



DATASHEET APULN Specification V1.35

Ultra-Low Noise Microwave Signal Generators

8 kHz to 6, 12.75, 20, 26 and 40 GHz



Document size:

1 title page
19 content pages

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.

INTRODUCTION

• Ultra-Low Noise Microwave Signal Generator 8 kHz to 6, 12.75, 20, 26 and 40 GHz

The APULN is an ultra-low-noise and fast-switching microwave signal generator covering a continuous frequency range from 100 kHz (8 kHz with option) up to 6, 12.75, 20 GHz, 26 or 40 GHz, respectively, with a lower than 0.001 Hz resolution.

The APULN provide an accurately levelled output power range and high spurious suppression. Advanced frequency synthesis combines fastest switching speed with ultra-low SSB phase noise and fine frequency and power resolution.

The APULN supports analog modulation including pulse and chirp modulation with programmable patterns.

The APULN 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 APULN 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 intuitively controlled by a PC based GUI Software. Moreover, the instrument offers various communication interfaces like USB, LAN or GPIB. Each interface allows for easy and 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 very straightforward.

FACTS & FIGURES & SPECIFICATIONS

Signal Specifications

| PARAMETER | MIN | TYPICAL | MAX | NOTE |
|---|---------|-------------|-------------|----------------------------------|
| Frequency Range | 100 kHz | | 6 GHz | APULN06 |
| | 100 kHz | | 12.75 GHz | APULN12 |
| | 100 kHz | | 20 GHz | APULN20 |
| | 100 kHz | | 26 GHz | APULN26 |
| | 100 kHz | | 40 GHz | APULN40 |
| | 8 kHz | | Fmax | Option 8K |
| Resolution | | 0.001 Hz | | |
| Phase Resolution | | 0.01 deg | | |
| Switching Speed | | 1.5 ms | | Valid signal after SCPI received |
| SCPI CW mode | | 500 μs | | |
| Sweep / List Mode | | 30 μs | | |
| SSB Phase noise at 1 GHz | | | | (see also plots / tables) |
| at 10 Hz from carrier | | -87 dBc/Hz | | Option LN |
| at 1 kHz from carrier | | -100 dBc/Hz | -95 dBc/Hz | |
| at 20 kHz from carrier | | -130 dBc/Hz | -125 dBc/Hz | |
| at 100 kHz from carrier | | -145 dBc/Hz | -140 dBc/Hz | |
| SSB Phase noise at 4 GHz | | | | |
| at 10 Hz from carrier | | -74 dBc/Hz | -70 dBc/Hz | Option LN |
| at 1 kHz from carrier | | -90 dBc/Hz | -85 dBc/Hz | |
| at 20 kHz from carrier | | -121 dBc/Hz | -116 dBc/Hz | |
| at 100 kHz from carrier | | -133 dBc/Hz | -128 dBc/Hz | |
| SSB Phase noise at 10 GHz | | | | |
| at 10 Hz from carrier | | -67 dBc/Hz | | Option LN |
| at 1 kHz from carrier | | -80 dBc/Hz | | |
| at 20 kHz from carrier | | -113 dBc/Hz | | |
| at 100 kHz from carrier | | -124 dBc/Hz | | |
| SSB Phase noise at 40 GHz | | | | |
| at 10 Hz from carrier | | -55 dBc/Hz | | Option LN |
| at 1 kHz from carrier | | -68 dBc/Hz | | |
| at 20 kHz from carrier | | -101 dBc/Hz | | |
| at 100 kHz from carrier | | -112 dBc/Hz | | |
| Harmonics (at +0 dBm Pout) | | | | |
| 0.01 to 6 GHz | | -40 dBc | -30 dBc | See plot |
| >6GHz | | -35 dBc | -25 dBc | |
| Option FILT, >1 GHz | | -60 dBc | -50 dBc | |
| Sub-Harmonics | | | | |
| <5 GHz | | -75 dBc | | |
| 5 - 20 GHz | | -70 dBc | | |
| >20 GHz | | -55 dBc | | |
| Option FILT, >20 GHz | | -65 dBc | | |
| Non-Harmonic Spurious (> 10 kHz offset) | | | | |
| <1.2 GHz | | -90 dBc | -85 dBc | |
| 1.2 - 2.5 GHz | | -92 dBc | -88 dBc | |
| 2.5 - 5 GHz | | -90 dBc | -86 dBc | |
| 5 - 10 GHz | | -84 dBc | -80 dBc | |
| 10 - 20 GHz | | -80 dBc | -74 dBc | |
| >20 GHz | | -70 dBc | -66 dBc | |

| PARAMETER | MIN | TYPICAL | MAX | NOTE |
|--|----------|---------|----------------------------|--|
| Output power level | | | | |
| 0.1 to 10 MHz | -25 dBm | | +26 dBm | |
| 0.01 to 6 GHz | -25 dBm | | +24 dBm | |
| 6 to 12.75 GHz | -25 dBm | | +22 dBm | |
| 12.75 to 26 GHz | -25 dBm | | +18 dBm | |
| 26 to 40 GHz | -25 dBm | | +15 dBm | See plots |
| Output power level (with option PE4) | | | | |
| 0.1 to 10 MHz | -55 dBm | | +26 dBm | |
| 0.01 to 6 GHz | -55 dBm | | +24 dBm | |
| 6 to 12.75 GHz | -55 dBm | | +22 dBm | |
| 12.75 to 20 GHz | -55 dBm | | +20 dBm | |
| 20 to 38 GHz | -55 dBm | | +16 dBm | |
| 38 to 40 GHz | -55 dBm | | +13 dBm | See plot |
| Output power level (APULN20, 26, 40 with option PE3) | | | | |
| 0.1 to 10 MHz | -90 dBm | | +26 dBm | |
| 0.01 to 6 GHz | -90 dBm | | +24 dBm | |
| 6 to 12.75 GHz | -90 dBm | | +22 dBm | |
| 12.75 to 20 GHz | -90 dBm | | +18 dBm | |
| 20 to 40 GHz | -90 dBm | | +15 dBm | See plot |
| Output power level (APULN20, 26, 40 with option PE2, only with Option 1URM) | | | | |
| 0.1 to 10 MHz | -120 dBm | | +15 dBm | |
| 0.01 to 20 GHz | -120 dBm | | +18 dBm | |
| 20 to 40 GHz | -120 dBm | | +15 dBm | |
| Output power level (with option FILT) | | | | |
| 0.1 to 10 MHz | -30 dBm | | +15 dBm | |
| 0.01 to 20 GHz | -30 dBm | | +13 dBm | |
| 20 to 40 GHz | -30 dBm | | +10 dBm | See plot |
| Power Resolution | | 0.01 dB | | |
| Power Level Uncertainty | | | | |
| <6 GHz | | 0.25 dB | 0.8 dB 1.2 dB 2.0 dB | -15 to +15 dBm -60 to -15 dBm or >15 dBm -100 to -60 dBm |
| 6 to 12.75 GHz | | 0.3 dB | 0.9 dB 1.3 dB 2.0 dB | -15 to +15 dBm -60 to -15 dBm or >15 dBm -100 to -60 dBm |
| 12.75 to 26 GHz | | 0.3 dB | 1.0 dB 1.6 dB 2.5 dB | -15 to +15 dBm -60 to -15 dBm or >15 dBm -100 to -60 dBm |
| 26 to 40 GHz | | 0.4 dB | 1.2 dB 2.5 dB 3.0 dB | -15 to +15 dBm -55 to -15 dBm or >15 dBm -100 to -60 dBm |
| Reverse Power Protection | | | | |
| DC Voltage | | | ±10 V | |
| RF Power | | | 30 dBm | |
| Output impedance | | | | |
| VSWR | | 1.4 | 1.8 | |



Modulation Capabilities (Option MOD)

