FS1 Frequency Synthesizer

Model AP4021A

Wideband synthesizer
8 kHz to 40 GHz

KEYSIGHT

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 / 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-compact, fast, and ultra-low phase noise frequency synthesizer with USB and LAN interface

The FS1 Frequency Synthesizer (AP4021A) is a wideband low phase-noise synthesizer settable from 8 kHz to 40 GHz. The settable output power range is from -10 to +25 dBm.

The module has a milli-Hz frequency resolution and uses a high-stability internal reference. The internal reference can be phase-locked to a user-settable external reference. For highest phase coherence, multiple FS1 Frequency Synthesizer can be cascaded with just one master reference clock.

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

The module has USB and LAN interfaces and can be controlled using the SCPI 1999 command set. Operated with an external 24V DC supply, it consumes less than 25 W.

Facts, Figures, and Specifications

Signal specifications

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

Frequency reference

Parameter	Min	Typical	Max	Note
Internal reference frequency		100 MHz 10 MHz		 Option LN1
Temperature stability			±100 ppb ±20 ppb	0 to 40 degC Option LN1
Aging 1st 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		5 dBm		
Output impedance		50 Ohms		
Bypass internal reference Input		100 MHz		High phase synchronous mode *Option LN1 is bypassed
Phase lock to external reference	1 MHz	10 MHz integer MHz	250 MHz	 Option 1ER *Option LN1 is bypassed
Reference Bypass mode		100 MHz		

Frequency reference (continued)

Parameter	Min	Typical	Max	Note
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

( ): Typical value

Parameter	Min	Typical	Max	Note
Output power level				(see plot)
10 MHz to 1.2 GHz	(0 dBm)		+20 dBm +18 dBm	Option 1EH
1.2 GHz to 20 GHz	(-10 dBm)		+18 dBm +13 dBm	Option 1EH
20 to 30 GHz	(+10 dBm)		+18 dBm +10 dBm	Option 1EH
30 to 40 GHz	(0 dBm)		+14 dBm +9 dBm	Option 1EH
Power resolution		0.5 dB		
Power accuracy		±0.5 dB	±2 dB	

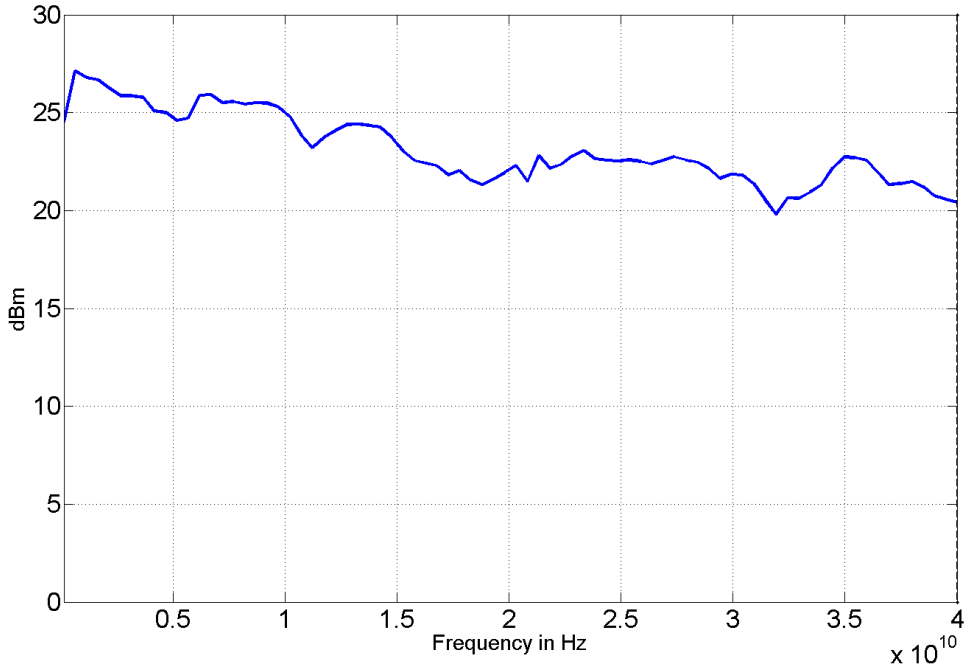


Figure 1. Maximum output power (standard)

