

AP5002A Microwave Analog Signal Generator

9 kHz to 12, 20, or 26 GHz



Definitions and Conditions

The specifications in the following pages describe the warranted performance of the instrument for $23 \pm 5 \text{ }^\circ\text{C}$ 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.

Specifications

Frequency parameters / range

Parameter	Min	Typical	Max	Note
Frequency range	9 kHz		12.0 GHz	AP5002A-512
	9 kHz		20.0 GHz	AP5002A-520
	9 kHz		26.0 GHz	AP5002A-526
Resolution		0.001 Hz		
Phase resolution		0.1 deg		
Frequency / Amplitude settling time		200 μs	300 μs	
			30 μs	Options UNZ, UNQ
Internal reference frequency		100 MHz		
Initial accuracy of internal reference			± 40 ppb	calibrated at $23 \pm 3 \text{ }^\circ\text{C}$ at the time of calibration, user adjustable
Temperature stability (0 to $45 \text{ }^\circ\text{C}$)			± 100 ppb	
Aging 1 st year		0.5 ppm		
Aging per day (after 30 days of operations)			5 ppb	
Warm-up time		5 min		
Output of internal reference	10 MHz		100 MHz	Both 10 MHz and 100 MHz reference output are available on the REF OUT port.
Output power		0 dBm		
Output impedance		50 Ω		
Bypass internal reference input	100 MHz, -5 to +10 dBm			High phase synchronous mode
Phase lock to external reference				
External input range	1 MHz		250 MHz	User programmable
Reference input level	-5 dBm	0 dBm	+13 dBm	
Lock range			± 1.5 ppm	
Reference input impedance		50 Ω		

Level performance

Parameter	Min	Typical	Max	Note
Power level				
Standard	-20 dBm		+12 dBm	9 to < 100 kHz
	-20 dBm		+15 dBm	100 kHz to 25 GHz
	-20 dBm		+10 dBm	> 25 to 26 GHz
With Option 1E1	-120 dBm		+12 dBm	9 to < 100 kHz
	-120 dBm		+15 dBm	100 kHz to 25 GHz
	-120 dBm		+10 dBm	> 25 to 26 GHz
With Option 1EA	-20 dBm		+12 dBm	9 kHz to < 100 kHz
	-20 dBm		+20 dBm	100 kHz to < 50 MHz
	-20 dBm		+23 dBm	50 MHz to 7.5 GHz
	-20 dBm		+20 dBm	> 7.5 to 18 GHz
	-20 dBm		+18 dBm	> 18 to 20 GHz
	-20 dBm		+16 dBm	> 20 to 25 GHz
	-20 dBm		+10 dBm	> 25 to 26 GHz
With Option 1E1 and 1EA	-120 dBm		+12 dBm	9 to < 100 kHz
	-120 dBm		+20 dBm	100 kHz to < 50 MHz
	-120 dBm		+23 dBm	50 MHz to 7.5 GHz
	-120 dBm		+20 dBm	> 7.5 to 18 GHz
	-120 dBm		+18 dBm	> 18 to 20 GHz
	-120 dBm		+16 dBm	> 20 to 25 GHz
	-120 dBm		+10 dBm	> 25 to 26 GHz
Resolution		0.01 dB		
Level uncertainty (ALC on, flatness correction: up to 2,000 points, temperature effects: 0.015 dB/ °C (typical) in range 0 to 45 °C)				
Power range	> +15 dBm to P_{max}	-15 to +15 dBm	-70 to < -15 dBm	< -70 dBm
9 kHz to 10 GHz	± 1.6 dB, ± 0.8 dB typ.	± 1.0 dB, 0.3 dB typ.	± 1.5 dB, ± 0.4 dB typ.	± 1.8 dB typ.
10 GHz to f_{max}	± 1.6 dB, ± 0.8 dB typ.	± 1.0 dB, 0.3 dB typ.	± 1.5 dB, ± 0.4 dB typ.	± 2.0 dB typ.

