

User's Guide

Agilent Technologies 85671A Phase Noise Utility



Agilent Technologies

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The following safety notes are used throughout this manual. Familiarize yourself with each of the symbols and its meaning before operating this instrument.

Caution

The *caution* note denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the instrument. Do not proceed beyond a *caution* sign until the indicated conditions are fully understood and met.

Warning

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

Instruction Manual



The **instruction manual** symbol. The product is marked with this symbol when it is necessary for the user to refer to the instructions in the manual.

General Safety Considerations

Warning

Before the spectrum analyzer is switched on, make sure it has been properly grounded through the protective conductor of the ac power cable to a socket outlet provided with protective earth contact.

Any interruption of the protective (grounding) conductor, inside or outside the instrument, or disconnection of the protective earth terminal can result in personal injury.

Caution

Before the spectrum analyzer is switched on, make sure its primary power circuitry has been adapted to the voltage of the ac power source.

Failure to set the ac power input to the correct voltage could cause damage to the instrument when the ac power cable is plugged in.

How to Use This Guide

Key Conventions.

The following key conventions are used in this guide:

- | | |
|------------------------------|---|
| <code>Front-panel key</code> | Text shown like this represents a key physically located on the spectrum analyzer. |
| <code>Softkey</code> | Text shown like this represents a softkey. (The softkeys are located next to the softkey labels, and the softkey labels are the annotation on the right side of the spectrum analyzer display.) |
| Screen Text | Text printed in this typeface indicates text displayed on the instrument's screen. |

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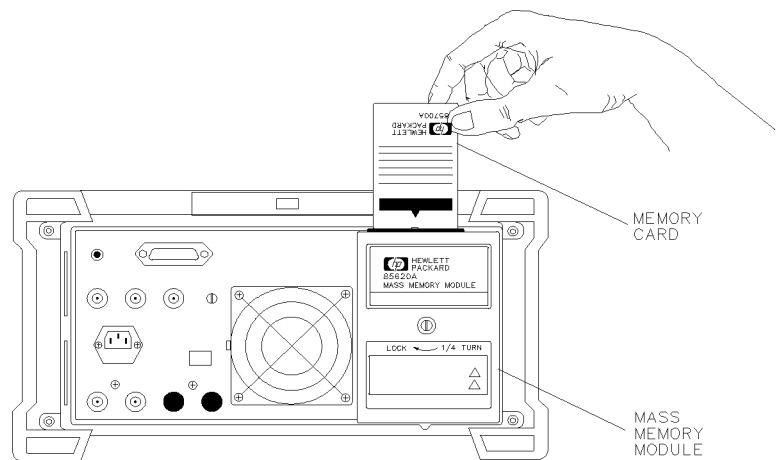
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Installing and Starting

The 85671A Phase Noise Measurement Utility is a down-loadable program (DLP) that is used with the 8560 E-Series and EC-Series spectrum analyzers. You need the following equipment to use the utility:

Phase Noise Measurement Utility	Mass Memory Module	Spectrum Analyzer
85671A	85620A (firmware revision C, 910116 and later)	8560A/E/EC (firmware 890720 and later) 8561A 8561B/E/EC (firmware 890720 and later) 8562A/B (firmware 870728 and later) 8563A/E/EC



pd71a

Figure 1-1. Equipment Used With Phase Noise Utility

When you first receive the phase noise utility on its memory cards you need to install it in the mass memory module. Once it is in the mass memory module it can be used by the spectrum analyzer.

The spectrum analyzer has direct access to the mass memory module using the **MODULE** key. To access the phase noise utility from the front panel of the spectrum analyzer, you will need to label one of the blank softkeys on the user menu. The following procedures describe how to copy the file, label the softkeys, and access the utility.

Copying the Phase Noise Utility

The phase noise utility comes on two memory cards. The file is called PH_NOIS1 and PH_NOIS2. Copy the utility from both memory cards to the mass memory module.

1. With the spectrum analyzer turned off, attach the mass memory module to the spectrum analyzer.
2. Insert one of the 86571A memory cards into the module. Make sure the arrow on the card is facing the matching arrow on the rim of the module's card slot.
3. Turn on the spectrum analyzer. After it completes its power-on sequence, press the **MODULE** key on the front panel.
4. Press the **UTILITY** softkey. After a short wait, the screen will list the current contents of the mass memory module. If there are files starting with PH_ do the next step, otherwise skip the next step.
5. The presence of files starting with PH_ indicates that an earlier version or a demo version of the utility is already loaded. To save time, we recommend that you delete those programs before continuing. Do one of the following steps.
 - a. If you **do not** find the program PH_REMOVE, press **MODULE**, **USER KEYS**, **PHASE NOISE**, and **EXIT ALL**. Repeat this process until the demo removes itself, then press **MODULE** **UTILITY**.
 - b. If you find the program PH_REMOVE, press **MODULE**, **KEYDEF**, and **CHOOSE DLP**. Move the cursor to highlight PH_REMOVE and press **EXECUTE NOW**, then press **MODULE** **UTILITY**.
6. Press the **CATALOG MEM CARD** key so that CARD is underlined. This will show the contents of the memory card. It should show the file PH_NOIS1 or PH_NOIS2.
7. Move the knob so that PH_NOIS1 (or PH_NOIS2) is highlighted and press the **COPY TO MEMORY** softkey. This will copy the utility from the memory card to the mass memory module.
8. Remove the first memory card and insert the other memory card.
9. Press the **CATALOG MEM CARD** key so that CARD is underlined. This will show the contents of the second memory card. Repeat the above process to copy the contents to the mass memory module.
10. To verify that the measurement utility is in the mass memory module, press the **CATALOG MEM CARD** so that MEM is underlined. This will show the contents of the mass memory module. There should be more than two pages of phase noise programs displayed beginning with PH_. The second page of programs can be viewed using the **NEXT PAGE** softkey.

Labeling a Softkey to Access the Phase Noise Utility

Label a spectrum analyzer softkey to access the utility which is stored in the mass memory module. The utility includes the PH_SETUP program which can be run at any time to assign softkeys and to return the program variables to the default values.

1. With the mass memory module attached to the back of the spectrum analyzer press the **MODULE** key.
2. To verify that the utility is in the mass memory module, press the **UTILITY**. The contents of the mass memory module should include many files beginning with PH_.
3. Press **MODULE** and **KEYDEF** to display the user-defined softkeys.
4. Now press the **CHOOSE DLP** softkey. This displays a list of the down-loadable programs (DLPs) in the mass memory module.
5. Locate and highlight the DLP labeled PH_SETUP, using the knob, the step keys, and the **NEXT COLUMN** and **NEXT PAGE** softkeys.
6. Press the **EXECUTE NOW** softkey to start the setup process below:

- a. Some initialization will automatically be done.
- b. You will be asked to press one of the empty softkeys along the right edge of the display so it can be labeled to access the utility. Press the key labeled **NO KEY** if you do not want to label a softkey.

The setup routine can be used to label only the first five user keys. If you have other programs in use which are using all of those softkeys, press the **NO KEY** softkey. Follow the manual procedure below to put the phase noise utility softkeys on the second page of the user keys menu.

- c. You will then be asked to press another softkey so it can be labeled to access the spot frequency measurement.
7. One user softkey should now be labeled **PHASE NOISE** and another labeled **MEASURE SPOT FRQ**. The installation is now complete.
8. To manually label the user keys do the following:
 - a. Press **MODULE** and **KEYDEF**. Then use the knob to point to the desired key label location.
 - b. Press **CHOOSE DLP**, move the knob to highlight the PH_NOISE program, and press **SELECT**.
 - c. Repeat the above process selecting the PH_SPOTF program, to set up the spot frequency measurement.
 - d. The key labels will not be the same as those assigned by the automatic setup program.

The automatic setup program should be run to initialize variables even if it is not used to set up the softkey labels.

Starting the Phase Noise Utility

The phase noise utility can be started easily once the program is in the mass memory module and a spectrum analyzer's user key has been labeled to access it.

The desired carrier signal should be visible on the spectrum analyzer before starting the utility. When the utility is started, it finds the largest signal in the current span and assumes this will be the carrier frequency.

