FS1 Frequency Synthesizer

Model AP4011A and AP4012A

Ultra-agile signal sources from 8 kHz to 20 GHz
(single- and multi-channel versions)





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 (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 FS1 Frequency Synthesizer is a very compact, very agile signal source with a frequency range of up to 20 GHz. It combines fast switching speed with low phase noise and good signal purity.

The single-channel unit AP4011A is available as a flange- and rack-mountable module.

The multi-channel version AP4012A is available in 1-, 2-, 3-, or 4-channel configurations in a standard 1U 19'' rack-mountable enclosure. For high phase coherence, RF channels are locked to a common frequency reference.

The FS1 Frequency Synthesizer has standard USB and Ethernet communication ports, and optionally GPIB (AP4012A). All communication ports support the SCPI-1999 command set. The FS1 Frequency Synthesizer AP4012A also features a Fast Control Port (FCP), allowing for ultra-fast user-controlled list sweeping and frequency hopping.

Facts, Figures, and Specifications

Signal specifications

Parameter	Min	Typical	Max	Note
Frequency range	100 kHz 8 kHz		20 GHz 20 GHz	 Option MFE
Frequency resolution		0.001 Hz		
Frequency switching time		500 µs 5 µs		 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 Typ.	Max.	100 Hz Typ.	Max.	1 kHz Typ.	Max.	20 kHz Typ.	Max.	100 kHz Typ.	Max.	1 MHz Typ.	Max.	10 MHz Typ.	Max.
100 MHz	-104	-99	-133	-128	-145	-140	-155	-150	-160	-155	-161	-156	-161	-156
1 GHz	-80	-74	-105	-101	-116	-112	-126	-123	-127	-124	-142	-139	-151	-147
2 GHz	-72	-66	-100	-96	-111	-107	-121	-118	-122	-119	-138	-135	-153	-149
5 GHz	-64	-58	-93	-88	-103	-99	-114	-111	-115	-112	-130	-127	-147	-142
10 GHz	-57	-51	-85	-82	-96	-93	-107	-104	-108	-105	-123	-120	-147	-143
20 GHz	-52	-46	-80	-76	-91	-87	-102	-99	-103	-100	-118	-115	-141	-137

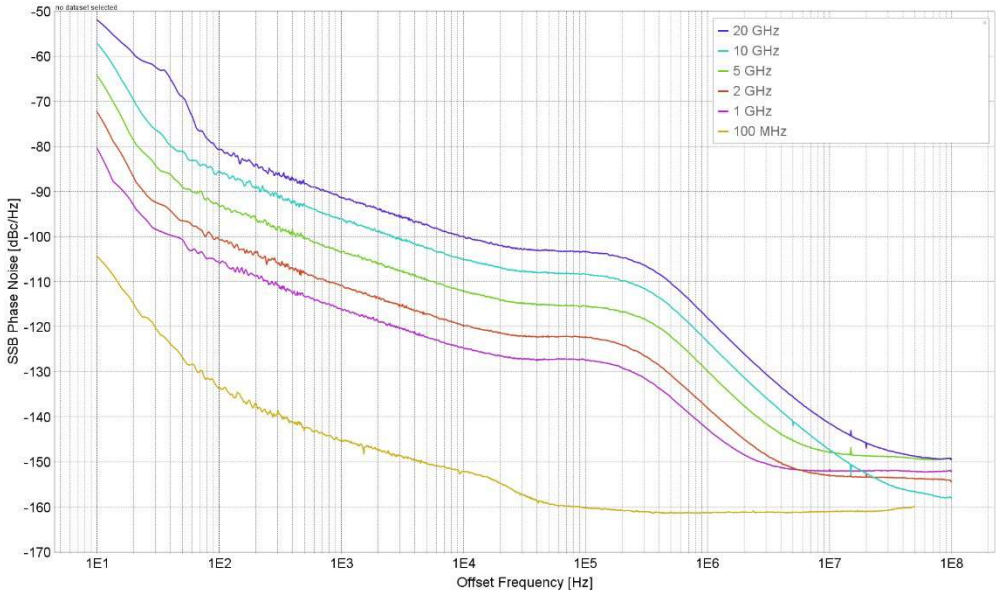


Figure 1. Phase noise performance

Spectral purity

Parameter	Min	Typical	Max	Note
Harmonics				At 0 dBm; See plot below
< 2.5 GHz		-5 dBc	0 dBc	
2.5 GHz to 8.0 GHz		-15 dBc	-10 dBc	
8.0 GHz to 20.0 GHz		-30 dBc	-23 dBc	
Sub-harmonics				At 0 dBm
< 10.0 GHz		-60 dBc		
10.0 GHz to 19.0 GHz		-50 dBc		
19.0 GHz to 20 GHz		-30 dBc		
Non-harmonic spurious				10 kHz to 0.5 GHz offset from carrier
All frequencies		-60 dBc		

