G2 Analog Signal Generator

Model AP5012A

Multi-channel RF and MW signal generators
300 kHz to 6, 12, 20, 33, and 40 GHz

KEYSIGHT

Introduction

Compact 300 kHz to 6, 12, 20, 33, or 40 GHz ultra-low phase noise, 25 µs phase coherent switching, multi-channel signal generator

The G2 Analog Signal Generator (AP5012A) is a phase-coherent, multi-channel, high output power, ultra-fast switching, and ultra-low phase noise signal generator with a frequency range from 300 kHz to 6, 12, 20, 33, or 40 GHz. It is ideally suited for a wide range of applications, where good signal quality, accurate and wide output power ranges, and very stable phase coherence among all channels are required. Excellent phase noise is combined with good spurious, harmonic rejection, and optional leading-edge switching speed of 25 µs.

A high-stability Oven Controlled Crystal Oscillator (OCXO) reference provides excellent frequency accuracy and stability. The generator accepts a wide range of external references including the commonly used 10 and 100 MHz for higher phase synchronization, and a flexible reference choice in the range of 1-250 MHz for those applications with customer- or system-specific reference frequencies. Moreover, the G2 Analog Signal Generator features a pair of high-frequency Clock (CLK) ports (one input and one output) that enable excellent phase synchronization among the outputs from multiple G2 Analog Signal Generator modules.

The G2 Analog Signal Generator comes in a standard 19 inch 1U (up to 4 channels) rack-mountable module form. It can 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.

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.

Table of Contents

Facts, Figures, and Specifications

Frequency parameters / range

Parameter	Min	Typical	Max	Note
Frequency range	300 kHz 300 kHz 300 kHz 300 kHz 300 kHz		6 GHz 12 GHz 20 GHz 33 GHz 40 GHz	AP5012A-506 AP5012A-512 AP5012A-520 AP5012A-533 AP5012A-540
Resolution		< 0.001 Hz		
Phase adjustment range	0 deg		360 deg	Individually adjustable per channel
Phase resolution		0.1 deg		
Switching speed CW mode Sweep / list mode		1.5 ms 500 µs 25 µs		After SCPI command received **Option UNZ**

Phase noise

Parameter	Min	Typical	Max	Note
SSB phase noise at 1 GHz				see plots / tables max output power, ALC Off
at 10 Hz from carrier		-87 dBc / Hz -98 dBc / Hz	-76 dBc / Hz -86 dBc / Hz	**Option LN1** **Option LN2**
at 1 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				max output power, ALC Off
at 10 Hz from carrier		-74 dBc / Hz -85 dBc / Hz	-68 dBc / Hz -74 dBc / Hz	**Option LN1** **Option LN2**
at 1 kHz from carrier		-116 dBc / Hz	-111 dBc / Hz[1]	
at 100 kHz from carrier		-132 dBc / Hz	-127 dBc / Hz	
SSB phase noise at 10 GHz				max output power, ALC Off
at 10 Hz from carrier		-67 dBc / Hz -77 dBc / Hz	-60 dBc / Hz -66 dBc / Hz	**Option LN1** **Option LN2**
at 1 kHz from carrier		-108 dBc / Hz	-103 dBc / Hz	
at 100 kHz from carrier		-125 dBc / Hz	-120 dBc / Hz	

1 With Option PHS, the phase noise for offsets >= 100 Hz at frequencies between 1.1 GHz and 10 GHz is typically 10 dB higher.

