

PN3 Signal Source Analyzer

Model E5045A, E5046A, E5047A

5 MHz to 7, 26, 40 GHz

Definitions

The specifications in the following pages describe the warranted performance of the instrument for 23 ± 5 °C after a 30-minute warm-up period (unless otherwise stated).

Min / Max: Parameter range that is guaranteed by product design, and / or production tested. Warranted performance specifications include guard-bands to account for the expected statistical performance distribution, measurement uncertainties, and changes in performance due to environmental conditions.

Typical: Expected mean values, not warranted performance.

Introduction

Fully integrated cross-correlation signal source analyzer for 5 MHz to 7, 26, 40 GHz

The PN3 Signal Source Analyzer is 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 or free-running VCOs, DROs, SAW or YIG oscillators, and others.

The flexible instrument comprises a two-channel cross-correlation system with two internal tunable reference sources and allows measurements with externally fed references.

Table of Contents

Facts, Figures, and Specifications 4

Connectors..... 21

Order Information 24

General Characteristics 25

The PN3 Signal Source Analyzer supports many other functions including:

- Absolute and residual phase noise measurements.
- Amplitude noise measurements.
- Pulsed absolute and residual phase noise measurements.
- Two-channel 100 MHz FFT analysis.
- Transient measurements (frequency, phase, amplitude vs. time).
- Spectrum analysis.
- Frequency counter function / power meter.

Additionally, the unit offers:

- Two programmable low noise DC supplies up to 15 V and 500 mA current capability.
- Three low noise tuning voltages for -5 to +20 V voltage range.

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.

Operated with an external 24 V DC supply, it consumes less than 70 W.



Facts, Figures, and Specifications

Phase noise measurement performance

Measurement parameters:

SSB phase noise [dBc / Hz], spurious noise [dBc], integrated RMS phase noise deviation [deg, rad], time jitter [s], residual FM / PM [Hz RMS]

Parameter	Min	Typical	Max	Note
RF frequency range	<i>FMIN</i> 5 MHz 5 MHz 5 MHz		<i>FMAX</i> 7 GHz 26 GHz 40 GHz	Using internal references E5045A E5046A E5047A
RF frequency range	5 MHz 5 MHz		7 GHz 18 GHz	Using external references E5045A E5046A / E5047A
Input power range < 18 GHz 18 GHz to 30 GHz > 30 GHz	-15 dBm -10 dBm -5 dBm		+20 dBm +23 dBm +23 dBm	Damage level +26 dBm
Input impedance VSWR		50 Ω 2		AC coupled, 10 V DC max
Offset analysis range	0.01 Hz 0.01 Hz		100 MHz > 25% of f_c	$f_c > 150$ MHz $f_c < 150$ MHz
Resolution (PPD)	200	200	1600	RBW adjustable (x1 / x2 / x4 / x8), PPD (points per decade) can be lower for lowest decade of measurement
Measurement accuracy		± 4 dB ± 3 dB ± 2 dB		Offset < 10 Hz Offset 10 Hz to 1 kHz Offset 1 kHz to 100 MHz
Spurious levels Internal References External References		-90 dBc -85 dBc		
Trigger				Single, continuous, manual, bus
Frequency counter Measurement parameters: Frequency [Hz]				
RF frequency range	<i>FMIN</i>		<i>FMAX</i>	
Absolute accuracy		300 ppb		
Sensitivity				See plot "Typical RF sensitivity"
Power detector Measurement parameters: RF Power Level [dBm]				
RF frequency range	<i>FMIN</i>		<i>FMAX</i>	E5045A, E5046A, E5047A
Absolute accuracy		± 1 dB		
Power range	-10 dBm		+13 dBm	

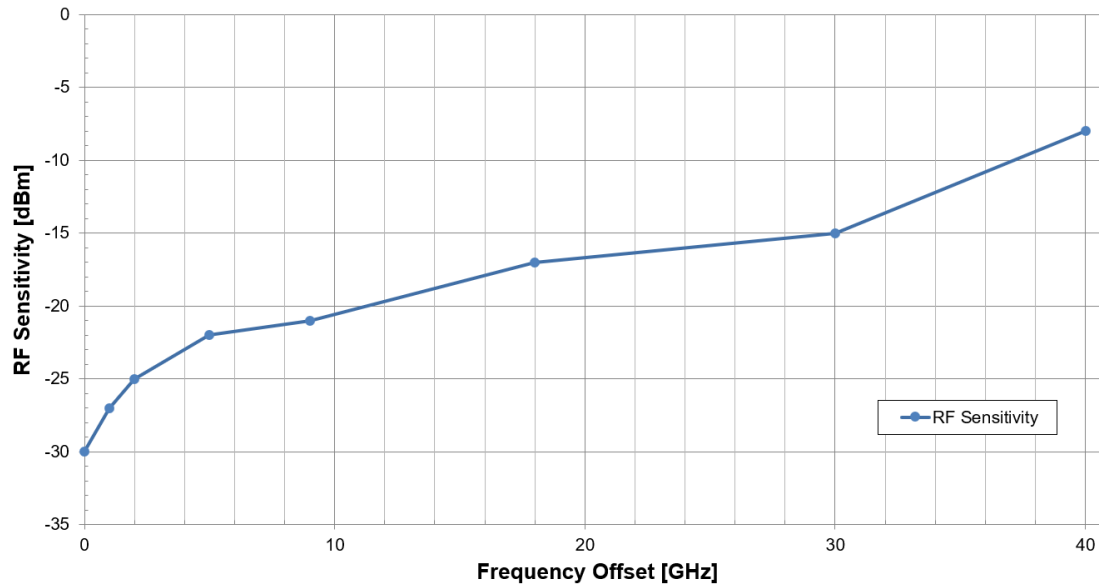


Figure 1. Typical RF sensitivity 5 MHz to 40 GHz (blue trace, in dBm)

Phase noise measurement time

Total measurement time consists of setup time, transfer time, plus the number of performed correlations times the time per correlation. The measurement times below are normalized to one correlation for nominal RBW settings per correlation and measurement times > 2 seconds.

