Application Note

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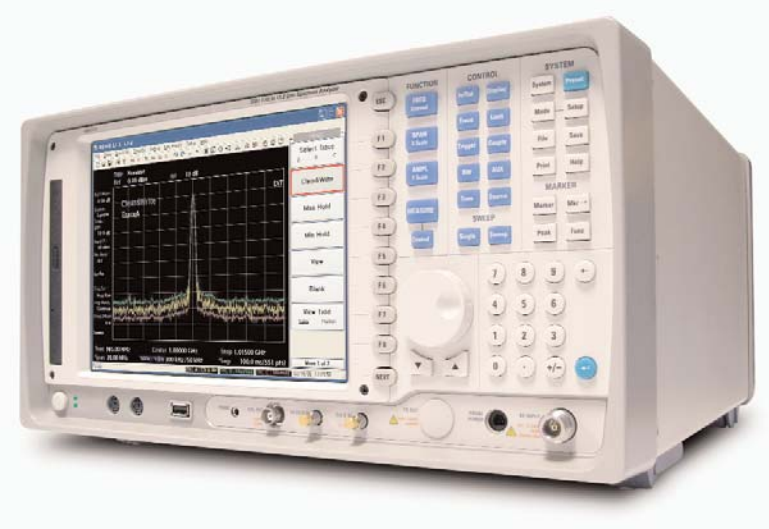
Aeroflex 3280 Series Spectrum Analyzers for Phase Noise Measurements



This application note introduces the capabilities of the Aeroflex range of spectrum analyzers to easily and quickly characterize the phase noise behavior of a system under test.

Introduction

The 3280 Series has been designed to achieve the best performance while keeping the cost to an affordable level. Ideally suited to design and production applications the 3280 Series uses a Windows XP operating system and a large color TFT LCD, making the 3280 very easy to operate with exceptional connectivity. RF and microwave performance that employs the very latest digital signal processing technology enables superb level accuracy , a wide choice of resolution bandwidths and a low level LO phase noise.

In addition to offering accurate and comprehensive RF and microwave capability, the 3280 Series includes a phase noise measurement capability that allows the evaluation of the phase noise of oscillators and systems.

Methods of Measuring Phase Noise

Today, noise measurements have become an essential factor in the characterization of signals. Spectral purity and stability of signals are essential to the quality of modern communication, transmission and radar systems. A fast and easy to use phase noise measurement system is therefore appreciated in most R&D and production environments.

Phase noise is a frequency domain measure of the short-term stability of an oscillator. It is measured and specified as noise power, relative to carrier power, in a one Hz bandwidth at a given frequency offset. Typically, for a communication system oscillator, the phase noise requirement is specified for several frequency offsets chosen according to system requirements.

Different methods and instruments can be used to characterize and measure the phase noise of a device under test, depending on the quality of the source and the required accuracy. In this note we will describe the two major ones, the Spectrum Analyzer and the Quadrature methods.

Spectrum Analyzer Method:

The simplest and fastest method of determining the phase noise of an oscillator is the direct measurement by means of a spectrum analyzer.

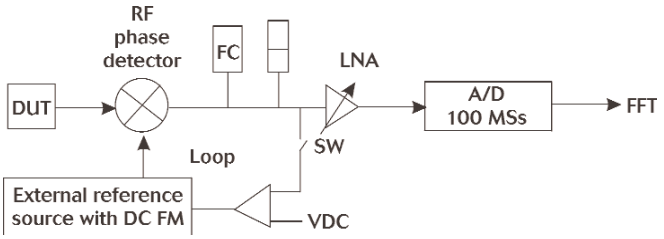
For this measurement, the critical points are:

- The phase noise of the local oscillators of the spectrum analyzer must be low enough to ensure that the characteristics of the DUT and not those of the spectrum analyzer are determined.
- The oscillator drift must be small relative to the spectrum analyzer bandwidth.

In practice, the spectrum analyzer provides an easy to use solution for phase noise measurements of stable, medium performance oscillators but remains limited for close to carrier (<100Hz) or high dynamic range measurements.