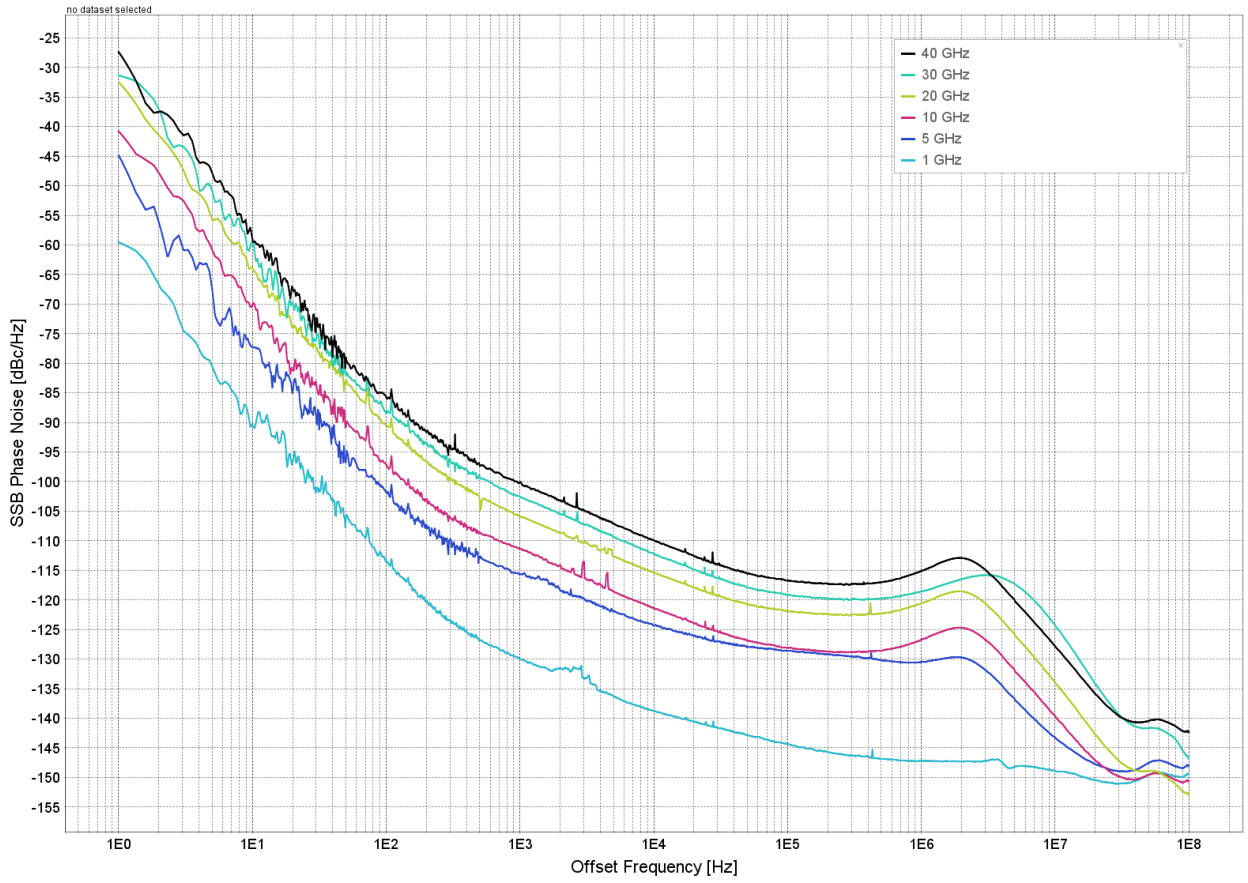


Figure 1. Phase noise with Option LN1 (at max. output power)

Spectral purity

Parameter	Min	Typical	Max	Note
Harmonics Option 506, 512, 520				at +5 dBm output power
50 to 200 MHz		-30 dBc	-20 dBc	
200 to 600 MHz		-35 dBc	-25 dBc	
600 MHz to 6 GHz		-40 dBc	-30 dBc	
6 to 20 GHz		-35 dBc	-25 dBc	
Harmonics Option 533, 540				
50 to 200 MHz		-30 dBc	-20 dBc	
200 MHz to 12 GHz		-35 dBc	-20 dBc	
12 to 20 GHz		-30 dBc	-20 dBc	
> 20 GHz		-25 dBc		
Sub-harmonics				
< 5GHz		-75 dBc	-70 dBc	
5-20 GHz		-70 dBc	-65 dBc	
> 20GHz		-55 dBc		
Non-harmonic spurious				> 10 kHz offset
< 1.2 GHz		-90 dBc		
1.2 to 2.5 GHz		-92 dBc		
2.5 to 5 GHz		-87 dBc		
5 to 10 GHz		-80 dBc		
10 to 20 GHz		-75 dBc		
20 to 40 GHz		-67 dBc		

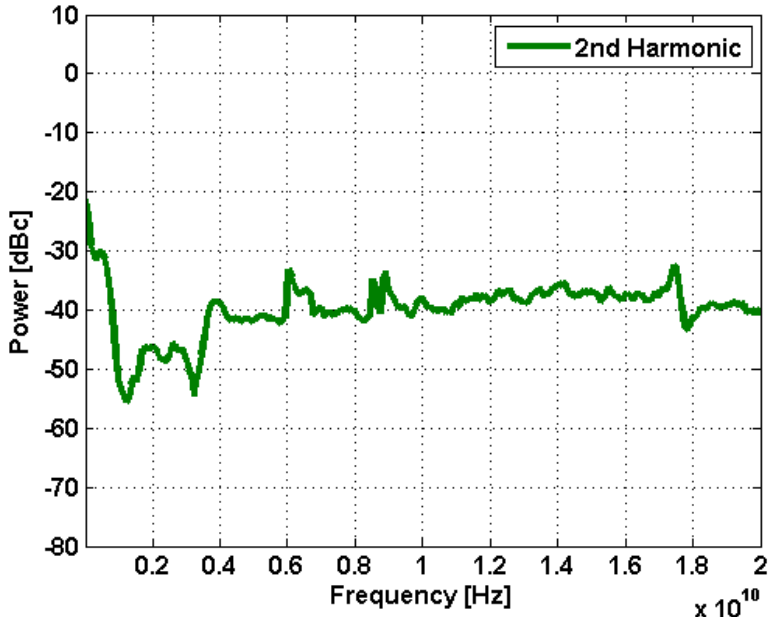


Figure 2. G2 Analog Signal Generator harmonic performance

Level performance

Parameter	Min	Typical	Max	Note
Output power level Option 506, 512, 520, 533, 540				
< 100 MHz	-20 dBm		+20 dBm	
100 MHz to 6 GHz	-20 dBm		+24dBm	
6 GHz to 18 GHz	-20 dBm		+23 dBm	
18 GHz to 20 GHz	-20 dBm		+20 dBm	
20 GHz to 40 GHz	-20 dBm		+18 dBm	
Output power level Option 506, 512, 520				**Option 1E2 or 2E2**
10 MHz to 12 GHz	-80 dBm		+20 dBm	
12 GHz to 15GHz	-80 dBm		+18 dBm	
15 GHz to 20 GHz	-80 dBm		+15 dBm	
Output power level Option 533, 540				**Option 3E2**
10 MHz to 20 GHz	-50 dBm		+19 dBm	
20 to 30 GHz	-50 dBm		+16 dBm	
30 to 40 GHz	-50 dBm		+14 dBm	
Power resolution		0.01 dB		
Thermal drift		0.015 dB / °C		

