G2 Analog Signal Generator

Model AP5011A

Ultra-low noise microwave signal generators
100 kHz to 12.75, 20, 26, and 40 GHz

KEYSIGHT

Introduction

Ultra-low noise microwave signal generator 100 kHz to 12.75, 20, 26 and 40 GHz

The AP5011A G2 Analog Signal Generator is an ultra-low-noise and fast-switching microwave signal generator covering a continuous frequency range from 100 kHz up to 12.75, 20 GHz, 26 or 40 GHz, with a lower than 0.001 Hz resolution.

The AP5011A G2 Analog Signal Generator provides an accurately levelled output power range and high spurious suppression. Advanced frequency synthesis combines the fastest switching speed with ultra-low SSB phase noise and fine frequency and power resolution.

The AP5011A G2 Analog Signal Generator supports analog AM, FM, PM modulation, as well as frequency chirps and pulse modulation with programmable patterns and narrow pulses.

The AP5011A G2 Analog Signal Generator allows for fast digital sweeps including flexible list sweeps, where frequency, power, and dwell times can be set individually. A flexible triggering system simplifies synchronization within test environments.

All AP5011A G2 Analog Signal Generator models operate with ultra-stable temperature compensated frequency reference (OCXO) to ensure minimal drift and can be phase-locked to an external reference.

The compact unit allows for full front panel control via touch panel display. It can also be controlled intuitively by a PC-based Graphical User Interface (GUI). Moreover, the instrument offers various communication interfaces like USB, LAN, or GPIB. Each interface allows for easy, fast communication using SCPI 1999 command set. Remote control of the instrument can be quickly attained from any host system.

A customer-supplied Application Programming Interface (API) or programming examples for Matlab, Labview, C++, and other commercially available tools make the control implementation straightforward.

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.

Typical: Expected mean values, not warranted performance.

Min and 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.

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Frequency parameters / range

Parameter	Min	Typical	Max	Note
Frequency range	100 kHz 100 kHz 100 kHz 100 kHz		12.75 GHz 20 GHz 26 GHz 40 GHz	AP5011A-512 AP5011A-520 AP5011A-526 AP5011A-540
Resolution		0.001 Hz		
Phase resolution		0.01 deg		
Switching speed SCPI CW mode Sweep / List mode		1.5 ms 500 µs 30 µs See sweep		Valid signal after SCPI received. Option UNZ Option UNQ

Phase noise

Parameter	Min	Typical	Max	Note
SSB phase noise at 1 GHz				(See also plots / tables)
at 10 Hz from carrier		-83 dBc/Hz -95 dBc/Hz	-80 dBc/Hz -85 dBc/Hz	Option LN1 Option LN2
at 1 kHz from carrier		-130 dBc/Hz	-125 dBc/Hz	
at 20 kHz from carrier		-142 dBc/Hz	-136 dBc/Hz	
at 100 kHz from carrier		-146 dBc/Hz	-140 dBc/Hz	
SSB phase noise at 4 GHz				
at 10 Hz from carrier		-71 dBc/Hz -83 dBc/Hz	-68 dBc/Hz -73 dBc/Hz	Option LN1 Option LN2
at 1 kHz from carrier		-117 dBc/Hz	-111 dBc/Hz	
at 20 kHz from carrier		-129 dBc/Hz	-123 dBc/Hz	
at 100 kHz from carrier		-133 dBc/Hz	-127 dBc/Hz	
SSB phase noise at 10 GHz				
at 10 Hz from carrier		-64 dBc/Hz -75 dBc/Hz	-60 dBc/Hz -65 dBc/Hz	Option LN1 Option LN2
at 1 kHz from carrier		-108 dBc/Hz	-103 dBc/Hz	
at 20 kHz from carrier		-121 dBc/Hz	-115 dBc/Hz	
at 100 kHz from carrier		-125 dBc/Hz	-119 dBc/Hz	
SSB phase noise at 40 GHz				
at 10 Hz from carrier		-55 dBc/Hz -66 dBc/Hz	-48 dBc/Hz -53 dBc/Hz	Option LN1 Option LN2
at 1 kHz from carrier		-96 dBc/Hz	-91 dBc/Hz	
at 20 kHz from carrier		-109 dBc/Hz	-103 dBc/Hz	
at 100 kHz from carrier		-113 dBc/Hz	-107 dBc/Hz	