1. With the mass memory module attached to the spectrum analyzer press **MODULE**.
2. Press **USER KEYS**. This will display the user-defined softkey menu. The label **PHASE NOISE** should be on the softkey selected in the installation.
3. Press the **PHASE NOISE** softkey to start the utility.

Using the Phase Noise Utility

The phase noise utility uses a series of softkey menus displayed along the right edge of the spectrum analyzer display. Use the **EXIT ALL** softkey to end the utility.

Note

DO NOT use other front-panel keys when the utility is running, except to enter data, or you will exit the utility prematurely.

The phase noise utility main menu allows you to:

MEASURE LOG PLOT

Make a phase noise measurement over a range of offset frequencies.

MEASURE SPOT FRQ

Continuously measure phase noise at a single offset frequency.

CONFIG

Set up the measurement parameters.

RECALL TRACE

Displays a trace that was saved previously. Make sure the current phase noise measurement state is set the same as the state of the saved trace.

HELP

Displays textual information associated with the utility.

EXIT ALL

Exits the phase noise utility and recalls the instrument state that was saved when the phase noise utility was first invoked.

Making A Log Plot Measurement

A log plot measurement of phase noise is probably the most common use of the phase noise utility. See the following example.

1. Connect the front panel CAL OUTPUT to the INPUT 50 Ω .
2. Make sure that the desired signal is on the display. When the utility is started it selects the highest displayed signal to measure.
3. Press **MODULE**, **USER KEYS**, and **PHASE NOISE**.
4. The configuration screen, Figure 1-2, shows the current measurement settings. Press **CONFIG** to access the configuration menu of softkeys.

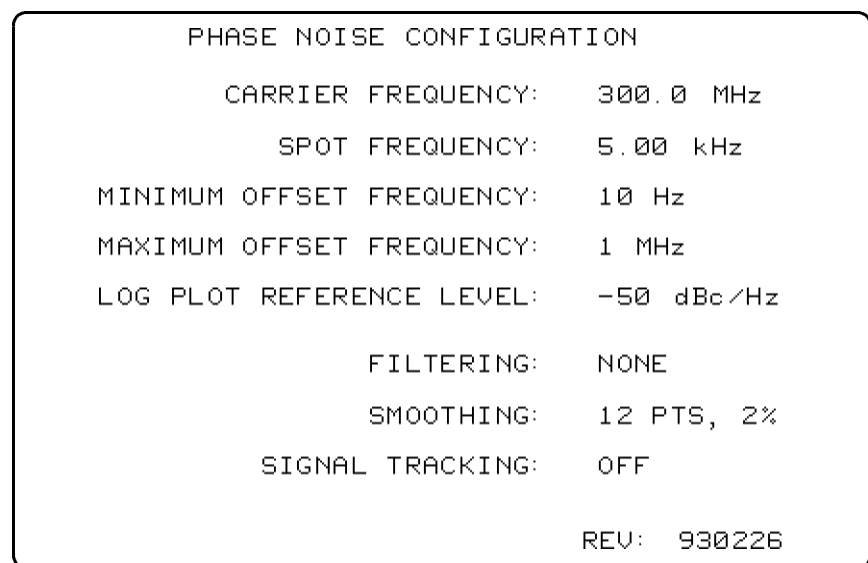


Figure 1-2. Configuration Screen

5. Press **MINIMUM OFFSET** and set the minimum offset frequency to 1 kHz.
6. Press **MAXIMUM OFFSET** and set the maximum offset frequency to 100 kHz.
7. Press **MAIN MENU** and **MEASURE LOG PLOT** to start the phase noise measurement. See Figure 1-3.

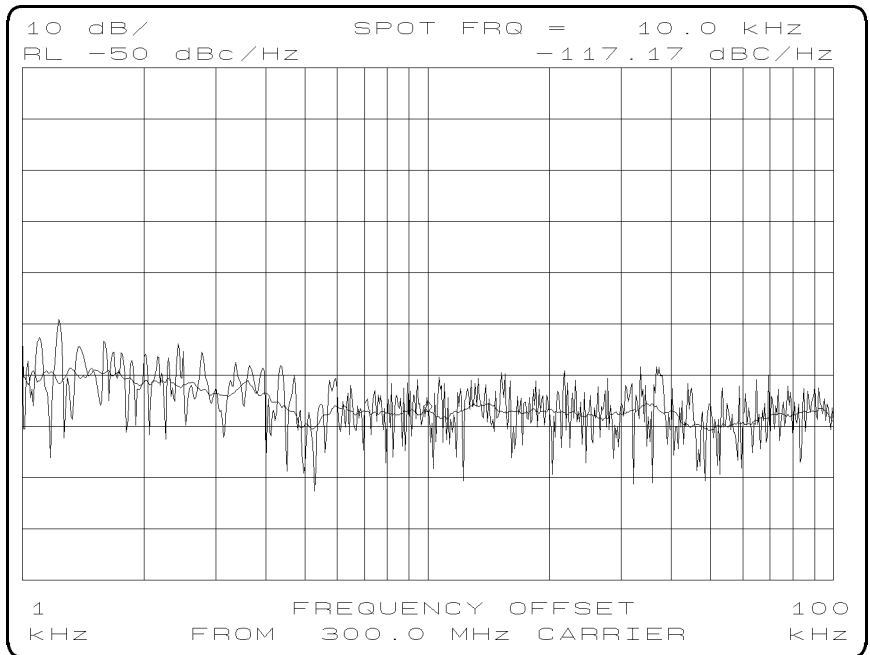


Figure 1-3. Log Plot Measurement

8. Press **SET SPOT FRQ** and change the spot frequency selection to a value between the minimum and maximum offset frequencies.
9. Press **SMOOTH TRACE** and **12 PTS 2% AVG**. Notice that the amount of smoothing that is currently selected is marked with an * (asterisk). Select different amounts of smoothing and notice the effects on the trace.

Removing the Phase Noise Utility

The phase noise utility can be removed from the mass memory module using a program included on the 85671A memory card.

1. Make sure the module is attached to the spectrum analyzer. (Always turn off the power before attaching or removing the mass memory module.)
2. Press **MODULE** key. Then press **KEYDEF** and **CHOOSE DLP**.
3. Use the knob, the step keys, the **NEXT COLUMN** softkey, and the **NEXT PAGE** softkey to locate and highlight the DLP labeled **PH_REMOVE**.
4. Press the **EXECUTE NOW** softkey. All of the entries related to the phase noise utility will be deleted from the mass memory module and the associated memory space will become available for other programs.
5. The user key labels will also be removed if they were created using the utility's automatic setup program.
6. To clear user key labels that were created manually, do the following:
 - a. Press **MODULE** and **KEYDEF**.
 - b. Use the step keys or the knob to highlight the user key that you want to clear. Press **CLEAR**.
 - c. Highlight another key if you want to clear more user key labels, or press **CLEAR ALL** to remove all of the labels.

Using the Phase Noise Utility

This chapter includes the following:

- Specifications and Characteristics
- Functionality
 - The Main Menu
 - Log Plot Measurements
 - Spot Frequency Measurements
 - RMS Phase Noise Measurement
 - Smoothing, Averaging, or Filtering
 - Signal Tracking
 - Printing and Plotting
 - Saving and Recalling Traces
- Measurement Considerations
 - Offsets ≥ 1 MHz
 - Slowly Drifting Signals
 - System Noise Floor
 - Use of the Bottom Division of the Display

Other Documentation

The document listed below provides information on making phase noise measurements. It can be obtained through your local Agilent Technologies office.

Part Number	Title
1000-1132	<i>RF and Microwave Phase Noise Measurement Seminar</i>

Specifications and Characteristics

Specifications shown are based on operation of the phase noise utility with an 8560 E-Series or 8560 EC-Series spectrum analyzer.