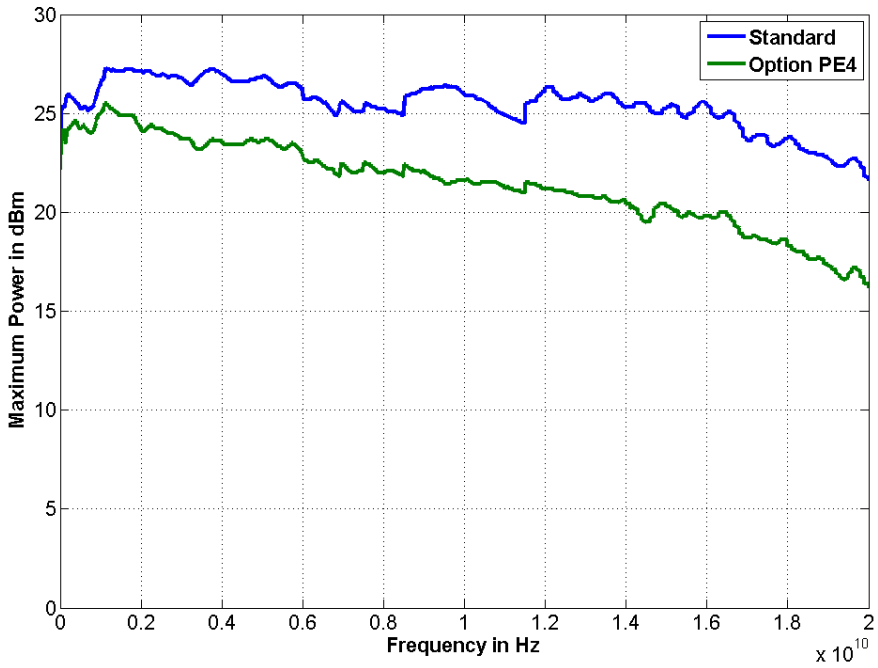


Figure 3. Maximum output power G2 Analog Signal Generator with and without Option 2E2

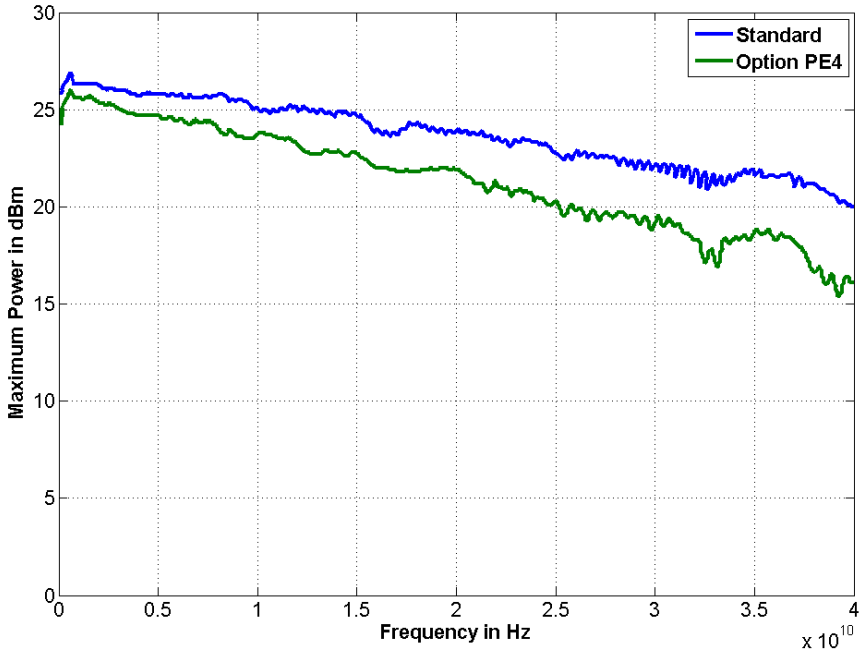


Figure 4. Maximum output power G2 Analog Signal Generator with and without Option 3E2

Relative power error (0.1 dB step)

( ): Typical value

	Min power to -50 dBm Option 1E2/2E2/3E2	-50 to -20 dBm Option 1E2/2E2/3E2	-20 to +15 dBm	+15 dBm to max power
300 kHz to 20 GHz	(< 0.1 dB)	0.5 dB (< 0.1 dB)	0.5 dB (< 0.1 dB)	(< 0.1 dB)
20 to 26 GHz	N / A	(< 0.1 dB)	(< 0.1 dB)	(< 0.1 dB)
26 to 40 GHz	N / A	(< 0.1 dB)	(< 0.1 dB)	(< 0.1 dB)

Power level uncertainty

( ): Typical value

	Min power to -50 dBm Option1E2/2E2/3E2	-50 to -15 dBm Option 1E2/2E2/3E2	-15 to +15 dBm	+15 dBm to max power
< 6 GHz	(4 dB)	1.2 dB	0.8 dB (0.25 dB)	1.2 dB
6 to 12 GHz	(4 dB)	1.3 dB	0.9 dB (0.3 dB)	1.3 dB
12 to 26 GHz	(4 dB)	2.0 dB	1.0 dB (0.3 dB)	2.0 dB
26 to 40 GHz	N / A	2.3 dB	1.2 dB (0.4 dB)	2.3 dB

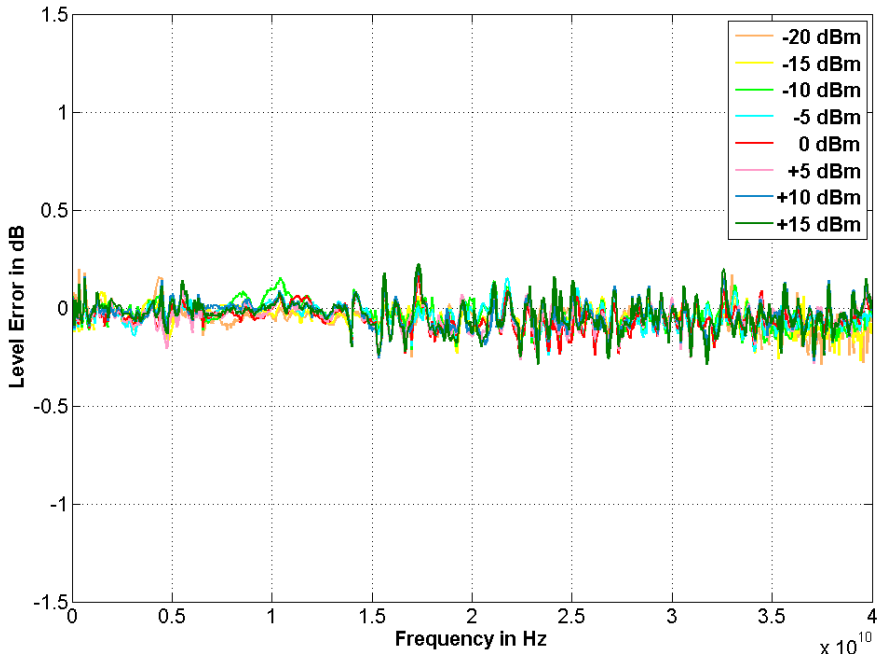


Figure 5. Level error (300 kHz to 40 GHz, G2 Analog Signal Generator)

