# AP5001A RF Analog Signal Generator

9 kHz to 2, 4, or 6.1 GHz




KEYSIGHT

# Definitions and Conditions

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.

# Specifications

## Frequency parameters / range

| Parameter | Min | Typical | Max | Note |
|---|---|---|---|---|
| Frequency range | 9 kHz | | 2.0 GHz | AP5001A-502 |
| | 9 kHz | | 4.0 GHz | AP5001A-504 |
| | 9 kHz | | 6.1 GHz | AP5001A-506 |
| Resolution | | 0.001 Hz | | |
| Phase resolution | | 0.1 deg | | |
| Settling time | | 20 µs | 200 µs | |
| Frequency update rate List/Sweep mode | | 400 µs | | Time from receipt of SCPI command firmware |
| Total jitter | | 68 fs RMS | | 10 Hz to 1 MHz BW |
| Reference frequency input | 8 MHz | | 200 MHz | User programmable |
| Reference input level | -5 dBm | 0 dBm | +13 dBm | |
| Lock Range | | | +/- 1.0 ppm | |
| Reference input impedance | | 50 Ω | | |
| Internal reference frequency output | | 10 MHz | | |
| Initial accuracy of internal reference | | | ± 40 ppb | Calibrated at 23 ± 3 °C at the time of calibration |
| Temperature stability (0 to 50 °C) | | | ±100 ppb | |
| Aging 1st year | | 0.5 ppm | | |
| Aging per day (after 30 days of operations) | | | 5 ppb | |
| Warm-Up time | | 5 min | | |
| Output of internal reference | | +0 dBm, 50 Ω | | |

# Level performance

| Parameter | Min | Typical | Max | Note |
|---|---|---|---|---|
| **Power level** | | | | |
| Standard | -30 dBm | | +15 dBm<br>+16 dBm<br>+17 dBm<br>+10 dBm | > 5.8 GHz and ≤ 6.1 GHz<br>> 2.5 GHz and ≤ 5.8 GHz<br>> 50 MHz and ≤ 2.5 GHz≤ 50 MHz |
| Option 1E1 | -120 dBm | | +15 dBm<br>+16 dBm<br>+17 dBm<br>+10 dBm | > 5.8 GHz and ≤ 6.1 GHz<br>> 2.5 GHz and ≤ 5.8 GHz<br>> 50 MHz and ≤ 2.5 GHz<br>≤ 50 MHz |
| Resolution | | 0.01 dB | | |
| Level uncertainty | | ± 0.3 dB<br>± 0.5 dB<br>± 0.8 dB | ± 0.8 dB<br>± 1.3 dB | -20 to + 10 dBm<br>-70 to -20 dBm<br>< -70 dBm |

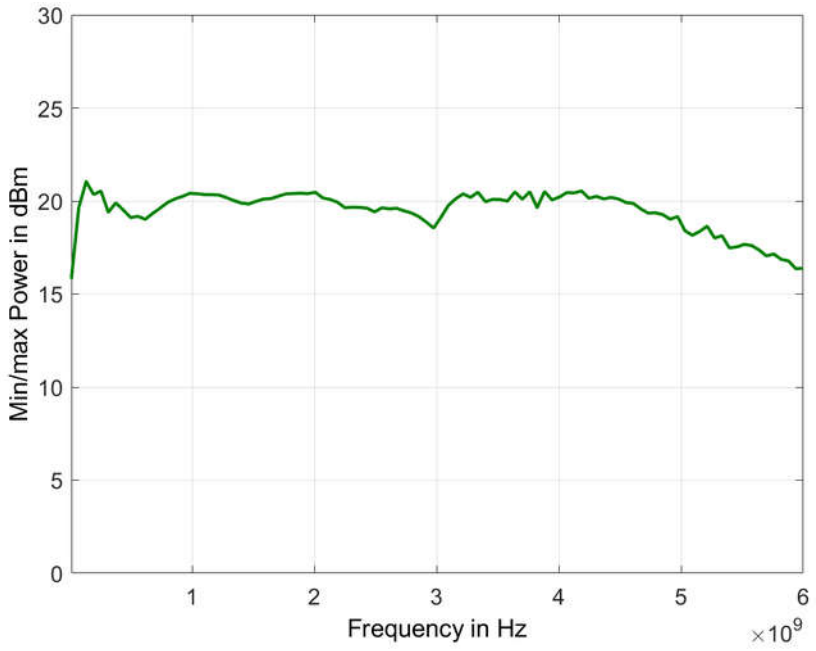



**Figure 1.** Typical maximum output power

# 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 | | 2.0 | | |

# Phase noise

| Parameter | Min | Typical | Max | Note |
|---|---|---|---|---|
| SSB Phase noise 500 MHz to 1 GHz, at 20 kHz from carrier | | -130 dBc/Hz | -124 dBc/Hz | |