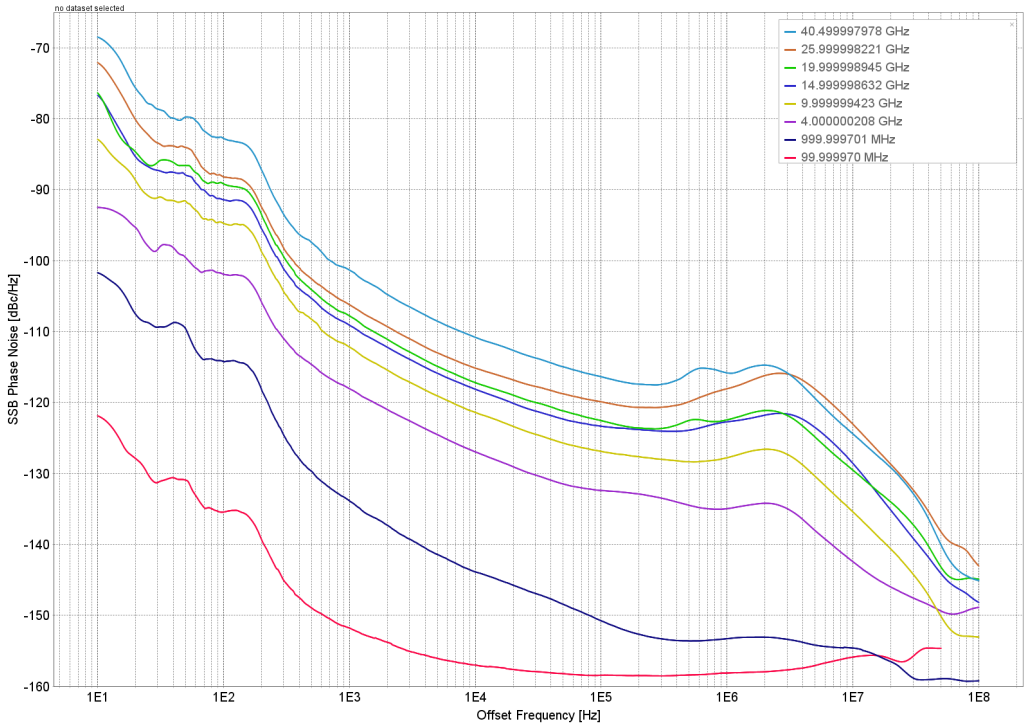


Figure 1. SSB phase noise performance with Option LN2

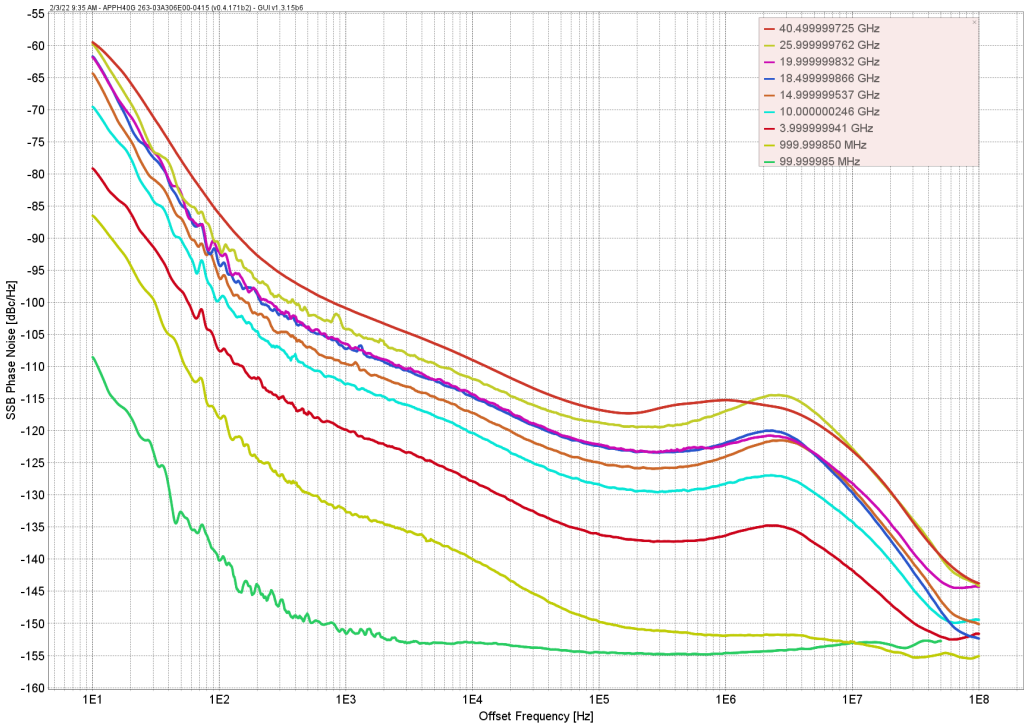


Figure 2. SSB phase noise performance, with Option LN1

Spectral purity

Parameter	Min	Typical	Max	Note
Harmonics (at 0 dBm Pout) 0.01 to 6 GHz > 6 GHz > 8 GHz > 11.5 GHz – 20 GHz > 10.5 GHz – 20 GHz Option 1EH, > 1 GHz – 20 GHz		 -40 dBc -35 dBc -55 dBc -55 dBc -30 dBc -60 dBc	 -27 dBc -45 dBc -45 dBc -23 dBc -45 dBc	 Option 512 Option 520 Option 526 or 540 All models, see plots
Sub-harmonics (at 0 dBm) < 5 GHz 5 – 20 GHz > 20 GHz Option 1EH, > 20 GHz		 -75 dBc -70 dBc -55 dBc -65 dBc	 -65 dBc -60 dBc -42 dBc typ. -55 dBc typ.	 0.5 x fundamental frequency, 1.5 x fundamental frequency	
Non-harmonic spurious (at 0 dBm)		-60 dBc		> 10 kHz offset

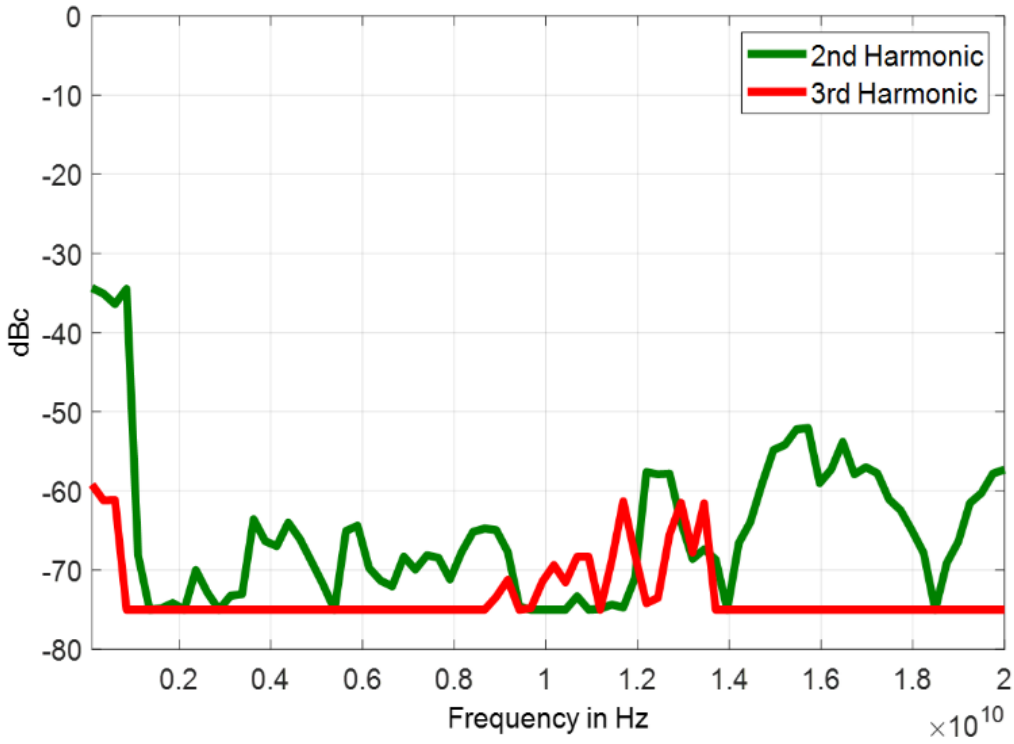


Figure 3. Harmonics (2nd, 3rd at P=+5 dBm, Option 540 with Option 1EH)

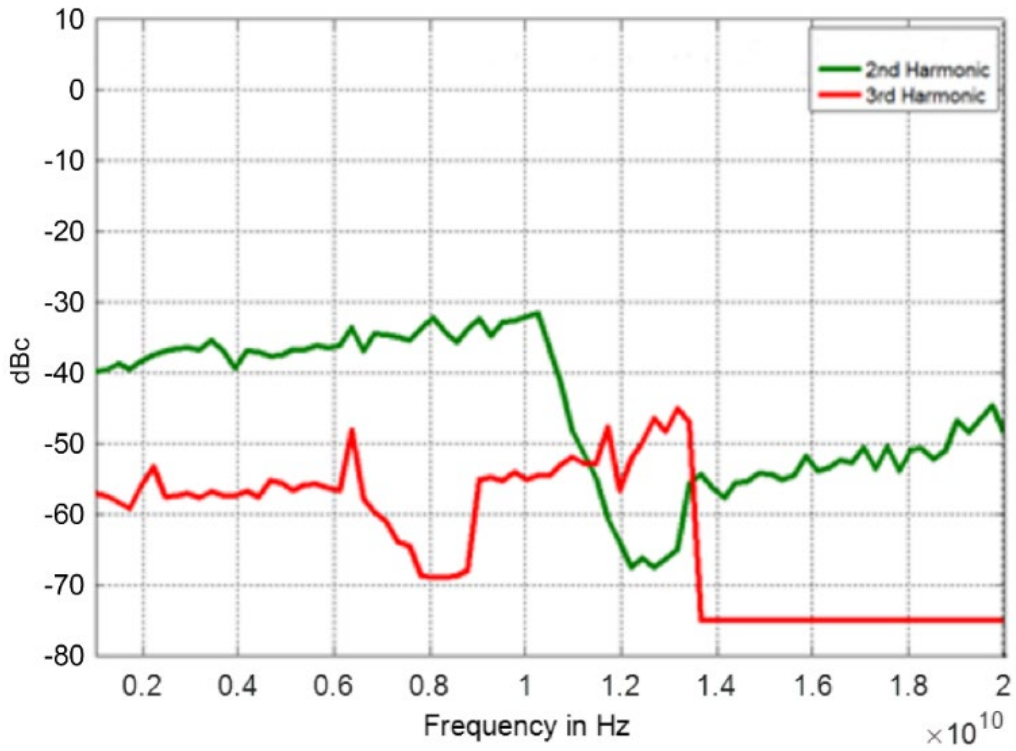


Figure 4. Harmonics (2nd, 3rd at P=5 dBm, Option 520)