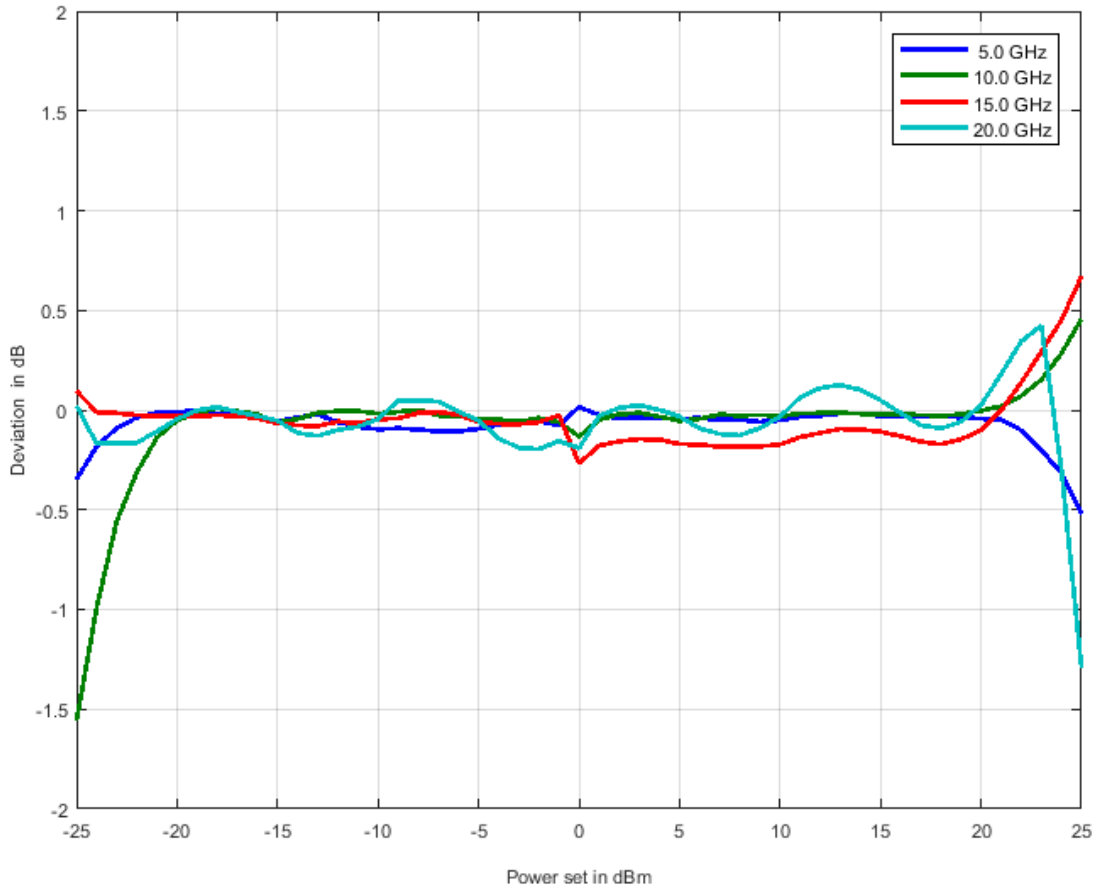


Figure 6. Level linearity

Figure 7. Level linearity with option **1E2**

Reverse power protection and VSWR

Parameter	Min	Typical	Max	Note
Reverse power protection				
DC voltage			±10 V	
RF power			26 dBm	
Output impedance		50 Ohms		
VSWR		1.3 1.6 1.9		< 15 GHz 15 to 35 GHz > 35 GHz

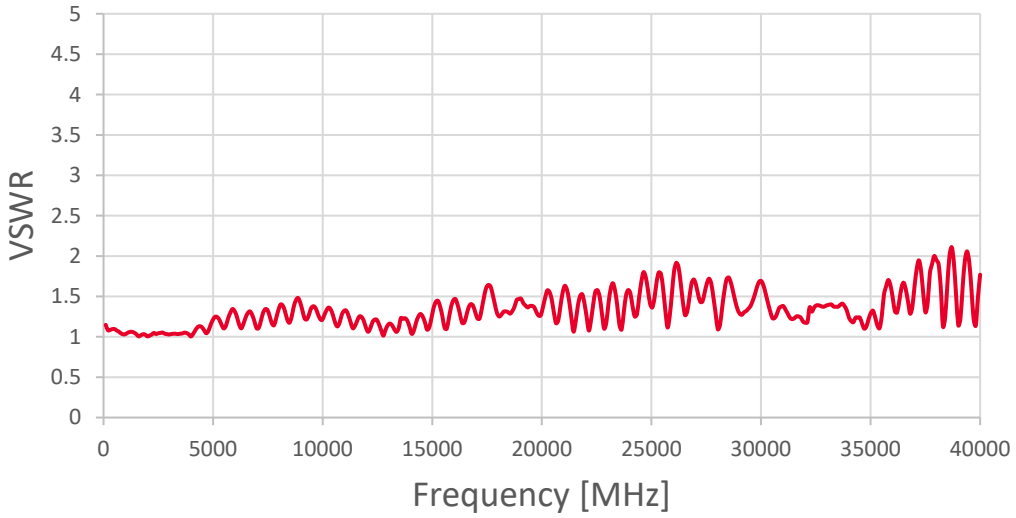


Figure 8. VSWR

Channel to channel performance

Parameter	Min	Typical	Max	Note
Isolation				
< 3 GHz	90 dB			
3 to 6.5 GHz	70 dB	80 dB		
> 6 GHz		> 60 dB		
300 kHz to 40 GHz	80 dB	> 90 dB		**Option H1E,** see plot
Relative phase stability				See plot
Between channels		0.096 ps		3 mrad at 5 GHz over 5 hours
Between synchronized modules		0.160 ps		5 mrad at 5 GHz over 5 hours
Phase-coherent switching				
Phase mismatch at outputs		15 ps		