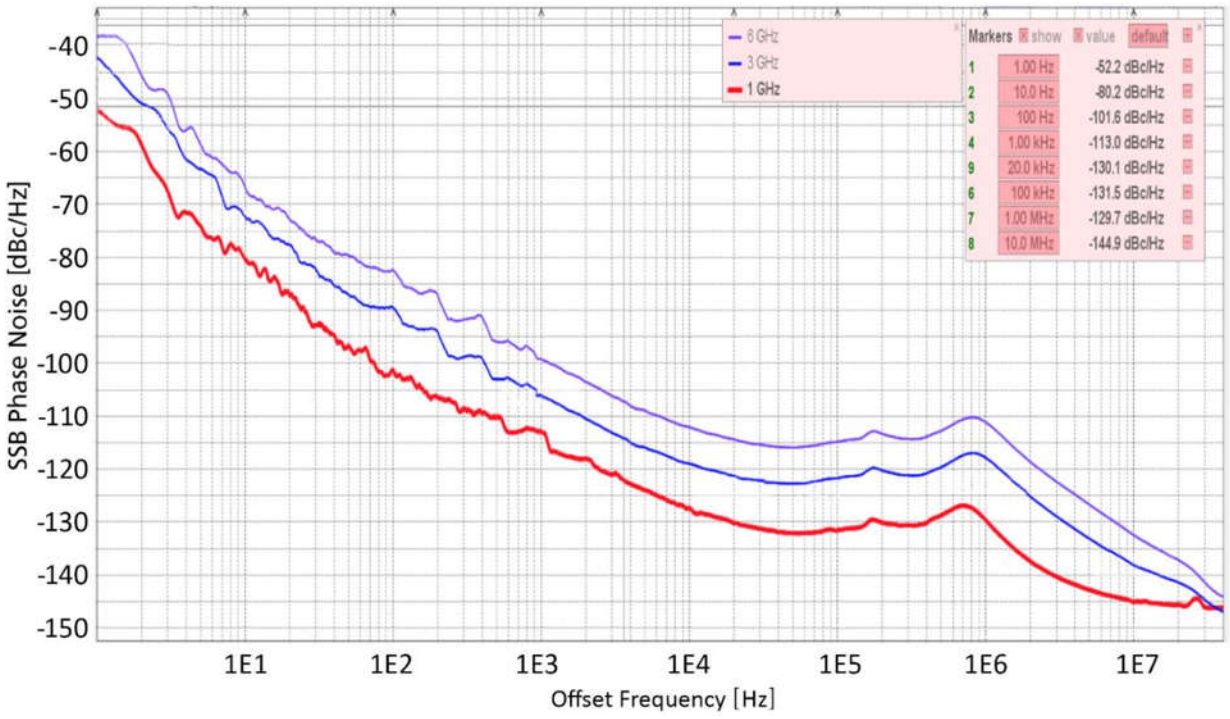



**Figure 2.** Typical phase noise

# Spectral purity

| Parameter | Min | Typical | Max | Note |
|---|---|---|---|---|
| Output harmonics | | -40 dBc | -30 dBc | $P_{out}$ = +10 dBm |
| Sub-harmonics | | -80 dBc | -70 dBc | |
| **Non-harmonic spurious** | | | | |
| < 1 MHz | | -70 dBc | -60 dBc | $P_{out}$ = +10 dBm |
| 1 MHz to 4.8 GHz | | -65 dBc | -55 dBc | $P_{out}$ = +10 dBm |
| 4.8 GHz to 6.1 GHz | | -60 dBc | | $P_{out}$ = +10 dBm |
| Residual FM at 1 GHz① | | | 3 Hz<br>12 Hz | 0.3 kHz to 3 kHz, weighted (ITU-T)<br>0.03 kHz to 23 kHz |