	Time per correlations	Default nr. of points (settable)
0.1 Hz to 100 MHz	80	250 per decade
1 Hz to 100 MHz	8	250 per decade
10 Hz to 100 MHz	0.8	250 per decade
100 Hz to 100 MHz	0.1	250 per decade
1 kHz to 100 MHz	0.01	250 per decade
10 kHz to 100 MHz	< 0.004	250 per decade

Absolute phase noise measurements with internal references

Parameter	Min	Typical	Max	Note
Internal references				Cross-correlation
Frequency range	5 MHz		FMAX	
RF tracking range		±1 ppm ±10 ppm ±1000 ppm		Option 200 Standard High drift mode

Absolute phase noise sensitivity — internal references (standard)

Abs. PN with internal references	1 Hz	10 Hz	100 Hz	Offset 1 kHz	10 kHz	100 kHz	1 MHz
10 MHz	-85	-125	-155	-165	-172	-175	-175
100 MHz	-65	-105	-135	-160	-172	-178	-178
1 GHz	-45	-85	-115	-140	-155	-160	-160
3 GHz	-35	-75	-105	-130	-145	-150	-155
10 GHz	-25	-65	-95	-120	-135	-140	-145
25 GHz	-15	-55	-85	-110	-130	-135	-140
40 GHz	-13	-53	-83	-108	-123	-133	-138
Remarks	Test conditions: carrier power ≥ 5 dBm; after one correlation						

Absolute phase noise sensitivity — internal references (Option 200)

Abs. PN with internal references (option 200)	1 Hz	10 Hz	100 Hz	Offset 1 kHz	10 kHz	100 kHz	1 MHz
10 MHz	-115	-140	-155	-165	-172	-175	-175
100 MHz	-95	-120	-135	-160	-172	-178	-178
1 GHz	-75	-100	-115	-140	-155	-160	-160
3 GHz	-65	-90	-105	-130	-145	-150	-155
10 GHz	-55	-80	-95	-120	-135	-140	-145
25 GHz	-45	-70	-85	-110	-130	-135	-140
40 GHz	-44	-68	-83	-108	-123	-133	-138
Remarks	Test conditions: carrier power ≥ 5 dBm; after one correlation						