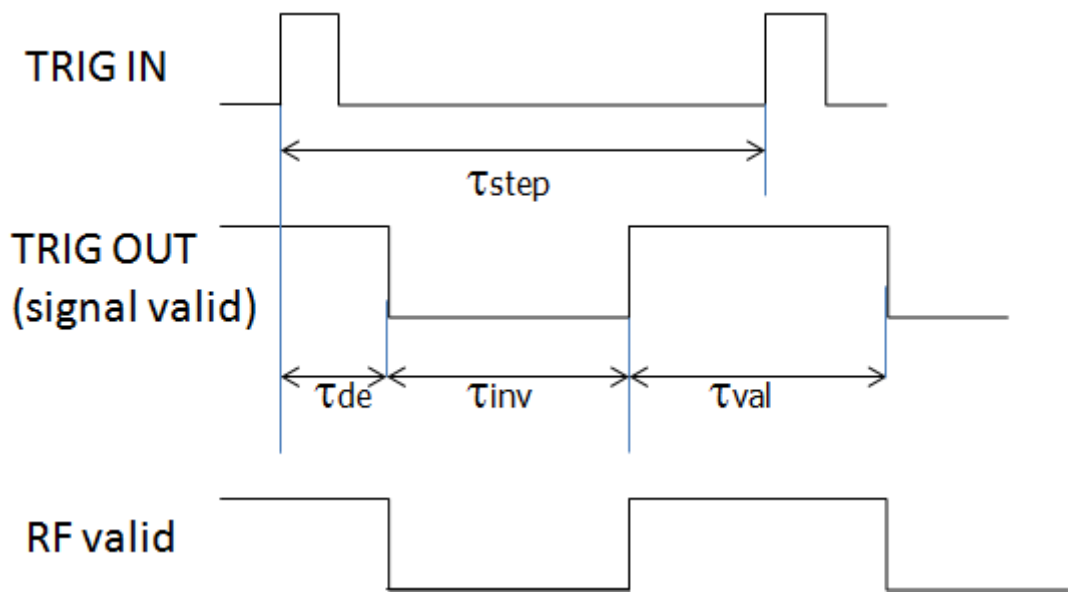
| PARAMETER | MIN | TYPICAL | MAX | NOTE |
|--|----------------------------|-------------------------|----------------|---|
| Pulse Modulation | | | | |
| Modulation source | | Internal/ External | | |
| Pulse rise/fall time | | 10 ns | | |
| On/off ratio (high ON/OFF mode) | | 80 dB 75 dB | 70 dB 65 dB | Pout > +10 dBm, f<18 GHz > 18 GHz |
| Pulse overshoot | | | 10% | |
| 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 |
| Minimum pulse settling range | 30 ns 10 ns | | 20 s 20 s | Option FS |
| Pulse Pattern Modulation & Staggered PRF | | | | Using internal pattern generator |
| Programmable pattern length | 2 | | 65536 | |
| Duty cycle | 0.05% | | 99.95% | |
| Pulse width resolution | | 5 ns | | |
| Pulse period (T) accuracy | | 0.00005xT+ 3ns | | |
| Pulse width accuracy | | 0.00005xT+ 5ns | | |
| Pulse width resolution | | 5 ns | | |
| Pulse jitter | | 1 ns | 5 ns | |
| Polarity | | selectable | | |
| Amplitude Modulation | | | | |
| Modulation source | | Internal/ (External) | | |
| Modulation Depth | 0% | | 90% | |
| Deviation accuracy | | 2% | 4% | 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 | | | |
| 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) |
| Chirped Pulse Modulation | | | | |
| Option FS & MOD | | | | |
| Modulation source | | Internal | | |
| Chirp span | 1 Hz | | 3 % | of RF |
| Chirp rate | 1 Hz | | 100 kHz | |
| Pulse width | 10 μs | | 1 sec | |
| Chirp slope | | | 0.5% / μs | of RF |
| Chirp mode | | Linear, exponential, | | |

| | | | | |
|--|--|----------------------------|--|--|
| | | up, down, bidirectional | | |
|--|--|----------------------------|--|--|

| PARAMETER | MIN | TYPICAL | MAX | NOTE |
|------------------------------------|--------|-------------------------|---------------|---|
| Frequency Modulation | | | | |
| 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 GHz (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 | | | | |
| 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 & 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, Sweep type: linear, logarithmic, random

| PARAMETER | MIN | TYPICAL | MAX | NOTE |
|------------------------------|-------------------------------|---------|--------------------|--|
| Sweep Parameters | | | | |
| | Frequency, power, phase, list | | | |
| Step time (t_{step}) | 500 μ s 30 μ s | | 19998 s 19998 s | Option FS |
| Settling time (t_{inv}) | | | 15 μ s | To stabilize phase and amplitude, depends on frequency step |
| Trigger latency (t_{de}) | | | 1 μ s | Time from trigger to initiate signal transient |
| Time resolution | | 5 ns | | |
| Timing accuracy per point | | 5 ns | | |



Frequency Reference

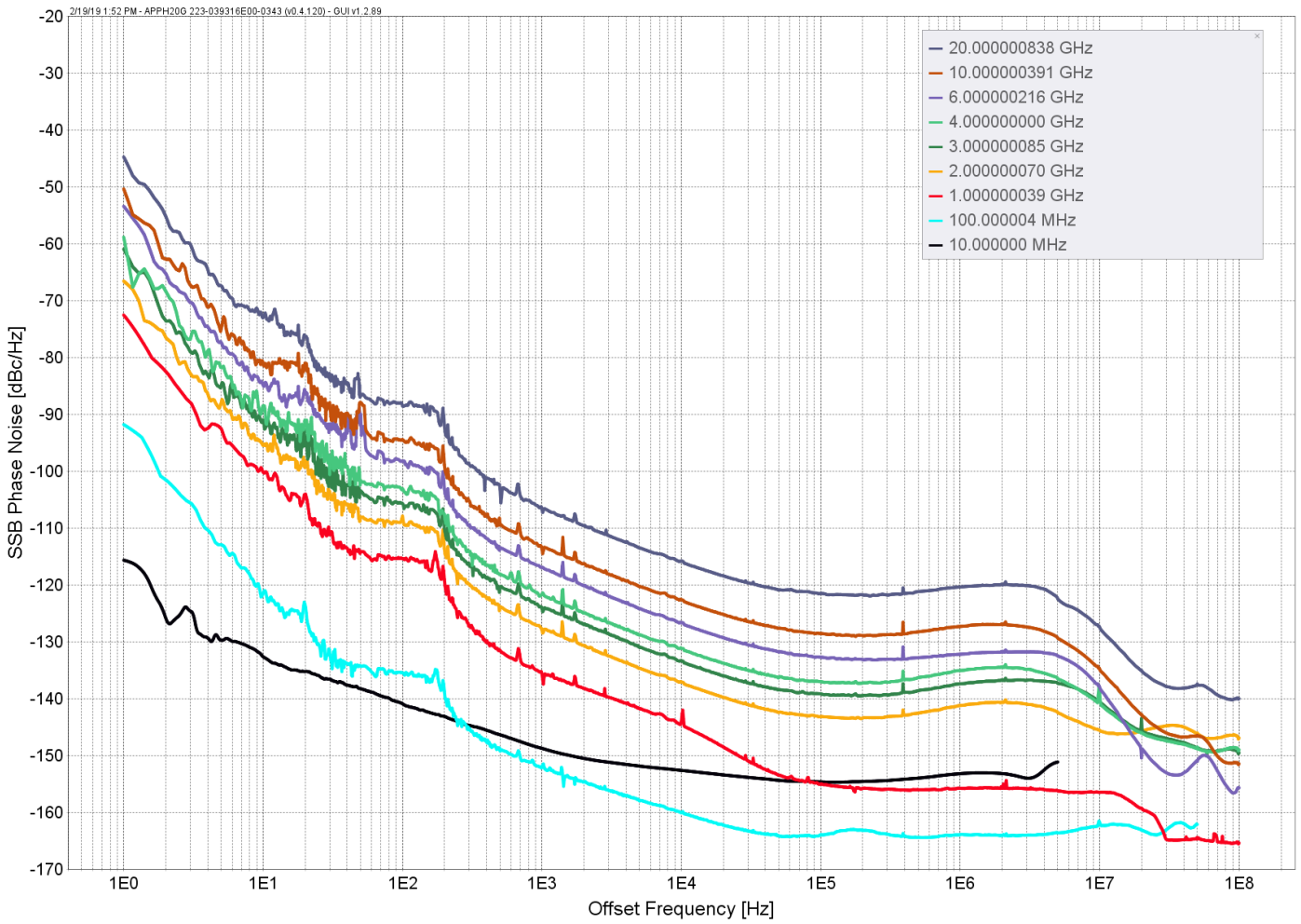
| PARAMETER | MIN | TYPICAL | MAX | NOTE |
|---|--------|----------------------------------|---------------------|---------------------------------------|
| Internal Reference Frequency | | 100 MHz 10 MHz | | Option LN |
| Temperature Stability 0 to 50 °C | | | ±100 ppb ±20 ppb | Option LN |
| Aging first year | | | 1 ppm 0.03 ppm | Option LN |
| Aging per day | | | 5 ppb 0.5 ppb | after 30 days operations Option LN |
| Warm-up time | | 5 min | | |
| Output of internal reference | | 100 MHz 10/100 MHz | | Option LN |
| Output power | | 0 dBm | | |
| Output impedance | | 50 Ohms | | |
| Bypass Internal reference Input | | 100 MHz | | High phase synchronous mode |
| Phase Lock to External Reference | | 10 MHz integer MHz 100 MHz | 250 | Option VREF |
| Bypass Mode | 5 | | | |
| 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 (TRIG IN): Input is TRIG IN at front panel