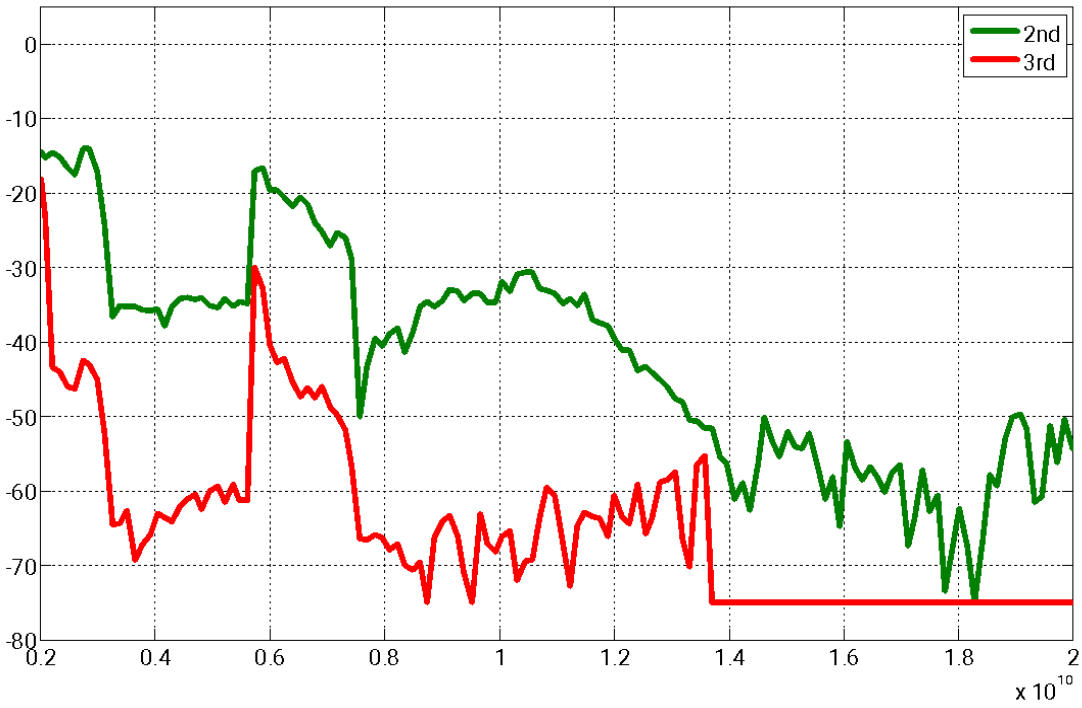


Figure 2. Harmonic performance at 0 dBm — Harmonic output power [dBc] vs. frequency [Hz]

Level performance

Parameter	Min	Typical	Max	Note
Output power level				Settable from -10 to +23 dBm
100 kHz to 250 MHz	0 dBm		18 dBm	
250 MHz to 17.0 GHz	0 dBm		20 dBm	
17.0 GHz to 20.0 GHz	0 dBm		18 dBm	
Power level uncertainty		1.0 dB	2.0 dB	0 to 15 dBm See plots below
Power resolution		0.5 dB		
Output impedance		50 Ω		
VSWR		1.7		
Reverse power protection				
DC voltage			7 V	
RF power			23 dBm	