Measurement characteristics	
Measurement modes	Measure log plot Measure spot frequency RMS Noise
Maximum number of decades	5 (whole decades only)
Filtering (ratio of video bandwidth to resolution bandwidth)	None (VBW/RBW = 1) Little (VBW/RBW = 0.3) Medium (VBW/RBW = 0.1) Maximum (VBW/RBW = 0.03)
Smoothing	12 points, (2%) 24 points, (4%) 48 points, (8%) 96 points, (16%)
Data Storage	5 internal trace memory registers

Log graph hardcopy output	
Printers	HP 3630A PaintJet, HP 2225A ThinkJet
Plotters	HP 7440A, HP 7470A, HP 7475A, HP 7550B (7550A emulation mode)

Carrier frequency Range	
100 Hz to 2.9 GHz	8560A, 8560E/EC
100 Hz to 6.5 GHz	8561A, 8561E/EC
9 kHz to 26.5 GHz	8562A, 8562B, 8563E/EC
100 Hz to 26.5 GHz	Agilent 8563E/EC Option 006

Offset frequency	
Range	10 Hz to 100 MHz

The minimum range is limited to $10 \times$ the narrowest resolution bandwidth of the spectrum analyzer.

2-2 Using the Phase Noise Utility

Input signal level	
Maximum	+ 17 dBm (ref level = -50 dBc/Hz)
Minimum (for optimum dynamic range)	-17 dBm (offsets ≤ 100 kHz, 10 dB input attenuation)

Measurement Accuracy (characteristic)	
Amplitude accuracy	±2.5 dB (≥10 dB above system noise floor)
Log graph frequency accuracy	± 5%
Amplitude repeatability	see table below

Filtering	Repeatability Characteristics*	
	No Smoothing	12 point Smoothing
none	±15 dB	±5 dB
little	±12 dB	±4 dB
medium	±7 dB	±2.5 dB
maximum	±4 dB	±1.5 dB

*Smoothing can cause additional amplitude errors near rapid transitions of the data, such as with discrete spurious signals and impulsive noise. The effect is more pronounced as the number of points smoothed increases.

RMS Phase Noise Calculation	
RMS phase noise is calculated over a user specified	integration range.
Data points used	All, 1/2, 1/4, 1/8

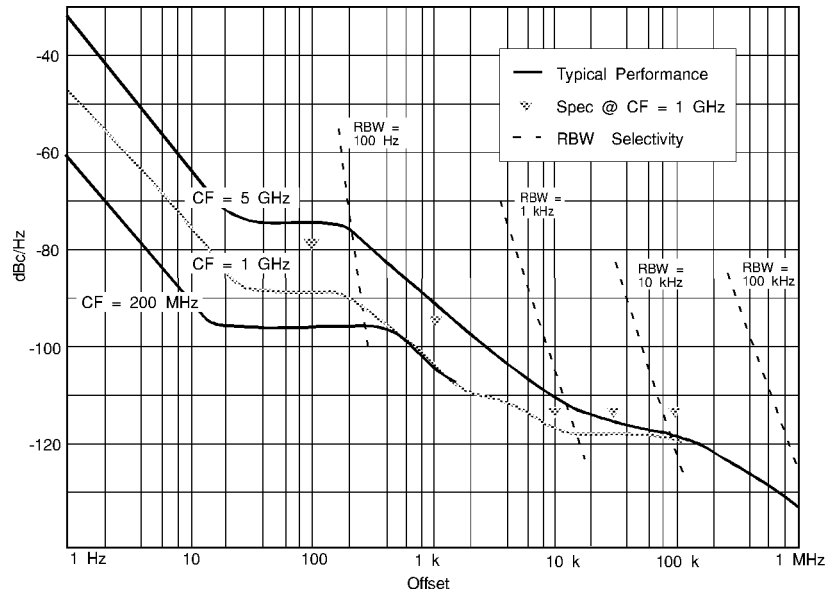


Figure 2-1.
8560 E-Series and EC-Series System Noise Floor Characteristics

Functionality

The utility's main function is to make phase noise measurements. It also has several other functions to make the measurements easier to make, save, compare, and print.

The Main Menu

When the phase noise program is started, the screen displays the main menu of softkeys and the configuration parameters as shown in Figure 2-2. The configuration parameters are either the default set for the first time the program is run, or they are the same as the last time the program was used. The only exception to this is the carrier frequency. It will reflect the highest signal, within the marker accuracy, that was present on the spectrum analyzer display when the phase noise program was invoked.

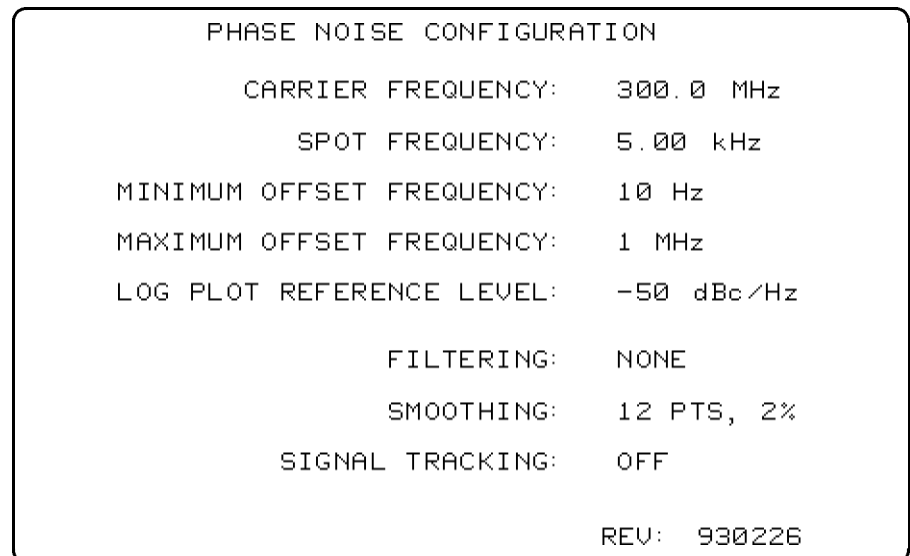


Figure 2-2. Main Menu

If a displayed parameter needs to be changed, this may be done using the **CONFIG** softkey.

If the parameters are the desired values, a phase noise measurement may be made either at a single offset frequency (**MEASURE SPOT FRQ**) or over a range of offset frequencies (**MEASURE LOG PLOT**).

The **RECALL TRACE** softkey will generate a log frequency graticule and annotation but will not make a measurement. This softkey allows you to recall a saved trace without waiting for a measurement to complete. There is no spectrum analyzer state saved with a saved trace, so the user must remember to reconstruct the state in order to correctly display a saved trace.

The **HELP** softkey makes information easily accessible to assist the user.

The **EXIT ALL** softkey returns the instrument to normal spectrum analyzer operation, and restores the original instrument state. This is the only recommended way to exit the phase noise program. Using

other keys, such as **PRESET**, will exit the utility but may leave it in a state that will cause unpredictable results the next time the utility is started.

Log Plot Measurements

The log plot measurement approximates an exponential frequency sweep with a set of linear sweeps pieced together to give a display of $\text{dBc}/\sqrt{\text{Hz}}$ vs. logarithmic frequency offset. Trace B, which is the dimmer trace, displays the point-by-point data as measured. Trace A, the brighter trace, displays a smoothed version of trace B. The amount of smoothing is determined by the current setting of the smoothing parameter. The phase noise at the selected spot frequency is also displayed numerically. The results of a log plot measurement may be smoothed, saved, or plotted.

The **MEASURE LOG PLOT** softkey, allows a measurement to be repeated with a single key press. This is useful for seeing effects of circuit changes where the carrier and offset frequencies of interest do not change.

The display includes a numerical readout (in dBc) of a single offset frequency that may be changed with **SET SPOT FRQ**. Changing the spot frequency will redraw the display with the marker in the new position and with the new value for the spot measurement.

Spot Frequency Measurements

A continuous phase noise measurement can be made at a single offset frequency using the spot frequency measurement function. When making several spot frequency measurements at different frequencies, set the minimum and maximum offset frequencies wide enough to include all of the desired frequencies.