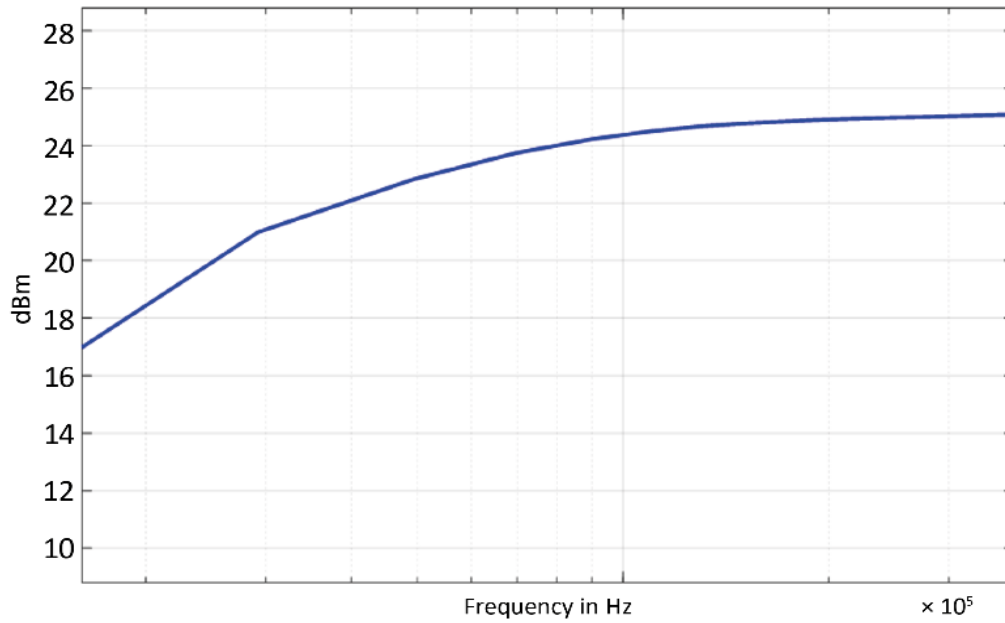


Figure 1. Typical maximum output power, 9 kHz to 1 MHz, with Option 1EA

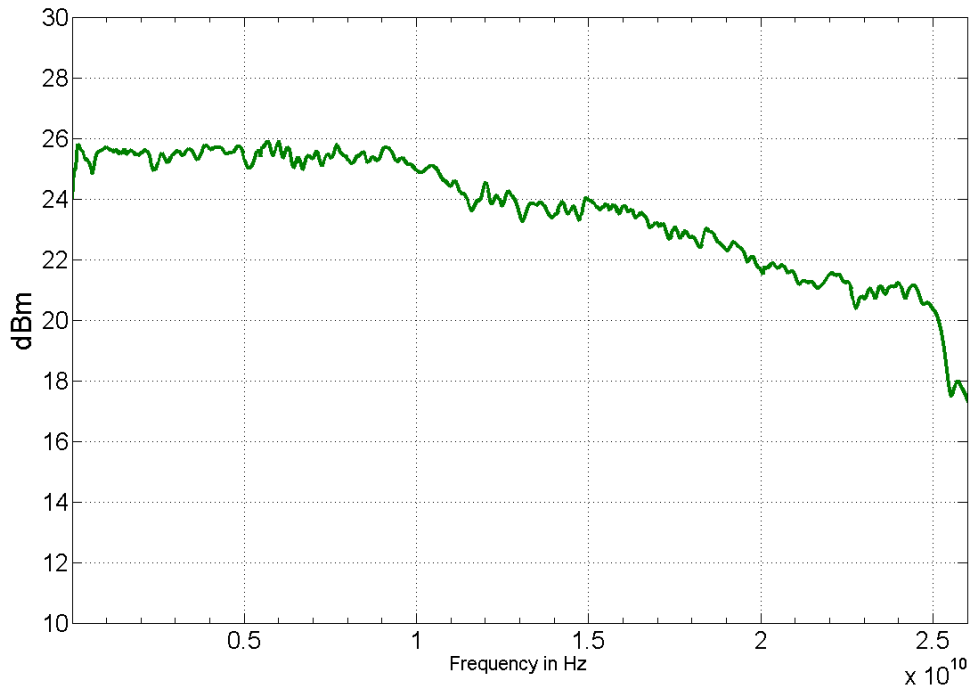


Figure 2. Typical maximum output power, 100 kHz to 26 GHz, with Option 1EA

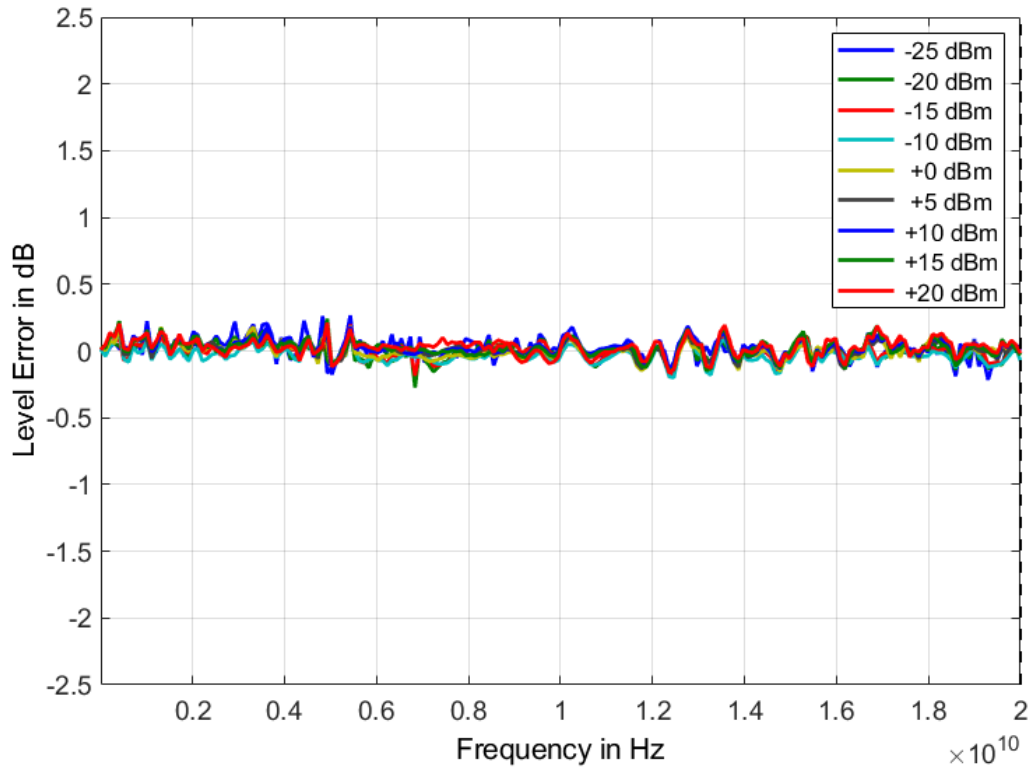


Figure 3. Typical frequency response, 0 to 20 GHz, at -20, 0, and +20 dBm

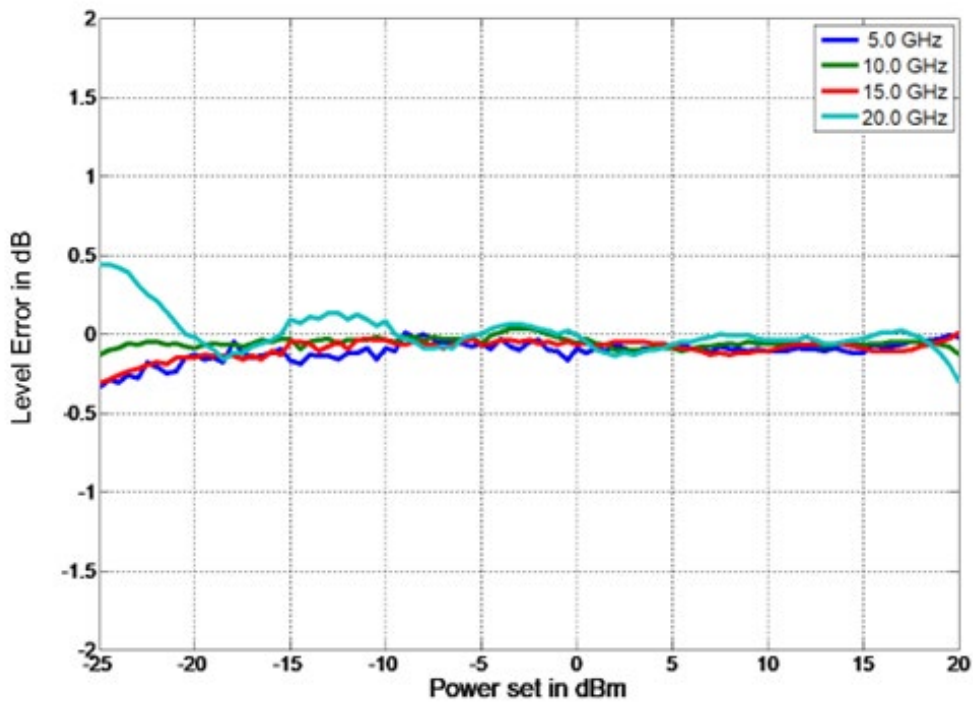


Figure 4. Absolute power level error, 0 to 20 GHz, at -20, 0, and +20 dBm

Reverse power protection and VSWR

Parameter	Min	Typical	Max	Note
Reverse power protection				
DC voltage			5 V	
RF power			+27 dBm	
Output impedance		50 Ω		
VSWR		1.5		≤ 6 GHz
		2.0		> 6 GHz

Phase noise

Parameter	Min	Typical	Max	Note
SSB Phase noise				
1 GHz, 20 kHz offset		-130 dBc/Hz	-124 dBc/Hz	
4 GHz, 20 kHz offset		-118 dBc/Hz	-112 dBc/Hz	
20 GHz, 20 kHz offset		-104 dBc/Hz	-98 dBc/Hz	
Wideband noise		-150 dBc/Hz		
Amplitude noise at 10 GHz		-130 dBc/Hz		

