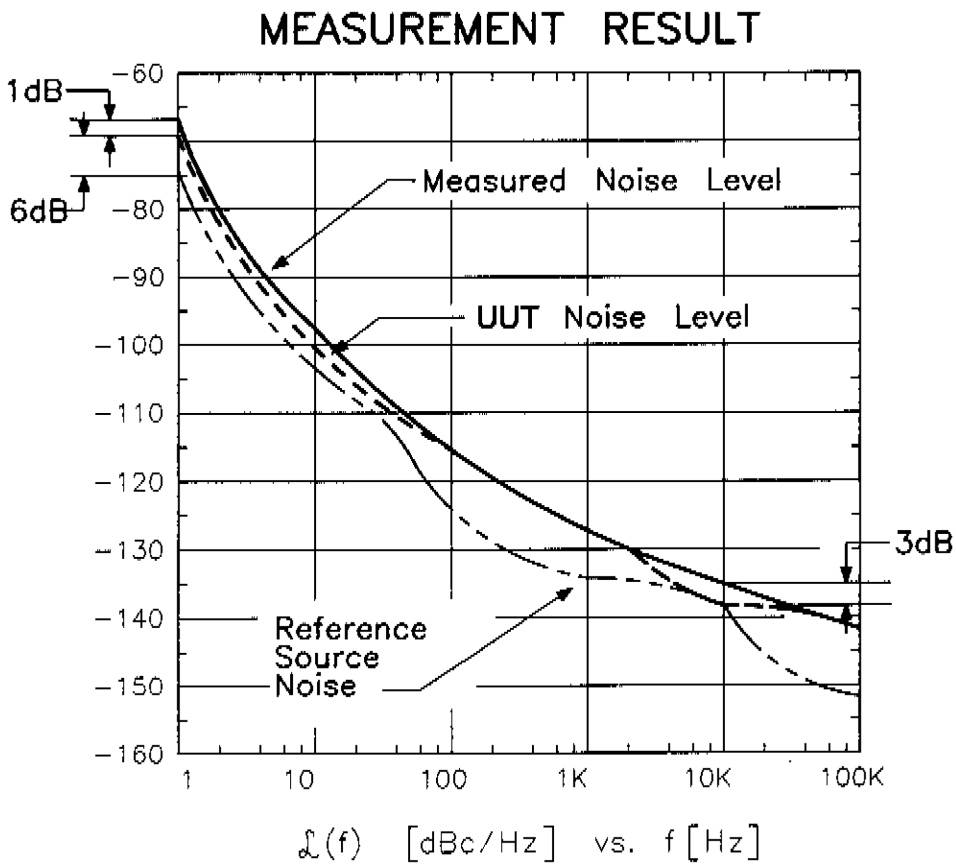
4 Increase in Measured Noise as Reference Source Noise Approaches UUT Noise



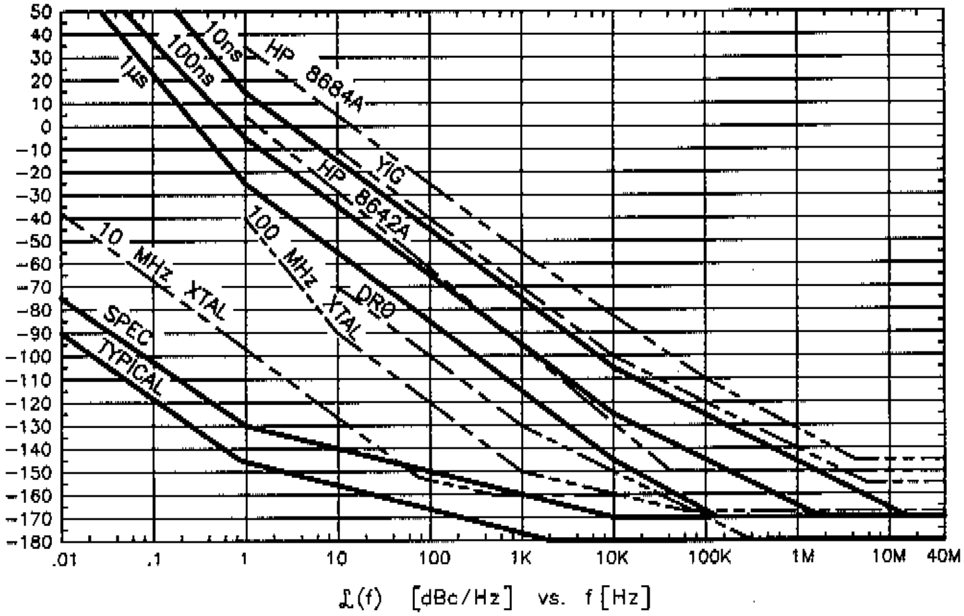
Description

The graph shown above demonstrates that as the noise level of the reference source approaches the noise level of the UUT, the level measured by the HP 3048A (which is the sum of all sources affecting the test system) is increased above the actual noise level of the UUT. (Refer to *Selecting a Reference* in chapter 3, *Signal Source Applications* of the HP 3048A Option 301 *Operating Manual* for further information about the noise contribution of sources.)

EXAMPLE



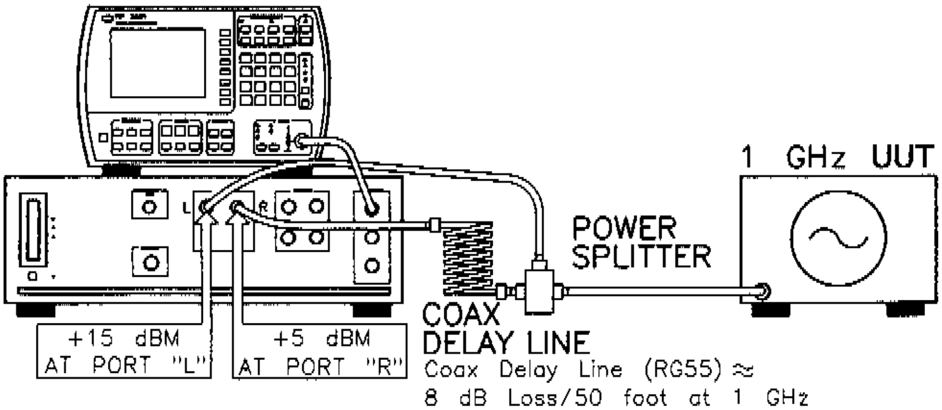
MEASUREMENT RESULT
1dB
6dB
3dB
-60
-80
-90
-100
-110
-120
-130
-140
-150
-160
Measured Noise Level
UUT Noise Level
Reference
Source
Noise
1
10
100
1K
10K
100K
ℒ(f) [dBc/Hz] vs. f [Hz]



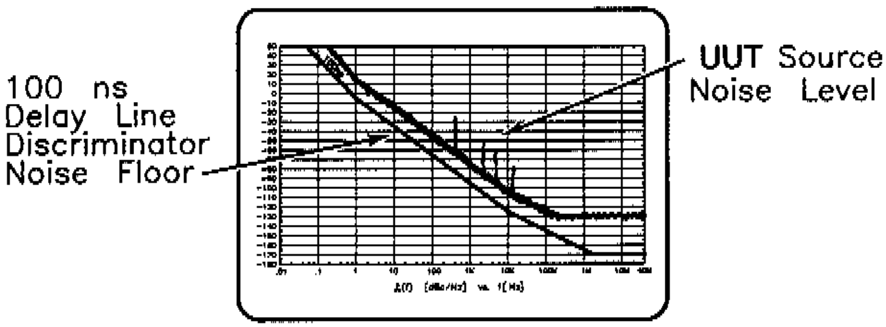
Description

The dependence of a frequency discriminator's sensitivity on the offset frequency is obvious in the graph shown above. By comparing the sensitivity specified for the phase detector of the HP 3048A to the delay line sensitivity, it is apparent the delay line sensitivity is "tipped up" by 20 dB/decade beginning at an offset of $\frac{1}{2\pi\tau}$. The sensitivity graphs indicate the delay line frequency discriminator can be used to measure some types of sources with useful sensitivity. Longer delay lines improve sensitivity, but eventually the loss in the delay line will exceed the available power of the source and cancel any further improvement. Also, longer delay lines limit the maximum offset frequency that can be measured. (Refer to *Calibration Technique* in chapter 2, *Measurement Definitions*, for delay line restrictions.)

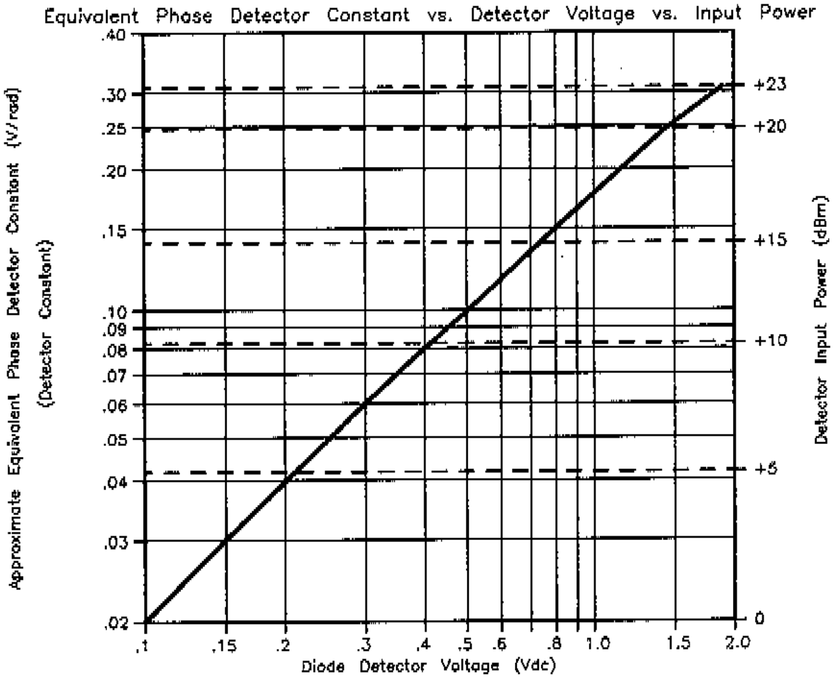
EXAMPLE



MEASUREMENT RESULT USING AN FM DISCRIMINATOR



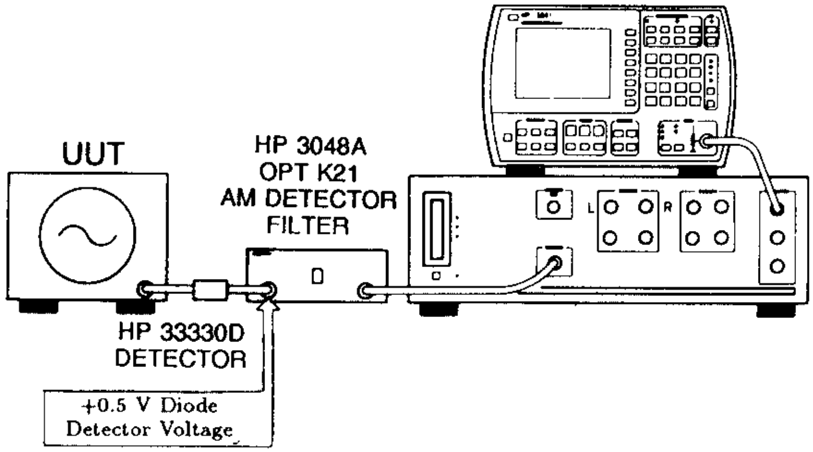
6 AM Calibration



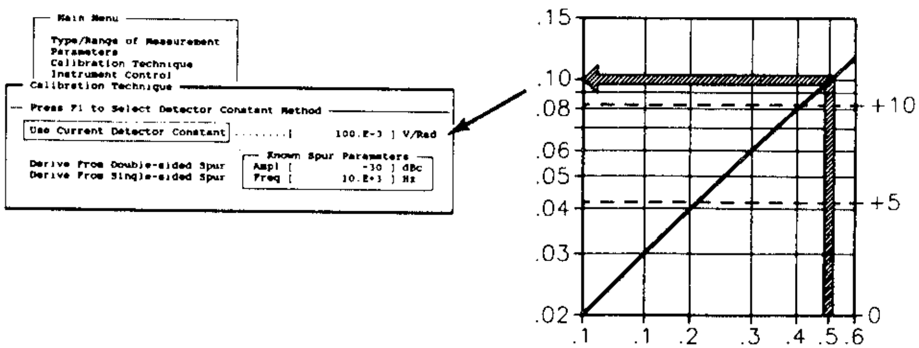
Description

The AM detector sensitivity graph shown above is used to determine the equivalent phase Detector Constant from the measured AM Detector input level or from the diode detector's dc voltage. The equivalent phase Detector Constant (phase slope) is read from the left side of the graph while the approximate detector input power is read from the right side of the graph. (Refer to *Calibration Technique* in chapter 2, *Measurement Definitions* for information about determining the AM Detector constant.)

EXAMPLE



MEASUREMENT RESULT

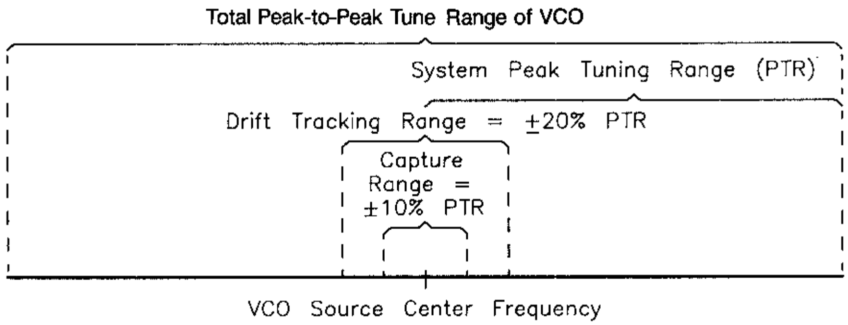


Peak Tuning Range (PTR) ≈ Tune Range of VCO X VCO Tune Constant

Min. PTR = .1 Hz

Max. PTR = 500 kHz (200 MHz with an RF Analyzer).

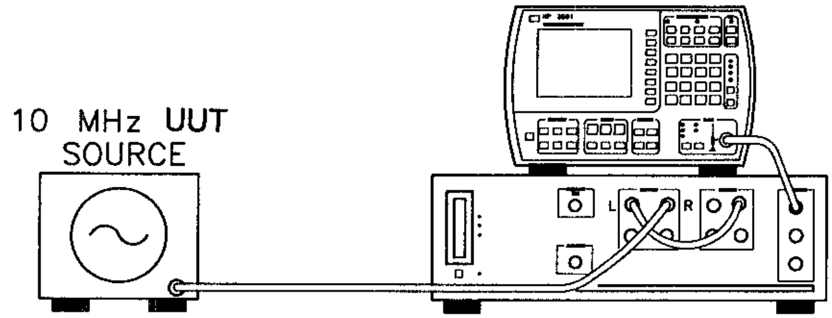
Drift Tracking Range = Allowable Drift During Measurement.

