Model 7000 Series

Phase Noise Test System

v2.18

- Fully Integrated System
- Cross-Correlation Signal Analysis
- 2 MHz to 7 or 26.5 GHz
- Additive or Absolute Phase Noise

BNC Berkeley Nucleonics

Test, Measurement and Nuclear Instrumentation since 1963

Introduction

The Model 7070 & 7300 are an integrated solution that offers an indispensable set of measurement functions for evaluating signal sources ranging from VHF to microwave frequencies such as crystal oscillators, PLL synthesizers, clocks, phase-locked VCOs, DROs, and others.
The flexible instrument comprises a two-channel cross-correlation system with two internal tunable references sources and allows also measurements with external references.

The 7000 series provides a complete set of measurement such as

- absolute and additive phase noise measurements
- PULSED phase noise measurements
- direct access to the two channel 50 MHz FFT analyzer
- transient measurements (frequency versus time, modulation domain analyzer)
- oscillator test bench (tuning, pushing, phase noise, current, power,..)
- spectrum monitoring
- or frequency counter function / power meter

Using proven cross-correlation measurement procedures and self-calibration routines, reproducible, and accurate measurements are obtained even under changing environmental conditions. Fully automated frequency acquisition and self-calibration greatly simplify use and applicability of the instrument, resulting in much faster measurement throughput and greater ease-of-use in actual operation.

It is a compact and powerful instrument available with LAN (VXI-11), USBTMC, or with GPIB (optionally) interfaces. Platform independent intuitive graphical user interface (GUI), API library, and powerful SCPI command language set is available.

Applications supported:

- ✓ Additive or absolute phase noise measurement
- ✓ Measure frequency droop on individual channels in frequency hopping systems
- ✓ Analyze chirp radar performance
- ✓ Calibrate frequency sweep signals.
- ✓ Calibrate intentional modulation (FM or FSK)
- ✓ Analyze PLL's and Frequency locked-loops
- ✓ Measure frequency settling times of VCO's
- ✓ Characterize start-up/warm-up of oscillators
- ✓ Spectrum and noise monitoring
- ✓ VCO characterization (tuning, supply pushing, power, current...)
- ✓ 50 MHz bandwidth FFT analyzer mode

Specifications

The specifications in the following pages describe the warranted performance of the instrument for 25 ± 5 °C after a 30 minute warm-up period. Typical specifications describe expected, but not warranted performance. Min and Max specifications are warranted.
Warranted performance. Specifications include guard-bands to account for the expected statistical performance distribution, measurement uncertainties, and changes in performance due to environmental conditions.

Parameter	Min.	Typ.	Max.	Note
Absolute Phase Noise Measurement 5 MHz to 26 GHz (CW)				
Measurement parameters	SSB phase noise [dBc/Hz], Spurious noise [dBc], Integrated rms phase deviation [deg, rad] or time jitter [s], Residual FM/PM [Hz rms]			
Model 7300 RF Frequency Range	5 MHz* 5 MHz*		26 GHz 17 GHz	using internal references using external references *works down to 1 MHz
Model 7070 RF Frequency Range	5 MHz* 5 MHz*		7 GHz 7 GHz	using internal references using external references *works down to 1 MHz
Input Power Range < 18'000 MHz > 18'000 MHz	 -10 dBm 0 dBm		 +20 dBm +23 dBm	+26 dBm is damage level See sensitivity plot
Input impedance **VSWR**		50 Ω 2		AC coupled, 10V DC max
Offset Analysis Range	0.01 Hz 0.01 Hz 0.01 Hz		50 MHz 20 MHz 5 MHz	for RF > 70 MHz for RF < 70 MHz RF < 25 MHz
Measurement Accuracy		±4 dB ±3 dB ±2 dB		< 10 Hz offset < 1 kHz offset > 1 kHz
System Phase Noise Floor 1 Hz 10 Hz 100 Hz 1 kHz 10 kHz 10 MHz		 -140 dBc/Hz -150 dBc/Hz -160 dBc/Hz -175 dBc/Hz -185 dBc/Hz -185 dBc/Hz		(cross-correlation, external references)
Phase Noise Sensitivity	See plot for sensitivity of internal sources			
Spurious levels External References Internal references		 -85 dBc -90 dBc		
Measurement time				See Table “Measurement Time”
Internal References				Cross-correlation
Frequency Range	1 MHz 1 MHz		30 GHz 7 GHz	7300 7070