RMS Phase Noise Measurement

Phase noise measurement results can be integrated over a selected frequency range to get the total RMS (root mean squared) noise in a given bandwidth. The frequency limits are set with softkeys. The number of points used for the integration may be selected. This allows you to choose between speed and accuracy. (Using fewer points does not usually reduce the accuracy very much.) The **EXECUTE** key initiates the calculation. The results are displayed in radians and degrees.

Smoothing, Averaging, or Filtering

Noise reduction on the trace can be accomplished several different ways. Smoothing is used with log plot measurements while trace averaging is for spot frequency measurements. Video filtering can be used with both types of measurements.

The smoothing process averages a number of adjacent trace points of trace B and displays the result in trace A for a log plot measurement. Smoothing is faster, but less accurate, especially for rapid changes in the trace like a trace with a discrete signal such as a spurious

sideband. Choose **SMOOTH TRACE** to display a menu of softkeys that allow different amounts of smoothing. Each amount of smoothing may be tried without redrawing the entire screen. When the desired amount is displayed, the smoothing menu exit key **PREVIOUS MENU** is pressed and the screen is redrawn to reflect any new spot frequency amplitude change that is caused by the change in smoothing.

Trace averaging can be used when making spot frequency measurements. Since noise is not correlated from sweep to sweep, successive traces can be averaged to reduce the peak to peak amplitude of the noise. Trace averaging gives more repeatable results.

Video filtering can be applied to the active trace when making spot frequency or log plot measurements. The amount of filtering can be changed from the **CONFIG** menu. Additional filtering will increase the accuracy and repeatability of the measurement, but will take longer. The filtering softkeys change the ratio of the video bandwidth to the resolution bandwidth.

Signal Tracking

Signal tracking can be used for log plot measurements to measure a slowly drifting signal. When it is enabled (ON), the measurement will follow a very slowly drifting signal by re-acquiring the signal between each of the ten sweeps that make up one complete log plot. When signal tracking is on, the measurement will be somewhat slower.

Note

When signal tracking is on, a slowly drifting signal will be tracked during a log plot measurement. The maximum drift rate that can be tracked will depend on instrument settings such as minimum offset frequency and the amount of filtering.

If the drift is not completely compensated, depending on the direction of drift, the measured phase noise will appear either higher or lower than it actually is.

Plotting and Printing

The log plot measurement results may be sent to a GPIB plotter or GPIB printer such as a ThinkJet or PaintJet by using the **HARD COPY** softkey. This brings up the menu of softkeys shown below.

HARD COPY

PLOT ALL

PLOT TRACE A

PLOT TRACE B

PRINT B&W

PRINT COLOR

PREVIOUS MENU

The **PLOT ALL** soft key will plot everything on the screen except the softkey annotation to a GPIB plotter set to address 5. The **PLOT TRACE A** and **PLOT TRACE B** softkeys give ways to add subsequent measurement traces to existing plots without replotting the annotation or graticule. This is considerably faster than plotting everything. The **PRINT B&W** softkey should be used with

monochrome printers, such as the HP ThinkJet. The printer needs to have its GPIB address set to 1. The **PRINT COLOR** softkey should be used with HP PaintJets. Their GPIB addresses should also be set to 1.

Log plot measurements include both trace A and trace B. An easy way to display just the smoothed information from trace A is to save trace A and recall it to trace B. This makes both traces contain the same data so that only the smoothed trace shows for use in a hard copy output.

Note

Only the softkeys in the utility should be used to plot or print. Unpredictable results will occur if any other keys are used, such as the **(COPY)** key. It is also important that the plotter or printer be connected and functional (that it have paper ready and be on line). If this is not the case, the spectrum analyzer may lock up and need to be turned off and back on to recover. When using a plotter or printer with the phase noise utility, make a trial plot from the normal spectrum analyzer mode to verify plotter operation whenever a change in the plotter setup has occurred.

Saving and Recalling Traces

The results of a log plot measurement may be saved into trace registers of the spectrum analyzer and recalled for later viewing. The spectrum analyzer state of the measurement is not saved. These trace registers are the same ones used by the front panel **(SAVE)**, **SAVE TRACE A** key combination in normal spectrum analyzer operation. Saving a trace in the phase noise utility overwrites any previous trace in the chosen trace register.

Use of the save and recall trace functions simplifies comparison of traces from separate measurements. When a trace is recalled, the instrument must be manually configured to match the state of the saved trace, since the spectrum analyzer state is not saved with the trace. A trace recalled into trace B can subsequently be smoothed and displayed in trace A.

Measurement Considerations

Offsets ≥ 1 MHz For measurements at offsets of 1 MHz the spectrum analyzer noise floor is usually about -133 dBm. To get this measurement range you must select 0 dB input attenuation before entering the utility.

Caution Input attenuation helps protect the spectrum analyzer input from being damaged by too much power from the device being tested. The use of 0 dB input attenuation should be minimized to protect the spectrum analyzer.

Slowly Drifting Signals

A log plot measurement can be made on a slowly drifting signal using the tracking function, but the measured value will be slightly inaccurate. The maximum drift rate that can be tracked will depend on instrument settings such as minimum offset frequency and the amount of averaging. Depending on the direction of the drift, the phase noise will appear either higher or lower than it actually is.

System Noise Floor The system noise floor should be checked with a clean source for the frequency offsets that will be measured. The signal frequency should be the same as the signal to be measured, since the system phase noise is a function of the spectrum analyzer center frequency. Do **NOT** use the internal calibrator to find the noise floor because phase noise cancellation will occur which will make the noise floor appear to be lower than it actually is.

Use of the Bottom Division of the Display

Phase noise measurements made in the bottom division of the display will not be as accurate as those made in the remainder of the display. If measurements are occurring in the bottom division the reference level, set in the utility, should be decreased (made more negative.)

Frequency Offset Limitations

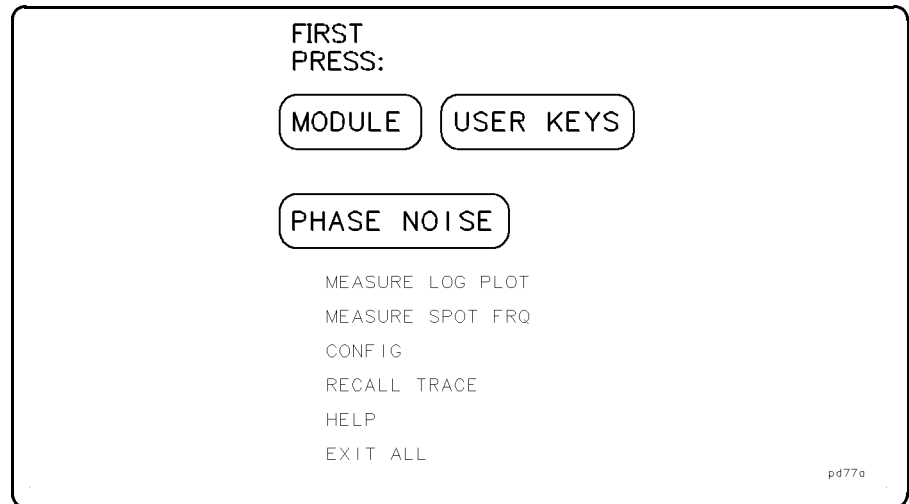
You define the range of offset frequencies to be measured using the **MIN OFFSET FREQ** and **MAX OFFSET FREQ** functions. There are limits on the number of significant digits entered when setting the minimum and maximum offset frequencies. The entry will be rounded to the nearest acceptable value.

