

G3 Analog Signal Generator Model AP5021A and AP5022A



Introduction

The G3 Analog Signal Generators are a series of phase-coherent, single- or multi-channel, fast-switching and low phase noise signal generators with a frequency range up to 12.75, 20, 40, and 54 GHz. They are ideally suited for a wide range of applications, where good signal quality, accurate and wide output power ranges, and very stable phase coherence among all channels are required. Good phase noise is combined with good spurious, harmonic rejection and optional high switching speed of 25 μ s.

A high-stability OCXO reference provides excellent frequency accuracy and stability. The device accepts a wide range of external references including the commonly used 10 and 100 MHz and variable in the range of 1-250 MHz for those applications with customer- or system-specific reference frequencies. Moreover, the G3 Analog Signal Generators feature a pair of high-frequency clock (CLK) ports (6 GHz, one input and one output) that enable excellent phase synchronization among the outputs of multiple G3 Analog Signal Generator instruments.

The AP5021A G3 Analog Signal Generator comes in a desktop enclosure (single channel) and the AP5022A G3 Analog Signal Generator comes in a 19-inch 2U (up to 4 channels) rack-mountable module form. It can 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 communication using SCPI 1999 compatible command system from user API or programming examples for many commercially available tools.

Definitions

The specifications in the following pages describe the warranted performance of the instrument for 23 $\pm$ 5 $^{\circ}$ 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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Facts, Figures, and Specifications

Signal specifications

Parameter	Min	Typical	Max	Note
Channels	1 1		1 4	AP5021A AP5022A
Frequency ranges				
Option 512	9 kHz		12.75 GHz	
Option 520	9 kHz		20 GHz	
Option 540	9 kHz		40 GHz	
Option 554	9 kHz		54 GHz	
Resolution		<0.001 Hz		
Phase adjustment range	0 deg		360 deg	Individually adjustable per channel
Phase resolution		0.1 deg		
Switching speed				
CW mode		1.5 ms		After SCPI command received
Sweep / List mode		500 μ s 15 μ s	25 μ s	Option UNZ, above 10 MHz
Thermal drift		0.015 dB/°C		

Frequency reference

Parameter	Min	Typical	Max	Note
Internal reference frequency		100 MHz 10 MHz		Option LN1 Option LN2
Temperature stability 0 to 50 °C			$\pm$ 100 ppb $\pm$ 20 ppb	Option LN1 Option LN2
Aging 1st year			1000 ppb 20 ppb	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		
Internal reference output		10 or 100 MHz		REF OUT, selectable
High frequency clock output		6 GHz		CLK OUT
Output power	-3 dBm +6 dBm		+ 3 dBm +12 dBm	10 MHz, 6 GHz 100 MHz
External reference frequency	1 MHz	10 MHz 100 MHz integer MHz 6 GHz	250 MHz	REF IN, Option LN2 disabled Bypass internal reference Option 1ER, Option LN2 disabled CLK IN, Bypass internal reference
Reference input level	-5 dBm +5 dBm	0 dBm	+10 dBm +13 dBm	100 MHz, bypass internal reference
Lock range			$\pm$ 1.5 ppm $\pm$ 100 ppm	Bypass internal reference
Reference ports impedance		50 Ohm		

Absolute phase noise

Absolute SSB phase noise with LN1 option, dBc/Hz

Specified values in plain text, typical values in parentheses. CW, level = +10 dBm or maximum available output power, whichever is lower.

Offset frequency	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
100 MHz	-100 (-105)	-130 (-135)	-143 (-145)	-150 (-155)	-156 (-160)	-156 (-160)	-156 (-160)
1 GHz	-80 (-85)	-110 (-115)	-132 (-134)	-143 (-145)	-147 (-149)	-148 (-150)	-153 (-155)
3 GHz	-70 (-75)	-100 (-105)	-123 (-125)	-133 (-134)	-136 (-138)	-136 (-138)	-145 (-147)
6 GHz	-64 (-69)	-94 (-99)	-117 (-119)	-126 (-128)	-130 (-132)	-130 (-132)	-139 (-142)
10 GHz	-60 (-65)	-90 (-95)	-114 (-116)	-124 (-126)	-128 (-130)	-128 (-130)	-135 (-138)
40 GHz	-48 (-53)	-78 (-83)	-102 (-104)	-112 (-114)	-116 (-118)	-116 (-118)	-123 (-126)
54 GHz	-46 (-51)	-76 (-81)	-98 (-101)	-108 (-111)	-111 (-114)	-111 (-114)	-116 (-119)

Absolute SSB phase noise with LN2 option, dBc/Hz

Specified values in plain text, typical values in parentheses. CW, level = +10 dBm or maximum available output power, whichever is lower.

Offset frequency	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
100 MHz	-116 (-120)	-130 (-132)	-143 (-145)	-150 (-155)	-156 (-160)	-156 (-160)	-156 (-160)
1 GHz	-96 (-100)	-110 (-112)	-132 (-134)	-143 (-145)	-147 (-149)	-148 (-150)	-153 (-155)
3 GHz	-86 (-90)	-100 (-103)	-123 (-125)	-133 (-134)	-136 (-138)	-136 (-138)	-145 (-147)
6 GHz	-80 (-84)	-94 (-98)	-117 (-119)	-126 (-128)	-130 (-132)	-130 (-132)	-139 (-142)
10 GHz	-76 (-80)	-90 (-94)	-114 (-116)	-124 (-126)	-128 (-130)	-128 (-130)	-135 (-138)
40 GHz	-64 (-68)	-78 (-82)	-102 (-104)	-112 (-114)	-116 (-118)	-116 (-118)	-123 (-126)
54 GHz	-63 (-62)	-76 (-80)	-98 (-101)	-108 (-111)	-111 (-114)	-111 (-114)	-116 (-119)