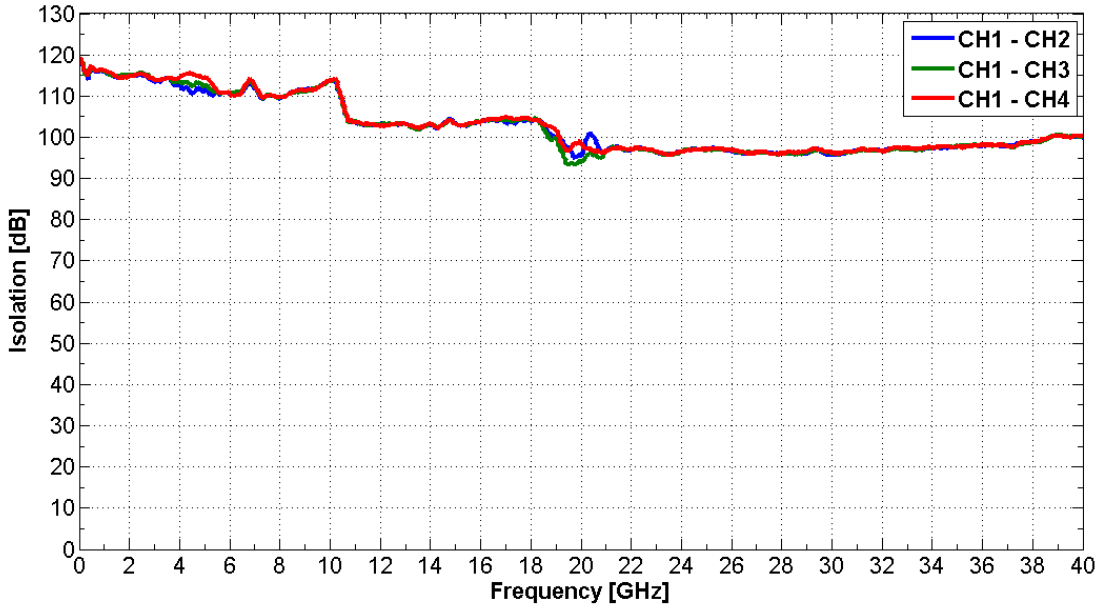


Figure 9. Channel-to-channel isolation with Option H1E (Channel under test: Channel 1, frequency f, power 10 dBm - Channel 2, 3, and 4: frequency f + 9 MHz, power 10 dBm - Measurement made on channel 1 at frequency f + 9 MHz)