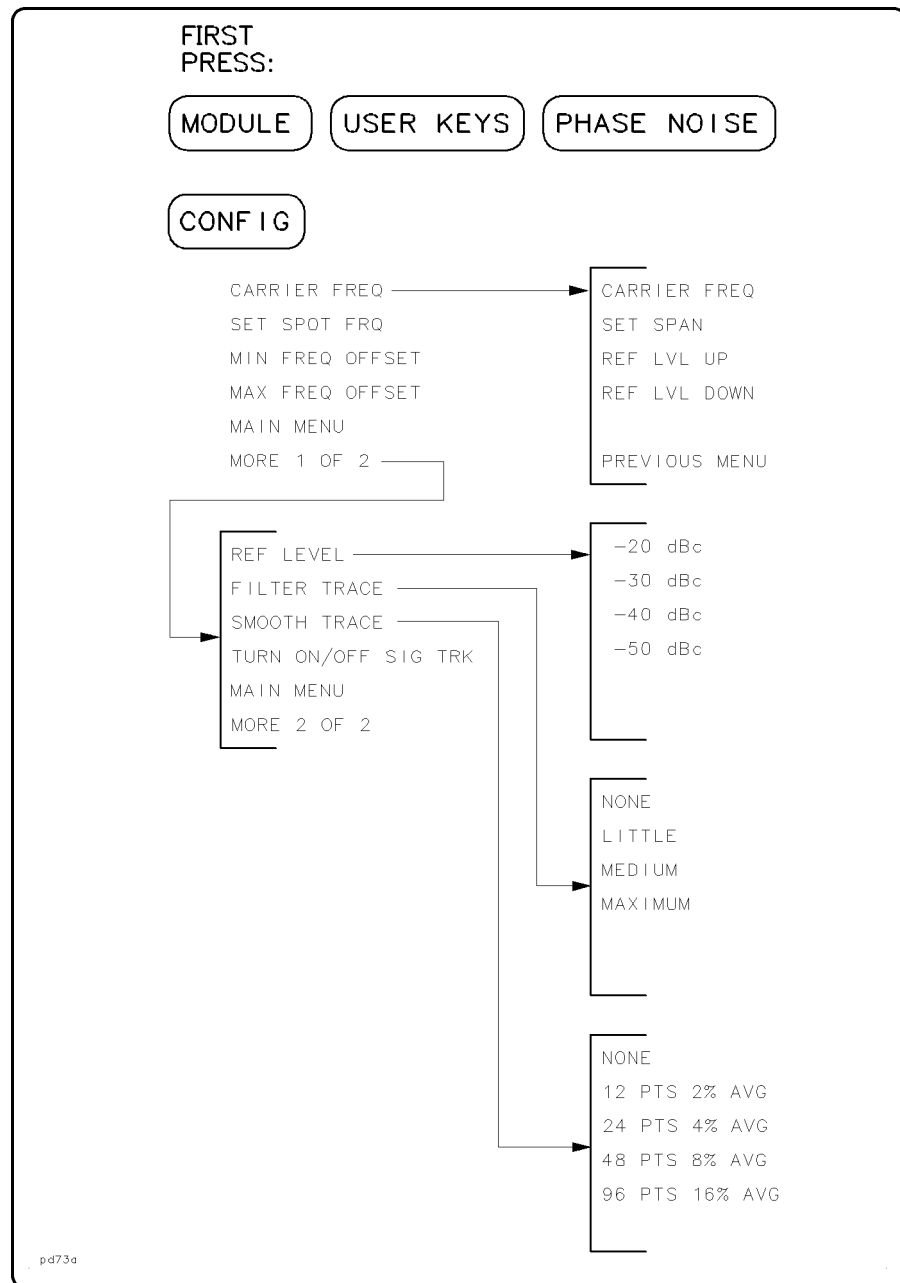
The offset range must be set to multiples of a decade, between 1 and 5 decades. There are limitations on how small the offset range can be. These limitations are determined by the carrier frequency and the desired minimum offset frequency. See the following:

Table 2-1. Offset Frequency Range Requirements

Spectrum Analyzer	Carrier Frequency	Minimum Offset Frequency	Required Offset Range
8560E/EC <i>and</i> 8561E/EC	all frequencies	<35 Hz <15 Hz	at least 2 decades at least 3 decades
8563E/EC <i>and</i> 8564E/EC <i>and</i> 8565E/EC	≤6.46 GHz " >6.46 GHz " "	<35 Hz <15 Hz <110 Hz <65 Hz <35 Hz	at least 2 decades at least 3 decades at least 2 decades at least 3 decades at least 5 decades

Softkey Menus and Descriptions





3-2 Softkey Menus and Descriptions

FIRST
PRESS:

