

# FS2 Frequency Synthesizer

Model AP4005A

Ultra-agile frequency synthesizer  
1 MHz to 40 GHz



# Definitions

The specifications in the following pages describe the warranted performance of the instrument for  $23 \pm 5$  °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.

# Introduction

The FS2 Frequency Synthesizer (AP4005A) is a compact frequency synthesizer for generating accurate and stable frequency signals in both continuous wave (CW) and pulse form, covering a frequency range of 1 MHz to 40 GHz, with a fast-switching time of 50  $\mu$ s and an output power of -10 to +20 dBm. The device shows excellent phase noise performance, e.g., at 10 GHz and 20 kHz offset -121 dBc / Hz is measured. The synthesizer is in a very compact flange-mountable form of 165 x 60 x 26 mm and weighs less than 0.5 kg. It consumes less than 23 W and is only passively cooled.

The Ethernet communication port is used for remote connection to a PC for control over graphical user interface (GUI) software using standard SCPI commands. The module can receive and provide external references of 100 MHz or 1 GHz. Multiple units can be phase synchronized to implement multi-channel phase-coherent outputs. The product is suitable for many applications: low phase noise system clock or reference sources, multi-channel phase-coherent configurations for radar, EW, quantum computing, etc.

# Facts, Figures, and Specifications

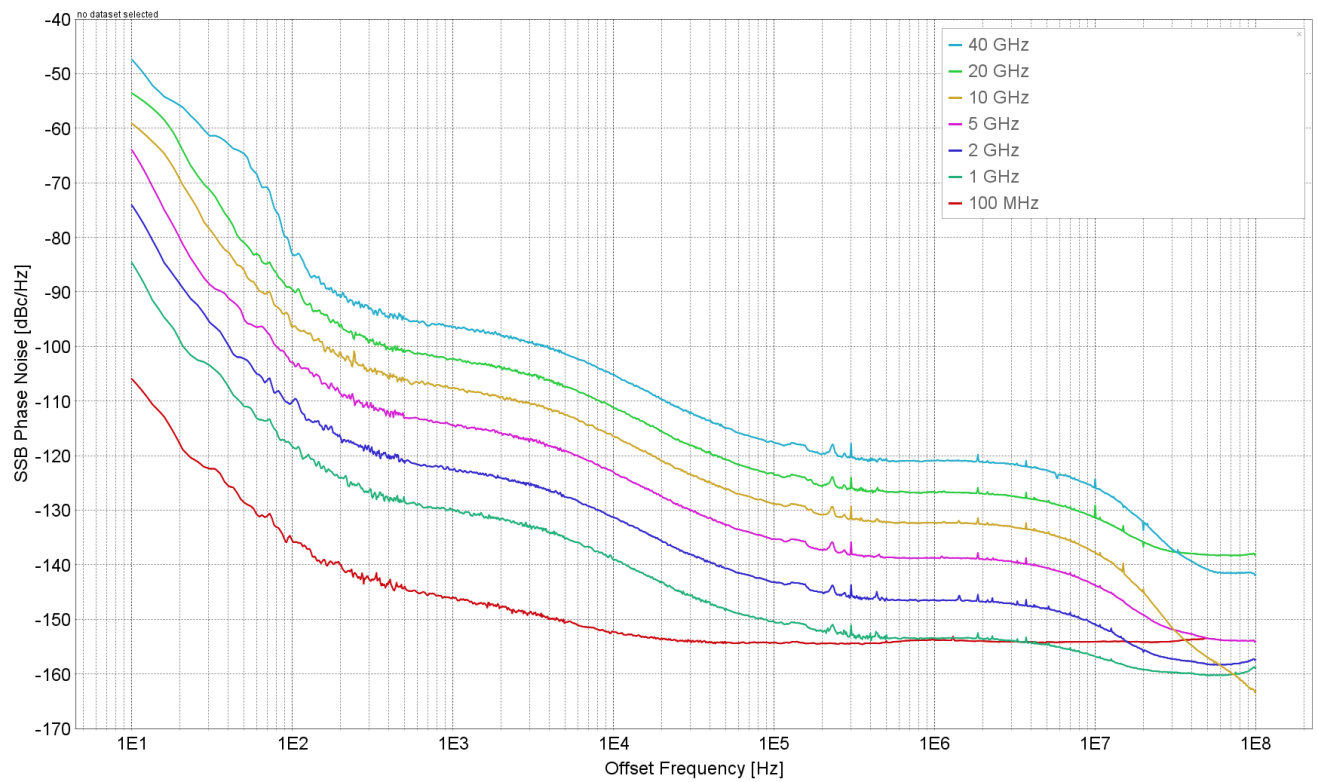
## Signal specifications

Parameter	Min	Typical	Max	Note
Frequency range	1 MHz		40 GHz	Settable to 45.2 GHz
Frequency resolution		0.001 Hz		GUI SW setting resolution
Frequency switching time		500 $\mu$ s 50 $\mu$ s		Option UNZ
Phase adjustment range	0 deg		360 deg	
Phase resolution		0.1 deg		

## Phase noise

CW mode, power level 10 dBm, values in dBc / Hz.

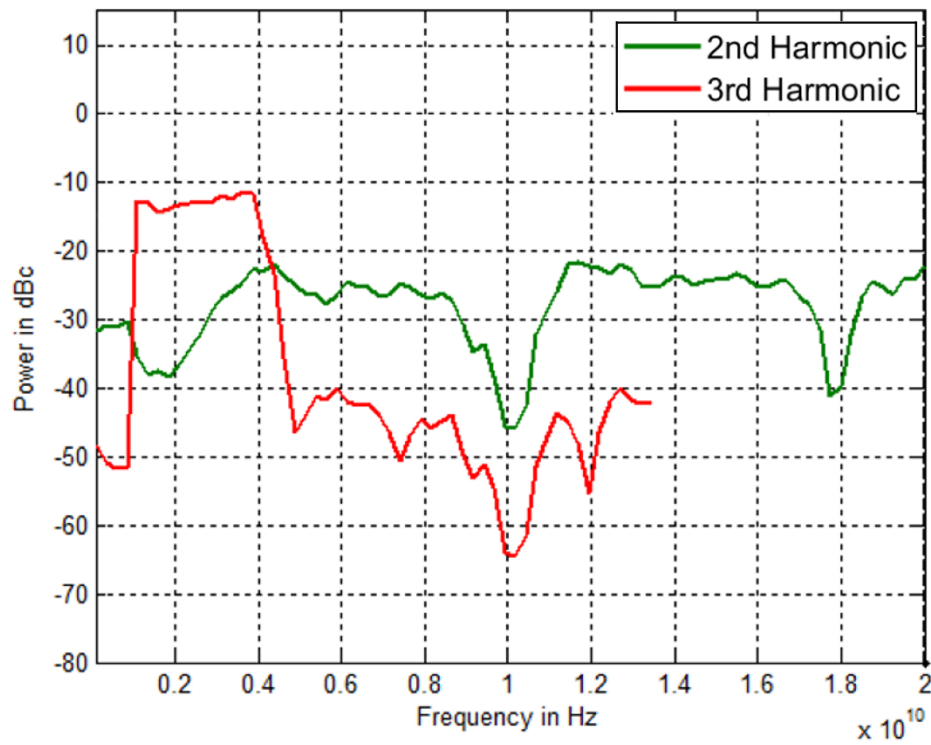
Offset frequency	10 Hz		100 Hz		1 kHz		20 kHz		100 kHz		1 MHz		10 MHz	
	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.
100 MHz	-105	-100	-135	-130	-145	-140	-153	-148	-154	-149	-153	-148	-154	-149
1 GHz	-84	-76	-118	-110	-130	-122	-143	-135	-150	-142	-153	-148	-156	-148
2 GHz	-74	-68	-110	-105	-122	-118	-135	-132	-143	-139	-146	-142	-150	-145
5 GHz	-63	-58	-102	-97	-114	-111	-127	-124	-135	-132	-138	-135	-143	-138
10 GHz	-59	-54	-96	-91	-107	-104	-121	-118	-128	-125	-132	-129	-137	-134
20 GHz	-53	-48	-89	-84	-102	-99	-115	-112	-123	-120	-126	-123	-130	-127
40 GHz	-47	-42	-83	-78	-96	-93	-109	-106	-117	-114	-120	-117	-125	-122