Parameter	Min.	Typ.	Max.	Note
Phase Noise Sensitivity				See Plots "Sensitivity"
RF Tracking Range		±2 ppm / s 15 ppm / s 200 ppm / s		Option LN Standard High Sens
External References				One or Cross-correlation
Frequency Range	5 MHz		17 GHz 7 GHz	7300 7070
RF Input Level Range < 2 GHz < 10 GHz > 10 GHz	 +5 dBm +10 dBm +13 dBm		 +23 dBm +23 dBm +23 dBm	+26 dBm is damage level
Reference Level Range	+13 dBm	+15 dBm	+ 23 dBm	
Tuning Voltage Range	0 V		+20 V	User adjustable
Output current			10 mA	
PULSED Absolute Phase Noise Measurement 30 MHz to 16 GHz (requires option PULSE)				
7300 RF Frequency Range	30 MHz 30 MHz		13 GHz 16 GHz	using internal references using external references
7070 RF Frequency Range	30 MHz 30 MHz		7 GHz 7 GHz	using internal references using external references
Input Power Range	3 dBm -5 dBm		+20 dBm +20 dBm	< 2 GHz > 2 GHz
Pulse rate (PRF)	1 kHz		2 MHz	
Pulse width **Duty cycle**	100 ns 0.2%		1 ms 60%	
Offset Analysis Range	0.01 Hz		To PRF	
Measurement Accuracy		±4 dB ±3 dB ±2 dB		< 10 Hz offset < 1 kHz offset > 1 kHz
Measurement time				See Table "Measurement Time"
Internal References				Cross-correlation
Frequency Range	2 MHz 2 MHz		13 GHz 7 GHz	7300 7070
Phase Noise Sensitivity				
External References				Single-channel or Cross-correlation
Frequency Range	5 MHz 5 MHz		18 GHz 7 GHz	7300 7070
Reference Level Range	+13 dBm	+15 dBm	+ 23 dBm	
Tuning Voltage Range	0 V		+20 V	User settable
Output current			10 mA	

Parameter	Min.	Typ.	Max.	Note
Residual (CW or PULSED) Phase Noise Measurement 5 MHz to 18 GHz				
Measurement parameters	SSB phase noise [dBc/Hz], Spurious noise [dBc], Integrated rms phase deviation [deg, rad] or time jitter [s], Residual FM/PM [Hz rms]			
RF Frequency Range	5 MHz		18 GHz 7 GHz	7300 7070
Input Power Range (RF port) **(REF ports)**	3 dBm 13 dBm		+23 dBm +20 dBm	
Offset Analysis Range	0.01 Hz 0.01 Hz 0.01 Hz		50 MHz 20 MHz 5 MHz	0.01 Hz via SCPI control for RF < 70 MHz RF < 25 MHz
Measurement Accuracy		±3 dB ±3 dB ±2 dB		< 10 Hz offset < 1 kHz offset > 1 kHz
Residual Phase Noise Floor 1 Hz 10 Hz 100 Hz 1 kHz 10 kHz 10 MHz		 -140 dBc/Hz -150 dBc/Hz -160 dBc/Hz -175 dBc/Hz -185 dBc/Hz -185 dBc/Hz		(cross-correlation engine)
Transient Measurements				
Measurement parameters	Frequency			
Frequency range	1 MHz 5 MHz 50 MHz 2.2 GHz 7.5 GHz		50 MHz 200 MHz 2.4 GHz 7.5 GHz 26.5 GHz	Band 1 Band 2 Band 3 Band 4 Band 5
Measurement bandwidth Wideband Narrowband		 Bands 1-5 20 MHz		
Frequency resolution				See table
Measurement time	50 us		10 s	
Time resolution	16 ns		500 ms	
Trigger mode		Free-run, Internal, external		
Spectrum Monitoring, Spectrum Scanning (optional)				