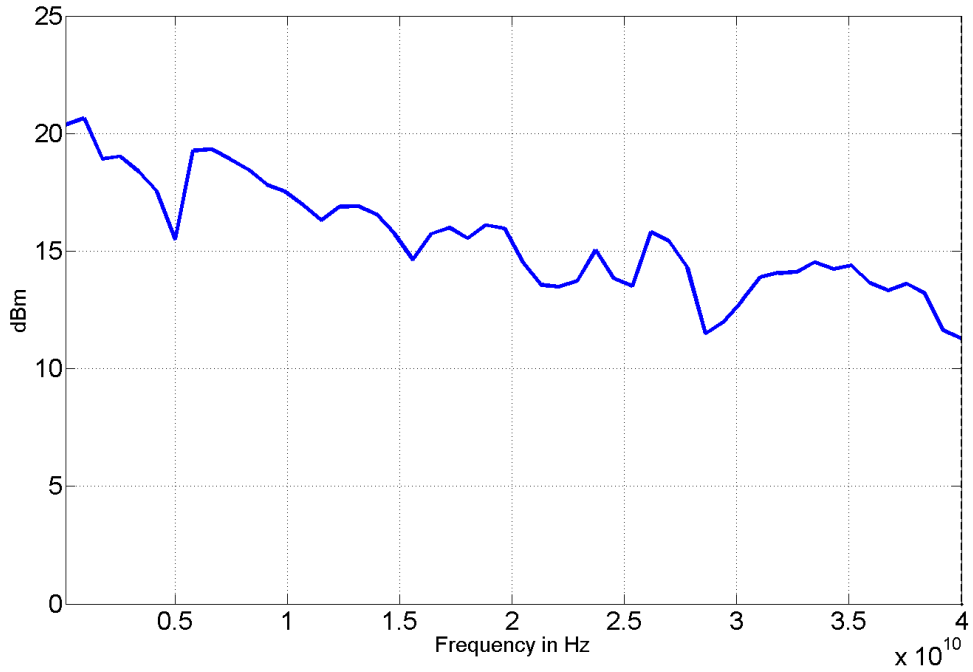


Figure 2. Maximum output power with 1EH

Reverse power protection and VSWR

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

Phase noise

Parameter	Min	Typical	Max	Note
SSB phase noise at 1 GHz				(see 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		