Jitter specifications

Carrier frequency	Min	Typical	Max	Note
155 MHz		20 fs	25 fs	BW 100 Hz to 1.5 MHz
622 MHz		18 fs	25 fs	BW 1 kHz to 5 MHz
1 GHz		21 fs	27 fs	BW 10 Hz to 10 MHz
2.488 GHz		25 fs	30 fs	BW 5 kHz to 20 MHz
9.952 GHz		20 fs	30 fs	BW 10 kHz to 80 MHz

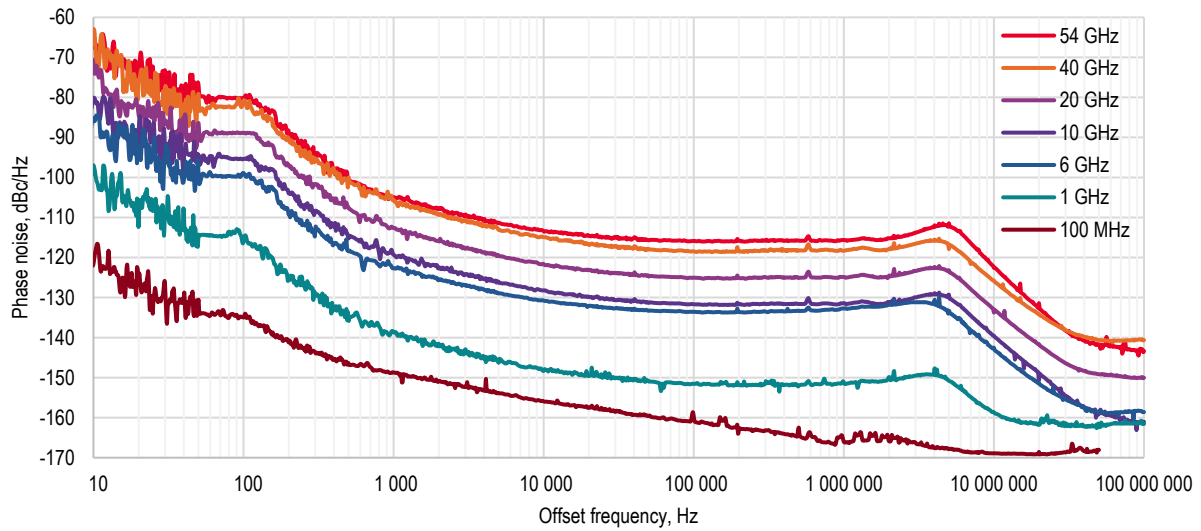


Figure 1. Phase noise at different frequencies, power +10 dBm, Option LN2

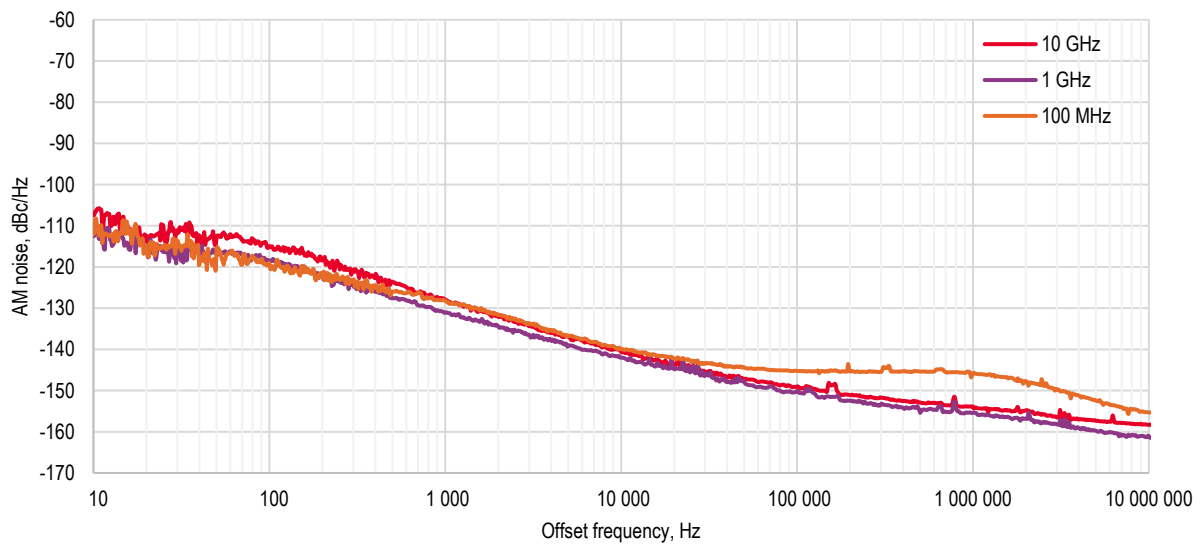


Figure 2. Amplitude noise at +10 dBm power

Spectral purity

Parameter	Min	Typical	Max	Note
Harmonics				at +10 dBm output power
9 kHz to 175 MHz		-30 dBc		
175 MHz to 2.5 GHz		-55 dBc	-45 dBc	
2.5 GHz to 22 GHz		-60 dBc	-50 dBc	
22 GHz to 30 GHz		-25 dBc	-20 dBc	
30 GHz to 54 GHz		-55 dBc		
Sub-harmonics				at +10 dBm output power
< 2.5 GHz		-80 dBc		
2.5 GHz to 11.3 GHz		-70 dBc	-60 dBc	
11.3 GHz to 50 GHz		-70 dBc	-55 dBc	
50 GHz to 54 GHz		-30 dBc	-20 dBc	
Non-harmonic spurious				10 kHz to 0.5 GHz offset from carrier
< 0.5 GHz			-75 dBc	
0.5 GHz to 2.5 GHz		-90 dBc	-86 dBc	
2.5 GHz to 5.6 GHz		-85 dBc	-80 dBc	
5.6 GHz to 11.3 GHz		-80 dBc	-74 dBc	
11.3 GHz to 22 GHz		-75 dBc	-68 dBc	
22 GHz to 44 GHz		-70 dBc	-62 dBc	
44 GHz to 54 GHz		-65 dBc	-56 dBc	

