7000 Series Signal Source Analyzers

Crystals
KVG, NELFC, Magic XTAL, Morion, Greenray, Rakon France & UK, MtronPTI, Quarzcom, SiTime, Semtech, RFX, Taitien Electronics, Haichuang, Haijiang, Panda Nanjing

Time and Frequency Standard Research
METAS, PSI, CNES, European XFEL, NRAO, DESY, Pohang Accelerator, Observatoire Paris

RF and Microwave modules
Rockwell Collins, British Aerospace (BAE), Teledyne, Mitsubishi, Raytheon, Quovo, Custom MMIC, NEC, Peregrine, Cobham, Knowles, Broadcom, JRC, Aoptix, Elbit, ELDES, JPL, FEI, EYAL Microwave, ST Electronics, CETC China, TMY Taiwan

Communications
NOKIA, Eriksson, Aeroflex Malaysia, Vitesse Semicon, Tektronix, Spreadtrum China

Signal Source Analyzers

Covering frequency up to 7 / 26 / 40 GHz, direct and additive phase noise and amplitude noise measurement, transient analysis, short- and long-time frequency stability analysis, one-step VCO characterization, baseband FFT, spectral analysis. Internal and external references.

Model	Description
Model 7070	1 MHz to 7 GHz
Model 7300	1 MHz to 26 GHz
Model 7340	1 MHz to 40 GHz

Key features

- Very easy operation: PC based GUI software, or remote control through LAN, USB or GPIB
- Single broadband input from 1 MHz to 7 / 26 / 40 GHz
- Low instrument noise floor (< -190 dBc/Hz)
- Offset range: 0.01 Hz to 100 MHz
- Flexible internal and external references
- Built-in 3 independent tuning voltages (-5 to +22 V)
- Built-in 2 independent DC supply voltages (0 to 15 V, 600 mA each)
- External 10 MHz reference input
- External trigger input
- Light weight: 11 kg (24 lbs) and compact size, portable

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Signal Source Analyzers – Key Functions

Description

Key functions:

- **Phase Noise Measurement**
  - Absolute, residual / additive
  - CW, pulse, burst measurement modes
  - High-drift or slowly modulated
  - With internal or external references
- **Amplitude Noise Measurement**
  - Absolute
  - CW and Pulse measurement modes
  - High-drift or slowly modulated
  - Always with internal references
- **Transient Measurement** (Frequency, Phase, Amplitude vs Time)
- **Short- and Long-Term Frequency Stability / Allan Deviation Measurement**: 1 s ... 10 days
- **Complete One-Step VCO Characterization** (Tuning, Tuning Sensitivity, Pushing, Power, Harmonics, Current, Phase Noise)
- **Baseband FFT Analyzer** (base-band 1 Hz to 100 MHz)
- **Spectral Analysis** (5 MHz to 7 / 20 GHz)

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Signal Source Analyzers – Options

Option	Description	Supported Models
Option LN	Enhance phase noise test sensitivity (HW)	All
Option PULSE	Add pulsed measurement capability (SW)	All
Option BURST	Burst mode phase noise measurement (SW)	All
Option AM	Add amplitude noise measurement capability (SW)	All
Option APN	Additive phase noise measurement (SW)	All
Option TRAN	Transient measurement (SW)	All
Option TSTAB	Time stability analysis (SW)	All
Option LO	Access to two internal references (HW)	All
Option VCO	One-step VCO characterization (SW)	All
Option SPEC	Spectrum Monitoring (SW)	All

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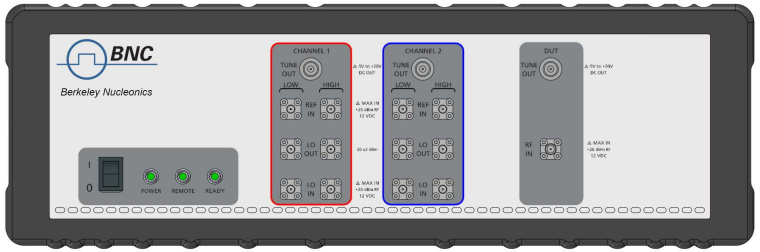
Signal Source Analyzers – Front and Rear Panels



Front

DUT in (-15 to +23 dBm)
DUT tuning voltage out (-5 to +22 V)
Ext. ref. in (up to +23 dBm)
Ext. ref. tuning voltage out (-5 to 22 V)

Rear

Baseband in 1, 2
Precision power supply voltage out 1, 2
Ext. trigger in
10 MHz ref. in
LAN, USB, GPIB
DC Power in

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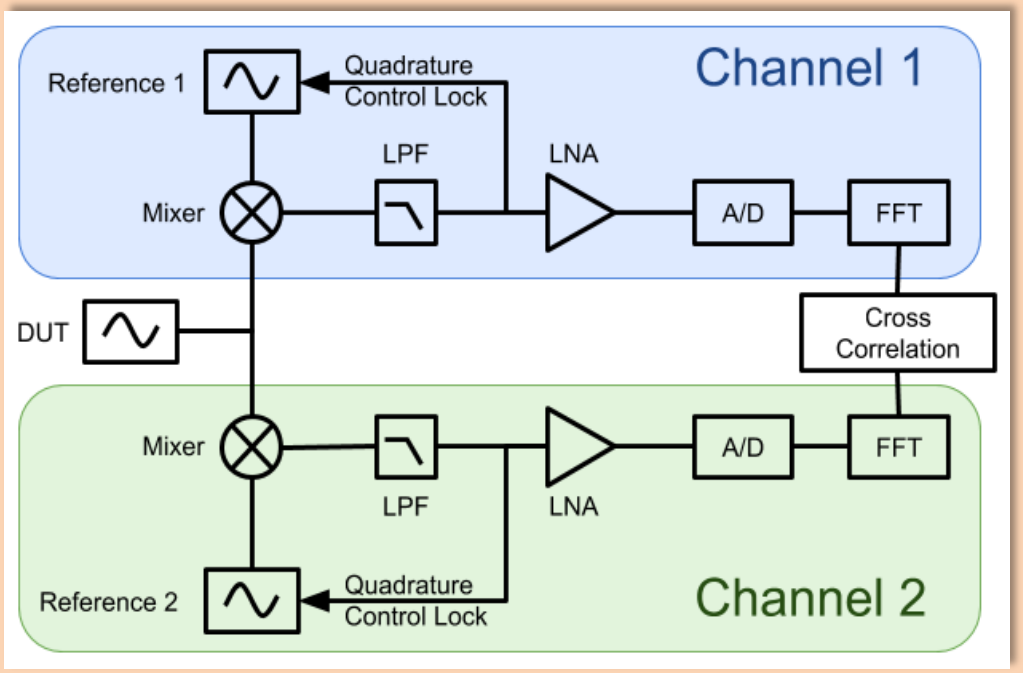
Fundamental Concept (Phase Noise Testing)