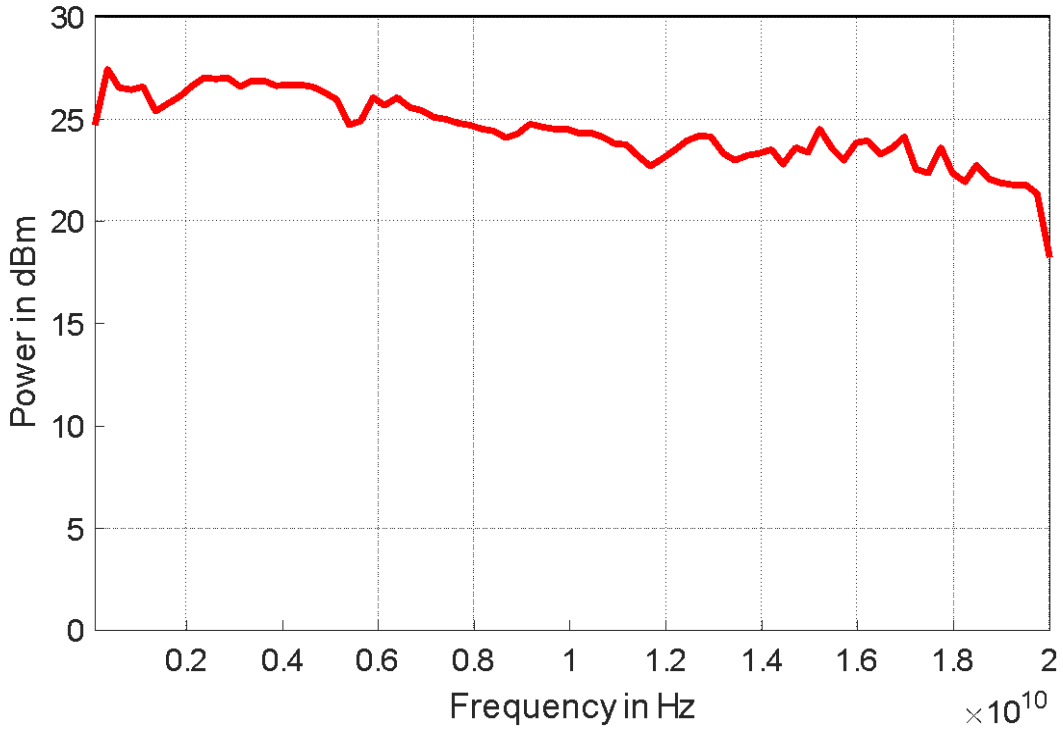


Figure 3. Typical maximum output power

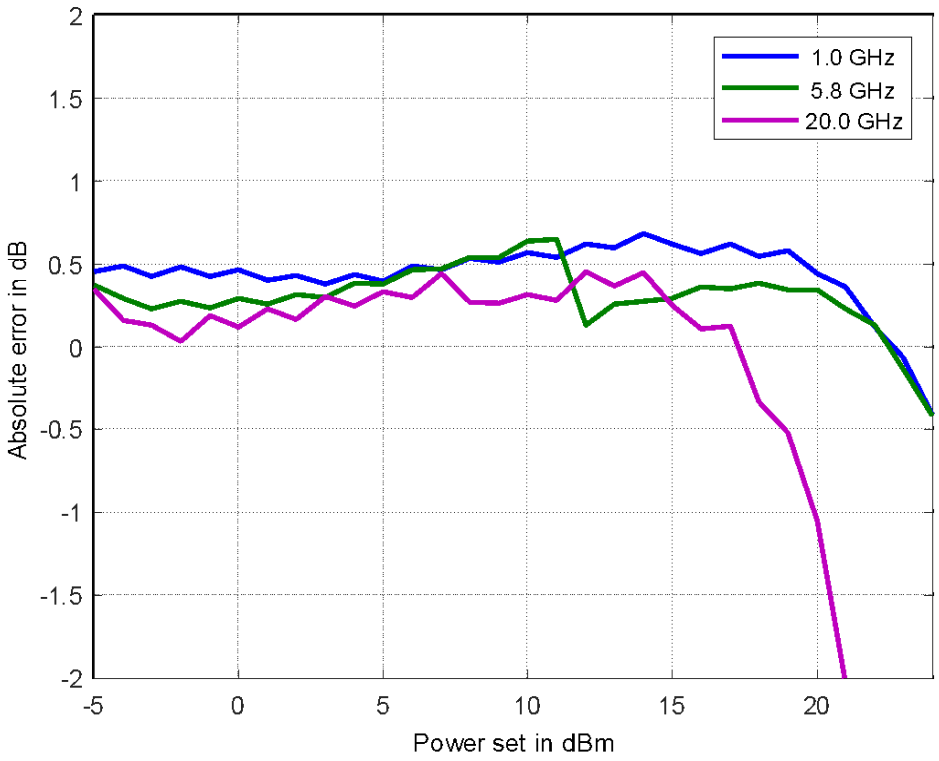


Figure 4. Power linearity

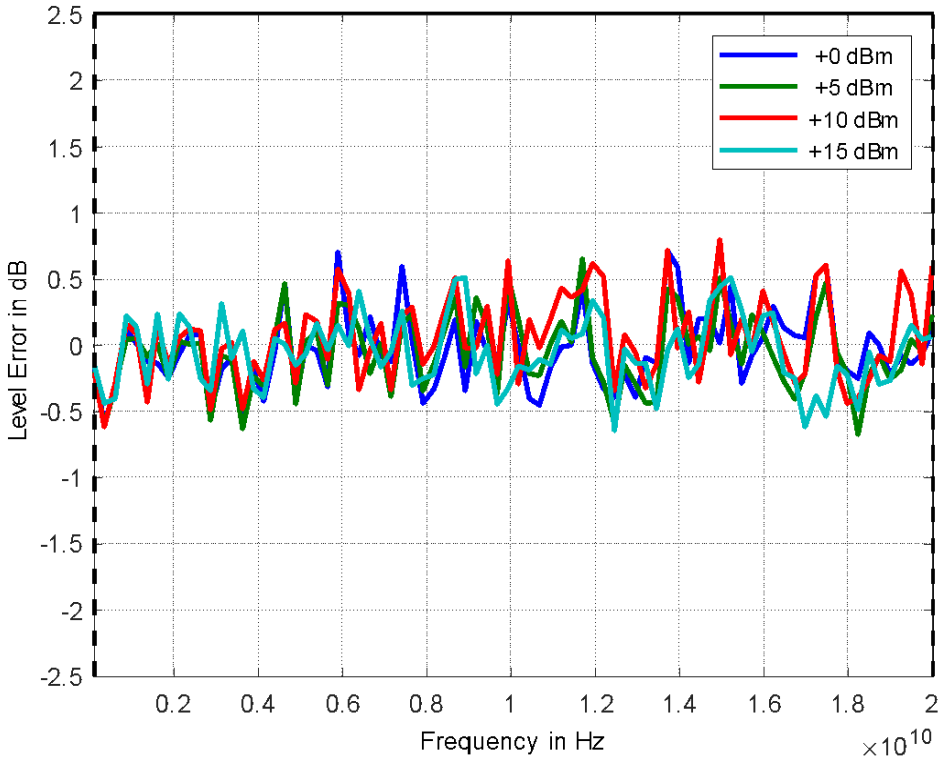


Figure 5. Power level accuracy

Channel-to-channel performance

Parameter	Min	Typical	Max	Note
Isolation				
< 3.0 GHz		100 dB		
3.0 GHz to 7.0 GHz		70 dB		
7.0 GHz to 20 GHz		60 dB		
Relative phase stability		15 mrad		See plots below

