7000 Series Phase Noise Tester / Signal Source Analyzer

Features

- All-In-One Compact Measurement System
- Measurements Down to -190 dBc/Hz
- Offset Range from 0.01 Hz to 100 MHz
- Highest Flexibility & Dynamic Range By Selectable Internal or External References
- Programmable Low Noise Power Supplies
- Powerful GUI and Programming Interface
- External Battery Pack Option

Applications

- High-Speed Production Testing of Phase Noise
- VCO Testing
- Additive Phase Noise Characterization of Amplifiers, Transmitters, Mixers
- Ultra-Low Phase Noise Crystal Oscillator Analysis
- Time Stability Analysis of Clocks
- Aerospace and Defense

7000 Series Datasheet v1.22

Phase Noise Tester / Signal Source Analyzer from 1 MHz to 7, 26, or 40 GHz

7000 Series Phase Noise Tester / Signal Source Analyzer

7000 series

Introduction

The 7000 series 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 references sources and also allows measurements with externally fed references.

The 7000 series 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 analyzer
- Transient measurements (frequency, phase, amplitude versus time)
- Spectrum analysis
- Frequency counter function / power meter

Additionally, the unit offers:

- Two programmable low noise DC supplies up to 15 V and 600 mA current capability
- Three low noise tuning voltages for -5 to +22 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 are available.

Available Options:

- **GPIB**: IEEE-488.2,1987 programming interface
- **LN**: ultra low close to carrier phase noise
- **P**: pulsed RF measurement capability
- **AM**: Amplitude noise measurement capability
- **BURST**: Pulse train measurements, masking of pulses
- **APN**: Additive phase noise measurement
- **TRAN**: Transient analysis
- **TSTAB**: Time stability analysis
- **VCO:** Voltage-controlled oscillator characterization
- **SPEC**: Spectrum monitoring

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Signal Specifications

The specifications in the following pages describe the warranted performance of the instrument for 23 ± 5 °C after a 30 minute warm-up period. Typical specifications describe expected, but not warranted performance. Min and Max specifications are warranted.

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				
Measurement Parameters	SSB phase noise [dBc/Hz] Spurious noise [dBc] Integrated RMS phase deviation [deg, rad] Time jitter [s] Residual FM/PM [Hz rms]			
RF Frequency Range	**FMIN**		**FMAX**	Using internal references
	1 MHz		7 GHz	Model 7070
	1 MHz		26 GHz	Model 7300
	1 MHz		40 GHz	Model 7340
RF Frequency Range				Using external references
	5 MHz		7 GHz	Model 7070
	5 MHz		18 GHz	Models 7300 / 7340
Input Power Range				Damage level +26 dBm
< 18 GHz	-15 dBm		+20 dBm	
18 GHz to 30 GHz	-15 dBm		+23 dBm	*See RF Sensitivity Plots*
30 GHz to 35 GHz	0 dBM		+23 dBm	
>35 GHz			+23 dBm	
Input impedance		50 Ω		AC coupled, 10V DC max
VSWR		2		
Offset Analysis Range	0.01 Hz		100 MHz	f_C > 150 MHz
	0.01 Hz		> 25% of f_C	f_C < 150 MHz
Resolution (PPD)	200	200	1600	RBW adjustable (x1/x2/x4/x8), PPD (point per decade) can be lower for lowest decade of measurement
Measurement Accuracy		±4 dB		Offset < 10 Hz offset
		±3 dB		Offset 10 Hz to 1 kHz offset
		±2 dB		Offset 1 kHz to 100 MHz offset
Phase Noise Sensitivity				See plot & sensitivity tables
Spurious Levels				
External References		-90 dBc		
Internal references		-85 dBc		
Measurement time				See Table “Measurement Time
Trigger				Single, continuous, manual, bus

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Parameter	Min.	Typ.	Max.	Note
Internal References				cross-correlation
Frequency Range	1 MHz		FMAX	
Phase Noise Sensitivity				See Plots “Sensitivity”
RF Tracking Range		±1 ppm ±10 ppm ±1000 ppm		**Option LN** Standard High drift mode
External References				Single channel or Cross-correlation
Frequency Range	5 MHz 5 MHz		7 GHz 18 GHz	Model 7070 Model 7300 / 7340
RF Input Level Range < 1.3 GHz > 1.3 GHz	 0 dBm 0 dBm		 +23 dBm +23 dBm	Damage level +26 dBm
Phase Noise Sensitivity				See plot & sensitivity tables
Reference Input Level Range < 1.3 GHz > 1.3 GHz	 +10 dBm +13 dBm	 +15 dBm +15 dBm	 +21 dBm +21 dBm	 Lower input Upper input
Tuning Voltage Range	-5 V		+20 V	User adjustable
Tuning Output Current			20 mA	
Absolute Phase Noise Measurement - Pulsed (Option P)				
RF Frequency Range	30 MHz 30 MHz		7 GHz 18 GHz	Model 7070 Model 7300 / 7340
RF Input Power Range	+5 dBm		+20 dBm	no power measurement
Pulse rate (PRF)	200 Hz		2 MHz	
Input Parameters Pulse rate (PRF) Pulse width Duty cycle	 200 Hz 200 ns 0.2%		 2 MHz 2 ms 60%	
Offset Analysis Range	0.01 Hz		PRF	
Measurement Accuracy		±4 dB ±3 dB ±2 dB		Offset < 10 Hz offset Offset 10 Hz to 1 kHz offset Offset 1 kHz to 100 MHz offset
Measurement time				See Table “Measurement Time”

