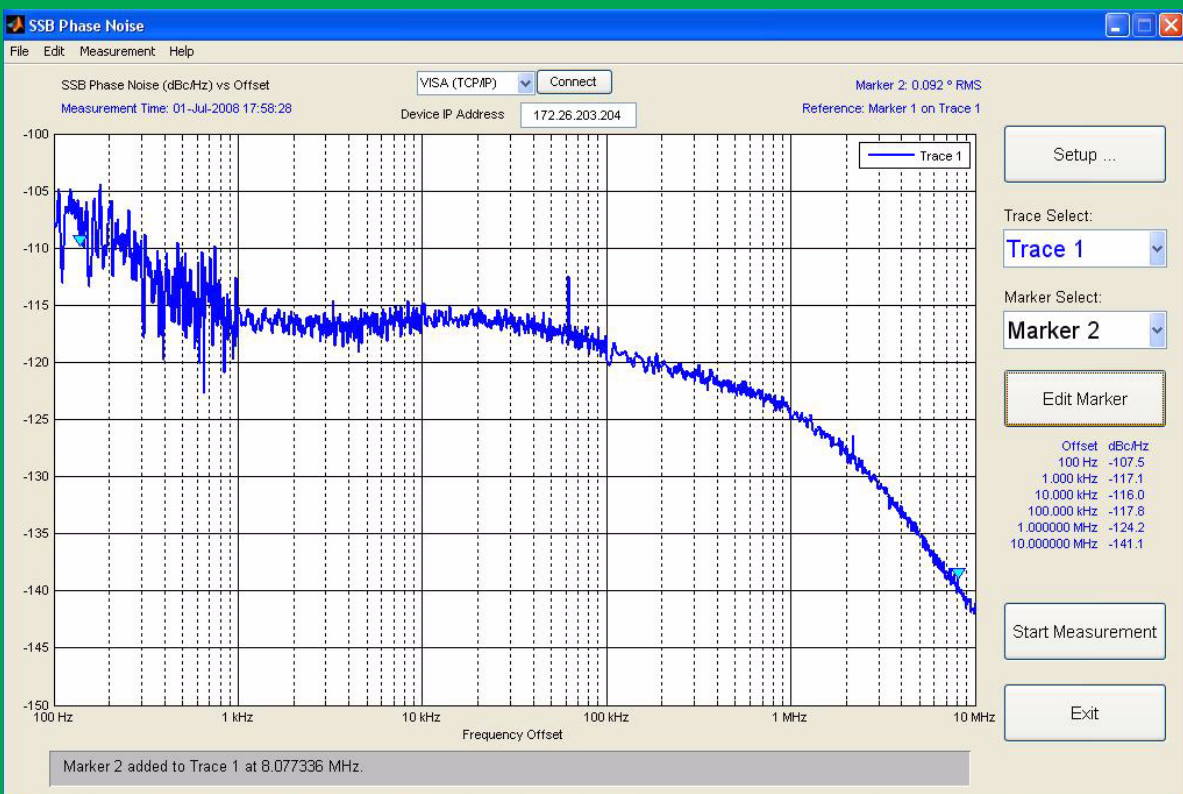
User Guide

PN 2300-517
Phase Noise Measurement Software

Tools to Measure and to Graph Phase Noise



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N274

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印刷线路板 (PCA)	×	○	×	×	○	○
机壳、支架 (Chassis)	×	○	×	×	○	○
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Danger

This indicates a very dangerous procedure that could result in serious injury or death, and possible loss related to equipment malfunction, if not performed properly.

Warning

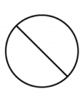
This indicates a hazardous procedure that could result in light-to-severe injury or loss related to equipment malfunction, if proper precautions are not taken.

Caution

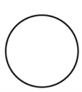
This indicates a hazardous procedure that could result in loss related to equipment malfunction if proper precautions are not taken.

Safety Symbols Used on Equipment and in Manuals

The following safety symbols are used inside or on the equipment near operation locations to provide information about safety items and operation precautions. Ensure that you clearly understand the meanings of the symbols and take the necessary precautions *before* operating the equipment. Some or all of the following five symbols may or may not be used on all Anritsu equipment. In addition, there may be other labels attached to products that are not shown in the diagrams in this manual.

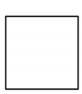


This indicates a prohibited operation. The prohibited operation is indicated symbolically in or near the barred circle.

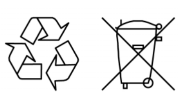


This indicates a compulsory safety precaution. The required operation is indicated symbolically in or near the circle.

This indicates a warning or caution. The contents are indicated symbolically in or near the triangle.



This indicates a note. The contents are described in the box.



These indicate that the marked part should be recycled.

For Safety

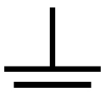
Warning

Always refer to the operation manual when working near locations at which the alert mark, shown on the left, is attached. If the operation, etc., is performed without heeding the advice in the operation manual, there is a risk of personal injury. In addition, the equipment performance may be reduced.

Moreover, this alert mark is sometimes used with other marks and descriptions indicating other dangers.

Warning

or

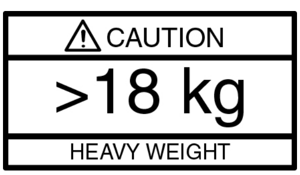


When supplying power to this equipment, connect the accessory 3-pin power cord to a 3-pin grounded power outlet. If a grounded 3-pin outlet is not available, use a conversion adapter and ground the green wire, or connect the frame ground on the rear panel of the equipment to ground. If power is supplied without grounding the equipment, there is a risk of receiving a severe or fatal electric shock.

Warning

This equipment can not be repaired by the operator. Do not attempt to remove the equipment covers or to disassemble internal components. Only qualified service technicians with a knowledge of electrical fire and shock hazards should service this equipment. There are high-voltage parts in this equipment presenting a risk of severe injury or fatal electric shock to untrained personnel. In addition, there is a risk of damage to precision components.

Warning



Use two or more people to lift and move this equipment, or use an equipment cart. There is a risk of back injury if this equipment is lifted by one person.

