Disruptive Phase Noise Measurement Technology
The Next Evolution of Instrumentation

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Presented by
Berkeley Nucleonics

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Berkeley Nucleonics Corporation

A trusted source for quality and innovative instrumentation since 1963

Test And Measurement
Nuclear Expertise
RF/Microwave

BNC at Our Core

BNC Mission: *Providing our customers with a better experience in using test equipment*

Market Philosophy: *Out-package, Out-perform, Out-service, Out-price all competitors*

Advantages of PC-Driven Instrumentation

Smaller, lighter, easily transportable, field use

Low cost of entry, low cost of ownership, better long-term reliability

Faster test data transfer

Easier node-ability

Feature and performance upgrades faster to market

Not locked into internal PC with operating system - many types of devices

Designed to resist obsolescence

BNC

BNC Model 7330 Signal Source Analyzer

Berkeley Nucleonics Corporation - 2955 Kerner Blvd - San Rafael CA 94901
800-234-7858 or LiveChat @ www.berkeleynucleonics.com

The BNC Value

- Compact, headless, ultra high-end Phase Noise Testing Systems
- The “one device solution”
  - Broadband 5 MHz to 40 GHz
  - Additive and Absolute noise measurements
  - Extensive toolsets for many DUT types
- Free updates for the life of the instrumentation
- Calibration resources, built in procedure
- Fraction of the cost of contemporary instruments

Why is Phase Noise increasingly important?

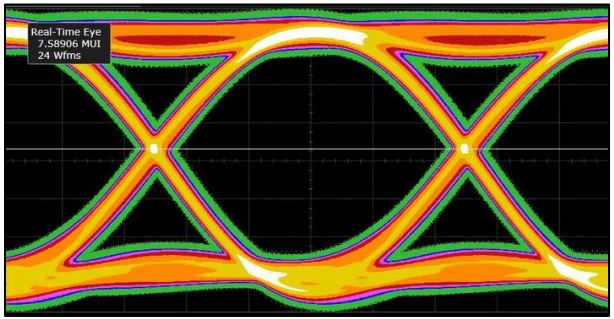
Higher data rates limit energy per information

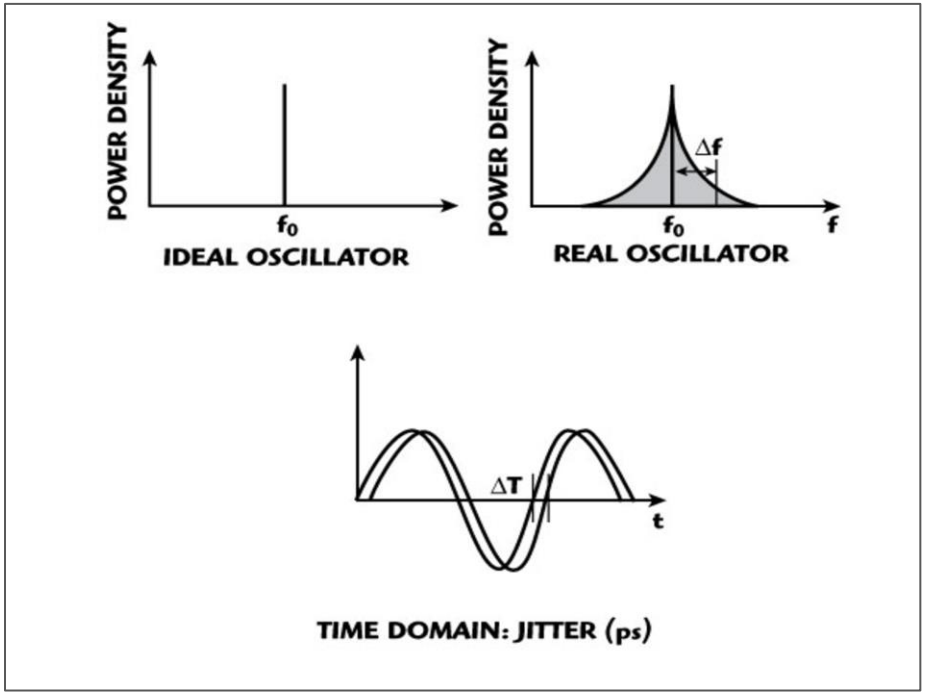
Less energy results in lower SNR

Tighter system margins demand for phase noise testing

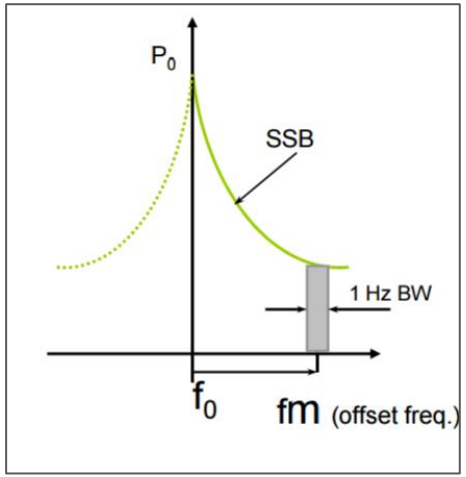
What is Phase Noise?