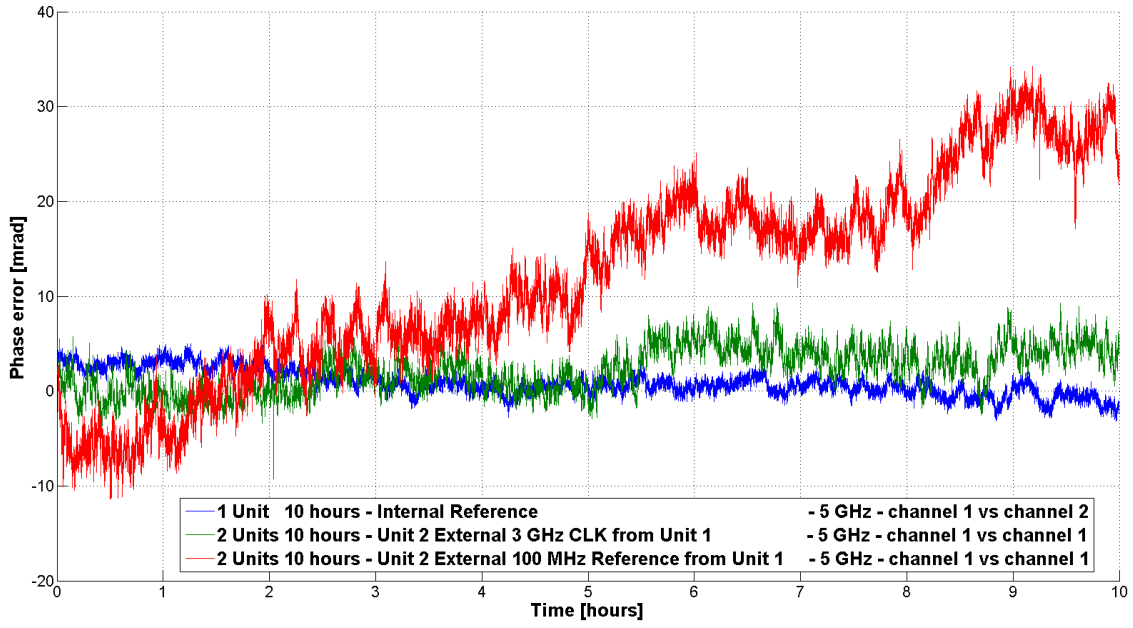


Figure 10. Channel-to-channel phase stability under different test conditions

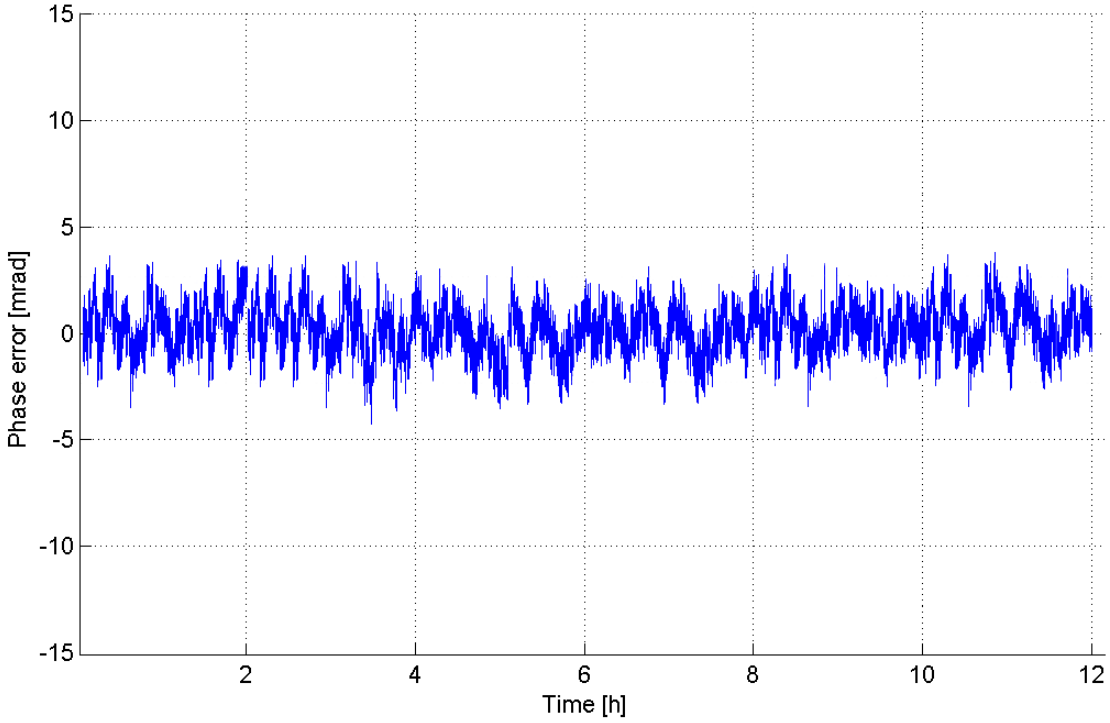


Figure 11. G2 Analog Signal Generator typical time domain channel-to-channel phase error at 10 GHz

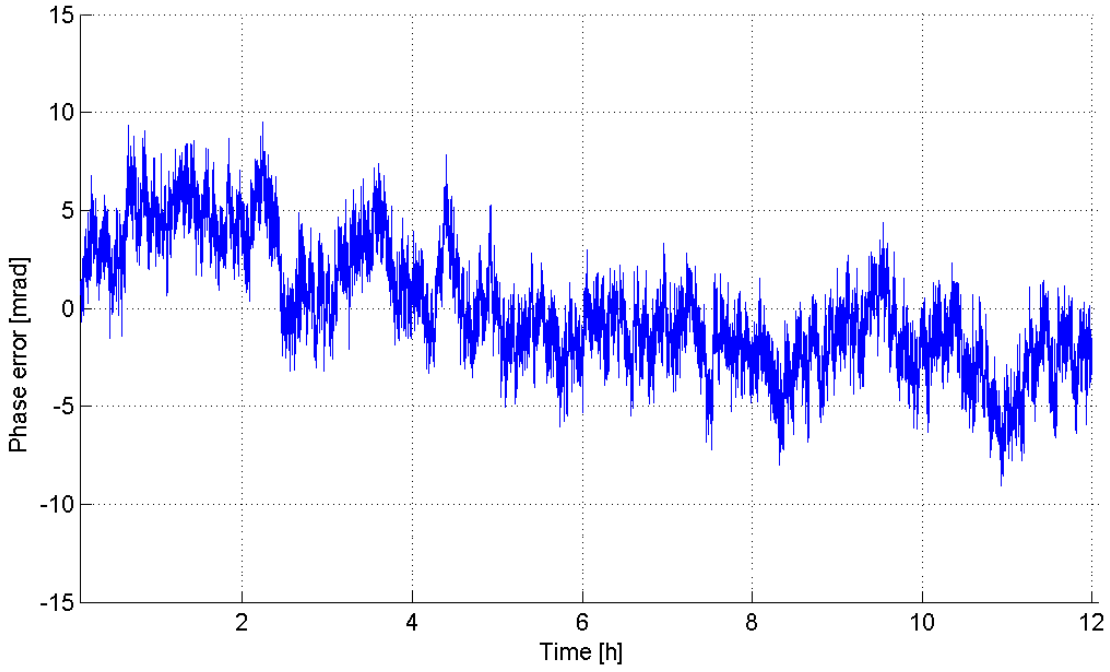


Figure 12. G2 Analog Signal Generator typical time domain channel-to-channel phase error at 20 GHz

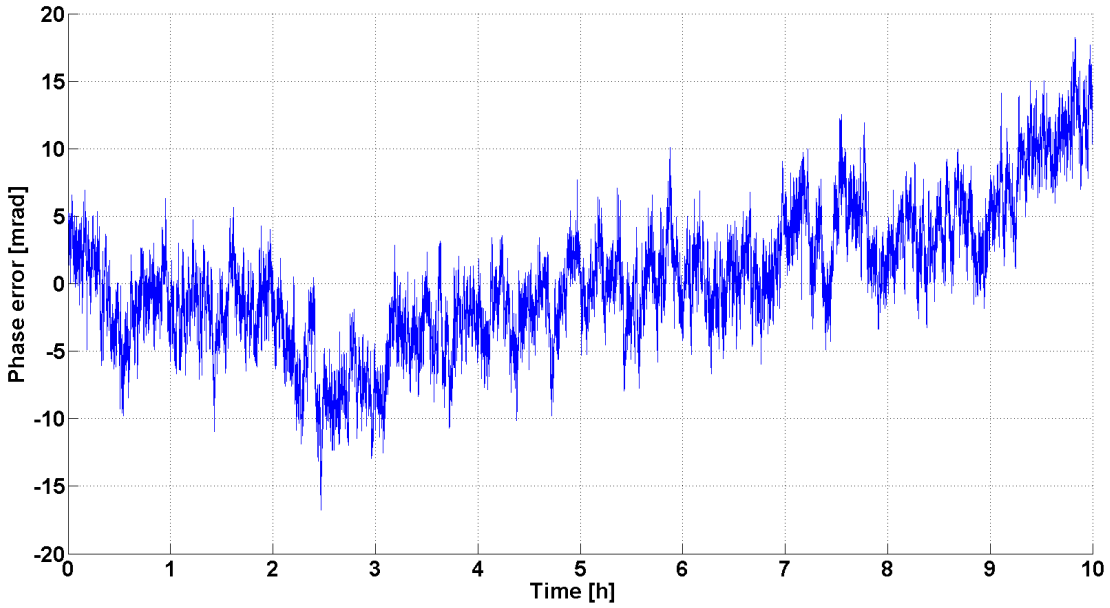


Figure 13. G2 Analog Signal Generator typical time domain channel-to-channel phase error at 38 GHz