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Parameter	Min.	Typ.	Max.	Note
Residual (additive) CW or PULSED (option P) Phase Noise Measurement				
Measurement parameters	SSB phase noise [dBc/Hz] Spurious noise [dBc] Integrated RMS phase deviation [deg, rad] time jitter [s] Residual FM/PM [Hz RMS]			
RF Frequency Range	5 MHz 5 MHz		7 GHz 18 GHz	7070 7300 / 7340
RF Input Power Range RF Port REF ports	 +3 dBm +13 dBm		 +23 dBm +20 dBm	
Offset Analysis Range	0.01 Hz		100 MHz	
Measurement Accuracy		±3 dB ±2 dB		Offset < 1 kHz Offset > 1 KHz
Additive Phase Noise Sensitivity				See sensitivity table
Transient Measurements (option TRAN)				
Measurement parameters Wideband mode Narrowband mode	 Frequency [Hz] Frequency [Hz], RF power[dB], Phase [deg]			
Frequency bands (wideband)	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 Narrowband	 200 kHz,		 80 MHz	 Bands 1-6 200 kHz, 1.25 MHz, 80 MHz
Frequency resolution				See table
Time span	10 µs		1 min	
Time resolution	16 ns		50 ms	
Trigger mode				Single, continuous, bus, internal (WB video or NB video) ,external

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Parameter	Min.	Typ.	Max.	Note
Burst Mode Phase Noise Measurements (Option P + Option BURST)				
Measurement parameters		Phase Noise [dBc/Hz]		
RF Frequency Range	5 MHz		FMAX	
Offset Frequency Range	1 / T		30 MHz	
Time Span (T)	10 µs		1 min	
Phase Noise Sensitivity 1 kHz 10 kHz 100 kHz 1 MHz 10 MHz		 -120 dBc/Hz -128 dBc/Hz -131 dBc/Hz -131 dBc/Hz -147 dBc/Hz		Single channel, f = 1 GHz
Absolute Amplitude Noise Measurement (option AM)				
Measurement Parameters		SSB Amplitude Noise [dBc/Hz],		
RF Frequency Range	5 MHz		18 GHz	
RF Input Power Range 5 MHz to 10 GHz 10 GHz to 18 GHz	 -20 dBm -10 dBm		 +20 dBm +20 dBm	
Offset Analysis Range	0.1 Hz		40 MHz	
Measurement Uncertainty		±2 dB		
AM Noise Sensitivity (1 corr) 1 Hz 10 Hz 100 Hz 1 kHz 10 kHz > 100 kHz		 -100 dBc/Hz -115 dBc/Hz -135 dBc/Hz -145 dBc/Hz -155 dBc/Hz -160 dBc/Hz		1 GHz, P_{in} = -10 dBm to +20 dBm

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Parameter	Min.	Typ.	Max.	Note
Baseband Noise Analyzer				
Input Connectors	2 BNC female (rear panel), AC coupled			
Measurement Parameters	Noise spectrum [dBV/Hz, dBm/Hz, nV/√Hz]			
Frequency Range	1 Hz		100 MHz	
DC Voltage Range Input Impedance	-12 V	 1 kΩ	+ 12 V	 DC
AC Voltage Range			+ 10 dBm	
Input Noise Density (1 correlation) 10 kHz		 < 1 nV/ √Hz		
Trigger				Single, continuous, manual, bus
Time Stability Tab (option TSTAB)				
Measurement Parameters	ADEV (with no dead time)			
Measurement Time	1s		10 days	
ADEV Sensitivity Tau= 1 s Tau 100 s		 5e-13 3e-14		with RBW 100 Hz
Spectrum Monitoring (option SPEC)				
Measurement Parameters	Spectral Noise Density [dBm, dBm/Hz, dBv/Hz]			
RF Frequency Range	10 MHz 10 MHz 10 MHz		7 GHz 26 GHz 40 GHz	7070 7300 7340
Monitor Span	5 kHz		100 MHz	
RBW	5.8 Hz		58 kHz	
Measurement Uncertainty Absolute Relative		 ±3 dB ±1 dB		
Noise floor 10 MHz to 4 GHz 4 GHz to 18 GHz 18 GHz to 40 GHz		 -130 dBm /Hz -120 dBm/Hz -100 dBm/Hz		
Spurious levels 10 MHz to 4 GHz 4 GHz to 18 GHz 18 GHz to 40 GHz		 -70 dBc -60 dBc -55 dBc		
Trigger				continuous, manual, bus

Parameter	Min.	Typ.	Max.	Note
VCO Characterization (option VCO)				
Measurement Parameters	Frequency (Hz) K_{vco} Tuning sensitivity (Δf/ΔVc) (Hz/V) Frequency Pushing (Hz/V) RF power level [dBm] DC supply current [mA] SSB PhN / AN [dBc/Hz]			
Sweep Parameters DC Supply Voltage DC Supply Current Tuning Voltage Tuning Current	 0 V -5 V		 15 V 550 mA 20 V 20 mA	 Adjustable Adjustable
RF Frequency Range Uncertainty	5 MHz	 0.5 ppm	FMAX	
RF Input Power Range Uncertainty	-5 dBm	 0.5 dB	+20 dBm 2 dB	
DC Supply Current Uncertainty	0 mA	 1%	550 mA	
Output settling time		20 ms		
Measurement speed		70 ms /point		includes frequency, K_{vco}, pushing, DC supply, and power measurement
Frequency Counter				
Measurement Parameters	Frequency [Hz]			
RF Frequency Range	1 MHz		FMAX	
Absolute Accuracy		300 ppb		or accuracy of external reference
Sensitivity				see plot “typical RF sensitivity plot”
Power Detector				
Measurement Parameters	RF Power Level mW, dBm			
RF Frequency Range	5 MHz 5 MHz		FMAX 27 GHz	7070, 7300 7340
Absolute Accuracy		±1 dB	±2.5 dB	
Power Range	-10 dBm		+13 dBm	
Tuning Voltage & Dual Power Supply				
DUT Tuning				BNC front panel output
DC Voltage Range	-5 V		+22 V	
Setting Resolution		1 mV		
Setting Uncertainty		±2 mV		
Noise Level		< 2 $nV_{rms}/\sqrt{Hz}$		> 2 kHz
DC current range	0 mA		35 mA	