Parameter	Min.	Typ.	Max.	Note
Measurement parameters	dBm, dBm/Hz, dBc/Hz			
Frequency range	5 MHz		26 GHz	
Monitoring bandwidth	1 kHz		30 MHz	
Resolution bandwidth (RBW)	1.8 Hz		1 MHz	
Absolute measurement uncertainty		± 2 dB		Pin = 0 dBm
Relative measurement uncertainty		± 1.5 dB		
Residual noise floor		tbd		RBW =
Trigger mode		Free-run, Internal		

Absolute Amplitude Noise Measurement (optional)

Measurement parameters	SSB phase noise [dBc/Hz], Spurious noise [dBc], Integrated rms phase deviation [deg, rad] or time jitter [s], Residual FM/PM [Hz rms]			
7300 RF Frequency Range	70 MHz		18 GHz	
7070 RF Frequency Range	70 MHz		7 GHz	
Input Power Range 0 dBm 0 dBm			 +20 dBm +23 dBm	
Offset Analysis Range	1 Hz		40 MHz	for RF > 70 MHz
Measurement Accuracy		±4 dB ±3 dB ±2 dB		< 10 Hz offset < 1 kHz offset > 1 kHz
AM noise sensiitivity 1 Hz 10 Hz 100 Hz 1 kHz 10 kHz 10 MHz		 -70 dBc/Hz -110 dBc/Hz -120 dBc/Hz -135 dBc/Hz -145 dBc/Hz -155 dBc/Hz		

FFT Analyzer

Input Connectors	2 BNC female (rear panel), AC coupled			
Measurement parameters	dBV/Hz, dBm/Hz, nV/√Hz			
DC Voltage Range Input Impedance	-12 V	 1 kΩ	+ 12 V	 DC
AC Voltage Range			+ 10 dBm	
Frequency Range	1 Hz		50 MHz	
Input Noise Density		< 1 nV/√Hz		10 kHz offset

VCO Characterization

Measurement parameters	Frequency (Hz), Tuning sensitivity (Δf/ΔVc) (Hz/V), Frequency Pushing (Hz/V), RF power level [dBm], DC supply current [mA] SSB PhN [dBc/Hz]			
Sweep parameters DC Supply Voltage Tuning Voltage	0 to 15 V / max 550 mA -5 to 20 V / max 20 mA			adjustable
RF frequency Uncertainty	5 MHz	0.5 ppm	26 GHz	
RF Power Uncertainty	-10 dBm	2 dB	20 dBm	
DC supply current Uncertainty	0 mA	1%	550 mA	
Output settling time		20 ms		
Measurement speed		70 ms per point		One point includes frequency, Kvco, pushing, DC supply, and power measurement
Trigger		Start, Trigger		

Frequency Counter

Measurement parameters	Frequency [Hz]			
Frequency Range	1 MHz		26 GHz	
Absolute Accuracy		300 ppb		
Sensitivity		-10 dBm		See typical sensitivity plot

Power Detector

Measurement parameters	Power mW ,dBm			
Frequency Range	5 MHz		26 GHz	
Accuracy		< 2 dB		
Power Range	-5 dBm		+15 dBm	