- Random, short-term fluctuations in phase of a waveform
- Caused by time domain instabilities (jitter)





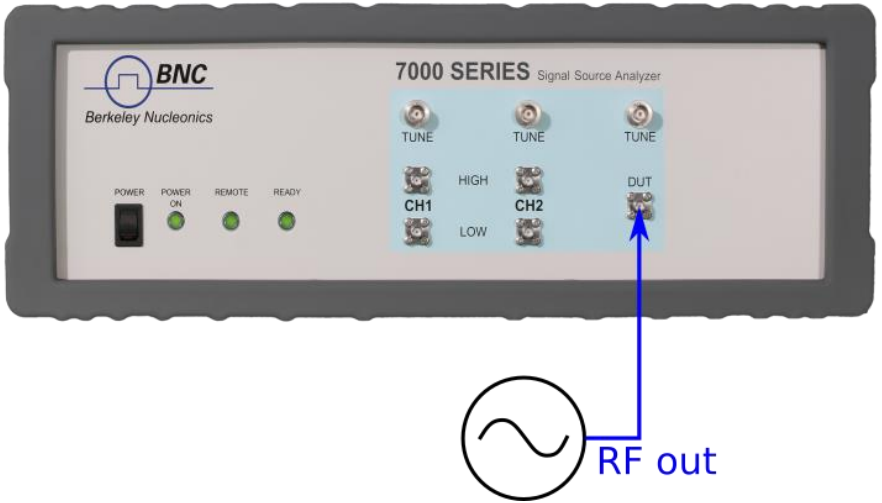
What is Phase Noise?



- Usually represented as single-sideband power spectral density in frequency domain
- Real world: Signals have fluctuations in both amplitude and phase
- Power spectral density can be separated in AM and PM power spectral density

Demo 1

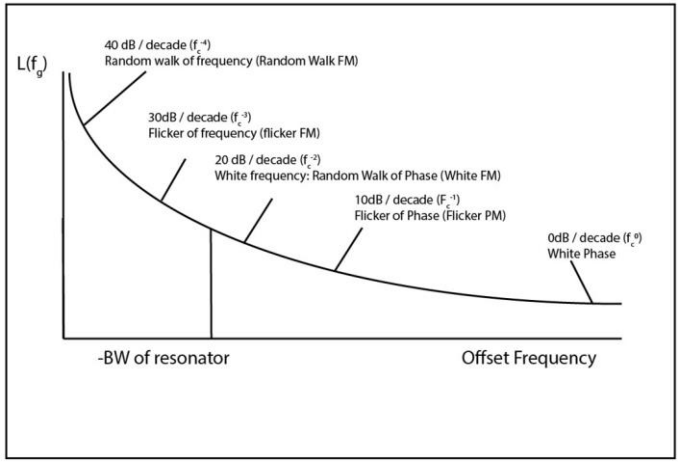
Absolute Phase Noise
Continuous Waveform



What is Phase Noise? Cont.

Common sources of random noise:

- ***Thermal noise:*** *Temperature fluctuations in electronic components*
- ***Shot noise:*** *Caused by discrete nature of electric current flow*
- ***1/f flicker noise:*** *Resistance fluctuations in electronic components*



Methods of Phase Noise Measurement

Spectrum Analyzer (SA):

Advantages:

- Already available
- Easy to use

Disadvantages:

- Noise figure limits dynamic range (typically -145 dBc/Hz is limit)
- LO and RBW limits close in phase noise measurements
- Cannot distinguish between AN and PN
- Cannot handle unstable DUTs