Description

- References can be internal or external
- Multiple cross-correlations overcome instrument-internal thermal noise and reference (uncorrelated) noise

- Except for high-drifting DUT, we chose to use «Zero-IF» front-end technique
- «Direct Sampling» for high-drifting DUTs
- «Heterodyne Zero-IF» to further increase measurement sensitivity especially in close-in offset area

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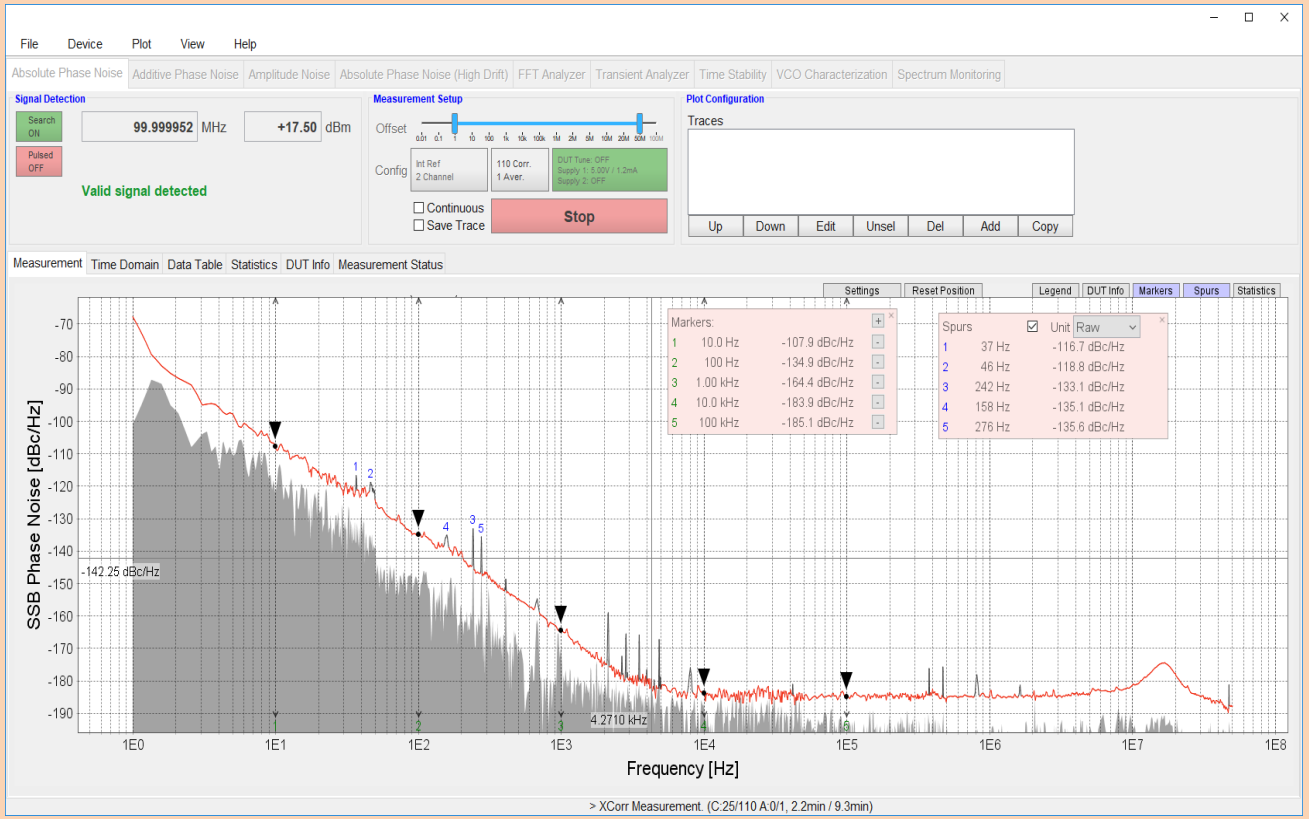
Absolute Phase Noise Measurement – Standard and LN mode



Description

- All on one GUI page
- Automatic DUT frequency search
- Frequency counter and power meter
- Adjustment of offset range, resolution, # of CC and AVG, etc.
- In the “Statistics” tab: jitter, Allen Deviation, etc.
- Spurious on / off