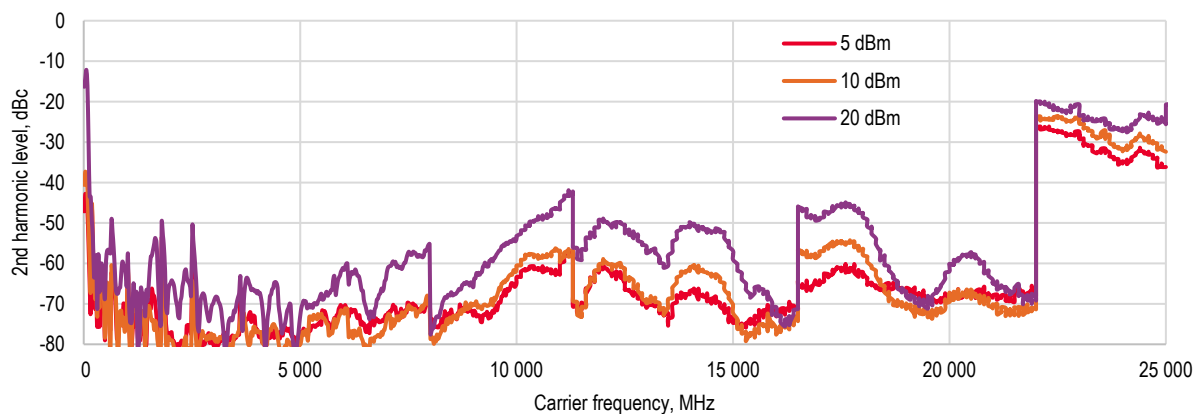


Figure 3. 2nd Harmonic

Channel to channel performance

Parameter	Min	Typical	Max	Note
Relative Phase Stability				See plot
Between channels			2 deg p-p	Measured 0.36 deg RMS over 10 hours
Between synchronized devices			2 deg p-p	Measured 0.36 deg RMS over 10 hours
Phase-coherent switching				
Phase mismatch		5 deg		
Channel-to-channel isolation	80 dB	90 dB		9 kHz to 50 GHz, 10 dBm, outputs are terminated with 50 Ohm

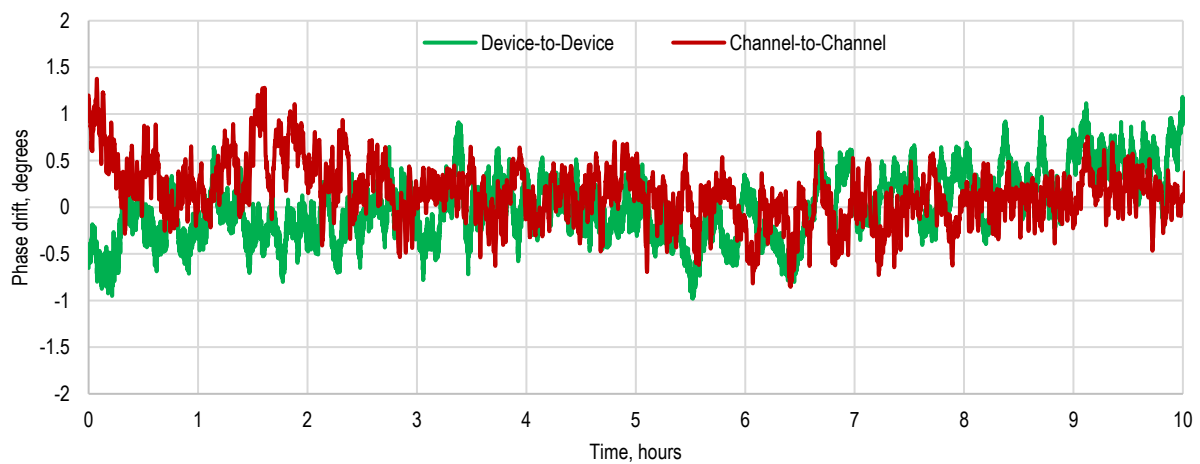


Figure 4. Relative phase drift. Measured at 54 GHz, 0 dBm output in temperature-controlled environment over 10 hours

Level performance

Parameter	Min	Typical	Max	Note
Output power level				Options 512, 520, 540, 554
9 kHz to 1 MHz	-20 dBm		+7 dBm	
1 MHz to 10 MHz	-20 dBm		+12 dBm	
10 MHz to 2.5 GHz	-20 dBm		+17 dBm	
2.5 GHz to 22 GHz	-20 dBm		+18 dBm	
22 GHz to 42 GHz	-20 dBm		+20 dBm	
42 GHz to 50 GHz	-20 dBm		+15 dBm	
50 GHz to 54 GHz	-20 dBm		+10 dBm	
Output power level				Options 512, 520, 540 and 1E1
9 kHz to 1 MHz	-120 dBm		+7 dBm	
1 MHz to 10 MHz	-120 dBm		+12 dBm	
10 MHz to 2.5 GHz	-120 dBm		+16 dBm	
2.5 GHz to 40 GHz	-120 dBm		+16 dBm	
Output power level				Options 554 and 2E1
9 kHz to 1 MHz	-110 dBm		+7 dBm	
1 MHz to 10 MHz	-110 dBm		+12 dBm	
10 MHz to 2.5 GHz	-110 dBm		+16 dBm	
2.5 GHz to 42 GHz	-110 dBm		+15 dBm	
42 GHz to 50 GHz	-110 dBm		+11 dBm	
50 GHz to 54 GHz	-110 dBm		+6 dBm	
Power resolution		0.01 dB		
Reverse power protection				
DC voltage			0 V	
RF power			26 dBm	
Output impedance		50 Ohms		
VSWR w/o xE1 or 0 dB xE1 ATT		1.3 1.3 1.4	1.7 1.8 1.7	< 15 GHz 15 to 48 GHz > 48 GHz
VSWR >0 dB xE1 ATT		1.1 1.5 1.6	1.3 1.7 1.8	< 15 GHz 15 to 48 GHz > 48 GHz