Level performance

Parameter	Min	Typical	Max	Note
Output power range (Option 512 and 520)				
0.1 to 10 MHz	-25 dBm		+24 dBm	
> 0.01 to 5 GHz	-25 dBm		+25 dBm	
> 5 to 18 GHz	-25 dBm		+21 dBm	
> 18 to 20 GHz	-25 dBm		+20 dBm	

Level performance (continued)

Parameter	Min	Typical	Max	Note
Output power range (Option 512 or 520 with mechanical step attenuator, option 1E1)				
0.1 to 10 MHz	-120 dBm		+23 dBm	
> 0.01 to 5 GHz	-120 dBm		+24 dBm	
> 5 to 12.75 GHz	-120 dBm		+18 dBm	
> 12.75 to 18 GHz	-120 dBm		+16 dBm	
> 18 to 20 GHz	-120 dBm		+15 dBm	
Output power range (Option 526)				
0.1 to 10 MHz	-25 dBm		+24 dBm	
> 0.01 to 5 GHz	-25 dBm		+25 dBm	
> 5 to 20 GHz	-25 dBm		+21 dBm	
> 20 to 26 GHz	-25 dBm		+18 dBm	
Output power range (Option 526 with mechanical step attenuator, Option 1E1)				
0.1 to 10 MHz	-120 dBm		+23 dBm	
> 0.01 to 5 GHz	-120 dBm		+24 dBm	
> 5 to 12.75 GHz	-120 dBm		+19 dBm	
> 12.75 to 20 GHz	-120 dBm		+17 dBm	
> 20 to 26 GHz	-120 dBm		+15 dBm	
Output power range (Option 540)				
0.1 to 10 MHz	-25 dBm		+24 dBm	
> 0.01 to 5 GHz	-25 dBm		+25 dBm	
> 5 to 26 GHz	-25 dBm		+21 dBm	
> 26 to 40 GHz	-25 dBm		+18 dBm	See plot
Output power range (with elec step attenuator, Option 1E2)				
0.1 to 10 MHz	-55 dBm		+22 dBm	
> 0.01 to 5 GHz	-55 dBm		+23 dBm	
> 5 to 12.75 GHz	-55 dBm		+21 dBm	
> 12.75 to 17 GHz	-55 dBm		+20 dBm	
> 17 to 30 GHz	-55 dBm		+17 dBm	
> 30 to 40 GHz	-55 dBm		+13 dBm	See plot
Output power range (Option 540 with mechanical step attenuator, Option 1E1)				
0.1 to 10 MHz	-120 dBm		+23 dBm	
> 0.01 to 5 GHz	-120 dBm		+24 dBm	
> 5 to 20 GHz	-120 dBm		+19 dBm	
> 20 to 30 GHz	-120 dBm		+15 dBm	
> 30 to 40 GHz	-120 dBm		+12 dBm	

Level performance (continued)

Parameter	Min	Typical	Max	Note
Output power range (all AP5011A with Option 1EH)				
0.1 to 10 MHz	-25 dBm		+15 dBm	
> 0.01 to 18 GHz	-25 dBm		+13 dBm	
> 18 to 38 GHz	-25 dBm		+10 dBm	
> 38 to 40 GHz	-25 dBm		+9 dBm	
Output power range (all AP5011A with Option 1EH, 1E1)				
0.1 to 10 MHz	-120 dBm		+15 dBm	
> 0.01 to 18 GHz	-120 dBm		+13 dBm	
> 18 to 33 GHz	-120 dBm		+10 dBm	
> 33 to 40 GHz	-120 dBm		+6 dBm	See plot
Power resolution		0.01 dB		

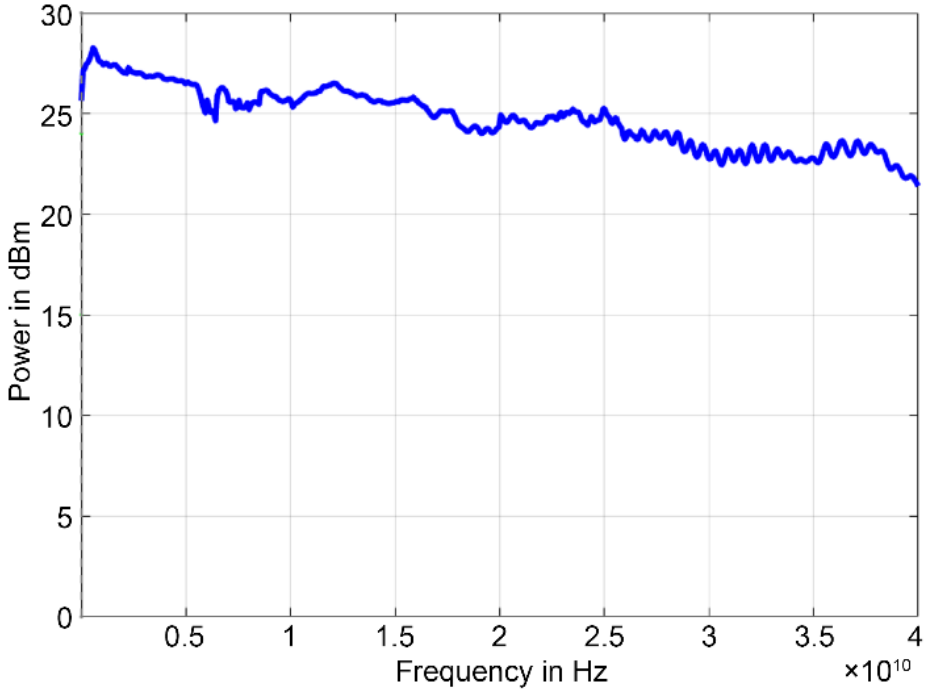


Figure 5. Maximum output power 0.01 to 40 GHz

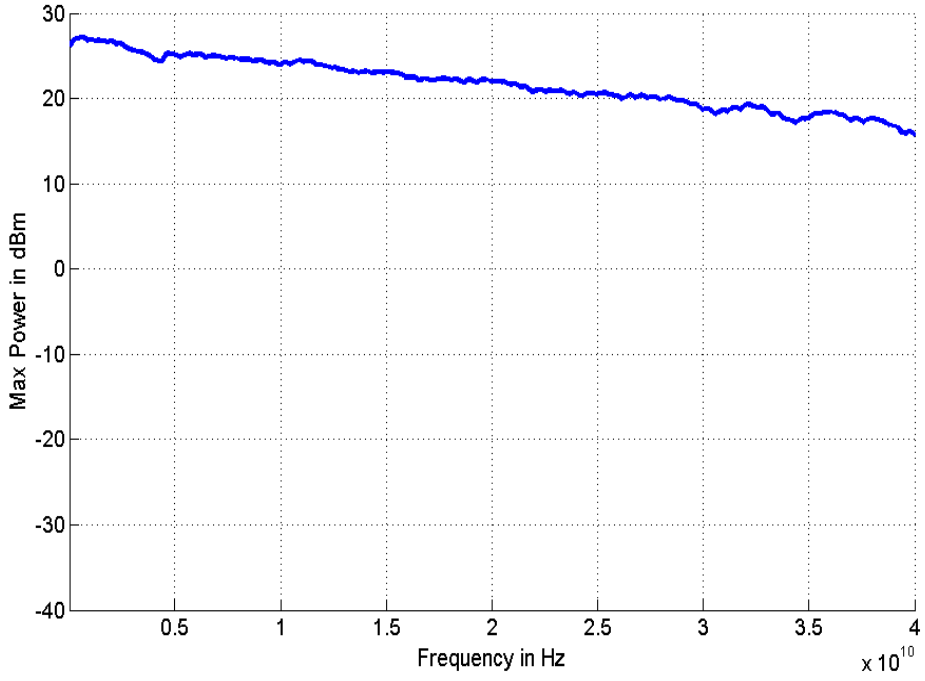


Figure 6. Max output power 0.01 to 40 GHz (Option 540 with Option 1E2)