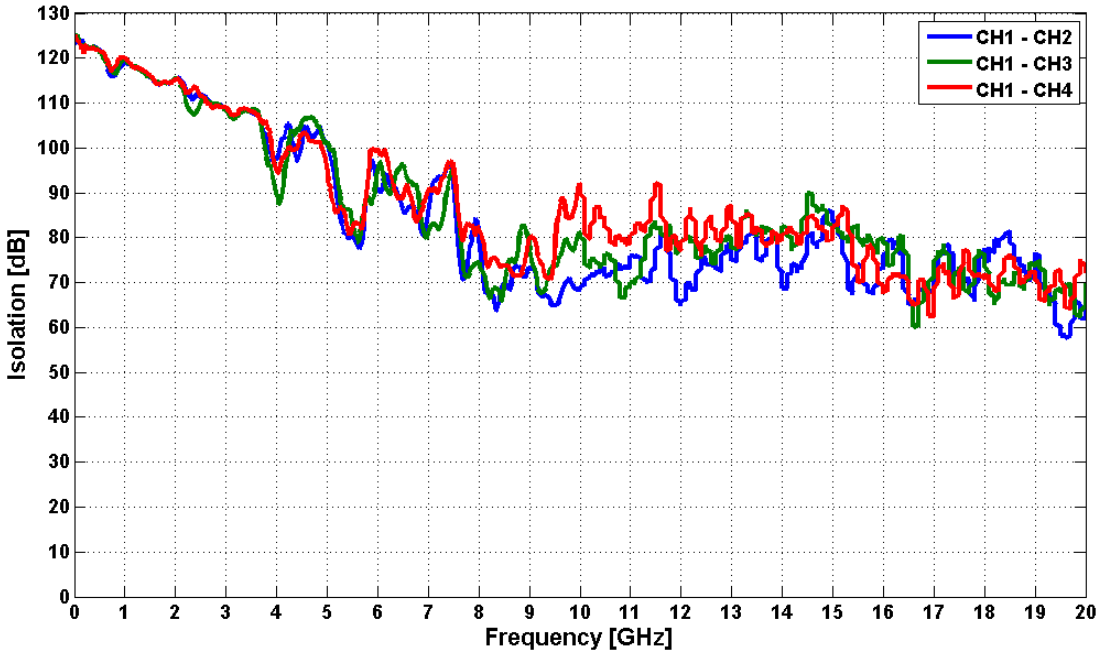


Figure 6. Channel-to-channel isolation — The measurement shows the impact of channel 2, 3, and 4 at f0+9 MHz on channel 1 (channel under test) operating at f0. All channels have 10 dBm output power.

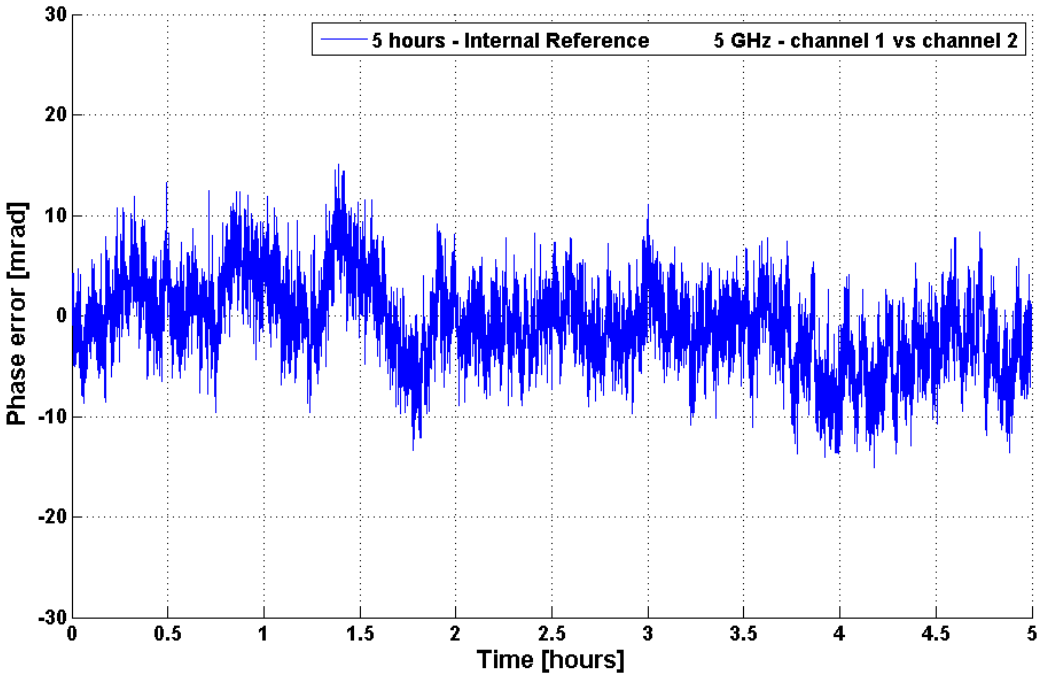


Figure 7. Channel-to-channel phase stability — The measurement shows the phase fluctuation between two RF channels in the same device, measured over 5 hours with a 5 GHz CW signal.