| 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 | | |

TYPICAL PERFORMANCE CURVES

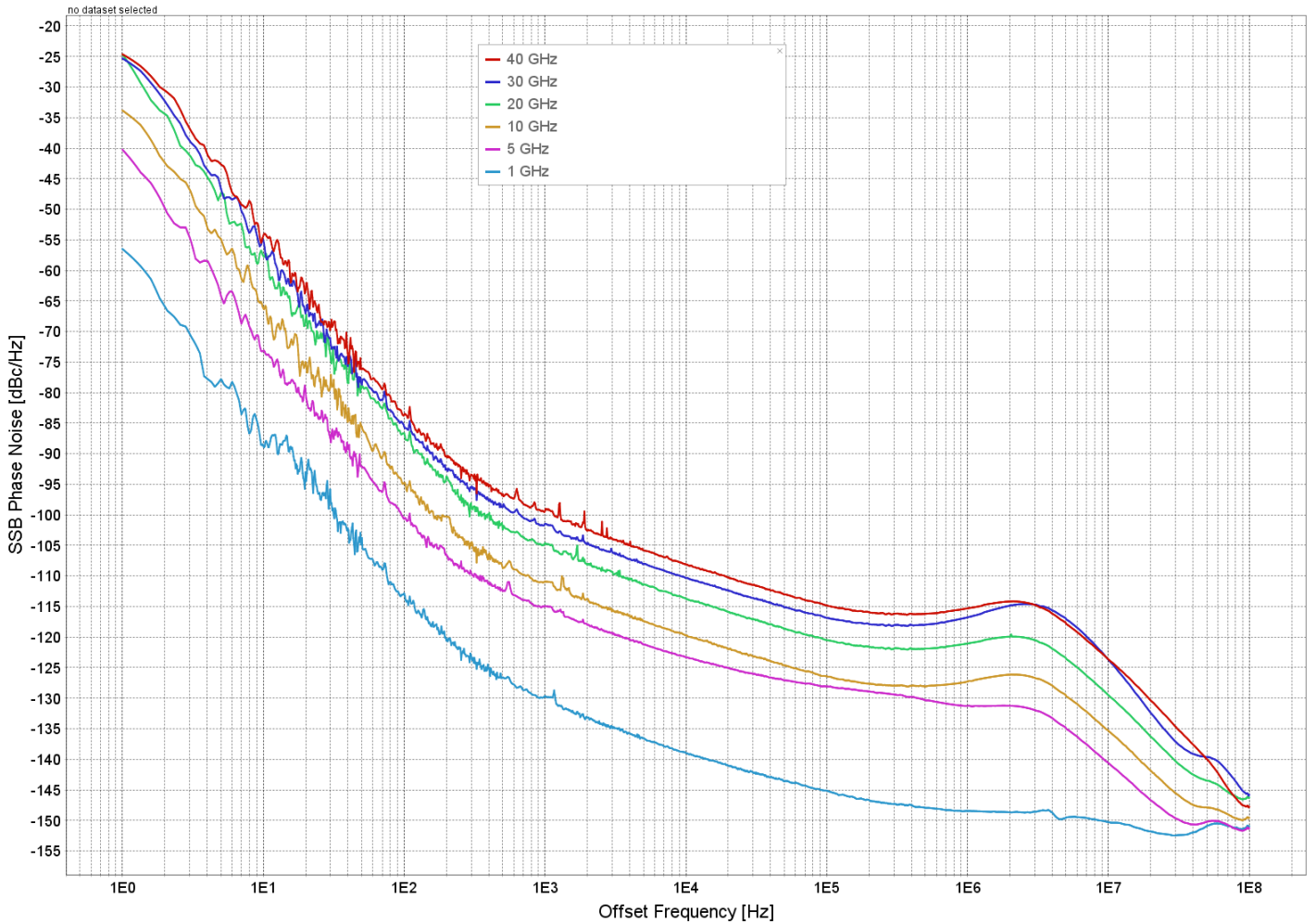
SSB Phase Noise Performance with option LN



Typical SSB Phase Noise [dBc/Hz], CW, level = 20 dBm, Option LN

| Offset → RF ↓ | 1 Hz | 10 Hz | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | floor |
|------------------|------|-------|--------|-------|--------|---------|-------|-------|
| 10 MHz | -116 | -133 | -141 | -149 | -153 | -155 | -154 | -155 |
| 100 MHz | -96 | -121 | -137 | -148 | -157 | -162 | -162 | -162 |
| 1 GHz | -76 | -100 | -120 | -132 | -142 | -153 | -156 | -165 |
| 2 GHz | -70 | -94 | -114 | -125 | -135 | -143 | -143 | -155 |
| 3 GHz | -66 | -90 | -110 | -122 | -132 | -139 | -139 | -151 |
| 4 GHz | -64 | -88 | -108 | -118 | -129 | -137 | -137 | -151 |
| 6 GHz | -60 | -84 | -104 | -115 | -124 | -132 | -133 | -151 |
| 10 GHz | -56 | -80 | -100 | -111 | -121 | -129 | -129 | -151 |
| 20 GHz | -50 | -74 | -94 | -105 | -116 | -123 | -123 | -150 |