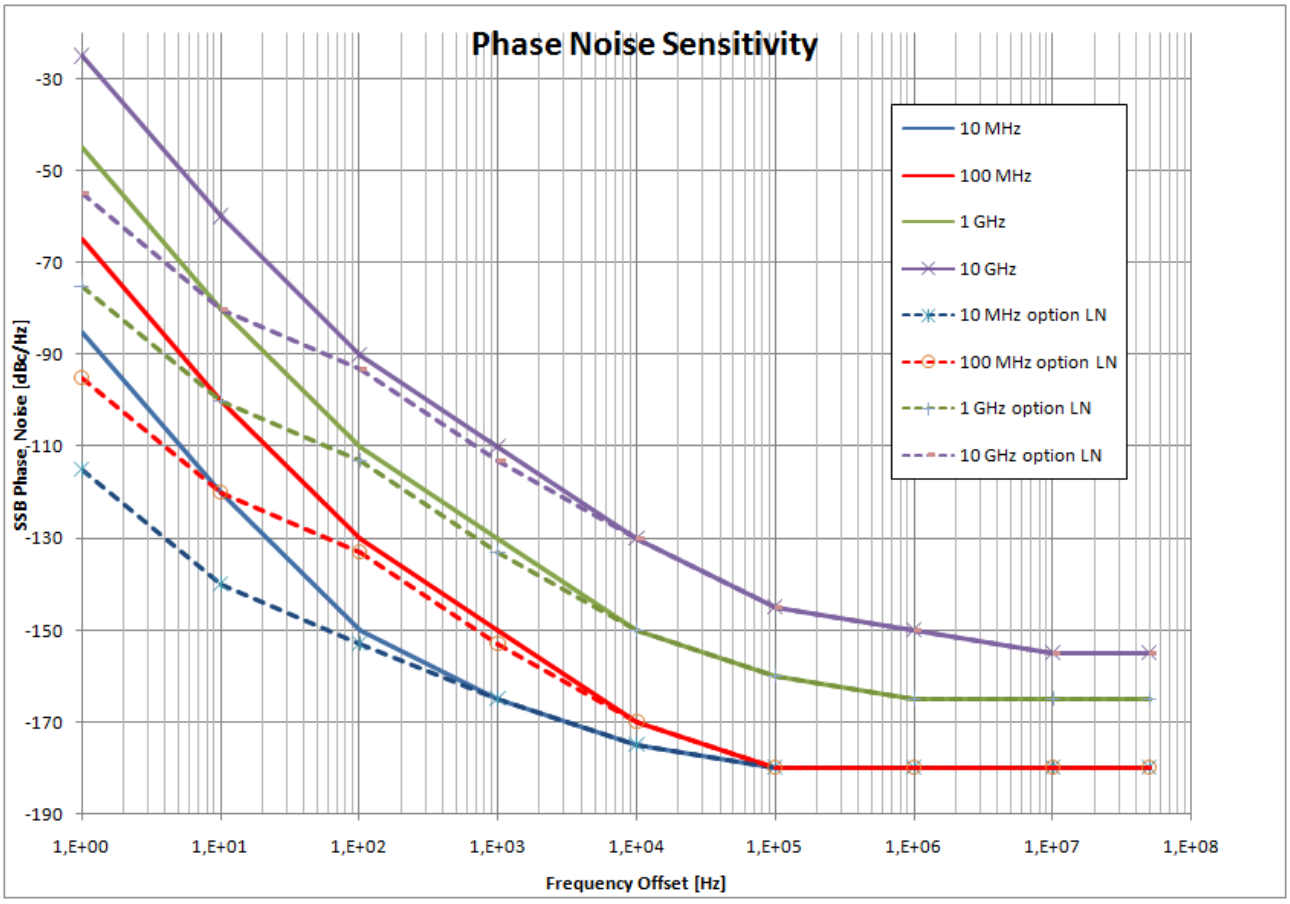
Tuning Voltage & Dual Power Supply

DUT TUNING	-5 V			
DC Voltage Range	-5 V		20 V	
Setting Resolution		1 mV		
Setting Uncertainty		±2 mV		
Noise Level		< 2 nVrms/√Hz		> 2 kHz
DC current range	0 mA		20 mA	
SUPPLY				
DC Voltage Range	0 V		15 V	
Setting Resolution		10 mV		
Setting Uncertainty		±10 mV		
Noise Level		< 10 nVrms/√Hz		> 20 kHz
Output Resistance		< 0.5 Ohm		
DC current meas. range	0 mA		550 mA	Per channel
Resolution		100 uA		