MODULE

USER KEYS

PHASE NOISE

HELP

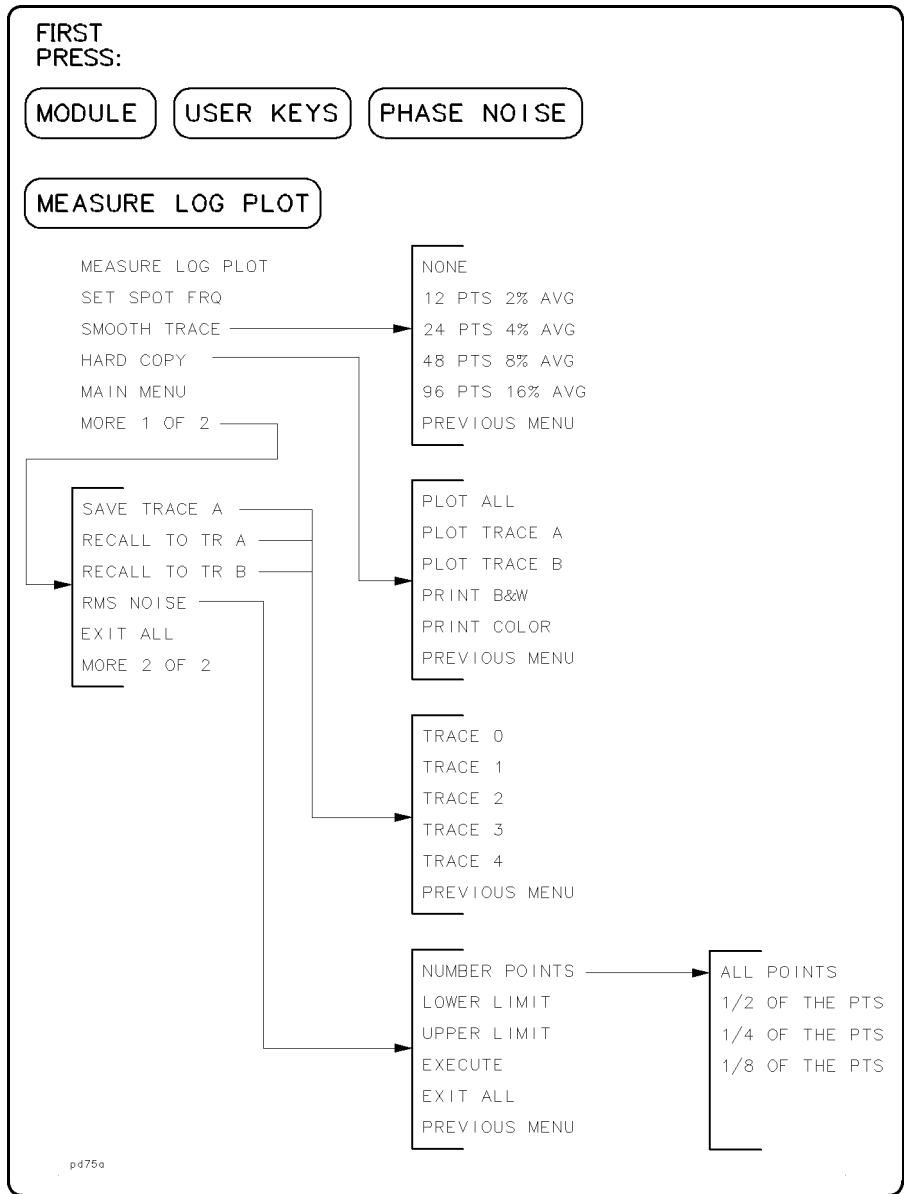
GENERAL INFO

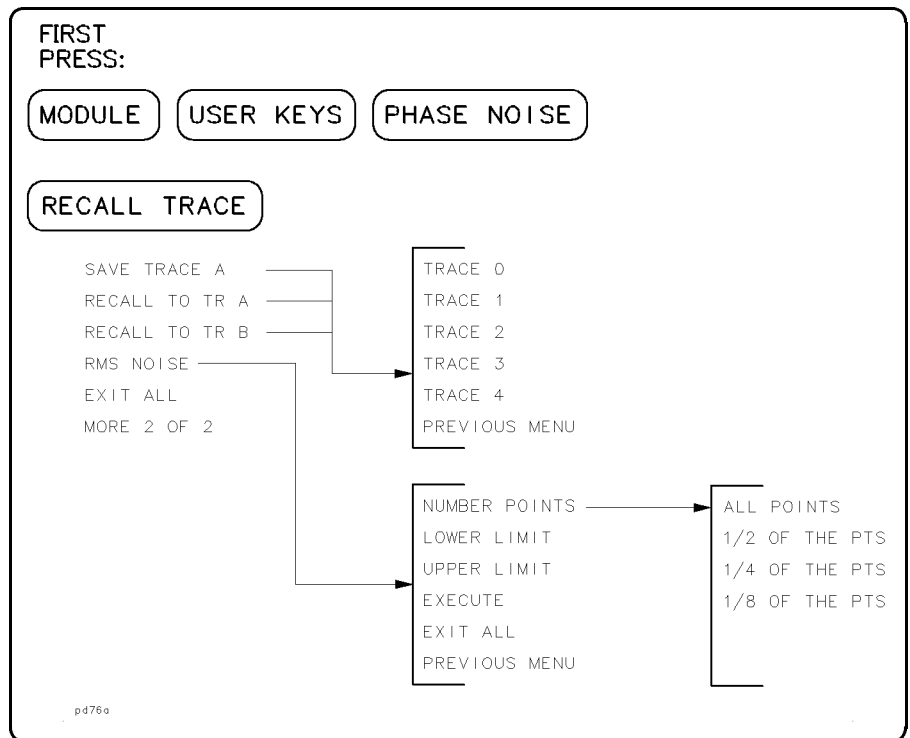
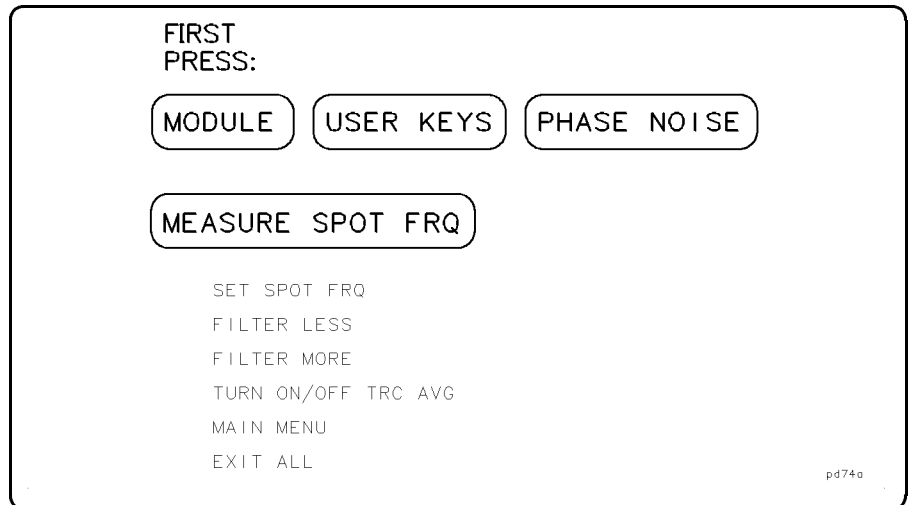
CAUTIONS

FEATURES

MAIN MENU

p472e





12 PTS 96 PTS
2% AVG through 16% AVG

sets the amount of trace smoothing to be used on a log plot measurement. A running average is taken with the selected quantity of trace points from trace B being averaged and put into trace A. The indicated averaging is based on there being 601 points in a trace.

Press front-panel keys **(MODULE)**, **USER KEYS**, and **PHASE NOISE**. Then press either **MEASURE LOG PLOT** and **SMOOTH TRACE** or **CONFIG**, **MORE 1 OF 2**, and **SMOOTH TRACE**.

**CARRIER
FREQ**

allows the user to change the signal which is selected for phase noise measurement. When the phase noise utility is started, the highest displayed signal is selected as the carrier signal. Pressing this softkey brings up a swept spectrum analyzer display showing the current span, center frequency, and reference level settings. At the same time, the softkey menus change to keys which enable changing the carrier frequency, the span, or the reference level to put the desired signal on the display. The active function area shows that the user should enter a carrier frequency. This must be done using the number keys and a units terminator key.

Pressing **CARRIER FREQ** or **SET SPAN** will display that parameter as the active function. You then enter a value using the number pad and terminate the entry with a units key such as Hz or MHz. **REF LVL UP** and **REF LVL DOWN** immediately increment the reference level by 10 dB in the selected direction.

When the desired signal is on screen, and is the highest signal on screen, **PREVIOUS MENU** should be pressed to return to the previous configuration.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

CAUTIONS

displays textual information outlining some situations which can cause unpredictable results or which can cause inaccurate measurements.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, and **HELP**.

CONFIG

brings up the softkeys that allow the measurement parameters to be changed. They are displayed on the initial screen, the one that accompanies the main menu keys.

Press front-panel keys **MODULE**, **USER KEYS**, and **PHASE NOISE**.

EXIT ALL

exits the phase noise utility and recalls the original state that was saved in state 9 when the phase noise program was first invoked. This is the only way to correctly exit the utility. Pressing other front panel keys will generally exit the program but the original state will not be restored.

Press front-panel keys **MODULE**, **USER KEYS**, and **PHASE NOISE**.

FEATURES

displays textual information outlining some of the functions of the phase noise program which enhance its usefulness and may not otherwise be obvious.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **HELP**.

FILTER LESS and FILTER MORE

change the amount of video filtering applied to the active trace when making a spot frequency phase noise measurement. **FILTER MORE** will reduce the peak to peak amplitude of the noise, and give more repeatable results while lengthening the sweep time. **FILTER LESS** will increase the video bandwidth until it is equal to the resolution bandwidth. There is no speed advantage in increasing the video bandwidth beyond the resolution bandwidth, so it is limited to this value.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **MEASURE SPOT FRQ**.

**FILTER
TRACE**

sets how much video filtering is to be applied when the phase noise measurement is done. More filtering will increase the accuracy and repeatability of the measurement, but will take a longer time. The different softkeys change the ratio of the video bandwidth to the resolution bandwidth, changing the amount of filtering. There are four different levels of filtering available. An asterisk denotes the current setting. Pressing one of the filtering keys will make the change, redraw the configuration to reflect the change, and put back the second page of the configuration menu softkeys.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

**GENERAL
INFO**

displays textual information about the phase noise utility. This helps you understand what the program measures and some of the basic limitations.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, and **HELP**.

**HARD
COPY**

access the softkeys that control direct printer or plotter outputs from the phase noise utility. HPGL plotters and HP raster graphics printers are supported. LaserJets, DeskJets, and other PCL printers are not supported.

The plotter or printer must be set up correctly. It must be turned on, have paper loaded, have the correct address, and be connected. If the output device is not set up properly when one of the print or plot keys is pressed, the spectrum analyzer can lock up. This would require the power be turned off and then back on. When using a plotter or printer with the phase noise utility, make a trial plot from the normal spectrum analyzer mode to verify plotter operation whenever a change in the plotter setup has occurred.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, and **MEASURE LOG PLOT**.

**LOWER
LIMIT**

sets the lower-frequency integration limit for the RMS noise calculation. The value must be between the minimum and maximum offset frequencies of the log plot measurement.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **RECALL TRACE**, and **RMS NOISE**.

MAIN
MENU

exits the current menu and brings up the phase noise utility's main menu softkeys. It also causes the configuration screen to be displayed or updated.

MAX FREQ
OFFSET

prompts the user for a new maximum offset frequency. This value is the maximum offset frequency displayed by a log plot measurement. All entries are rounded up to give an integral number of decades of offset frequency range, based on the minimum frequency offset setting. The maximum number of decades of frequency offset range is limited to five. The minimum number of decades of frequency offset range is dependent on the carrier frequency and the current setting of the minimum frequency offset.