Caution

Electrostatic Discharge (ESD) can damage the highly sensitive circuits in the instrument. ESD is most likely to occur as test devices are being connected to, or disconnected from, the instrument's front and rear panel ports and connectors. You can protect the instrument and test devices by wearing a static-discharge wristband. Alternatively, you can ground yourself to discharge any static charge by touching the outer chassis of the grounded instrument before touching the instrument's front and rear panel ports and connectors. Avoid touching the test port center conductors unless you are properly grounded and have eliminated the possibility of static discharge.

Repair of damage that is found to be caused by electrostatic discharge is not covered under warranty.

Table of Contents

Chapter 1 — General Information

1-1 About this Manual

This software user guide provides general operating information for the PN 2300-517 Phase Noise Measurement Software.

The Phase Noise Measurement Software provides measurement displays of Single-Sideband Noise versus Frequency Offset, using a logarithmic frequency axis.

1-2 Conventions

Throughout this manual, the terms MS271xB Spectrum Analyzer and MS272xB Spectrum Analyzer are used interchangeably to refer to the Anritsu Spectrum Analyzer that is being used with this software. The term DUT is used in place of device under test.

Path names may be used to represent the keystrokes and button presses for a desired action or procedure. The path name generally begins with a front panel key, keyboard key, or menu selection followed by additional menu selections, each separated by a vertical line (|).

Note	In cases where a submenu is automatically expanded by accessing the main menu, the path shows that submenu as part of the selection.

1-3 Software Description

The PN 2300-517 software provides the tools that are needed to easily measure and graph single-sideband noise. The data can be exported for use within other applications. PN 2300-517 is a Windows-based application that controls MS271xB or MS272xB Spectrum Analyzers to provide a fully automated measurement engine.

1-4 Software Installation

The Phase Noise Measurement Software is designed to be installed on a PC.

To install the Phase Noise Measurement Software (PN 2300-517) onto a PC, close all applications, insert the installation CD-ROM, and follow the on-screen instructions. MATLAB, NI-VISA, and USB Software Key supporting software must be available in order to run the Phase Noise application. These files are on the CD-ROM and are executed from buttons in the Anritsu Startup Menu (which opens from the CD-ROM, refer to Figure 1-1). The Phase Noise Measurement Software installation program first copies the installation files to the PC hard disk, and then begins the installation.

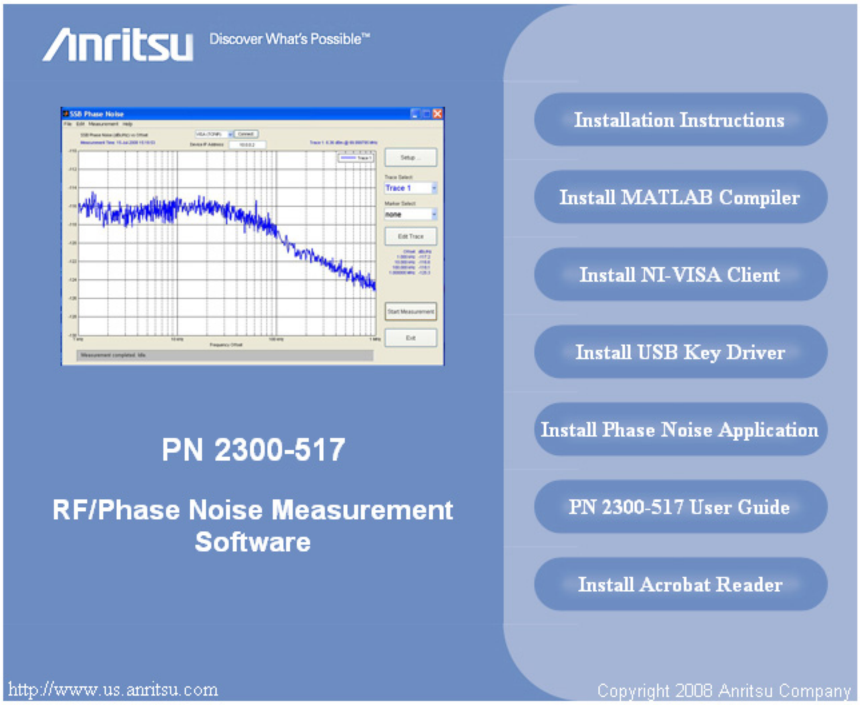


Figure 1-1. Anritsu Startup Menu

If the Anritsu Startup Menu does not appear when the CD-ROM is inserted, then you can explore the CD-ROM files and open the Read_Me_First.txt file for instructions to open the Anritsu Startup Menu. The Anritsu Startup Menu is opened by the `Startup.htm` file.

Hardware and Software Requirements

For connection to a PC, Anritsu Spectrum Analyzers offer an RJ45 connector (for Ethernet 10/100 Base T connections).

Software installation requires a computer with a CD-ROM drive. This software operates on a computer with one of the following Microsoft® Windows® operating systems:

- Windows 2000 (Service Pack 4, or above)
- Windows XP (Service Pack 2, or above)
- Windows Vista®

Installation Steps

MATLAB Compiler Runtime Component

All MATLAB stand-alone applications require that a MATLAB Compiler Runtime component be installed on the computer that is running the application. This is a one-time installation for each computer that will be executing the Phase Noise Measurement Software application.

Click the Install MATLAB Compiler button. A self-extracting executable walks you through its installation process.

The `MCRInstaller.exe` file is located on the CD-ROM in the **MATLAB** folder.

NI-VISA

Remote programming of the supported Spectrum Analyzers requires that the controlling PC has a VXI-11 client installed. This step installs the NI-VISA deployment software that will act as a VXI-11 client. If the controlling PC already has a VXI-11 client installed (NI-VISA is included, for example, with GPIB hardware), then this step can be omitted.

Click the Install NI-VISA Client button. A self-extracting executable walks you through the installation process.

The `visa430runtime.exe` file is located on the CD-ROM in the **NI-VISA** folder.

The NI-VISA VXI-11 client is licensed by National Instruments Corporation. A printed software license is included in the PN 2300-517 Phase Noise Measurement Software shipping package.

USB Security Key Driver

The USB Security Key requires new driver software to allow your PC to detect and operate the key.

Click the Install USB Key Driver button. A self-extracting executable walks you through the installation process.

The `HASPUserSetup.exe` file is located on the CD-ROM in the **USB Software Key** folder.

Phase Noise Application

Click the Install Phase Noise Application button to extract the Phase Noise Application files. The installation program copies the installation files to the PC hard disk and then begins the installation.