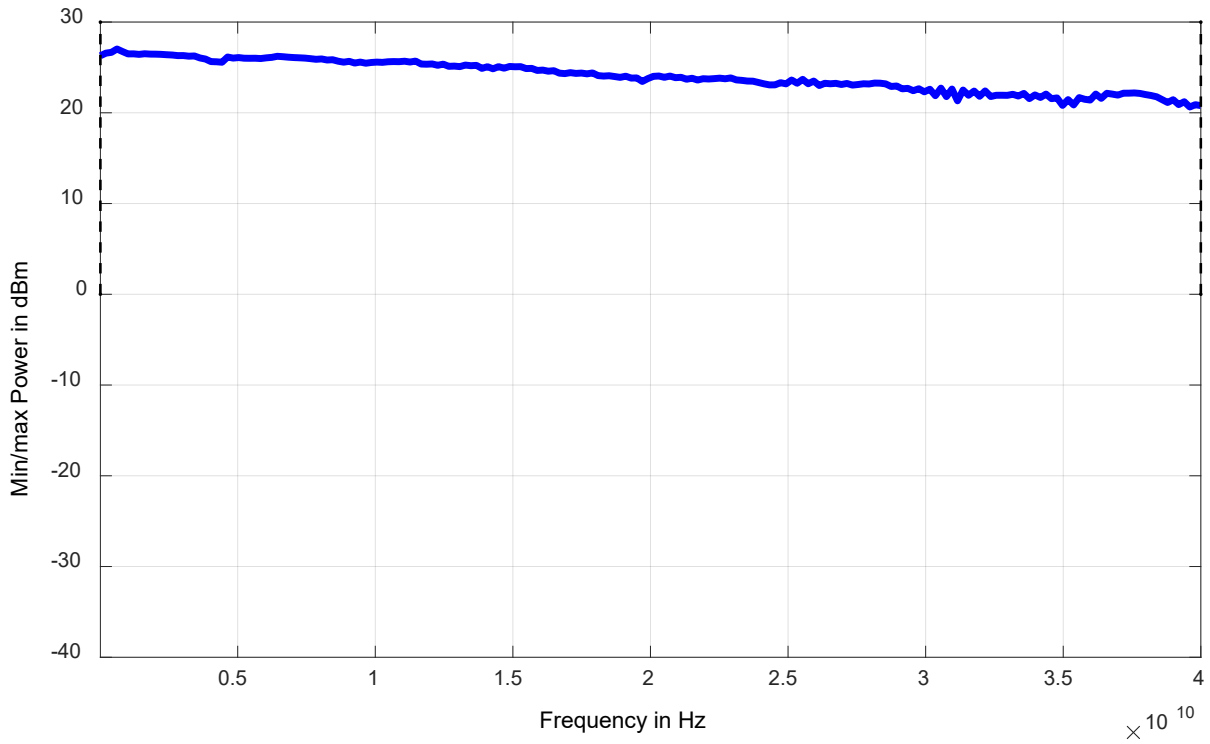
SSB Phase Noise Performance, without option LN



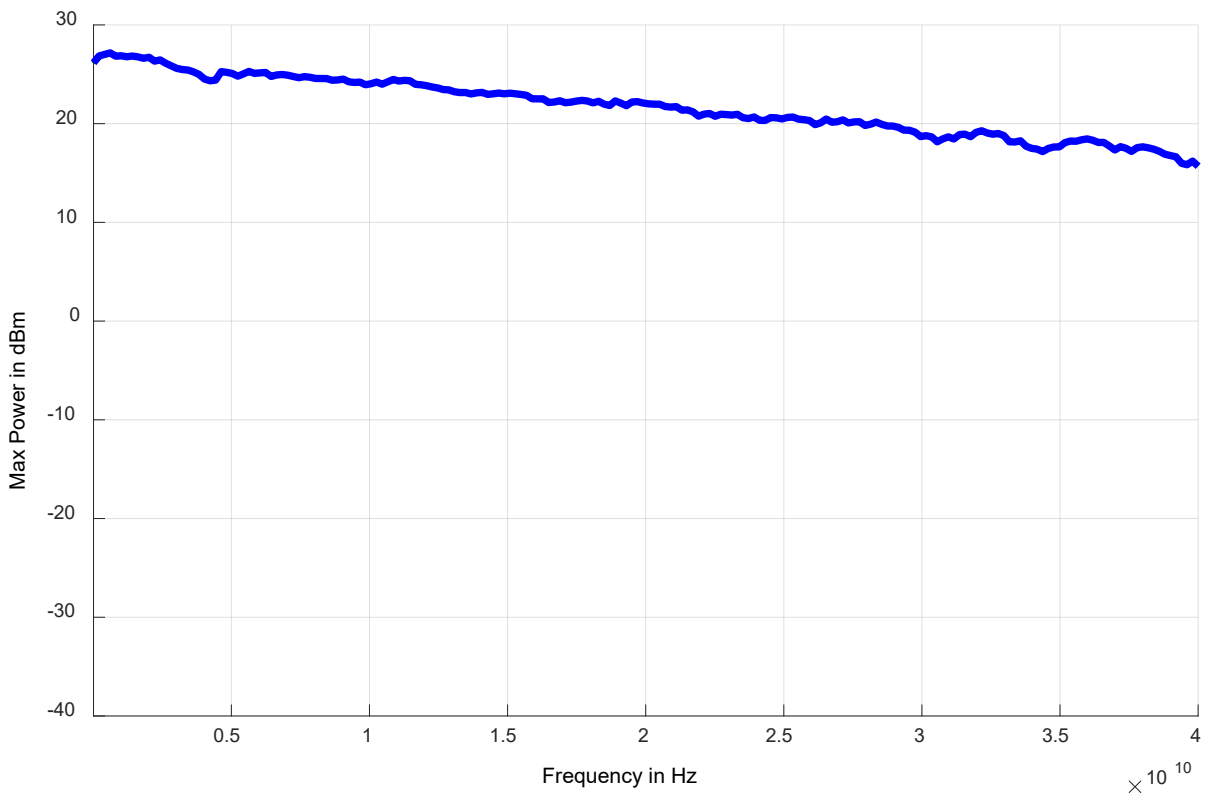
Typical SSB Phase Noise [dBc/Hz], CW, level = 20 dBm, without option LN

| Offset → RF ↓ | 1 Hz | 10 Hz | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | floor |
|------------------|------|-------|--------|-------|--------|---------|-------|-------|
| 10 MHz | -96 | -128 | -146 | -149 | -153 | -155 | -154 | -155 |
| 100 MHz | -76 | -108 | -140 | -148 | -157 | -162 | -162 | -162 |
| 1 GHz | -57 | -88 | -114 | -130 | -140 | -145 | -150 | -165 |
| 5 GHz | -41 | -74 | -101 | -116 | -123 | -128 | -131 | -151 |
| 10 GHz | -37 | -68 | -95 | -111 | -121 | -127 | -127 | -151 |
| 20 GHz | -31 | -62 | -90 | -105 | -116 | -121 | -121 | -150 |
| 40 GHz | -25 | -56 | -84 | -100 | -110 | -115 | -115 | -150 |