Power level error

Absolute power level error. Specified values in plain text, typical values in brackets

Frequency range	-120 or -110 to -50 dBm Option 1E1 or 2E1	-50 to -15 dBm Option 1E1 or 2E1	-15 to +15 dBm	+15 dBm to max power
9 kHz to 20 GHz	(2.0 dB)	(1.2 dB)	0.8 dB (0.3 dB)	1.2 dB
20 to 40 GHz	(2.3 dB)	(1.8 dB)	0.2 dB (0.4 dB)	2.3 dB
40 to 54 GHz	(2.5 dB)	(2.0 dB)	1.3 dB (0.5 dB)	2.5 dB

Power level error (continued)

Relative power level error. Step of 0.1 dB. Specified values in plain text, typical values in brackets

Frequency range	-120 or -110 to -50 dBm Option 1E1 or 2E1	-50 to -15 dBm Option 1E1 or 2E1	-15 to +15 dBm	+15 dBm to max power
9 kHz to 20 GHz	0.5 (< 0.1 dB)	0.5 dB (< 0.1 dB)	0.5 dB (< 0.1 dB)	(< 0.1 dB)
20 GHz to 40 GHz	(< 0.1 dB)	(< 0.1 dB)	(< 0.1 dB)	(< 0.1 dB)
40 GHz to 54 GHz	(< 0.1 dB)	(< 0.1 dB)	(< 0.1 dB)	(< 0.1 dB)

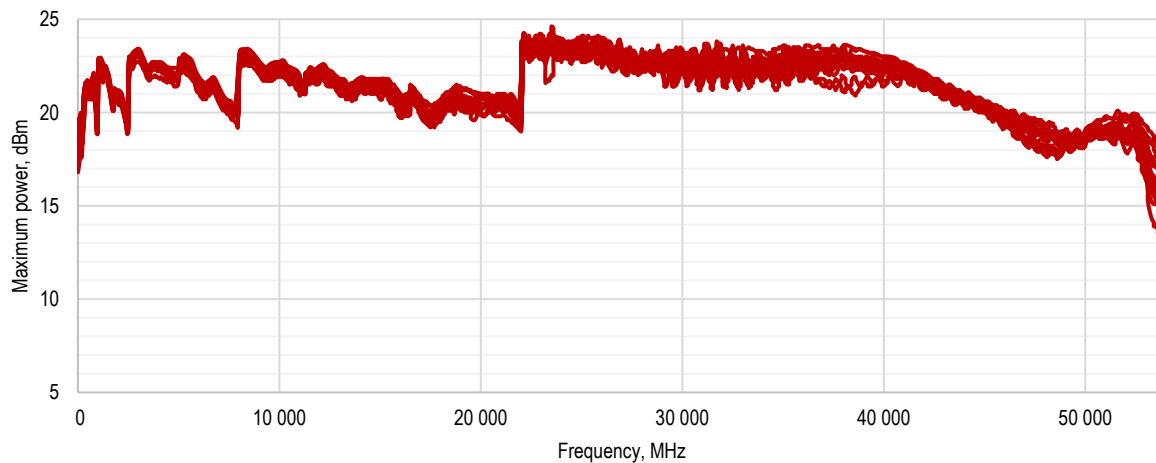


Figure 5. Maxpower 10 MHz to 54 GHz (over 20 devices)

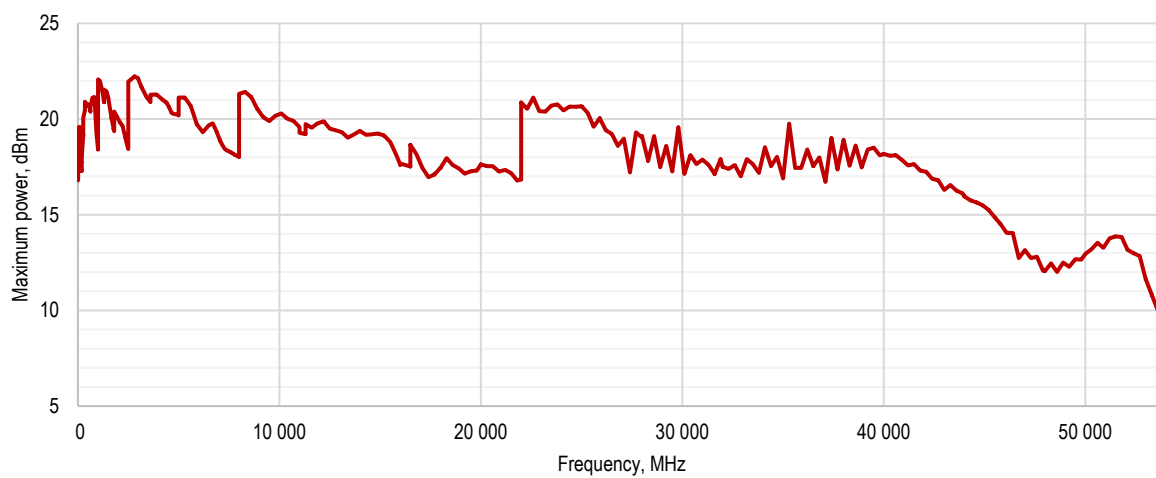


Figure 6. Maxpower 10 MHz to 54 GHz (option 2E1)

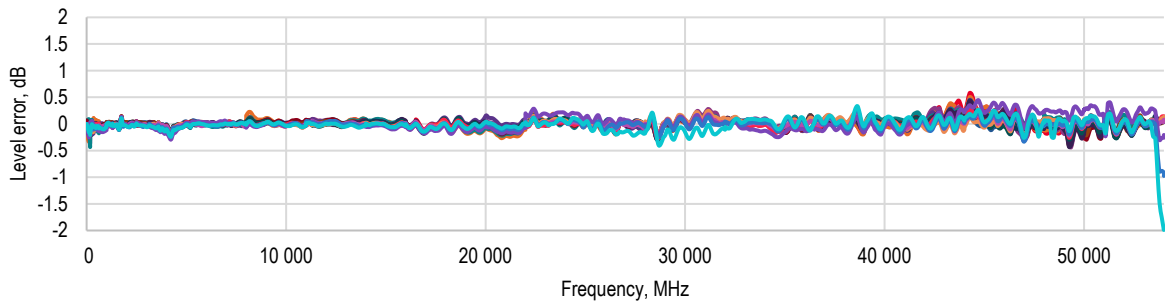


Figure 7. Absolute power level error between -15 and +15 dBm over frequency (option 554)