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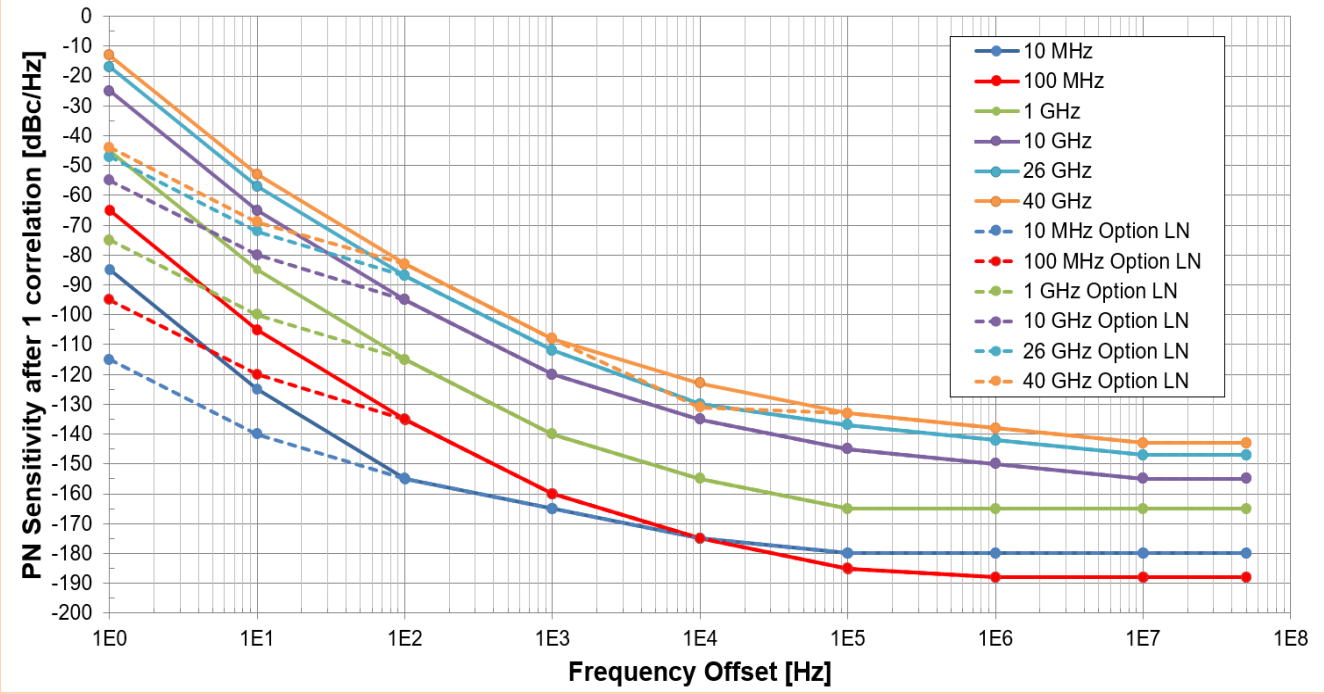
Absolute Phase Noise Measurement – Sensitivity Levels



Description

- Measurements (left) done with 1 cross-correlation
- When using internal references, LN mode improves phase noise test sensitivity especially in the offset range < 1 kHz.
- Regardless with internal / external references, multiple cross-correlation further improves the measurement sensitivity:
  - 10 correlations: ~ 5 dB better
  - 100 correlations: ~ 10 dB better
  - Limit: system noise floor

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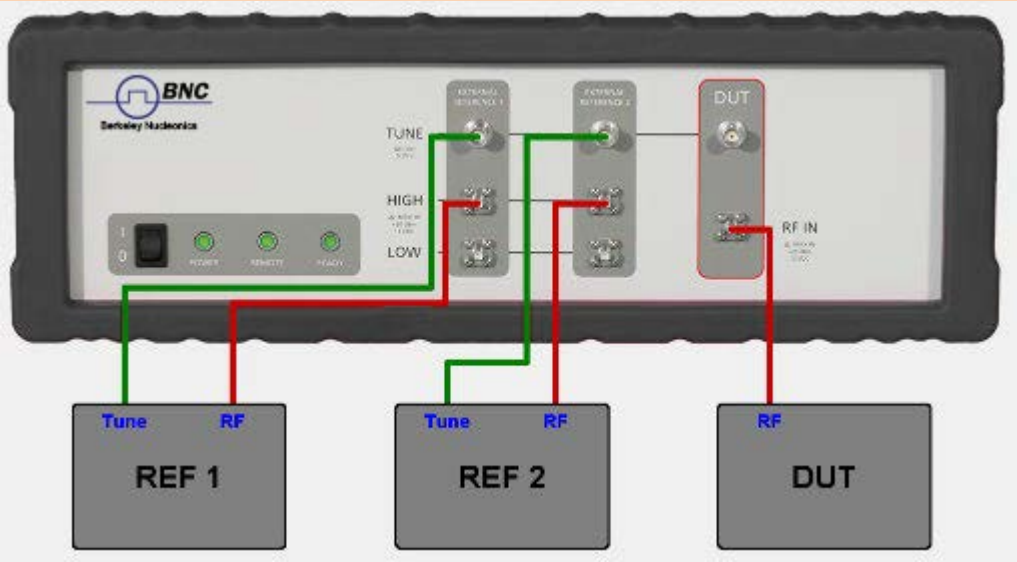
Absolute Phase Noise Measurement – With External References



Description

- The internal references, since they need to be adjustable in a wide frequency range, regardless whether it is in standard or LN mode, have significant influence on phase noise measurement sensitivity. Measuring DUTs with extremely low phase noise would then require a lot of cross-correlation and thus time-consuming.
- Using external references can reduce the number of cross-correlations, and therefore, shorten the measurement time. Choice of external references:
  - frequency-tunable (voltage control input)
  - frequency tuning ranges need to overlap with DUT frequency
  - phase noise of refs can be 10…15 dB worse than DUT's.
- Both single and dual ref channels possible.

