

FS1 Frequency Synthesizer

Model AP4022A

Multi-channel wideband synthesizer system
8 kHz to 40 GHz



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.

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.

Introduction

Multi-output ultra-low phase noise wideband frequency synthesizer with USB and LAN interface

The FS1 Frequency Synthesizer (AP4022A) is a multi-channel / multi-output, wideband, ultra-low phase noise frequency synthesizer with USB and LAN interface, settable from 100 kHz (8 kHz with Option MFE) to 40 GHz.

The product is available with 1, 2, 3, or 4 fully independently configurable outputs. Frequency, output power, phase, and modulation can be set independently for each output channel.

The settable output power range is from -5 to +25 dBm.

The FS1 Frequency Synthesizer has a milli-Hz frequency resolution and uses a high-stability OCXO internal reference. The reference can be phase-locked to a 10 or 10 MHz external reference. With option 1ER, a user-settable range from 1 to 250 MHz is available.

For highest phase coherence, multiple FS1 Frequency Synthesizers can be cascaded with just one master reference clock.

When ordered with option 1EH, the FS1 Frequency Synthesizer provides excellent harmonic rejection even with a full output power.

The FS1 Frequency Synthesizer offers dedicated sweeping capabilities with switching speeds of only 500 μ s (20 μ s with Option UNZ) and internal phase and narrow pulse modulation.

The module has USB and LAN interfaces (optionally also GPIB) and can be controlled using the SCPI-1999 command set.

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Facts, Figures, and Specifications

Signal specifications

Parameter	Min	Typical	Max	Note
Frequency range	100 kHz	8 kHz	40 GHz	Settable to 43.5 GHz Option MFE
Resolution		0.001 Hz		
Phase resolution		0.01 deg		
Switching speed CW mode Sweep / list mode		1.5 ms 500 μ s 500 μ s 20 μ s		after SCPI command received Option UNZ

Frequency reference

Parameter	Min	Typical	Max	Note
Internal reference frequency		100 MHz 10 MHz		Option LN1
Internal reference output frequency				
Temperature stability			± 100 ppb ± 20 ppb	0 to 45 degC Option LN1
Aging 1 st year			1 ppm 0.02 ppm	Option LN1
Aging per day			5 ppb < 0.5 ppb	after 30 days operations Option LN1
Warm-up time		5 min		
Output of internal reference		100 MHz		
		10 / 100 MHz		Option LN1
Output power	0 dBm	5 dBm		
Output impedance		50 Ohms		
Bypass internal reference input		100 MHz		High phase synchronous mode
Phase lock to external reference	1 MHz	10 MHz integer MHz	250 MHz	Option 1ER
Reference bypass mode		100 MHz		
Reference input level				
10 MHz or 1-250 MHz	-5 dBm	0 dBm	+13 dBm	
Bypass 100 MHz	5 dBm		+15 dBm	
Reference input impedance		50 Ohm		
Lock range				
10 MHz or 1-250 MHz			± 1.5 ppm	
Bypass 100 MHz			> 100 ppm	

Level performance

Parameter	Min	Typical	Max	Note
Output power range				(see also plots)
8 kHz to 10 MHz	-10 dBm		+20 dBm	Option MFE
10 MHz to 5 GHz	-10 dBm		+20 dBm	
5 to 20 GHz	-5 dBm		+20 dBm	
20 to 28 GHz	10 dBm		+19 dBm	
28 to 40 GHz	0 dBm		+16 dBm	
10 MHz to 5 GHz	-10 dBm		+15 dBm	Option 1EH
5 to 20 GHz	-10 dBm		+12 dBm	Option 1EH
20 to 28 GHz	5 dBm		+12 dBm	Option 1EH
28 to 40 GHz	-10 dBm		+10 dBm +8 dBm	Option 1EH Option 1EH+MFE