The `PhaseNoiseAppSetup.exe` file is located on the CD-ROM in the **Phase Noise Application** folder.

The Phase Noise Application is started as follows:

Double-click on the PhaseNoiseApp icon:

- You have the option (during software installation) of having the PhaseNoiseApp icon placed on your PC desktop.
- When the application graph appears, enter the IP address of the Spectrum Analyzer and click the Connect button.

The application must extract components of the MatLAB Compiler runtime when it starts up. This can take from several seconds up to a few minutes, depending upon the PC on which it is running. A DOS message window is displayed while the application is running but requires no action on the part of the user.

The Phase Noise Measurement Software allows all functions to operate without the USB Security Key except “Start Measurement.” Attempts to start a measurement without the Security Key cause an error message to be displayed.

1-5 Display Types:

- Multiple phase noise trace plots on the same scale, each in a different color
- Smoothed traces
- Limit lines
- Phase Noise versus Time at a user-specified offset
- Integrated noise in seconds, degrees, or hertz

Example Measurement Display

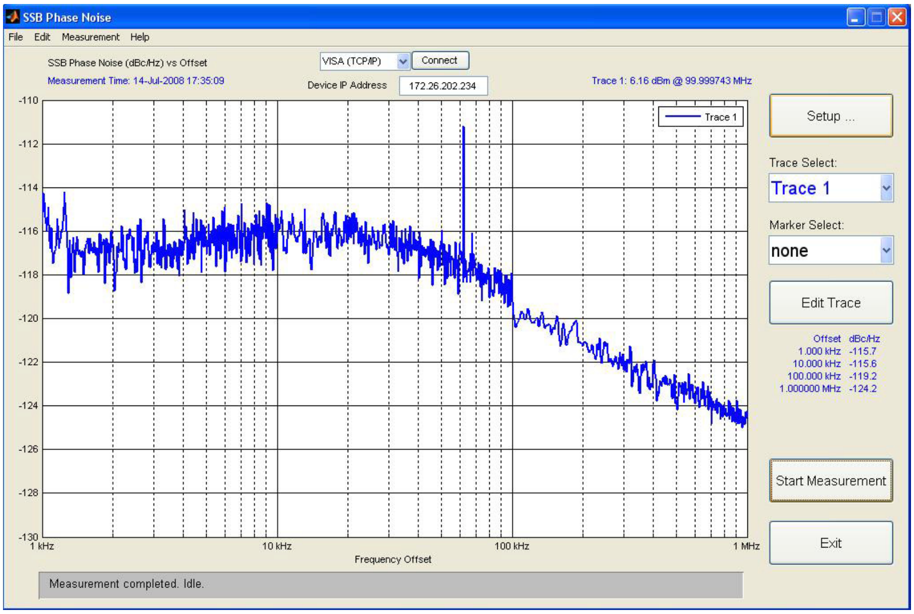


Figure 1-2. Phase Noise Measurement at 100 MHz

Chapter 2 — Graphical User Interface

2-1 Introduction

This chapter provides an overview of the graphical user interface (GUI). After launching the Phase Noise Measurement Software, you can access the measurement setup parameters and application controls that are found in the following sections:

- "Measurement Setup Dialog"
- "Edit Trace Dialog"
- "Edit Marker Dialog"
- "Printer and Page Setup"

2-2 Launching the Phase Noise Measurement Software

The Phase Noise Measurement Software measures the phase noise of the largest signal that is within the currently set frequency range. Prior to making a phase noise measurement, the DUT should be set up and connected to the Spectrum Analyzer RF input. To ensure that the analyzer input is not overloaded, the signal being measured should be greater than the sum of all of the other signals that are present at the analyzer input, as indicated by a red trace or "ADC Error" message (or both) on the Spectrum Analyzer display. The best measurement results are obtained when the DUT signal level is near 0 dBm.