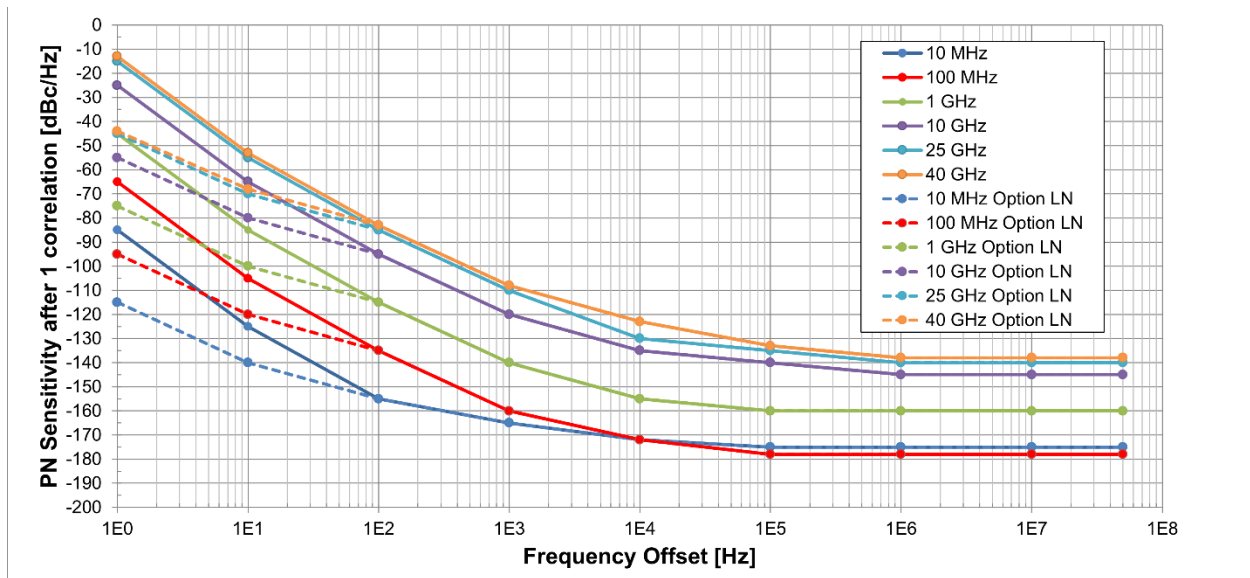


Figure 2. After 1 correlation

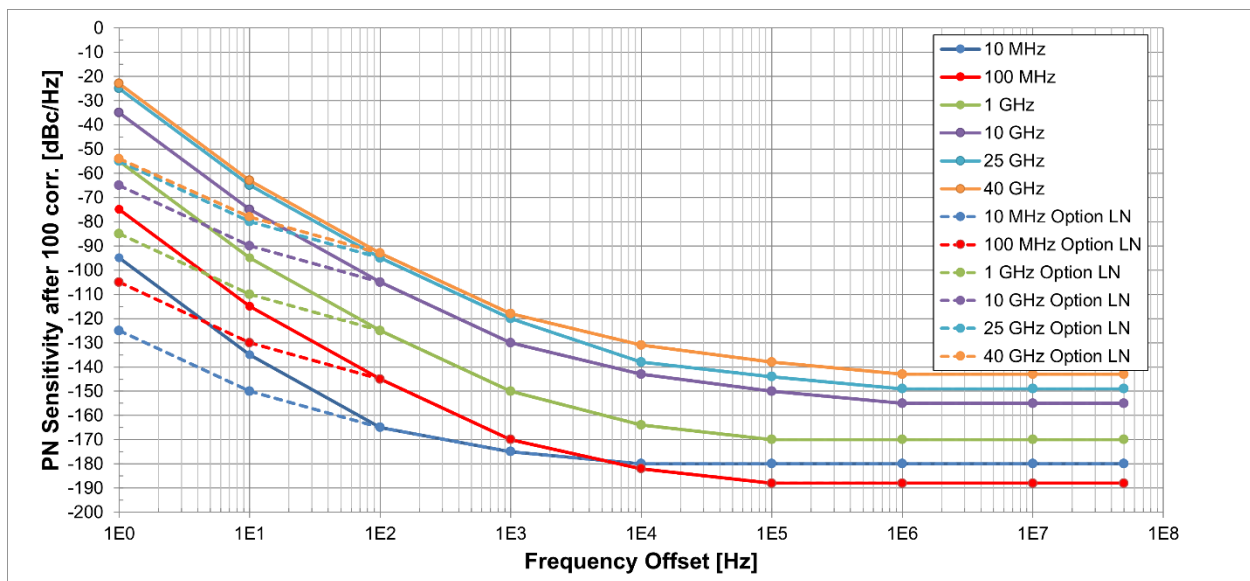


Figure 3. After 100 correlations

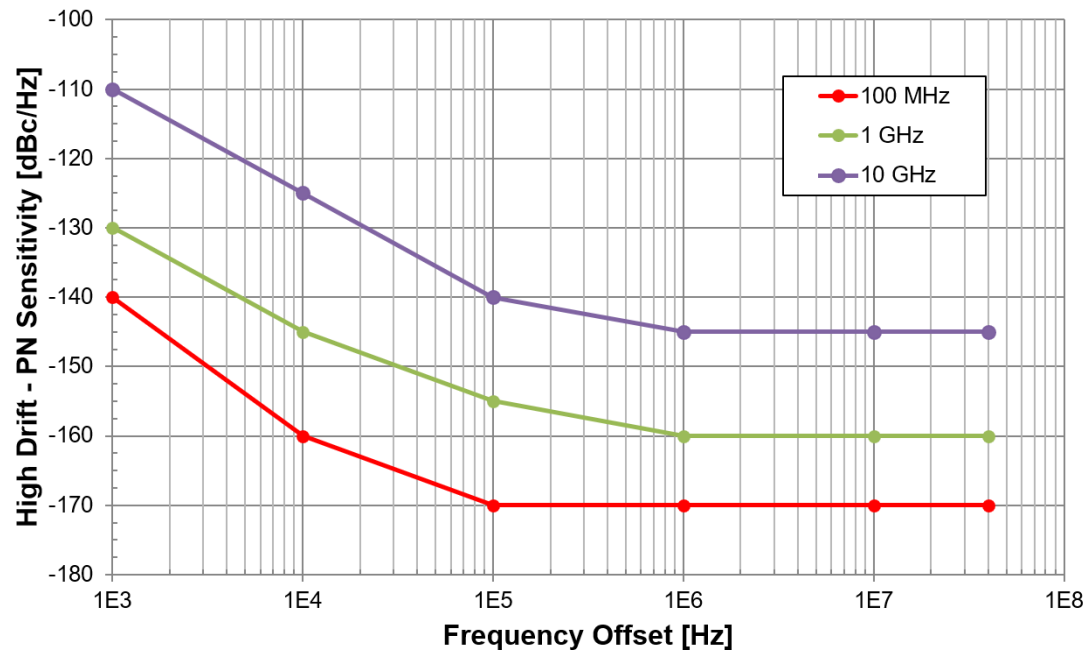


Figure 4. Phase noise sensitivity — High Drift

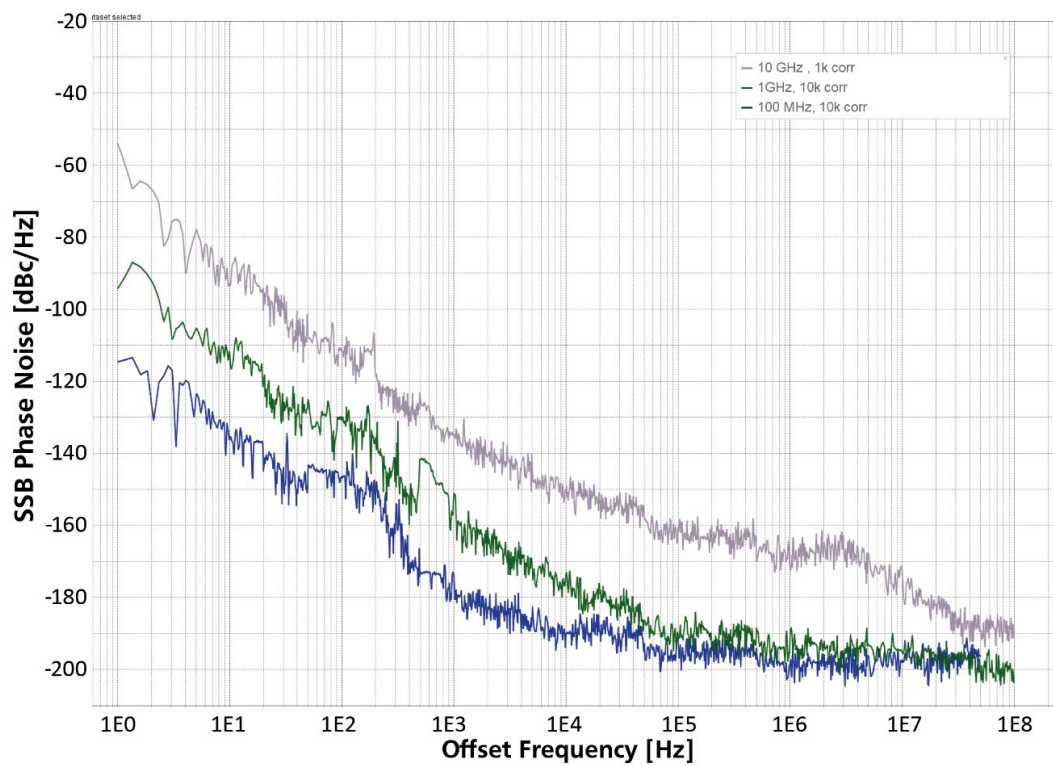


Figure 5. Typical noise floor example (after > 1k correlations at 100 MHz, 1 GHz, 10 GHz)

Absolute phase noise measurements with external references

Parameter	Min	Typical	Max	Note
External references				single channel / cross-corr.
Frequency range	5 MHz 5 MHz		7 GHz 18 GHz	E5045A E5046A / E5047A
RF input power range	0 dBm		+23 dBm	Damage level +26 dBm
Reference input level range < 1.3 GHz > 1.3 GHz	+10 dBm +13 dBm	+15 dBm +15 dBm	+21 dBm +21 dBm	Low frequency input ports High frequency input ports
Tuning voltage range	-5 V		+20 V	User adjustable
Tuning output current		20 mA		

Absolute phase noise sensitivity — external references

Abs. PN with external references	1 Hz	10 Hz	100 Hz	Offset 1 kHz	10 kHz	100 kHz	1 MHz
10 MHz	-135	-150	-155	-170	-175	-175	-175
100 MHz	-120	-130	-140	-170	-178	-178	-178
1 GHz	-100	-110	-125	-155	-170	-170	-170
3 GHz	-95	-110	-125	-155	-170	-170	-170
10 GHz	-90	-110	-120	-145	-155	-155	-155
18 GHz	-85	-105	-115	-130	-140	-145	-145
Remarks	Test conditions: carrier power $\geq$ 5 dBm; after one correlation						

Absolute phase noise measurement — pulsed (Option 006 / 007)