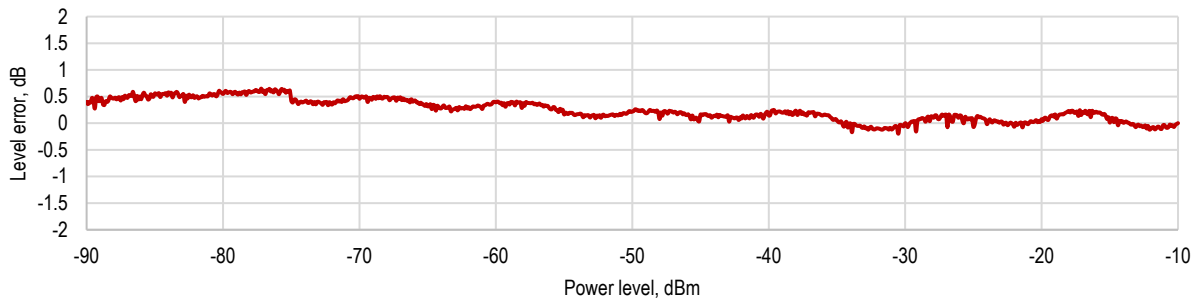


Figure 8. Absolute power level error between -90 and -10 dBm at 20 GHz (options 520 and 1E1)

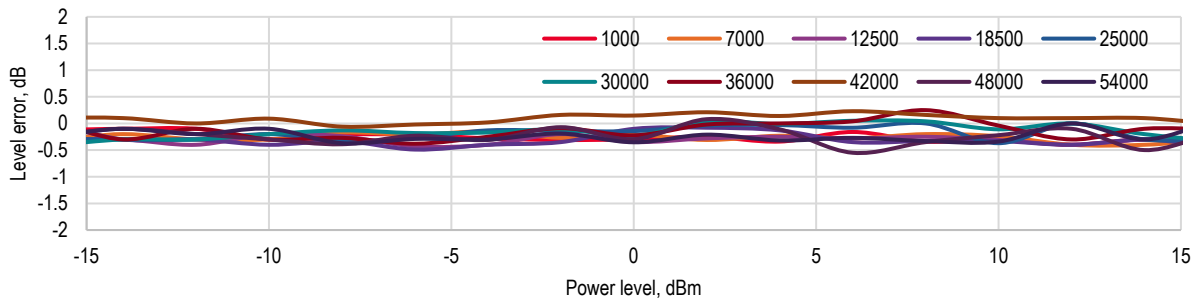


Figure 9. Absolute power level error at different frequencies (option 554)

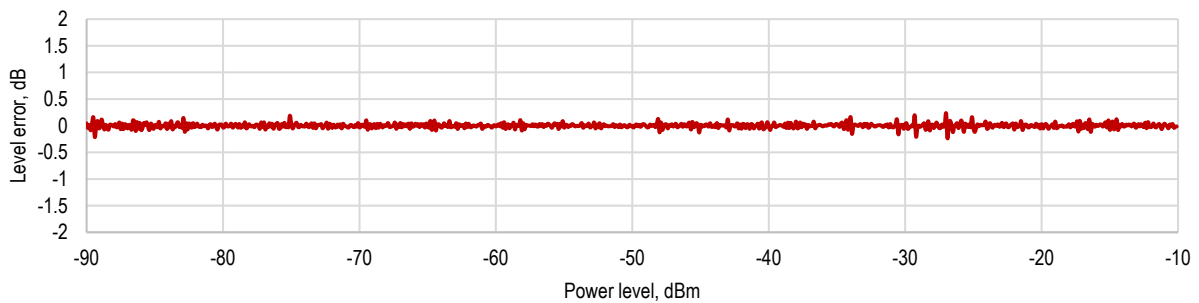


Figure 10. Relative power level error at 20 GHz (options 520 and 1E1)

Modulation capabilities

Parameter	Min	Typical	Max	Note
Pulse modulation				Option PMR
Modulation source		Internal/External		
External input amplitude	TTL			
Pulse rise/fall time		5 ns	10 ns	
On/off ratio (power $\geq +10$ dBm)	80 dB	100 dB		
Pulse overshoot			10%	
Pulse delay		20 ns		
Pulse polarity		Normal, inverse		selectable
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 pattern modulation and staggered PRF				using internal pattern generator
Pulse width	10 ns		20 s	
Programmable pattern length	2		65536	
Duty cycle	0.05%		99.95%	
Pulse width resolution		5 ns		
Pulse period (T) accuracy		$0.00005 \times T + 3$ ns		
Pulse width accuracy		$0.00005 \times T + 5$ ns		
Pulse jitter		2 ns	5 ns	
Polarity		selectable		

Modulation capabilities (continued)

Parameter	Min	Typical	Max	Note
Amplitude modulation				Option UNT
Modulation source		Internal		
Modulation depth	0%		100%	
Depth accuracy			$0.05 \cdot \text{DEPT} + 2\%$	1 kHz rate, 30% depth >10 MHz and -10 to +10 dBm or <-20 dBm with options xE1
Depth resolution		1%		
Distortion (THD)			3%	1 kHz rate, 30% depth
Modulation rate	0.1 Hz		30 kHz	
Modulation waveforms	Sine			
Frequency modulation				Option UNT
Modulation source		Internal		
Frequency deviation (peak)	0		$N \cdot 20 \text{ MHz}$	Or 10% of carrier whichever is lower. For N values see below ¹
Deviation accuracy			$0.01 \cdot \text{DEV} + 2\text{Hz}$	
Distortion (THD)			3%	1 kHz rate, 10 kHz deviation
Modulation rate	0.1 Hz		30 kHz	
Modulation waveforms	Sine			
Phase modulation				Option UNT
Modulation source		Internal		
Phase deviation (peak)	0		$1000 \cdot N \text{ rad}$	For N values see below
Deviation accuracy			$0.01 \cdot \text{DEV} + 10^{-3}$	
Modulation rate	0.1 Hz		30 kHz	
Distortion (THD)			3%	1 kHz rate, $10 \cdot N$ rad deviation