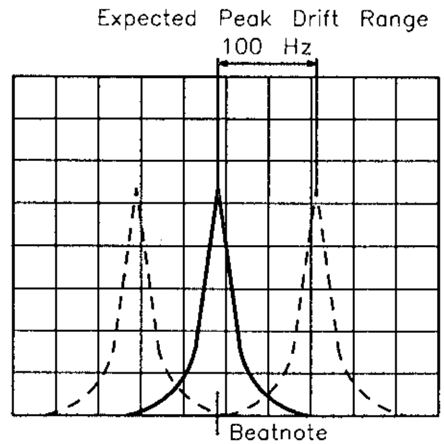


Description

The tuning that range the HP 3048A actually uses to maintain quadrature is limited to a fraction of the peak tuning range (PTR) to ensure the tuning slope is well behaved and the VCO Tune Constant remains accurate. After phase lock is established, the test system monitors the tuning voltage required to maintain lock during calibration. If the tuning voltage exceeds 10% of the peak tuning range during system calibration, the HP 3048A stops the procedure and informs the user that the source needs to be retuned before the measurement can begin. If the tuning voltage exceeds 20% of the PTR during the measurement, the test system again informs the user and requests the oscillator be retuned or the problem be otherwise corrected before proceeding with the measurement. These limits have been found to guarantee good results. (Refer to the *Calibration Technique* and *Parameters* sections in chapter 2, *Measurement Definitions* for a description of the test system's requirements when making a PLL measurement.)

EXAMPLE





Required Peak Tuning Range(PTR) = Peak Drift X 10
= 100 Hz X 10
= 1 kHz

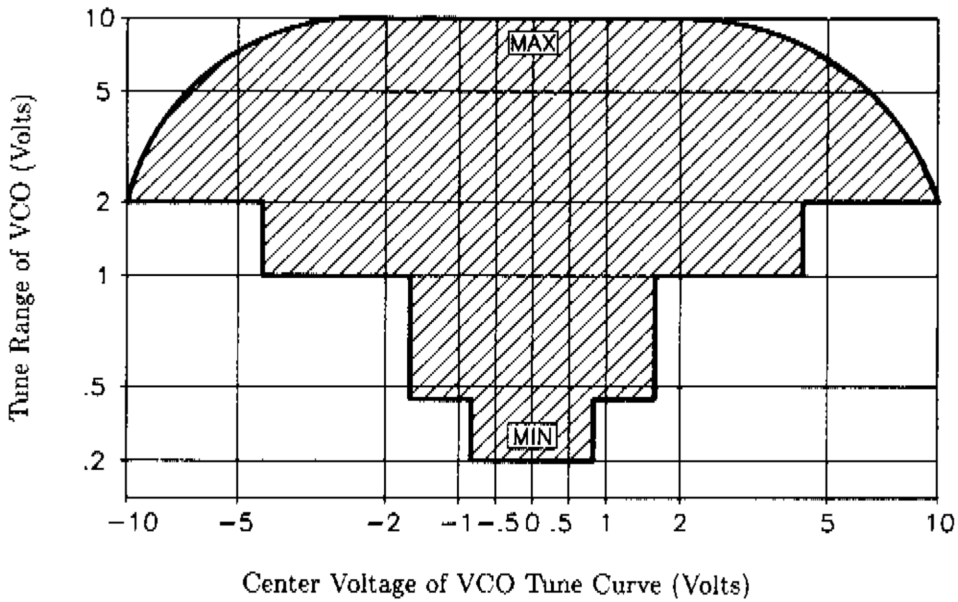
MEASUREMENT RESULT

```
 ┌─ Main Menu ───────────────┐
── Parameters ─────────────────────────────────────────────
 Carrier Frequency ......................[       10.E+6 ] Hz
 Detector Input Freq ....................[       10.E+6 ] Hz
 VCO Tune Constant ......................[          100 ] Hz/Volt
 Center Voltage of VCO Tune Curve .......[            0 ] Volts
 Tune Range of VCO ......................[±          10 ] Volts
 VCO Tune Port Input Resistance .........[        1.E+6 ] Ohms
── Press F1 to Select Detector ────────────────────────────
  Low  Freq Phase Detector (5 MHz to 1600 KHz)
  High Freq Phase Detector (1.2 GHz to 18 GHz)
  External  Phase/AM Detector
```

10 MHz B
VCO Tune Constant

Required
Tune Range of VCO = PTR/TC
= 1 kHz/100 Hz
= 10V

8 Tune Range of VCO vs. Center Voltage

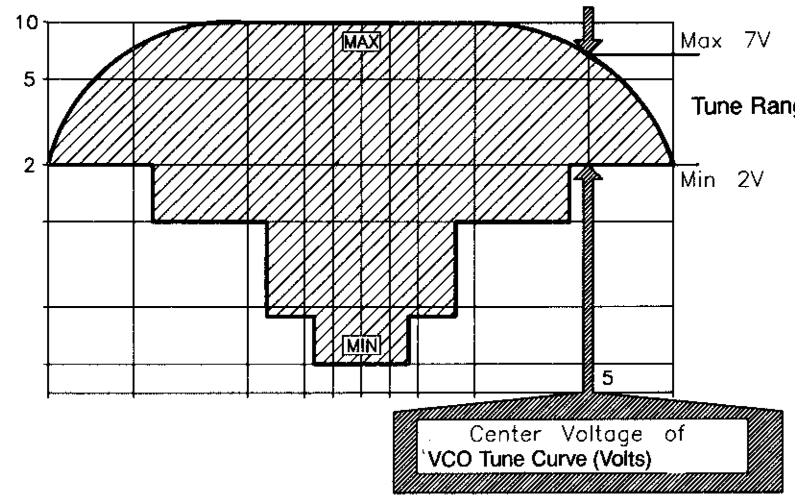


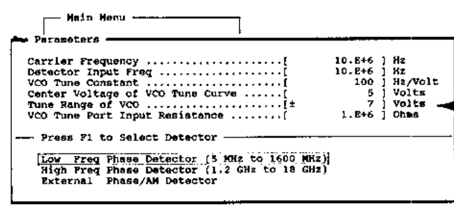
$|\text{Center Voltage}| + |\text{Tune Range of VCO}| \leq 12\text{V}$

Description

The graph shown above outlines the minimum to maximum Tune Range of VCO which the HP 3048A provides for a given center voltage. The Tune range of VCO decreases as the absolute value of the center voltage increases due to hardware limitations of the test system. (Refer to *Parameters* in chapter 2, *Measurement Definitions* for further information about the Tune Range of VCO.)

EXAMPLE





```
┌─ Main Menu ──────────┐
Parameters
  Carrier Frequency ......................[      10.E+6 ] Hz
  Detector Input Freq ....................[      10.E+6 ] Hz
  VCO Tune Constant ......................[         100 ] Hz/Volt
  Center Voltage of VCO Tune Curve .......[           5 ] Volts
  Tune Range of VCO ......................[±          7 ] Volts
  VCO Tune Port Input Resistance .........[       1.E+6 ] Ohms
── Press F1 to Select Detector ──────────────────────────
   Low  Freq Phase Detector (5 MHz to 1600 MHz)
   High Freq Phase Detector (1.2 GHz to 18 GHz)
   External  Phase/AM Detector
```

Acceptable Entry
2V to 7V

9 Tuning Characteristics of Various VCO Source Options

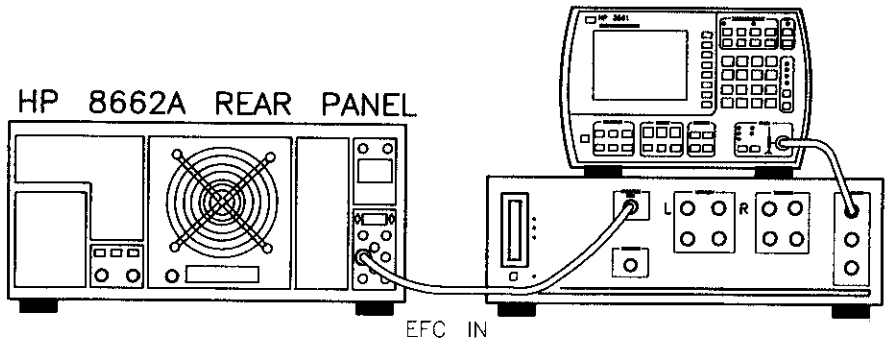
VCO Source	Carrier Freq.	VCO Tune Constant (Hz/V)	Center Range (V)	Tune Range of VCO (±V)	Input Resistance (ohms)	Calibration Technique
HP 8662/3A						
EFC	v_o	$5\,E-9\times v_o$	0	10	$1\,E+6$	Measure
DCFM		FM Deviation	0	10	1k (8662)	Calculate
					600 (8663)	Calculate
HP 8642A/B		FM Deviation	0	10	600	Calculate
HP 8640B		FM Deviation	0	10	600	Calculate
HP 8656B		FM Deviation	0	10	600	Calculate
Other Signal Generator DCFM Calibrated for ±1V		FM Deviation	0	10	R_{in}	Calculate
10 MHz Source A						
Direct		10	0	10	$1\,E+6$	
Multiplied	v_o	$1\,E-6\times v_o$	0	10	$1\,E+6$	
As a Timebase:						Measure
To HP 8662/3A	v_o	$1\,E-6\times v_o$	0	$10\,E+9\div v_o$	$1\,E+6$	
To other synthesized signal generators	v_o	$1\,E-6\times v_o$	0	$1\,E+6\times \text{PTR}^{*}\div v_o$	$1\,E+6$	
10 MHz Source B						
Direct		100	0	10	$1\,E+6$	
Multiplied	v_o	$10\,E-6\times v_o$	0	10	$1\,E+6$	
As a Timebase:						Measure
To HP 8662/3A	v_o	$10\,E-6\times v_o$	0	$1\,E+9\div v_o$, (up to 2.5V max.)	$1\,E+6$	
To other synthesized signal generators	v_o	$10\,E-6\times v_o$		$100\,E+3\times \text{PTR}^{*}\div v_o$	$1\,E+6$	
350–500 MHz Source		$12\,E+6$	0	2	$1\,E+6$	Measure
Other User VCO Source		Estimated within a factor of 2	−10 to +10	See Graph 8	$1\,E+6$	Measure

* Limited PTR due to PLL BW limitations.

Description

The table shown above lists tuning parameters for several VCO source options. (Refer to *Parameters* in chapter 2, *Measurement Definitions* for further information on tuning sources.) Example A on the next page uses an HP 8662A as the signal source.

EXAMPLE A




```
┌─ Main Menu ──────────┐
─ Parameters ──────────────────────────────────────
  Carrier Frequency ......................[      100.E+6 ] Hz
  Detector Input Freq ....................[      100.E+6 ] Hz
  VCO Tune Constant ......................[      500.E-3 ] Hz/Volt
  Center Voltage of VCO Tune Curve ......[            0 ] Volts
  Tune Range of VCO ......................[±          10 ] Volts
  VCO Tune Port Input Resistance ........[        1.E+6 ] Ohms
── Press F1 to Select Detector ────────────────────
   Low  Freq Phase Detector (5 MHz to 1600 MHz)
   High Freq Phase Detector (1.2 GHz to 18 GHz)
   External  Phase/AM Detector
```

Vo = 100 MHz

5E − 9 X 100 E6 = .5

Tune Port Resistance

```
┌─ Main Menu ──────────┐
─ Calibration Technique ───────────────────────────
── Press F1 to Select Detector Constant Method ────
  Use Current Detector Constant .......(      277.7E-3 ] V/Rad
  Measure the Detector Constant.
── Press F2 to Select VCO Tune Constant Method ────
  Use Current Tune Constant (        106.7 Hz/Volt).
  Measure the Tune Constant.
  Calculate from Expected Tune Constant (  499.975E-3 Hz/Volt).
── Press F3 to Toggle Verification of Loop Suppression ──
  The computed PLL suppression  WILL  be verified.
```

Refer To Chapter 2 Calibration Technique For Details On Determining the VCO Tune Constant

9 Tuning Characteristics of Various VCO Source Options (continued)

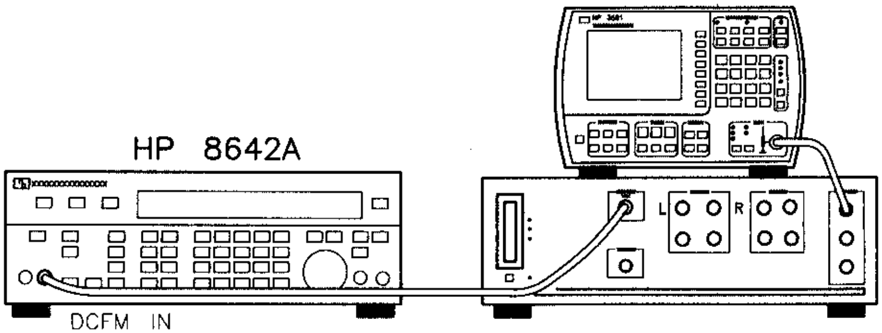
VCO Source	Carrier Freq.	VCO Tune Constant (Hz/V)	Center Range (V)	Tune Range of VCO (±V)	Input Resistance (ohms)	Calibration Technique
HP 8662/3A EFC DCFM	 v_o	 $5\,E-9\times v_o$ FM Deviation	 0 0	 10 10	 1 E + 6 1k (8662) 600 (8663)	 Measure Calculate Calculate
HP 8642A/B		FM Deviation	0	10	600	Calculate
HP 8640B		FM Deviation	0	10	600	Calculate
HP 8656B		FM Deviation	0	10	600	Calculate
Other Signal Generator DCFM Calibrated for ±1V		FM Deviation	0	10	R_{in}	Calculate
10 MHz Source A Direct Multiplied As a Timebase: To HP 8662/3A To other synthesized signal generators	 v_o v_o v_o	 10 $1\,E-6\times v_o$ $1\,E-6\times v_o$ $1\,E-6\times v_o$	 0 0 0 0	 10 10 $10\,E+9\div v_o$ $1\,E+6\times PTR^{*}\div v_o$	 1 E + 6 1 E + 6 1 E + 6 1 E + 6	Measure
10 MHz Source B Direct Multiplied As a Timebase: To HP 8662/3A To other synthesized signal generators	 v_o v_o v_o	 100 $10\,E-6\times v_o$ $10\,E-6\times v_o$ $10\,E-6\times v_o$	 0 0 0 	 10 10 $1\,E+9\div v_o$, (up to 2.5V max.) $100\,E+3\times PTR^{*}\div v_o$	 1 E + 6 1 E + 6 1 E + 6 1 E + 6	Measure
350–500 MHz Source		12 E + 6	0	2	1 E + 6	Measure
Other User VCO Source		Estimated within a factor of 2	−10 to +10	See Graph 8	1 E + 6	Measure

* Limited PTR due to PLL BW limitations.