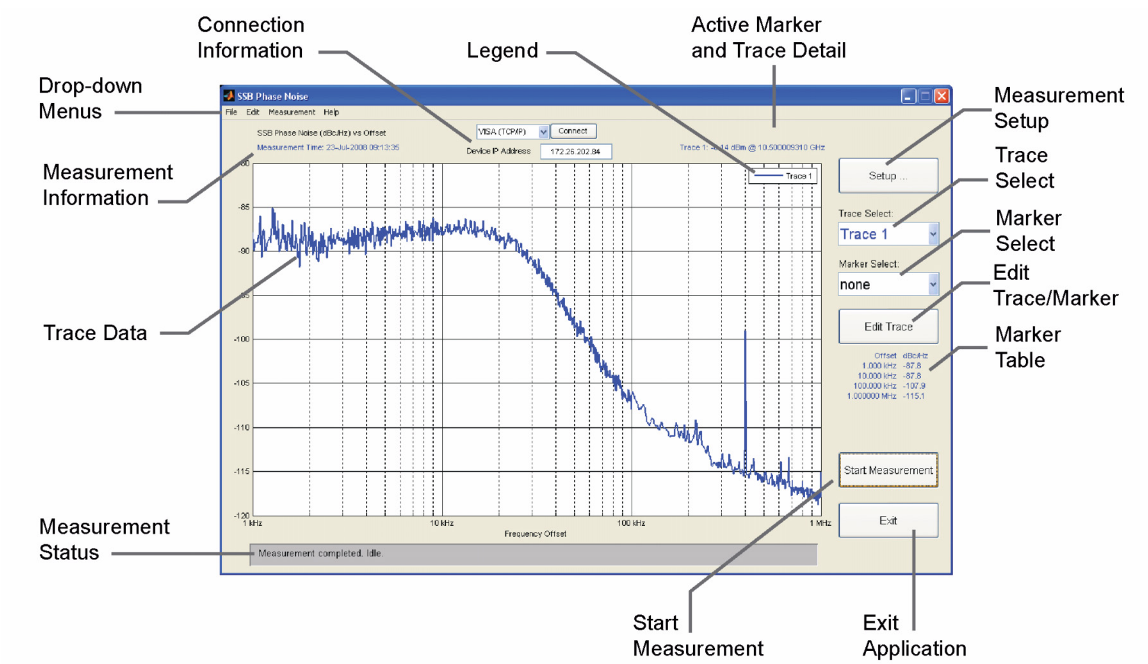


Figure 2-1. Main SSB Phase Noise Display

Notes on the Phase Noise GUI

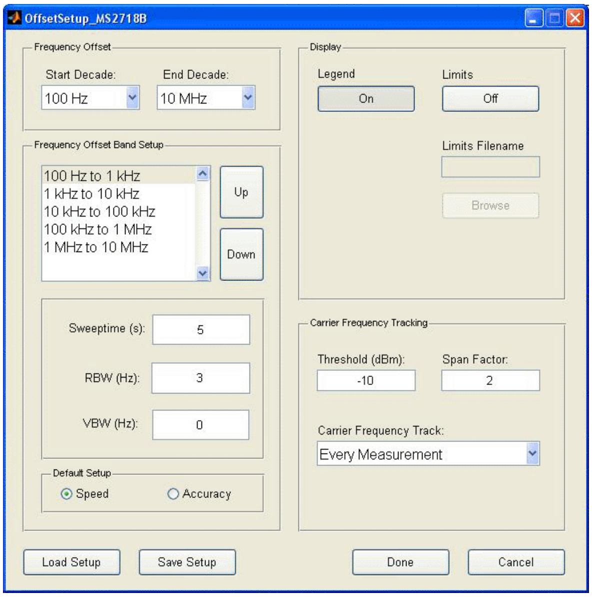
The Phase Noise GUI displays up to eight user-defined offset markers for the selected trace, which is shown in the lower right corner (refer to Figure 2-1, "Main SSB Phase Noise Display"). The Marker Table color corresponds to the color of the selected trace. The markers are defined in the file named `markertable.txt.` An example of `markertable.txt` is given below:

```
This is a comment line
12
120
12000
1.2e3
120000
1200000
18000000
099000000
```

The file can have up to nine text lines. The first line must be a comment line and is ignored. The offsets are displayed in the same order as in the table. The actual reported values are the closest data points to the specified offsets in the file.

2-3 Measurement Setup Dialog

The Measurement Setup dialog is accessed from the main GUI via the Setup... button or from the `Measurement | Setup...` drop-down menus.



Frequency Offset:

The frequency offset controls the start decade and the end decade for the measurement graticule.

Frequency Offset Band Setup:

The frequency offset band setup configures each measurement band with unique settings.

Default Setup:

The Speed and Accuracy selections change Sweeptime, RBW, and VBW to be optimized either for speed or for accuracy.

Display:

The Display settings control the Legend and the Limits.

Carrier Frequency Tracking:

Use these controls to select the carrier frequency tracking feature and to set the Span Factor and the Threshold value.

Load Setup and Save Setup:

Setups can be saved as `*.mat` files and later reloaded.

Figure 2-2. Offset Setup Dialog

Notes on the Display

The user-defined limit lines are defined in a comma separated value (`.csv`) file format. This file can be made by using a text editor, and can then be saved to any directory that is accessible to the application. The file must have a CSV extension. The phase noise measurement application has a browse feature that allows you to locate and load the limit line file. Refer to the **Display** settings in Figure 2-2, “Offset Setup Dialog”.

The first line of the file is for comments and is ignored by the application. The second line of the file contains the starting frequency followed by the specification limit. The following lines of the file each contain the frequency of a step and the specification limit. An example user-defined limit line file is shown below:

```
This file shows the test specification for an example oscillator
10, -40
100, -70
10000, -110
100000, -115
```

By clicking on a measurement trace, you can check whether all of the measurement points are below the limit line. If all of the measured points are on or below the limit line, then a green “Pass” message is displayed in the status window. If any points are above the limit line, then a red “Fail” message is displayed in the status window.

Notes on Carrier Frequency Tracking

Carrier frequency tracking allows the selection of one of the following four different modes of carrier frequency tracking. In each mode, the carrier power is measured at the start of the noise measurement and is checked against the threshold. If no signal is found above the threshold, then the measurement is terminated.

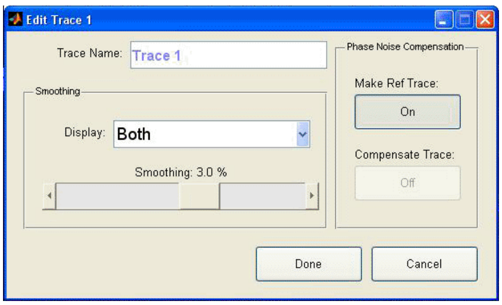
- **Use SPA Center Frequency:** This mode does not measure the carrier frequency. The measurement is made with the assumption that the carrier is at the center frequency of the Spectrum Analyzer at the time that the measurement is started. As a result, this selection takes the least time to begin a noise measurement.
- **1st Measurement Only:** This mode measures the carrier frequency only at the beginning of the first noise measurement by repeatedly centering the signal and decreasing the initial span setting of the Spectrum Analyzer until the carrier frequency has been accurately determined. When the first noise measurement is successfully completed, the same carrier frequency is used for all subsequent measurements. However, if all of the current measurements are deleted, or if a different carrier frequency tracking mode is selected for a new measurement, then the carrier frequency will be measured again at the beginning of the new measurement.
- **Every Measurement:** This mode measures the carrier frequency at the beginning of each noise measurement by repeatedly centering the signal and decreasing the initial span setting of the Spectrum Analyzer until the carrier frequency has been accurately determined.
- **Each Band in Measurement:** This mode measures the carrier frequency at the beginning of the noise measurement by repeatedly centering the signal and decreasing the initial span setting of the Spectrum Analyzer until the carrier frequency has been accurately determined. The carrier frequency is then measured again at the start of each new band by beginning with a span that is set to `(span factor) × (lowest offset frequency in the band)`.

  For example, if the span factor is set to 2, and if a noise measurement from 100 Hz to 100 kHz is performed, then, after measuring the noise of the 100 Hz to 1 kHz band, the span is set to 2 × 1 kHz and the carrier is measured again. After measuring the noise of that band, the span is changed to 2 × 10 kHz, and the carrier frequency is measured again. After measuring the noise of that band, the span is changed to 2 × 100 kHz, and the carrier frequency is measured again.

2-4 Edit Trace Dialog

The Edit Trace dialog is accessed from the Phase Noise Measurement application GUI via the Edit Trace button (refer to Figure 2-1). The Edit Trace functions apply only to the active trace, which can be selected from the Select Trace drop-down combo box or by left clicking a displayed trace.