¹ N=1 for frequencies 9 kHz to <175MHz
 N=1/64 for frequencies 175 to <177 MHz
 N=1/32 for frequencies 177 to <353 MHz
 N=1/16 for frequencies 353 to <706 MHz
 N=1/8 for frequencies 0.706 to <1.4125 GHz
 N=1/4 for frequencies 1.4125 to <2.825 GHz
 N=1/2 for frequencies 2.825 to <5.65 GHz
 N=1 for frequencies 5.65 to <11.3 GHz
 N=2 for frequencies 11.3 to <22 GHz
 N=4 for frequencies 22 to <44 GHz
 N=6 for frequencies 44 to 54 GHz

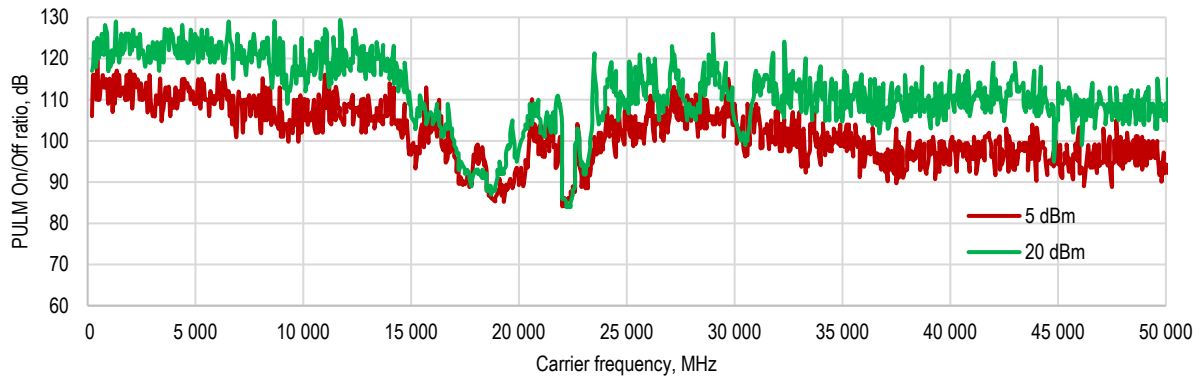


Figure 11. Pulse on/off ratio

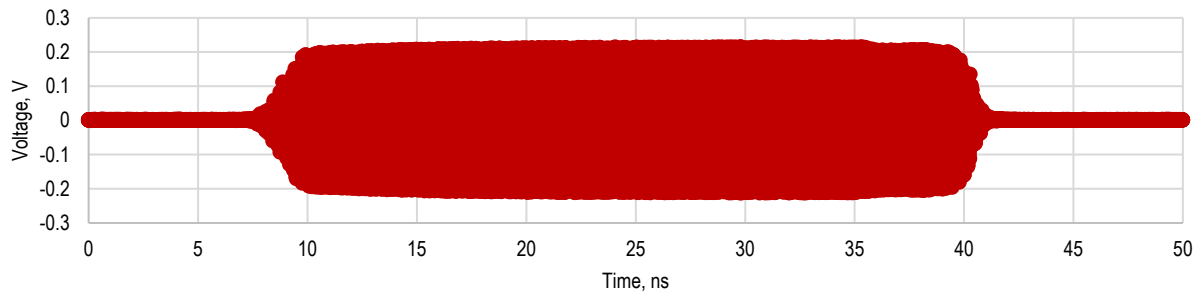


Figure 12. 10 GHz pulse-modulated

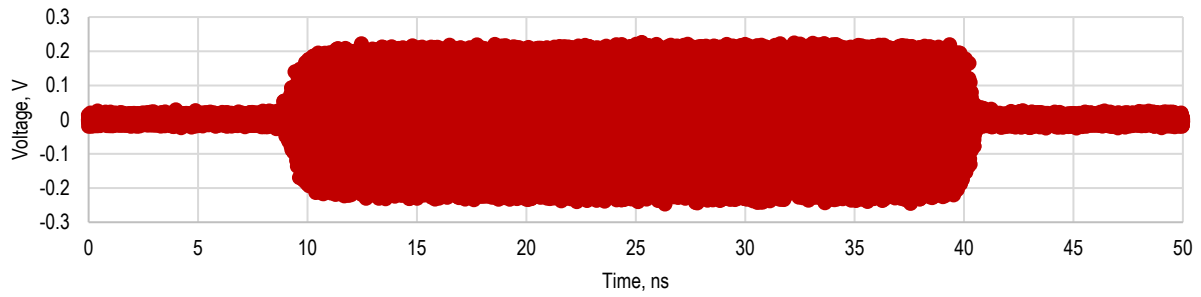
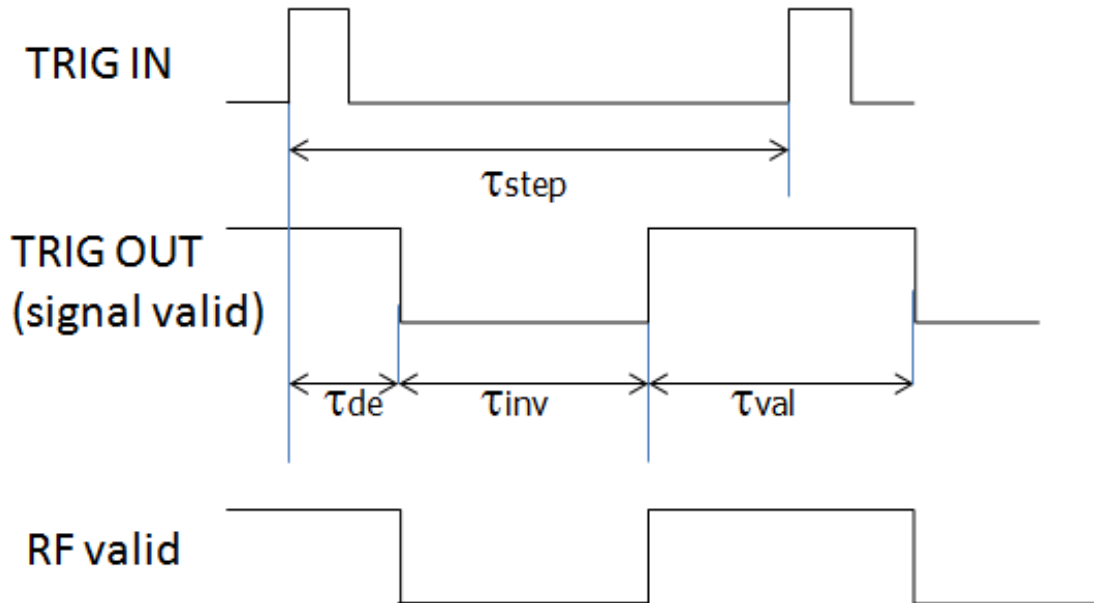