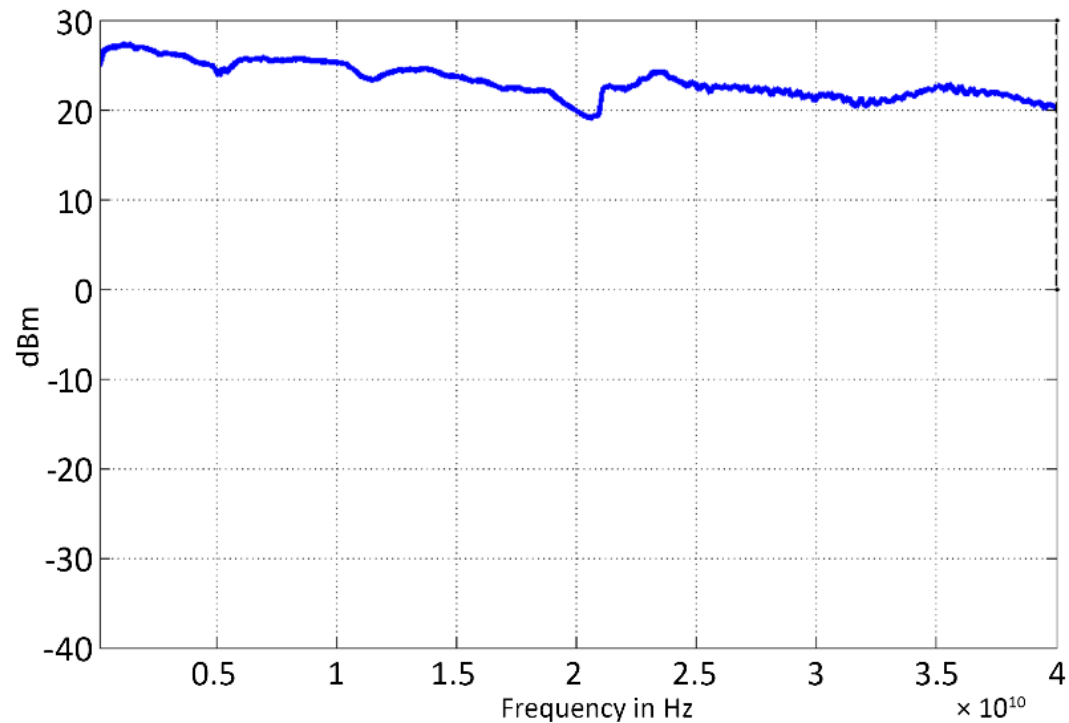


Figure 1. Maximum output power (without Option 1EH)