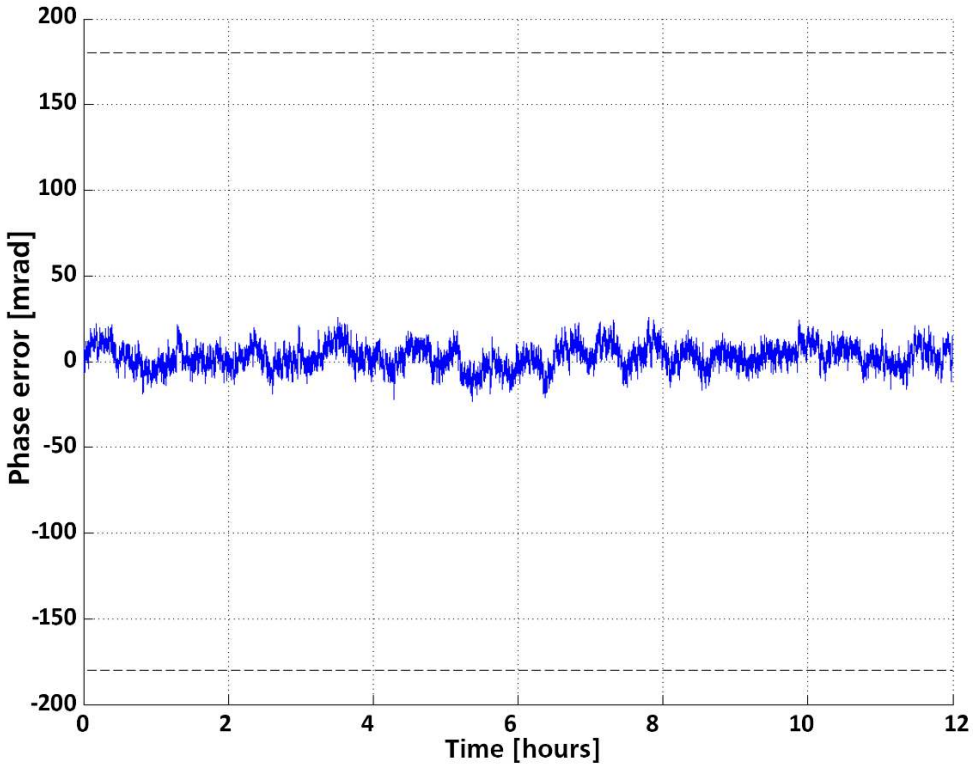


Figure 8. Typical time domain channel-to-channel phase error at 10 GHz — measured over 12 hours

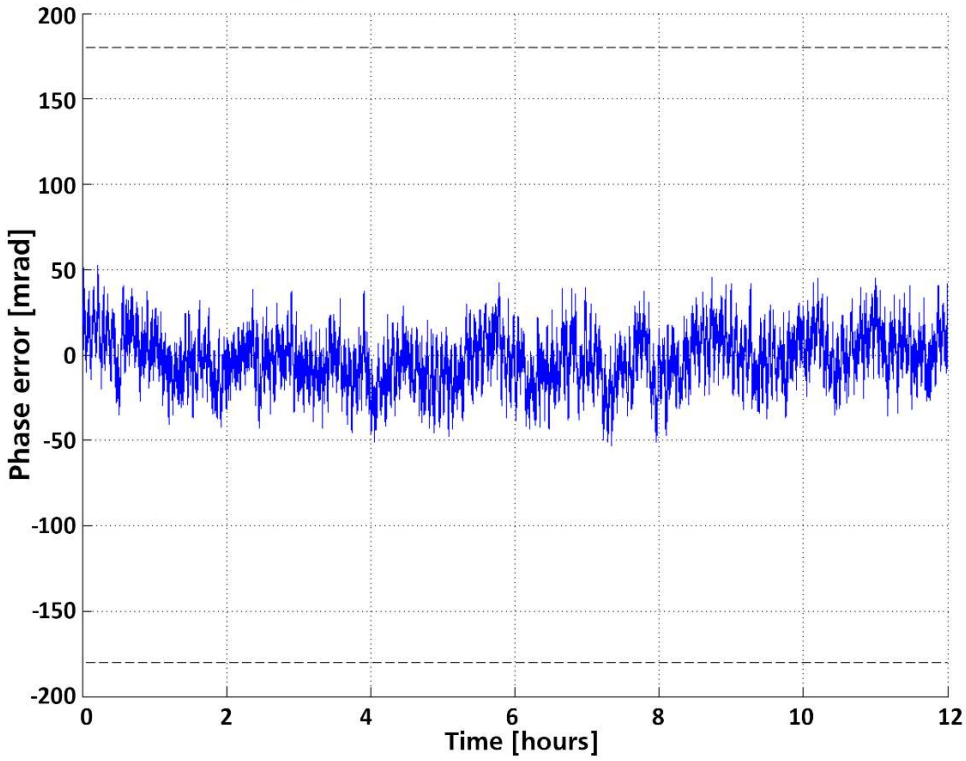


Figure 9. Typical time domain channel-to-channel phase error at 20 GHz — measured over 12 hours