Parameter	Min	Typical	Max	Note
RF frequency range	30 MHz 30 MHz		7 GHz 26 GHz 40 GHz	E5045A E5046A E5047A
RF input power range	+10 dBm		+20 dBm	No power measurement
Input parameters Pulse rate (PRF) Pulse width	500 Hz 1 μ s 50 ns		1 MHz 1 ms 1 ms	Option 006 Option 007 Option 006 Option 007
Duty cycle	2% 0.2%		60% 60%	
Offset analysis range	0.01 Hz		PRF	
Measurement accuracy		± 4 dB ± 3 dB ± 2 dB		Offset < 10 Hz Offset 10 Hz to 1 kHz Offset 1 kHz to 100 MHz
Measurement time				See table "Meas. time"

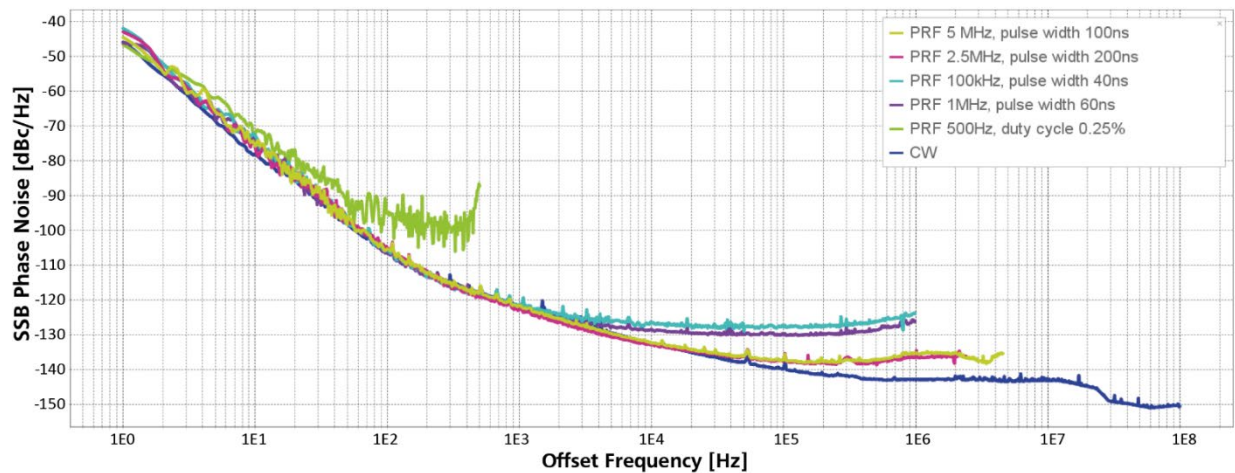


Figure 6. 3.8 GHz pulsed signals, with pulse widths ≥ 40 ns and PRF ≤ 5 MHz (Option 007)

Residual (additive) phase noise measurement — CW (Option 020) and pulsed (Option 020 + 006)

Measurement parameters:

SSB phase noise [dBc / Hz], spurious noise [dBc], integrated RMS phase noise deviation [deg, rad], time jitter [s], residual FM / PM [Hz RMS]

Parameter	Min	Typical	Max	Note
RF frequency range	10 MHz 10 MHz		7 GHz 18 GHz	E5045A E5046A / R5047A
RF input power range				
RF port	+3 dBm		+23 dBm	
REF ports	+13 dBm		+20 dBm	
LO output power range	+14 dBm		+25 dBm	Option 300
Offset analysis range	0.01 Hz		100 MHz	
Measurement accuracy		±3 dB ±2 dB		Offset < 1 kHz Offset > 1 kHz

Additive phase noise sensitivity — single channel

Abs. PN with external references	1 Hz	10 Hz	100 Hz	Offset 1 kHz	10 kHz	100 kHz	1 MHz
$10\text{ MHz} \leq f \leq 1\text{ GHz}$	-130	-140	-150	-160	-170	-170	-170
$1\text{ GHz} \leq f \leq 4\text{ GHz}$	-130	-140	-150	-160	-170	-170	-170
$4\text{ GHz} \leq f \leq 16\text{ GHz}$	-115	-125	-135	-145	-150	-155	-160
Remarks	Test conditions: RF carrier power $\geq 10\text{ dBm}$; REF $\geq 13\text{ dBm}$ Two channel cross-correlation can improve noise floor by 5 dB per 10x correlations.						

LO output (Option 300)

Parameter	Min	Typical	Max	Note
Use: Additive phase noise				
Frequency range	0 GHz		18 GHz	
Frequency resolution		1 Hz		
Power level	14 dBm	22 dBm	25 dBm	
Use: LO for downconversion				
Frequency range	2 GHz		20 GHz	
Frequency resolution		0.5 GHz		
Power level	14 dBm	22 dBm	25 dBm	

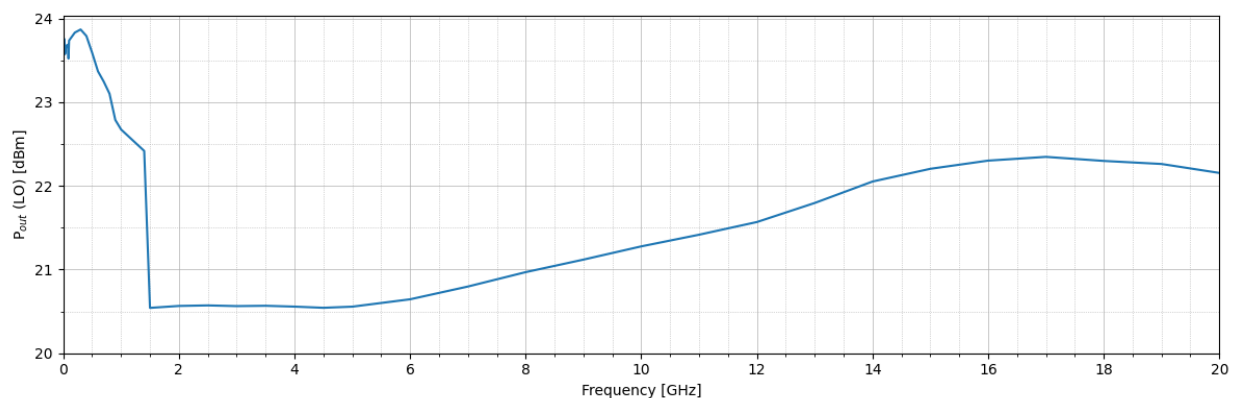


Figure 7. Option 300 – power output (typical)

Absolute amplitude noise measurement (Option 001)

Measurement parameters:

SSB amplitude noise [dBc / Hz]