After the maximum frequency offset is changed, the spot frequency will also be adjusted, if necessary, to keep it between the minimum and maximum offset frequencies. The maximum offset frequency available for the 8560 E-Series and EC-Series is 100 MHz.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

MEASURE
LOG PLOT

initiates a phase noise measurement over the range of offset frequencies shown on the configuration screen. The results are displayed on a $\text{dBc}/\sqrt{\text{Hz}}$ vs. log frequency screen. A numeric readout is made at the selected spot frequency. The utility measures only the upper noise sidebands.

Press front-panel keys **MODULE**, **USER KEYS**, and **PHASE NOISE**.

MEASURE
SPOT FRQ

puts the spectrum analyzer in the appropriate state for continuously measuring the phase noise at a single offset frequency. The span is set to four times the offset frequency, with the carrier in the center of the displayed frequency range. The spectrum analyzer remains sweeping continuously. The resultant noise amplitude at the spot frequency is indicated by the spectrum analyzer's normal noise marker (the numeric value is in the upper right hand corner of the screen). **MEASURE SPOT FRQ** gives a single frequency measurement more quickly than using **MEASURE LOG PLOT**.

When the **MEASURE SPOT FRQ** key is pressed a new set of softkeys becomes available to enable filtering, averaging, and changing the spot frequency. The utility measures only the upper noise sidebands.

Press front-panel keys **(MODULE)**, **USER KEYS**, and **PHASE NOISE**. If a user key has been assigned, press **(MODULE)**, **USER KEYS**.

MIN FREQ OFFSET

prompts the user for a new minimum offset frequency. This value is the minimum offset frequency displayed by a log plot measurement. All entries are rounded to one significant digit, and must be between 10 Hz and 1 MHz, inclusive. The minimum offset frequency that can be selected is determined by $10\times$ the narrowest resolution bandwidth available.

After the minimum frequency offset is changed, the spot frequency will also be adjusted, if necessary, to keep it between the minimum and maximum offset frequencies.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

NUMBER POINTS

sets the number of points to be used for the integration in the RMS noise calculation. The integration range selected limits the displayed frequency range so that only a portion of the 601 display data points are available for the integration. A choice of ALL, 1/2, 1/4, or 1/8 of those available data points can be used for the integration. There is a large speed advantage using fewer points, with very little degradation in accuracy.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **RECALL TRACE**, and **RMS NOISE**.

**PRINT
B&W**

initiates a screen dump to an attached black and white GPIB printer that supports HP raster graphics, such as an HP ThinkJet. The printer's GPIB address must be set to 1. All of the display is printed with the exception of the softkeys.

The printer must be set up correctly. It must be turned on, have paper loaded, have the correct address, and be connected. If the plotter is not set up properly when **PRINT B&W** is pressed, the spectrum analyzer is likely to lock up and require the power be turned off and then back on.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **MEASURE LOG PLOT**, and **HARD COPY**.

**PRINT
COLOR**

initiates a screen dump to an attached color GPIB printer that supports HP raster graphics, such as the HP PaintJet. The printer's GPIB address must be set to 1. All of the display is printed with the exception of the softkeys.

The printer must be set up correctly. It must be turned on, have paper loaded, have the correct address, and be connected. If the plotter is not set up properly when **PRINT COLOR** is pressed, the spectrum analyzer is likely to lock up and require the power be turned off and then back on.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **MEASURE LOG PLOT**, and **HARD COPY**.

**PLOT
ALL**

initiates a screen dump to an attached GPIB HPGL plotter. The plotter's GPIB address must be set to 5. All of the display is plotted with the exception of the softkey labels.

The plotter must be set up correctly. It must be turned on, have paper loaded, have the correct address, and be connected. If the plotter is not set up properly when **PLOT ALL** is pressed, the spectrum analyzer is likely to lock up and require the power be turned off and then back on.

Some plotters must be configured to respond to HP-GL commands. For example, the 7550B must be set to 7550A emulation mode before it can be used.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **MEASURE LOG PLOT**, and **HARD COPY**.

PLOT TRACE A and **PLOT TRACE B**

send a single trace to an attached GPIB plotter. These keys are useful to plot traces from separate measurements onto a single plot in order to compare them. Execution of these commands are much faster than using the **PLOT ALL** key.

The plotter must be set up correctly. It must be turned on, have paper loaded, have the correct address, and be connected. If the plotter is not set up properly when **PLOT TRACE A** is pressed, the spectrum analyzer is likely to lock up and require the power be turned off and then back on.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **MEASURE LOG PLOT**, and **HARD COPY**.

RECALL TO TR A and **RECALL TO TR B**

allow a trace, which has previously been saved in a trace register, to be retrieved into the desired displayed trace. Pressing either of these softkeys will bring up a softkey menu which gives a choice of the five trace registers. Pressing one of the five trace softkeys will immediately move the selected saved trace to the display.

Different saved traces may be recalled in succession without redrawing the entire display. Recalling traces to both trace A and trace B lets the user compare saved traces. The spectrum analyzer state is not saved with a saved trace, so you must reconstruct the state in order to correctly display a saved trace.

Press front-panel keys **(MODULE)**, **USER KEYS**, **PHASE NOISE**, **MEASURE LOG PLOT**, and **MORE 1 OF 2**.

RECALL TRACE

displays the same log frequency display as the **MEASURE LOG PLOT** key does, but no measurement is made and no trace is displayed. It also accesses a set of softkeys to save or recall a trace. This key gives you to have a faster way of displaying a saved trace than by doing a complete measurement first and then recalling the trace. Remember that there is no state saved with a saved trace. You must reconstruct the state in order to correctly display a saved trace.

Press front-panel keys **(MODULE)**, **USER KEYS**, and **PHASE NOISE**.

REF
LEVEL

changes the $\text{dBc}/\sqrt{\text{Hz}}$ value corresponding to the top graticule line for the log plot display. The reference level may need to be changed depending on the phase noise level of the source and the frequency offset range being measured. Pressing this softkey accesses softkeys that can be used to select reference levels of -20 dBc , -30 dBc , -40 dBc , or -50 dBc . An asterisk denotes the current setting. Selecting one of these values will change the reference level, redraw the configuration to reflect the change, and put back the second page of the configuration menu softkeys.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

RMS
NOISE

allows integration of the noise displayed by trace A. The integration can be done over a selected frequency range to get the total RMS noise in a given bandwidth. The results are displayed in both radians and degrees. Pressing **RMS NOISE** clears the screen, displays text which briefly describes the measurement, and brings up softkeys to change parameters and execute. The integration limits are set by **UPPER LIMIT** and **LOWER LIMIT**. These need to be within the range of the offset frequencies.

The **EXECUTE** softkey initiates the measurement which can take as much as several minutes. The number points used to sample the trace can be selected with **NUMBER POINTS**. More points give more accuracy, while less points give more speed.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and either **RECALL TRACE** or **MEASURE LOG PLOT**, **MORE 1 OF 2**.

SAVE
TRACE A

saves the data in the bright trace (trace A) in a trace register. Before the saving is done, a menu of softkeys appears which allows 1 of the 5 trace registers to be selected. These are the same trace registers that are used by the normal spectrum analyzer mode (accessible from the **SAVE** and **RECALL** front-panel keys), so the user must make sure that a selected register does not contain any data which should not be written over. **SAVE TRACE A** saves only the trace; it does not save any state data.

Trace B may be saved by selecting NONE for smoothing, which will make trace A identical to trace B, and then saving trace A. The trace may be saved in more than one register if desired. The **PREVIOUS MENU** softkey must be pressed to exit this menu.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, **MEASURE LOG PLOT**, and **MORE 1 OF 2**.

**SET
SPOT FRQ**

prompts the user for a new frequency offset to be measured. This function can be used to change the frequency for a spot frequency measurement, or to select a frequency where the noise amplitude will be displayed for a log plot measurement.

The frequency entered must be between the minimum and maximum frequencies displayed on the configuration screen. If the configuration screen is not being displayed when this key is pressed, the minimum and maximum frequency limits will be displayed below the graticule as the start and stop frequencies.