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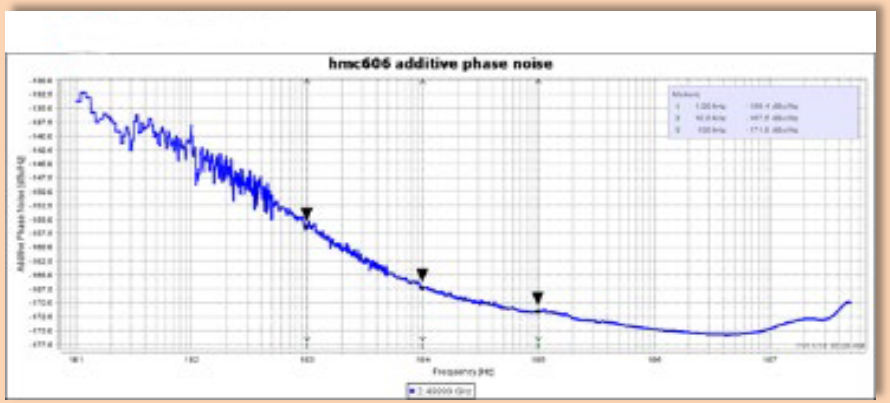
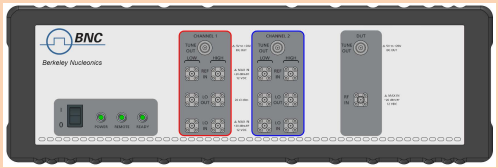
Residual Phase Noise Measurement



Description

- Measuring additive / residual phase noise of non-oscillating DUTs (LNA, mixer, multiplier / divisor, etc.) with extremely low instrument noise floor
- Using external signal source or internal reference source (option LO)



- Choice of accessories:
  - Oscillation source: Phase noise non-critical, but similar or better amplitude noise than the expected additive phase noise of the DUT.
  - Splitter: Good isolation, ideally non-resistive – low insertion loss
  - Phase shifter: min. 180° phase shift at target frequency
- Power balancing
  - REF IN ports need at least 13 dBm, RF (DUT) port at least 3 dBm
  - Dual-channel: REF IN power levels should be similar

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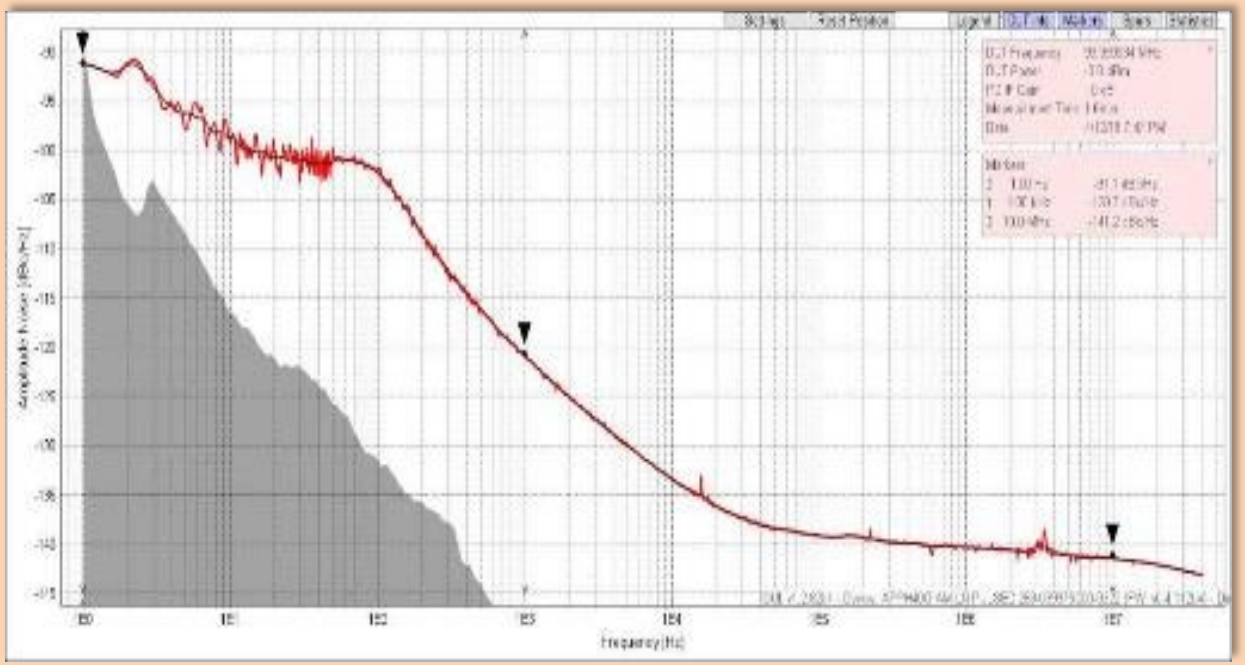
Amplitude Noise



Description

- Frequency range: up to 7 / 18 / 18 GHz
- Input power range:
  - 1 MHz to 10 GHz: -20…+20 dBm
  - 10 GHz to 18 GHz: -10…+20 dBm
- Offset Analysis Range: 0.1 Hz to 40 MHz
- No PLL, direct sampling
- Cross-Correlation further reduces measurement noise floor