**Figure 1.** SSB phase noise performance

## Spectral purity

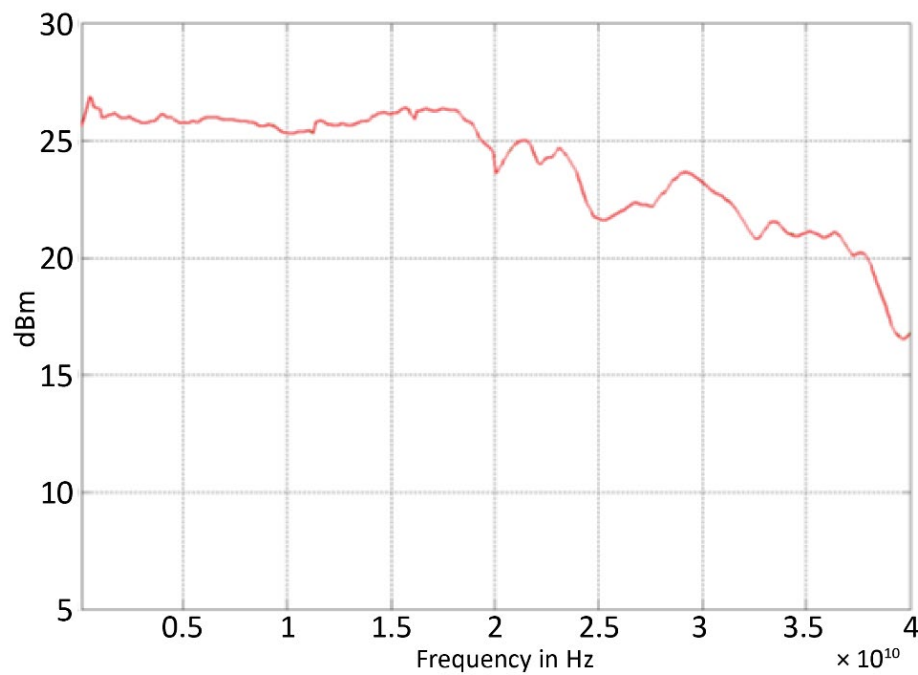
Parameter	Min	Typical	Max	Note
<b>Harmonics</b>				At 10 dBm; See plot below
< 1 GHz		-30 dBc	-25 dBc	
1 GHz to 5 GHz		-10 dBc	-7 dBc	
5 GHz to 20 GHz		-20 dBc	-15 dBc	
20 GHz to 40 GHz		-18 dBc		
<b>Sub-harmonics</b>				At 10 dBm
< 20 GHz		-75 dBc		
20 GHz to 40 GHz		-55 dBc		
<b>Non-harmonic spurious</b>				10 kHz to 0.5 GHz offset from carrier
< 1 GHz		-70 dBc		
1 GHz to 20 GHz		-50 dBc		
20 GHz to 40 GHz		-45 dBc		



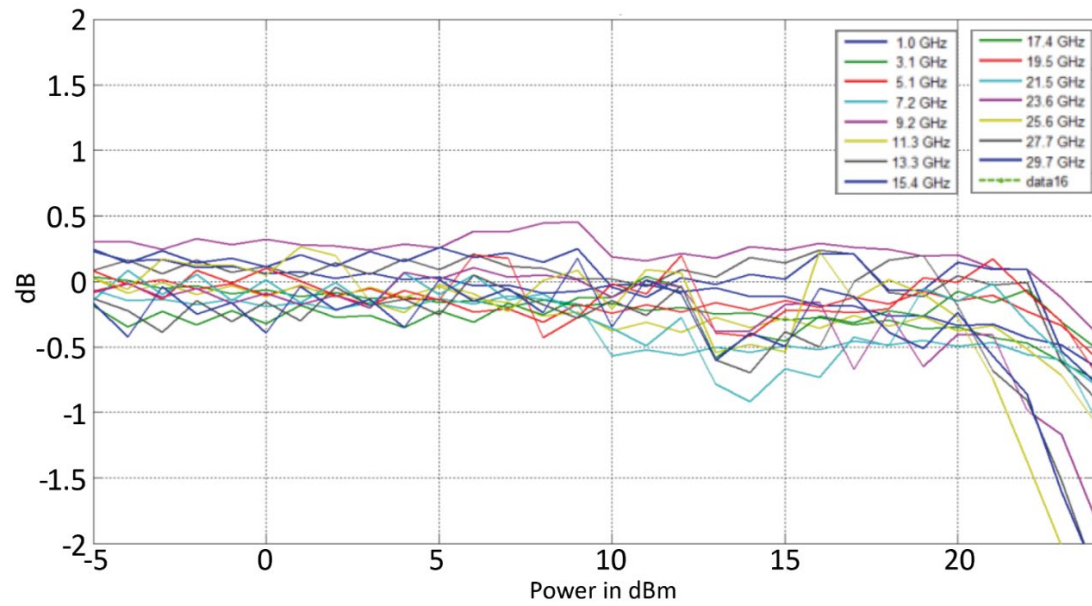
**Figure 2.** Harmonics (at 10 dBm output power)