Figure 13. 50 GHz pulse-modulated

Sweeping capability

Parameter	Min	Typical	Max	Note
Sweep parameters	Frequency, power, phase, list			
Sweep types	Linear, logarithmic, random			
Step time ($t_{\text{step}} = t_{\text{dwell}} + t_{\text{off}}$)	500 μs 15 μs		19998 s	Option UNZ
Dwell time (t_{dwell})	0 μs		9999 s	
Off time (t_{off})	0 μs		9999 s	
Time resolution		5 ns		
Timing delay (t_{de})		50 ns		
Transient time (t_{inv})		15 μs	25 μs	
Timing accuracy per point		5 ns		
Number of points	2		10000	Per channel



Trigger input

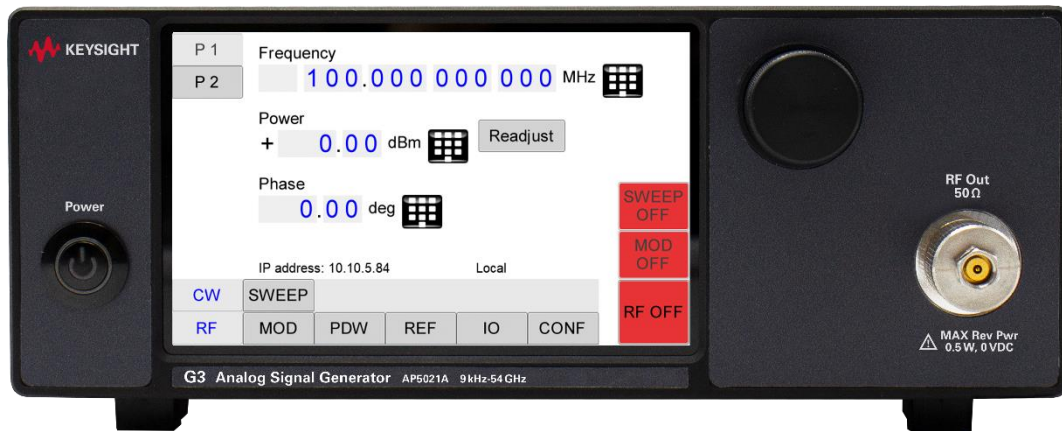
Parameter	Min	Typical	Max	Note
Trigger types	Continuous Single (point) Gated Gated direction			
Trigger source	External Bus (LAN, USB)			
Trigger modes	Continuous free run Trigger and run Reset and run			
Trigger latency		5 ns		
Trigger uncertainty		10 ns		
External trigger delay	50 ns		40 s	settable
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

Parameter	Min	Typical	Max	Note
Video output (of internal pulse modulator)				
Output		CMOS		
Period	30 ns		50 s	
Pulse width	15 ns		50 s	
RF delay		10 ns		
Trigger output. Synchronization mode for multiple sources				
Modes	Trigger on sweep start Trigger on each point Signal valid			

Connectors

Single-channel front panel (desktop enclosure)



- Power switch
- Rotary knob
- RF Outputs:
 - AP5021A-512: N female
 - AP5021A-520 or AP5021A-540: 2.92mm male hand-tight
 - AP5021A-554: 1.85 mm male hand-tight

Single-channel rear panel (desktop enclosure)



- Trigger output (TRIG OUT): BNC female
- PULSE IN: Pulse modulation input: BNC female
- Reference input (REF IN): BNC female
- High stability reference input (CLK IN, 6 GHz): SMA female
- Trigger input (TRIG IN): BNC female
- Reference output (REF OUT): BNC female
- High stability reference output (CLK OUT, 6 GHz): SMA female
- GPIB: IEEE-488.2, 1987 with listen and talk (optional)
- LAN connection: RJ-45
- USB 2.0 device
- Card slot (SD)
- 100-240V AC power plug
- Ground reference screw (earth) M4

Multi-channel front panel (19" 2 HU)



- RF outputs:
 - AP5022A-512 or AP5022A-520: SMA female
 - AP5022A-540: 2.92mm female
 - AP5022A-554: 1.85 mm female

Multi-channel rear panel (19" 2 HU)