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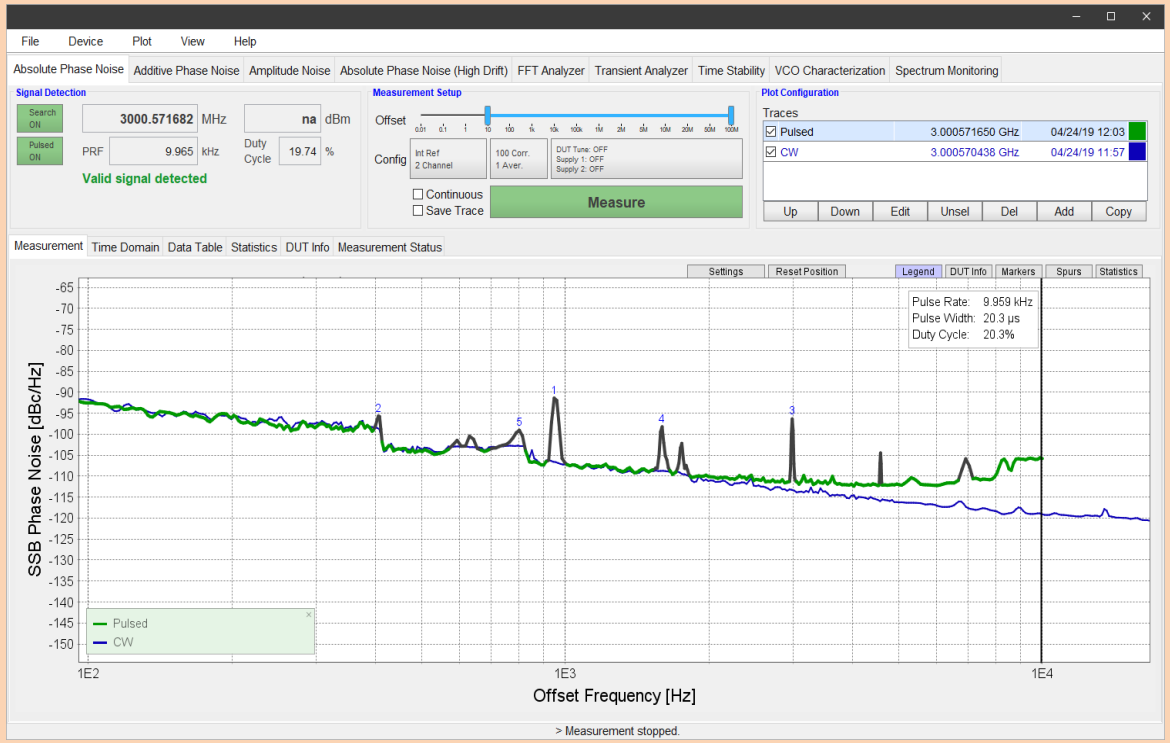
Phase and Amplitude Noise Measurement in Pulse & Burst Mode



Description

PULSED Absolute and additive phase noise

- Detects pulses / pulse trains with a fast power detector
- Can lock to periodic pulsed signals and (aperiodic) pulse trains
- Automatic detection of duty cycle and pulse repetition frequency (PRF)

PULSED Amplitude noise

- Pulsed characteristic can be analyzed directly with I/Q demodulation
- Measured digitally

BURST mode

- Phase noise of individual pulses can be observed
- User selectable single pulse or pulse bursts (packet of pulses)

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Performing Correct Phase and Amplitude Noise Measurements

Description

1. **Reduce environmental influences**
   - High Use high quality, possibly short coaxial cables for RF and control/tuning signals and shielded wires for DC power supply
   - Use precision DC power supplies or batteries to reduce influence from AC power grid (50 or 60 Hz) and from switching power supplies
   - Minimize mechanical disturbances (vibrations, movement of setup during measurement, loud sounds)
   - Reduce or shield from noise and interference sources (mobile phones, other DUTs, unrelated wiring/cords, computers)
   - Shielding can help to reduce: crosstalk, temperature variation, mechanical vibration
2. **Use 7000 series original AC power adapter**
3. **Setup in general**
   - Fixed setup so it can't move around
   - Sufficiently warming up of 7000 series, DUTs and other components
4. **External references**
   - Ideally use separate power supplies for each channel
   - Physically separate references (to reduce channel-to-channel crosstalk)

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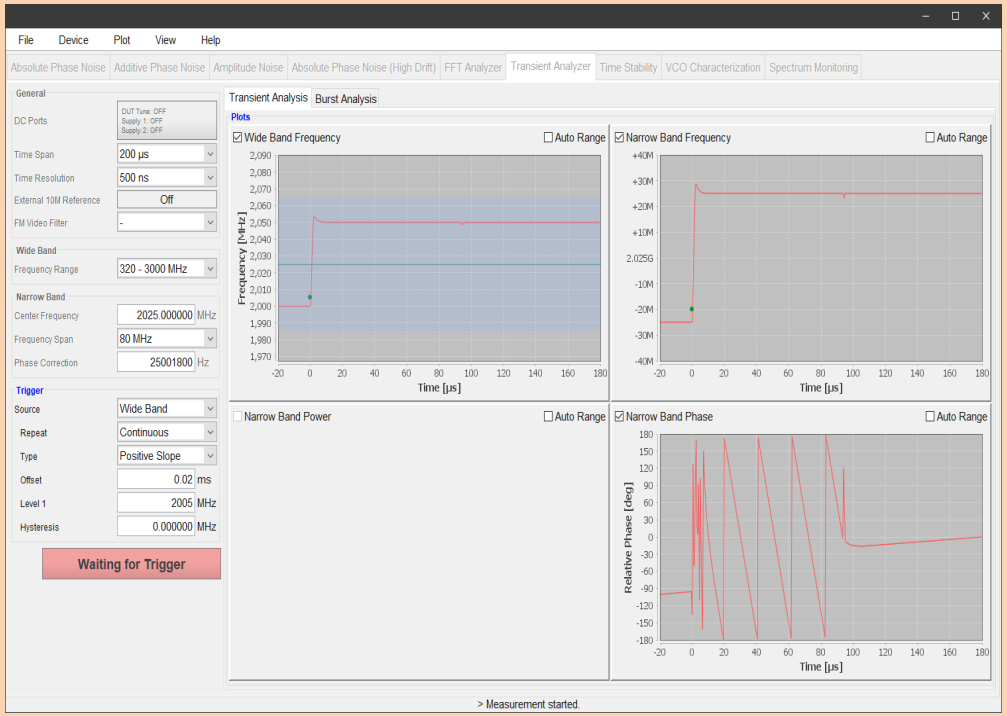
Transient Analysis