Description

The table shown above lists the tuning parameters for several VCO source options. (Refer to *Parameters* in chapter 2, *Measurement Definitions* for further information on tuning sources.) Example B on the next page uses an HP 8642A as the signal source.

EXAMPLE B




```
┌─ Main Menu ─────────┐
─ Parameters ──────────────────────────────────────────
  Carrier Frequency ......................[      900.E+6 ] Hz
  Detector Input Freq ....................[      900.E+6 ] Hz
  VCO Tune Constant ......................[       1.5E+6 ] Hz/Volt
  Center Voltage of VCO Tune Curve .......[            0 ] Volts
  Tune Range of VCO ......................[±          10 ] Volts
  VCO Tune Port Input Resistance .........[          600 ] Ohms
── Press F1 to Select Detector ─────────────────────────
   Low  Freq Phase Detector (5 MHz to 1600 MHz)
   High Freq Phase Detector (1.2 GHz to 18 GHz)
   External  Phase/AM Detector
```

Vo = 900 MHz

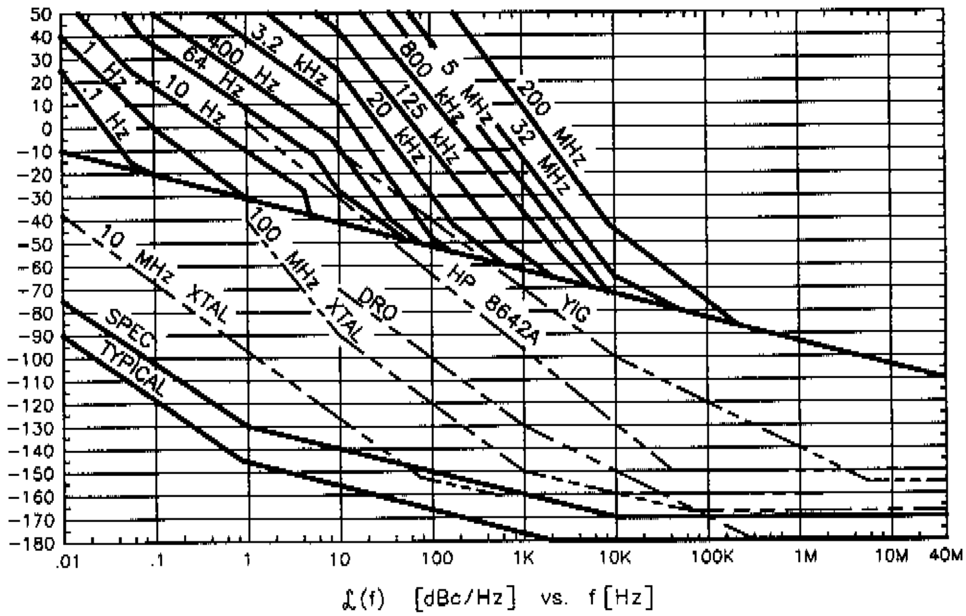
Peak FM Deviation

Tune Port Resistance

```
┌─ Main Menu ─────────┐
─ Calibration Technique ───────────────────────────────
─ Press F1 to Select Detector Constant Method ─────────
  Use Current Detector Constant .......[      277.7E-3 ] V/Rad
  Measure the Detector Constant.
─ Press F2 to Select VCO Tune Constant Method ─────────
  Use Current Tune Constant (        106.7 Hz/Volt).
  Measure the Tune Constant.
  Calculate from Expected Tune Constant (  499.975E-3 Hz/Volt).
─ Press F3 to Toggle Verification of Loop Suppression ─
  The computed PLL suppression  WILL  be verified.
```

Refer To Chapter 2
Calibration **Technique**
Enhanced Tuning Ranges
For Details On Deter-
mining the VCO
Tune Constant

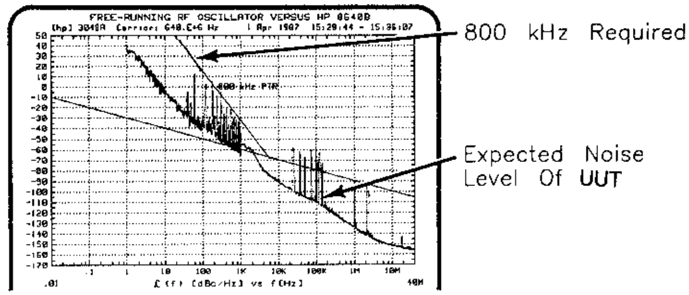
10 Peak Tuning Range Required Due to Noise Level



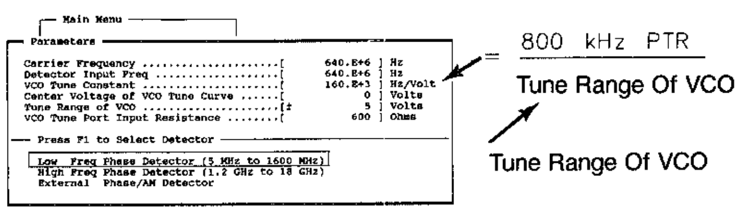
Description

The graph shown above provides a comparison between the typical phase noise level of a variety of sources and the minimum tuning range that is necessary for the test system to create a phase lock loop of sufficient bandwidth to make the measurement. Typically, sources with higher phase noise require a wider Peak Tuning Range. These sources are usually designed with a wider tuning range in order to meet their application requirements. (Refer to the PLL section of *Parameters* in chapter 2, *Measurement Definitions* for further understanding of the Peak Tuning Range requirements.)

EXAMPLE

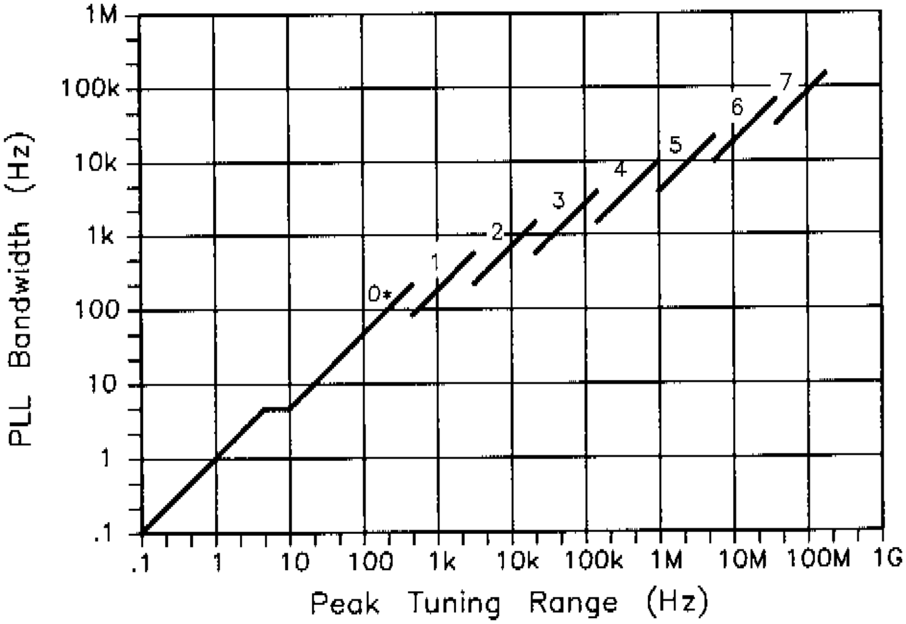


FREE-RUNNING RF OSCILLATOR VERSUS HP 8640B
[hp] 3048A Carrier: 640.E+6 Hz 1 Apr 1987 15:20:44 - 15:36:07
800 kHz PTR
£(f) [dBc/Hz] vs f[Hz]
800 kHz Required
Expected Noise Level Of UUT



Main Menu
Parameters
Carrier Frequency ....[640.E+6] Hz
Detector Input Freq ....[640.E+6] Hz
VCO Tune Constant ....[160.E+3] Hz/Volt
Center Voltage of VCO Tune Curve ......[0] Volts
Tune Range of VCO ....[± 5] Volts
VCO Tune Port Input Resistance ....[600] Ohms
Press F1 to Select Detector
Low Freq Phase Detector (5 MHz to 1600 MHz)
High Freq Phase Detector (1.2 GHz to 18 GHz)
External Phase/AM Detector
= 800 kHz PTR / Tune Range Of VCO
Tune Range Of VCO

11 Phase Lock Loop Bandwidth vs. Peak Tuning Range

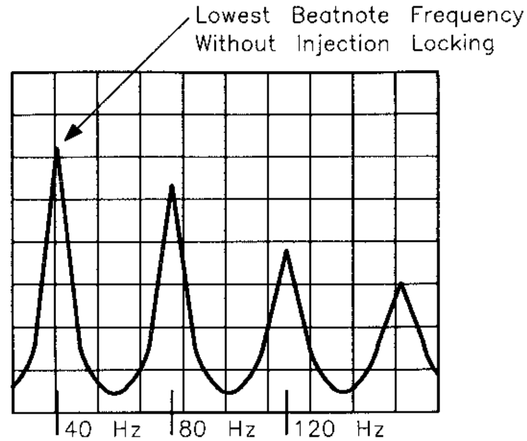


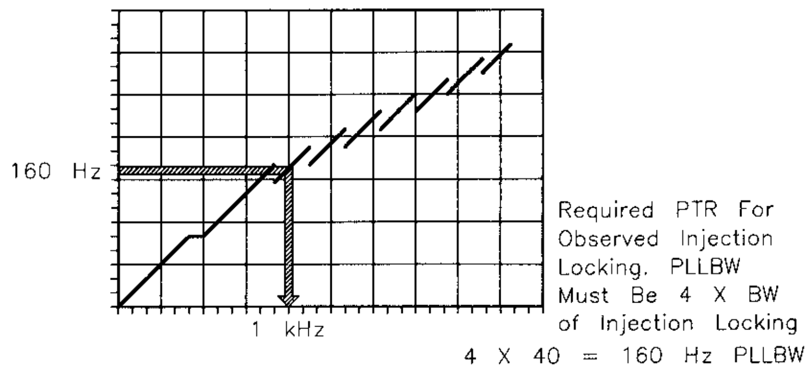
* Lag/Lead Filter Number

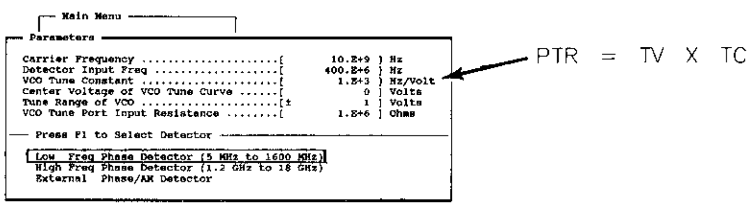
Description

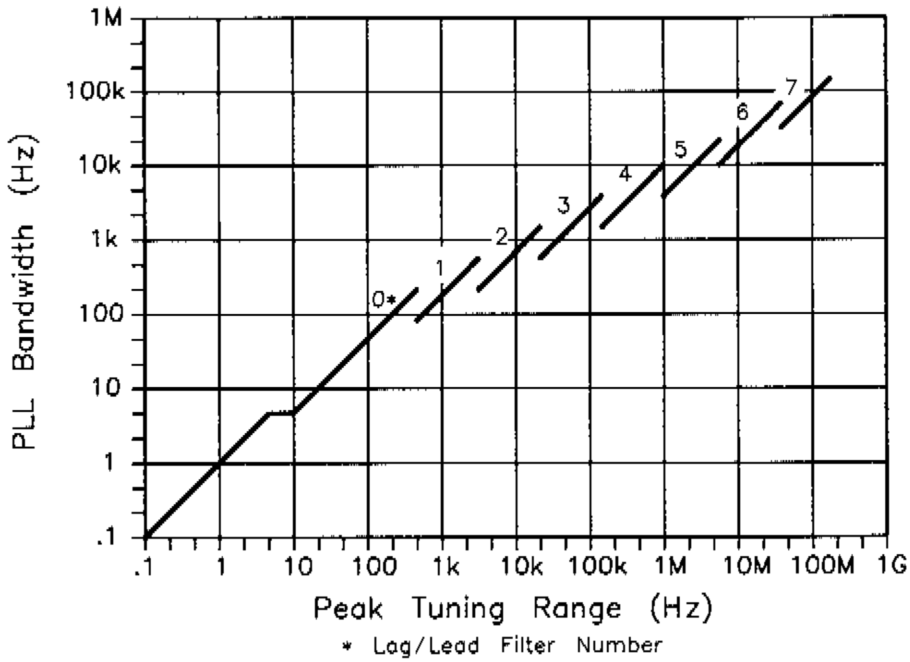
The graph shown above illustrates the closed Phase Lock Loop Bandwidth (PLL BW) chosen by the test system as a function of the Peak Tuning Range of the source. Knowing the approximate closed PLL BW allows you to verify that there is sufficient bandwidth on the tuning port and that sufficient source isolation is present to prevent injection locking. (Refer to *Parameters* in chapter 2, *Measurement Definitions* for a description of the Peak Tuning Range requirements.) Example A describes the observed injection locking that takes place.

EXAMPLE A
OBSERVED INJECTION LOCKING







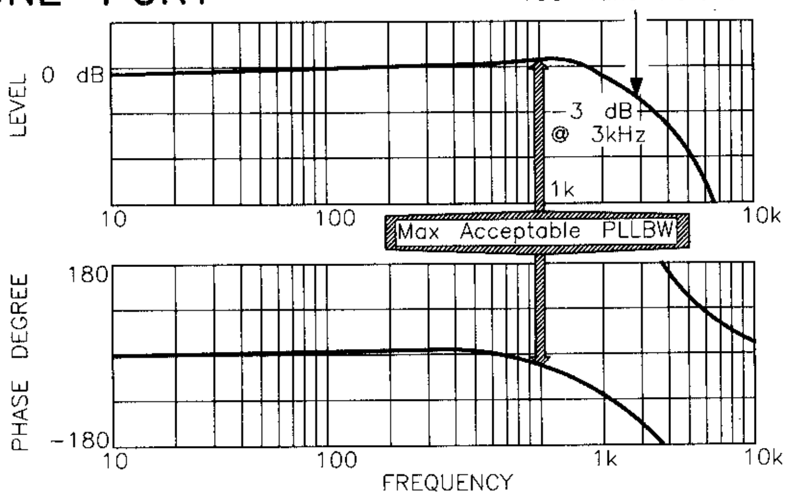


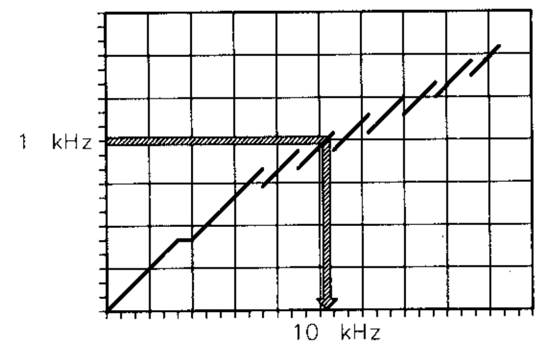
Description

The graph shown above illustrates the closed Phase Lock Loop Bandwidth (PLL BW) chosen by the test system as a function of the Peak Tuning Range of the source. Knowing the approximate closed PLL BW allows you to verify that there is sufficient bandwidth on the tuning port and that sufficient source isolation is present to prevent injection locking. (Refer to *Parameters* in chapter 2, *Measurement Definitions* for a description of the Peak Tuning Range requirements.) Example B describes the frequency response of the VCO tune port.