## Level performance

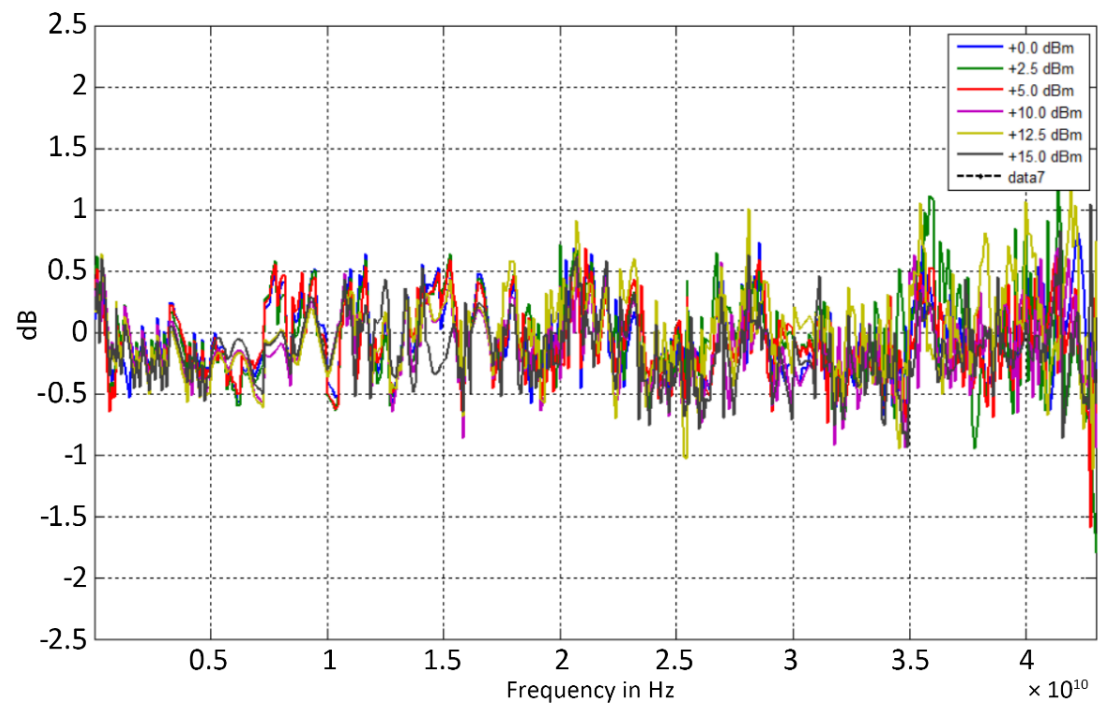
Parameter	Min	Typical	Max	Note
<b>Output power level</b>				Settable to +30 dBm; See plot below
< 20 GHz	-10 dBm		22 dBm	
20 GHz to 30 GHz	-10 dBm		18 dBm	
30 GHz to 40 GHz	-10 dBm		15 dBm	
<b>Power level uncertainty</b>		1.0 dB	2.0 dB	0 to 15 dBm See plots below
<b>Power resolution</b>		0.5 dB		
<b>Output impedance</b>		50 $\Omega$		
<b>VSWR</b>		1.7		
<b>Reverse power protection</b>				
DC voltage			7 V	
RF power			23 dBm	