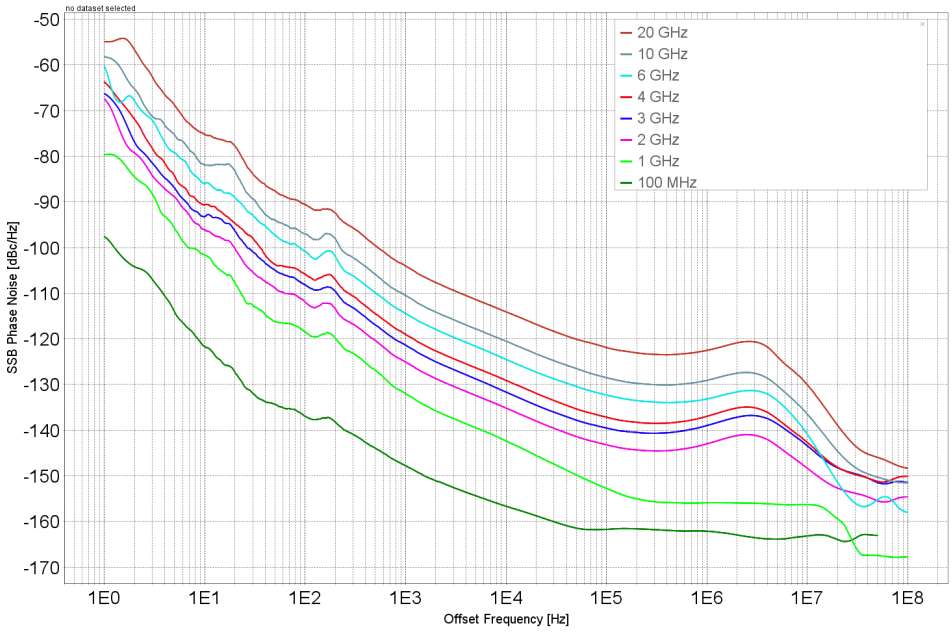


Figure 3. Phase noise performance with Option LN1

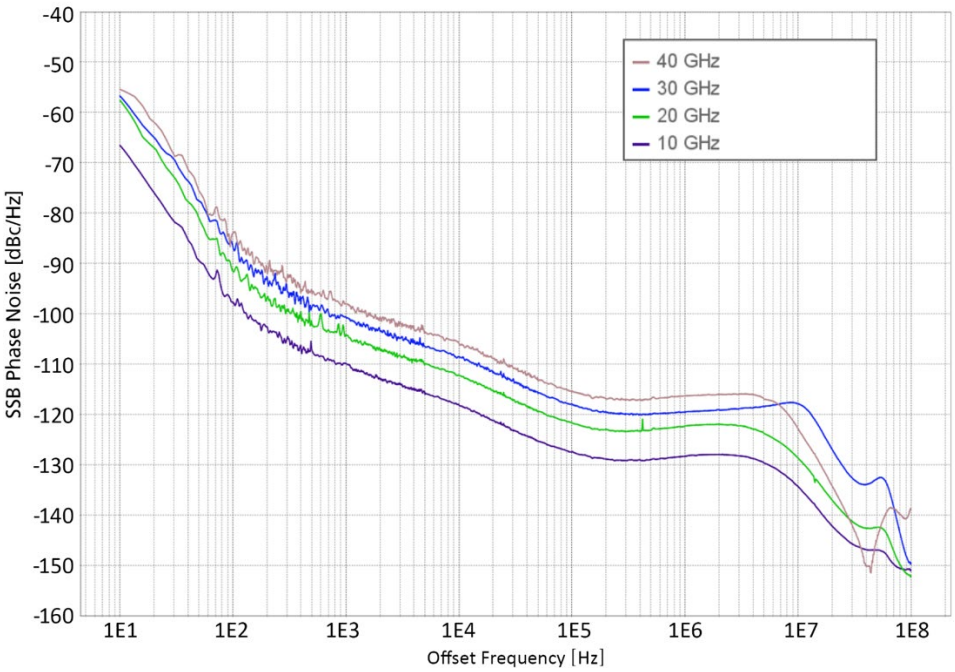


Figure 4. Phase noise performance without Option LN1 (LN0, standard phase noise)