EXAMPLE B

FREQUENCY RESPONSE OF THE VCO TUNE PORT



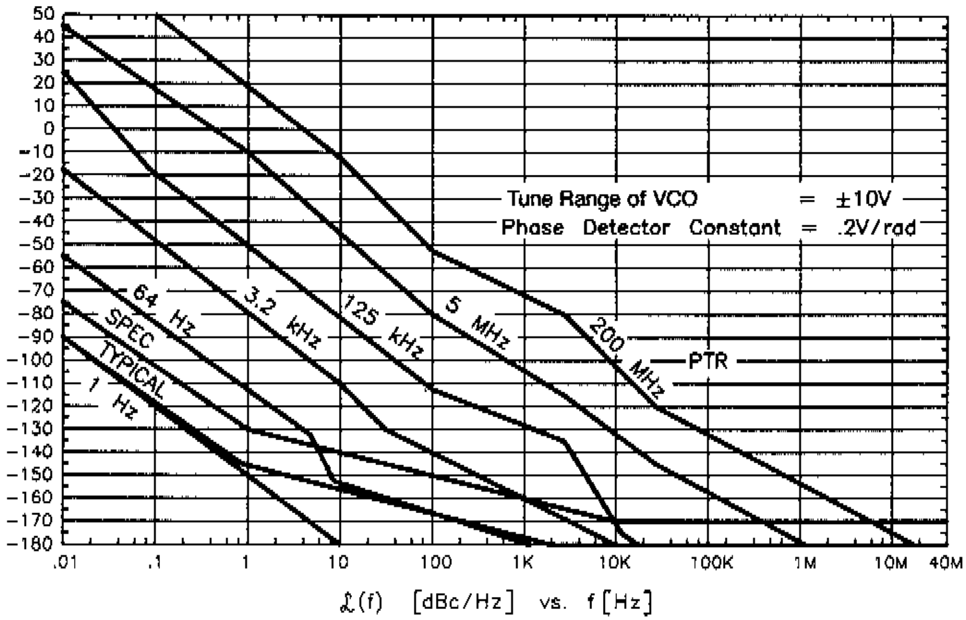


Max EFC BW For The HP 8662A Is ≈ **1 KHz**

```
┌─ Main Menu ──────────┐
─ Parameters ─────────────────────────────────────────────
  Carrier Frequency .....................[       10.E+9 ] Hz
  Detector Input Freq ...................[      400.E+6 ] Hz
  VCO Tune Constant .....................[       10.E+3 ] Hz/Volt
  Center Voltage of VCO Tune Curve ......[            0 ] Volts
  Tune Range of VCO .....................[±           1 ] Volts
  VCO Tune Port Input Resistance ........[        1.E+6 ] Ohms
── Press F1 to Select Detector ───────────────────────────
   Low  Freq Phase Detector (5 MHz to 1600 MHz)
   High Freq Phase Detector (1.2 GHz to 18 GHz)
   External  Phase/AM Detector
```

TV X TC = PTR

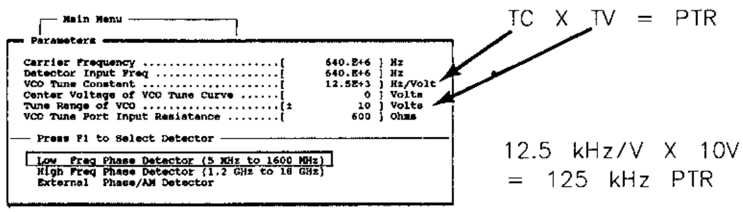
12 HP 3048A Noise Floor Limits Due to Peak Tuning Range

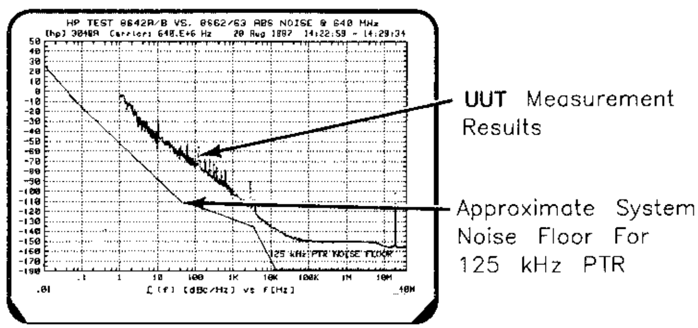


Description

The graph shown above illustrates the equivalent phase noise at the Peak Tuning Range entered for the source due to the inherent noise at the HP 11848A Tune Voltage Output port. (A Tune Range of VCO ±10 V and phase Detector Constant of 0.2V/Rad is assumed.)

EXAMPLE


Main Menu
Parameters
Carrier Frequency ....[640.E+6] Hz
Detector Input Freq ....[640.E+6] Hz
VCO Tune Constant ....[12.5E+3] Hz/Volt
Center Voltage of VCO Tune Curve ......[0] Volts
Tune Range of VCO ....[± 10] Volts
VCO Tune Port Input Resistance ....[600] Ohms
Press F1 to Select Detector
Low Freq Phase Detector (5 MHz to 1600 MHz)
High Freq Phase Detector (1.2 GHz to 18 GHz)
External Phase/AM Detector
TC X TV = PTR
12.5 kHz/V X 10V
= 125 kHz PTR


HP TEST 8642A/B VS. 8662/63 ABS NOISE @ 640 MHz
125 kHz PTR NOISE FLOOR
ℒ(f) [dBc/Hz] vs f[Hz]
UUT Measurement Results
Approximate System Noise Floor For 125 kHz PTR

Messages 8

Introduction

The HP 3048A displays messages to aid you during the measurement process. These messages are grouped into four categories:

Error: Numbered error messages are listed in numerical order in table 8-1 and unnumbered error messages listed in alphabetical order in table 8-2.

Reference: Reference messages are listed in numerical order in table 8-3.

Warning: Warning messages are listed in alphabetical order in table 8-4.

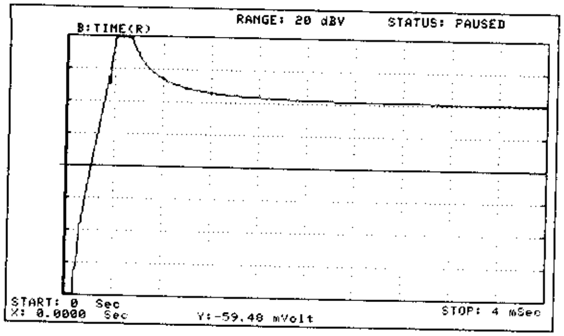
Status: Status messages (prompts and updates) are listed in alphabetical order in table 8-5.

Table 8-1. Numbered Error Messages (1 of 17)

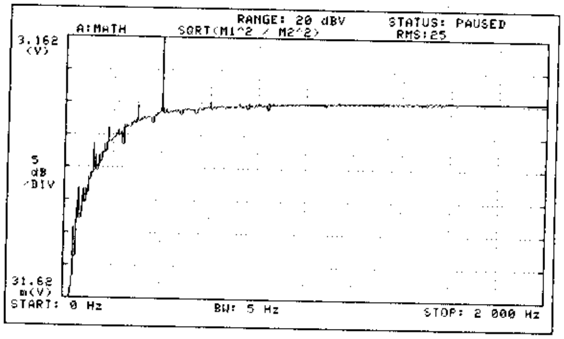
1	**Signal level entering the Noise Input port of the 11848A exceeds 1 Volt peak.**
	Action: Press **R** to retry. If the overload condition was transient, the HP 3048A proceeds with the measurement. If Error 1 occurs again, reduce the signal level at the NOISE INPUT port on the HP 11848A. If an HP 11729C is being used to make an AM measurement, insert a 20 dB (50 Ω) pad in the NOISE INPUT signal path. The pad should be connected directly to the HP 11848A.
2	**Loop suppression peak exceeds 10 dB. To proceed without verifying the loop suppression press P.** Excessive peaking can be caused by various conditions. Continuing with the measurement without verifying loop suppression may result in measurement accuracy degradation at offset frequencies within a decade of the PLL bandwidth. **NOTE** *The SOURCE OUT port on the rear-panel of the HP 3561A must be connected to the NOISE INPUT port on the rear panel of the HP 11848A.* Excessive loop suppression peaking is generally caused by one of three conditions. Each condition produces a somewhat different response of the loop suppression curve. The loop suppression curve is displayed on the HP 3561A after the test system has completed the loop suppression characterization. Figure 8-1 illustrates the typical curve response for each of the three conditions.
	Action: If the loop suppression peak for your measurement exceeds 10 dB (Error 2), observe the loop suppression curve displayed on your HP 3561A. Then refer to the following condition described for the curve in figure 8-1 that most closely resembles the curve displayed on your HP 3561A.

Table 8-1. Numbered Error Messages (2 of 17)

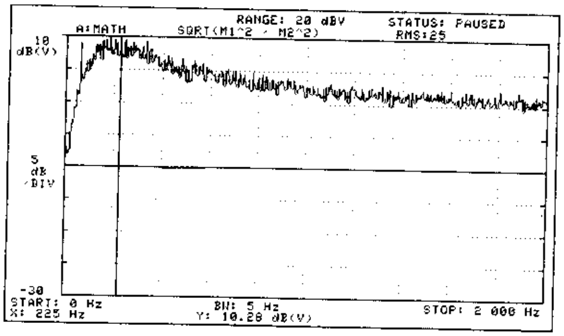
2
(cont'd)



1. Narrow Modulation Bandwidth



2. Large Spur on Input Signal.



3. High Noise on Input Signal

Figure 8-1. HP 3561A Display of Loop Suppression Curves.

Table 8-1. Numbered Error Messages (3 of 17)

2 (cont'd)

1. Narrow Modulation Bandwidth

A broad peak on a relatively clean loop suppression curve occurs when the modulation bandwidth of the VCO's tune port is not wide enough to provide adequate phase margin for the test system's phase lock loop (PLL). The VCO's modulation bandwidth (the upper frequency limit of the VCO's tuning port) should be greater than approximately ten times the PLL bandwidth set for the measurement. PLL bandwidth is shown as a function of the Peak Tuning Range (PTR) in figure 8-2. (The PTR for the measurement is determined by multiplying the VCO's Tune Constant by its Tune Range of VCO.)

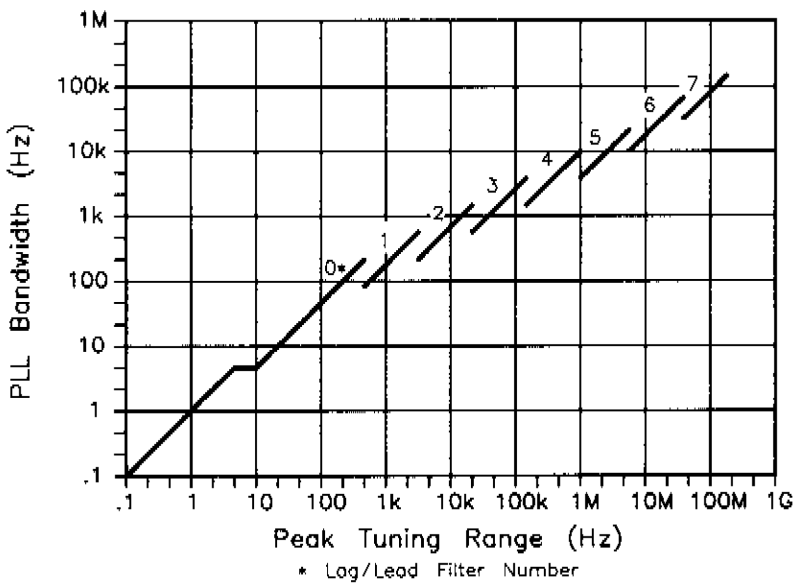


Figure 8-2. Phase Lock Loop Bandwidth as a Function of the Peak Tuning Range of the Measurement.

Table 8-1. Numbered Error Messages (4 of 17)

2 (cont'd)	If the modulation bandwidth of the VCO source you are using is not at least 10 times greater than the PLL bandwidth for the measurement, there are generally three possible actions you can take. • Increase the modulation bandwidth of the VCO source. If the VCO source is a breadboard or prototype oscillator, it may be possible to make the component changes necessary to provide sufficient modulation bandwidth. • Use a different VCO source with greater modulation bandwidth. • Decrease the PLL bandwidth to 1/10 the VCO's modulation bandwidth by decreasing the Peak Tuning Range (PTR) for the measurement. Use figure 8-2 to determine the PTR required. The PTR can be reduced by decreasing the Tune Range of VCO value entered. Divide the required PTR by the VCO's Tune Constant to determine the appropriate Tune Range of VCO to enter. (Keep in mind that reducing the PTR limits the test system's Frequency Drift Tracking Range for the measurement. For further information about changing the PTR, refer to *Changing the PTR* in chapter 3 of the *Operating Manual*.) If you do not know the modulation bandwidth for your VCO source, you can determine it by locating the 3 dB roll-off frequency of the VCO tune port. The following steps describe a procedure for determining the modulation bandwidth. a. Connect a tracking generator output (such as the HP 3585A/B) to the tuning input port on your VCO. b. Set the tracking generator output to sweep the audio spectrum. c. Connect the RF output from your VCO to a modulation analyzer (such as an HP 8901A). d. Set the modulation analyzer to measure FM. e. Connect an audio spectrum analyzer to the MODULATION OUTPUT on the HP 8901A. f. Increase the frequency spectrum of the tracking generator, if necessary, until the 3 dB roll-off frequency can be seen on the audio analyzer's display. The 3 dB frequency should be $\geq$ ten times the PLL bandwidth for the measurement. The modulation bandwidth of a VCO can also be determined using the Bessel Null technique. Apply a series of audio frequencies to the tune port of the VCO. Observe the VCO's output signal on an RF spectrum analyzer and adjust the audio modulation level for the first carrier null. Calculate the VCO's modulation sensitivity at each modulation frequency using the level and frequency of the audio signal at the null setting. Plot the modulation sensitivity versus the audio frequency to determine the modulation bandwidth.