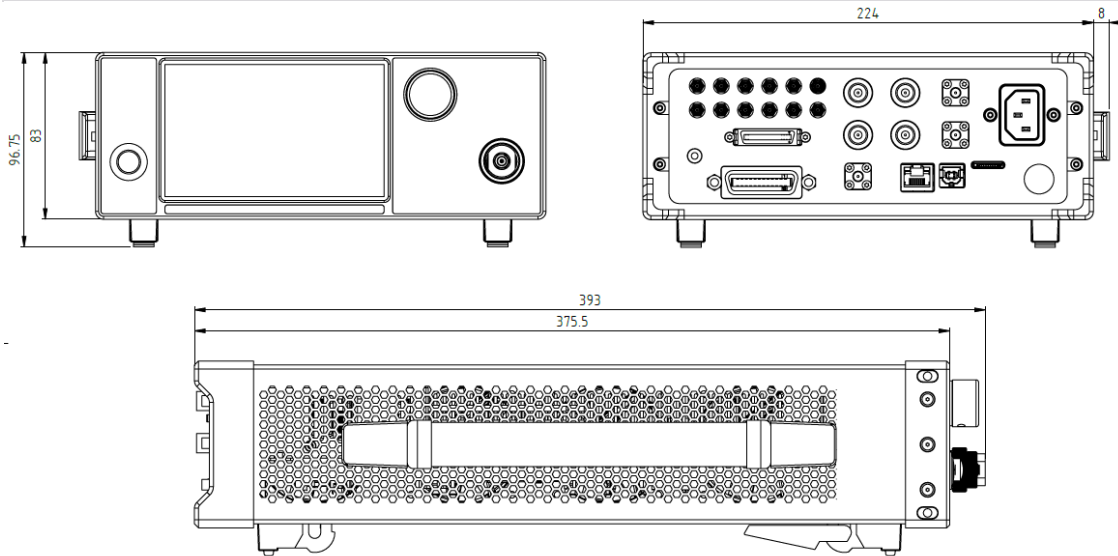
- Channel 1, 2, 3, 4 PULM input: BNC female
- High stability reference input (CLK IN, 6 GHz): SMA female
- High stability reference output (CLK OUT, 6 GHz): SMA female
- Trigger input (TRIG IN): BNC female
- Trigger output (TRIG OUT): BNC female
- Reference input (REF IN): BNC female
- Reference output (REF OUT): BNC female
- GPIB: IEEE-488.2, 1987 with listen and talk (optional)
- LAN connection: RJ-45
- USB 2.0 device
- Card slot (SD)
- FUSE (3.15 A)
- 100-240V AC power plug
- Power switch
- Ground reference screw (earth) M4

Mechanical Specifications

Desktop enclosure: Dimensions and weight

Including connectors

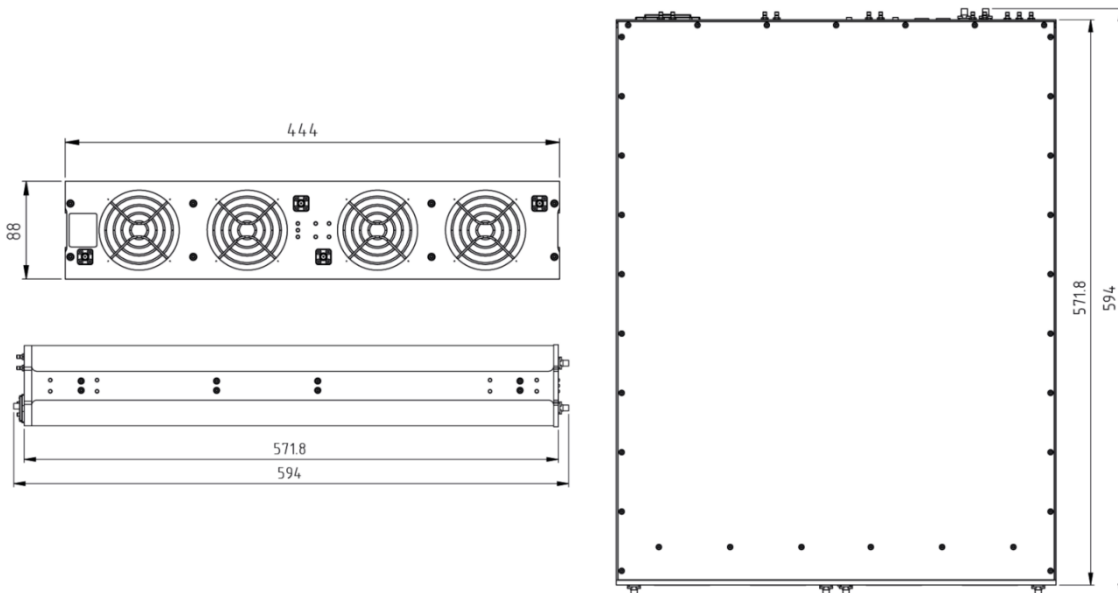
W x L x H = 232 x 393 x 96.75 mm [9.1 x 15.5 x 3.8 in], ≤10 kg [22 lbs]



19" 2 HU: Dimensions and weight

Including connectors

W x L x H = 444 x 594 x 88 mm [17.5 x 23.4 x 3.5 in], 18 kg [39.7 lbs]



General Characteristics

Remote programming interfaces

- 10/100 Mbit Ethernet interface
- USB 2.0 device
- GPIB (IEEE-488.2,1987) with listen and talk (Option GPB)
- Control Language SCPI Version 1999.0

Power requirements: 100 - 240 VAC, 50 or 60 Hz, 200W maximum (80W + 30W per channel), <100W (desktop)

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

Operating ambient temperature range: 0 to +45 °C

Storage ambient temperature range: -40 to +70 °C

Relative humidity range: 20 to 85 %RH (desktop models), 20 to 90 %RH (rack mount models)

Operating and storage altitude up to 15,000 feet/4600 m



Safety / EMC comply with applicable Safety and EMC regulations and directives.

Weight:

Multi-channel: 19" 2HU HI enclosure 18 kg [39.7 lbs]

Single-channel: Desktop enclosure ≤10 kg [22 lbs]

Dimensions:

Multi-channel: 19" 2HU HI enclosure W x L x H = 444 x 594 x 88 mm [17.5 x 23.4 x 3.5 in]

Single-channel: Desktop enclosure W x L x H = 232 x 393 x 96.75 mm [9.1 x 15.5 x 3.8 in]

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