Note	The Edit Trace button and the Edit Marker button share the same button location. The function of the button is determined by the active selection from the Trace Select and Marker Select drop-down list boxes or by clicking on a displayed trace or marker.



Trace Name:

By default, the traces are labeled Trace 1, Trace 2, and so forth. The trace name can be edited.

Smoothing:

Select None, Both, or Smoothed Only.

"Smoothed Only" smooths the selected trace.

"Both" adds a new, smoothed trace in addition to the original trace.

Adjust the smoothing slider for the amount of desired smoothing, which is indicated in percent.

Phase Noise Compensation:

Make Ref Trace: Alternates the current trace On and Off as a reference trace.

Compensate Trace: Alternates trace compensation On and Off for the current trace.

Figure 2-3. Edit Trace Dialog

Notes on Trace Smoothing

Because of the nature of noise, obtaining measurement results with small peak-to-peak variation is very time consuming. This is because each point needs to have several measurements taken to average out to a final value.

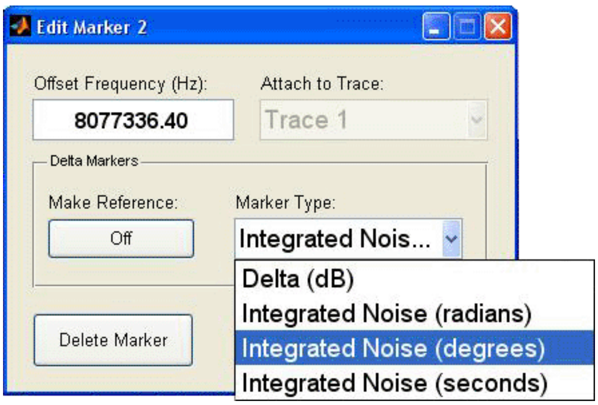
At times, however, a smooth trace is desired without allowing for the time necessary for each point to average out to a final value, and the user is willing to degrade the accuracy in order to acquire results more quickly.

Trace Smoothing provides this option by calculating a moving average on the measured data. Each point on a smoothed trace is the average of the power of a fixed number of measured data points on each side of, and including, that particular point.

2-5 Edit Marker Dialog

The Edit Marker dialog is accessed from the Phase Noise Measurement Software GUI via the Edit Marker button. The Edit Marker functions apply only to the active marker, which can be selected from the Select Marker drop-down list box or by left clicking a displayed marker.

Note	The Edit Marker button and the Edit Trace button share the same button location. The function of the button is determined by the active selection from the Marker Select and Trace Select drop-down list boxes or by clicking a displayed trace or marker.



Offset Frequency:

Specifies the marker frequency offset relative to the carrier.

Attach to Trace:

Specifies the trace to which the marker is applied.

Delta Markers

Make Reference:

Sets the current marker as a reference marker for the markers of other types.

Marker Type:

Sets the current marker type as one of the following:

- Delta (dB)
- Integrated Noise (radians)
- Integrated Noise (degrees)
- Integrated Noise (seconds)

If no marker is selected as a reference marker, then the marker value is given relative to the carrier power (dBc).

Delete Marker:

Removes the indicated marker from the display.

Figure 2-4. Edit Marker Dialog

Notes on Marker Type

If only a single marker is active, then it will automatically show the offset frequency and the noise level at that offset frequency relative to the carrier power level, normalized to a 1 Hz bandwidth (dBc/Hz). This marker information is displayed above the Legend and active trace. When multiple markers have been added to the phase noise plot, several options are available:

- **Make Reference Off** for all of the markers: The selected marker indicates the offset frequency of the marker and its dBc/Hz noise level. This is the default setting when a marker is added.
- **Make Reference On** for one of the markers allows the following options:
  - **Delta (dB):** Selecting the reference marker displays the offset frequency and dBc/Hz noise level of the reference marker. Selecting a different marker displays the difference of the frequency and power between the selected marker and the reference marker.
  - **Integrated Noise (radians):** This marker type displays the integrated noise (in radians) between the selected marker and the reference marker. The power in coherent spurs is not treated differently than the phase noise power is treated, which may skew some measurements because the spur level is decreased by
    `10 × LOG 10 (Power Bandwidth of Resolution Bandwidth Filter)`.
    The Integrated Noise in radians is calculated as follows:

$$\text{Integrated Noise (radians)} = \sqrt{2\int_{f_1}^{f_2} 10^{\left(\frac{\text{SSB}\phi\text{Noise}\frac{\text{dBc}}{\text{Hz}}}{10}\right)} df}$$

  - **Integrated Noise (degrees):** This marker type displays the integrated noise (in degrees) between the selected marker and the reference marker. The power in coherent spurs is not treated differently than the phase noise power is treated, which may skew some measurements because the spur level is decreased by
    `10 × LOG 10 (Power Bandwidth of Resolution Bandwidth Filter)`.
    The Integrated Noise in degrees is calculated as follows:

$$\text{Integrated Noise (degrees)} = \frac{180^\circ}{\pi\,\text{rad}}\sqrt{2\int_{f_1}^{f_2} 10^{\left(\frac{\text{SSB}\phi\text{Noise}\frac{\text{dBc}}{\text{Hz}}}{10}\right)} df}$$

- **Integrated Noise (seconds):** This marker type displays the integrated noise (in seconds) between the selected marker and the reference marker. The power in coherent spurs is not treated differently than the phase noise power is treated, which may skew some measurements because the spur level is decreased by
`10 × LOG 10 (Power Bandwidth of Resolution Bandwidth Filter)`.
The Integrated Noise in seconds is calculated as follows:

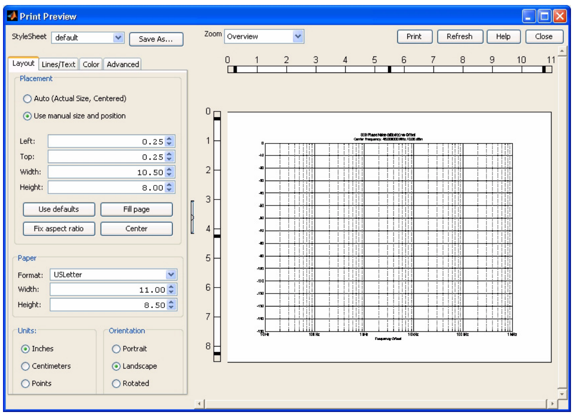
$$\text{Integrated Noise (second)} = \frac{1}{2\pi f_{\text{carrier}}}\sqrt{2\int_{f_1}^{f_2} 10^{\left(\frac{\text{SSB}\phi\text{Noise}\frac{\text{dBc}}{\text{Hz}}}{10}\right)} \, df}$$

2-6 Printer and Page Setup

The Page Setup and Print Preview dialog boxes are accessed from the File drop-down menu. These dialog boxes allow you to configure: the layout of the measurement, the graphing and printing parameters, and other advanced processing parameters.