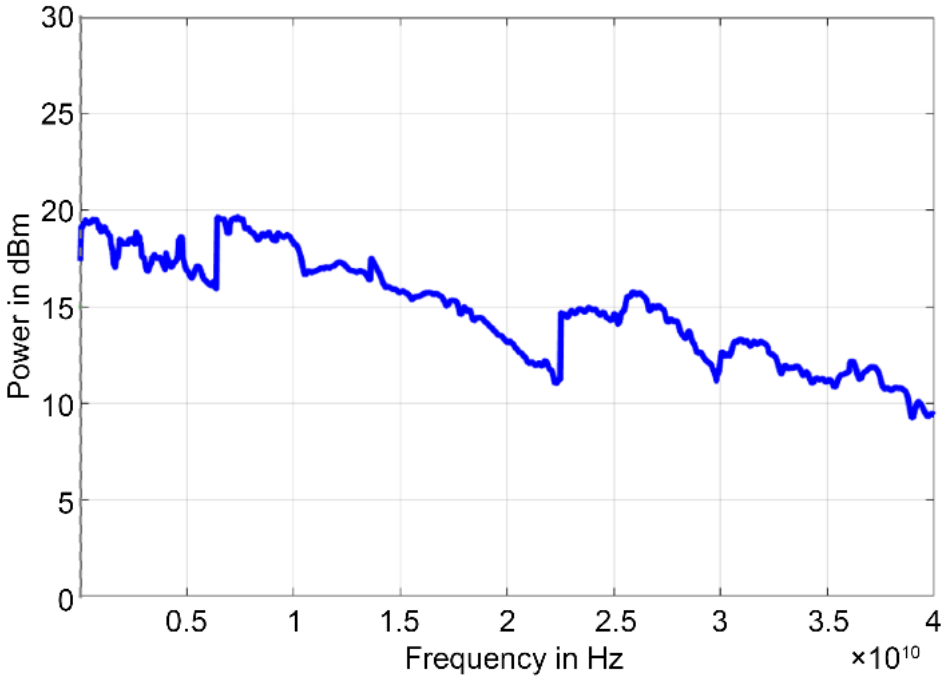


Figure 7. Max output power 0.01 to 40 GHz (with Option 1EH and 1E1)

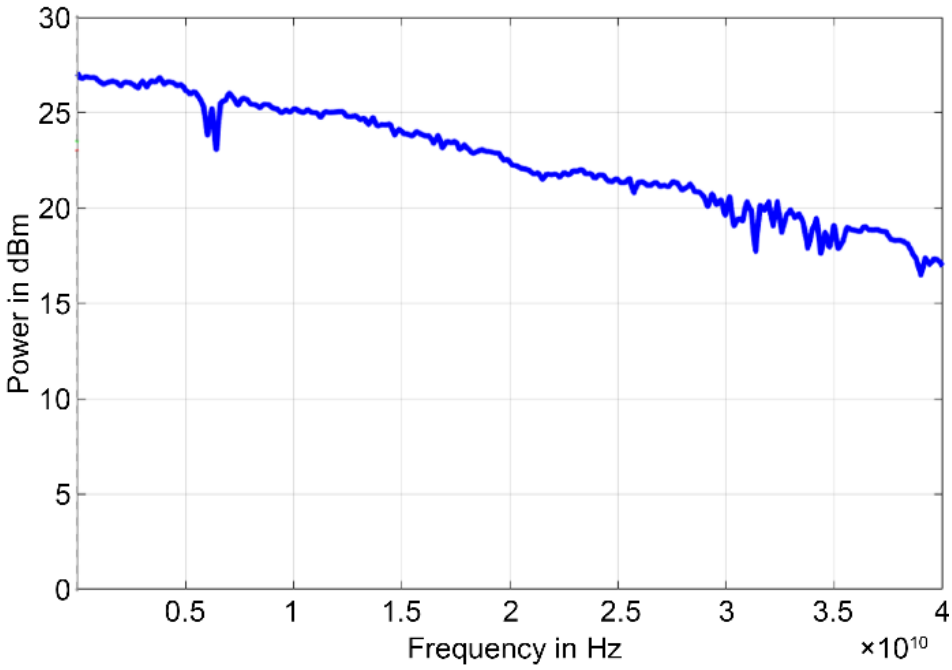


Figure 8. Max output power 0.01 to 40 GHz (with Option 1E1)

Reverse power protection and output impedance

Parameter	Min	Typical	Max	Note
Reverse power protection				
DC voltage			±10 V	
RF power			30 dBm	
Output impedance		50 Ohms		
VSWR		< 2.0 (meas.)		

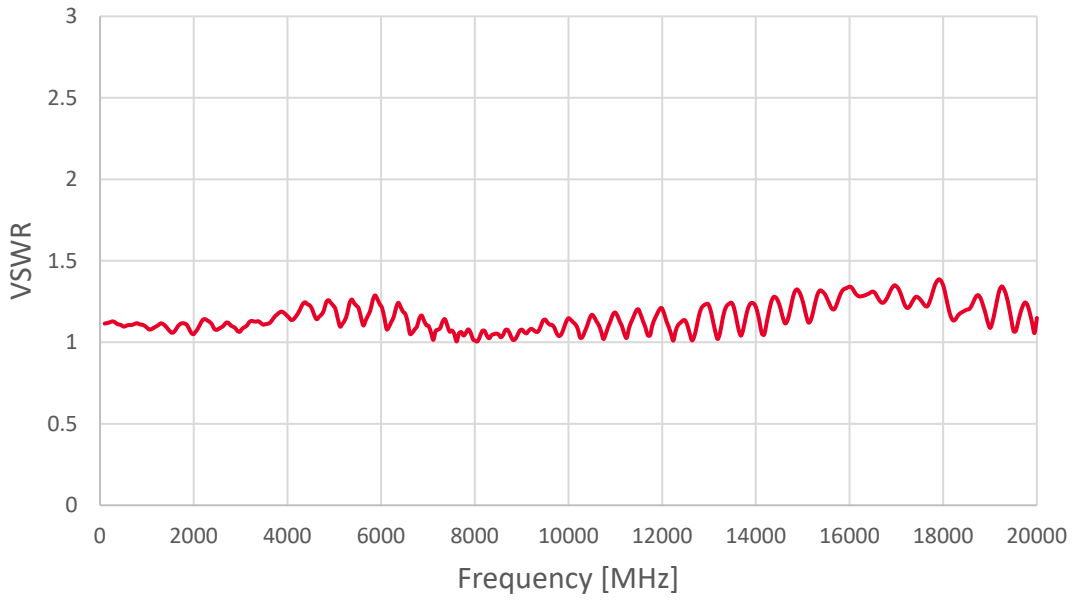


Figure 9. VSWR (Option 520)

Power level uncertainty

Plain text indicates warranted maximum. ( ): Typical value.