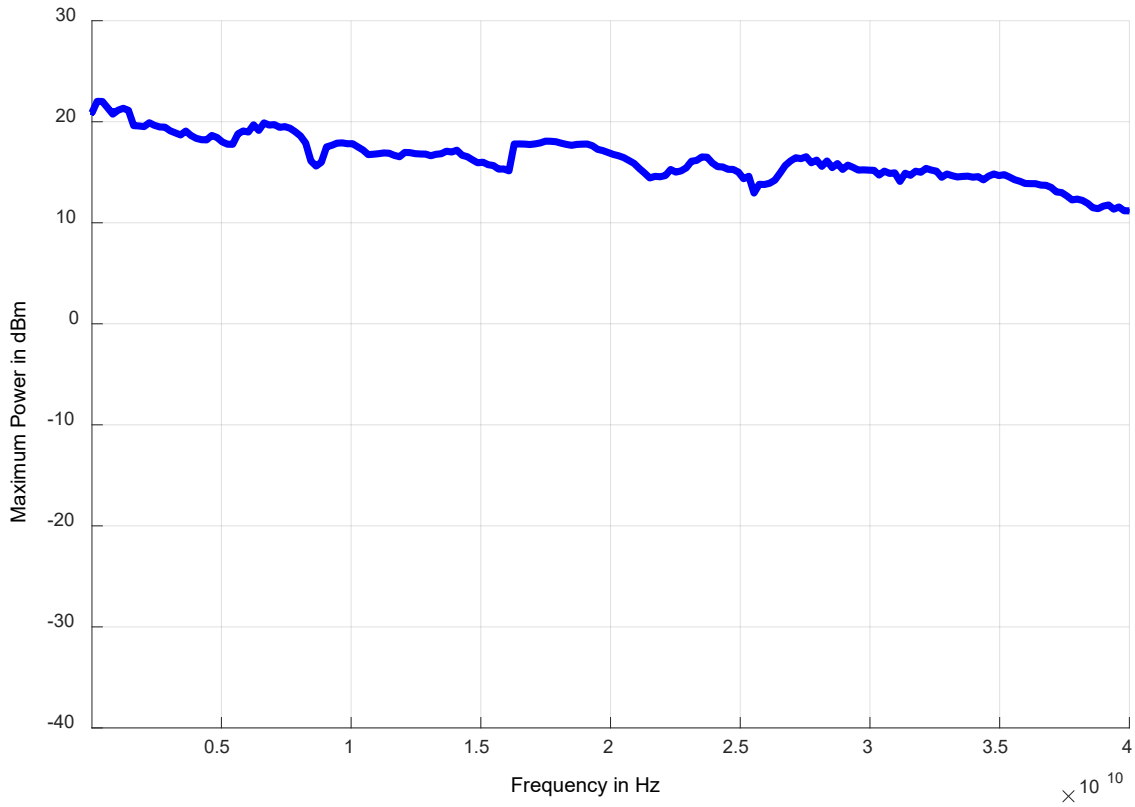
Maximum Output Power 0.01 to 40 GHz



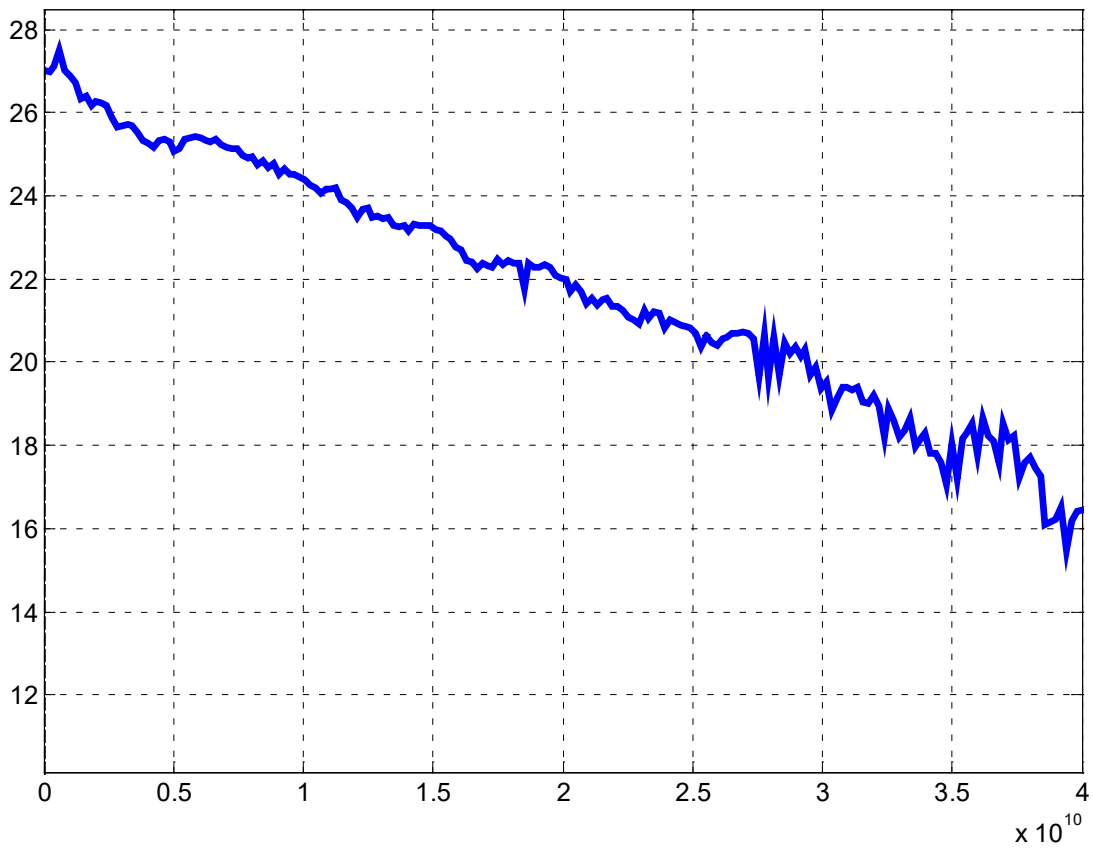
Max Output Power 0.01 to 40 GHz (APULN40 with option PE4)



Max Output Power 0.01 to 40 GHz (with option FILT)



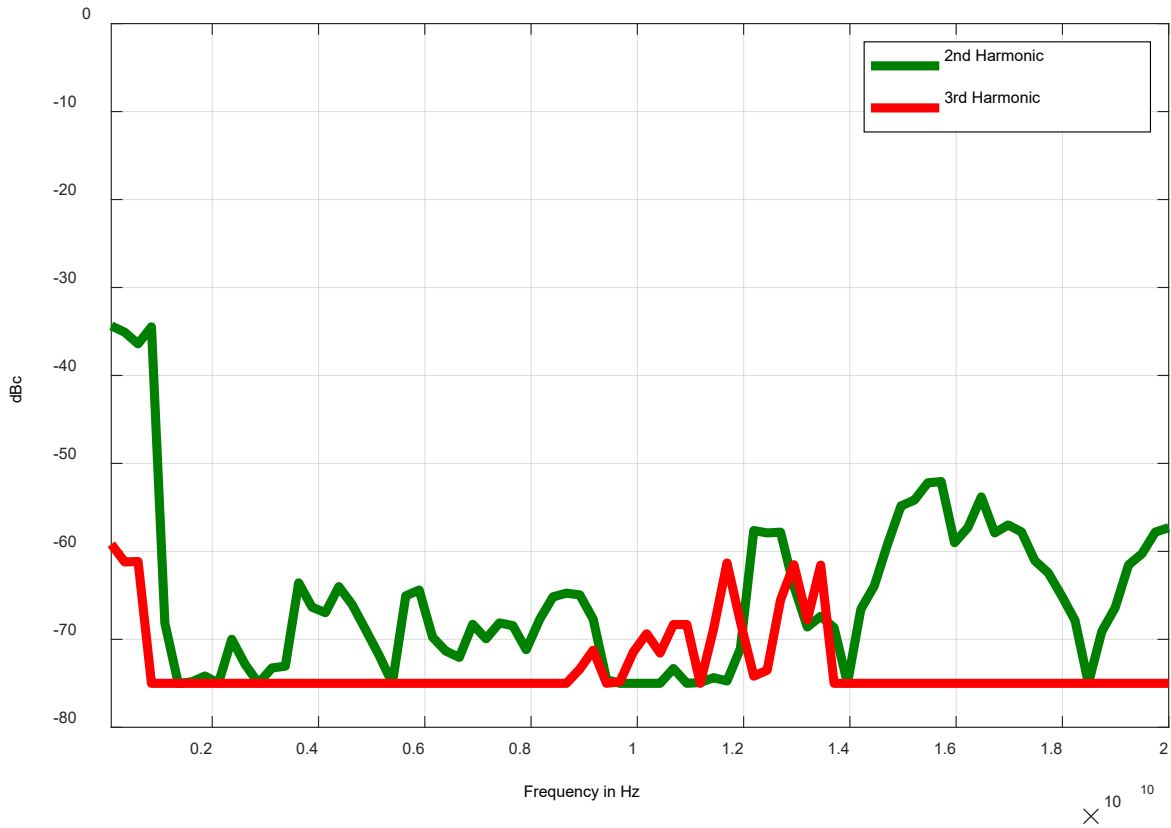
Max Output Power 0.01 to 40 GHz (with option PE2)