Note	Before printing is possible, a local or remote printer must be installed.

As shown in the following table, the printer and page setup parameters can be saved as a Style Sheet for later recall. The Zoom can be manually set (up to 400%) or to Overview for full-page viewing. When the page is set up, press the Print button to send the graph to a previously installed printer.



Placement:

The Placement group box allows you to select between Auto or Manual. When Manual is selected, the Left and Top margins can be specified as well as the Width and Height of the graph.

Paper:

The Paper group box lets you specify the size of the printer paper.

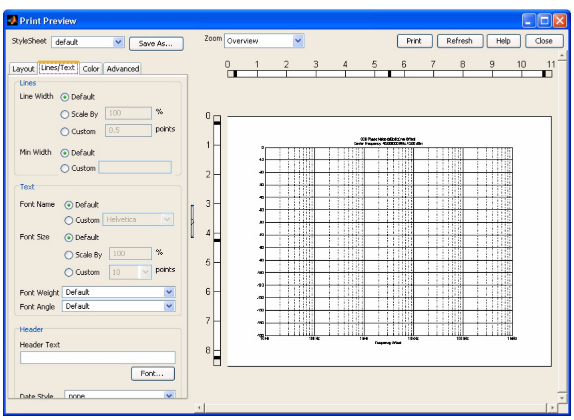
Units:

The Units group box lets you select Inches, Centimeters, or Points as the standard units.

Orientation:

The Orientation group box lets you select the paper orientation of Portrait, Landscape, or Rotated.

Figure 2-5. Printer Setup Dialog, Layout Tab



Lines/Text:

The Lines/Text group box lets you configure the graph's graticule scale.

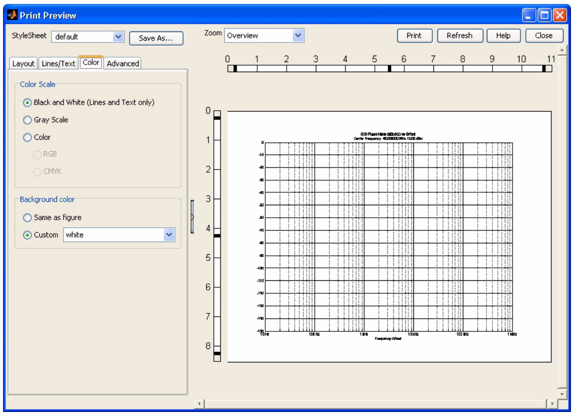
Text:

The Text group box lets you select the font style and size, along with other font attributes.

Header:

The Header group box lets you type the graph's header text as well as select the date format, if desired.

Figure 2-6. Printer Setup Dialog, Line/Text Tab



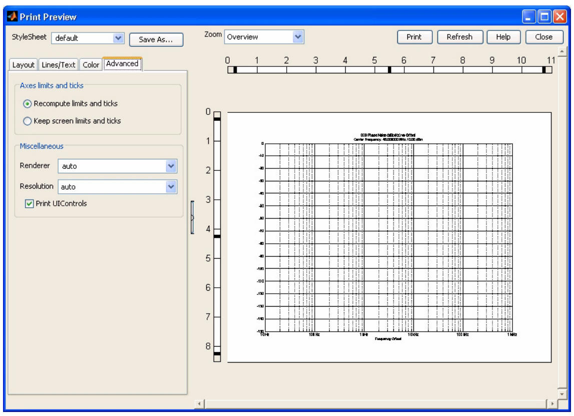
Color:

The Color Scale group box has options for selecting the color space of Black and White, Gray Scale, RGB, or CMYK.

Background Color:

The Background Color group box has selections for the background color of the plot.

Figure 2-7. Printer Setup Dialog, Color Tab



Axes, Limits, and Ticks:

Recompute limits and ticks

Keep screen limits and ticks

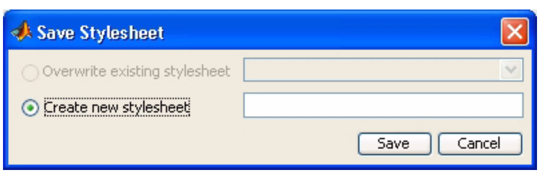
Miscellaneous:

Renderer: default, Painters, ZBuffer

Resolution: selects screen and print resolution

Print UIControls: Prints the User Interface controls

Figure 2-8. Printer Setup Dialog, Advanced Tab



Save Stylesheet

The printer page setup is saved as a stylesheet. Select to create a new stylesheet or overwrite an existing stylesheet.

Figure 2-9. Save Stylesheet Dialog

Chapter 3 — Measurement Example

3-1 Introduction

This chapter illustrates how to make a common phase noise measurement. These directions are presented here with the assumption that you have a basic understanding of Spectrum Analyzer measurements, and that the Spectrum Analyzer front panel and menu structure are familiar to you. Refer to your Spectrum Analyzer operating manual for a description of the instrument menus and their structure. After you are familiar with the instrument, the directions in this manual introduce you to phase noise measurements.