Parameter	-15 to +15 dBm	-70 to < -15 dBm, Option 1E1	-110 to < -70 dBm, Option 1E1
< 6 GHz	± 0.8 dB (± 0.25 dB)	± 1.1 dB	(± 2.0 dB)
6 to < 12.75 GHz	± 0.9 dB (± 0.3 dB)	± 1.2 dB	(± 2.0 dB)
12.75 to < 26 GHz	± 1.0 dB (± 0.3 dB)	± 1.4 dB	(± 2.0 dB)
26 to 40 GHz	± 1.2 dB (± 0.4 dB)	± 1.5 dB	(± 2.1 dB)

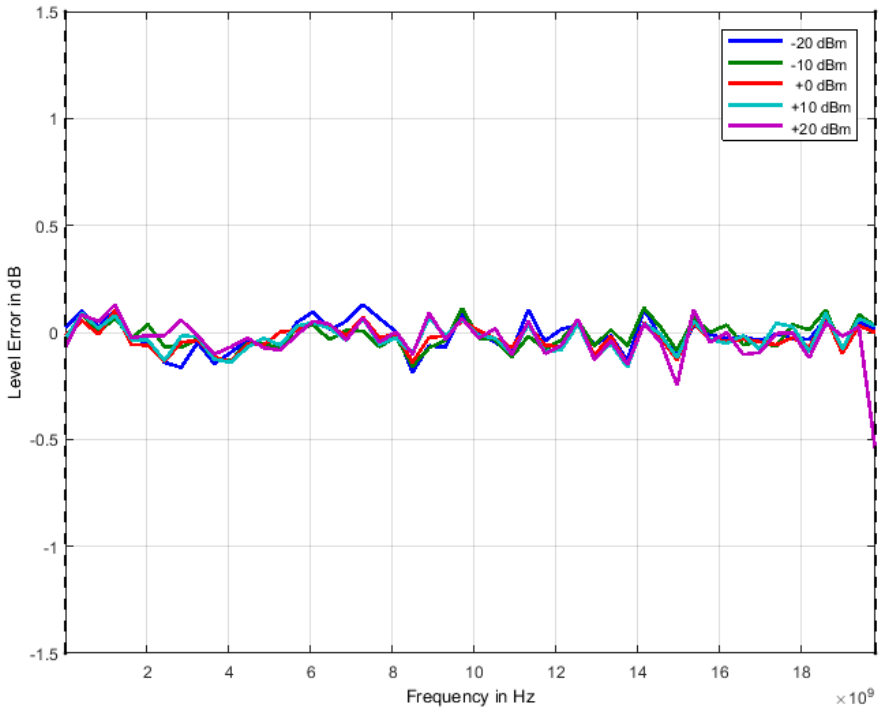


Figure 10. Typical frequency response 0 to 20 GHz at different power levels (Option 520)

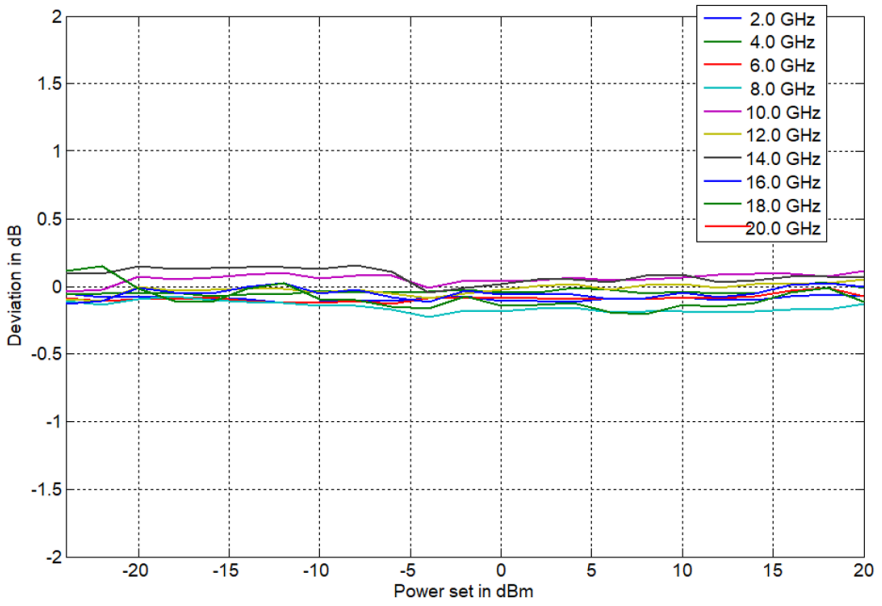


Figure 11. Typical output power linearity (Option 520)

Modulation capabilities

Pulse modulation (Option PMR, PME)

Parameter	Min	Typical	Max	Note
Pulse modulation				
Modulation source		Internal/ external		
Pulse rise/fall time		5 ns		
On/off ratio (high ON/OFF mode)		80 dB 75 dB		Pout > +10 dBm, f<18 GHz ≥ 18 GHz
Pulse overshoot			10%	Excluding video feedthrough
Pulse delay		20 ns		
Pulse polarity		Normal, inverse		selectable
External input threshold	0.85 V	0.9 V	0.95 V	TTL compatible
External input voltage range	-0.5 V		+5.5 V	TTL compatible
External input hysteresis		60 mV		
Internal pulse generator				
Repetition frequency (PRF)	0.1 Hz		50 MHz	= 1/T
Duty cycle	1% to 99% in 1% steps			within specified minimum pulse width
Pulse width setting range (ALC hold)	100 ns 15 ns		20 s	Option PME Option PMR
Pulse pattern modulation and staggered PRF				Using internal pattern generator
Programmable pattern length	2		4096	
Duty cycle	0.05%		99.95%	
Pulse width resolution		5 ns		
Pulse period (T) accuracy		0.00005 x T+ 3ns		
Pulse width accuracy		0.00005 x T+ 5ns		
Pulse jitter		1 ns		
Polarity		selectable		