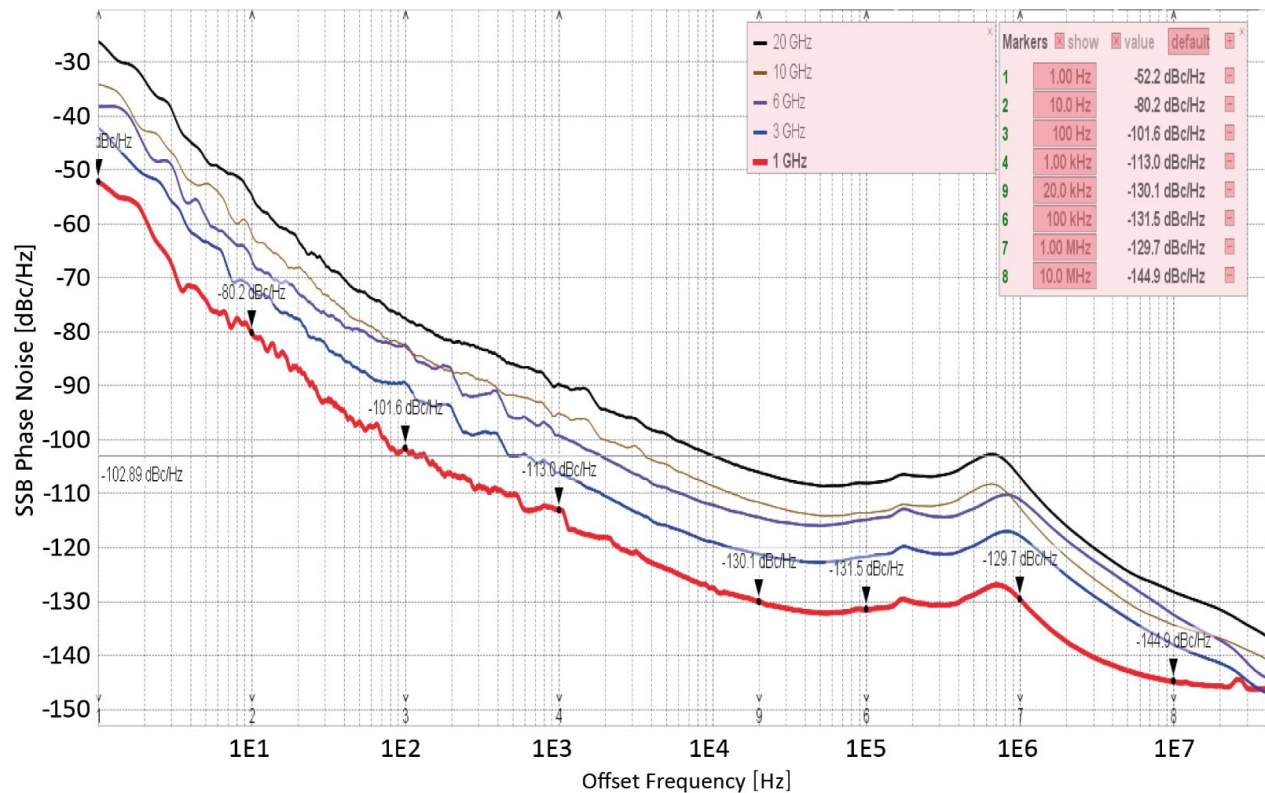


Figure 5. Typical phase noise at different frequencies, 1 Hz to 100 MHz offset

Spectral purity

Parameter	Min	Typical	Max	Note
Output harmonics		-40 dBc	-30 dBc	$P_{out} = +5$ dBm
Sub-harmonics		-75 dBc	-65 dBc	< 20 GHz
		-50 dBc	-40 dBc	> 20 GHz
Non-harmonic spurious				
≤ 312 MHz		-80 dBc	-66 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 312 to 625 MHz		-75 dBc	-70 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 625 MHz to 1.5 GHz		-75 dBc	-65 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 1.5 to 2.5 GHz		-70 dBc	-65 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 2.5 to 5 GHz		-65 dBc	-60 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 5 to 10 GHz		-60 dBc	-55 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 10 to 20 GHz		-55 dBc	-50 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
> 20 GHz		-50 dBc	-45 dBc	CW, $P_{out} = +10$ dBm, > 3 kHz offset
Residual FM at 10 GHz		15 Hz		0.3 kHz to 3 kHz, weighted, (ITU-T), RMS
Residual AM at 10 GHz		0.02%		RMS value (0.01 kHz to 15 kHz)

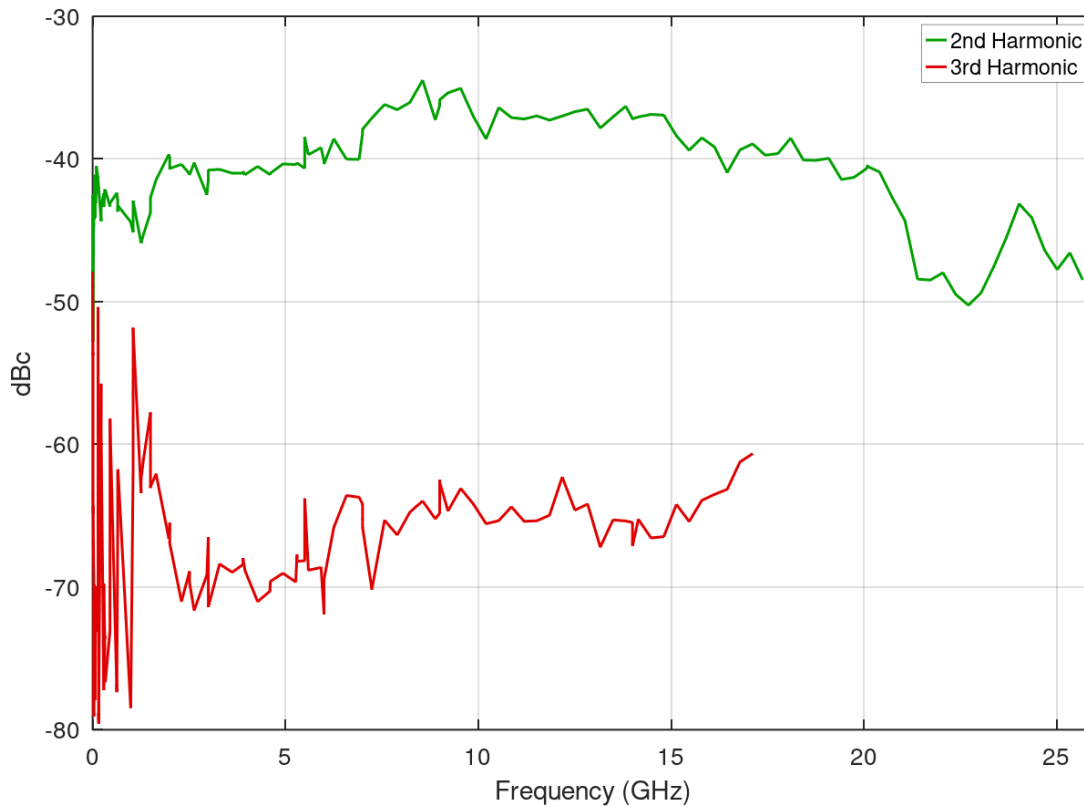


Figure 6. Typical harmonics, $P_{out} = +5$ dBm

Sweeping capability

Sweeps can be performed with combined internal or external AM/FM/PM/pulse modulation running. With modulation enabled, the minimum step time increases to 2 ms.