Description

- Look at short term behavior in time domain
- Wideband and narrowband mode (200 kHz up to 30 GHz span)
- Excellent time resolution (down to 8 ns)
- Frequency, Phase, Amplitude vs time
- Burst mode phase noise
- Trigger mode can be set to internal (self-detecting), external (TRIG IN) or free running
- 4 display fields (max 3 pictures displayable)
  - Wide band freq vs time
  - Narrow band freq vs time
  - Amplitude/Power vs time
  - Phase vs. time or phase noise

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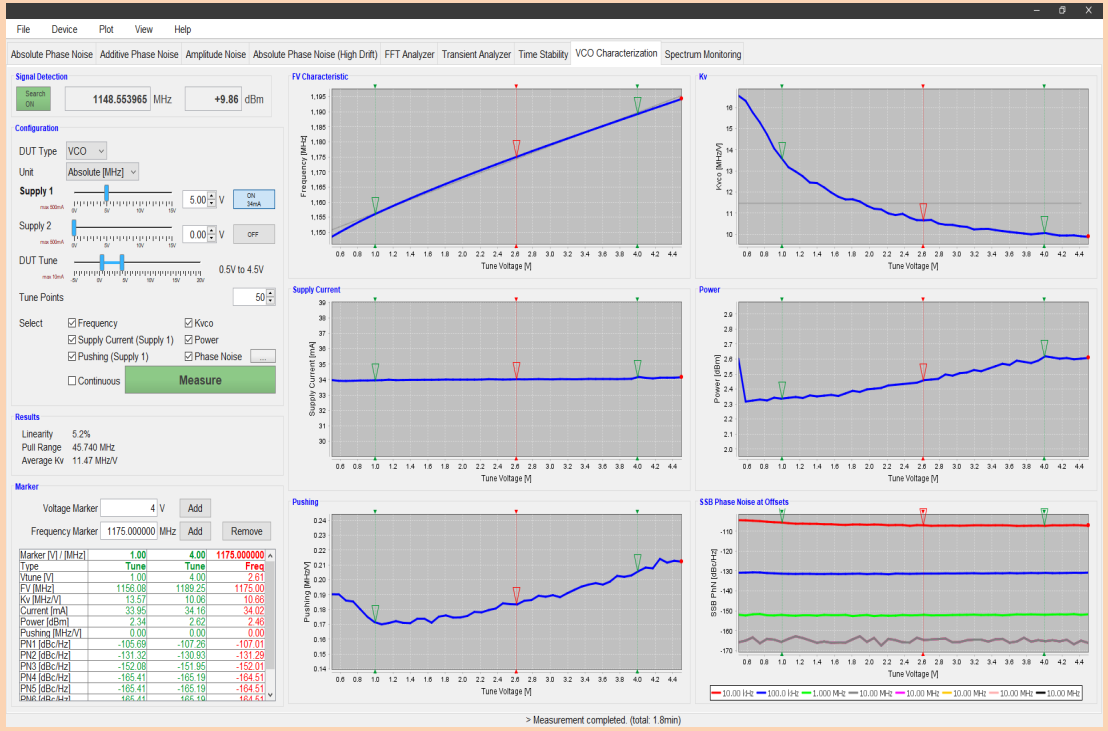
VCO Characterization



Description

- One-step, full characterization of both VCO- (wide frequency tuning range) and VCXO-style (narrow frequency tuning range) DUTs
- 6 display fields:
  - Freq vs. tuning voltage
  - Kvco vs tuning voltage
  - Supply current vs tuning voltage
  - Power and harmonics vs tuning voltage
  - Pushing vs tuning voltage
  - Phase noise vs. tuning voltage
- Can control various supply and tuning voltages in sweep mode (outputs available at front and rear)

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Long-Time Frequency Stability Analysis

Description

- Testing time from 1 s to 10 days
- Frequency drift over time
- Allan Deviation (ADEV) over time

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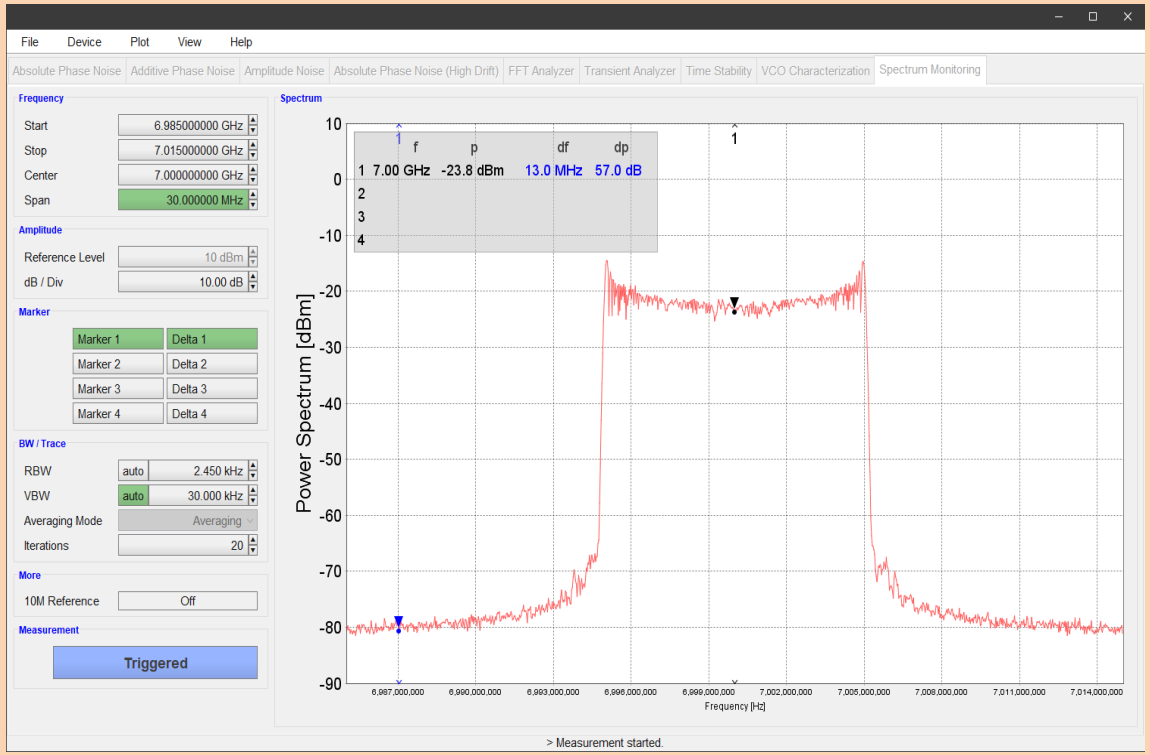
Spectral Analysis