Table 8-1. Numbered Error Messages (5 of 17)

2 (cont'd)	**2. Large Spur on Input Signal** A sharp peak on an otherwise correct loop suppression curve is evidence of a large spur (typically > -40 dBc) near the phase lock loop (PLL) bandwidth of the measurement (within a factor of two). Press **P** to continue with the measurement. The measurement results may not be totally accurate but the noise graph will provide you with the offset frequency and approximate level of the spur. (Chapter 6, *Evaluating Measurement Results* in the *Operating Manual* provides information that helps you isolate the spur source). If you are not able to reduce the spur level to < -40 dBc, it may be possible to make an accurate noise measurement by changing the PLL bandwidth. Measurement accuracy is only affected by spurs > -40 dBc that are within a factor of 2 of the PLL bandwidth. The PLL bandwidth is shown as a function of Peak Tuning Range (PTR) in figure 8-2. (The PTR for the measurement is determined by multiplying the VCO's Tune Constant by the Tune Range of VCO entered for the measurement. For further information about changing the PTR, refer to chapter 3, *Changing the PTR* in the *Operating Manual* **3. High Noise on Input Signal** **NOTE** *Be sure that SOURCE OUT on the rear panel of the HP 3561A is connected to NOISE INPUT on the rear panel of the HP 11848A.* A noisy loop suppression curve is caused when one or both of the input signals has noise near the small angle line at offsets near the phase lock loop (PLL) bandwidth. For information about verifying the noise level and recommended actions for compensating for a high noise level, refer to chapter 3, *Evaluating Noise Above the Small Angle Line* in the *Operating Manual.*
3	**Unable to detect the presence of a beatnote.**
	Action: 1. Check to be sure that the correct Phase Detector is selected in the Parameters window. 2. Check sources to verify the frequency of each output signal. 3. Check for a beatnote. (A procedure for tuning the beatnote to within the Capture Range for the measurement is provided in the *Checking the Beatnote* section of each Phase Lock Loop measurement example in chapter 3 of the *Operating Manual.* An oscilloscope connected to the HP 11848A AUX MONITOR port can be helpful for monitoring and zeroing the beatnote.)

4	**Unable to close the Phase Lock Loop.**
	Action: There are several possible conditions that can prevent the test system from being able to close the phase lock loop. These conditions and the actions recommended for verifying them are listed below in the order of probable cause. 1. The test system is not able to tune the beatnote to within the capture range set for the measurement. This possibility is minimized by carefully following the *Checking the Beatnote* procedure in each measurement example in chapter 3 of the *Operating Manual.* If an oscilloscope is available, you will find that connecting the scope to the AUX MONITOR port on the HP 11848A allows you to continuously monitor the beatnote throughout the measurement. By aborting this measurement and reinitiating a New Measurement, you can observe the beatnote as the HP 3048A attempts to close the phase lock loop (a message will appear on the display to let you know when this is happening). The beatnote frequency, as seen on the scope, should decrease and then go to zero (dc). Watching the beatnote's response as the test system attempts to adjust it to 0 Hz can provide clues about tuning problems that may exist. 2. The beatnote drifted beyond the HP 3048A's capture range before the test system was able to acquire lock. For further information on verifying the frequency stability of the beatnote, refer to chapter 3, *Tracking Frequency Drift* in the *Operating Manual.* 3. The VCO Tune Constant entered for the measurement was not within a factor of 2 of the actual VCO Tune Constant, and the HP 3048A was not configured to *measure* the tune constant for verification. For details on verifying the VCO Tune Constant, refer to chapter 3, *Estimating the Tuning Constant* in the *Operating Manual.* 4. The Peak Tuning Range set for the measurement is > 10 MHz and is causing the loop dynamics to be non-linear. When this condition exists, the non-linear response of the beatnote as the test system attempts to close the phase lock loop can often be seen on an oscilloscope connected to the AUX MONITOR port on the HP 11848A. 5. One of the sources is being injection locked as the HP 3048A is tuning the beatnote to 0 Hz. (Refer to chapter 3, *Minimizing Injection Locking* in the *Operating Manual* for recommended actions.) 6. The modulation bandwidth of the VCO source's tuning port is not wide enough to provide adequate phase margin for the test system's phase lock loop (PLL). The VCO's modulation bandwidth (the upper frequency limit of the VCO's tuning port) should be greater than approximately ten times the PLL bandwidth set for the measurement. PLL bandwidth is shown as a function of the Peak Tuning Range (PTR) in figure 8-3. (The PTR for the measurement is determined by multiplying the VCO's Tune Constant by its Tune Range of VCO.)

4 (cont'd)

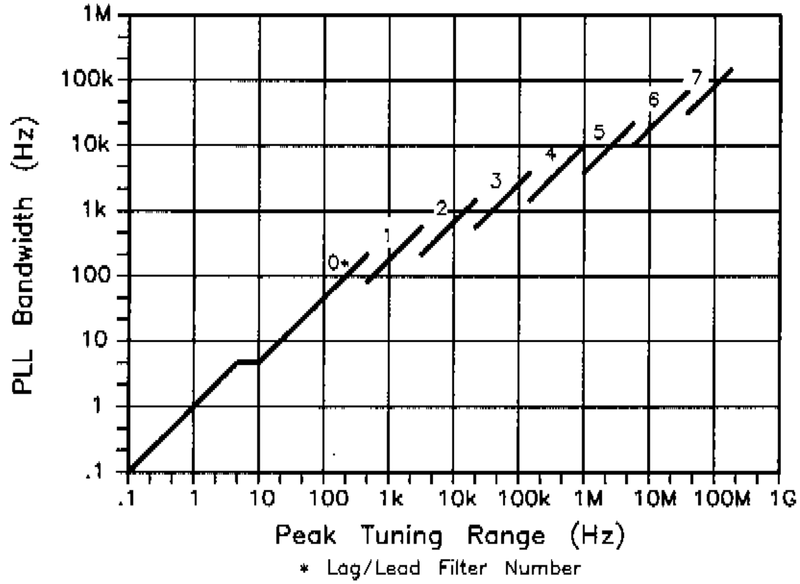


Figure 8-3. Phase Lock Loop Bandwidth as a Function of the Peak Tuning Range of the Measurement.

If the modulation bandwidth of the VCO source you are using is not at least 10 times greater than the PLL bandwidth for the measurement, there are generally three possible actions you can take.

- Increase the modulation bandwidth of the VCO source. If the VCO source is a bread-board or prototype oscillator, it may be possible to make the component changes necessary to provide sufficient modulation bandwidth.
- Use a different VCO source with greater modulation bandwidth.
- Decrease the PLL bandwidth to 1/10 the VCO's modulation bandwidth by decreasing the Peak Tuning Range (PTR) for the measurement. Use figure 8-3 to determine the PTR required. The PTR can be reduced by decreasing the Tune Range of VCO value entered. Divide the required PTR by the VCO's Tune Constant to determine the appropriate Voltage Tuning Range to enter. (Keep in mind that reducing the PTR limits the test system's Frequency Drift Tracking Range for the measurement. For further information about changing the PTR, refer to chapter 3, *Changing the PTR* in the *Operating Manual*.)

Table 8-1. Numbered Error Messages (8 of 17)

4 (cont'd)	If you do not know the modulation bandwidth for your VCO source, you can determine it by locating the 3 dB roll-off frequency of the VCO tune port. The following steps describe a procedure for determining the modulation bandwidth. a. Connect a tracking generator output (such as the HP 3585A/B) to the tuning input port on your VCO. b. Set the tracking generator output to sweep the audio spectrum. c. Connect the RF output from your VCO to a modulation analyzer (such as an HP 8901A). d. Set the modulation analyzer to measure FM. e. Connect an audio spectrum analyzer to the MODULATION OUTPUT on the HP 8901A. f. Increase the frequency spectrum of the tracking generator, if necessary, until the 3 dB roll-off frequency can be seen on the audio analyzer's display. The 3 dB frequency should be $\geq$ ten times the PLL bandwidth for the measurement. The modulation bandwidth of a VCO can also be determined using the Bessel Null technique. Apply a series of audio frequencies to the tune port of the VCO. Observe on an RF spectrum analyzer and adjust the audio modulation level for the first carrier null. Calculate the VCO's modulation sensitivity at each audio frequency using the level and frequency of the audio signal at the null setting. 7. The noise on one or both sources exceeds the small angle limit. For information about verifying the noise level and recommended action, refer to chapter 3, *Evaluating Noise Above the Small Angle Line* in the *Operating Manual*. For information about measuring sources with high close-in noise, refer to the *Ignore Out of Lock* section of chapter 5, *Measurement Mode* in the HP 3048A Option 301 *Reference Manual*.
5	**Measured VCO peak tuning range exceeds 500 kHz/200 MHz.** The Peak Tuning Range limit for the test system is 500 kHz (or 200 MHz if an RF analyzer is configured in the test system). The Peak Tuning Range is the product of the VCO Tune Constant multiplied by the Tune Range of VCO. (If the test system *measures* the VCO's Tune Constant, it will use the measured value to compute the Peak Tuning Range for the measurement.)
	Action: Reduce the VCO Tune Range entered for the VCO source you are using, or select a VCO source with a lower Tune Constant.
6	**Unable to establish quadrature.** Occurs when source is under System Control and the test system is unable to acquire quadrature. The test system attempts to acquire quadrature at the beginning of the measurement and after it has completed a measurement segment if quadrature was lost at any time while the segment was being measured.
	Action: Manually adjust for quadrature by adjusting the source frequency (or the Phase Shifter if one is being used). Adjust for center scale on the HP 11848A Quadrature Meter.

Table 8-1. Numbered Error Messages (9 of 17)

7	**Measured beatnotes depict non-linear VCO tune constant.** (Error 7 only occurs when the software has been configured to *Measure the Tune Constant*.) The values shown on the display represent the measured beatnote frequencies for four Control Voltage settings. The Control Voltage settings are each derived as a percentage of the entered Tune Range of VCO (−45%, −15%, +15%, +45%) relative to the entered Center Voltage of VCO Tune Curve. For Example: Tune Range of VCO = ±10V Center Voltage of VCO Tune Curve = 0V Control Voltage Settings = −4.5V, −1.5V, +1.5V, +4.5V. Refer to chapter 2, *Parameters* in the *Reference Manual* for test system VCO linearity requirements. Note that between the four measured frequency values shown on the display, three frequency range intervals are created. (For example, the measured values 95 Hz, 98.2 Hz, 101.2 Hz, 105 Hz produce the following intervals: Interval 1 = 3.2 Hz, Interval 2 = 3 Hz and Interval 3 = 3.8 Hz.)
	Action: 1. This error occurs if a Tune Range of VCO ±10 volts has been defined for a source with calibrated DC FM, and the software is configured to *Measure the VCO Tune Constant* rather than to *Calculate* it. Refer to chapter 2, *Parameters* in the *Reference Manual* for details on extending the Tune Range of VCO for calibrated DC FM. 2. If Interval 2 (described above) >> 1, and Interval 2 >> 3, then: Reduce the value entered for the Tune Range of VCO and then start a New Measurement. 3. If there appears to be too little or no change between the measured frequency values (Intervals 1, 2, and 3 ≈ 0) then : • Check the Control Voltage cable connections. • Verify that the VCO's tuning is enabled. • Perform the *Estimating the Tuning Constant* procedure provided in chapter 3 of the *Operating Manual* to verify the tuning response of the VCO and check that the entered VCO Tune Constant is within a factor of 2 of the actual value. • Refer to chapter 2, *Parameters* in the *Reference Manual* for Tune Constant linearity requirements. • Verify that the beatnote is tuned to within the Capture Range for the measurement.

Table 8-1. Numbered Error Messages (10 of 17)

7 (cont'd)	**4.** If the Frequency Intervals vary greatly and are considerably larger than expected for the tuning range of the the VCO, then: • Check for erratic frequency drift of the beatnote. (Beatnote stability is directly related to the frequency stability of each signal source used in the measurement.) 5. If all four measured frequencies are 0 Hz, then: • Check for injection locking. Refer to *Minimizing Injection Locking* in chapter 3, of the *Operating Manual* for further information.
8	**Unable to find a beatnote.** System was not able to detect a beatnote above −24 dBm (20 mVpk) between 0.1 Hz and 40 MHz.
	Action: Verify the presence of the beatnote signal. (Refer to the *Checking the Beatnote* procedure provided in each Phase Lock Loop measurement example in chapter 3 of the *Operating Manual*.) If you are making a Phase lock loop measurement, be sure the VCO Tune Constant value entered for the measurement is within a factor of 2 of the actual value. Refer to *Calibration Process* in chapter 2 of the *Reference Manual* for information about the beatnote calibration technique.
9	**The calibration spur could not be found.** The HP 3048A was unable to detect a spur within a factor of 2 of the entered spur frequency.
	Action: **1.** Check that the correct spur frequency was entered. **2.** Verify the output signal from the spur source. 3. Increase the spur level up to but not exceeding a maximum of −20 dBc. **NOTE** *If a single sided spur is being used and the source frequency is adjusted to maintain quadrature, the frequency of the spur source will also have to be adjusted to maintain the desired spur offset.*
10	**Waveform departs too drastically from sinusoidal to be used in calculation of the Phase Detector Constant.** The test system measures the slope of the waveform at both the positive and the negative zero crossings. If the true slopes differ in magnitude by more than 10%, Error 10 is generated.
	Action: Check the harmonic content of the two input signals to the Phase Detector. All even harmonics must be below −20 dBc to guarantee good symmetry of the beatnote waveform. If possible, increase the PTR to >10 kHz so that the beatnote is >1 kHz. The HP 3048A then measures the fundamental and its harmonics. (<1 kHz beatnote system measures slope of sinusoid.)

11

DC offset too large. Waveform does not cross 0 volts. This error occurs when the test system is measuring the phase Detector Constant and one of the following conditions exist:

1. The dc offset is greater than the peak beatnote voltage due to a large dc offset or a low beatnote level.
2. The beatnote frequency is much lower than expected and only the top or bottom portion of a sine wave peak is actually measured.

Action:

1. Observe the beatnote on the time record of the HP 3561A or on an oscilloscope connected to the AUX MONITOR port of the HP 11848A.
   Verify that the beatnote amplitude is correct for the signal level at the R input port on the HP 11848A. Figure 8-4 shows the relationship between the beatnote level and the level at the R input port.