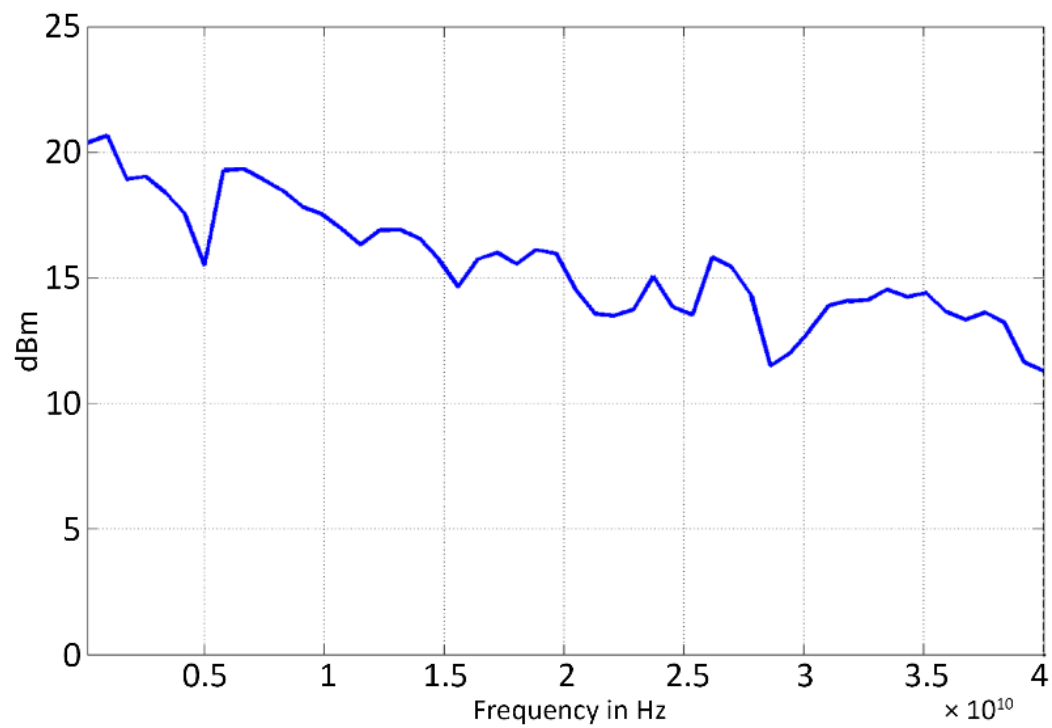


Figure 2. Maximum output power with 1EH

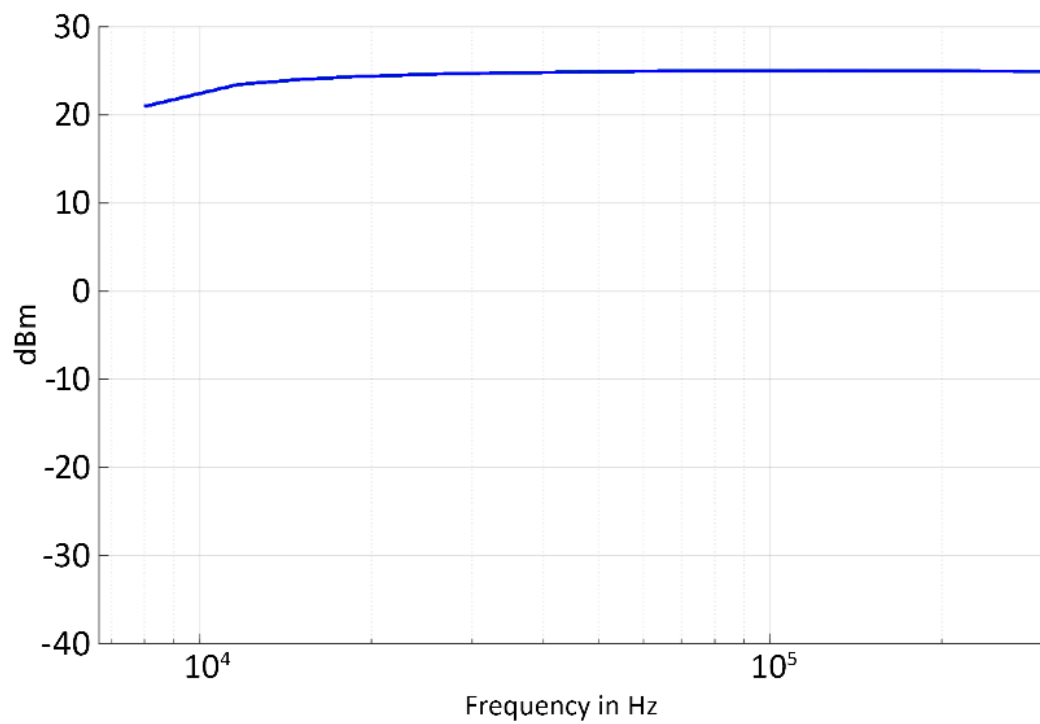


Figure 3. Maximum output power at 8 to 250 kHz

Level accuracy

Parameter	Min	Typical	Max	Note
Power resolution		0.5 dB		
Power accuracy		± 1.0 dB	± 2.5 dB	

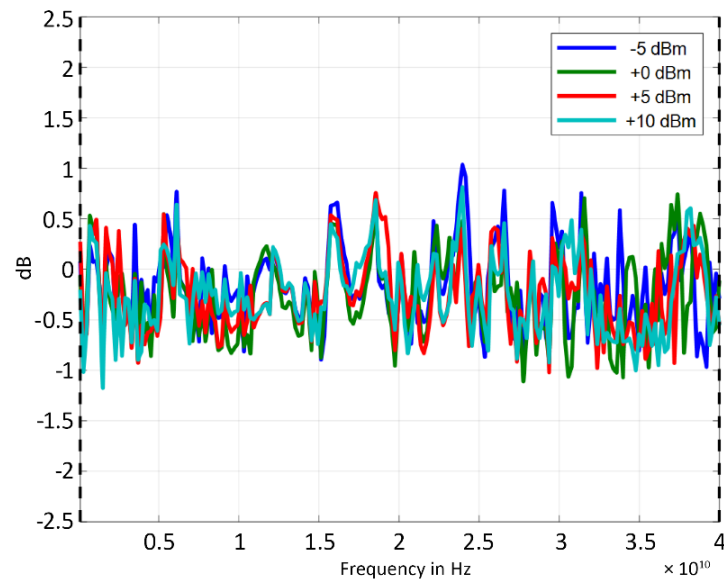


Figure 4. Power level accuracy (with Option 1EH)

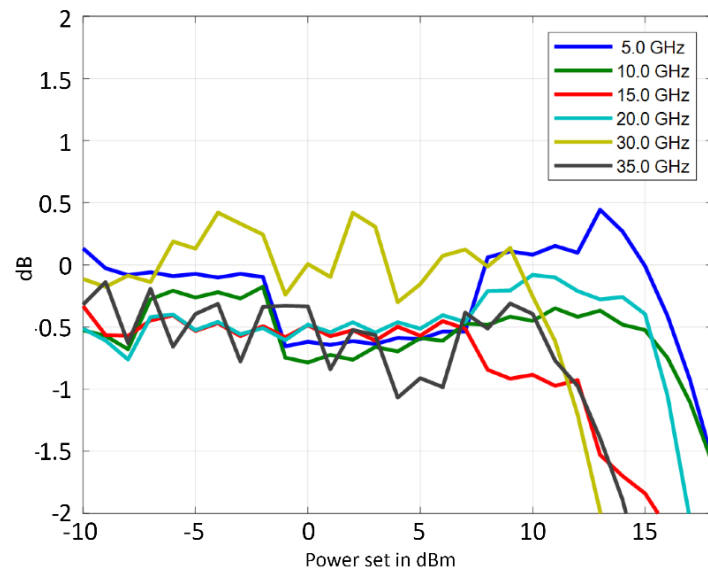


Figure 5. Power level linearity (with Option 1EH)