Quadrature Method:

In the Quadrature System two oscillators at identical frequencies are used. Typically one of the oscillators will be the source being tested and the other will be a reference source whose performance is known to be better than the source under test. The oscillator outputs are combined in a mixer and the relative phase adjusted to produce zero volts at the output of the mixer (source in quadrature). The resulting output signal is filtered, amplified by a Low Noise Amplifier (LNA) and measured by a Fast Fourier Transform (FFT) Analyzer or similar device. Quadrature is maintained with the aid of a PLL (Phase Locked Loop), whose impact on the noise needs to be calibrated.



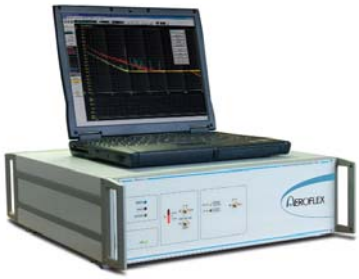
Base system operating diagram

Phase Noise Analyzers based on that method provide high performance in dynamic and offset range but require the use of a good internal or external reference source. Extensive data processing and calibration also ensure fast measurement and high accuracy. Such a solution is ideal for synthesizer and oscillator characterization but is of course dedicated to Phase Noise measurements and does not have the flexibility and variety of capability of a Spectrum Analyzer.

Aeroflex Solutions for Phase Noise:

As a leader in phase noise measurements techniques in RF and microwave, Aeroflex can propose a large range of test solutions including:

3280 Series spectrum analyzers with phase noise measurement capability



PN8000 Series low cost automated phase noise test set

Phase Noise Measurements with 3280 Series Spectrum Analyzers

Due to their very low SSB phase noise (see table beside), the 3280 Series spectrum analyzers is an ideal tool for applications requiring phase noise measurements. In a dedicated Phase Noise measurement menu, the 3280 allows log plot measures of SSB phase noise versus offset frequencies (dBc/Hz versus log frequencies). This allows you to display the phase noise log plot of the device under test. Optimal configuration and performance is achieved by selecting the variety of settings available in the 3280:

- Automatic carrier search allows for verification of carrier and level to prevent errors due to frequency drift
- Select and display offset frequency in logarithmic scales from 10 Hz to 1000 MHz
- Display markers and decade table
- Measure phase noise with or without a selected number of averages
- Display simultaneously measured and smoothed traces (user defined smoothing rate)
- Apply video filtering with adjustable VBW/RBW rate
- Select filter mode to chose from two LO optimization modes (Narrow >50 kHz, Wide <50 kHz)
- Store traces or image files

Making Phase Noise Measurements

The following example describes how to set up and optimze the settings of the 3280 spectrum analyzer to make phase noise measurements.

Basic Configuration:

- Select Phase Noise Mode:

  [Mode] [Phase Noise]

- Set Center Frequency:

  [Frequency] [Carrier Freq] xxGHz or

  [Frequency] [Carrier Search]

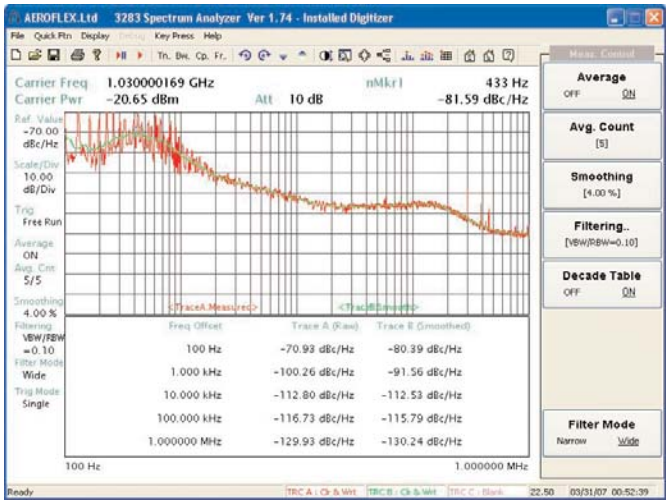
- Make Log Phase Noise Measurement:

  [Measure][Log plot]

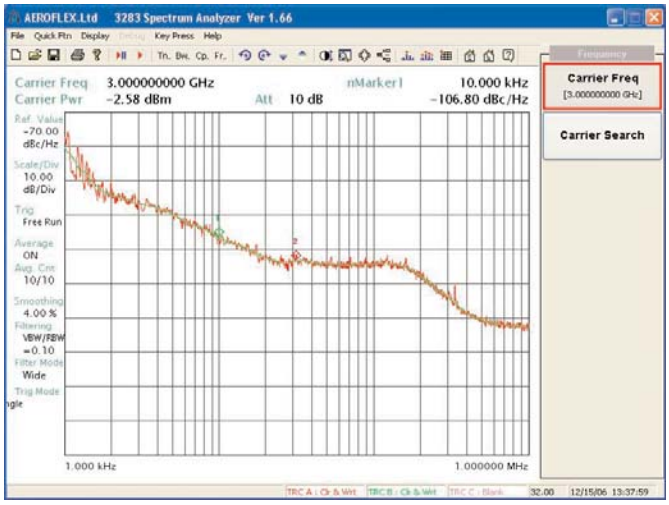
SSB phase noise, dBc/Hz at offset:

CW freq	Frequency offset				
	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz
10 MHZ	<-78	<-102	<-113	<-113	<-135
	<-76	<-110	<-113	<-113	<-135
	<-76	<-100	<-113	<-113	<-136
	<-68	<-98	<-110	<-111	<-135
	<-60	<-83	<-107	<-110	<-135

SSB phase noise of 3280 local oscillator



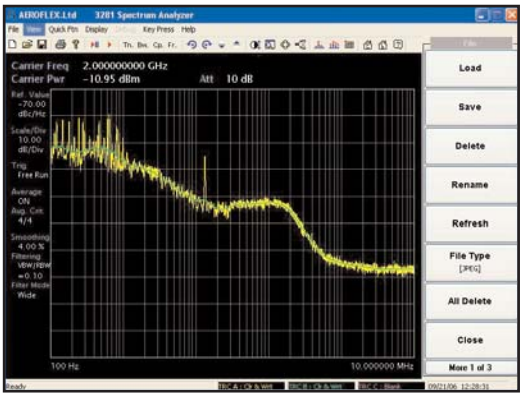
SSB phase noise log plot with decade table



SSB phase noise log plot with [Frequency] menu

Improve display settings :

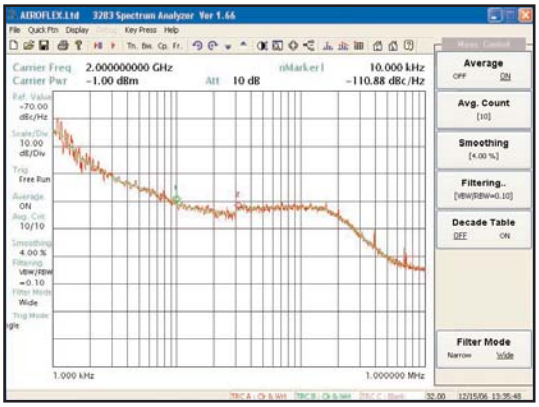
- Select Span of offset frequencies :start [SPAN] [Start]100 [Hz]
- Select Span of offset frequencies :stop [SPAN] [Stop] 10 [MHz]
- Select Reference level : [Amplitude] [Reference] 50 [-dBm]
- Select Scale per division [Amplitude] [scale] 10 [dB/div]