Parameter	Min	Typical	Max	Note
Digital power / frequency / list sweep (Sweep type: linear, logarithmic, random)				
Switching Speed (t_{switch})	400 μ s		19998 s	
	40 μ s			Option UNZ
	40 μ s			$f_{step} < 2.2$ GHz, Option UNQ
	100 μ s			$f_{step} \geq 2.2$ GHz, Option UNQ
Dwell time (t_{dwell})	10 μ s		9999 s	
Off-time (incl. settling time) (t_{off})	0		9999 s	
Settling time ($t_{settling}$)			270 μ s	
			30 μ s	Options UNZ, UNQ
Timing delay (t_{delay})		2 to 10 μ s		Trigger input to start of transition
		50 ns		Trigger input to start of transition, options UNZ, UNQ
Time resolution		0.1 μ s		
		5 ns		Options UNZ, UNQ
Timing accuracy per point		3 μ s		
		5 ns		Options UNZ, UNQ
Sweep list length	2		10000	

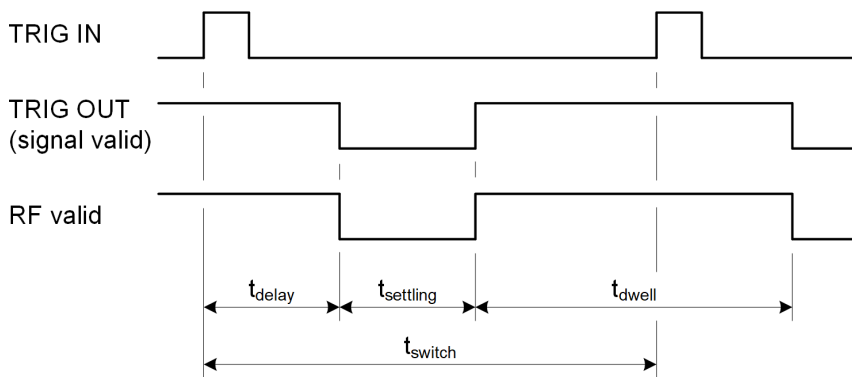


Figure 7. Timing diagram

Modulation capabilities

All modulation types (FM, PM, AM, and pulse modulation) may be enabled simultaneously except that FM and phase modulation cannot be combined. For example, AM and FM can run concurrently and will modulate the output RF.

Parameter	Min	Typical	Max	Note
Pulse modulation				
On/off ratio		75 dB		at +10 dBm
Repetition frequency	DC		10 MHz	
Pulse width	100 ns		5 s	ALC hold
	30.281 ns		5 s	ALC hold, Option UNQ, UNZ
	500 ns			ALC on
Pulse rise/fall time		30 ns		<5 GHz
		5 ns		>5 GHz
Duty cycle	0.05%		99.95%	
Pulse resolution		30 ns		
Polarity		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		
Delay (to RF)		20 ns	40 ns	
Pulse pattern modulation				
Pulse bit width	100 ns			ALC hold
	30.281 ns			ALC hold, Options UNQ, UNZ
	500 ns			ALC on
Programmable pattern length	2		4096	
Duty cycle	0.05%		99.95%	
Pulse bit resolution		30.281 ns		
		5 ns		Options UNQ, UNZ
Polarity		selectable		
N-Pulse Modulation				Requires Option UNQ or UNZ
Period	30 ns		21 s	
N-Pulse type		1 - 4		No overlapping with other pulses
N-Pulse width (P1, P2, P3, P4 Widths) individually settable	30 ns		21 s	ALC hold
	500 ns		21 s	ALC on
N-Pulse delay (P1 Delay)	0 ns		21 s	
N-Pulse delay (P2, P3, P4)	Min: end of prior pulse + min off time			
N-Pulse width and delay resolution		5 ns		
N-Pulse off time	1 μ s		21 s	Determined by pulse delay and prior pulse width