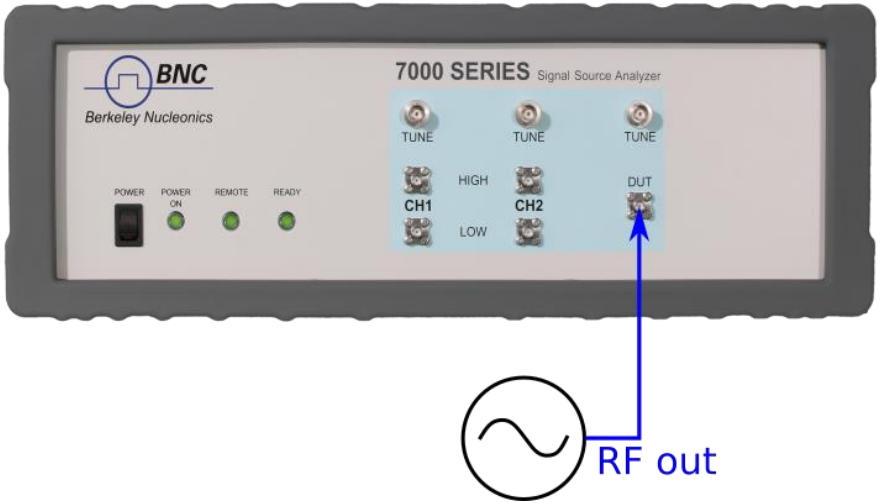
Dedicated Signal Source Analyzer (SSA):

BNC SSA Advantages:

- High dynamic range (-185 dBc/Hz)
- Can analyze as close as 0.01 Hz to the carrier
- distinguish and measure AN & PN separately
- Can measure “additive” phase and amplitude noise of non-self-oscillating devices
- Higher throughput, excellent in ATE environments
- Handles many types of DUTs: from ultra low noise to drifty and modulated DUTs
- Toolset for signal source analysis

Demo 2

Absolute Phase Noise, Spectrum Monitoring, Transient Analysis
CW with FM (frequency modulation)



Many DUTs

High drift sources

DRO

VCO

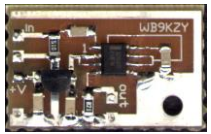
YIG

Non-self oscillating devices

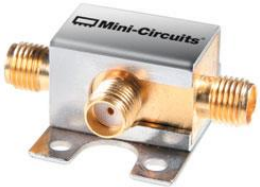
PA

Frequency translation devices

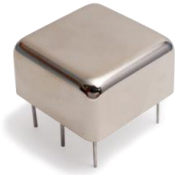
Prescaler



Mixer



Ultra low phase noise



OCXO

Atomic clock

PLL synthesizer

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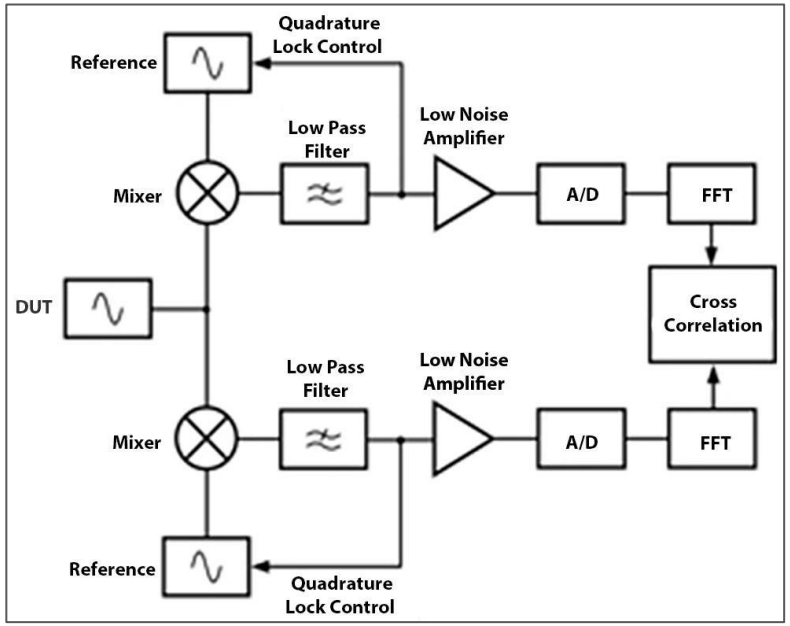
How does the BNC SSA measure Phase Noise?

"Phase fluctuations of DUT are converted into voltage, filtered and digitized to derive SSB phase noise"

1) Downconversion of DUT signal (with internal / external LO's)
   a) Depending on DUT stability and frequency:

      direct conversion, heterodyne, dual-heterodyne with low or zero-IF
1) Resulting baseband signal is amplified, filtered and digitized
2) Digital signal processing (FPGA): filtering, down-sampling, FFT, I/Q demodulation
3) Crosscorrelation rejects noise contributions from receiving channels
4) GUI serves as visualization and extended postprocessing tool.