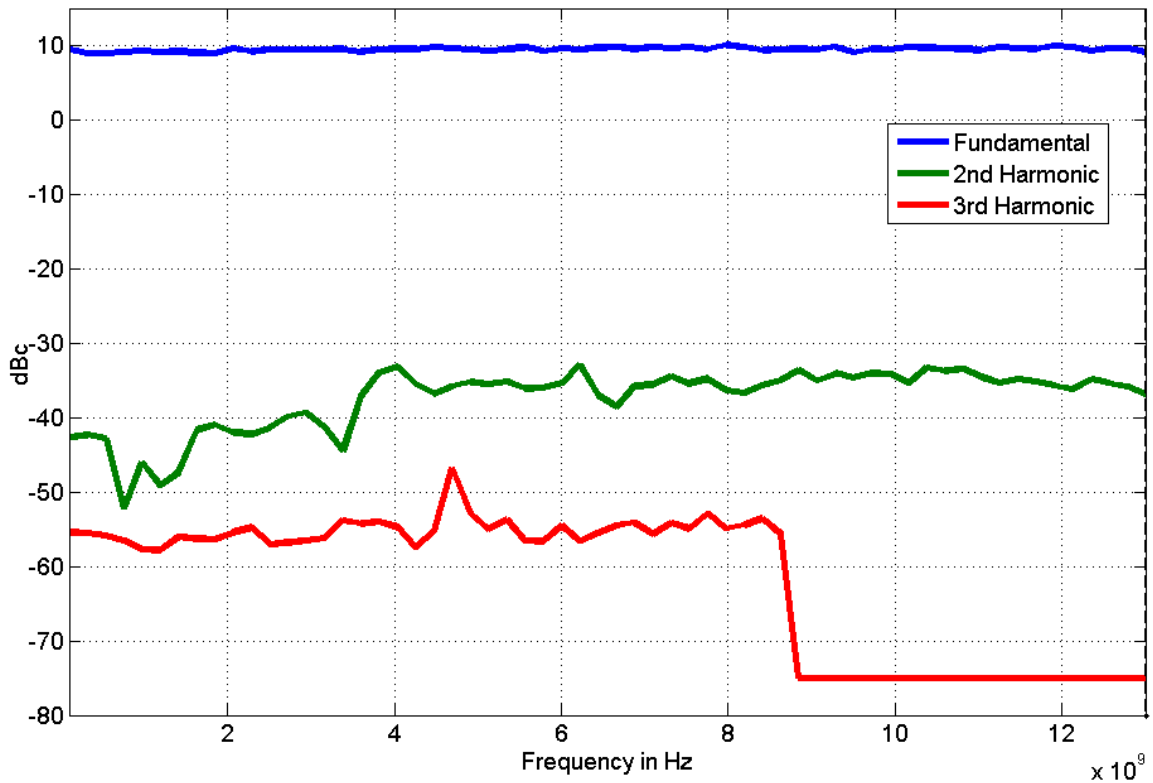
Max Output Power 0.01 to 40 GHz (with option 8K)

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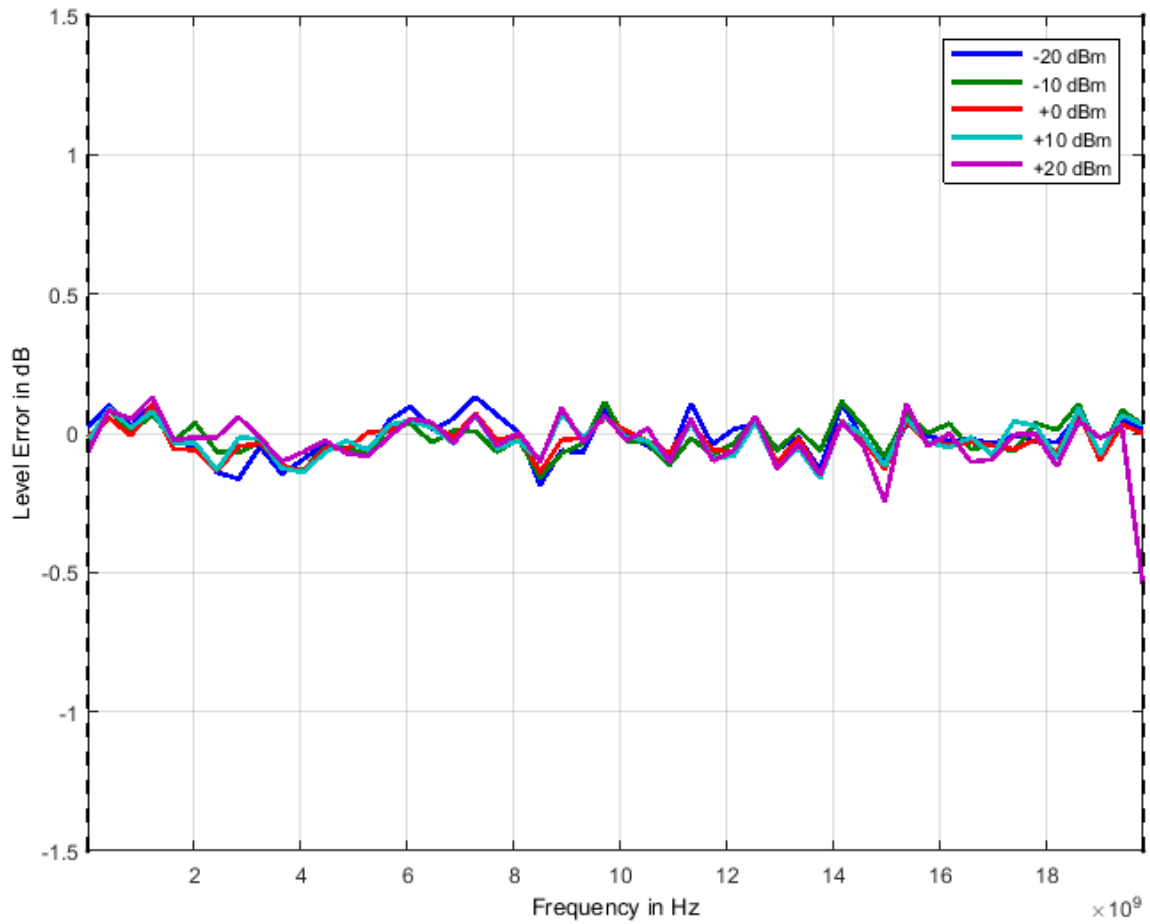
Harmonics (2nd, 3rd at P=+5 dBm, APULN40 with option FILT)



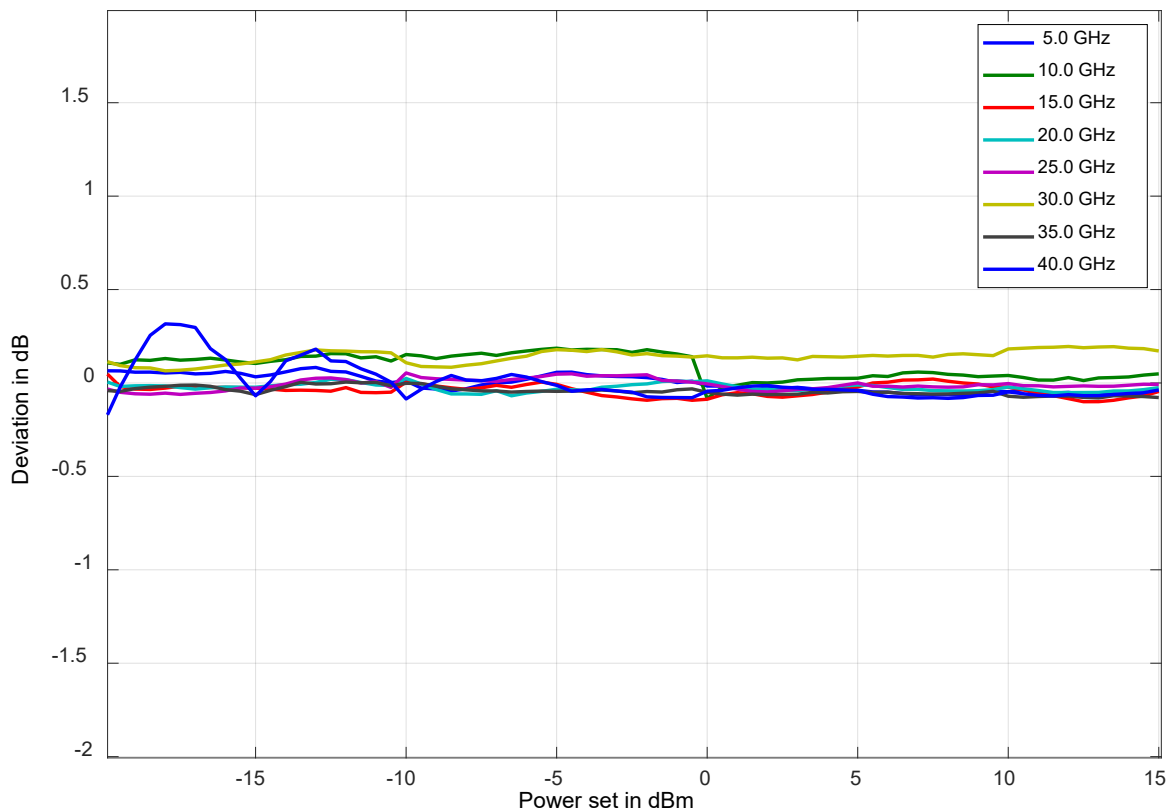
Harmonics (2nd, 3rd at P=+10 dBm, APULN20)