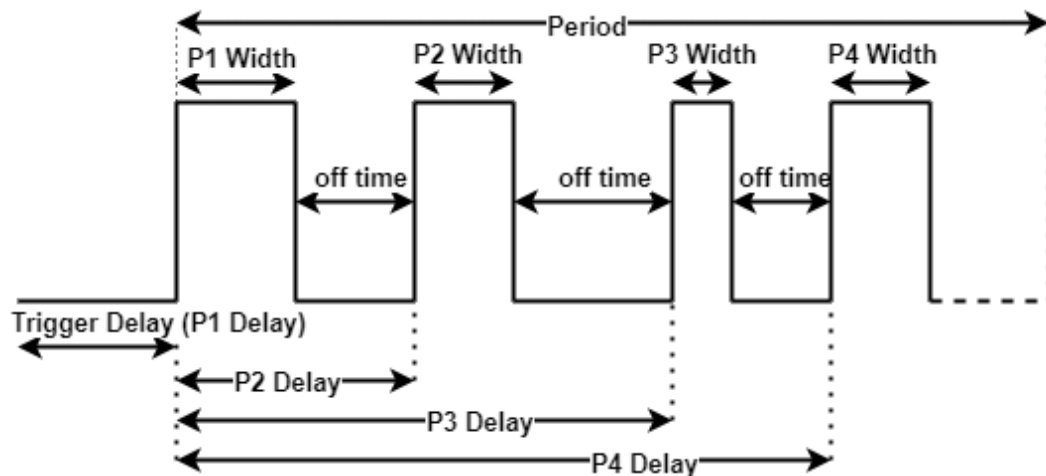


Figure 8. N-Pulse modulation

Frequency modulation				
Maximum Frequency deviation (peak)	0		0.05 x f	< 0.5 GHz
	0		N x 200 MHz	0.5 to < 2.5 GHz (N=0.125) 2.5 to < 5 GHz (N=0.25) 5 to < 10 GHz (N=0.5) ≥ 10 GHz to 26 GHz (N=1)
Deviation accuracy		0.5%	2%	≤ 100 kHz rate
		2%	5%	> 100 kHz rate
Distortion		< 1%		1 kHz rate, 50 kHz deviation
Modulation rate	DC		100 kHz	> -3 dB frequency response
Modulation waveforms	Sine, triangle, FSK			
External input sensitivity	0 to N x 200 MHz / V, AC coupled			adjustable for ±1 V range
	0 to N x 100 MHz / V, DC coupled			Discrete values; ±5 V range
External input impedance	600 Ω			
	1 MΩ			Option MDH
Total harmonic distortion	< 1%			1 kHz rate & N x 1 MHz deviation
Frequency chirps (linear ramp, up/down)				
Span	10%			of carrier frequency
Chirp time (t_{chirp})	10 ns			60 s
Slope	100 MHz/μs			
Total duration of finite repeated chirps (t_{chirp} x repetitions)				64.1 s 21.4 s
Number of frequencies				Option UNQ or UNZ 65,000
Phase modulation				
Phase deviation (peak)	0			< 500 MHz
				N x 300 rad
				0.5 to < 2.5 GHz (N=0.125) 2.5 to < 5 GHz (N=0.25) 5 to < 10 GHz (N=0.5) ≥ 10 GHz to 26 GHz (N=1)

Deviation accuracy		0.5%	2%	≤ 100 kHz rate
		2%	5%	> 100 kHz rate
Modulation rate	DC		100 kHz	> -3 dB frequency response Max. phase deviation degrades above 20 kHz modulation rate
Modulation waveforms	Sine, triangle, FSK			
External input sensitivity	Settable 0.1 rad/V to 360 rad/V			
External input impedance	600 Ω			
	1 MΩ		Option MDH	
Total harmonic distortion	< 1%	1 kHz rate & N x 100 rad deviation		
Amplitude modulation				
Modulation rate	0.1 Hz	50 kHz		
Modulation depth	0%	95%		settable
Modulation waveforms	Sine, triangle, square			
Accuracy (f > 10 MHz)		1.3%	4%	f-carrier, modulation depth = 80% & 1 kHz modulation rate, power 0 dBm
Distortion (f > 10 MHz)		1.6%	4%	
External Input range	0 V	5 V		to GND

Multi-purpose output (FUNC OUT)

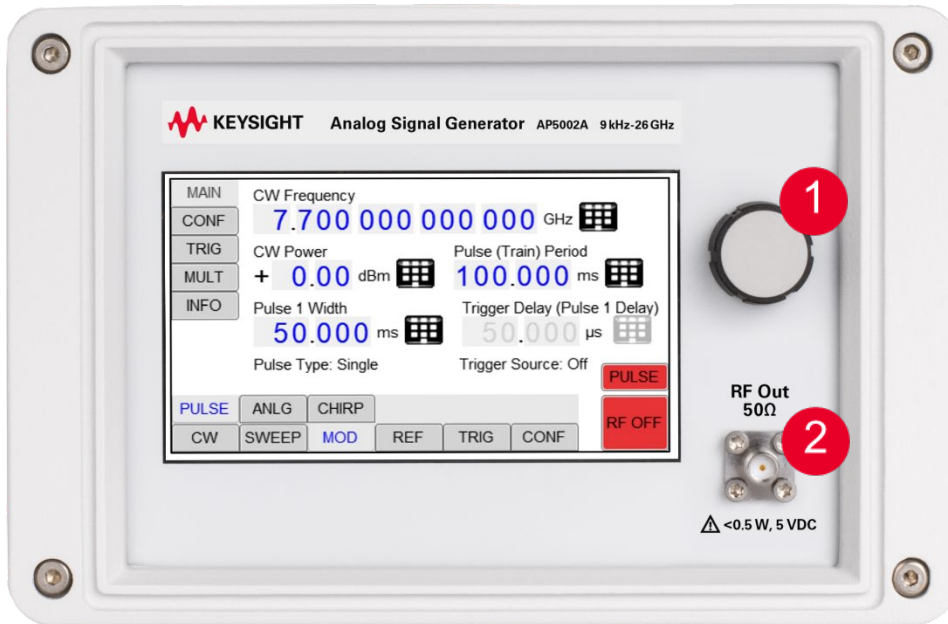
Parameter	Min	Typical	Max	Note
Multifunction generator (sine, triangle, square wave)				
Frequency range	10 Hz		3 MHz	sine
	10 Hz		1 MHz	triangle
	10 Hz		50 kHz	square
Frequency resolution		0.1 Hz		
Output voltage amplitude peak-peak	10 mV		2 V	sine, triangle
		5V		square (CMOS output)
Harmonic distortion		1 %		< 100 kHz, 1 Vpp
Output impedance		50 Ω		sine, triangle
		CMOS		square
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			Option UNQ or UNZ