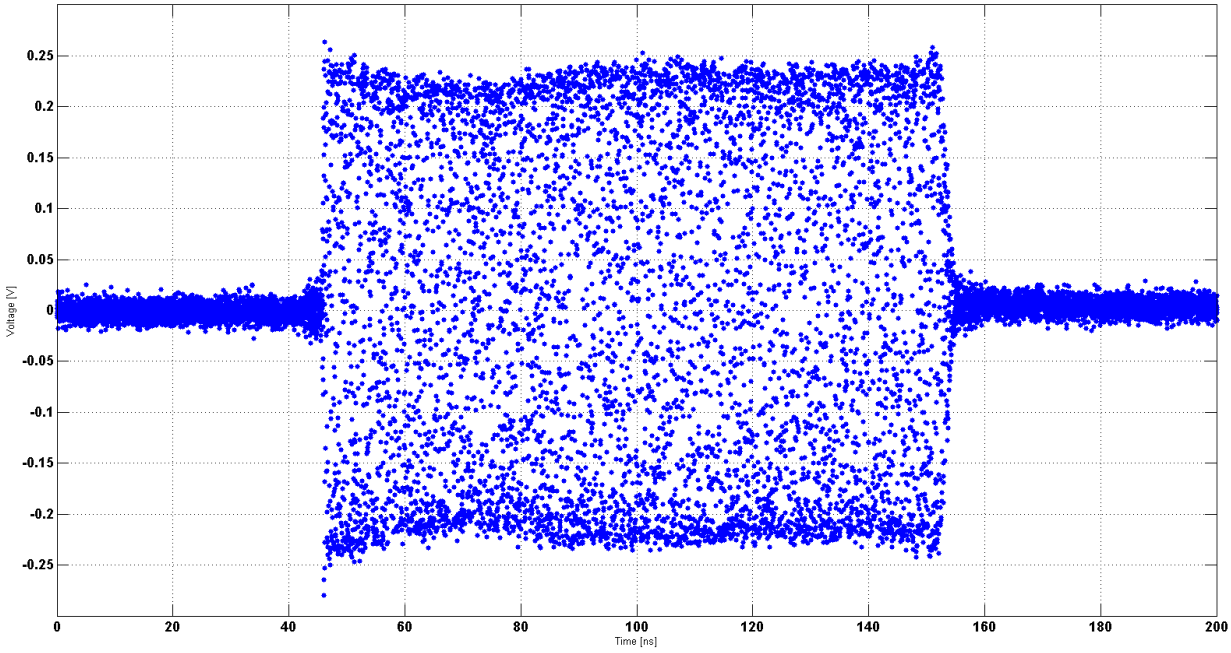


Figure 12. Option 540 100 ns pulse modulation - 40 GHz carrier frequency

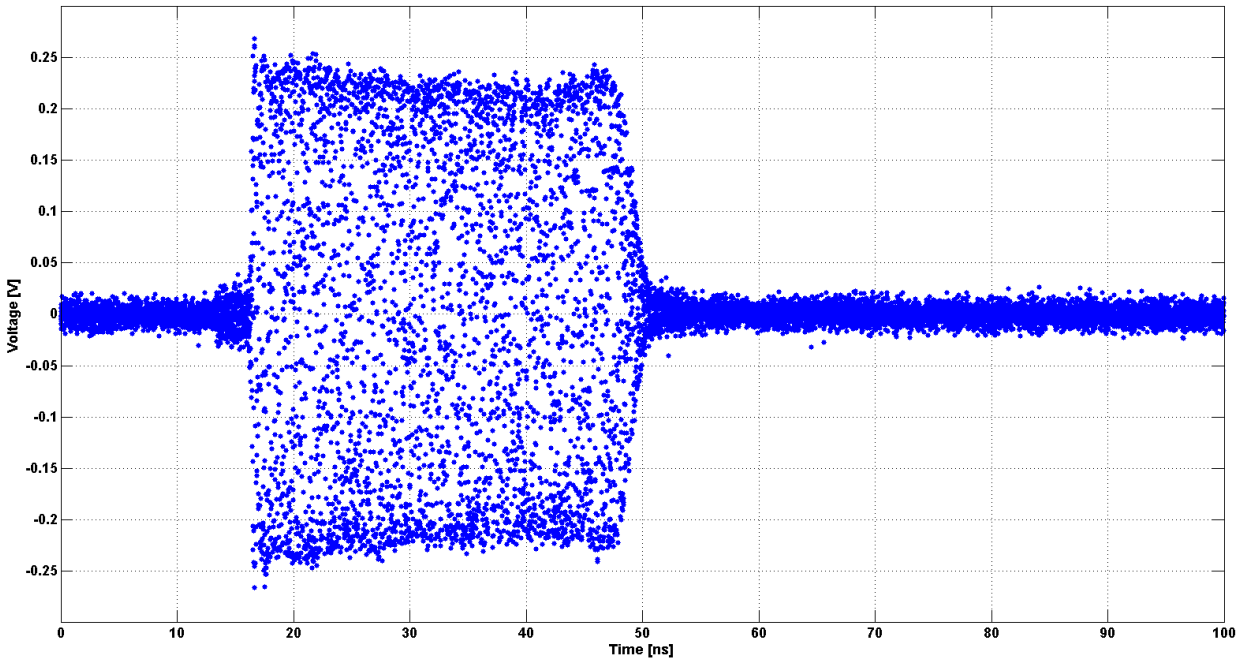


Figure 13. Option 540 with Option PMR or PME pulse modulation 30 ns - 40 GHz carrier frequency

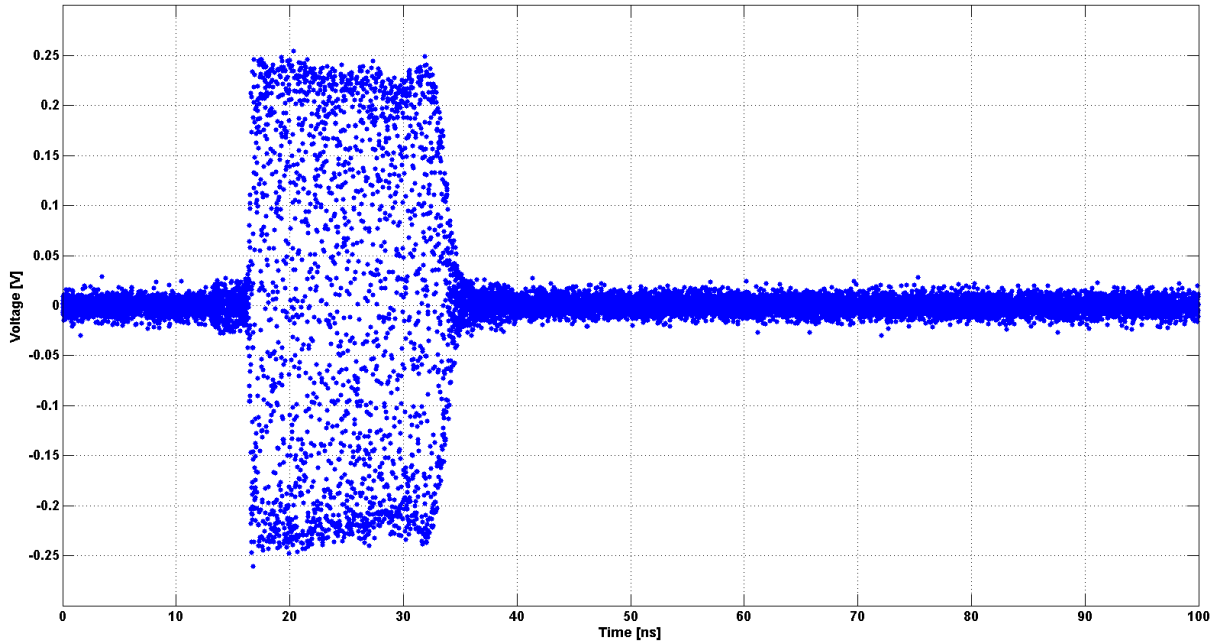


Figure 14. Option 540 with Option PMR pulse modulation 20 ns - 40 GHz carrier frequency

Chirped pulse modulation (Options WC1)

Parameter	Min	Typical	Max	Note
Modulation source		Internal		
Chirp span	1 Hz		3%	of RF
Chirp rate	1 Hz		100 kHz	
Pulse width	10 µs 10 µs 500 µs 10 µs 500 µs		1 sec	Option PMR Option PME, f<31.8 GHz, BW<2.2 GHz Option PME, f<31.8 GHz, BW>2.2 GHz Option PME, f>31.8 GHz, BW<0.55 GHz Option PME, f>31.8 GHz, BW>0.55 GHz
Chirp slope			0.5% / µs	of RF
Chirp mode		Linear, exponential, up, down, bidirectional		

Amplitude modulation (Option UNT)

Parameter	Min	Typical	Max	Note
Modulation source		Internal		
Modulation depth	0%		80%	Settable to 95%
Deviation accuracy		2%		1 kHz rate, 30% depth
Deviation resolution		1%		
Distortion (THD)		1%		1 kHz rate, 30% depth
Modulation rate	0.1 Hz		30 kHz	
Modulation waveforms	Sine			

Frequency modulation (Option UNT)