SSB phase noise Log plot from 100 Hz to 10 MHz

Improve measurement settings:
Averaging

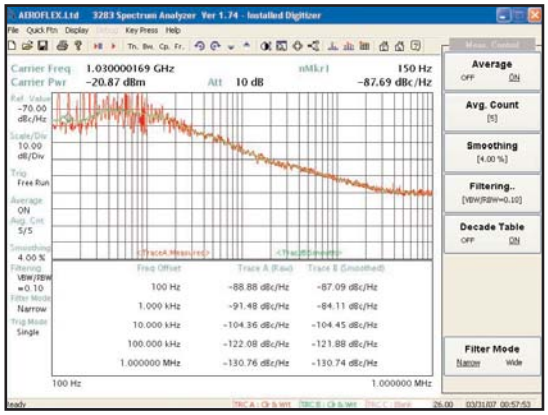
- Activate Averaging [Measurement Control] [Average]ON
- Select number of Average [Measurement Control] [Avg. Count]10



SSB phase noise log plot with 10x average

Improve measurement settings:
Filtering: use of filtering results in an averaging and smoothing effect on the noise. The degree of noise reduction is function of the ratio VBW/RBW, the lower the ratio, the lower the noise.

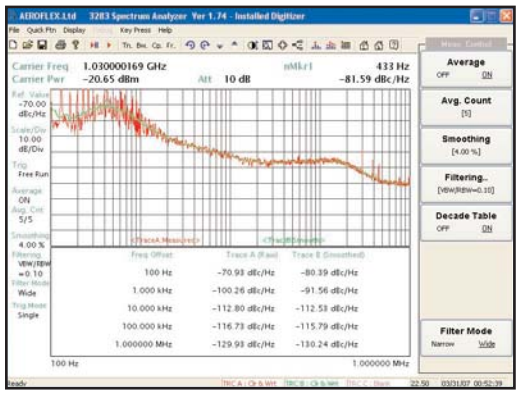
- Select Filtering Ratio [Measurement Control] [Filtering] [VBW/RBW=0.1]



Phase noise log plot in narrow filter mode

Improve measurement settings:
Filter Mode: allow the user to select different LO filtering modes to optimize the phase noise for different measurement conditions. In Wide mode the phase noise is optimized for the close to carrier area at the expense of offsets beyond 50 kHz, whether Narrow is optimized for offsets above 50 kHz

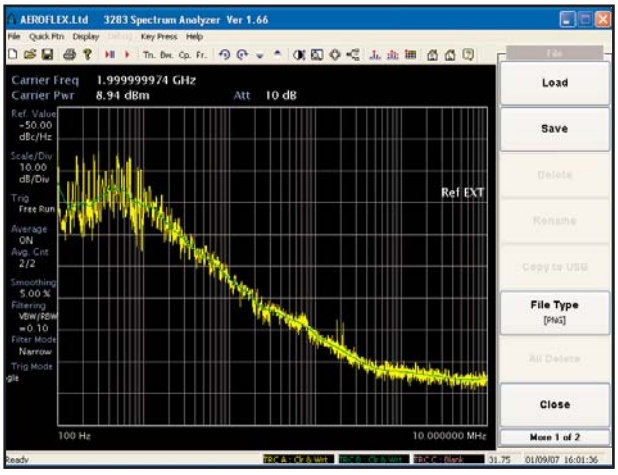
- Select Filter Mode [Measurement Control] [Filter Mode] Wide



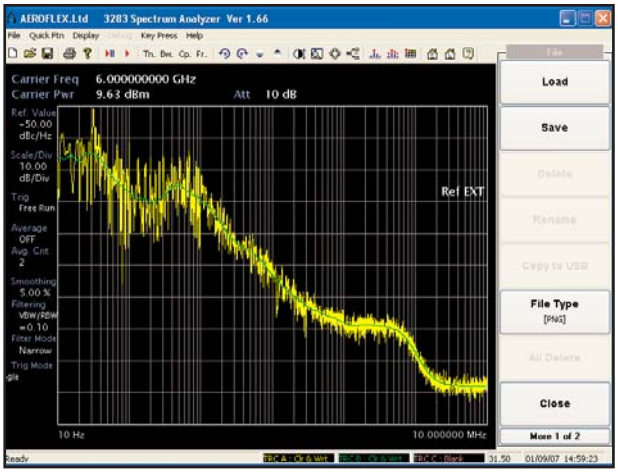
Phase noise log plot in wide filter mode