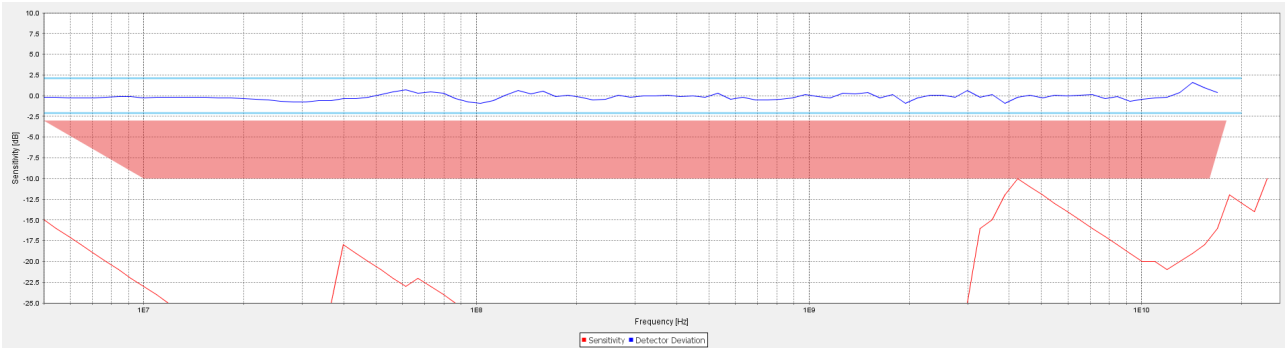
Performance Data Plots

Phase Noise Sensitivity (dBc /Hz)

Measurement time ~25 seconds, after first cross-correlation; further correlations will improve sensitivity by 5 dB by for 10, 10 dB for 100, and 15 dB for 1000 respective correlations performed.



Phase Noise typical RF Sensitivity 5 MHz to 26 GHz (red trace, in dBm)



Phase Noise Measurement Time

Total measurement time consists of setup time, transfer time plus the number of performed correlations times the time per correlation

	Typical setup time (sec)	Time per average (sec)	Nr. of points
0.1 Hz to 50 MHz	**2**	**80**	**~ 1800**
1 Hz to 50 MHz	**2**	**10**	**~ 1700**
10 Hz to 50 MHz	**2**	**1.5**	**~ 1500**
100 Hz to 50 MHz	**2**	**0.5**	**~ 1300**
1 kHz to 50 MHz	**<2**	**0.2**	**~ 1050**
10 kHz to 50 MHz	**<2**	**<0.1**	**~ 800**

Wideband: Transient Measurement Time Resolution vs Frequency Resolution (residual FM, 5% video bandwidth)

Time resolution Frequency Bands	64 ns	256 ns	1 µs	5 µs	20 µs
1 to 50 MHz	300 Hz	150 Hz	60 Hz	10 Hz	2 Hz
5 to 200 MHz	500 Hz	250 Hz	100 Hz	100 Hz	10 Hz
50 MHz to 2 GHz	2.5 kHz	1 kHz	100 Hz	100 Hz	50 Hz
0.2 to 7 GHz	20 kHz	2.5 kHz	1 kHz	200 Hz	100 Hz
7 to 26.5 GHz	50 kHz	7 kHz	2 kHz	400 Hz	200 Hz

Narrowband: Transient Measurement Time Resolution vs Frequency Resolution (residual FM, 50 MHz Span, 5% video bandwidth, typical)

Time resolution Frequency range	64 ns	256 ns	1 µs	5 µs	20 µs
< 200 MHz	75 Hz	10 Hz	2 Hz	1 Hz	1 Hz
< 2 GHz	200 Hz	25 Hz	10 Hz	5 Hz	1 Hz
< 7 GHz	500 Hz	150 Hz	25 Hz	5 Hz	1 Hz
< 13 GHz	1.5 kHz	400 Hz	40 Hz	10 Hz	2 Hz
> 13 GHz	3 kHz	750 Hz	50 Hz	15 Hz	3 Hz

Narrowband: Transient Measurement Time Resolution vs Frequency Resolution (residual FM, 1.25 MHz Span, no video filter, typical typical)

Time resolution Frequency range	256 ns	1 µs	5 µs	>= 20 µs
< 200 MHz	80 Hz	10 Hz	0.5 Hz	0.1 Hz
< 2 GHz	150 Hz	30 Hz	2.5 Hz	0.1 Hz
< 7 GHz	250 Hz	50 Hz	5 Hz	0.2 Hz
> 7 GHz	800 Hz	25 Hz	5 Hz	1 Hz

Narrowband: Transient Measurement Time Resolution vs Frequency Resolution (residual FM, 200 kHz Span, typical)