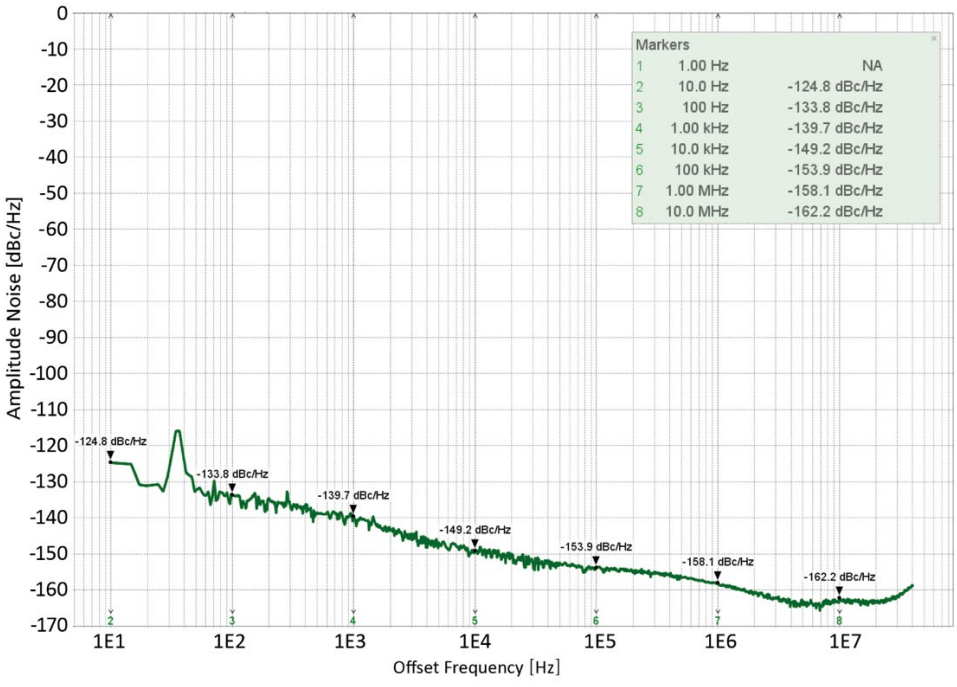


Figure 5. Amplitude noise at 10 GHz

Spectral purity

Parameter	Min	Typical	Max	Note
Output harmonics (at 9 dBm Pout)		-15 dBc -55 dBc -55 dBc	 -45 dBc -35 dBc	 Option 1EH, at 1 to 13.5 GHz Option 1EH, H2 at 13.5 to 20 GHz
Sub-harmonics		-75 dBc -50 dBc		< 20 GHz > 20 GHz
Non-harmonic spurious		-75 dBc		

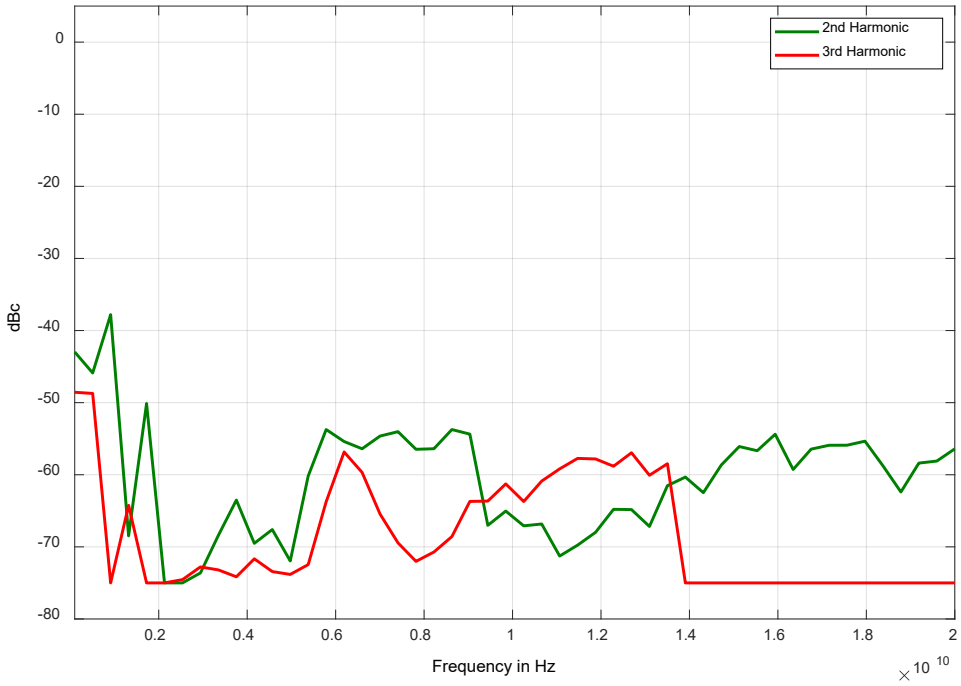


Figure 6. Harmonics @ 0 dBm (with Option 1EH)