Parameter	Min.	Typ.	Max.	Note
DC Power Supplies				BNC rear panel output (Channel 1 & 2)
DC Voltage Range	0 V		15 V	
Setting Resolution		10 mV		
Setting Uncertainty		±10 mV		
Noise Level		< 10 $nV_{rms}/\sqrt{Hz}$		> 20 kHz
Output Resistance		< 0.5 Ω		
DC current meas. range	0 mA		550 mA	Per channel
Resolution		100 µA		

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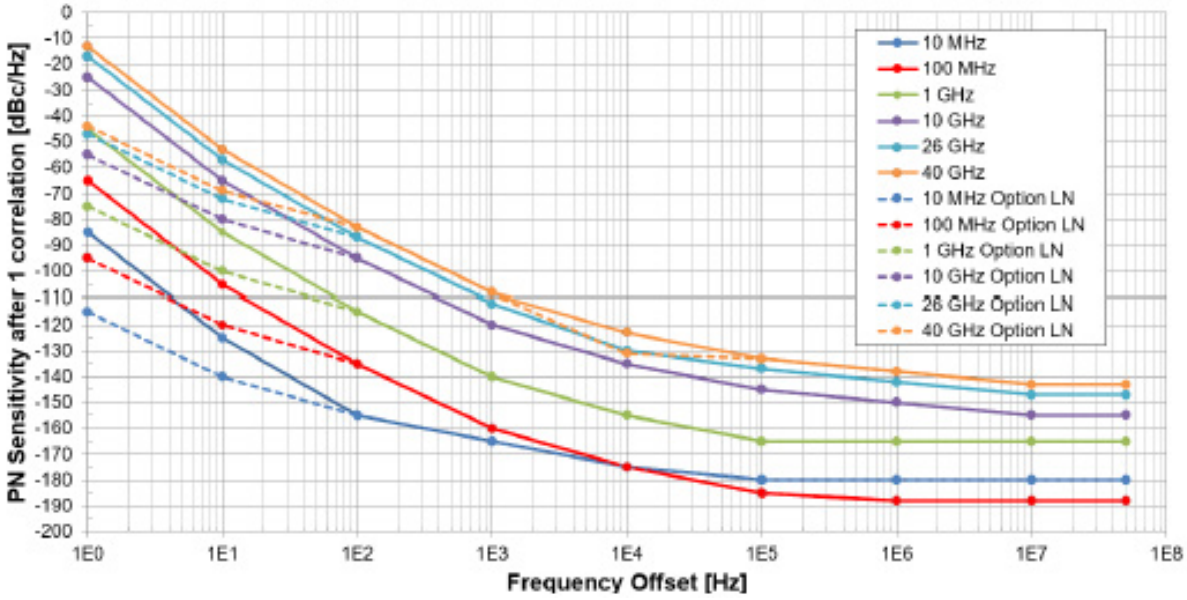
Performance Data Plots

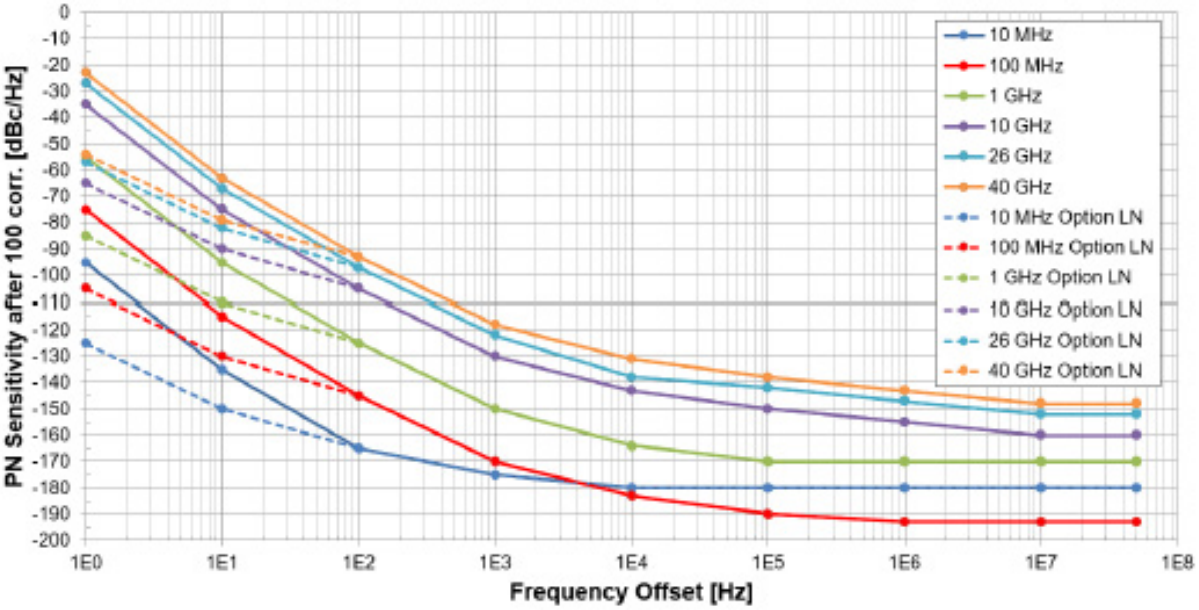
Phase Noise Sensitivity (standard and option LN) Internal References

Measurement time ~10 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. The plot show typical performance.