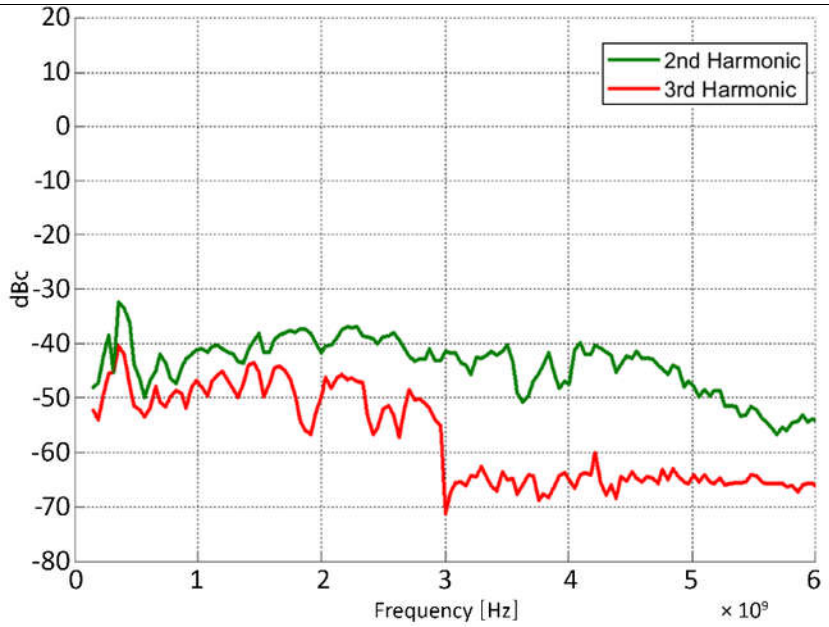



**Figure 3.** Typical harmonics, at +10 dBm

# 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 |
|---|---|---|---|---|
| **Frequency sweep (Sweep type: linear, logarithmic, random)** | | | | |
| Step time ($t_{step}$) | 400 µs | | 19998 s | |
| Dwell time ($t_{dwell}$) | 50 µs | | 9999 s | |
| Off-time (incl. transient time) ($t_{off}$) | 0 / 50 µs | | 9999 s | |
| Timing accuracy per point | | 1 µs | | |
| **Generalized list sweep (allows individual setting of frequency, power, dwell-time, and off-time for each point)** | | | | |
| List size | 2 | | 20.000 | |
| Step time ($t_{step}$) | 200 µs | | 19998 s | |
| Dwell time ($t_{dwell}$) | 50 µs | | 9999 s | |
| Off-time (incl. transient time) ($t_{off}$) | 0 / 50 µs | | 9999 s | |
| Time resolution | | 0.1 µs | | |
| Timing accuracy per point | | 1 µs | | |

# 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 | | 70 dB | | |
| Repetition frequency | DC | | 33 MHz | |
| Pulse width | 30 ns<br>50 µs | | 20 s<br>20 s | ALC hold<br>ALC on |
| Pulse rise/fall time | | 25 ns | | |
| Pulse train length (pulses) | 2 | | 4,192 | |
| Video crosstalk | | -40 dB | | |
| 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 | |
| **Frequency modulation** | | | | |
| Maximum Frequency deviation (peak) | 0 | | 0.05 x f | < 0.25 GHz |
| | 0 | | N x 200 MHz | 0.5 to 2.5 GHz (N=0.125)<br>2.5 to 5 GHz (N=0.25)<br>5 to 6.1 GHz (N=0.5) |
| Modulation waveforms | Sine, triangle, FSK | | | |
| Deviation accuracy | | 0.5% | 2% | < 100 kHz rate |
| | | 2% | 5% | > 100 kHz rate |
| Modulation rate | 1 Hz/DC | | 800 kHz | -3 dB frequency response<br>Max. phase deviation degrades above 20 kHz modulation rate |
| External input sensitivity | < N x 100 MHz for 1 Vpp | | | Settable in AC mode<br>Discrete values in DC mode |
| Total harmonic distortion | < 1% | | | 1 kHz rate and N x 100 kHz deviation |
| **Frequency chirps (linear ramp, up/down)** | | | | |
| Span | | | 10% | |
| Dwell time ($t_{chirp}$) | 10 ns | | 60 s | |
| Slope | | 100 MHz/µs | | |
| Total duration of finite repeated chirps ($t_{chirp}$ x repetitions) | | | 64.1 s | |
| Number of frequencies | | | 20,000 | |
| **Phase modulation** | | | | |
| Phase deviation (peak) | 0 | | N x 300 rad | 0.5 to 2.5 GHz (N=0.125)<br>2.5 to 5 GHz (N=0.25)<br>5 to 6.1 GHz (N=0.5) |