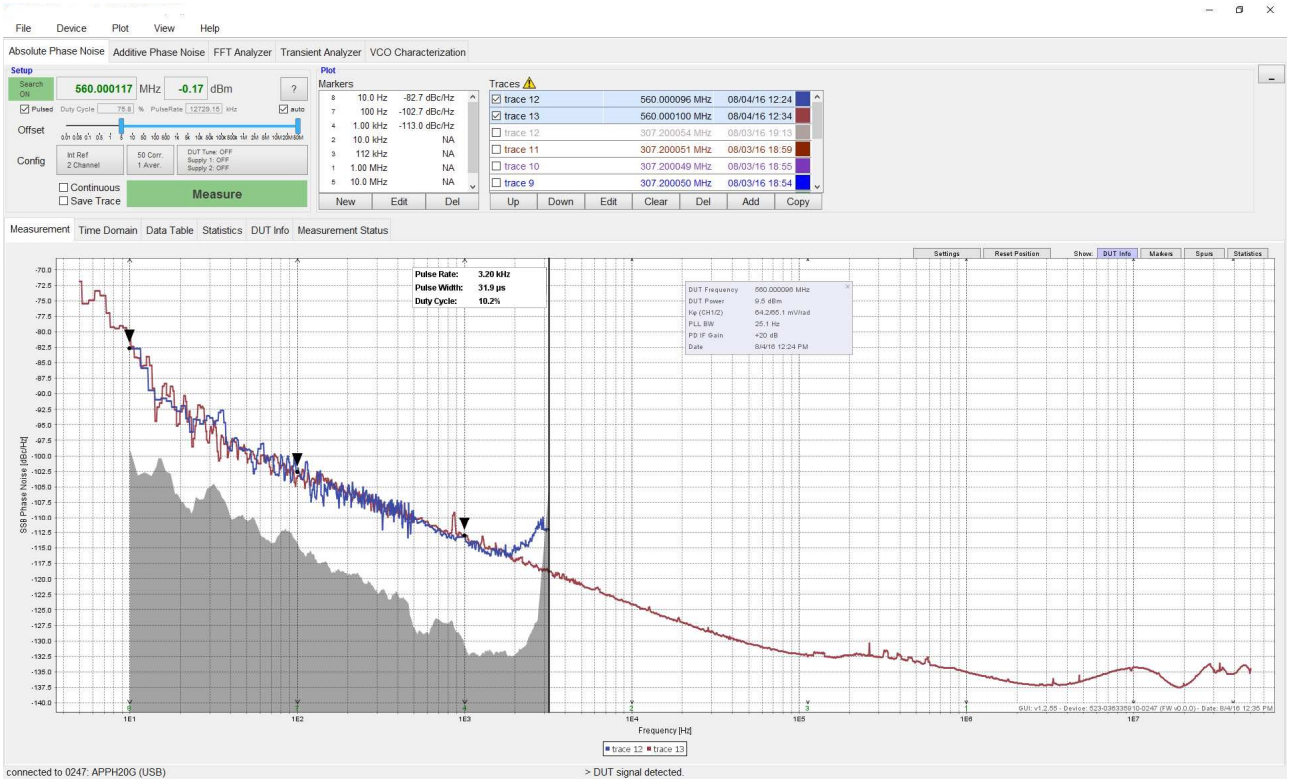
Time resolution Frequency range	5 µs	>=20 µs
< 200 MHz	0.2 Hz	0.1 Hz
< 2 GHz	0.5 Hz	0.1 Hz
< 7 GHz	1 Hz	0.2 Hz
> 7 GHz	5 Hz	0.5 Hz