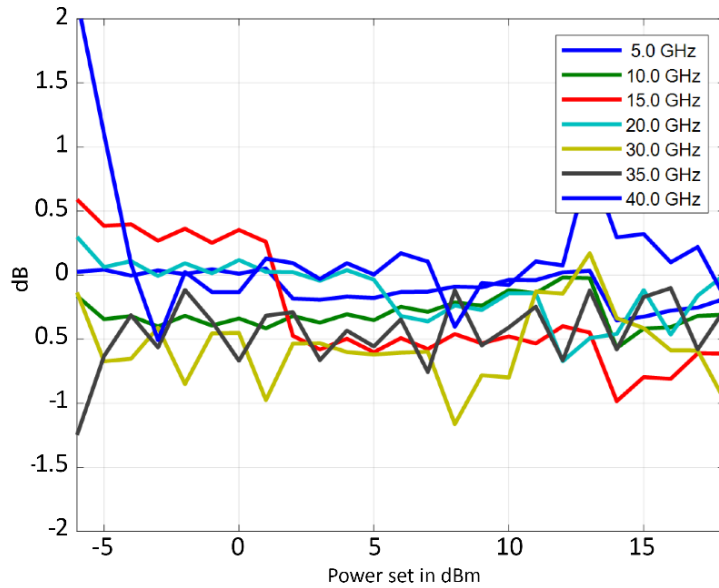


Figure 6. Power level linearity

Reverse power protection and VSWR

Parameter	Min	Typical	Max	Note
Reverse power protection				
DC voltage		7 V		
RF power			20 dBm	
Output impedance		50 Ohms		
VSWR		1.8		

Phase noise

Parameter	Min	Typical	Max	Note
SSB Phase noise at 1 GHz				(see also plot)
at 10 Hz from carrier		-93 dBc / Hz		Option LN1
at 1 kHz from carrier		-130 dBc / Hz		
at 100 kHz from carrier		-145 dBc / Hz		
Wideband noise		-160 dBc / Hz		
SSB Phase noise at 10 GHz				
at 10 Hz from carrier		-73 dBc / Hz		Option LN1
at 1 kHz from carrier		-110 dBc / Hz		
at 100 kHz from carrier		-125 dBc / Hz		
Wideband noise		-160 dBc / Hz		