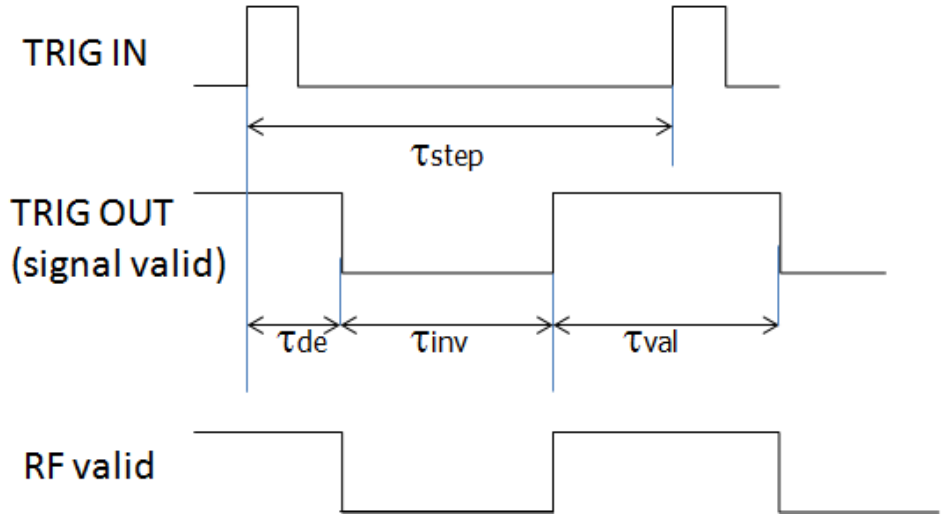
Parameter	Min	Typical	Max	Note
Modulation source		Internal/External		
Maximum frequency deviation (peak)	N · 200 MHz			<1.25 GHz (N=1) 1.25 GHz to 2.5 GHz (N=0.125) 2.5 GHz to 5 GH (N=0.25) 5 GHz to 10 GHz (N=0.5) 10 GHz to 20 GHz (N=1) 20 GHz to 40 GHz (N=2)
Deviation accuracy		0.50%	2%	
Distortion (THD)		< 1 %		1 kHz rate, 10 kHz deviation
Modulation rate	0.1 Hz		80 kHz	
Modulation waveforms	Sine			
External input voltage range	0 V		+10 V	Input voltage must be positive
External input termination		600 Ohms		Internal termination
External input coupling		AC		Cutoff 1 Hz typical (-3 dB) DC coupling on request

Phase modulation (Option UNT)

Parameter	Min	Typical	Max	Note
Modulation source		Internal/external		
Phase deviation (peak)	0		300 · N· rad	
Deviation accuracy		0.50%	2%	
Modulation rate	0.1 Hz		80 kHz	
Modulation waveforms	Sine			
Distortion (THD)		< 1%		1 kHz rate and N x rad deviation
External input voltage range	0 V		+10 V	Input voltage must be positive
External input termination		600 Ohms		Internal termination
External input coupling		AC		Cutoff 1 Hz typical (-3 dB)

Sweeping capability

Parameter	Min	Typical	Max	Note
Sweep parameters	Frequency, power, phase, list			
Sweep types	Linear, logarithmic, random			
Frequency Step time (t_{step}) f< 31.8 GHz, fstep<2.2 GHz f< 31.8 GHz, fstep>2.2 GHz f> 31.8 GHz, fstep<0.55 GHz f> 31.8 GHz, fstep>0.55 GHz	500 µs 30 µs 30 µs 100 µs 30 µs 500 µs		19998 s	Step time = transition time + dwell time Option UNZ Option UNQ Option UNQ Option UNQ Option UNQ
Settling time (t_{inv})			15 µs	To stabilize phase and amplitude, depends on frequency step
Time resolution		5 ns		
Timing accuracy per point		5 ns		



Frequency reference

Parameter	Min	Typical	Max	Note
Internal reference frequency		100 MHz 10 MHz		Option LN1 Option LN2
Temperature stability 0 to 50 °C			±100 ppb ±20 ppb	Option LN1 Option LN2
Aging first year			1 ppm 0.02 ppm	Option LN1 Option LN2
Aging per day			5 ppb 0.5 ppb	after 30 days operations Option LN1 Option LN2
Warm-up time		5 min		
Output of internal reference		100 MHz 10/100 MHz		Option LN1 Option LN2
Output power		0 dBm		
Output impedance		50 Ohms		
Bypass internal reference input		100 MHz		High phase synchronous mode *Option LN2 is bypassed
Phase lock to external reference Bypass mode	5	10 MHz integer MHz 100 MHz	250	Option 1ER *Option LN2 is bypassed
Reference input level				
10 MHz or 1-250 MHz	-5 dBm	0 dBm	+10 dBm	
100 MHz	5 dBm		+15 dBm	
Lock range				
10 MHz or 1-250 MHz			±1.5 ppm	
100 MHz			> 100 ppm	
Reference input impedance		50 Ohms		

Trigger

Parameter	Min	Typical	Max	Note
Trigger types	Continuous, single (point), gated, gated direction			
Trigger source	external, bus (LAN, USB)			
Trigger modes	Continuous free run, trigger and run, reset and run			
Trigger uncertainty		10 ns		
External trigger delay	50 ns		40 s	settable
External delay resolution		5 ns		
Trigger modulo	1		255	Execute only on Nth trigger event
Trigger polarity	Rising, falling			
External trigger input threshold	0.85 V	0.9 V	0.95 V	TTL compatible
External trigger input voltage range	-0.5 V		+5.5 V	TTL compatible
External trigger input hysteresis		60 mV		

Multi-purpose output (FUNC OUT): Output is TRIG OUT at rear panel

Parameter	Min	Typical	Max	Note
MULTIFUNCTION GENERATOR	sine, triangle, square wave			
Frequency range	10 Hz 10 Hz 10 Hz		3 MHz 1 MHz 50 kHz	sine triangle square
Frequency resolution		0.1 Hz		
Output voltage amplitude peak-peak	10 mV	 5V	2 V	Sine, triangle Square (CMOS output)
Harmonic distortion		1%		< 100 kHz, 1 Vpp
Output impedance		50 Ohms CMOS		Sine, triangle square wave
VIDEO OUTPUT (of internal pulse modulator)				
Output		CMOS		
Period	30 ns		50 s	
Pulse width	15 ns		50 s	
RF delay		10 ns		
TRIGGER OUT Synchronization mode for multiple sources				
Modes	Trigger on sweep start Trigger on each point Signal Valid			