| | | | | |
|---|---|---|---|---|
| Deviation accuracy | | 0.5% | 2% | < 100 kHz rate |
| | | 2% | 5% | > 100 kHz rate |
| Modulation rate | 1 Hz | | 800 kHz | > -3 dB frequency response |
| Modulation waveforms | Sine, triangle, FSK | | | |
| External Input sensitivity | N x 40 rad for 1 Vpp | | | |
| Total harmonic distortion | < 1% | | | 1 kHz rate and N x 20 rad deviation |
| **Amplitude modulation** | | | | |
| Modulation rate | 10 Hz | | 50 kHz | Applies to internal and external |
| Modulation depth | 0 % | | 95 % | |
| Modulation waveforms | Sine, triangle, square | | | |
| Accuracy (f<10 MHz) | | 1.3 % | 4 % | f-carrier, modulation depth = 80% and 1 kHz modulation rate, power 0 dBm |
| Distortion (f<10 MHz) | | 1.6 % | 4 % | |
| Accuracy (f>10 MHz) | | 1.6 % | 4 % | |
| Distortion (f>10 MHz) | | 1 % | 4 % | |
| External input sensitivity | X % per 1 Vpp | | | Settable |

# Multi-purpose output (FUNC OUT)

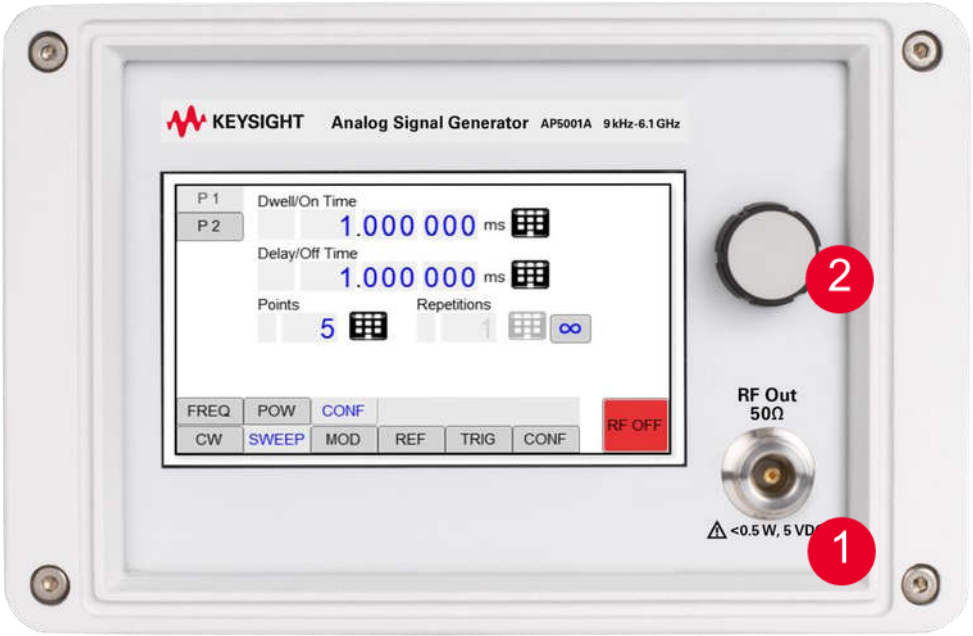
| Parameter | Min | Typical | Max | Note |
|---|---|---|---|---|
| **Multifunction generator (sine, triangle, square wave)** | | | | |
| Frequency range | 10 Hz | | 3 MHz | Sine |
| | 10 Hz | | 1 MHz | Triangle |
| | 10 Hz | | 50 kHz | Square |
| Frequency resolution | | 0.6 Hz | | |
| Output voltage 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 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 | | | |
| Trigger waveform pulse width | | 100 ns | | |