Trigger (TRIG IN)

Parameter	Min	Typical	Max	Note
Trigger types	Continuous, single, gated, gated direction			
Trigger source	RF key, external, bus (LAN, USB)			
Trigger modes	Continuous free run, trigger and run, reset and run			
Trigger latency		2 μ s		
		130 ns		Option UNQ or UNZ
Trigger uncertainty		5 μ s		
		10 ns		Option UNQ or UNZ
External trigger delay	50 μ s		40 s	programmable
	50 ns		10 s	Option UNQ or UNZ
External delay resolution		15 ns		
		10 ns		Option UNQ or UNZ
Trigger modulo	1		255	Execute only on the N th 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		

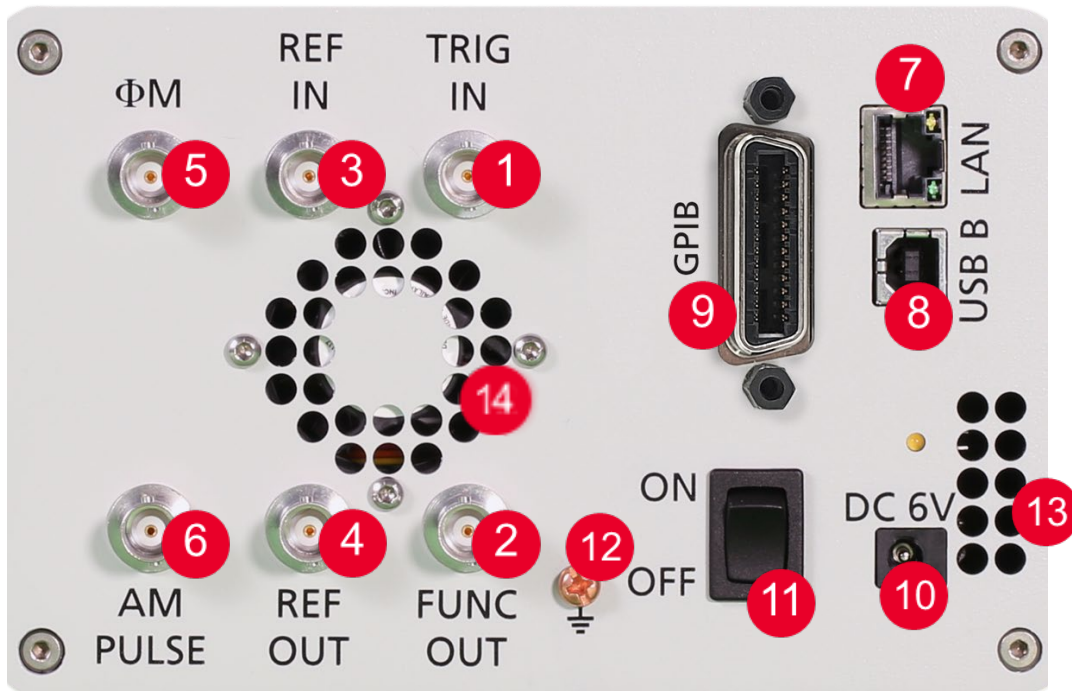
Connectors

Front (3U Housing)



1. **Rotary Knob** changes the value selected on the screen.
2. **RF 50 Ω Output connector** SMA-female

Rear (3U Housing)



1. **Trigger input** BNC female
2. **Function output** BNC female
3. **External reference input** BNC female
4. **Internal reference output** BNC female
5. **FM/PM modulation** input BNC female
6. **AM and Pulse modulation** BNC female
7. **LAN connection** RJ-45
8. **USB 2.0 device**
9. **GPIB Port**
10. **DC Power plug** (6V, 6 A)
11. **DC power switch**
12. **Ground Screw**
13. **Fan Holes** (air intake)
14. **Fan Holes** (air exit)

Front (Option S1E 1U Housing)



19" rack-mount module

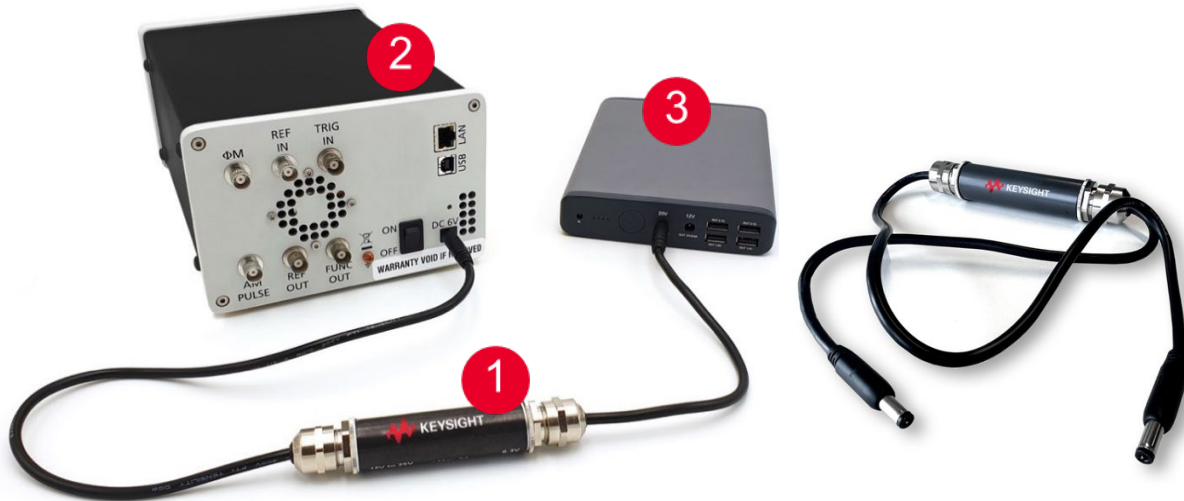
Rear (Option S1E 1U Housing)