After 1 Correlation



After 100 Correlation



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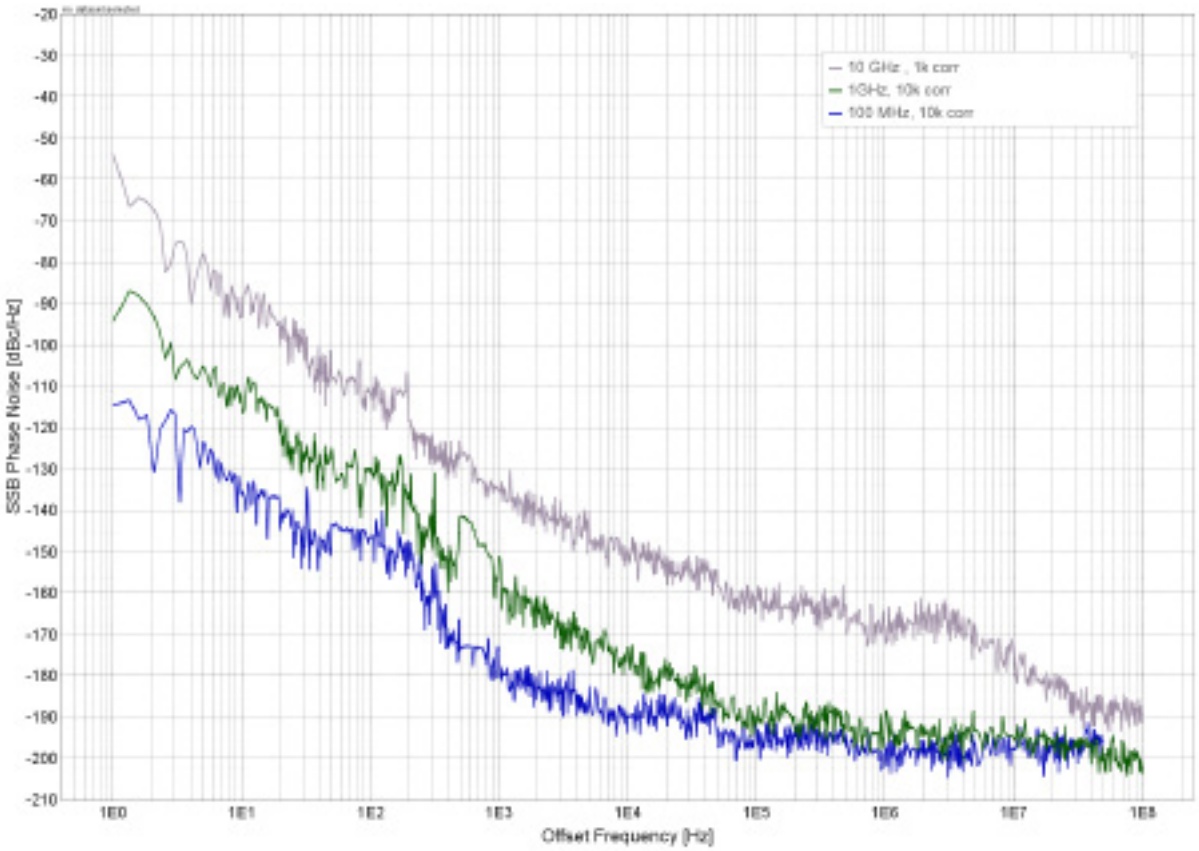
Typical Noisefloor Example
(after >1k correlations at 100MHz, 1GHz, 10GHz)