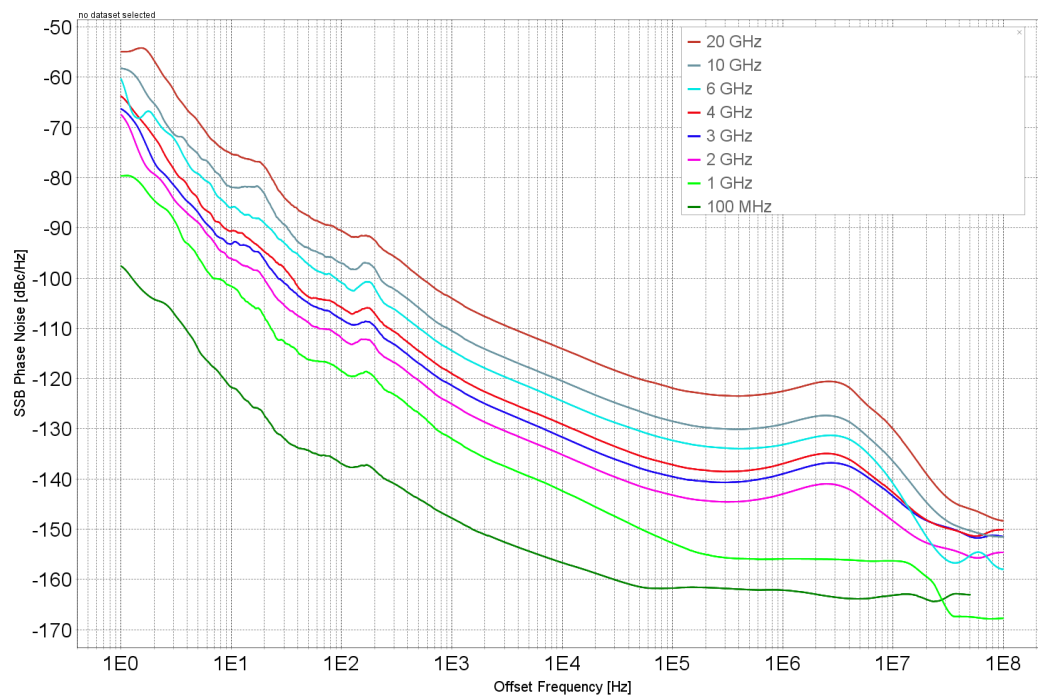


Figure 7. Phase noise performance with Option LN1

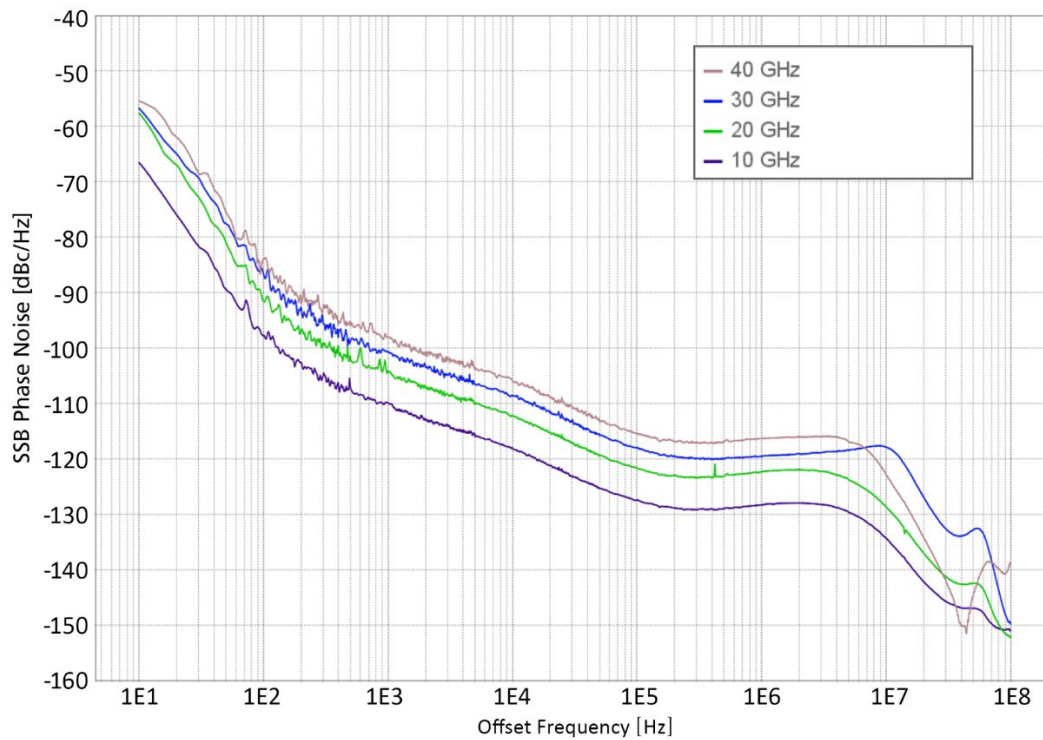


Figure 8. Phase noise performance without Option LN1 (LN0, standard phase noise)