How does the BNC SSA measure Phase Noise?

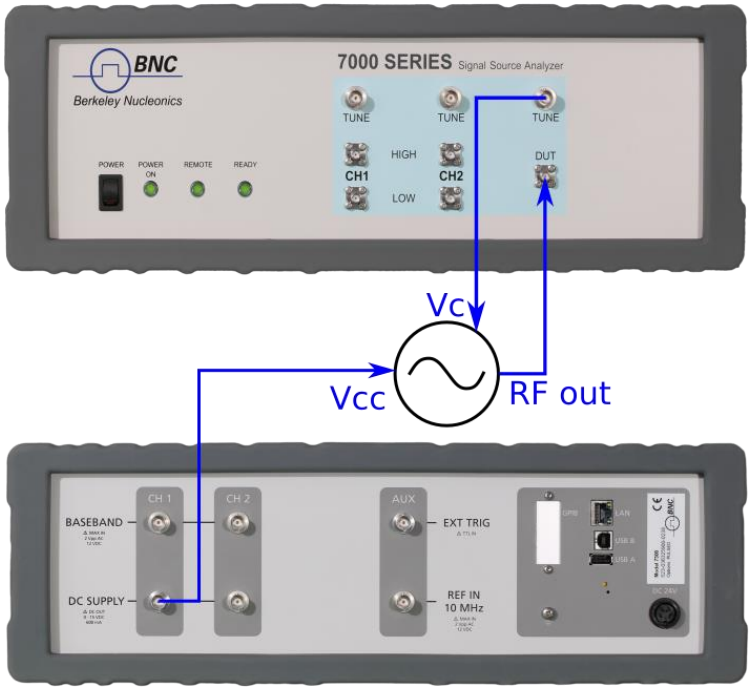


- Crosscorrelation overcomes instrument thermal noise and reference noise
- DPLL (phase locked loop) tracks DUT

Single Instrument - many Applications

- Absolute and additive phase and amplitude noise of CW or modulated signals (pulsed, FM)
- Transient measurement to derive frequency, power and phase over time
- Complete test bench for voltage controlled oscillators (frequency, K_{VCO}, supply pushing, phase noise, power, current consumption)
- Cross-spectrum baseband analyzer (100MHz bandwidth)
- Programmable dual low noise DC supplies (up to 15V, 0.5A each)

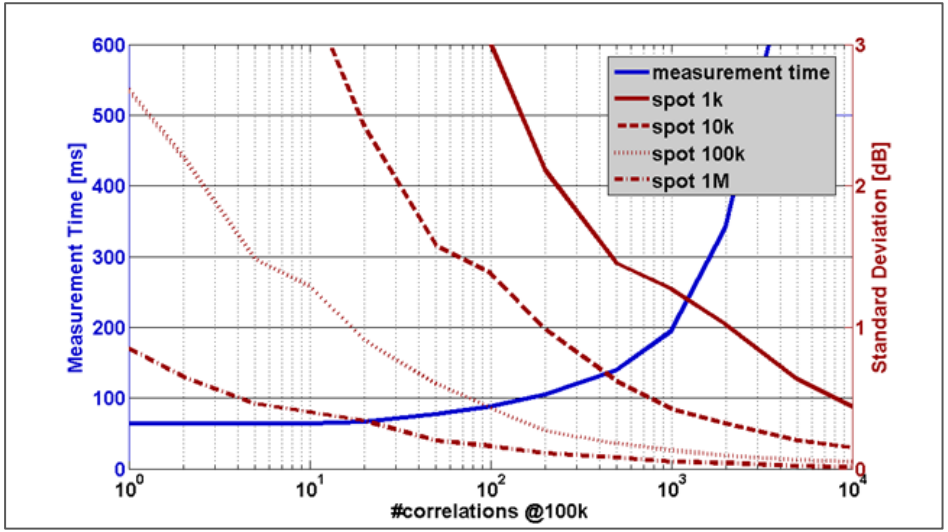
Demo 3



VCO Characterization

How does the 7330 excel Automated Testing?