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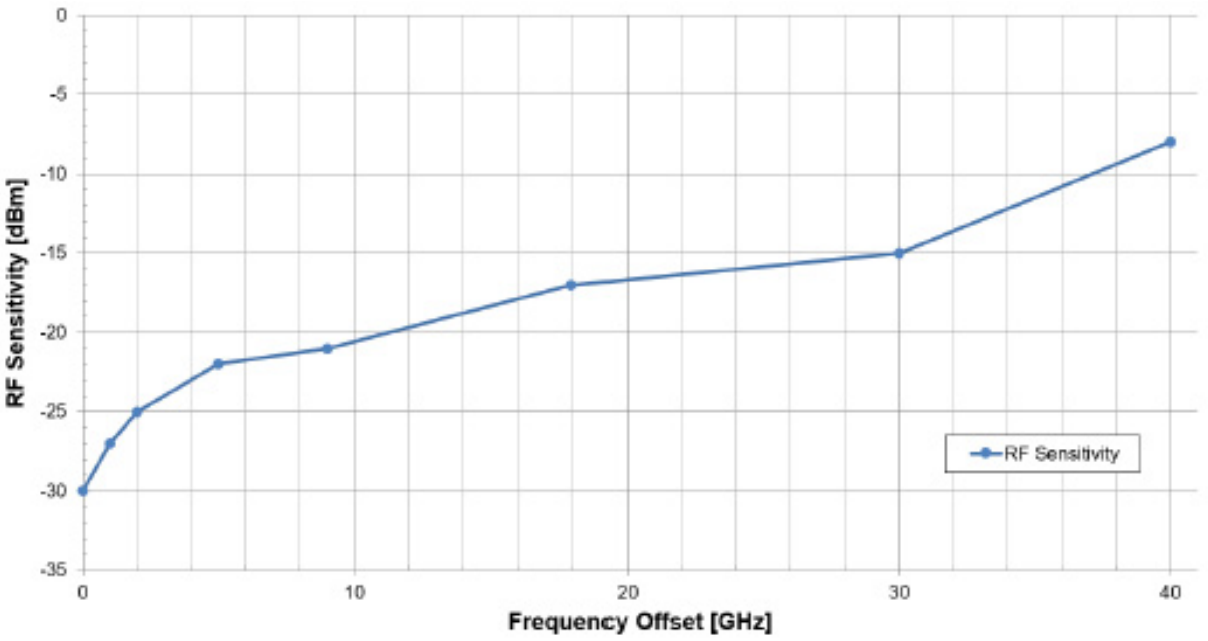
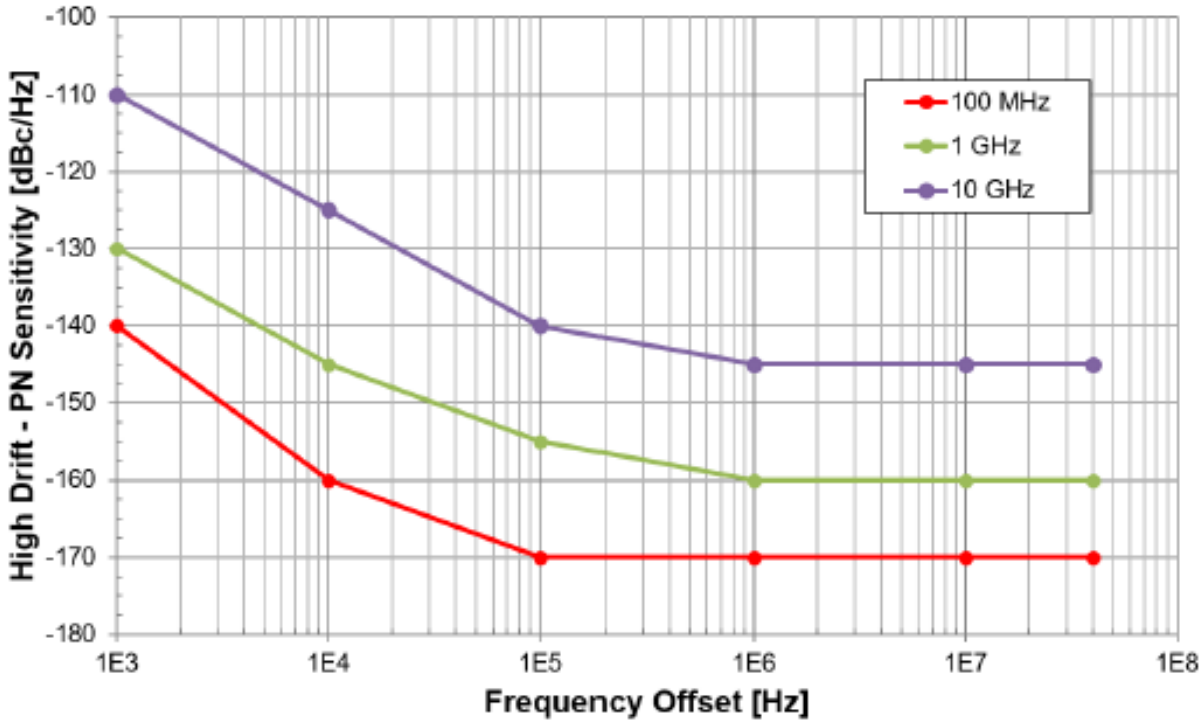
Typical RF Sensitivity 5 MHz to 40 GHz (blue trace, in dBm)



Phase Noise Sensitivity - High Drift



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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 correlation (sec)	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 Sensitivity

Internal References (with Option LN)

Abs. PN with INTERNAL references (option LN)	OFFSET						
	1 Hz	10 Hz	100 Hz	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
Remarks:	Test conditions: carrier power: >= 5 dBm; after one correlation						

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Absolute Phase Noise Sensitivity

External References

Abs. PN with EXTERNAL references	OFFSET						
	1 Hz	10 Hz	100 Hz	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	-120	-140	-145	-145
Remarks:	Test conditions: carrier power: >=5 dBm; after one correlation						

Additive Phase Noise Sensitivity

Single channel

Additive PN (1 channel)	OFFSET						
	1 Hz	10 Hz	100 Hz	1 kHz	10k Hz	100 kHz	1 MHz
10 MHz ≤ f ≤ 1 GHz	-130	-140	-150	-160	-170	-170	-170
1 GHz < f ≤ 4 GHz	-130	-140	-150	-160	-170	-170	-170
4 GHz < f ≤ 16 GHz	-115	-125	-135	-145	-150	-155	-160
Remarks:	Test conditions: RF carrier power: >=10 dBm; REF >=13 dBm Two channel cross-correlation can improve noise floor by 5 dB per 10x correlations.						

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Transient Analysis

Frequency measurement uncertainty is ± (resolution + time-base uncertainty). Tabulated resolutions are measured with the 7000 series and DUT locked to the same 10 MHz reference. Input level 0 dBm.

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

Time Resolution	16 ns	128 ns	500 ns	1 µs	≥10 µs
Frequency Band	**Frequency Resolution [Hz]**				
5 to 100 MHz	3 k	100	30	15	10
20 to 400 MHz	5k	700	200	100	20
80 to 1.6 GHz	10 k	1 k	200	100	50
320 to 3 GHz	30 k	1.5 k	300	150	150
1.3 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 Measurement- Narrowband: Frequency Resolution vs. Time Resolution (residual FM, 80 MHz Span, 5% video bandwidth, typical)

Time Resolution	16 ns	128 ns	500 ns	1 µs	10 µs	≥20 µs
Frequency Range	**Frequency Resolution [Hz]**					
< 200 MHz	1.5 K	50	10	4	4	4
< 800 MHz	2.5 K	150	15	10	4	4
< 2 GHz	2.5 K	500	20	10	4	4
< 20 GHz	30 K	4 K	150	70	20	7
> 20 GHz	50 K	4 K	400	150	50	15