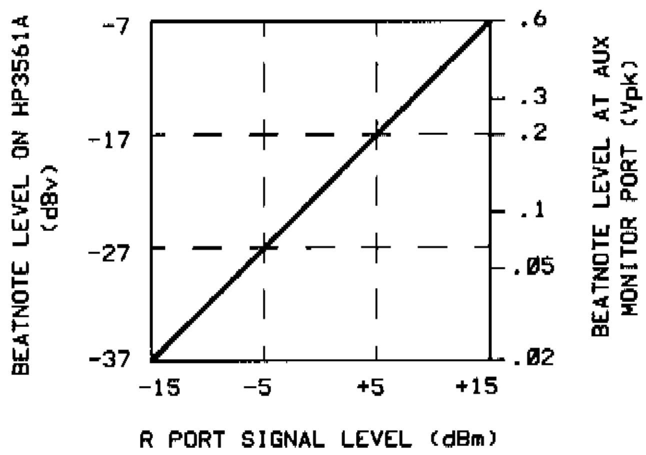
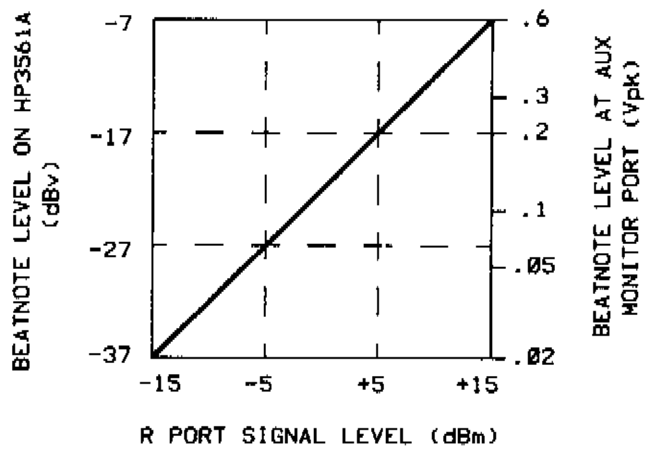


Figure 8-4. Beatnote Level Relative to the Signal Level at the R Port.

2. Verify that the phase detector DC offset is < 50 mV.
3. If the software was not configured to measure the VCO Tune Constant, verify that the entered value is within a factor of 2 of the VCO's actual Tune Constant. A procedure for verifying the VCO's Tune Constant is contained in *Estimating the Tuning Constant* in chapter 3 of the *Operating Manual.*
4. When the test system measures the Phase Detector Constant, the beatnote frequency should be set to approximately 10% of the Peak Tuning Range (PTR) set for the measurement. If it is not, verify the VCO Tuning Constant and Voltage Tuning Range entered for the measurement.

Table 8-1. Numbered Error Messages (12 of 17)

12	**Insufficient span. Less than one waveform found.** A minimum of four zero crossings is necessary across the HP 3561A's display. This error occurs when the test system is measuring the phase Detector Constant and the expected beatnote is < 1 kHz.
	Action: When the test system measures the phase Detector Constant, the beatnote frequency should be set to approximately 10% of the Peak Tuning Range (PTR) set for the measurement. If it is not, verify the VCO Tune Constant and Tune Range of VCO entered for the measurement. A procedure for evaluating the tuning sensitivity of the VCO is provided in *Estimating the Tuning Constant* in chapter 3 of the *Operating Manual.*
14	**DC offset from mixer > 1/2 peak voltage.** The dc offset of the Phase Detector is determined and then used to adjust the phase Detector Constant for true slope at the zero voltage point.
	Action: Observe the beatnote on the HP 3561A display or with an oscilloscope connected to the AUX MONITOR port on the HP 11848A. 1. Verify that the beatnote amplitude is correct for the signal level at the R input port on the HP 11848A. Figure 8-5 shows the relationship between the beatnote level and the level at the R port.  Figure 8-5. Beatnote Level Relative to the Signal Level at the R Port.

14 (cont'd)	2. Verify that the Phase Detector DC offset is < 50 mV. If the dc offset is within this limit and the beatnote level is < −23 dBV (< 0.1 Vpk at AUX MONITOR port), increase the beatnote level, if possible, by increasing the signal level at the R port. If the beatnote level cannot be increased sufficiently it may be necessary to decrease the dc offset by changing the carrier frequency.
15	**Detector Constant < 0.02 V/Rad.** The measured phase Detector Constant was below the test system's 20 mV limit.
	Action: Observe the beatnote on the HP 3561A display or with an oscilloscope connected to the AUX MONITOR port on the HP 11848A. Verify that the beatnote amplitude is correct for the signal level at the R input port on the HP 11848A. Figure 8-6 shows the relationship between the beatnote level and the level at the R port. If necessary, increase the signal level at the R port and verify that the signal level at the L port is ≥ +15 dBm (≥ +7 dBm for the 1.2 GHz to 18 GHz Phase Detector).

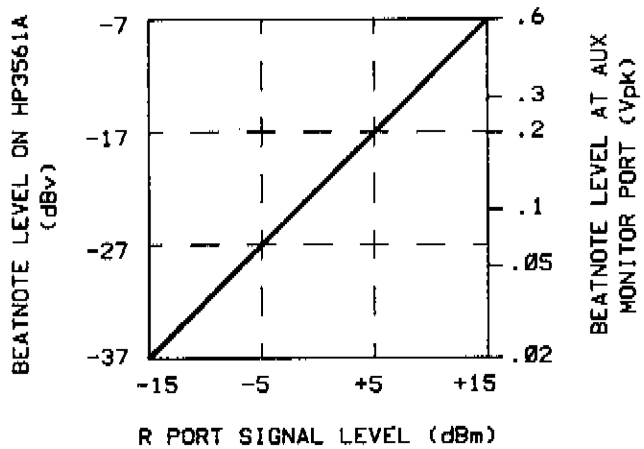
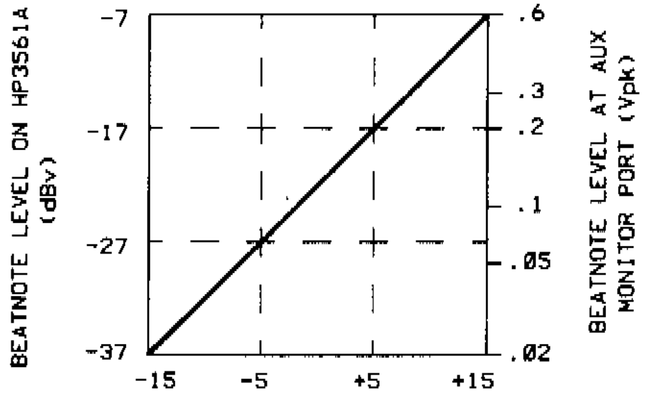


Figure 8-6. Beatnote Level Relative to the Signal Level at the R Port.

16	**Detector Constant > 10 V/Rad.** The measured phase Detector Constant exceeded the test system's 10 V limit.
	Action: An internal phase detector cannot produce a beatnote large enough to result in a > 10 V/rad detector constant. Therefore, this message should only occur with an external detector with gain. To reduce the detector constant, insert a 10 or 20 dB pad between the external detector and the noise input.  **Figure 8-7. Beatnote Level Relative to the Signal Level at the R Port.**
17	**Measured tune range of the VCO is less than 0.2 Hz. The test system was probably unable to cause a beatnote.** The Tune Range of VCO is measured in this case as: 2 × entered Tune Range of VCO × measured VCO Tune Constant
	Action: If the *expected* tune range of the VCO source is much larger than 0.2 Hz: 1. Check the Control Voltage cable connection. 2. Verify that the VCO source's tuning capability is enabled. 3. Verify the VCO's tuning response by performing the procedure provided in *Estimating the Tuning Constant* in chapter 3 of the *Operating Manual.* 4. Perform the procedure for adjusting the beatnote frequency to within 10% of the Peak Tuning Range (PTR) set for the measurement. (The procedure for adjusting the beatnote is provided in the *Checking the Beatnote* portion of each measurement example in chapter 3 of the *Operating Manual.* If the *expected* tuning range of the VCO source is near 0.2 Hz: 1. Increase the tuning range, if possible, by increasing the Tune Range of VCO value entered for the measurement.

18	**The system perceives that the signals from the two sources differ by more than 15% of the total tuning range. The sources may be re-tuned to reduce the beatnote frequency. Or the VCO Tune Range may be adjusted.** Once the test system has measured the VCO Tune Constant, it is able to predict the Control Voltage necessary to phase lock the loop. If the tuning range required for lock is > 15% of the Peak Tuning Range (PTR), The test system may not be able to pull the sources into lock, and will have very little tuning range (< 5% of PTR) left for drift tracking.
	Action: 1. Tune the center frequency of one or both sources to adjust the beatnote to within the Capture Range set for the measurement. As you adjust the beatnote frequency toward 0 Hz, you may find it helpful to manually decrement the analyzer's span setting. (A complete procedure for adjusting the beatnote is provided in the *Checking the Beatnote* portion of each Phase Lock Loop measurement example in chapter 3 of the *Operating Manual.*) 2. If necessary, change the Center Voltage value entered for the VCO to reduce the initial beatnote frequency, or increase the entered Tune Range of VCO to provide a larger Peak Tuning Range (PTR). (Details on adjusting the PTR are provided in *Changing the PTR* in chapter 3 of the *Operating Manual.*)
20	**Unable to detect presence of HP 3561A noise source. Check cabling and HP 3516A Noise Source Function.**
	Action: Verify that the HP 3561A rear-panel "Source Out" port is connected to the HP 11848A rear-panel "Noise Input" port.

Table 8-1. Numbered Error Messages (16 of 17)

23	**The currently defined measurement has not been properly calibrated.** Run 'New Measurement' to calibrate.
	Action: Select New Measurement to allow the HP 3048A to calibrate the measurement.
26	**System attempted to set (instrument) to (–) MHz.** Test will be aborted.
	Action: Verify that the *Parameters* defined for the measurement are correct and that the source's frequency range is adequate.
27	**Entered carrier frequency cannot be tested.** Press Abort.
	Action: Verify the carrier frequency. If the frequency is correct, verify the HP 11729C filter table in the Instrument Addresses table.

Table 8-25. Numbered Error Messages (17 of 17)

31	**Random noise obscures waveform.** The test system is unable to measure the Detector Constant due to an erratic waveform. This error occurs during the phase Detector Constant calibration.
	Action: Observe spectrum of beatnote and evaluate with respect to small angle criterion for expected PLL BW.
32	**Beatnote not expected at frequency.**
	Action: Observe the beatnote at the connect diagram. Verify that it is less than 5% of the Peak Tune Range. Verify that the VCO is properly tuned by the voltage output of the HP 11848A. Verify that the VCO Tune parameters are correct in the Parameter menu.

Table 8-2. Unnumbered Error Messages (1 of 3)

Cannot use the specified Tune Constant. The VCO Tune Constant was set to zero because the last New Measurement was aborted. **Action:** Define a method for determining the VCO Tune Constant other than use the current Tune Constant. Then select **New Measurement**
External Timebase not allowed with Internal Source. **Action:** Redefine the timebase in the *Instrument Control* menu.
Files not created using identical segments. The 2 Oscillator Comparison or the 3 Oscillator Comparison can only be performed using data acquired from identical segments and measurement spans. **Action:** Remeasure the devices. Do not change any segment table entries or measurement definitions between measurements.
Insufficient data files for 3 Oscillator Comparison. Less than three Result files were found. **Action:** Store a Result file for each of the three measurements to be compared.
Insufficient data files for 2 Oscillator Comparison. Less than two Result Files were found. **Action:** Store a Result file for each of the two measurements to be compared. (Note that these files cannot be identical, they must be distinct measurements).
Internal sources may not be used to drive the high frequency detector. The HP 11848A internal oscillators can not be used as the input for the 1.2 to 1.8 GHz phase detector. **Action:** Define a different source or phase detector.
No test-instruments defined. Measurement initiated with an empty Configuration file. **Action:** Define the equipment being used in the Instrument Addresses table.

Table 8-2. Unnumbered Error Messages (2 of 3)

'10 MHz A' and internal '400 MHz Osc./VCO' are mutually exclusive. 10 MHz A cannot operate while one of the 400 MHz Oscillators is on. **Action:** Redefine the source selections in the *Instrument Control* diagram.
3561A Noise Source not functioning or not connected to 11848A. The HP 11848A can not detect the required noise source for this setup. **Action:** Verify that the HP 11848A's rear-panel noise input is connected to the HP 3561A's SOURCE OUT and attempt to re-run the test.
Peak tuning range exceeds Hz. The maximum Peak Tuning Range is 500 kHz (or 200 MHz when using a configured RF analyzer). **Action:** Reduce the Peak Tuning Range by reducing the Control Voltage or Tune Constant of VCO value defined for the VCO source in the *Parameters* window.
Plot range is not within span range. A Plotted Range has been defined that is not within the Measurement Range specified in the segment tables. **Action:** Define each of the Plotted Ranges in the segment table so they are each within the Measurement Ranges defined in the table.
Range limits must be in ascending order. A segment has been defined with a lower limit greater than the upper limit. **Action:** Redefine the segment range so that the upper limit is greater than the lower limit.
Source specification is invalid and must be corrected. The HP 3048A has detected an error in the Instrument Control diagram. **Action:** Check the *Instrument Control* diagram for accuracy and compatibility with other parameters defined for the measurement.
The currently defined measurement has not been properly calibrated. Select New Measurement to calibrate. The phase Detector Constant or Tune Constant of VCO has not been calibrated. **Action:** Check that the appropriate calibration method has been defined in the *Calibration Technique* window. Select **New Measurement** to initiate calibration.
The frequency of the Internal 400 MHz Osc. cannot be tuned. The test system cannot obtain quadrature since the HP 11848A internal 400 MHz oscillator cannot be tuned. **Action:** Use a tunable source or manually adjust quadrature using a phase shifter or line stretcher.

Table 8-2. Unnumbered Error Messages (3 of 3)

Unable to calculate. The HP 3048A was unable to perform the selected calculation. **Action:** Check the parameter entry data to make sure it is compatible with the selected calculation. For further information, refer to the HP 3048A Option 301 Reference Manual, chapter 4, *Manipulate Results.*

Table 8–3. Reference Messages (1 of 7)

1	**Establish quadrature manually.**
	Action: Manually adjust the source frequency or the phase shifter to attain quadrature (within ± 1 division of center scale on the HP 11848A's Quadrature Meter). If the meter is pegged, connect an oscilloscope or voltmeter to the AUX MONITOR port on the HP 11848A and then adjust the source frequency or the phase shifter to decrease voltage level until the level can be observed on the quadrature meter.
2	**WARNING: FM Deviation of (instrument) changed from ___to ___ Hz.** In order to zero the beatnote, the HP 3048A had to change the center frequency of the source. As a result, FM deviation must be adjusted to within the limits of the source at the new frequency. Note that a reduced Tune Constant (deviation) will result in a narrower Peak Tuning Range (PTR) for the measurement.
	Action: If the narrower PTR is adequate for the measurement, proceed. If the resulting PTR will not provide sufficient Capture and Drift Tracking Ranges for the stability of the signal sources, you may need to select a different VCO source with a greater tuning range. If your VCO source is an HP 8642A/B and the carrier frequency for the measurement is < 123 MHz, the following steps will enable you to increase the tuning range of the HP 8642A/B. 1. Configure the *Instrument Control* diagram for manual control of the HP 8642A/B. 2. Select the HP 8642A/B HET Band for 1.5 MHz maximum deviation. Note that the increase in deviation causes an increase in the HP 8642A/B's noise level as well.