**Figure 3.** Typical maximum output power



**Figure 4.** Power level linearity



**Figure 5.** Frequency response

## Reference frequency

Parameter	Min	Typical	Max	Note
<b>Internal reference frequency</b>		100 MHz		
Calibrated accuracy of int. reference		±30 ppb		Calibrated at 23 ± 3°C
Temperature stability (0 to 40°C)			±100 ppb	
Aging 1st year			500 ppb	
Aging per day			5 ppb	After 30 days operation
Warm-up time		5 min		
<b>Reference frequency input</b>		100 MHz, 1 GHz		
Reference input level 100 MHz 1 GHz	-5 dBm -5 dBm		+10 dBm +10 dBm	
Lock range 100 MHz 1 GHz			±100 ppm ±100 ppm	
Reference input impedance		50 Ω		
<b>Reference frequency output</b>		100 MHz, 1 GHz		Selectable; 100 MHz reference out not possible when using 1 GHz external reference
Output power 100 MHz 1 GHz	0 dBm -1 dBm		5 dBm 5 dBm	
Reference output impedance		50 Ω		

### Reference architecture

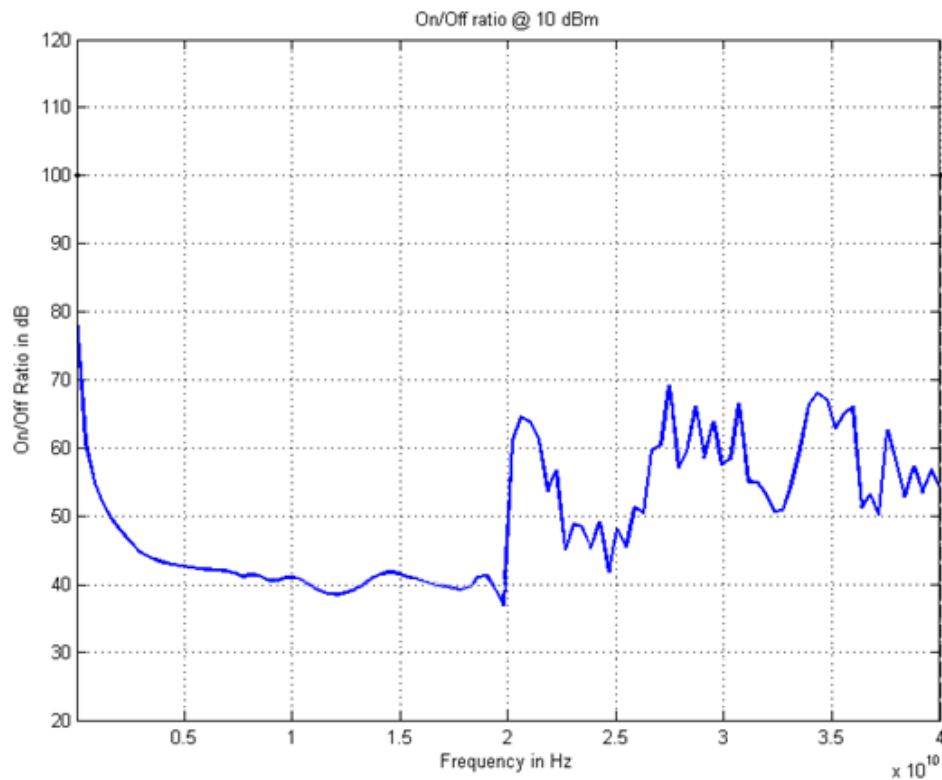
100 MHz and 1 GHz external reference frequencies are bypassing the internal reference circuit and are acting directly as reference signal for the synthesizer.

Reference out signal is directly provided by the internal available reference signals. If 1 GHz external reference is configured, 100 MHz reference output signal is not possible.



## Modulation capability

Parameter	Min	Typical	Max	Note
<b>Pulse modulation</b>				
Modulation source	Internal External (TRIG)			Trigger port can be reconfigured as external modulation port
On / off ratio < 1 GHz 1 GHz to 27 GHz 27 GHz to 40 GHz	45 dB 30 dB 40 dB	50 dB 35 dB 45 dB		At 10 dBm; See plot below.
Pulse rise / fall time		9 ns		
Pulse polarity	Normal Inverse			Selectable
External pulse latency		45 ns	60 ns	
<b>Internal pulse generator</b>				
Repetition frequency	47.6 mHz		25 MHz	=1/T
Pulse width	30 ns		21 s	Pulse width <= Pulse period
Pulse width resolution		10 ns		