Modulation capabilities

Pulse modulation

Parameter	Min	Typical	Max	Note
Pulse modulation				
Modulation source		Internal / external		
External input amplitude	TTL			
Pulse rise / fall time		10 ns		
On / off ratio		90 dB 80 dB 75 dB	80 dB 65 dB	f < 6.5 GHz 6.5 to 18 GHz > 18 GHz (power > +10 dBm)
Pulse overshoot			10%	Excluding video feedthrough
Pulse delay		20 ns		
Pulse polarity		Normal, inverse		selectable
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
Pulse pattern modulation and staggered PRF				using internal pattern generator
Pulse width	25 ns		20 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 jitter		2 ns	5 ns	
Polarity		selectable		

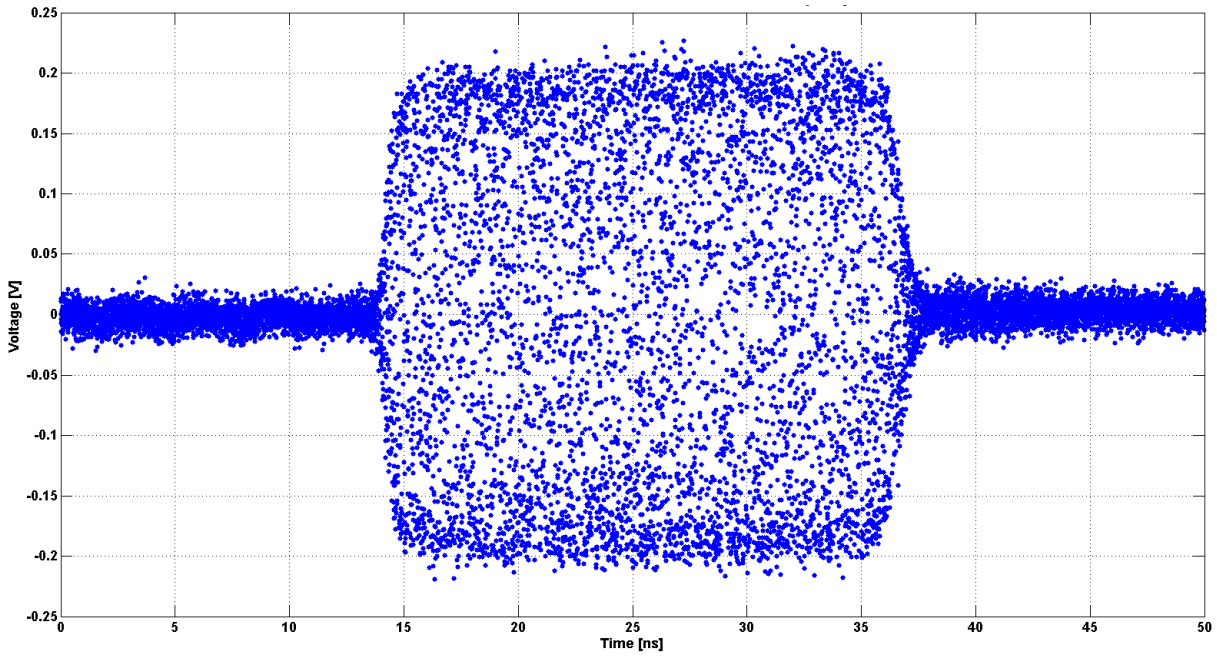


Figure 14. G2 Analog Signal Generator 25 ns pulse modulation — 40 GHz carrier frequency

Amplitude modulation

Parameter	Min	Typical	Max	Note
				Option UNT
Modulation source		Internal		
Modulation depth	0%		90%	
Deviation accuracy		2%		1 kHz rate, 30% depth, 10dBm
Deviation resolution		1%		
Distortion (THD)		2%		1 kHz rate, 30% depth, 10dBm
Modulation rate	0.1 Hz		20 kHz	
Modulation waveforms		Sine		

Frequency modulation

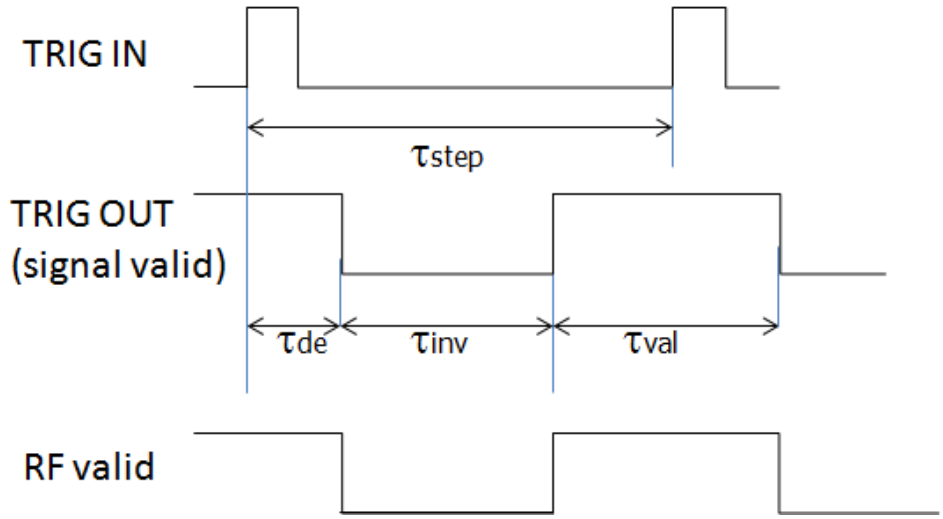
Parameter	Min	Typical	Max	Note
				Option UNT
Modulation source		Internal		
Maximum frequency deviation (peak)	N · 200 MHz			< 1.25 GHz (N=1) 1.25 GHz to 2.5 GHz (N=0.125) 2.5 GHz to 5 GHz (N=0.25) 5 GHz to 10 GHz (N=0.5) 10 GHz to 20 GHz (N=1) 20 GHz to 40 GHz (N=2)
Deviation accuracy		0.50%	2%	
Distortion (THD)		< 1 %		1 kHz rate, 10 kHz deviation
Modulation rate	0.1 Hz		80 kHz	
Modulation waveforms	Sine			