1. **Trigger input** BNC female
2. **Function output** BNC female
3. **External reference input** BNC female
4. **Internal reference output** BNC female
5. **FM/PM modulation input** BNC female
6. **AM and Pulse modulation** BNC female
7. **LAN connection** RJ-45
8. **USB 2.0 device**
9. **GPIB Port**
10. **Ground Screw**

Accessories

Y9614A External Power Bank Adapter Cable (3U Housing only)



The Y9614A (# 1 above) is designed to power the 3U AP5001A or AP5002A (# 2 above) from an external, customer supplied, power bank (# 3 above) with output voltage of 12V to 25V. Power bank capacity of 50 Ah is recommended and it should be equipped with a barrel connector per below specifications with a maximum output current of 7 A.

The Y9614A has two connectors marked as 'Input' and 'Output'. The output connector is directly connected to the DC 6.3V input port on the rear of an AP5001A or AP5002A. The input connector is directly connected to a customer supplied power bank.

Caution: Do not exchange input and output connectors

Y9614A specifications

Parameter	Value	Note
Input connector	Barrel connector 2.1 x 5.5 mm, outer sleeve negative	Connected to power bank
Output connector	Barrel connector 2.1 x 5.5 mm, outer sleeve negative	Connected to AP5001A/2A
Input voltage range	12 V to 25 V DC	
Input power consumption	Typ. 36 W	
Output voltage	6.3 V DC	
Output current	Max 5 A	
Cooling	To ensure sufficient passive cooling, air circulation around the module must be possible.	

Y9611A 3U rack mount



General Characteristics

Remote programming interfaces	Ethernet 100BaseT LAN interface USB 2.0 host & device Control language SCPI Version 1999.0
Power requirements	6.3 ± 0.2 VDC; 30 W maximum
Power requirements (option S1E)	100-240VAC, 50-60Hz; 42 W max
Mains adapter supplied (except option S1E)	100-240 VAC in/ 6.3 V 5.71 A DC out
Environmental (Levels similar to MIL-PRF-28800F Class 3/4)	Environmental stress Samples of this product have been type tested to be robust against the environmental stresses of storage, transportation, and end-use; those stresses to temperature, humidity, shock, vibration, altitude, and power line conditions.
Storage temperature range	–40 to 70 °C
Operating temperature range	0 to 55 °C (40 °C for Y9614A)
Max. Relative Humidity	85% up to 45°C ambient (40 °C for Y9614A)
Operating and storage altitude	up to 15,000 feet
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
Weight	Weight ≤ 4.3 kg (9.5 lbs) net, ≤ 5.4 kg (12 lbs) shipping, Weight S1E ≤ 6 kg (13.23 lbs) net, ≤ 8 kg (17.63 lbs) shipping, Weight (Y9614A empty) ≤ 0.167 kg (0.37 lbs) net
Dimensions	Including connectors: W x L x H = 174 x 262 x 117 mm [6.83 x 10.30 x 4.60 in]
Dimensions (option S1E)	W x L x H = 426 x 460 x 42 mm [16.8 x 18.1 x 1.7 in]
Recommended calibration cycle	24 months
Compatibility languages supporting commonly used commands	Keysight N5171B EXG, N5173B EXG, N5181A/B MXG, N5183A/B MXG Rohde & Schwarz SMB100A, SMB100B, SMC100A, SMCV100B, SMA and SML models

Ordering information

Model/option	Description	Additional information
AP5002A	RF Microwave Signal Generator	
AP5002A-512	Frequency range, 9 kHz to 12 GHz	
AP5002A-520	Frequency range, 9 kHz to 20 GHz	
AP5002A-526	Frequency range, 9 kHz to 26 GHz	
AP5002A-1E1	Step attenuator	
AP5002A-1EA	High output power	
AP5002A-UNQ	Band limited fast switching	not license upgradeable
AP5002A-UNZ	Fast switching	not license upgradeable
AP5002A-GPB	GPIB interface	not license upgradeable
AP5002A-S1E	1U rack-mount module	not license upgradeable
AP5002A-1EM	Move RF output to rear panel	Requires option S1E, not license upgradeable
AP5002A-UK6	Commercial calibration certificate with test data	
AP5002A-MDH	1 M Ω FM/PM input impedance	not license upgradeable
Y9611A	Rack mount kit, 3HU	
Y9612A	Portable bag	
Y9614A	External power bank adapter cable with voltage converter	For use with customer supplied power bank
AP5002AU-F01	Frequency upgrade from 12 GHz to 20 GHz	License key only
AP5002AU-F02	Frequency upgrade from 12 GHz to 26 GHz	License key only
AP5002AU-F03	Frequency upgrade from 20 GHz to 26 GHz	License key only
AP5002AU-1E1	Add step attenuator	License key only
AP5002AU-1EA	Add high output power	License key only

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