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

Time Resolution	256 ns	500 ns	1 µs	10 µs	>=20 µs
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

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Narrowband: Transient Measurement Frequency Resolution vs. Time Resolution (residual FM, 200 kHz Span, no video bandwidth, typical)

Time Resolution	1 µs	10 µs	>=20 µs
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

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)
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

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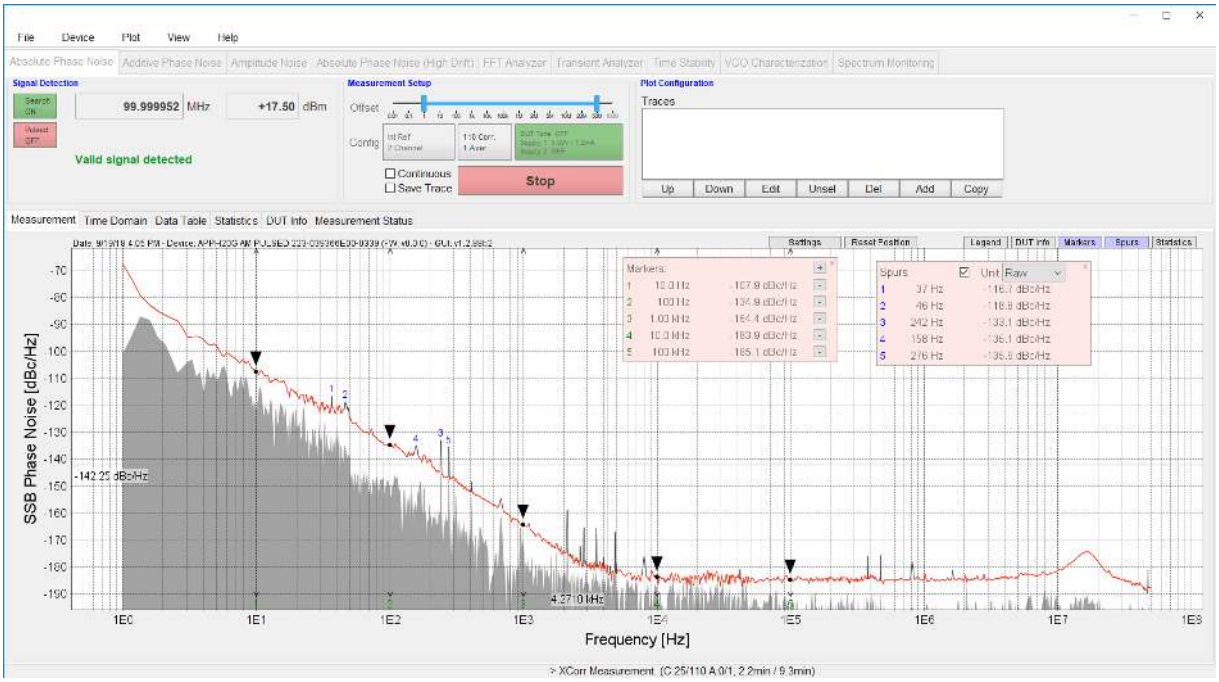
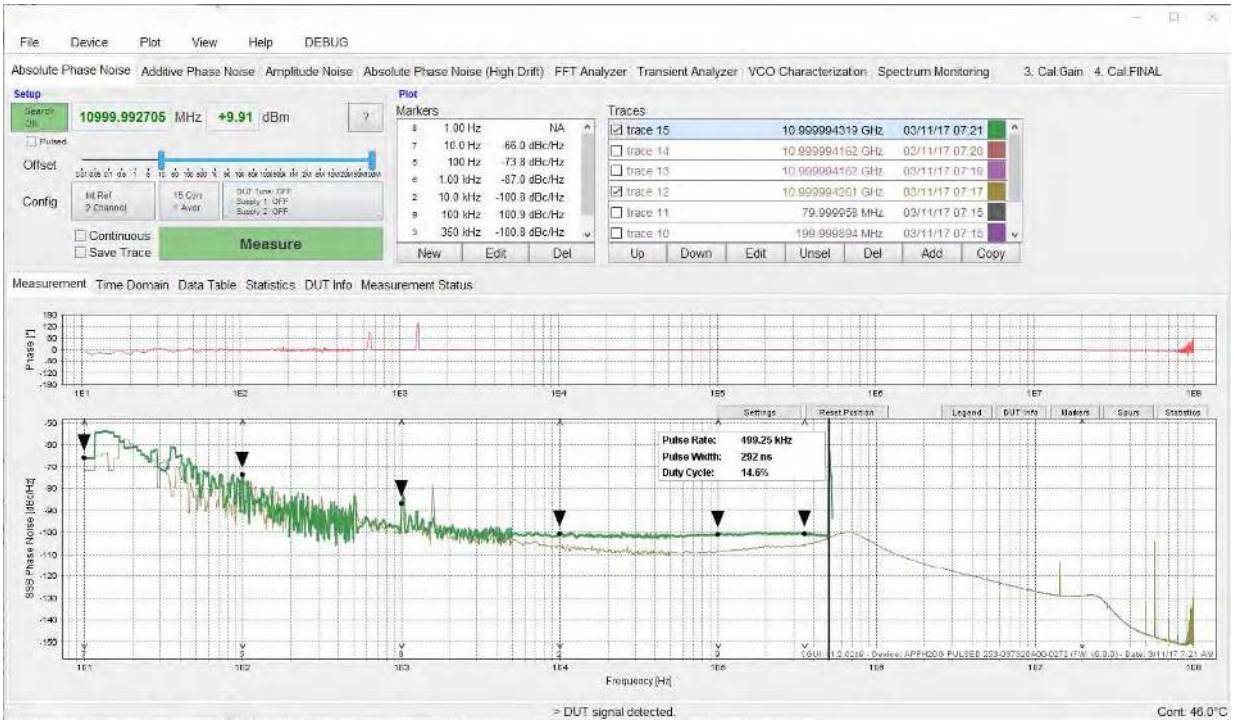
GUI Interface (Absolute Phase Noise)