Parameter	Min	Typical	Max	Note
RF frequency range	5 MHz		7 GHz 26 GHz 40 GHz	E5045A E5046A E5047A
RF input power range	-10 dBm		+20 dBm	5 MHz to 40 GHz
Offset analysis range	0.1 Hz		40 MHz	
Measurement uncertainty		±2 dB		
AM noise sensitivity (1 corr.)				
1 Hz		-100 dBc / Hz		1 GHz, Pin = -10 dBm to +20 dBm
10 Hz		-115 dBc / Hz		
100 Hz		-135 dBc / Hz		
1 kHz		-145 dBc / Hz		
10 kHz		-155 dBc / Hz		
> 100 kHz		-160 dBc / Hz		

Transient analysis (Option 002)

Measurement parameters:

Wideband mode (WB): frequency [Hz], narrowband mode (NB): frequency [Hz], RF power [dB], phase [deg]

Parameter	Min	Typical	Max	Note
RF frequency bands (WB)	5 MHz 20 MHz 80 MHz 320 MHz 1.3 GHz 5.2 GHz		100 MHz 400 MHz 1.6 GHz 3 GHz 26 GHz FMAX	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6
Measurement spans Wideband Mode (WB) Narrowband Mode (NB)	200 kHz		80 MHz	Bands 1-6 200 kHz, 1.25 MHz, 80 MHz
Frequency resolution				See table
Time span	10 μ s		1 min	Limited to <2 million samples
Time resolution	16 ns		50 ms	Limited to <2 million samples
Trigger mode				Single, continuous, internal (WB video or NB video), external

Transient analysis — wideband: frequency resolution vs. time resolution (residual FM, 5% video bandwidth, typical)

Frequency measurement uncertainty is $\pm$ (resolution + time-base uncertainty). Tabulated resolutions are measured with the PN3 Signal Source Analyzer and DUT locked to the same 10 MHz reference. Input level 0 dBm.

Time resolution	16 ns	128 ns	500 ns	1 μ s	$\geq 10 \mu$ s
Frequency band	Frequency resolution [Hz]				
5 MHz to 100 MHz	3 k	100	30	15	10
20 MHz to 400 MHz	5 k	700	200	100	20
80 MHz to 1.6 GHz	10 k	1 k	200	100	50
320 MHz to 3 GHz	30 k	1.5 k	300	150	150
1.3 GHz to 26 GHz	100 k	6 k	2 k	1 k	1 k
5.2 GHz to FMAX	500 k	20 k	4 k	2 k	2 k

Transient analysis — narrowband: frequency resolution vs. time resolution (residual FM, 80 MHz span, 5% video bandwidth, typical)

Frequency measurement uncertainty is $\pm$ (resolution + time-base uncertainty). Tabulated resolutions are measured with the PN3 Signal Source Analyzer and DUT locked to the same 10 MHz reference. Input level 0 dBm.

Time resolution	16 ns	128 ns	500 ns	1 μ s	10 μ s
Frequency range	Frequency resolution [Hz]				
< 200 MHz	1.5 k	50	10	4	4
< 800 MHz	2.5 k	150	15	10	4
< 2 GHz	2.5 k	500	20	10	4
< 20 GHz	30 k	4 k	150	70	20
> 20 GHz	50 k	4 k	400	150	50

Transient analysis — narrowband: frequency resolution vs. time resolution (residual FM, 1.25 MHz span, no video bandwidth, typical)

Frequency measurement uncertainty is $\pm$ (resolution + time-base uncertainty). Tabulated resolutions are measured with the PN3 Signal Source Analyzer and DUT locked to the same 10 MHz reference. Input level 0 dBm.

Time resolution	256 ns	500 ns	1 μ s	10 μ s	$\geq 20 \mu$ s
Frequency range	Frequency resolution [Hz]				
< 200 MHz	60	30	15	1.5	0.5
< 800 MHz	70	30	15	1.5	1.5
< 2 GHz	100	40	15	3	1.5
< 20 GHz	1 k	300	150	30	15
> 20 GHz	3 k	1 k	400	60	30

Transient analysis — narrowband: frequency resolution vs. time resolution (residual FM, 200 kHz span, no video bandwidth, typical)

Frequency measurement uncertainty is $\pm$ (resolution + time-base uncertainty). Tabulated resolutions are measured with the PN3 Signal Source Analyzer and DUT locked to the same 10 MHz reference. Input level 0 dBm.

Time resolution	1 μ s	10 μ s	$\geq 20 \mu$ s
Frequency range	Frequency resolution [Hz]		
< 200 MHz	1	0.5	0.3
< 800 MHz	1.5	0.5	0.3
< 2 GHz	3	1	0.4
< 20 GHz	20	10	3
> 20 GHz	50	20	10

Time stability measurement (Option 004)

Measurement parameters:

ADEV (no dead time)

Parameter	Min	Typical	Max	Note
Measurement time	1 s		10 days	
Resolution bandwidth (RBW)		100 Hz		
ADEV sensitivity $\tau = 1$ s $\tau = 100$ s		5e-12 1e-12		With RBW 100 Hz

Baseband noise analysis

Input connectors:

2 BNC female (rear panel), AC coupled

Measurement parameters:

Noise spectrum [dBV / Hz, dBm / Hz, nV / $\sqrt{\text{Hz}}$]

Parameter	Min	Typical	Max	Note
Frequency input range	1 Hz		100 MHz	
DC voltage input range Input Impedance	-12 V	1 k Ω	+12 V	DC
AC voltage range			+10 dBm	
Input noise density (1 correlation) 10 kHz		<10 nV / $\sqrt{\text{Hz}}$		
Trigger				Single, continuous, manual, bus

Spectrum monitoring (Option 005)

Measurement parameters:

Spectral noise density [dBm, dBm / Hz, dBv / Hz]

Parameter	Min	Typical	Max	Note
RF frequency range	5 MHz 5 MHz 5 MHz		7 GHz 26 GHz 40 GHz	E5045A E5046A E5047A
RBW	5.8 Hz		58 kHz	
Measurement uncertainty				
Absolute		±3 dB		
Relative		±1 dB		
Noise floor				
10 MHz to 4 GHz		-95 dBm / Hz		
4 GHz to 18 GHz		-90 dBm / Hz		
18 GHz to 40 GHz		-80 dBm / Hz		
Spurious (SFDR)				
10 MHz to 4 GHz		-70 dBc		Spurious free dynamic range
4 GHz to 18 GHz		-60 dBc		
18 GHz to 40 GHz		-55 dBc		
Trigger				Continuous

VCO characterization (Option 003)

Measurement parameters:

Frequency [Hz], KVCO (tuning sensitivity) ($\Delta f / \Delta V_c$) [Hz / V], frequency pushing [Hz / V], RF power level [dBm], DC supply current [mA], SSB phase noise [dBc / Hz]