3-2 Phase Noise Measurement Example

This example measures the phase noise of a 100 MHz signal from a DUT. Set up the equipment as shown in the following diagram (the MS2718B in Figure 3-1 represents any Anritsu Spectrum Analyzer):

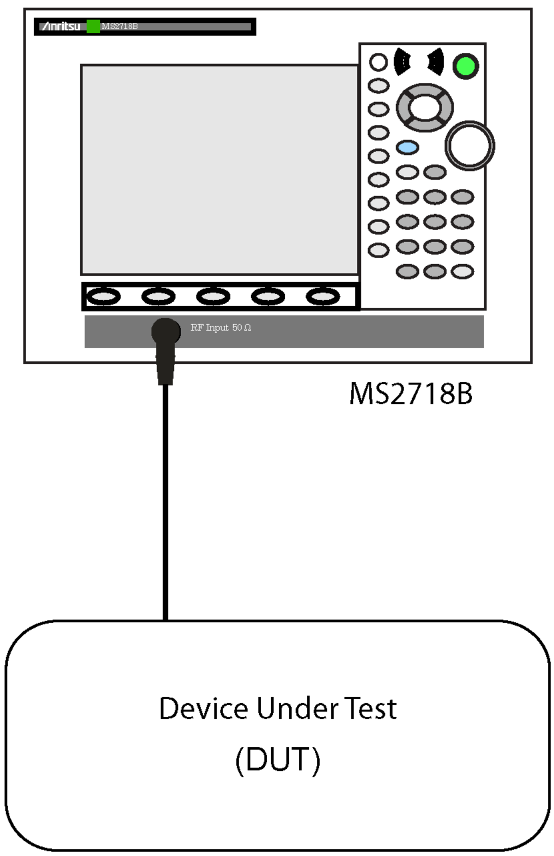


Figure 3-1. Phase Noise Measurement Setup

Setup

1. Preset the Spectrum Analyzer.
2. Set up the Spectrum Analyzer as follows:
    - **a.** Set Center Frequency to 100 MHz
    - **b.** Set Span to 1 MHz.
    - **c.** Adjust the reference level such that the signal peak is near the reference level (top of the graticule).
    - **d.** Launch the Phase Noise Measurement Software.
3. After the Phase Noise Measurement Software loads, press the Setup button to configure the measurement as desired, and then press Done.
4. Press the Start Measurement button and wait for the measurement to be completed.
5. After the measurement is completed, the measurement results can be manipulated by using the Edit Trace dialog, can be sent to a printer for hard copy printouts, or can be exported as a CSV file.

The following is an example plot of the measurement:

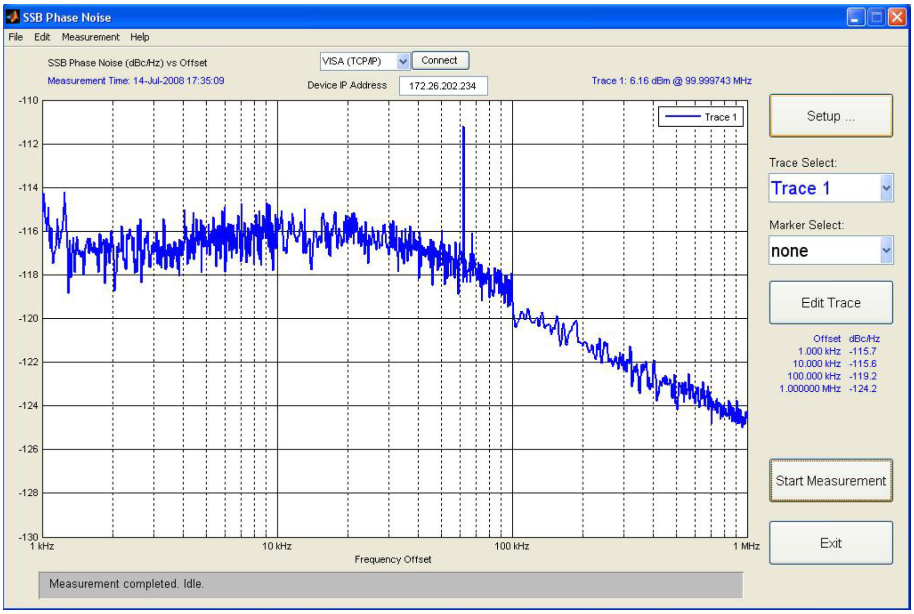


Figure 3-2. Example – 100 MHz Phase Noise Measurement

Appendix A Specifications

A perfect sine wave has a non-varying period (T) equal to the reciprocal of the frequency (F):

```
T = 1/F
```

A-1 Phase Noise Description

All actual signal sources, as contrasted to perfect sine waves, have some undesired random noise modulation of their phase that causes their period to fluctuate from cycle to cycle even though the average period can be reasonably constant. This noise is called phase noise. When the frequency or phase of a sine wave is modulated with another sine wave, the total power does not change. The spectral content does change, from having all of the power at a single frequency to having sidebands (on each side of the unmodulated frequency) spaced at intervals equal to the modulation frequency. Bessel math functions can be used to determine the amplitude of the individual sidebands for any given amount of modulation. Broadband noise also distributes the RF power when it modulates the phase of a sine wave, but instead of producing discrete coherent sidebands, it creates a 'skirt' on each side of the desired frequency, as is shown in Figure A-1:

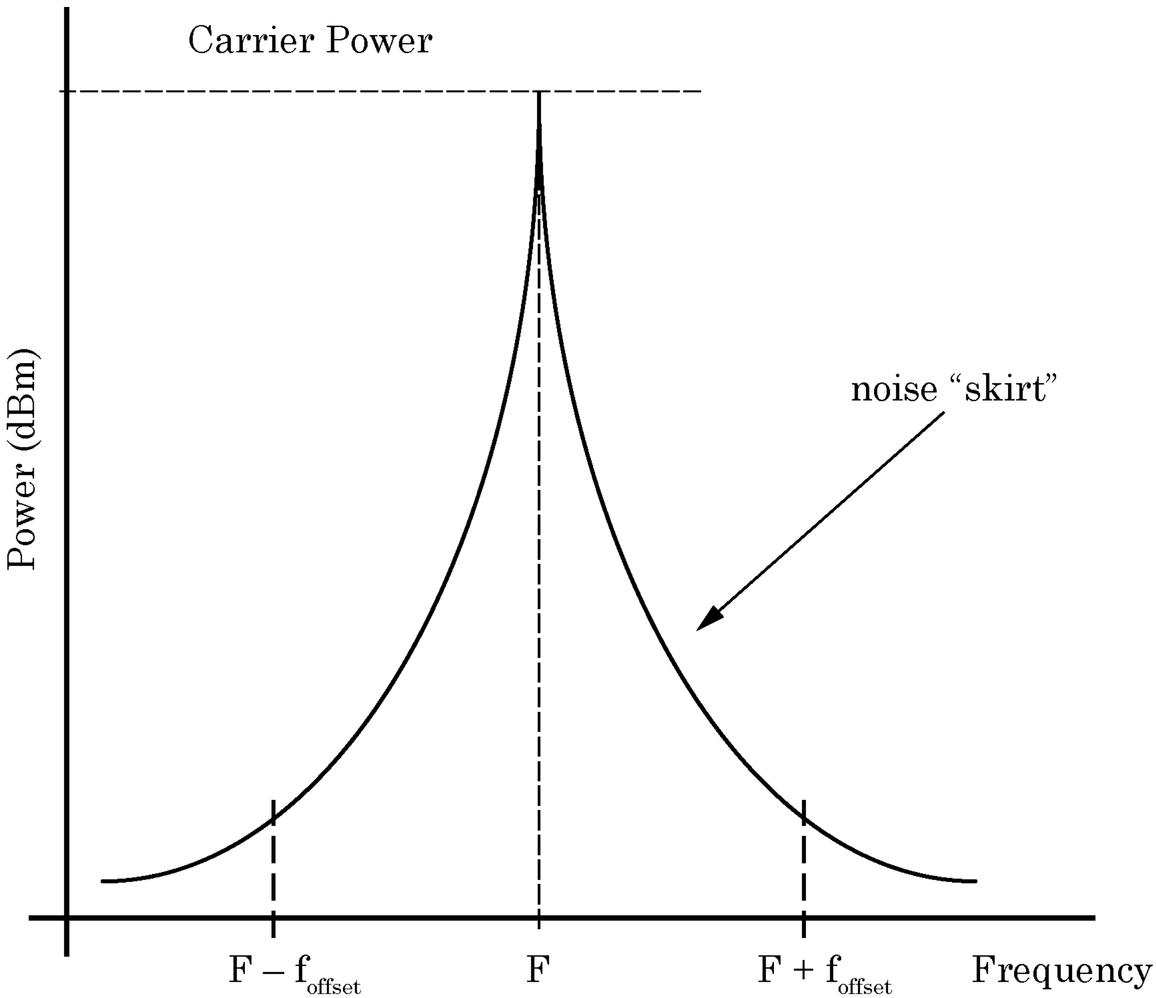


Figure A-1. Carrier Phase Noise

A-2 Phase Noise Expressions

For convenience of use, phase noise is usually normalized to a 1 Hz bandwidth and specified at particular offsets from the carrier frequency. This spectral power density (noise power in a 1 Hz bandwidth) is compared to the carrier power in a ratio in which the carrier power includes the power that makes up the noise skirts. When the power of the noise for both $F - f_{offset}$ and $F + f_{offset}$ are included, it is referred to as Double Sideband Phase Noise. But when only one of the offsets is measured, it is referred to as Single Sideband Phase Noise or SSB Phase Noise. Additionally, the ratio is most often expressed in decibels as in the following formulas:

$$SSB\phi Noise@f_{offset}\frac{dBc}{Hz} = 10LOG_{10}\left|\frac{P_{noise}(F + f_{offset})W}{P_{carrier}W}\right|$$

Or

$$SSB\phi Noise@f_{offset}\frac{dBc}{Hz} = P_{noise}(F + f_{offset})\frac{dBm}{Hz} - P_{carrier}dBm$$

Note that making a measurement with such a low bandwidth is very time consuming. Instead, a higher bandwidth is often used, and the measurement is scaled accordingly. Provided that the noise power verses frequency is relatively flat over the measurement power bandwidth, the ratio of the measurement power bandwidth to the 1 Hz normalized bandwidth yields the power scaling factor:

$$SSB\phi Noise@f_{offset}\frac{dBc}{Hz} = P_{noise}(F + f_{offset})dBm - 10LOG_{10}\left(\frac{PowerBandwidth}{1Hz}\right) - P_{carrier}dBm$$

For example, a 100 Hz power bandwidth allows 100 times as much noise power through as a 1 Hz power bandwidth. Therefore, the measurement is scaled by `10 x LOG10(100 / 1) = 20 dB.` So, if a carrier measures –5 dBm, and if the noise measured at 10 kHz from the carrier using a power bandwidth of 100 Hz is –65 dBm, then:

$$SSB\phi Noise@10kHz = -65dBm - 20dB - (-5dBm) = -80\frac{dBc}{Hz}$$

Which means that, in this example, at 10 kHz away from the carrier, the RMS noise power in a 1 Hz bandwidth is 80 dB less than the carrier power.

The power bandwidths of the RBW filters in the MS278xB are about 6% wider than a “brick wall” filter of the same bandwidth, which means:

$$SSB\phi Noise@f_{offset}\frac{dBc}{Hz} = P_{noise}(F + f_{offset})dBm - 10LOG_{10}\left(\frac{RBW \times 1.06}{1Hz}\right) - P_{carrier}dBm$$

The increased width (by 6%) affects the reading by only 0.25 dB.

Note	When measuring phase noise, the Carrier Power should be measured with a wide enough bandwidth to capture the significant power in the noise skirts. This Phase Noise Measurement application does not identify spurs; therefore, their displayed levels are reduced by the scaling of the power bandwidth. For instance, if the measurement bandwidth is 10 kHz, then a –60 dBc spur will look as if it is approximately –100 dBc.

When measuring phase noise with a Spectrum Analyzer, both the analyzer phase noise and its DANL can impact the measurement. The analyzer setup should be tailored to reduce this impact. For instance, when a large signal is near the displayed frequency range, the DANL is limited by the effective noise figure of the ADC. This becomes an issue at offset frequencies above 100 kHz.

By moving the start frequency above the carrier frequency by 100 kHz, a 3 kHz RBW filter knocks the carrier level down enough so that the reference level can be decreased by 20 dB. This adds gain to the IF that improves the DANL. Excess RF attenuation also limits the DANL.

To optimize the DANL without overloading the ADC, measure the carrier power level. If the carrier power is greater than 0 dBm, then set the attenuation equal to the carrier power level; otherwise, set the attenuation equal to 0 dB. If the ADC does overload, then the attenuation should be increased.

AM noise on a source looks like phase noise when measured with a Spectrum Analyzer. The Spectrum Analyzer does not differentiate between them. Phase noise measurements made with a Spectrum Analyzer use the assumption that the AM noise is much less than the phase noise, which is true with most quality sources.

Notes

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