Table 8-3. Reference Messages (2 of 7)

3	**Cause FIRST/SECOND calibration PEAK voltage.**
	Action: Adjust the frequency of the source, or adjust the phase shifter to get either a positive or negative peak voltage reading using the Marker function on the HP 3561A. To ensure that you have adjusted to the maximum peak setting, adjust to slightly beyond the maximum peak and then back to it. (The peak voltage setting can also be determined using a voltmeter or oscilloscope connected to the AUX MONITOR port on the HP 11848A.) When the peak setting has been attained, press **P**. When you are prompted to cause the second calibration peak, adjust to a maximum peak of the opposite polarity using the same technique. **NOTE** *For this calibration technique to be most accurate, the two signal paths to the HP 11848A Phase Detector should be well matched (>10 dB return loss) and the R port level should be at least 5 dB below the L port level. If you are not able to attain a true peak setting, you will have to use a different calibration technique.*
4	**Apply modulation to carrier.** Either a double-sided spur or modulation of the same type as is being measured.
	Action: Apply the modulation type required for your measurement. Apply angle modulation for a Phase Noise without PLL or FM discriminator measurement, or apply amplitude modulation for an AM measurement. Ensure that the modulation is applied at a level that will enable the HP 3048A to readily detect it above the noise of the device-under-test. The following maximum limits should also be observed. • Double-sided spur < −20 dB • AM < 10% (−26 dB) The offset frequency of the spur should be between 1 Hz and 50 kHz (or between 1 Hz and 20 MHz if an RF analyzer is configured in the test system).
5	**Apply calibration spur to carrier.** A single-sided spur is expected.
	Action: The spur is typically generated by combining a signal near the frequency of the device-under-test (UUT) with the UUT output. This can be done using a power splitter or a directional coupler. Turn on the spur signal source and note the amplitude of the spur signal relative to the amplitude of the UUT. The spur level should be high enough to be readily observable above the noise of the UUT on a spectrum analyzer. The spur level should not exceed −20 dBc relative to the UUT amplitude.

Table 8-3. Reference Messages (3 of 7)

6	**Remove the calibration spur.** If the spur signal is not removed, it will appear in the measurement and could affect the measurement results.
	Action: Disconnect or turn off the spur source without disturbing the frequency or amplitude settings of the source. **NOTE** *If you want to determine the frequency and amplitude of you spur source, leave the source connected and turned on during the measurement. The spur signal should appear in your measurement results. Note, however, that a large spur signal can prevent the test system from having the full dynamic range necessary to make a valid noise measurement.*
7	**Offset the source and reference signals by at least 1 Hz and not more than 50 kHz/1 MHz/20 MHz.** The test system requires that two different signals be applied to the input ports of the HP 11848A's Phase Detector. The frequencies of the two sources must differ as follows: • With RF Spectrum Analyzer in System, phase detector input frequency <95 MHz, Offset Range: 1 Hz to 1 MHz • With RF Spectrum Analyzer in System, phase detector input frequency >95 MHz, Offset Range: 1 Hz to 20 MHz • Without RF Spectrum Analyzer in System, Offset Range: 1 Hz to 50 kHz
	Action: Adjust the frequency of the unit-under-test (UUT) to offset it from the reference source frequency. If the UUT cannot be adjusted to create a frequency offset that is within the offset range specified above, substitute a different source for the UUT. Adjust the substitute source for the same power level as the UUT source it is replacing. Terminate any ports in 50Ω that are not connected during the substitution. Reconnect the UUT source after the calibration is completed.
8	**Remove the beatnote and connect the test system for noise measurement.**
	Action: Readjust the unit-under-test (UUT) to the frequency of the reference source or reconnect UUT.
9	**Phase lock has been lost. Select Proceed to attempt to re-lock the loop.** This message can be caused by any one of the following conditions. 1. Frequency drift > 25% of the Peak Tuning Range. 2. A phase transient > 0.25 radians. 3. Out-of-Lock detector set by search oscillator.

Table 8-3. Reference Messages (4 of 7)

9 (cont'd)	**Action:** Press **P** to cause the test system to attempt to relock the loop and re-measure the frequency segment. If the software is unable to relock the loop, Error 4 will be displayed, refer to Error 4 for recommended actions. (Note that this error is most typically caused by frequency drift of one of the sources. If this condition persists, it may be necessary to increase the Peak Tuning Range for the measurement.)
10	**The LNA of the HP 11848A is currently IN/OUT.** This message only appears if the Carrier Type "Pulsed" has been selected. The HP 3048A evaluates the total noise from the Phase Detector to determine whether the Low-Noise-Amplifier (LNA) should be switched IN or OUT. The LNA is normally switched in to provide the maximum measurement sensitivity for the test system. If the HP 3048A determines that the noise level from the Phase Detector will overload the LNA, the LNA is switched out. When the LNA is switched out, the test system's measurement sensitivity is degraded by 20 to 30 dB depending on the offset frequency. If you are measuring a device that has a very low noise level (near the test system's noise floor) this degradation may affect the measurement results.
	Action: Under most condition it is recommended that you proceed with the decision made by the HP 3048A. Toggling the LNA IN when the HP 3048A has determined it should be switched OUT can cause the noise from the Phase Detector to be compressed and the measurement results to be inaccurate. There are certain conditions when you may want to toggle the LNA OUT, however. 1. When Pulse Mode is enabled. If the Phase Detector dc offset is > 5 mVdc, the test system may not detect that the noise level is high enough to overload the LNA. 2. To duplicate the exact conditions that existed for a previous measurement where the LNA was switched out. 3. When you are performing the System Noise Floor Test and you want to evaluate the test system's noise floor without the LNA in the measurement path. If the HP 3048A has decided to switch OUT the LNA and you are concerned about measurement sensitivity, you may want to further evaluate the decision. Connect an oscilloscope to the AUX Monitor Port on the HP 11848A. Observe the LNA output and toggle the LNA IN. If the peak output level exceeds $-0.5V$ or $+1V$, the noise may be clipped or compressed so the measurements must be made with the LNA OUT. If the noise is not significantly clipped, the measurement may be made with the LNA IN.

Table 8-3. Reference Messages (5 of 7)

11	**The LNA of the HP 11848A has been bypassed. This will result in a degradation of the test system noise floor.** The HP 3048A evaluates the total noise from the Phase Detector to determine whether the Low-Noise-Amplifier (LNA) should be switched IN or OUT. The LNA is normally switched in to provide the maximum measurement sensitivity for the test system. If the HP 3048A determines that the noise level from the Phase Detector will overload the LNA, the LNA is switched out. When the LNA is switched out, the test system's measurement sensitivity is degraded by 20 to 30 dB depending on the offset frequency. If you are measuring a device that has a very low noise level (near the test system's noise floor) this degradation may affect the measurement results.
	Action: Proceed with the measurement. When the measurement is complete, evaluate the results to determine the possible causes of the high noise level at the Phase Detector output. A few possible causes are: 1. A large spur (> −40 dBc) on one of the input signals. 2. A high noise pedestal on one of the sources. 3. Spurs at the output of the Phase Detector. To determine whether bypassing the LNA has affected your noise measurement results, compare your results to the noise floor provided by the HP 3048A when the LNA is OUT. Use the phase Detector Constant value measured by the HP 3048A to determine the test system's noise floor with the LNA OUT from the Approximate HP 3048A Phase Noise Floor vs R Port Signal Level (refer to chapter 7, graph 1) graph. If it appears that your measurement may have been limited by the test system's noise floor with the LNA bypassed, it may be necessary to take one of the following actions to prevent the LNA from being switched out. 1. Reduce the phase Detector Constant by reducing the signal level into the R port of the Phase Detector. Then restart a New Measurement. 2. Suppress the noise and spurs at the Phase Detector output by increasing the Phase Lock Loop (PLL) bandwidth. The PLL bandwidth is increased by increasing the Peak Tuning Range (PTR) for the measurement. Details on increasing the PTR are provided in *Changing the PTR* in chapter 3 of the *Operating Manual*. If you want to further evaluate the LNA decision, abort the measurement and access the *Advanced Functions* window. Select the Carrier Type "Pulsed" and then start a Repeat Measurement. When the LNA decision is displayed again, connect an oscilloscope to the AUX Monitor port or the HP 11848A. Observe the LNA output and toggle the LNA IN. If the peak output level exceeds −0.5V or +1V, the noise may be clipped or compressed so the measurements must be made with the LNA OUT. If the noise is not significantly clipped, the measurement may be made with the LNA IN.
12	**A comparison of theoretical and actual PLL suppression indicates a degradation of the accuracy specified for the HP 11848A.** The Phase Lock Loop (PLL) Suppression is verified by measuring the actual loop suppression at frequencies near the predicted PLL bandwidth. This message is displayed when the measured loop suppression differs from the theoretical by > 1 dB.

Table 8-3. Reference Messages (6 of 7)

12 (cont'd)	**Action:** 1. The key factor for having a good match between the measured loop suppression and the theoretical is the accuracy of the phase Detector Constant and the VCO Tune Constant. Abort the measurement and verify that these calibration constants are accurate. a. Verify that the VCO Tune Constant entered for the measurement is within a factor of 2 of the VCO's actual tuning constant. (A procedure for evaluating the sensitivity of your VCO is provided in *Estimating the Tuning Constant* in chapter 3 of the *Operating Manual*.) b. Verify the phase Detector Constant by connecting an oscilloscope to the AUX MONITOR port on the HP 11848A. The peak voltage at the AUX MONITOR port should equal the phase Detector Constant measured by the test system. 2. If the calibration constants are accurate, begin a New Measurement and proceed to the hardware Connect Diagram. Observe the beatnote signal on the HP 3561A using the *Checking the Beatnote* procedure provided in each PLL measurement example in chapter 3 of the *Operating Manual*. a. Verify that the beatnote signal is sinusoidal (or triangular if the input signals are square waves or if the levels of both input signals are $> +15$ dBm). b. Verify that all even harmonics are ≤ -30 dBc on the beatnote and ≤ -20 dBc on the input signals. c. Check for injection locking. d. Check for noise that exceeds the small angle line. (Refer to *Evaluating Noise Above the Small Angle Line* in chapter 3 of the *Operating Manual* for a procedure.) 3. If the beatnote signal meets the preceding tests, proceed with a New Measurement. a. If the measured curve does not match the theoretical because it is noisy, press **F8** to proceed with the measurement using the theoretical PLL suppression data. The accuracy of the measurement results will be unverified but the results may help you to identify the source of the problem. b. If the measured curve does not match the theoretical because it has high peaks and the Accuracy Degradation is ≤ 2 dB, press **F1** to proceed with the measurement using an adjusted PLL suppression. The accuracy of the results will be degraded by 2 dB within a decade of the PLL bandwidth for the measurement. Figure 8-8 shows PLL bandwidth relative to the Peak Tuning Range (PTR) set by the VCO source. (Refer to chapter 2 in the *Reference Manual* for further information about the PTR.)

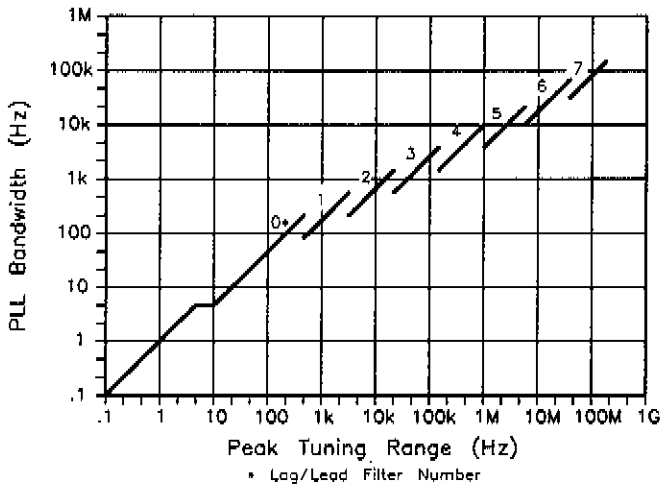
12 (cont'd)	c. If the Accuracy Degradation is >2 dB, perform steps 1. and 2. again very carefully, pay close attention to the accuracy of the calibration constants and injection locking. If the Accuracy Degradation is still >2 dB, ** press F1 to proceed with the adjustment to get an approximate noise measurement for use in further troubleshooting the problem.  **Figure 8-8. Phase Lock Loop Bandwidth Relative to the Peak Tuning Range.**
13	**Establish a beatnote less than or equal to ( ) Hz.** System perceives that sources are not within 5% of the defined Peak Tuning Range. Since the Reference Source is under manual control, the user is required to establish zerobeat.
	Action: Manually adjust the Reference Source to acquire a beatnote on the analyzer (on oscilloscope if corrected to the HP 11848A any monitor port) of less than or equal to the specified frequency.

Table 8-4. Warning Messages (1 of 2)

Calibration AM Rate changed... This warning informs the user of an automatic change in AM rate for the Calibration Source. The message occurs at test time to inform the user that some parameters have changed.
Calibration FM DEV changed from... This warning informs user of an automatic change in FM Deviation for the Reference Oscillator or Calibration Source. The message occurs at test time to inform the user that some parameters have changed.
Calibration FM Rate changed from... This warning informs user of an automatic change in FM Rate for the Reference Oscillator or Calibration Source. The message occurs at test time to inform the user that some parameters have changed.
Currently stored caldata files will be overwritten. This can be circumvented by using another disk... If data disk includes files LOWDATA.CAL& HIGHDATA.CAL, they will be overwritten. New calibration data may be recorded on a separate, initialized disk if it is desired to retain old caldata files.
Entered VCO Tune Const. changed from... This warning informs user of an automatic change in the VCO Tune Constant for the Reference Oscillator or Calibration Source. The message occurs at test time to inform the user that some parameters have changed.
RF Analyzer accuracy worse than 5 dB. This warning appears during the calibration of an RF analyzer. The difference in amplitude measurements between the HP 3561A and the RF analyzer is >5 dB when measuring the same 100 kHz calibration tone. **Action:** Verify the proper operation of the RF analyzer and HP 3561A using the appropriate calibration procedures discussed in their own calibration manuals.
Specified test-span not encompassed by currently defined segments... The user tried to perform a measurement for which his segment table does not contain defined segments. **Action:** Check the Plotted Ranges in the segment table against the offset frequency range specified for the test.