GUI Interface (Pulsed RF Absolute Phase Noise)



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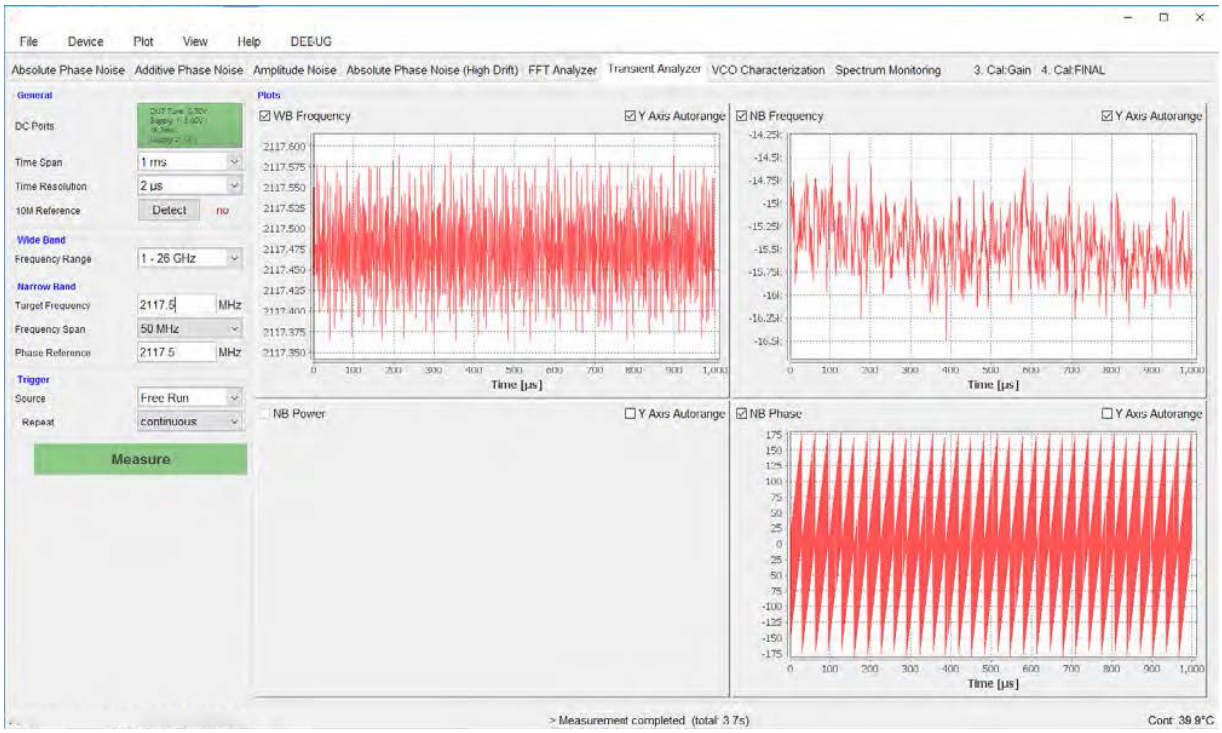
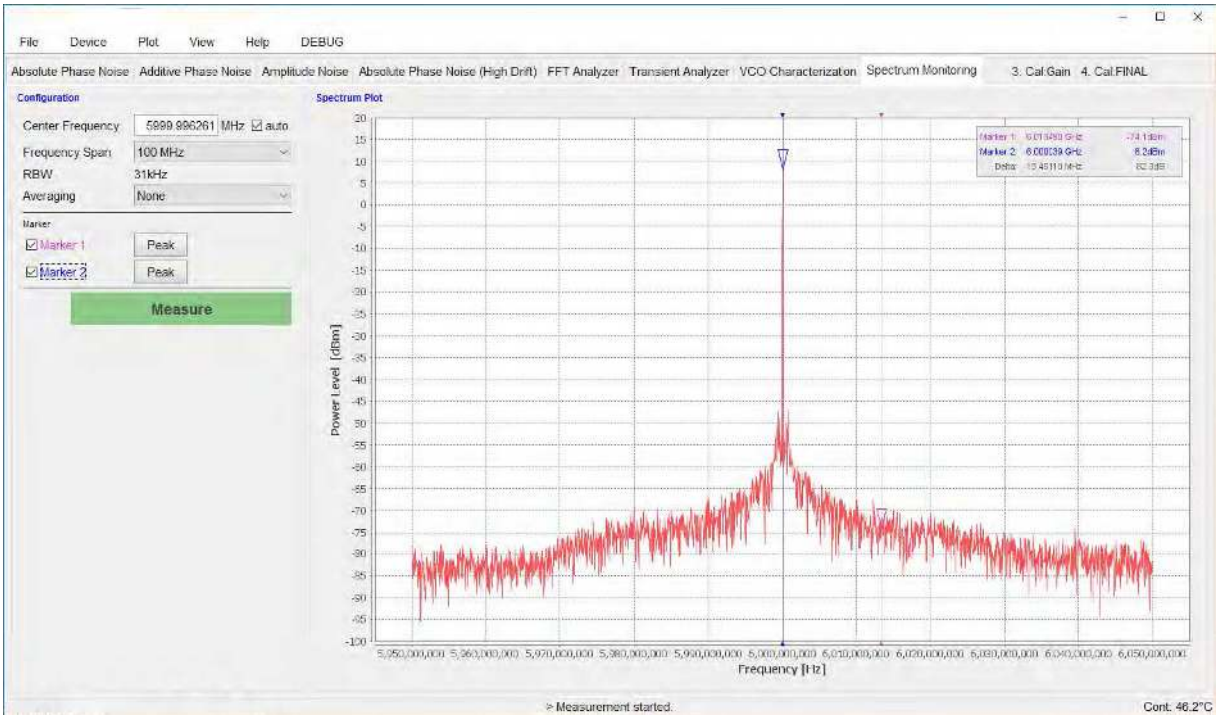
GUI Interface (Transient Analyzer)