## 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 µs | | |
| Trigger uncertainty | | 5 µs | | |
| External trigger delay | 50 µs | | 40 s | |
| External delay resolution | | 15 ns | | |
| 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 | | |

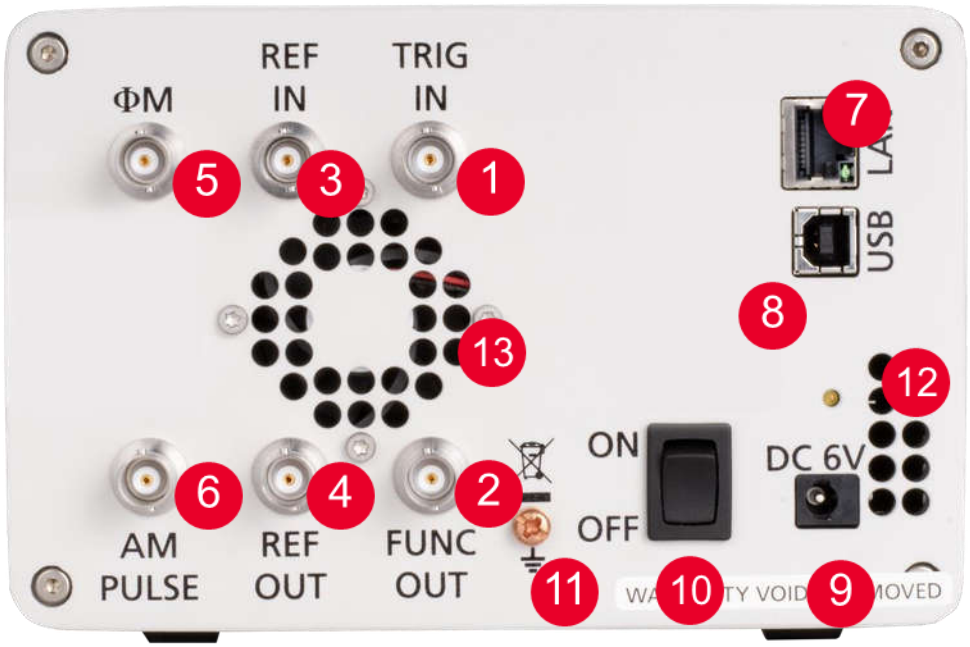
# Connectors

## Front




1. **RF output** N female
2. **Rotary knob**

# Rear




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. **DC Power plug (6V, 6 A)**
10. **DC power switch**
11. **Ground Screw**
12. **Fan Holes** The air intake of the fan
13. **Fan Holes** The holes by which the air is extruded

# General Characteristics

**Remote programming interfaces**

Ethernet 100BaseT LAN interface
USB 2.0 host and device
Control language SCPI Version 1999.0

**Power requirements:** 6 VDC; 20 W maximum

**Mains adapter supplied:** 100-240 VAC in/ 6 V 6.0 A DC out

**Storage temperature range** –40 to 70 °C

**Operating temperature range** 0 to 45 °C

**Operating and storage altitude** Up to 15,000 feet

CE

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

**Weight** ≤ 2.5 kg (6 lbs) net, ≤ 4 kg (8 lb.) shipping

**Dimensions:**
Excluding connectors: W x L x H = 172 x 250 x 106 mm [6.83 x 9.84 x 4.60 in]
Including connectors: W x L x H = 172 x 273 x 106 mm [6.83 x 10.66 x 4.60 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 |
|---|---|---|
| **AP5001A** | **RF Analog Signal Generator** | |
| AP5001A-502 | Frequency range, 9 kHz to 2 GHz | |
| AP5001A-504 | Frequency range, 9 kHz to 4 GHz | |
| AP5001A-506 | Frequency range, 9 kHz to 6.1 GHz | |
| AP5001A-1E1 | Step attenuator | |
| AP5001AU-F01 | Frequency upgrade from 2 GHz to 4 GHz | License key only |
| AP5001AU-F02 | Frequency upgrade from 2 GHz to 6.1 GHz | License key only |
| AP5001AU-F03 | Frequency upgrade from 4 GHz to 6.1 GHz | License key only |
| AP5001AU-1E1 | Add step attenuator | License key only |

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