**Figure 6.** On / off ratio — pulse modulation (at 10 dBm output power)

## Sweeping capability

Parameter	Min	Typical	Max	Note
<b>Sweep parameters</b>	Frequency, power, list			
Number of list points	1		50'000	
<b>Sweep type</b>	Linear, random			
Step time	500 $\mu$ s 85 $\mu$ s		21 s 21 s	Option UNZ
Step delay/off time	0 s		21 s	
Timing resolution		10 ns		
Timing accuracy per point		20 ns		
<b>Generalized list sweep</b>				
Allows for individual setting of frequency, power, step-time and off-time for each point				

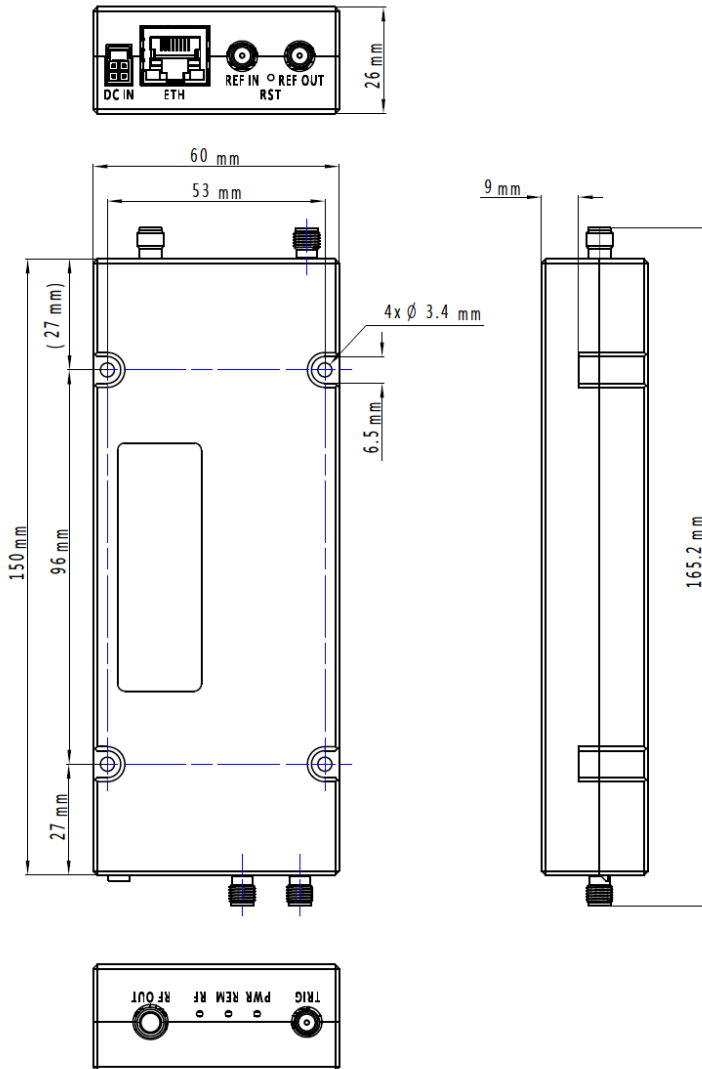
## Trigger (TRIG)

Parameter	Min	Typical	Max	Note
<b>Trigger types</b>	Continuous Single (point) Gated			
<b>Trigger source</b>	External (TRIG) Bus (Ethernet)			
<b>Trigger modes</b>	Continuous free run Trigger and run			
External trigger latency		140 ns		
External trigger uncertainty		20 ns		
External trigger delay	0 s		20 s	Settable
External delay resolution		10 ns		
<b>Trigger modulo</b>	1		255	Execute only on Nth trigger event
<b>Trigger polarity</b>	Rising Falling			
Gated trigger polarity	Normal Inverse			
<b>External TRIG input threshold</b>	0.85 V	0.9 V	0.95 V	TTL compatible
<b>External TRIG input voltage range</b>	-0.5 V		+5.5 V	TTL compatible 10 k $\Omega$ pull-down
<b>External TRIG input hysteresis</b>		60 mV		

# Mechanical Specifications

## Dimensions and weight

Including connectors	W x L x H = 165 x 60 x 26 mm
Excluding connectors	W x L x H = 150 x 60 x 26 mm
Weight	< 0.5 kg