Reference frequency

Parameter	Min	Typical	Max	Note
Internal reference frequency		100 MHz		
Calibrated accuracy of int. reference		±40 ppb		Calibrated at 23 ± 3 °C
Temperature stability (0 to 40 °C for AP4011A; 0 to 45 °C for AP4012A)			±100 ppb	
Aging 1st year			500 ppb	
Aging per day			5 ppb	After 30 days operation
Warm-up time		5 min		
Reference frequency input	10 – 250 MHz			
Reference input level	-5 dBm		+13 dBm	
Reference frequency resolution		1 MHz		
Lock range			±1.0 ppm	
Reference input impedance		50 Ω		
Reference frequency output	100 MHz			
Output power	10 dBm	12 dBm	14 dBm	
Reference output impedance		50 Ω		

Modulation capabilities

Parameter	Min	Typical	Max	Note
Pulse modulation				
Modulation source		Internal External (PULSE)		Per channel configurable
On / off ratio < 3.0 GHz 3.0 GHz to 12.0 GHz 12.0 GHz to 20.0 GHz	 85 dB 65 dB 50 dB	 90 dB 70 dB 60 dB		At 10 dBm
Pulse rise / fall time		9 ns		
Video crosstalk		-40 dB		
Pulse polarity		Normal Inverse		Selectable
External pulse latency		20 ns		
External PULSE input threshold	0.85 V	0.9 V	0.95 V	TTL compatible
External PULSE input voltage range	-0.5 V		+5.5 V	TTL compatible
External PULSE input hysteresis		60 mV		
Internal pulse generator				
Repetition frequency	47.6 mHz		25 MHz	=1/T
Pulse width	30 ns		21 s	Pulse width <= Pulse period
Pulse width resolution		10 ns		

Sweeping capability

Parameter	Min	Typical	Max	Note
Sweep parameters		Frequency, power, list		
Number of list points	1		50’000	
Sweep type		Linear, random		
Step time	500 µs 20 µs		21 s 21 s	 **Option UNZ**
Step delay/off time	0 s		21 s	
Timing resolution		10 ns		
Timing accuracy per point		20 ns		

Generalized list sweep
Allows for individual setting of frequency, power, step-time and off-time for each point

Trigger (TRIG / TRIG IN)

Parameter	Min	Typical	Max	Note
Trigger types		Continuous Single (point) Gated		
Trigger source		External (TRIG / TRIG IN) Bus (Ethernet, USB, GPIB)		
Trigger modes		Continuous free run Trigger and run		
External trigger latency		17 µs		
External trigger uncertainty		5 µs		
External trigger delay	0 s		20 s	Settable
External delay resolution		10 ns		
Trigger modulo	1		255	Execute only on Nth trigger event
Trigger polarity		Rising Falling		
Gated trigger polarity		Normal Inverse		
External TRIG input threshold	0.85 V	0.9 V	0.95 V	TTL compatible
External TRIG input voltage range	-0.5 V		+5.5 V	TTL compatible
External TRIG input hysteresis		60 mV		

Multi-purpose output (TRIG OUT)

The multi-purpose output is only available on AP4012A devices.

Parameter	Min	Typical	Max	Note
Trigger output				
Trigger output modes		Trigger on sequence start Trigger on each point		
Trigger output pulse width		2 µs		
Pulse video output				
Pulse video output mode		Internal pulse generator output		
Pulse video output latency		40 ns		
Electrical port specifications				
Output low level		0 V		CMOS compatible
Output high level		2.2 V		CMOS compatible

Mechanical Specifications

AP4011A dimensions and weight

Parameter	Value
Including connectors	W x L x H = 105 x 270 x 60 mm
Weight	≤ 1.0 kg

AP4012A dimensions and weight

Parameter	Value
Including connectors	W x L x H = 428 x 467 x 44 mm
Weight	≤ 10.0 kg

Interfaces

AP4011A front panel

Label	Type	Description
POWER	Switch	Power switch with ON / OFF indicator LED
REMOTE	LED	Remote connection status indicator
RF ON	LED	RF output ON / OFF indicator
RF OUT	SMA	RF output
REF IN	BNC	Reference signal input
REF OUT	BNC	Reference signal output
PULSE	BNC	Pulse interface
TRIG	BNC	Trigger input interface