GUI

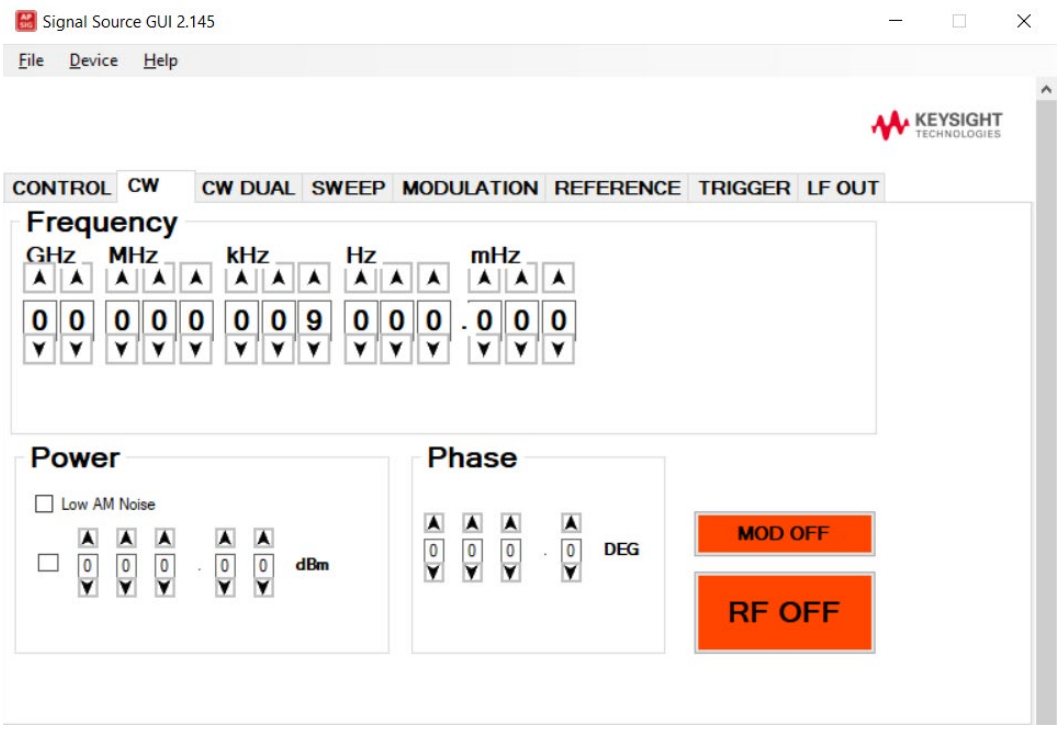


Figure 15. Desktop app GUI

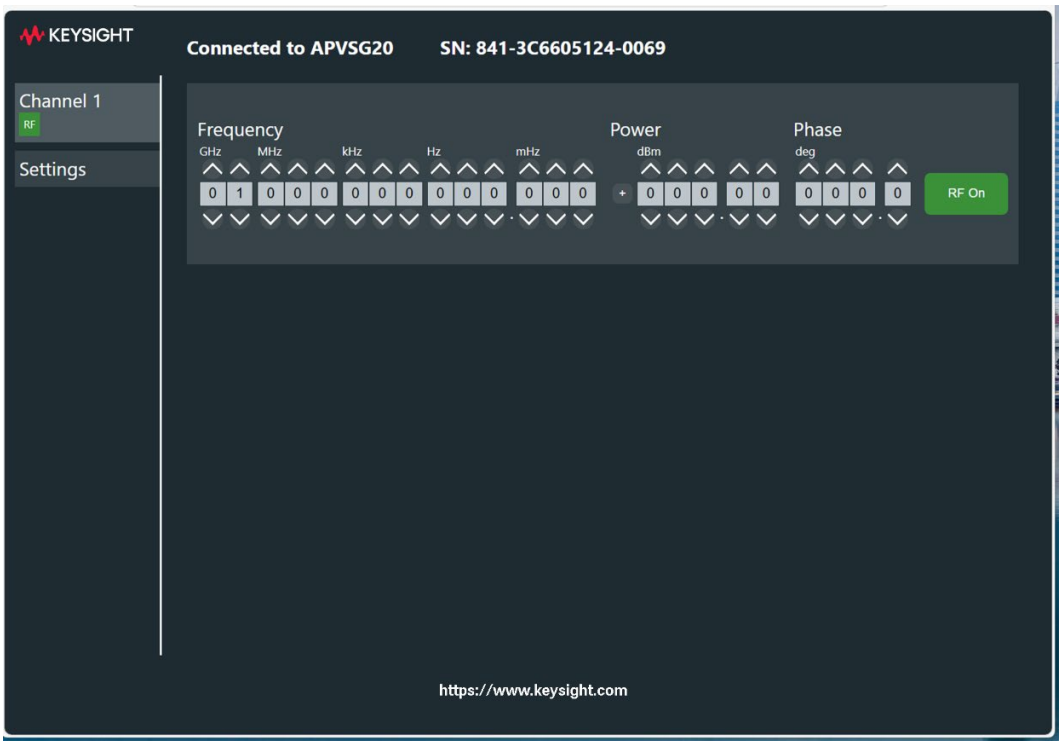


Figure 17. Web browser GUI

Connectors, Keys

Front panel

1. Color touch display
2. RF output:

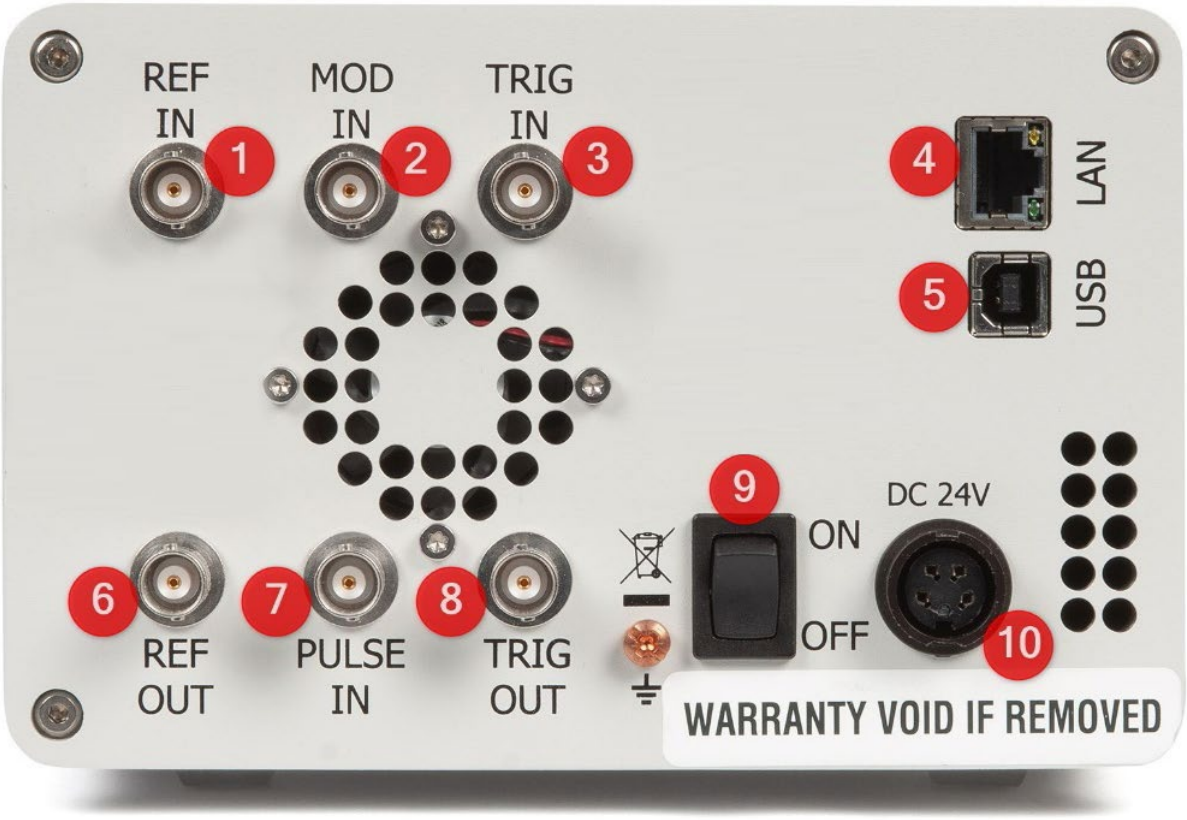
a. Option 540: K (2.92 mm) female

b. Options 512, 520, and 526: SMA female

3. Rotary knob

Rear panel

1. REF IN: External reference input: BNC female
2. MOD IN: Modulation input for FM/PM: BNC female
3. TRIG IN: Trigger input: BNC female
4. LAN connection: RJ-45
5. USB 2.0 host and device
6. REF OUT: Internal reference output: BNC female
7. PULSE IN: Pulse modulation input: BNC female
8. TRIG OUT: Trigger output: BNC female
9. DC power switch
10. DC Power plug (24 V, 3 A)



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: 24V ± 3.0 VDC; 45 W maximum

AC adapter supplied: Input rating 100-240 VAC 50/60 Hz, Output rating 24 V DC and 160 W max

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

Samples of this product have been type-tested to be robust under the environmental conditions of storage, transportation, and end-use with different temperature, humidity, shock, vibration, altitude, and power line conditions.

Operating temperature range: 0 to 40 °C
Storage temperature range: -40 to 70 °C
Operating humidity range: 20 to 90 %RH (non-condensing)
Operating altitude: up to 2000 m)

CE

EMC: complies and EMC regulations and directives for emission and immunity to interference (EN 61326-1 Industrial, EN/IEC 61326-2-1).

Safety: complies with applicable Safety regulation in line with IEC/EN 61010-1

This product complies with directive 2011/65/EU

Weight: 2.5 kg (6 lbs) net, ≤ 4 kg (8 lb.) with ship-ready package

Dimensions: 106 mm H x 172 mm W x 290 mm L / 4.21 in H x 6.77 in W x 11.42 in L, incl. connectors

Recommended calibration cycle: 24 months