Phase modulation

Parameter	Min	Typical	Max	Note
				Option UNT
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

Parameter	Min	Typical	Max	Note
Sweep parameters		Frequency, power, phase, list		
Sweep type		Linear, logarithmic, random		
Step time (t_{step})	500 µs 25 µs 50 µs <=70 µs		19998 s	**Option UNZ** (1, 2 channels)[2] in band **Option UNZ** (3, 4 channels)[3] in band **Option UNZ** cross band
Dwell time (t_{dwell})	15 µs		9999 s	
Off time (t_{off})	15 µs		9999 s	
Time resolution		5 ns		
Timing delay (τ_{de})		50 ns		
Transient time (τ_{inv})			25 µs	
Timing accuracy per point		5 ns		
Number of points	2		10000	Per channel



2 Applies to the range -45 dBm to -20 dBm
3 Applies when channels are swept simultaneously.

Frequency reference

Parameter	Min	Typical	Max	Note
Internal reference frequency		100 MHz 10 MHz		**Option LN1** **Option LN2**
Temperature stability 0 to 50 degC			±100 ppb ±20 ppb	**Option LN1** **Option LN2**
Aging 1st year			1000 ppb 20 ppb	**Option LN1** **Option LN2**
Aging per day			5 ppb 0.5 ppb	after 30 days operations **Option LN1** **Option LN2**
Warm-up time		5 min		
Output of internal reference		10 MHz 100 MHz		REF OUT port, selectable
Output of high frequency clock		3 GHz		CLK OUT port high phase synchronous mode
Output power		0 dBm 9 dBm		10 MHz, 3 GHz 100 MHz
Output impedance		50 Ohms		
Bypass internal reference input		100, 1000 MHz		*Option LN2 is bypassed
Phase lock to external reference	1 MHz	10 MHz integer MHz	250 MHz	REF IN port **Option 1ER** *Option LN2 is bypassed
High frequency clock input (bypass internal reference)		3 GHz		CLK IN port high phase synchronous mode
Reference input level				
10 MHz or 1-250 MHz or 3 GHz	-5 dBm	0 dBm	+10 dBm	
100, 1000 MHz	+5 dBm		+13 dBm	
Lock range				
10 MHz or 1-250 MHz			±1.5 ppm	
100 MHz			100 ppm	
Reference input impedance		50 Ohms		

Trigger (TRIG IN)

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		

Multi-purpose output (FUNC OUT): Output is TRIG OUT at rear panel

Parameter	Min	Typical	Max	Note
MULTIFUNCTION GENERATOR	**sine, triangle, square wave**			
Frequency range	10 Hz 10 Hz		3 MHz 1 MHz 50 kHz	sine triangle square
Frequency resolution		0.1 Hz		
Output voltage amplitude peak-peak	10 mV	 5V	2 V	Sine, triangle Square (CMOS output)
Harmonic distortion		1 %		< 100 kHz, 1 Vpp
Output impedance		50 Ohms CMOS		Sine, triangle square wave
VIDEO OUTPUT (of internal pulse modulator)				
Output		CMOS		
Period	30 ns		50 s	
Pulse width	15 ns		50 s	
RF delay		10 ns		
TRIGGER OUT Synchronization mode for multiple sources				
Modes	Trigger on sweep start Trigger on each point Signal Valid			

Connectors

Front

- RF outputs:
  - AP5012A-533 and AP5012A-540: K (2.92 mm) female
  - AP5012A-506, AP5012A-512, and AP5012A-520: SMA female
- External pulse modulation inputs: BNC female
- DC power switch

Rear

- Unit-to-unit synchronization signal input (SYNC IN): SMA female [4](unreleased functionality)
- Unit-to-unit synchronization signal output (SYNC OUT): SMA female [4](unreleased functionality)
- High Stability Reference input (CLK IN, 3 GHz): SMA female
- High Stability Reference output (CLK OUT, 3 GHz): SMA female
- Trigger output (TRIG OUT): BNC female
- Trigger input (TRIG IN): BNC female
- Reference output (REF OUT): BNC female
- Reference input (REF IN): BNC female
- GPIB: IEEE-488.2, 1987 with listen and talk (optional)
- LAN connection: RJ-45
- USB 2.0 device
- FUSE (3.15 A)
- 100-240V AC power plug

4 Allows to extend option PHS over multiple units.

Casings standard 19" 1HU

High isolation casing 19" 1HU (option H1E, rack mount kit included)

General Characteristics

Remote programming interfaces:

Ethernet 100BaseT LAN interface

USB 2.0 device

GPIB (IEEE-488.2,1987) with listen and talk (Option GPIB)

Control Language SCPI Version 1999.0

Power requirements: 100 - 240 VAC, 50 or 60 Hz, 160W maximum (80W + 20W per channel)

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 humidity range: 20 – 90 %RH up to +45 °C (non-condensing)

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

CE

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

Weight: ≤ 10.0 kg (21 lbs) net

Dimensions: 19" 1HE enclosure

AP5012A-506, AP5012A-512, AP5012A-520: 44 mm H x 426 mm W x 465 mm L [1.7 in H x 16.8 in W x 18.3 in L]

AP5012A-533, AP5012A-540: 44 mm H x 426 mm W x 485 mm L [1.7 in H x 16.8 in W x 19.1 in L]

Dimensions: 19" 1HU HI enclosure

44 mm H x 440 mm W x 470 mm L [1.7 in H x 17.3 in W x 18.5 in L]