Data Processing Capabilities

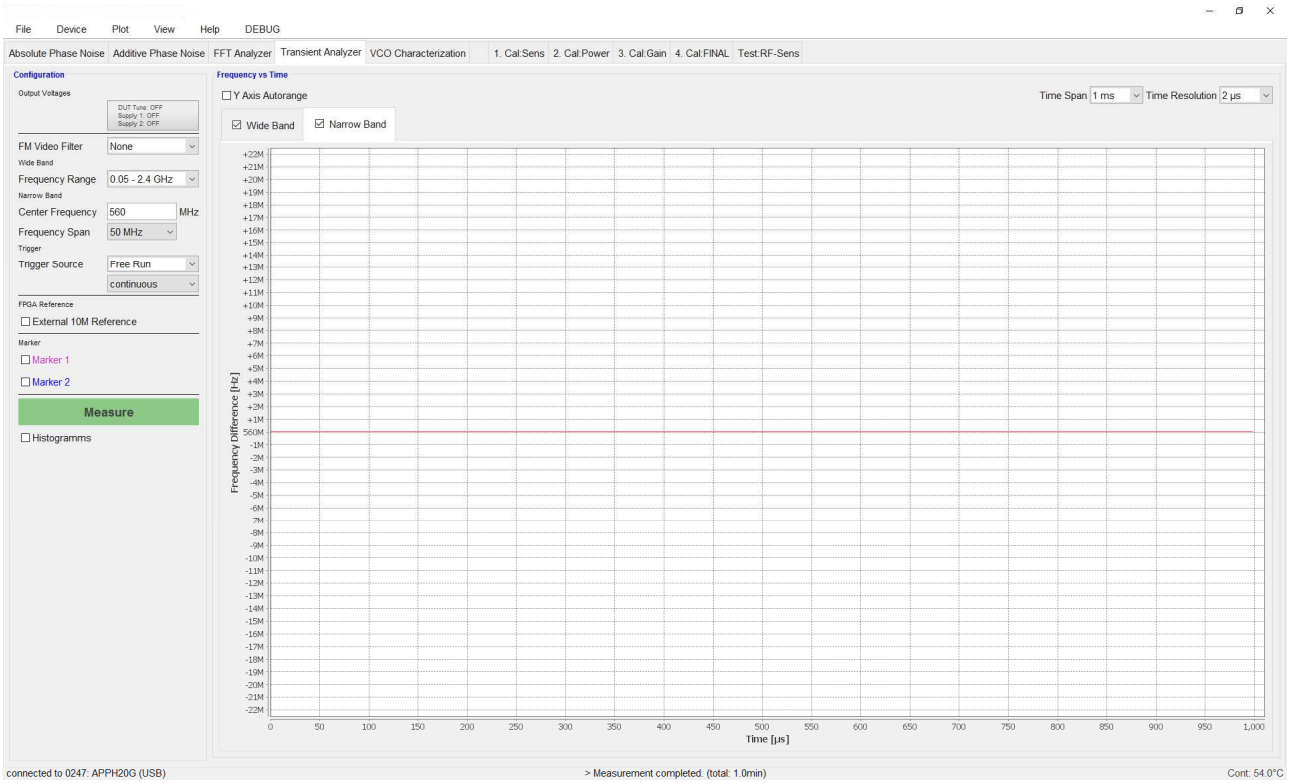
Graphical user interface: The analyzer employs a graphical user interface based on Windows OS.

Display Functions	Phase Noise, Time Domain, Data Table, Residual, Statistics
Trace Functions **Data Traces**	Display current measurement and/or multiple memory data (up to 16 traces)
Math	Addition, subtraction, multiplication, or division of trace data, offset corrections
Title	Add customized title to each measurement window
Auto-Scale	Automatically selects scale resolution and reference value to vertically center the trace.
Statistics	Calculates and displays mean, standard deviation, and peak-to-peak deviation of the trace.
Marker Functions	16 independent markers