Parameter	Min	Typical	Max	Note
Sweep parameters				
DC Supply Voltage	0 V		15 V	Adjustable
DC Supply Current		500 mA		
Tuning Voltage	-5 V		20 V	Adjustable
Tuning Current		20 mA		
RF frequency range	<i>FMIN</i>		<i>FMAX</i>	
Uncertainty		0.5 ppm		
RF input power range	-5 dBm		+20 dBm	
Uncertainty		0.5 dB		
DC supply current	0 mA		500 mA	
Uncertainty		1%		
Output settling time		20 ms		
Measurement speed		70 ms / point		Frequency, Kvco, pushing, supply current, and power

Tuning voltage and dual power supply

Parameter	Min	Typical	Max	Note
DUT tuning				BNC front panel output
DC voltage range	-5 V		+22 V	
Setting resolution		1 mV		
Setting uncertainty		±10 mV		
Noise level		< 5 nV _{rms} / √Hz		> 2 kHz
DC current max		20 mA		
DC power supplies				BNC rear panel output (Channel 1 and 2)
DC voltage range	0 V		15 V	
Setting resolution		10 mV		
Setting accuracy		±20 mV		
Noise level		< 10 nV _{rms} / √Hz		> 20 kHz
Output resistance		< 0.5 Ω		
DC current measurement range	0 mA		500 mA	Per channel
Resolution		100 μA		

Data processing capabilities

Graphical user interface: The analyzer employs a graphical user interface based on the Windows operating system.

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)
Title	Add customized title to each measurement window
Auto-scale	Automatically selects scale resolution and reference value to vertically center the trace
Marker functions	16 independent markers

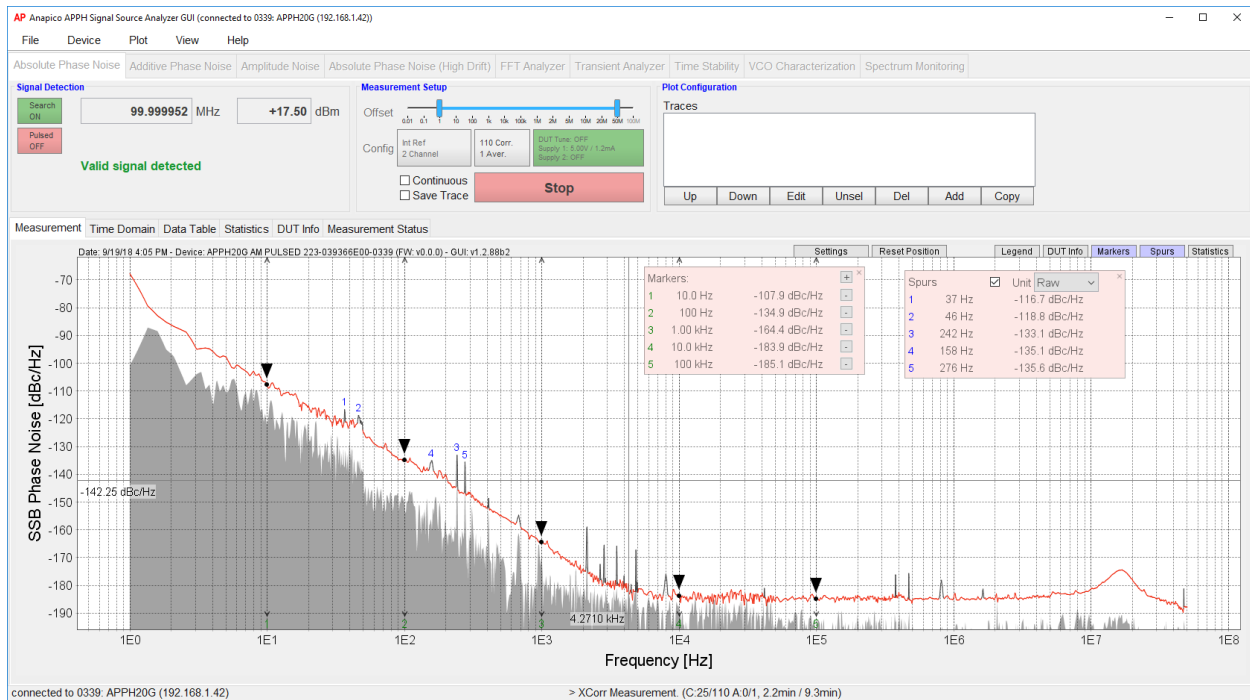


Figure 8. GUI interface (absolute phase noise)

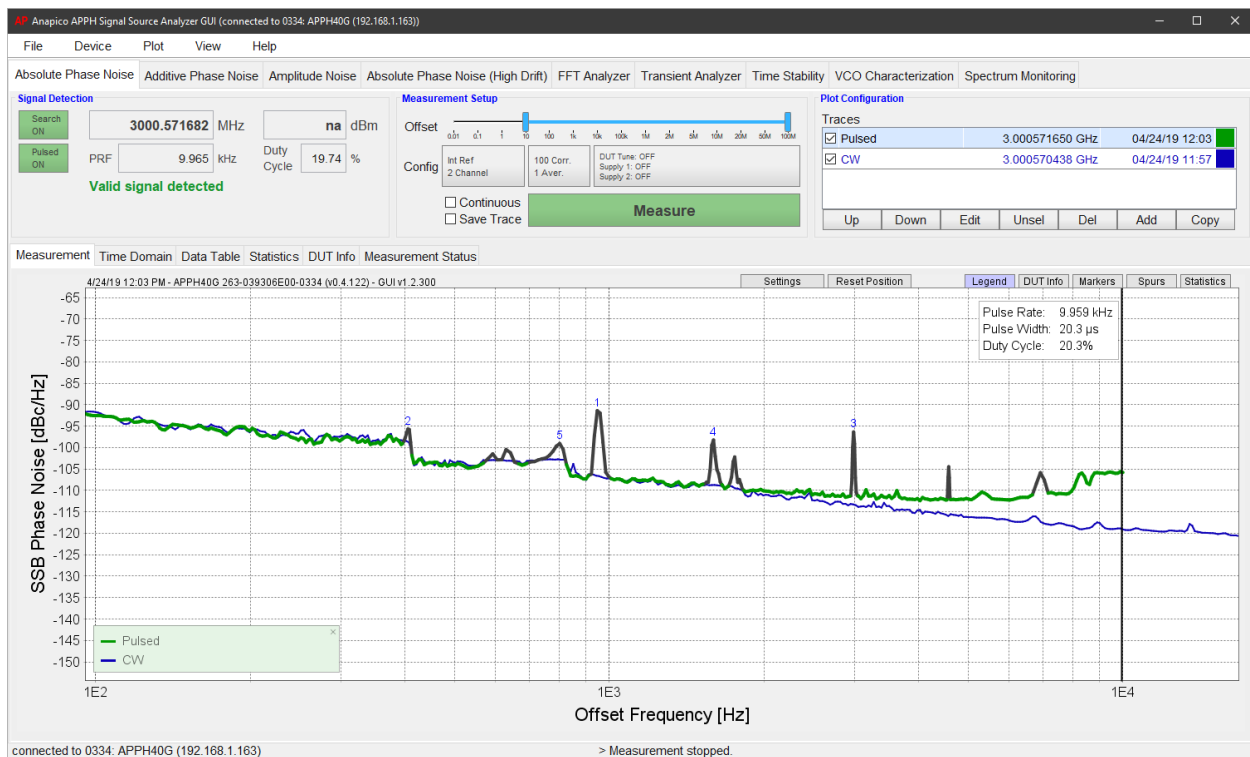


Figure 9. GUI interface (PULSED RF absolute phase noise)