AP4011A rear panel

Label	Type	Description
DC 24V	DC power plug	DC power supply input
USB	USB type B	USB port
LAN	RJ-45	Ethernet port



AP4012A front panel

Label	Type	Description
ON / OFF	Switch	Power switch ON / OFF
POWER	LED	Power ON / OFF indicator
REMOTE	LED	Remote connection status indicator
PULSE (per channel)	BNC	Pulse interface
# channel index (per channel)	LED	RF output ON / OFF indicator
RF OUT (per channel)	SMA	RF output



AP4012A rear panel

Label	Type	Description
⏚	M4	Ground reference screw (earth)
FCP	26-pin 3M Mini-D Ribbon	Fast control port (**Option UNZ**)
TRIG OUT	BNC	Multi-purpose output interface (trigger output / pulse video output)
TRIG IN	BNC	Trigger input interface
REF OUT	BNC	Reference signal output
REF IN	BNC	Reference signal input
GPIB	GPIB 24-pin female	GPIB interface (**Option GPB**)
LAN	RJ-45	Ethernet port
USB	USB type B	USB port
FUSE		Fuse
-	C13	100-240V AC power plug



FCP interface

The Fast Control Port (FCP) interface is only available on AP4012A devices with **Option UNZ**.

For fast, time critical settings like frequency changes the device can be controlled over the FCP interface. It is a parallel port that can be operated in either ‘8-bit Mode’ or ‘16-bit Mode’. If activated, frequency and/or amplitude of the device are controlled by the FCP. With FCP, memory is addressed and filled with frequency or amplitude information.

To enable and configure the communication over FCP, the device has to be configured in advance over SCPI.

Features:

8-bit or 16-bit parallel port for fast, time critical settings like frequency

Sequential submission of 48-bit frequency word or access to pre-defined frequency table

Optional amplitude control and support for multi-channel models (only with 16-bit bus)

Signal source confirms the received data with ACK (only in 8-bit mode) and informs the controller by the BUSY signal while processing the information.

Connector: 26 pin 3M Mini-D Ribbon Receptacle
8-bit Mode: Address A<3..0>, Data D<3..0>, STROBE, ACK, BUSY
16-bit Mode: Address A<7..0>, Data D<7..0>, STROBE, BUSY
Input signal: 0 to 5 V
Input impedance: 4,7 kΩ
Maximum toggle rate: 10 MHz, frequency switching starts after transfer of last byte

Order Information

Model number	Option number	Description
AP4011A	**520**	Frequency range, 100 kHz to 20 GHz
AP4011A	**MFE**	Frequency range extension to 8 kHz
AP4011A	**UNZ**	Fast switching
AP4011A	**UK6**	Commercial calibration certificate with test data
AP4012A	**001**	Add channel 1
AP4012A	**002**	Add channel 2; requires Option 001
AP4012A	**003**	Add channel 3; requires Option 002
AP4012A	**004**	Add channel 4; requires Option 003
AP4012A	**520**	Frequency range, 100 kHz to 20 GHz; required for each channel
AP4012A	**MFE**	Frequency range extension to 8 kHz; required for each channel, if ordered
AP4012A	**UNZ**	Fast switching; required for each channel, if ordered
AP4012A	**UK6**	Commercial calibration certificate with test data; required for each channel, if ordered
AP4012A	**GPB**	GPIB interface

General Characteristics

Remote programming interfaces:

1 Gbit Ethernet

USB2.0

GPIB (Option GPB)

Control language: SCPI Version 1999.0

Power requirements

AP4011A: 24 VDC; 20 W maximum

AP4012A: 100 – 240 VAC, 50 or 60 Hz, 55 W maximum (23 W + 8 W per channel)

Mains adapter supplied (AP4011A): 100-240 VAC in / 24 V, 2.7 A DC out

CUI SD165-U and Meanwell LRS-150f-24 power supply defines the spec.:

Operating temperature range 0 to 40 °C (AP4011A); 0 to 45 °C (AP4012A)

Storage temperature range -40 to 80 °C (AP4011A); -40 to 85°C (AP4012A)

Operating altitude up to 2,000 m (AP4011A); up to 15,000 feet (AP4012A)

CE

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

Recommended calibration cycle: 24 months

Operating humidity range: 20 – 80 % (AP4011A), 20 - 90% (AP4012A)

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