Description

- 5 MHz to 7 / 20 GHz
- Uncertainty: +/- 3 dB absolute; +/- 1 dB relative
- Noise floor: about -90 dBm/Hz

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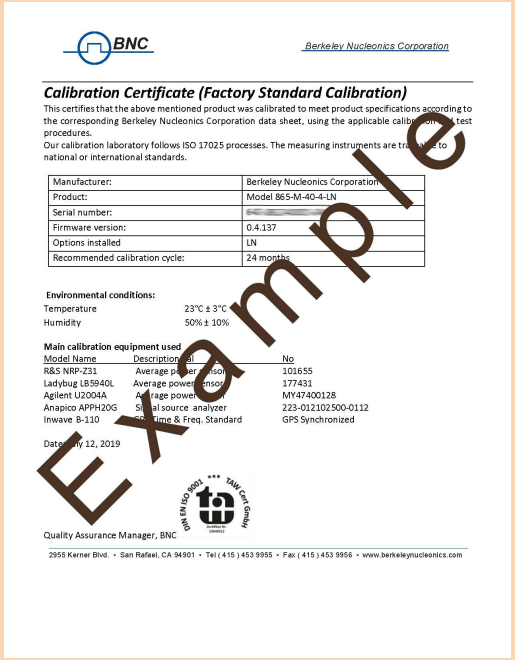
Traceable Calibration Procedure



BNC — Berkeley Nucleonics Corporation

Calibration Certificate (Factory Standard Calibration)

This certifies that the above mentioned product was calibrated to meet product specifications according to the corresponding Berkeley Nucleonics Corporation data sheet, using the applicable calibration and test procedures.
Our calibration laboratory follows ISO 17025 processes. The measuring instruments are traceable to national or international standards.

Manufacturer:	Berkeley Nucleonics Corporation
Product:	Model 865-M-40-4-LN
Serial number:	[redacted]
Firmware version:	0.4.137
Options installed	LN
Recommended calibration cycle:	24 months

Environmental conditions:

Temperature	23°C ± 3°C
Humidity	50% ± 10%

Main calibration equipment used

Model Name	Description	No
R&S NRP-Z31	Average power sensor	101655
Ladybug LB5940L	Average power sensor	177431
Agilent U2004A	Average power sensor	MY47400128
Anapico APPH20G	Signal source analyzer	223-012102500-0112
Inwave B-110	Real time & Freq. Standard	GPS Synchronized

Date: July 12, 2019

Quality Assurance Manager, BNC

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Example

Description

- Traceable Phase & Amplitude Noise Standard to ±0.5 dB, delivered with calibration certificate of accredited metrological testing lab.
- APPH built-in user calibration procedures
- Used at meteorological lab, or by APPH end customer to quickly calibrate the phase and amplitude measurement correctness

Model	Description
APNS	Traceable Phase & Amplitude Noise Standard

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Competitive Comparison

Parameters	BNC 7000 Series			R&S FSWP		Keysight E5052B/E5053A
Frequency Range	1 MHz to 7 / 26 / 40 GHz			1 MHz to 8 / 26 / 50 GHz		10 MHz to 7 / 26 GHz
Offset Range	0.01 Hz to 100 MHz			0.01 Hz to 1000 MHz		1 Hz to 100 MHz
PhN Sensitivity dBc/Hz	**Std**	**LN**	**EXT**	**Option B60**	**Option B61**	
@100 MHz, 10 Hz offset	-105	-120	-130	-108	-117	-111
@100 MHz, 10 kHz offset	-175	-175	-178	-170	-170	-164
@1 GHz, 10 Hz offset	-85	-100	-110	-88	-97	-91
@1 GHz, 10 kHz offset	-155	-155	-170	-166	-166	-146
Measurement Modes						
PhN / AM noise / pulsed / pulse trains	Y / Y / Y / Y			Y / Y / Y / Y		Y / Y / N / N
Supporting ext. ref.	Y			N		N
Residual phase noise CW / pulsed	Y / Y			Y / Y		N / N
Burst Mode phase & amplitude noise	Y / Y			N / N		N / N
VCO Testing	Y			Y		Y
Transient Analyzer	Y			Y		Y
Time Stability (ADEV)	Y			N		N
Spectrum Analysis	Y			Y		Y
Integrated Supplies / Tuning Voltage	Y / Y			Y / Y		Y / Y
Instrument Weight	10 kg			24 kg		25 kg
Power Consumption	70			300		500