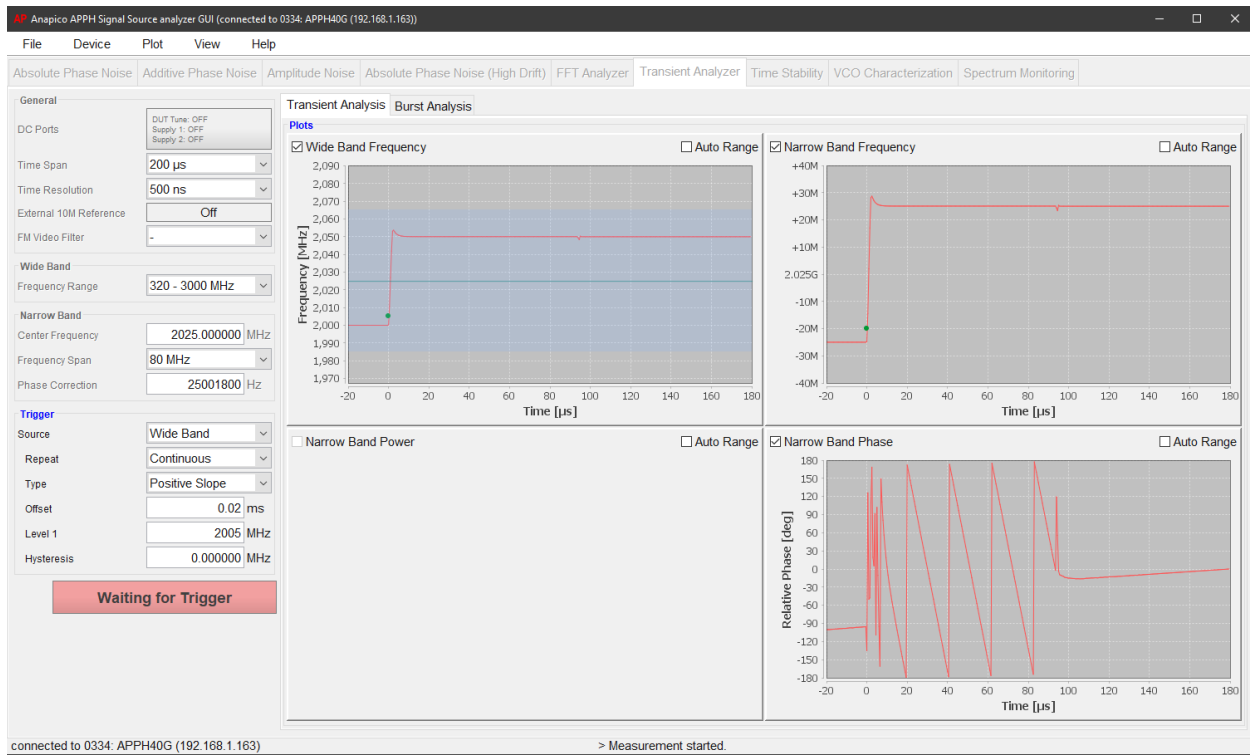


Figure 10. GUI interface (transient analyzer)

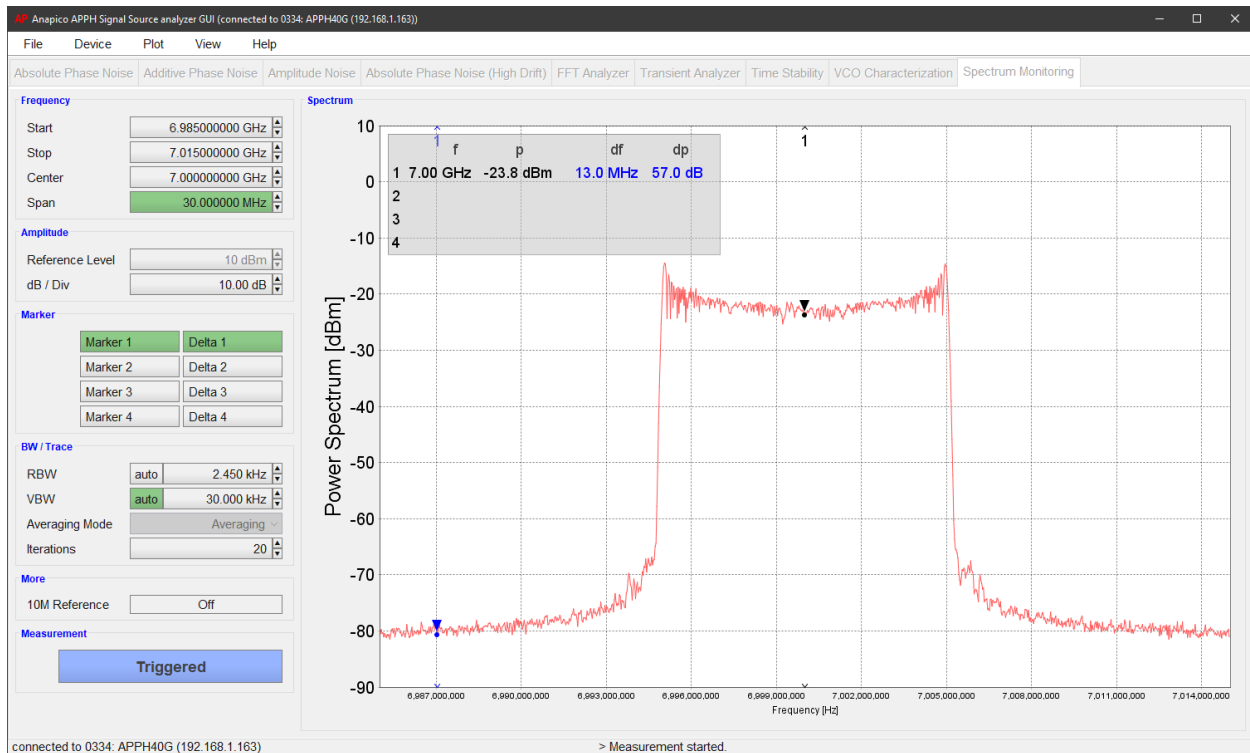


Figure 11. GUI interface (spectrum monitoring)