GUI Interface (Spectrum Monitoring)



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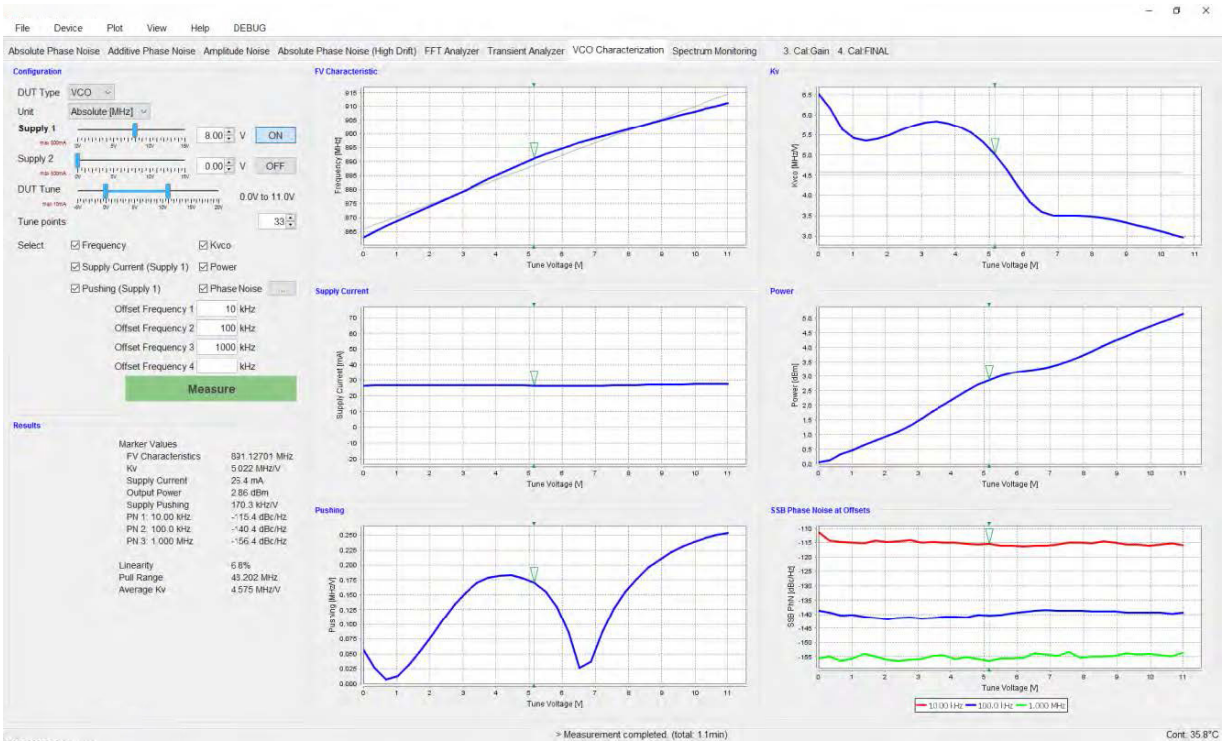
GUI Interface (VCO Testing)



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Connectors

Front panel:

RF Inputs

RF IN: SMA female (for model 7070 / Model 7300); K female (for Model 7340)
REF1 IN HIGH / LOW, REF2 IN HIGH/LOW: SMA Female

DC Outputs

REF1 TUNE, REG2 TUNE: BNC female

Operation

Switch I/0: DC Power Switch
POWER, READY, REMOTE: Status LED

Rear Panel:

HF/VHF/AUX Inputs

BASEBAND CH1, BASEBAND CH2: BNC female
REF IN 10 MHz
EXT TRIG: BNC Female

DC Outputs

DC SUPPLY CH2, D C 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

7000 Series Phase Noise Tester / Signal Source Analyzer

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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 V ± 3.0 VDC ; 70 W maximum
Mains adapter supplied 100-240 VAC in/ 24 V 4.0 A DC out
Operating temperature range 0 to 40 °C
Storage temperature range –40 to 70 °C
Operating and storage altitude up to 15,000 feet (4600 m)

CE notice

Complies with EMC regulations and directives for emission and immunity to interference (EN 61326-1 Industrial, EN/IEC 61326-2-1)
Complies with applicable Safety regulations in line with IEC/EN 61010-1

Weight ≤ 10 kg (21 lbs) net
Dimensions Incel 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 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 230 mm [9 in]; can be turned 360° in 30° steps

*Specifications subject to change

Options

- **GPIB**: IEEE-488.2,1987 programming interface
- **LN**: ultra low close to carrier phase noise
- **P**: pulsed RF measurement capability
- **AM**: Amplitude noise measurement capability
- **BURST**: Pulse train measurements, masking of pulses
- **APN**: Additive phase noise measurement
- **TRAN**: Transient analysis
- **TSTAB**: Time stability analysis
- **VCO:** Voltage-controlled oscillator characterization
- **SPEC**: Spectrum monitoring