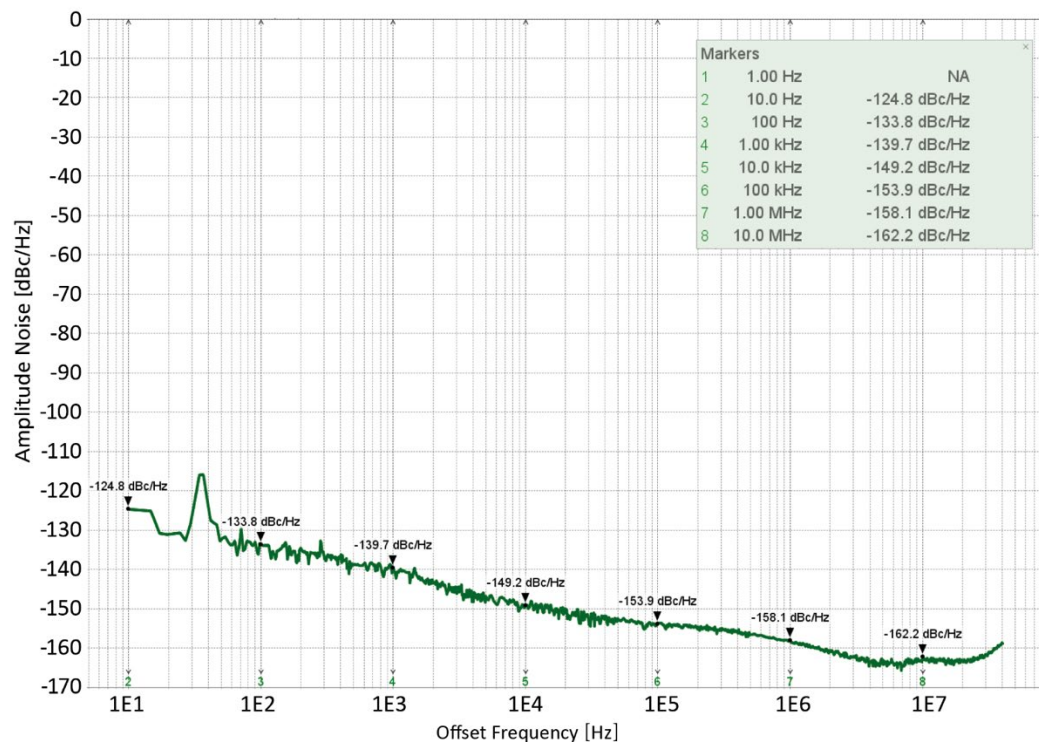


Figure 9. Amplitude noise at 10 GHz

Spectral purity

Parameter	Min	Typical	Max	Note
Output harmonics @ 5 dBm < 1.2 GHz 1.2 to 2.5 GHz 2.5 to 5 GHz 5 to 12 GHz 12 to 20 GHz > 20 GHz		-25 dBc -15 dBc -30 dBc -15 dBc -25 dBc -20 dBc	-20 dBc -9 dBc -23 dBc -9 dBc -20 dBc -12 dBc	(see also plots)
Output harmonics @ 0 dBm < 1 GHz > 1 GHz		-35 dBc -55 dBc	-25 dBc -45 dBc	Option 1EH
Sub-harmonics @ 5 dBm		-75 dBc -55 dBc	-50 dBc -25 dBc	< 20 GHz > 20 GHz
Non-harmonic spurious @ 5 dBm CW, offset from 10 kHz until 500 MHz < 1.2 GHz 1.2 - 2.5 GHz 2.5 - 5 GHz 5 - 10 GHz 10 - 20 GHz > 20 GHz		-90 dBc -85 dBc -80 dBc -75 dBc -70 dBc -65 dBc	-60 dBc -55 dBc -55 dBc -55 dBc -55 dBc -50 dBc	

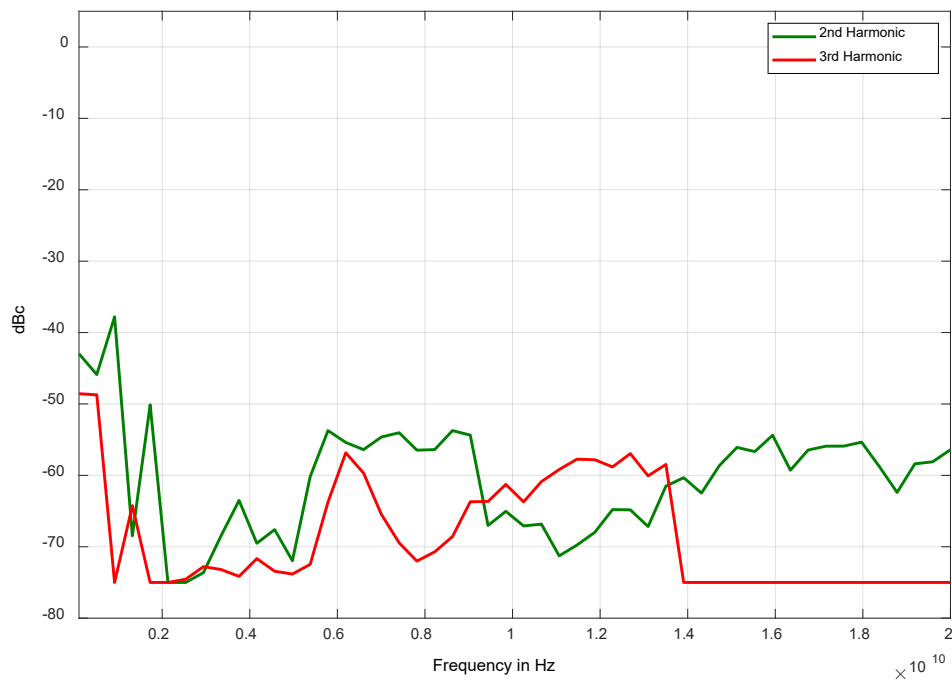


Figure 10. Harmonics @ 0 dBm (with Option 1EH)