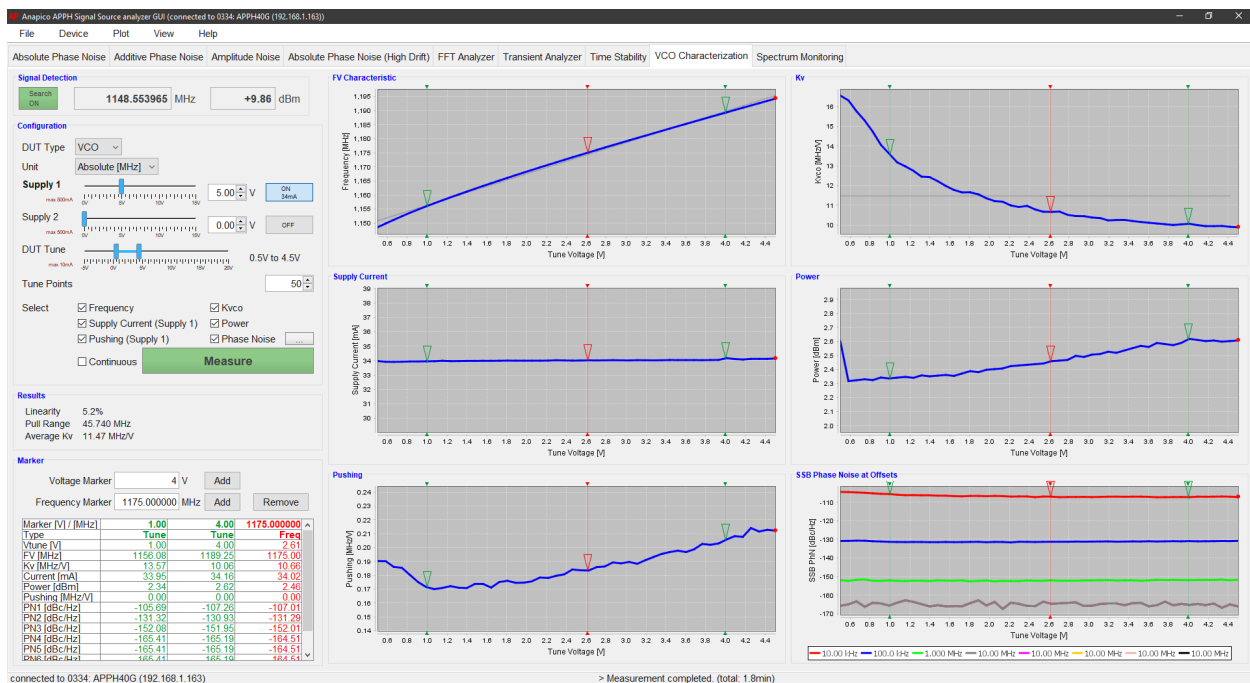


Figure 12. GUI interface (VCO testing)

Connectors

Front



RF inputs

RF IN: SMA female (for E5045A / E5046A); K female (for E5047A)

REF1 IN HIGH / LOW, REF2 IN HIGH / LOW: SMA female

DC outputs

REF1 TUNE, REF2 TUNE: BNC female

Operation

Switch I / 0: DC Power Switch

POWER, READY, REMOTE: Status LED

Rear



HF / VHF / AUX inputs

BASEBAND CH1, BASEBAND CH2: BNC female

REF IN 10 MHz: BNC female

EXT TRIG: BNC female

DC outputs

DC SUPPLY CH1, DC SUPPLY CH2: BNC female

Operation

LAN: RJ-45

USB B: USB 2.0 device

DC 24V: DC Power Plug (24V, 2A)

GPIB (Option GPIB): IEEE-488 GPIB Connector

Front — Option 300



Additional RF inputs

LO1 IN HIGH / LOW, LO2 IN HIGH / LOW: SMA female

RF1 IN, RF2 IN: SMA female

Additional RF outputs

LO1 OUT HIGH / LOW, LO2 OUT HIGH / LOW: SMA female

RF1 OUT, RF2 OUT: SMA female

Order Information

Product / Option	Description
E5045A	Base Model: 7 GHz Signal Source Analyzer
E5046A	Base Model: 26 GHz Signal Source Analyzer
E5047A	Base Model: 40 GHz Signal Source Analyzer
Option 001	Amplitude noise measurement
Option 002	Transient analysis
Option 003	VCO characterization
Option 004	Time stability analysis
Option 005	Spectrum monitoring
Option 006	Pulsed signal measurement (option 006 and 007 are mutually exclusive)
Option 007	Pulsed signal measurement for narrow pulses and low duty cycles (option 006 and 007 are mutually exclusive)
Option 008	Burst mode phase noise measurement
Option 020	Additive phase noise measurement
Option 200	Ultra-low noise internal sources
Option 300	Access to internal reference (if use for residual phase noise measurement, order Option 020, too)
Option 800	GPIO interface

General Characteristics

Remote programming interfaces:

- Ethernet 100BaseT LAN interface
- USB 2.0 device
- GPIB (IEEE-488.2, 1987) with listen and talk (option GPIB)
- Control language SCPI Version 1999.0

Power requirements: 24V $\pm$ 3.0 VDC; 70 W maximum

Mains adapter supplied: 100-240 VAC, 50-60 Hz in / 24 V, 6.67 A DC out

Environmental, Safety and Regulatory Information:

(Levels similar to MIL-PRF-28800F Class 3/4)

Intended use: Only use the product indoors. The product case is not waterproof (IP22).

Operating temperature: +5 °C to +50 °C

Altitude: $\leq$ 4600 m above sea level (approximately 15100 ft)

Relative Humidity: 5% to 75 $\pm$ 5% (in temperature range of 30 °C to 40 °C) and 5% to 45 $\pm$ 5% (temperature > 40 °C)

Overvoltage category: II

Pollution degree: suitable for pollution degree 2 environments where nonconductive contamination can occur.

 Safety / EMC complies with applicable Safety and EMC regulations and directives.
Emission limits for class A equipment.

Weight: $\leq$ 12.0 kg (27 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° in 30° steps

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