Phase Noise Measurements with 3280 Series Spectrum Analyzers

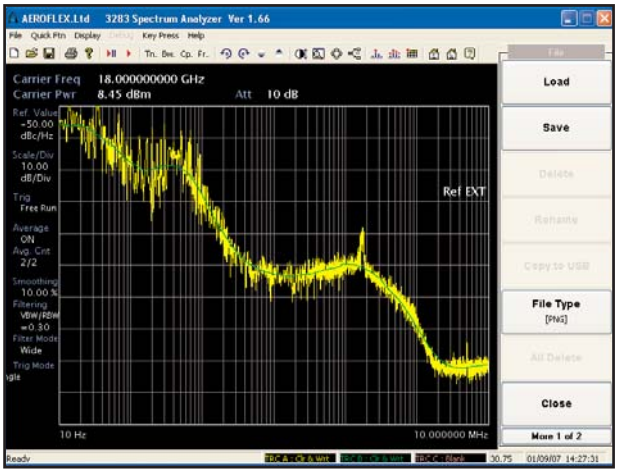
Typical phase noise measurement capability at different center frequencies:



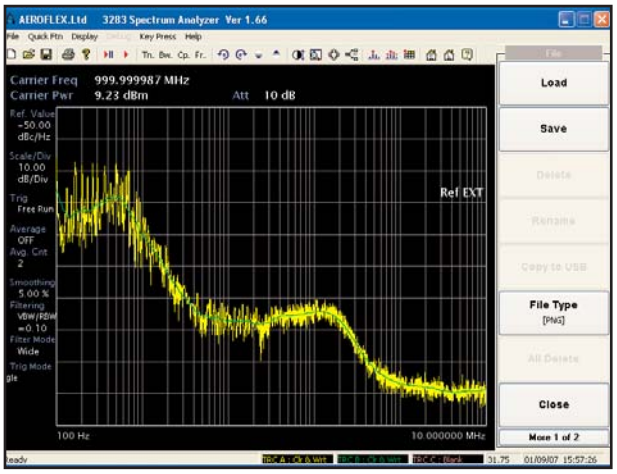
Phase noise 2 GHz narrow filter mode



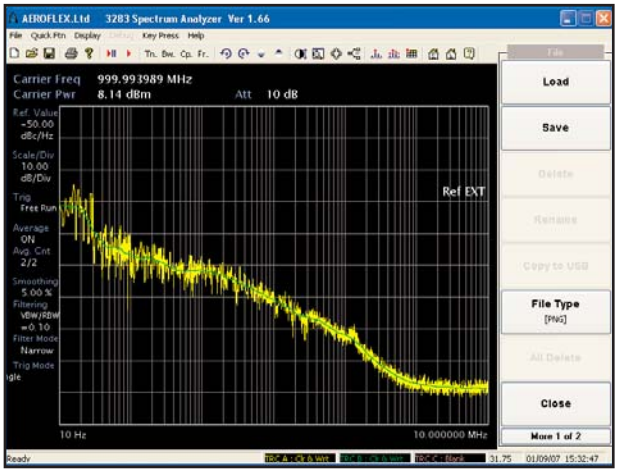
Phase noise 6 GHz narrow filter mode



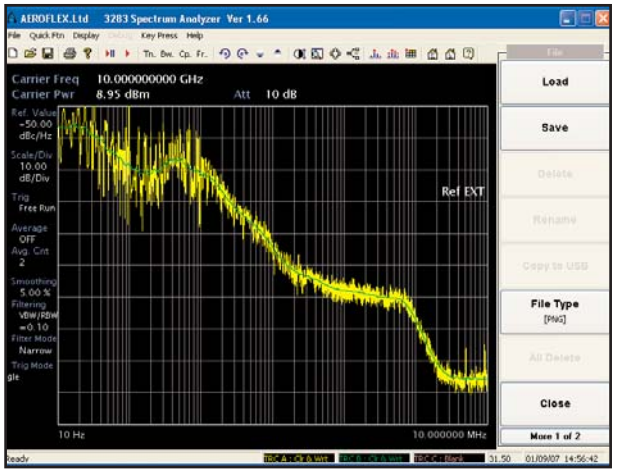
Phase noise 18 GHz wide filter mode



Phase noise 1 GHz wide filter mode



Phase noise 1 GHz narrow filter mode

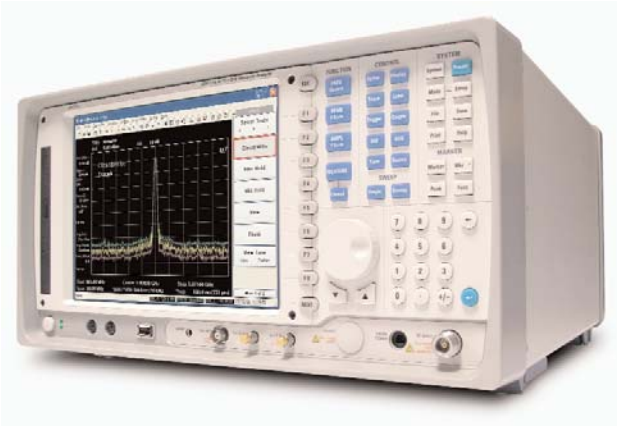


Phase noise 10 GHz narrow filter mode

Aeroflex range of spectrum and phase noise analyzers:

3280 Series Spectrum Analyzers

RF and microwave performance that employs the very latest digital signal processing technology for enabling superb level accuracy and a wide choice of resolution bandwidths.



3281 - 3 Hz to 3 GHz

3282 - 3 Hz to 13.2 GHz

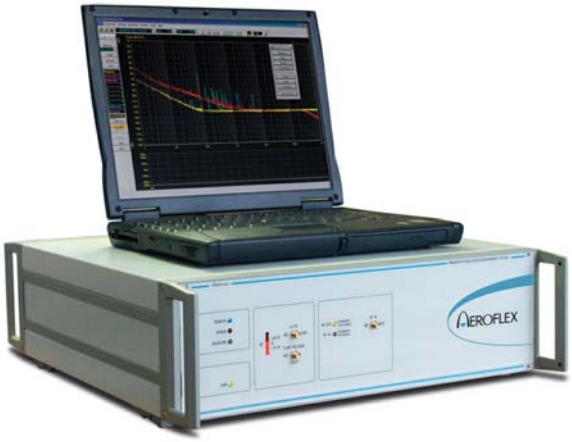
3283 - 3 Hz to 26.5 GHz

- High level accuracy ±0.15 dB up to 3 GHz Digital IF offers resolution bandwidths from 5 MHz to 1 Hz Low DANL of <-150 dBm/Hz
- +18 dBm third order intermodulation performance
- Excellent LO phase noise <-115 dBc/Hz, 1 GHz/10 kHz offset
- Optional tracking generator - all models

www.aeroflex.com/products/gentest/specanalyzers/3280.cfm

PN8000 Phase Noise Test System

Aeroflex brings high performance phase noise testing capability into a new era with the PN8000, a low cost automated phase noise test system. The PN8000 is designed for manufacturers of crystal oscillators, synthesizers and PLL (phase lock loop) components who do not need the additional performance of the options available in the PN9000 or PN9500.



Detector Frequency Range: 2 MHz to 1.8 GHz (option 18 GHz)

Offset Analysis: 1 Hz to 1MHz (20 MHz option)

Measurement Accuracy: ±2 dB up to 20 MHz

Reference Tuning Voltage: ±20 Volt with 5 mV resolution

Phase Lock Loop Gain: Proportional and Integral (DUT drift compensation)

Loop Compensation: Automatic (can be disabled)

Phase Noise: Typical values for nominal RF and LO input levels

www.aeroflex.com/products/gentest/phasenoise/pn8000.cfm

For more information on the Aeroflex Products mentioned in this application note, do not hesitate to visit our web site **www.aeroflex.com**

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Our passion for performance is defined by three attributes represented by these three icons: solution-minded, performance-driven and customer-focused.

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