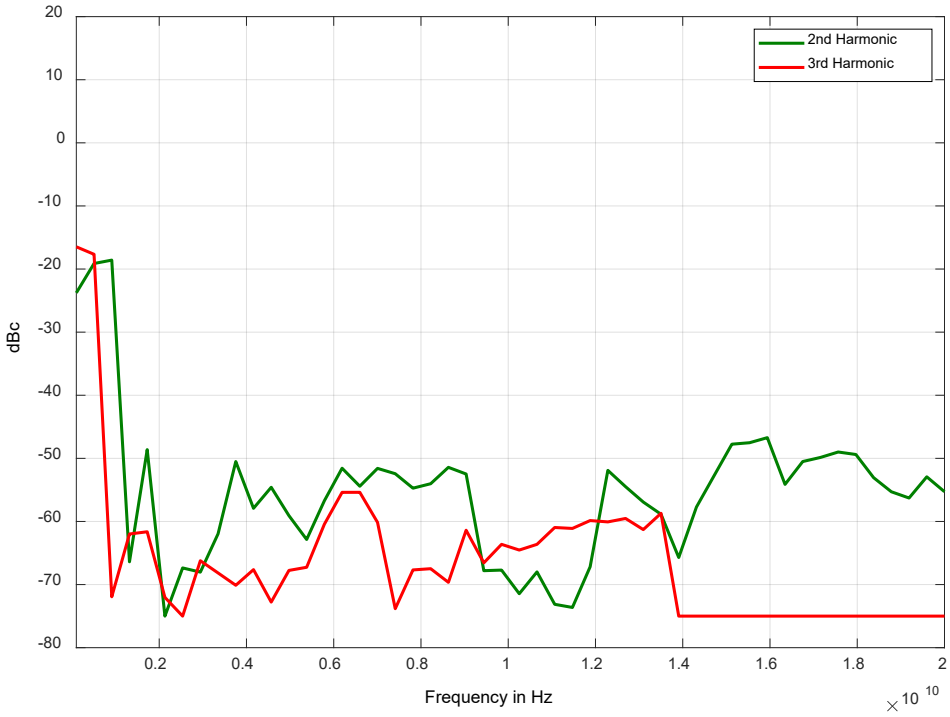


Figure 7. Harmonics +15 dBm (with Option 1EH)

Modulation capabilities

Pulse modulation

Parameter	Min	Typical	Max	Note
Modulation source		Internal / external		
Pulse rise / fall time		10 ns		
On / off ratio		40 dB		Pout > +10 dBm, see plot
Pulse overshoot			10%	Excluding video feedthrough
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		