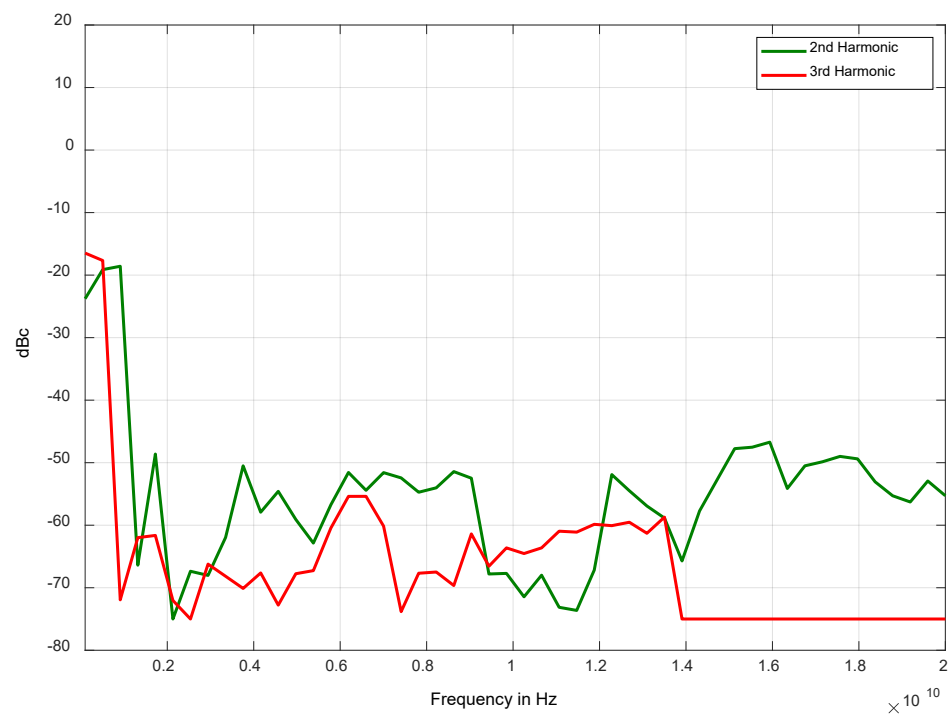


Figure 11. Harmonics +15 dBm (with Option 1EH)

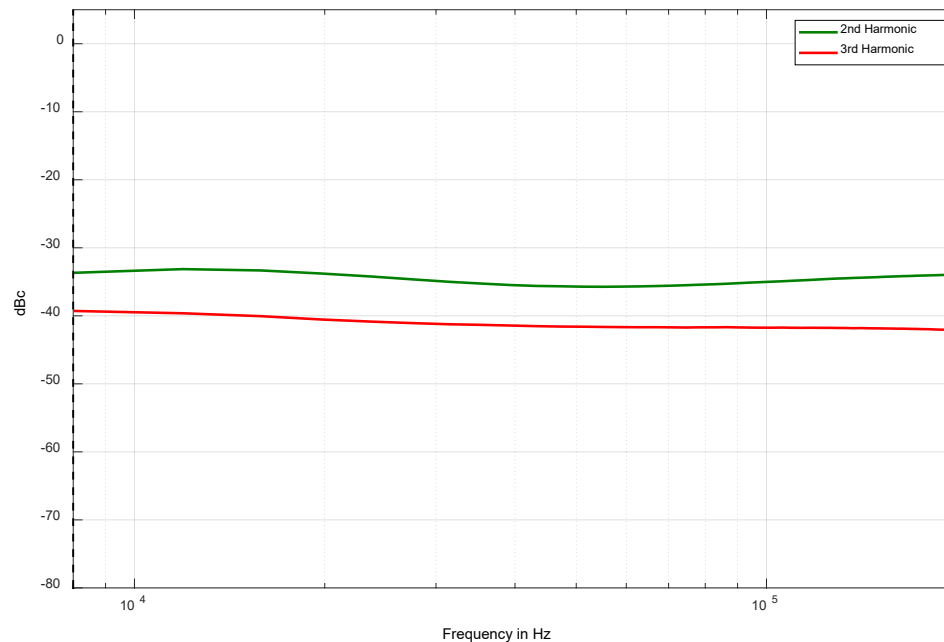


Figure 12. Harmonics at lower frequencies and 0 dBm

Modulation capabilities

Pulse modulation

Parameter	Min	Typical	Max	Note
Modulation source		Internal / external		
Pulse rise / fall time		10 ns		
On / off ratio				
Frequency range				
Min. freq. to 6 GHz			25 dBc	
6 to 12 GHz			18 dBc	
12 to 15 GHz			25 dBc	
15 to 22 GHz			18 dBc	
22 to max. freq.			25 dBc	
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		