- **Throughput optimized solution**: measurement speed <100 ms with excellent accuracy and repeatability
- Easy Integration:
  - API (COMM Library, drivers)
  - SCPI command control



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Industry Comparison

Manufacturer	BNC	NoiseXT	R&S	Keysight
Absolute Frequency Range	5 MHz to 7/26/40 GHz	10 MHz to 7/26 GHz	1 MHz to 8/26 GHz	1 MHz to 8/26 GHz
Equipment	7000 Series	NoiseXT DCNTS (PN9000)	R&S FSWP26	Keysight E5052B + E5053A
Offset range	0.01 Hz to 100 MHz	0.01 Hz to 40 MHz	0.01 Hz to 1 GHz	1 Hz to 100 MHz
Additive Phase Noise	Yes	Yes	Yes(Option)	No
Pulsed/AM/VCO Tester	Y/Y/Y	Y/Y/N	Y/Y/Y	N/Y/Y
Internal/External References	Y/Y	Y/Y	Y/N	Y/N
Cost	$48K -$66K	N/A	$150K base	$150K base

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BNC's Unique Value Conclusion

BNC offers a solution which provides:

- All in one instrument to cover all analysis from 5MHz to 40GHz
- Low cost of entry, low cost of ownership, with excellent reliability & long life
- Reduces complexity and hardware of measurements
- Fastest analysis time in the industry which can increase yield in production environments
- Extremely versatile: portable, DC input, rackmount, benchtop, ATE implementation
- Unparalleled Customer Service Experience

Q and A answered

Q: can system measure -170 dBc/Hz @ 10 GHz on driver amplifier at 10/20/30 GHz?

A: Yes, this can be done. The critical component in the setup is the oscillator, which needs to show good phase and especially amplitude noise performance. Both noise parameters are effectively suppressed but of course only to a certain degree.

Q: Can the 7300 series Signal Analyzer be used to directly measure modulation bandwidth on free running VCO's?

A: No, the 7300 series can measure the modulation depth and rate, but the modulation signal needs to be applied externally by a modulation source using for example a bias-T.

Q: For VCO characterization, what is the minimum step size for the voltages (VCC, Vtune)?

A: Settable minimum step size is 400 uV, though we have specified down to 10mV.

Q: Can we measure the phase noise of a 10 GHz source at 10 KHz with 150 ms?? Then how far we can go? -165 dBc/Hz?

A: Since a time of 150 ms was mentioned I assume this is a question about ATE. Yes, we can measure this, also in the mentioned time. Sensitivity at 10 GHz and 10 kHz offset is (datasheet) -140 dBc/Hz after one correlation. To get down to -165 dBc/Hz, many correlations would be needed that will take time. It might be an option to use external references here to speed this process up.

Q and A answered

Q: in direct-conversion mode, do you provide high-resolution (14 digits/s or so) frequency counting and ADEV/TDEV analysis?

A: Yes, ADEV measurements are available. They can be measured in two modes, first mode is by directly derive them from a phase noise measurement. This gives valid measurement for very small tau up to about 1s. For longer tau, a second approach is used that measures frequency versus time data over long periods and directly calculates ADEV from this signal.

Q: Noise floor additive PN or AN?

A:

Parameter	Min.	Typ.	Max.	Note
Residual Phase Noise Floor				(cross-correlation engine, external source)
1 Hz		-140 dBc/Hz		
10 Hz		-150 dBc/Hz		
100 Hz		-160 dBc/Hz		
1 kHz		-175 dBc/Hz		
10 kHz		-188 dBc/Hz		
10 MHz		-188 dBc/Hz		

Q: Is there any/specific SW needs to be installed before one can use the GUI shown?

A: Yes, the graphical user interface is a Java based application, so a recent version of the Java Runtime Environment (JRE) needs to be installed on the computer. There are no additional SW requirements.

Q: Can u suggest or supply the OSC/Sig Gen that can make this -170 dBc/Hz @ 10 GHz Res PN measurement. Can be handled after the webinar

A: The main challenge in this measurement is the oscillator phase noise and amplitude noise. If you frequency is fixed at 10 GHz, a fixed frequency, no ALC setup might be best to have the best AM and PM performance. Can you give us more information about the DUT, etc?

Q and A answered

Q: Can you show Test system setup w/ recommended Source for the low res/add PN 20 GHz driver amplifier?

A: Please find the setup to the right. A CW signal is split into two paths, one for the DUT input, one for the REF input. A shifter and the DUT can be placed freely on one of those two paths. Additional attenuators may be required to guarantee the minimum power level inputs of 13 dBm at the REF input and 3 dBm at the DUT input.

Q: Is there any accuracy comparison data available between BNC and other competitors?

A: See attached comparison chart