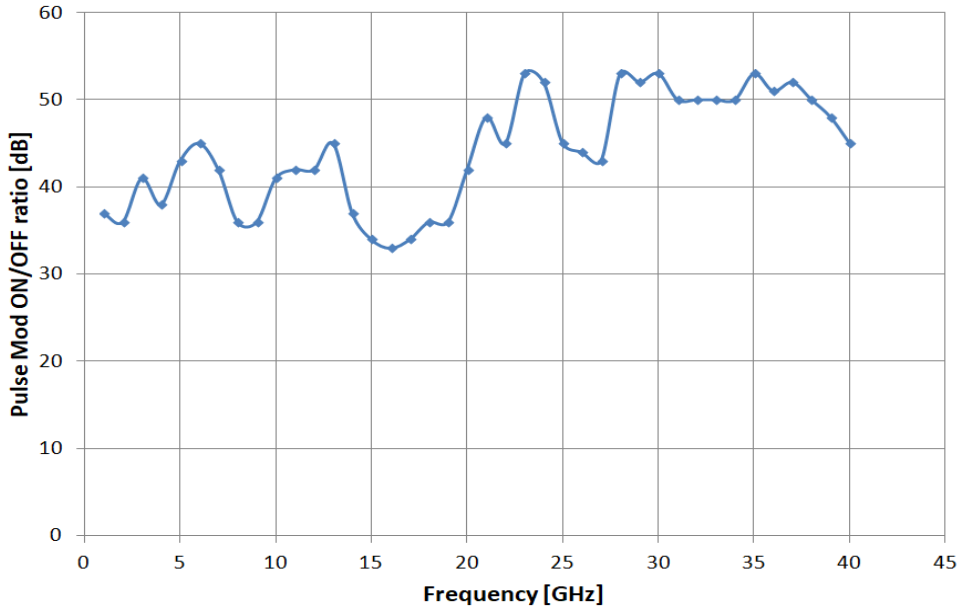


Figure 8. Pulse modulation on-off ratio

Internal pulse generator

Parameter	Min	Typical	Max	Note
Duty cycle	1% to 99% in 1% steps			within specified minimum pulse width
Pulse width setting range	30 ns		5 s	
Pulse pattern modulation and staggered PRF				using internal pattern generator
Programmable pattern length	2		4096	
Duty cycle	0.05%		99.95%	
Pulse period (T) accuracy		0.00005xT+ 3ns		
Pulse width accuracy		0.00005xT+ 5ns		
Pulse width resolution		5 ns		
Pulse jitter		2 ns	5 ns	
Polarity		selectable		

Frequency modulation

Parameter	Min	Typical	Max	Note
Frequency modulation				
Modulation source		Internal		
Maximum frequency deviation (peak)	N · 400 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			

Phase modulation

Parameter	Min	Typical	Max	Note
Modulation source		Internal		
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 and N x rad deviation

Sweeping capability

Sweep type: linear, logarithmic, random

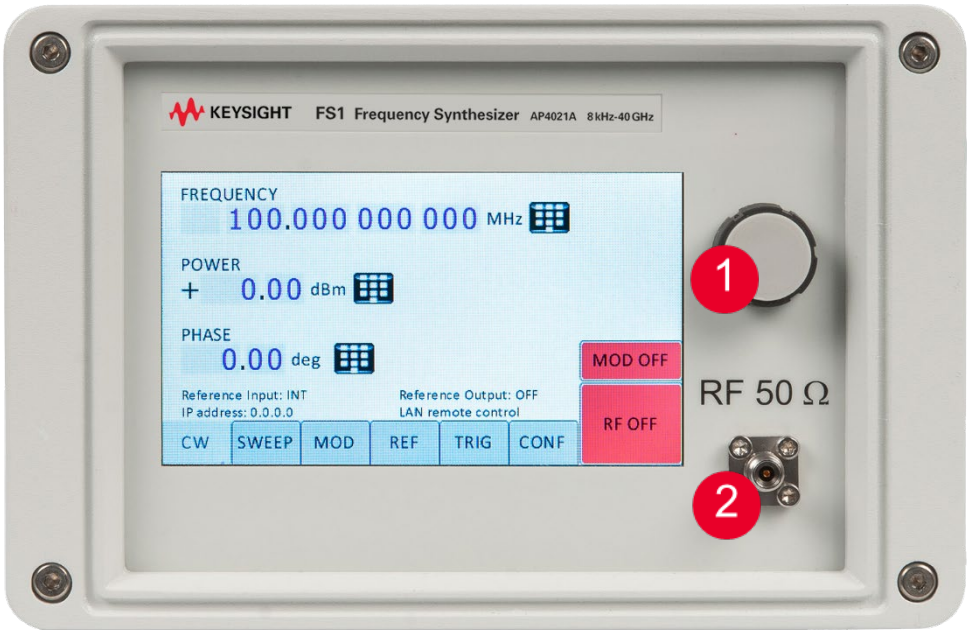
Parameter	Min	Typical	Max	Note
Frequency sweep				
Step time (t_{step})	500 µs 20 µs			Option UNZ
Dwell time (t_{dwell})	15 µs			