Table 8-4. Warning Messages (2 of 2)

The data in this RESULT FILE is not compatible with the current GRAPH TYPE. Plotting this data may give unexpected results. **Action:** Press **P** to proceed or **A** to Abort.
(instrument) is not responding... **Action:** Check that the correct HP-IB addresses have been entered into the Instrument Addresses table. Also check that the instrument is connected via HP-IB, and that its power is ON.

Table 8-5. Status Messages (1 of 11)

Acceptable 'Tuning Range' for this 'Center Voltage': The HP 3048A has automatically adjusted the Voltage Tune Range for the VCO to within acceptable limits. This is often due to the Tune Voltage Range limitation imposed by a Center Tune Voltage that is not equal to zero volts.

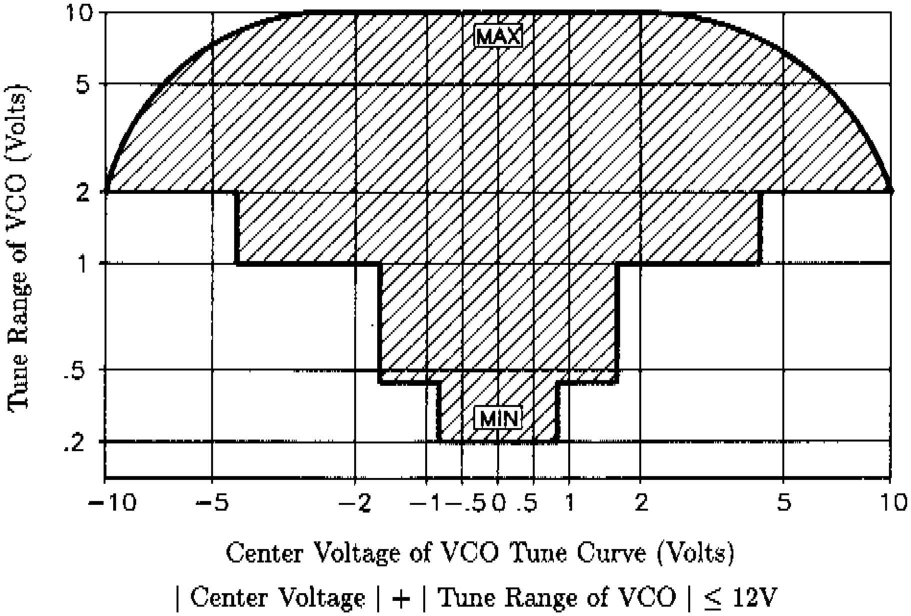


Figure 8-9. HP 3048A Tune Range of VCO Limits Relative to the Center Voltage of the VCO Tune Curve.

ADJUST 3585A TRACKING GENERATOR FOR MAXIMUM LEVEL... The level from the tracking generator is inadequate for the measurement.

Action: Turn the HP 3585A/B tracking generator knob fully CW and verify that the tracking generator output is connected to the correct HP 11848A Input.

Apply modulation to carrier... This is required for the Single Sided and Double Sided Spur and FM Rate and Deviation calibration techniques.

Action: Apply the modulation signal to the carrier.

Approx internal noise floor (LNA in, Offsets > 10 kHz: dBc/Hz... The Detector Constant and LNA determine the System Noise Floor.

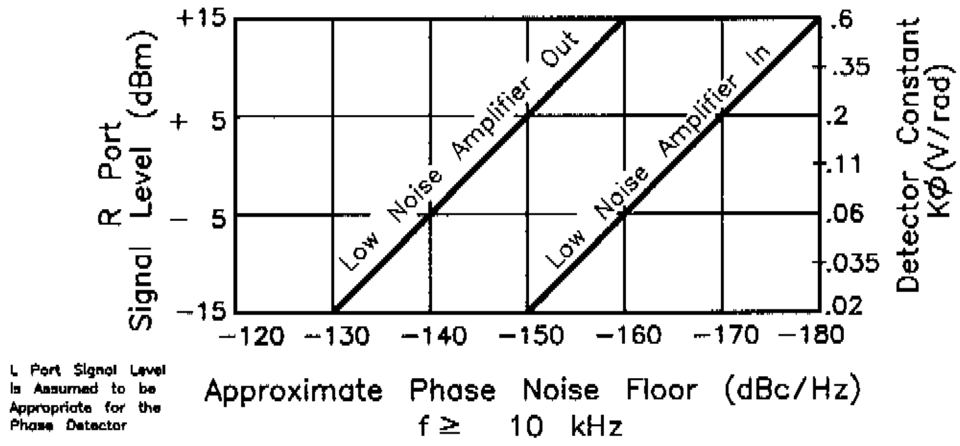


Figure 8-10. Approximate HP 3048A Phase Noise Floor vs R Port Signal Level.

Automatically establishing quadrature... The test system is establishing quadrature.

Beatnotes: f1, f2, f3, f4... Beatnote frequencies for −45%, −15%, +15%, and +45% of the Tuning Range around the Center Voltage are shown in conjunction with the non-linear Tuning Constant error.

Action: Correct the Tuning Constant error by finding a linear region in the center of the VCO Tuning Curve (Refer to Error Message 7).

Table 8-5. Status Messages (3 of 11)

Calibrating the RF Level of HP XXXXX... The test system measures the amplitude of a 100 kHz tone with both the RF analyzer and the HP 3561A. This insures consistency between the two analyzers at 100 kHz.
Cause FIRST calibration PEAK voltage... During calibration of the Phase Detector, the user is required to adjust the dc output of the phase detector to its maximum and minimum peak. **Action:** Adjust frequency or phase angle to drive the phase detector output to the positive or negative peak.
Cause SECOND calibration PEAK voltage... During calibration of the Phase Detector, the user is required to force the dc output of the phase detector to its maximum and minimum peak. **Action:** Adjust frequency or phase angle to drive the phase detector output to the opposite peak.
Checking for HP3561A Noise Source... The noise source is being tested for proper output level using the Performance Test technique described in the HP 3561A Service Manual. The HP 3048A also checks path attenuation in the HP 11848A.
Checking for overload... The test system verifies that an overload condition does not exist when using an AM detector.
Checking the PLL... The test system verifies that it is still phase locked.
Closing the Phase Lock Loop... This message notifies the user that the test system is in the process of closing the phase lock loop.

Table 8-5. Status Messages (4 of 11)

Crunch... The HP 3048A is performing an integration. Depending on controller speed and limits of integration this may take several minutes.
CURRENT (cal path) (PLEASE BE PATIENT)... This message indicates that a calibration path in HP 11848A is being characterized. This takes approximately 3 minutes.
Determining Presence of a Beat Note... The HP 3048A is checking the Peak Detector for a dc voltage indicating a beatnote.
Establish quadrature manually... The HP 3048A is unable to automatically establish quadrature. **Action:** If possible, manually adjust frequency or phase to achieve quadrature (0 ± 1 division on HP 11848A Interface Quadrature Meter).
Setting 785 Hz. beatnote... The HP 11848A internal 10 MHz sources are offset by 785 Hz during spur calibration (Spur Accuracy Test) to prevent extraneous signals from appearing when Phase Modulation sidebands are impressed on 10 MHz source.
Evaluating flatness of measured noise segments... The HP 3048A informs the user that an evaluation is in progress.
Finding spurs... The HP 3048A is searching and recording the amplitude and frequency of the spurs within the data currently in memory.
Finding the calibration spur... The HP 3048A is measuring and recording the calibration spur level.

Table 8-5. Status Messages (5 of 11)

Generating theoretical loop suppression... The HP 3048A is fitting the theoretical response generated from the calibration data and entered parameters to the measured response of the loop suppression.
LAG/LEAD... Indicates which Lag/Lead number is currently switched in during the functional check.
Manipulating FFT data... The HP 3048A is removing the spurs and processing the data from the selected Result Files.
Manipulating RF data... The HP 3048A is removing the spurs and processing the data from the selected Result Files.
Marker not within defined measurement span... The Marker position for the currently defined span in Noise Monitor Mode is outside of the Plotted Range specified in the Segment table. **Action:** Move the Marker or select the appropriate span and press TAKE SWEEP. If the appropriate SPAN is not available in the Segment table, the table must be modified to include the desired Plotted Range.
Measuring PLL suppression... When Verification of the Loop Suppression is selected, the test system locks the phase lock loop, injects noise into the loop, and then measures the response of the loop.

Table 8-5. Status Messages (6 of 11)

Measuring reference trace... This message indicates that a reference path for a transfer function measurement is in progress (Functional Checks).
Measuring the Phase Detector Constant... Measuring the phase Detector Constant is part of measurement calibration.
NO MARKED SPURS FOUND IN SPECIFIED RANGE... The HP 3048A was unable to detect any spurs in the specified range.
No Measurement Calibration is needed for the following measurement type: Noise Measurement Using HP3561A only, and (Baseband Noise)... Calibration Technique is not applicable for the measurement type selected.
NON-CLEARABLE SRQ EXISTS ON... The computer is unable to clear an SRQ on an instrument. (Often caused by placing the HP 3561A into free-run, auto trigger mode.) **Action:** Abort the measurement and press PRESET on the HP 3561A.
Offset the source and reference signals by at least 1 Hz and not more than 1 or 20 MHz, or 100 kHz. Press proceed when ready... This is a prompt for the beatnote calibration method. **Action:** Adjust the sources to obtain an offset frequency of $\geq$ 1 Hz and $\leq$ 100 kHz (or 20 MHz if an RF analyzer is being used).
One moment please... The HP 3048A is averaging the data taken for the low frequency spans.
Phase Det. Constant: Momentary display of the phase Detector Constant determined in the measurement calibration.

Table 8–5. Status Messages (7 of 11)

Phase lock has been lost. Press 'Proceed' to attempt to re-lock the loop... Phase lock was lost during the Phase Lock Loop measurement. **Action:** Press **P** to proceed (if you want to continue the measurement), or **A** to abort.
PLEASE BE PATIENT... The test system is in the process of making a 1 Hz Low Pass Filter calibration which takes approximately 3 min.
Plotting curve-fit corrections... This message informs the user that the HP 3048A is processing the curve-fit corrections.
Preparing for calibration... The test system is being preset for calibration.
Pre-setting HPXXXXX... The HP 3048A is setting up the specified instrument.
Pre-setting INTERNAL... The HP 3048A is setting up the HP 11848A Internal Oscillator.
RANGE IS UNACCEPTABLE... The specified measurement range has a Start Frequency greater than or equal to the Stop Frequency. **Action:** Re-define the Measurement Range.

Table 8-5. Status Messages (8 of 11)

Selecting the LNA... The HP 3048A is determining if the Low Noise Amplifier is required.
Setting up measurement configuration... The HP 3048A is configuring the instruments and/or the HP 11848A internal paths for the measurement.
Solving for (Osc unknown)... The HP 3048A is computing the noise of a source.
Solving for Osc_A,B,or C... The HP 3048A is computing the noise of each of the sources.
Span too narrow. Cannot integrate... The specified Range of Integration is not great enough to span a bin of the noise trace. **Action:** Increase the specified Range of Integration.

Table 8-5. Status Messages (9 of 11)

SYSTEM OPERATING IN PULSE MODE. ESTABLISH QUADRATURE VIA AUX. MONITOR PORT... The Carrier Type "Pulsed" was selected and the HP 3048A cannot verify quadrature or establish quadrature automatically. **Action:** Use a dc-coupled oscilloscope connected to the HP 11848A Aux Monitor Port to achieve quadrature (dc). Refer to *Carrier Type* in chapter 5, Advanced Functions for information on establishing quadrature with a pulsed measurement.
Taking (RF_Model) sweep... This message indicates that the test system is performing a measurement.
Taking HP 3561A sweep... This message indicates that the test system is performing a measurement.
TEST PATH: REFERENCE PATH... Indicates which HP 11848A internal path is being used for a reference measurement in a transfer function measurement.
The LNA is currently (in/out) When the Carrier Type "Pulsed" is selected in the Advanced Functions window, a "Toggle LNA" key appears in some windows to allow the user to select between having the LNA in or out. If the HP 3048A decides to switch OUT the LNA and you are concerned about measurement sensitivity, you may want to further evaluate the decision. Connect an oscilloscope to the AUX Monitor Port on the HP 11848A. Observe the LNA output and toggle the LNA IN. If the peak output level exceeds −0.5V or +1V, the noise may be clipped or compressed so the measurements must be made with the LNA OUT. If the noise is not significantly clipped, the measurement may be made with the LNA IN.
The LNA of the HP11848A has been bypassed. This will result in a degradation of the system noise floor. This is a status message indicating a high input level into HP 11848A. If you want to further evaluate the LNA decision, abort the measurement and access the Advanced Functions window. Select the Carrier Type "Pulsed" and then start a Repeat Measurement. When the LNA decision is displayed again, connect an oscilloscope to the AUX Monitor port or the HP 11848A. Observe the LNA output and toggle the LNA IN. If the peak output level exceeds −0.5V or +1V, the noise may be clipped or compressed so the measurements must be made with the LNA OUT. If the noise is not significantly clipped, the measurement may be made with the LNA IN.
The plotted data was derived from Two-oscillator or Three-oscillator comparison... This message is shown as the parameter summary for a result that was computed, not measured.

Table 8-5. Status Messages (10 of 11)

Timed-out setting ( ) on the... The HP 3048A attempted to address an instrument, but the instrument did not respond. **Action:** Access the Instrument Addresses table and and confirm that the correct HP-IB address have been entered and that the instrument is responding.
Timed-out reading the ( )... The HP 3048A attempted to address an instrument but it did not respond. **Action:** Access the Instrument Addresses table and confirm that the correct HP-IB address have been entered and that the instrument is responding.
Unable to Automatically Zero Beat the sources. Establish a beatnote less than or equal to ( ) Hz... The HP 3048A was unable to adjust the beatnote to within 5% of the Peak Tuning Range. **Action:** Adjust the source frequency until the beatnote is within 5% of the PTR.
Unable to integrate over non-contiguous data... Segments of the data are missing within the specified Integration Range. **Action:** Verify the Segment table ranges and remeasure the device across the entire desired integration range.
VCO Tune Constant: This message momentarily displays the measured VCO Tune Constant.
Verifying phase lock... The HP 3048A is verifying phase lock.

Table 8-5. Status Messages (11 of 11)

Verifying Quadrature... The HP 3048A is checking the dc level out of the Phase Detector.
Verifying system configuration... The HP 3048A is checking for a response from the instruments entered in the Instrument Addresses table.
Verifying zero-beat... The HP 3048A is checking that the beatnote is within 5% of the Peak Tuning Range.
Zero beating sources... The HP 3048A is automatically tuning the VCO to create a beatnote that is within 5% of the Peak Tuning Range.

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