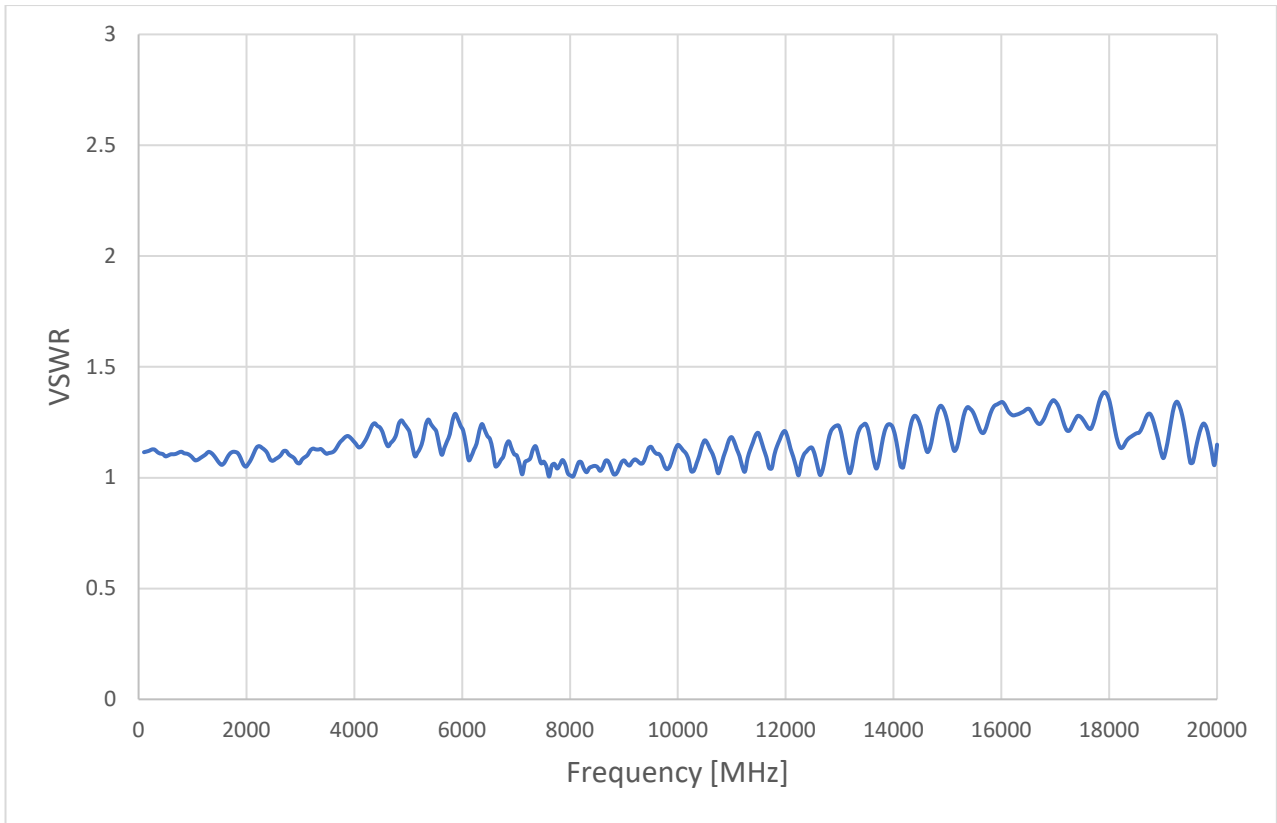
Typical Frequency Response 0 to 20 GHz at different power levels (APULN20)



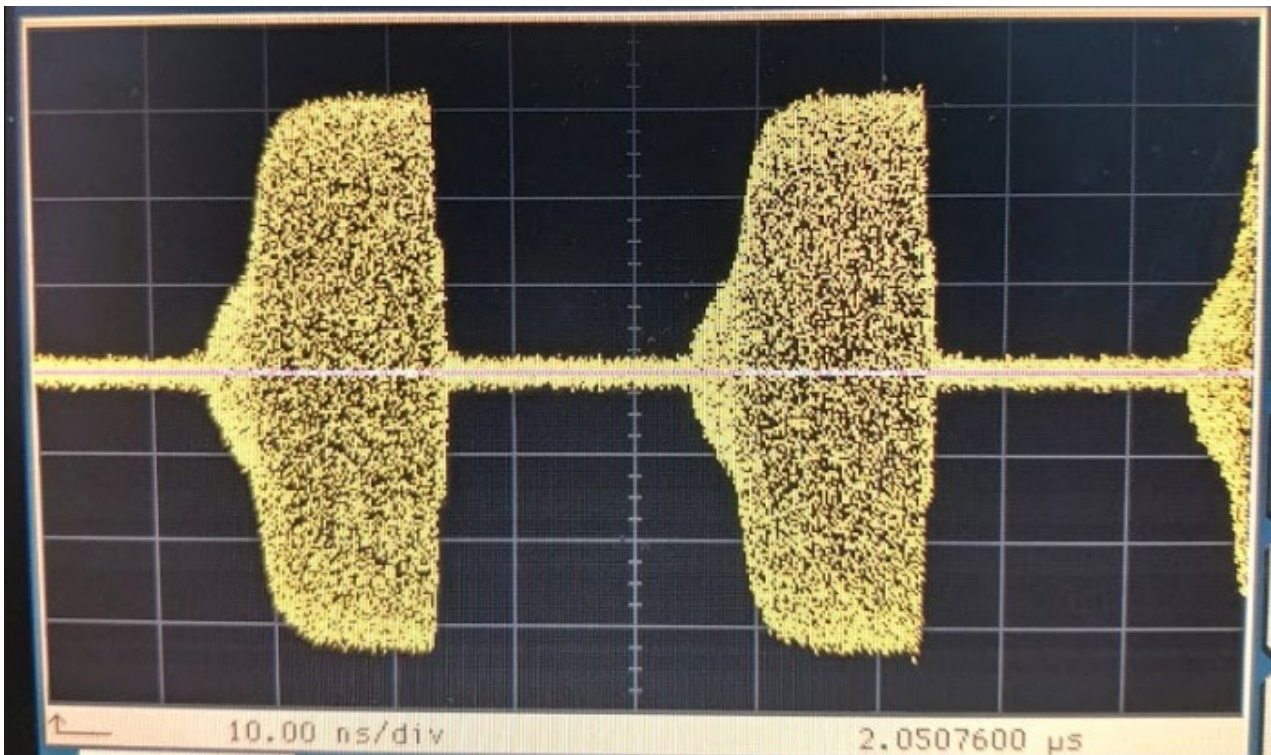
Typical Output Power Linearity (APULN40)