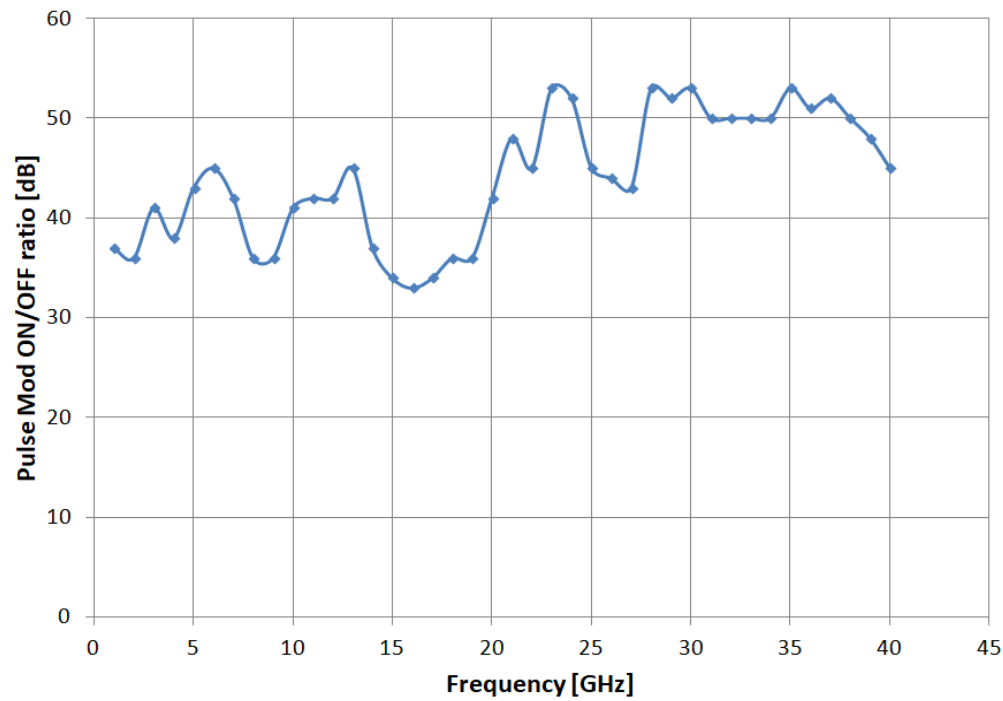


Figure 13. Pulse modulation on-off ratio

Internal pulse generator

Parameter	Min	Typical	Max	Note
Repetition frequency (PRF)	0.1 Hz		100 MHz	= 1/T
Duty cycle	1 % to 99 % in 1% steps			within specified minimum pulse width
Minimum pulse settling range	30 ns		20 s	
Pulse pattern modulation and staggered PRF				Using internal pattern generator
Pulse width	30 ns		5 s	
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		< 100 ps	1 ns	
Polarity		selectable		

Frequency modulation

Parameter	Min	Typical	Max	Note
Modulation source		Internal		
Maximum frequency deviation (peak)	$N \cdot 400 \text{ MHz}$			$< 1.25 \text{ GHz}$ (N=1) $1.25 \text{ GHz to } 2.5 \text{ GHz}$ (N=0.125) $2.5 \text{ GHz to } 5 \text{ GHz}$ (N=0.25) $5 \text{ GHz to } 10 \text{ GHz}$ (N=0.5) $10 \text{ GHz to } 20 \text{ GHz}$ (N=1) $20 \text{ GHz to } 40 \text{ GHz}$ (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			

Phase modulation

Parameter	Min	Typical	Max	Note
Modulation source		Internal		
Phase deviation (peak)	0		$300 \cdot N \cdot \text{rad}$	
Deviation accuracy		0.50%	2%	
Modulation rate	0.1 Hz		80 kHz	
Modulation waveforms	Sine			
Distortion (THD)	$< 1\%$			1 kHz rate and $N \times \text{rad}$ deviation

Sweeping capability, sweep type: Linear, logarithmic, random

Parameter	Min	Typical	Max	Note
Frequency sweep				
Step time (t_{step})	500 μs 20 μs			Option UNZ
Dwell time (t_{dwell})	15 μs			

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	
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		

Connectors

Front



1. DC power switch
2. External pulse modulation inputs: BNC female (1 to 4)
3. RF outputs: K (2.92 mm) female (1 to 4)

Rear



1. Reserved for future use
2. Reserved for future use
3. Reserved for future use
4. Reserved for future use
5. Reference output (REF OUT): BNC female
6. Reference input (REF IN): BNC female
7. Trigger output (TRIG OUT): BNC female
8. Trigger input (TRIG IN): BNC female
9. GPIB: IEEE-488.2, 1987 with listen and talk (optional)
10. USB 2.0 device
11. LAN connection: RJ-45
12. FUSE (3.15 A)
13. 100-240V AC power plug

Order Information

Model number	Option number	Description
AP4022A	001	Add channel 1
AP4022A	002	Add channel 2; requires Option 001
AP4022A	003	Add channel 3; requires Option 002
AP4022A	004	Add channel 4; requires Option 003
AP4022A	540	Frequency range, 100 kHz to 40 GHz; required for each channel
AP4022A	MFE	Frequency range extension to 8 kHz; required for each channel, if ordered
AP4022A	LN0	Standard phase noise
AP4022A	LN1	Enhanced phase noise and frequency stability; required for each channel, if ordered
AP4022A	UNZ	Fast switching; required for each channel, if ordered
AP4022A	1EH	Improved harmonics; required for each channel, if ordered
AP4022A	UK6	Commercial calibration certificate with test data; required for each channel, if ordered
AP4022A	1ER	Flexible reference input
AP4022A	GPB	GPIB interface

General Characteristics

Remote programming interfaces:

- Ethernet 100BaseT LAN interface
- USB 2.0 host and device
- GPIO (IEEE-488.2, 1987) with listen and talk (optional)
- Control language SCPI Version 1999.0

Power requirements: 100-240 VAC, 50/60 Hz, 150W

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

Operating temperature range 0 to 45 °C

Storage temperature range -40 to 70 °C

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



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

Weight ≤ 10.0 kg (22 lbs) net

Dimensions: 19" 1HU enclosure: 43 mm H x 426 mm W x 460 mm L [1.7 in H x 16.8 in W x 18.1 in L]

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