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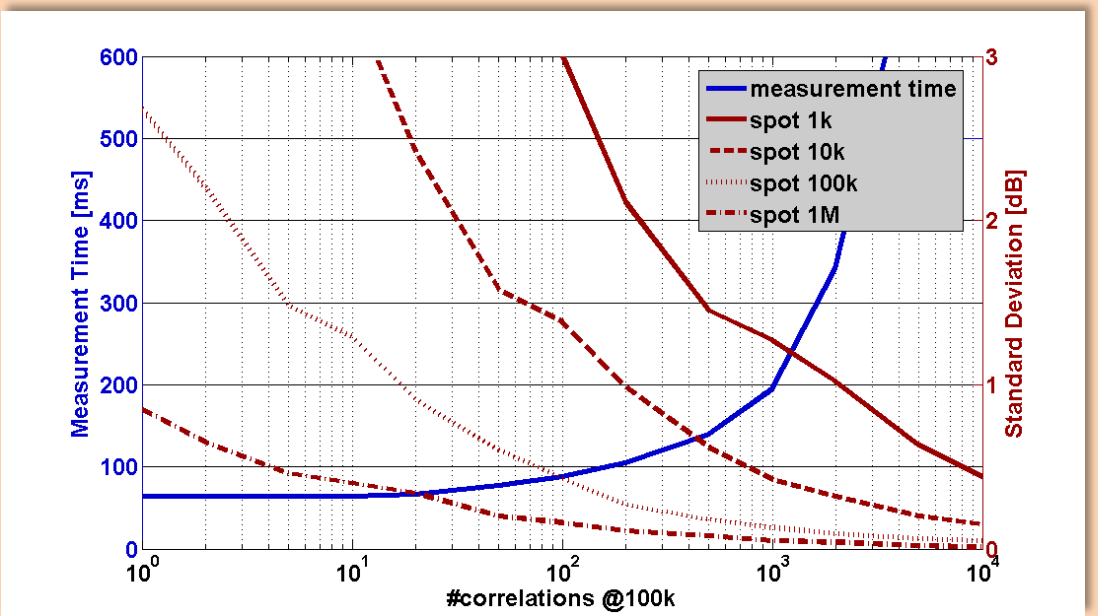
ATE Interfaces



Description

- Supports LAN, USB, GPIB
- SCPI command control
- Throughput optimized solution: **measurement speed <200 ms** with excellent accuracy and repeatability
- Application Programming Interface for various languages (C, C++, Java, VBA, Matlab, Python, .NET library)

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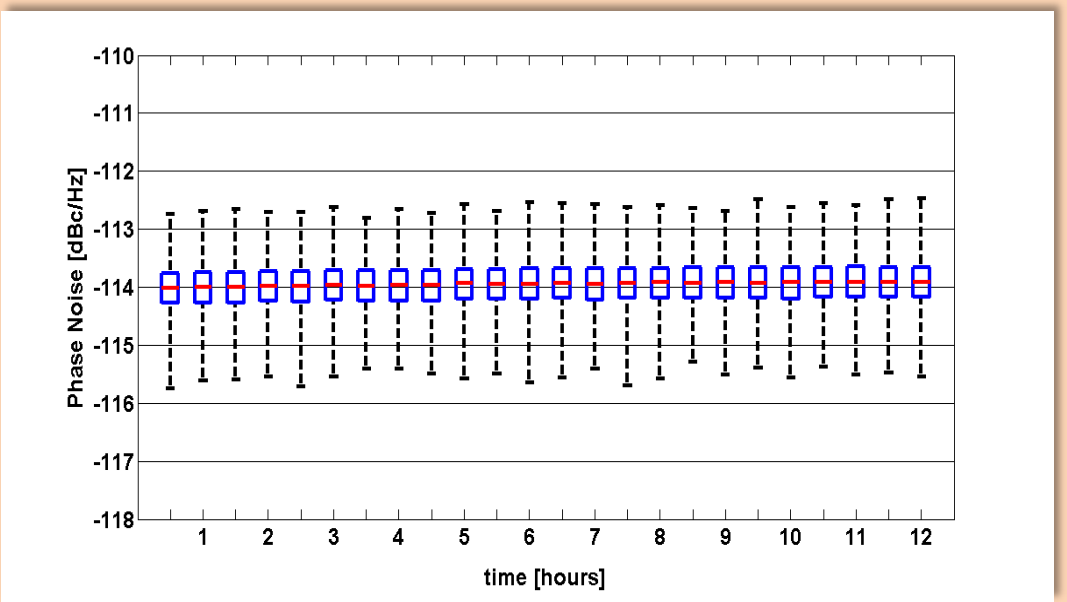
Excellent Repeatability



Description

- Plot shows about 250’000 measurements over 12 hours with same DUT
- Fast and robust measurement results
- Excellent repeatability

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Applications

Function	Application	Target Customer
Absolute Phase Noise / ATE	Automated (production) testing	Electronics manufacturers, semiconductor factories, design houses
Absolute Phase Noise	CW: Synthesizer, VCO, PLL, YIG, DRO, OCXO PULSED: Radar	R&D
Residual / Additive Phase Noise	Amplifier, transmitter, pre-scaler, phase coherence , synthesizer, phase stability	Active RF component manufacturer, semiconductor R&D, synthesizer R&D, accelerator time synchronization
Transient Analysis	Synthesizer switching, crystal startup behavior, modulation analysis, BURST mode phase noise analysis	Crystal manufacturer, synthesizer manufacturer
Time Stability	Device and module stability analysis	
VCO Testing	Characterization of VCO and other tuneable oscillating devices	VCO manufacturer
Spectrum Monitoring	Frequency drift, harmonics, modulations	

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