Trigger (TRIG IN): Input is TRIG IN at front panel

Parameter	Min	Typical	Max	Note
Trigger types	Continuous, single (point)			
Trigger source	External, bus (LAN, USB)			
Trigger modes	Continuous free run, trigger and run			
Trigger latency		5 ns		
Trigger uncertainty		10 ns		
External trigger delay	50 ns		20 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		

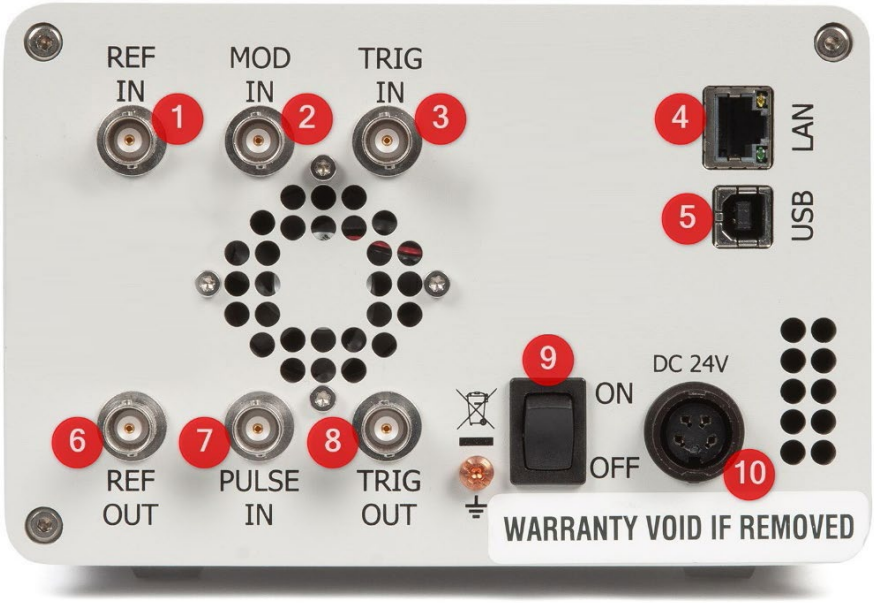
Connectors

Front



1. **Rotary button** The rotary button is used to change the value selected on the screen.
2. **RF 50 Ω connector** This female K-type connector provides the output for generator signals. The impedance is 50 ohm. The reverse power damage level is +20 dBm maximum. The maximum allowed DC level is +/- 7 V. Please check the data sheets for more details.

Rear



1. **REF IN** External reference input: BNC female
2. **MOD IN** Modulation input for FM / PM: BNC female
3. **TRIG IN** Trigger input: BNC female
4. **LAN connection** RJ-45
5. **USB 2.0** host and device
6. **REF OUT** Internal reference output: BNC female
7. **PULSE IN** Pulse modulation input: BNC female
8. **TRIG OUT** Trigger output: BNC female
9. **DC power switch**
10. **DC power plug** (24 V, 3 A)

Order Information

Model number	Option number	Description
AP4021A	**540**	Frequency range, 100 kHz to 40 GHz
AP4021A	**MFE**	Frequency range extension to 8 kHz
AP4021A	**LN0**	Standard phase noise
AP4021A	**LN1**	Enhanced phase noise and frequency stability
AP4021A	**UNZ**	Fast switching
AP4021A	**1EH**	Improved harmonics
AP4021A	**1ER**	Flexible reference input
AP4021A	**UK6**	Commercial calibration certificate with test data

General Characteristics

Remote programming interfaces:

Ethernet 100BaseT LAN interface

USB 2.0

Control language SCPI Version 1999.0

Power requirements 24V VDC

Mains adapter supplied: 100-240 VAC, 50/60 Hz, 1.4 A max in / 24 VDC, 65 W out

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

Operating temperature range 0 to 40 °C

Storage temperature range -40 to 70 °C

Operating altitude up to 2,000 m

CE

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

Weight: ≤ 1.0 kg (2.2 lbs) net

Dimensions: (W x L x H): 10.5 x 27 x 6 cm [4.13 x 10.63 x 2.36 in]