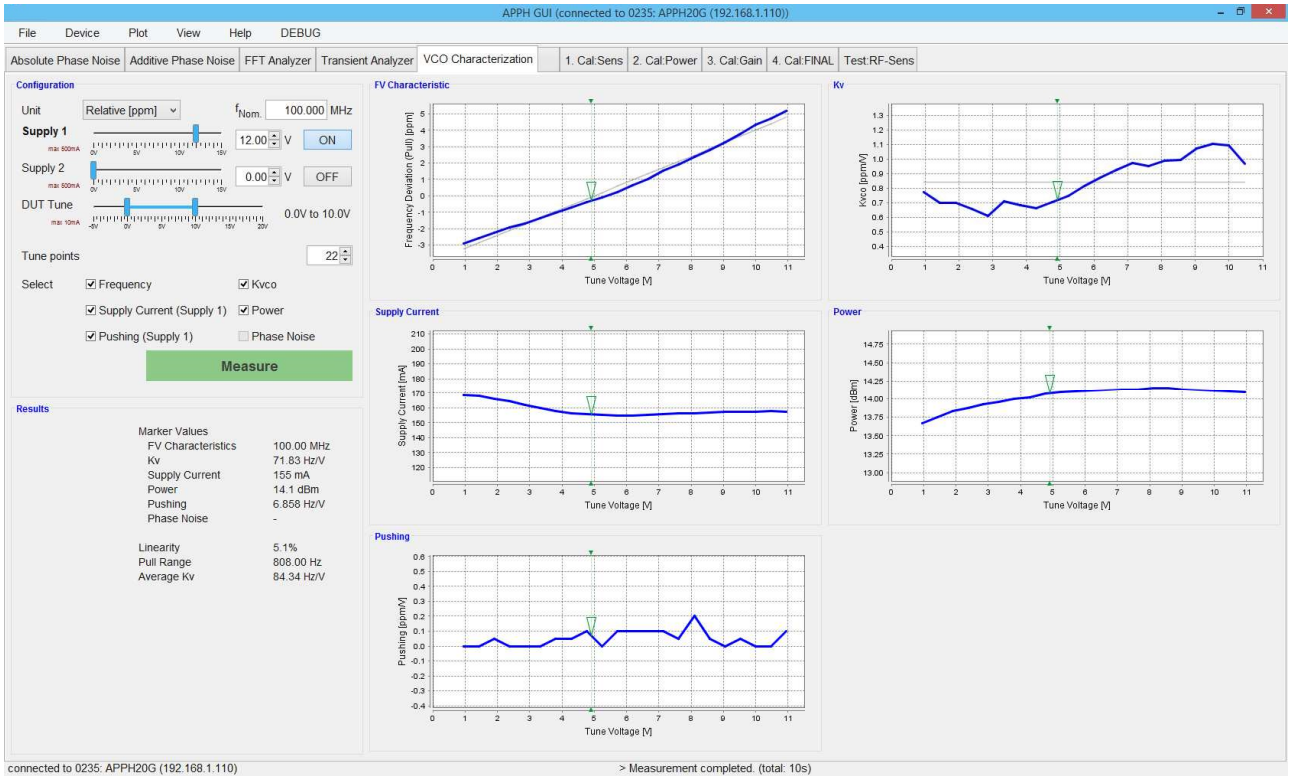
GUI Interface (Absolute Phase Noise)



GUI Interface (Transient)



GUI Interface (VCO Characterization)



Connectors

1. RF inputs: RF IN, REFIN1 HIGH and LOW, REFIN2 HIGH and LOW: SMA female
2. Tuning outputs: TUNE1, TUNE2 : BNC female
3. DC power switch
4. Status LEDs: POWER, READY, REMOTE

Connectors (Rear)

1. Baseband inputs (BB1, BB2): BNC female
2. Supply outputs (SUPPLY1, SUPPLY2): BNC female
3. AUX inputs: EXT TRIG and 10 MHZ REF IN: BNC female
4. LAN connection: RJ-45
5. USB 2.0 host and device
6. DC Power plug (24V, 2A)

General Characteristics

Remote programming interfaces
Ethernet 100BaseT LAN interface,
USB 2.0 host & device
GPIB (IEEE-488.2,1987) with listen and talk (optional)
Control language SCPI Version 1999.0

Power requirements 24 VDC; 24 W maximum
Mains adapter supplied: 100-240 VAC in/ 24V, 2A DC out
Operating temperature range 0 to 45 °C
Storage temperature range –40 to 70 °C
Operating and storage altitude up to 15,000 feet

CE notice
Safety/EMC complies with applicable Safety and EMC regulations and directives.

Weight ≤ 10 kg (21 lbs) net
Dimensions incl. rubber: 154 mm H x 467.5 mm W x 342 mm L [6.1 in H x 18.4 in W x 13.5 in L]
with handle: 154 mm H x 520 mm W x 342 mm L [6.1 in H x 20.5 in W x 13.5 in L]
handle: radius 230mm [9 in]; can be turned 360°

Options

- ***GPIB****: IEEE-488.2,1987 programming interface*
- ***LN:*** *ultra low close to carrier phase noise*
- ***PULSE:*** *pulsed RF measurement capability*

WARRANTY Berkeley Nucleonics Corporation warrants all instruments, including component parts, to be free from defects in material and workmanship, under normal use and service for a period of two years. If repairs are required during the warranty period, contact the factory for component replacement or shipping instructions. Include the serial number of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by Berkeley Nucleonics Corporation.

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