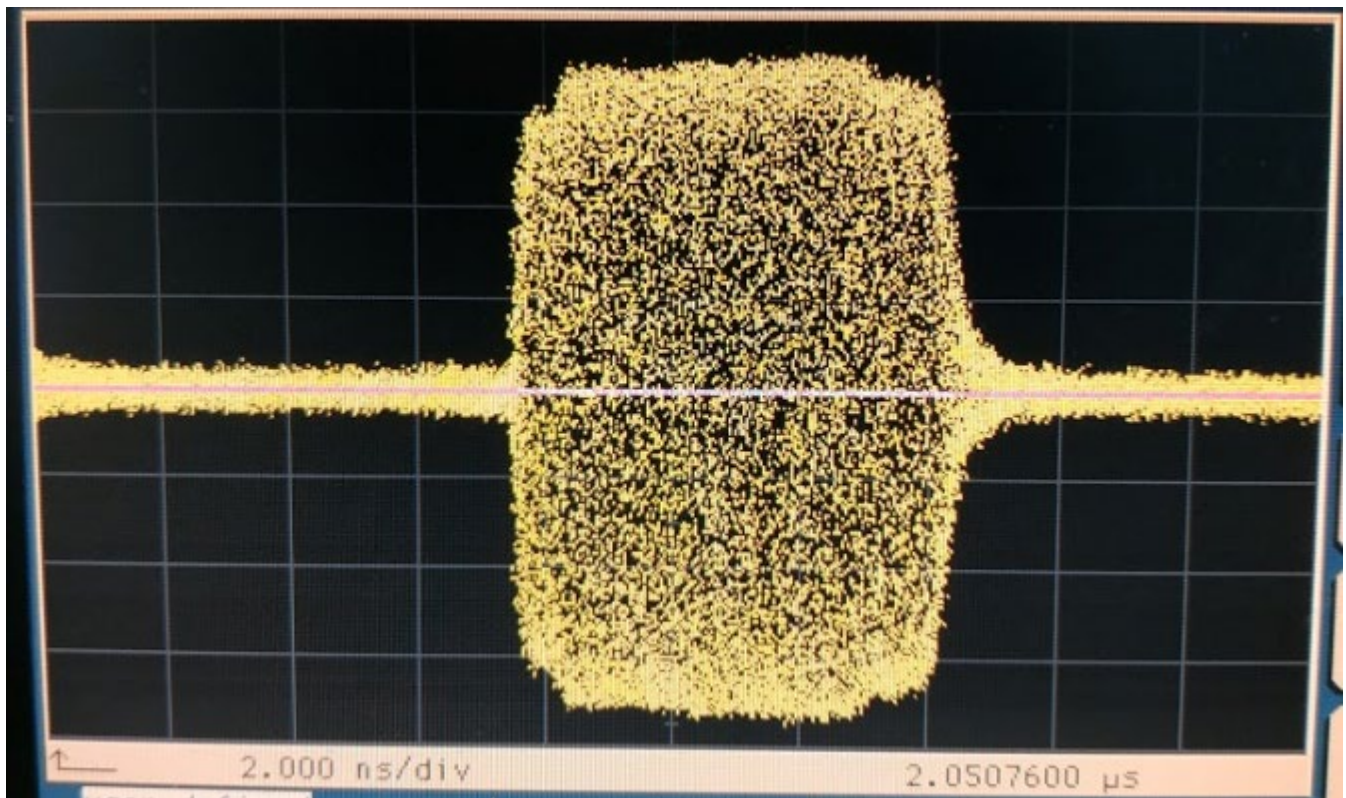
Typical VSWR (APULN20)



Internal Pulse Modulation (10 GHz, 40ns period, 15 ns pulse width)



 Internal Pulse Modulation (38.8 GHz, 15ns period, 7 ns pulse width)



Front panel:

1. RF output:

APULN40: K (2.92 mm) female

APULN06,12,2026: SMA female

2. Rotary knob



Rear panel:

1. TRIG IN: Trigger input: BNC female

2. TRIG OUT: Trigger output: BNC female

3. REF OUT: Internal reference output: BNC female

4. REF IN: External reference input: BNC female

5. MOD IN modulation input for AM/FM/PM: BNC female

6. PULSE IN: Pulse modulation input: BNC female

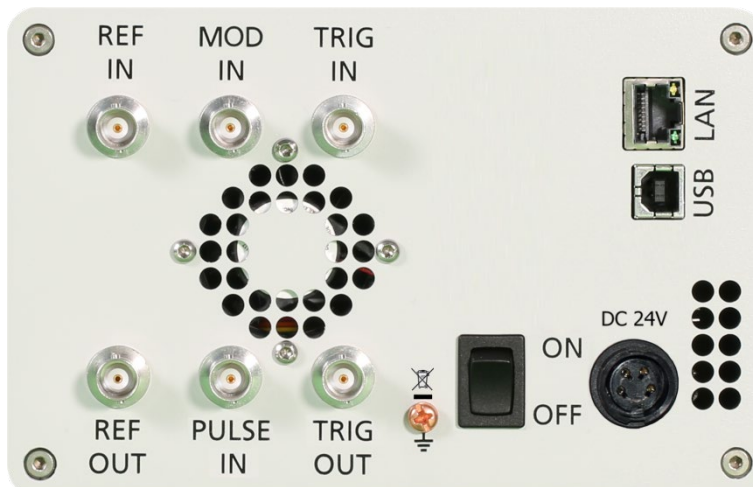
7. LAN connection: RJ-45

8. USB 2.0 host and device

9. GPIB: IEEE-488.2, 1987 with listen and talk (optional)

10. DC Power plug (24V, 3 A)

11. DC power switch



ORDERING INFORMATION



| HOST MODEL | PRODUCT | DESCRIPTION |
|---------------|-------------------------|---|
| APULN06 | APULN06 | 100 kHz – 6 GHz |
| APULN12 | APULN12 | 100 kHz – 12.75 GHz |
| APULN20 | APULN20 | 100 kHz – 20 GHz |
| APULN26 | APULN26 | 100 kHz – 26 GHz |
| APULN40 | APULN40 | 100 kHz – 40 GHz |
| APULNXX | Option LN | Enhanced close in phase noise & frequency stability |
| APULNXX | Option FS | Ultra-fast switching speed |
| APULNXX | Option MOD | Analog modulation |
| APULNXX | Option FILT | Enhanced harmonic rejection |
| APULN26/40 | Option 8K | Frequency range extension to 8 kHz |
| APULNXX | Option VREF | Variable external Reference |
| APULN6/12 | Option PE4-12 | Electrical step attenuator (6 & 12 GHz version) |
| APULN20/26 | Option PE4-20/26 | Electrical step attenuator (20 & 26 GHz version) |
| APULN40 | Option PE4-40 | Electrical step attenuator (40 GHz version) |
| APULN20/26/40 | Option PE3 | Mechanical step attenuator down to -90 dBm (20, 26 & 40 GHz version) |
| APULN20/26/40 | Option PE2 | Mechanical step attenuator down to -120 dBm (20, 26 & 40 GHz version) |
| APULNXX | Option EB | Adapter cable to external power bank |
| APULNXX | Option GPIB | GPIB interface |
| APULNXX | Option LH | Desktop housing with color touch display |
| APULNXX | Option 1URM | 19" 1HU rack enclosure |
| APULNXX | Option REAR | Move output to the rear |
| APULNXX | Option FLASH | MicroSD card slot for removable microSD memory |
| APULNXX | Option WE | One year warranty extension |
| APULNXX | Option ReCal | Recalibration with test data |

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; 25 W maximum

Mains adapter supplied: 100-240 VAC in/ 24 V 4.0 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.

Operating temperature range 0 to 45 °C

Storage temperature range -40 to 70 °C

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



notice

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.) shipping

Dimensions 106 mm H x 172 mm W x 290 mm L (incl. connectors) [4.21 in H x 6.77 in W x 11.42 in L]

Recommended calibration cycle 24 months



Document History

| Version/Status | Date | Author | Notes |
|----------------|------------|--------|---|
| V123 | 2019-02-28 | jk | New layout |
| V124 | 2019-03-21 | jk | Min. Pulse width w. option FS |
| V125 | 2019-10-1 | jk | Pulsed chirps w. option FS |
| V126 | 2019-10-21 | jk | Max power settings revised |
| V130 | 2020-01-26 | jk | Option FILT added |
| V131 | 2020-05-21 | jk | Option 8K added |
| V132 | 2020-07-21 | jk | Refined power ranges, plots added |
| V133 | 2021-02-25 | db | Pulse and trigger input electrical specifications |
| V134 | 2021-05-10 | db | AM, FM, PM input electrical specifications |
| V135 | 2021-06-03 | yg | Adding PE2, PE3, changing o/p power ranges |

AnaPico Inc. of Switzerland

Europastrasse 9
8152 Glattbrugg
Switzerland

Phone +41 44 440 00 50
Email sales@anapico.com

www.anapico.com
www.anapico.com/downloads/