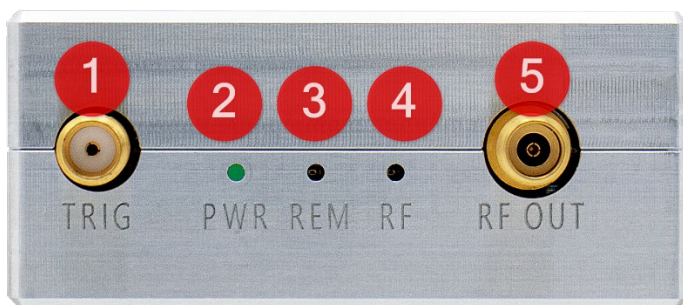
## Installation instructions

The module relies on passive and/or active cooling. It is mandatory to mount the device on a heatsinking surface. Make sure the synthesizer operates under the conditions specified in this datasheet. Otherwise, the thermal protection will turn off the RF output.

# Interfaces

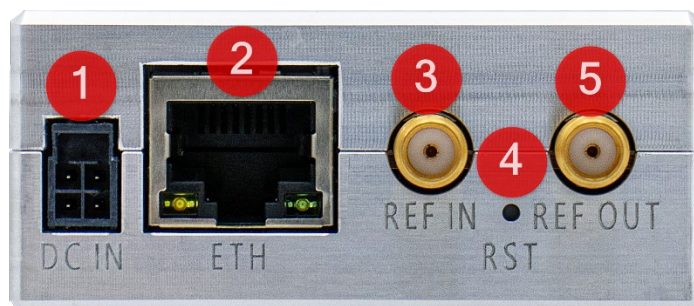
## Front panel

Label	Type	Description
1. TRIG	SMA	Trigger / Pulse interface
2. PWR	LED	Power ON / OFF indicator
3. REM	LED	Remote connection status indicator
4. RF	LED	RF output ON / OFF indicator
5. RF OUT	2.92 mm	RF output



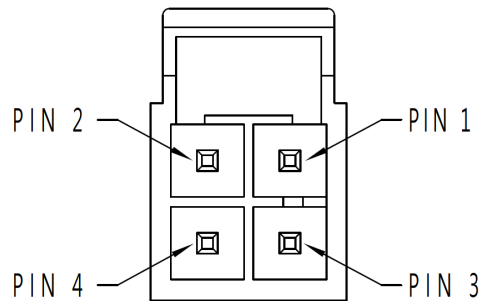
## Rear panel

Label	Type	Description
1. DC IN	1053141104 (Molex)	DC input (see also "Power connector assembly")
2. ETH	RJ-45	Ethernet port
3. REF IN	SMA	Reference signal input
4. RST	Button	Reset button
5. REF OUT	SMA	Reference signal output



## Power connector assembly

Pin	Assignment
1	DC supply (see also "Power requirements")
2	GND
3	DC supply (see also "Power requirements")
4	GND



The power connector is a 4-pin, 2.50-mm spaced double-row header. Keysight recommends Molex manufactured receptacles 1053081204 and contacts 1053002200 with TPA retainer 1053252002 from its Nano-Fit series.

## Reset functionality

The reset functionality of the device can be used if the device has a wrong configured IP address and cannot be found in the local area network anymore. While pressing the reset button (> 2 s), the device will be reconfigured to auto IP addressing mode (DHCP / Zero-conf) and restarts itself. After the device is up and running again, it gets a new IP address and can be discovered by the Keysight Signal Generator UI.

## Order Information

Model number	Option number	Description
AP4005A	540	Frequency range, 1 MHz to 40 GHz
AP4005A	UNZ	Fast switching
AP4005A	UK6	Commercial calibration certificate with test data

# General Characteristics

## Remote programming interfaces:

1 Gbit Ethernet

Control language: SCPI Version 1999.0

**Power requirements:** 24 VDC; 20 W typical, 23 W maximum

**Mains adapter supplied:** 100 – 240 VAC, 50/60 Hz, 1.4 A max in / 24 V, 2.7 A DC out

**Storage temperature range:** -40 to 85 °C

**Operating temperature range:** 0 to 40 °C

**Operating humidity range:** 5 to 95% (non-condensing)

**Operating altitude:** up to 2,000 m



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

**Recommended calibration cycle: 24 months**