After an entry has been made, the analyzer will be set to measure the phase noise at the new offset frequency, and the softkeys will reappear. If a spot frequency measurement is being made, the frequency will be changed and the measurement will continue. If a log plot measurement is being made the display is redrawn on the screen, the spot frequency marker position is updated, and the noise amplitude at the new frequency is displayed numerically. Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and either **CONFIG**, **MEASURE LOG PLOT**, or **MEASURE SPOT FRQ**.

**SMOOTH
TRACE**

changes the amount of smoothing that is done after the measurement is complete. The smoothing function is much faster than filtering. However, it may cause errors if the noise changes rapidly with frequency, or if there are discrete signals present.

The function takes a running average of points across the screen from trace B and puts the average into trace A. The number of points to be averaged is selectable by softkeys once the **SMOOTH TRACE** key has been pressed. Each softkey label shows the number of points to be averaged and the associated percent averaging, which is the number of points in the average divided by the total number of points in the trace (601). An asterisk denotes the current setting.

When the amount of smoothing is set from within the config menu, the value is changed and updated on the configuration screen and the second page of the configuration menu softkeys is displayed.

When smoothing is selected from the log plot measurement menu, the smoothing occurs immediately after a softkey is pressed. The result is shown on the screen with trace A. Different amounts of smoothing may be quickly evaluated. When the desired amount is achieved, the **PREVIOUS MENU** key can be pressed to return to the log plot menu. Upon return, the log plot display is redrawn to reflect any spot frequency amplitude change that may have occurred because of a change in smoothing.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

**TURN ON(OFF)
SIG TRK**

enables and disables the signal tracking mode for log plot measurements. When it is enabled (ON), the measurement will follow a very slowly drifting signal by re-acquiring the signal between each of the ten sweeps that make up one complete log plot. With signal track on, the measurement will be somewhat slower.

Note

When signal tracking is on, a slowly drifting signal will be tracked during a log plot measurement. The maximum drift rate that can be tracked will depend on instrument settings such as minimum offset frequency and the amount of averaging.

Depending on the direction of drift, the phase noise will appear either higher or lower than it actually is.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **CONFIG**.

TURN ON(OFF)
TRC AVG

toggles trace averaging on and off. Trace averaging averages successive traces to reduce the peak to peak amplitude of the noise, since noise is not correlated from sweep to sweep. Like video filtering, trace averaging gives a more repeatable result.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, and **MEASURE SPOT FRQ**.

UPPER
LIMIT

sets the upper-frequency integration limit for the RMS noise calculation. The value must be between the minimum and maximum offset frequencies of the log plot measurement.

Press front-panel keys **MODULE**, **USER KEYS**, **PHASE NOISE**, **RECALL TRACE**, and **RMS NOISE**.

If You Have A Problem

Signal disappears during measurement

If the output frequency of the device under test is sensitive to changes in match, such as an unbuffered oscillator, the signal may disappear during the measurement process. The input attenuation, and therefore the input match, of the spectrum analyzer is varied during the measurement process. A buffer (attenuation and/or amplification) between the device and the spectrum analyzer may be required.

Repeated measurements have different results

If you make the same phase noise measurement several times and the results keep changing, either getting better or getting worse, it may be because the signal is drifting and the rate of drift is changing. It may be possible to measure a drifting signal, but the phase noise can appear either higher or lower than it actually is, depending on the direction of the drift. This effect is usually more noticeable when the device is first turned on.

A signal with a constant drift rate will have a repeatable, but incorrect, phase noise plot. Drift can easily be verified by making a spot frequency measurement which does not track drift.

Measured value or noise floor is not correct

- The system noise floor is affecting the measurement. It must be checked with a clean source for the frequency offsets being examined (such as an 8662). Set the source frequency the same as the signal to be tested, since the system phase noise is a function of the spectrum analyzer center frequency. Do **NOT** use the internal calibrator to find the noise floor because phase noise cancellation will occur. This will make the noise floor appear to be lower than it actually is.
- Phase noise measurements made in the bottom division of the display will not be as accurate as the remainder of the display. If measurements are occurring in the bottom division, the reference level (under the **CONFIG** key) should be decreased (made more negative).
- The phase noise can appear to be either higher or lower than it actually is. When signal tracking is on, a slowly drifting signal will be tracked during

a log plot measurement. The maximum drift rate will depend on settings such as minimum offset frequency and the amount of averaging. Depending on the direction of drift, the phase noise will appear either higher or lower than it actually is.

Log Plot Measurement has unexpected discontinuities

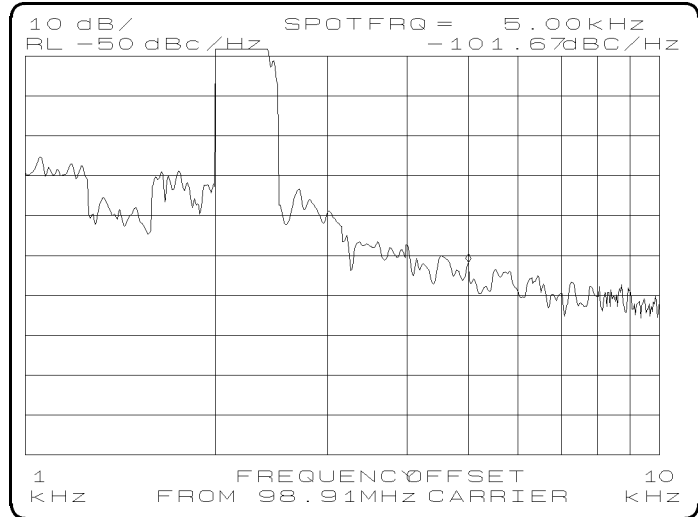


Figure 4-1. Log Plot of Drifty or Noisy Signal

Discontinuities like those shown in Figure 4-1 can occur if the minimum frequency offset is less than the residual FM of the signal. The utility makes a log plot measurement in ten successive sweeps. If the signal has enough residual FM that the resolution bandwidth misses the peak on some of the sweeps, the measured power will be incorrect and the trace will have discontinuities.

Phase noise utility terminates unexpectedly

Pressing almost any of the front panel keys will abort the utility. After the DLP is started, no keys should be pressed, and the knob should not be turned except when there is an active function waiting for a user input. Then use the number keys and the terminators (such as kHz, or MHz). The knob can be used during a spot frequency measurement.

The **PRESET** key may be used to exit the utility in the middle of a measurement. Use of the **PRESET** key will prevent the original instrument state from being restored. This may give unpredictable results when the utility is restarted. The original instrument state can be restored by recalling state 9. If the power is turned off and back on again the utility can be restarted.

Cannot change the configuration parameters

All of the parameters on the config screen are set to zero and they cannot be changed if the setup program has not been run. Exit the utility and use the **KEYDEF** softkeys to choose and execute the PH_SETUP program. This will initialize the program parameters.

Spectrum analyzer states were lost

- The phase noise utility should not be invoked if a state is already saved in state 9 that must not be overwritten. This state register is used to save the initial instrument settings so that they can be restored when the utility is finished.
- The spectrum analyzer and the utility use the same trace registers for saving traces. The phase noise utility allows you to use the TRACE 0 through TRACE 4 registers. No traces should be saved in these registers outside the utility, since they may be overwritten (lost).

Cannot print or plot

- Hard copy output can only be made from a log plot measurement.
- The spectrum analyzer keys cannot be used for printing or plotting from the phase noise utility. Use the softkeys in the **HARD COPY** menu under the **MEASURE LOG PLOT** function.
- The printer or plotter must be functional before trying to output. It is a good idea to try it before starting the phase noise utility. If it is not functional, the spectrum analyzer power must be turned off and on to recover. Check the following:
 - the power is turned on
 - the printer is on line
 - the paper is in place
 - it is a GPIB printer or plotter
 - the GPIB cable connected
 - the GPIB address set to 5 for a plotter
 - the GPIB address set to 1 for a printer

Phase noise utility disappears from memory

A demo version of the phase noise utility is available. After the demo has been used ten times, it automatically removes itself from memory. If you had the demo and would like permanent access to the utility, order the 85671A.

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