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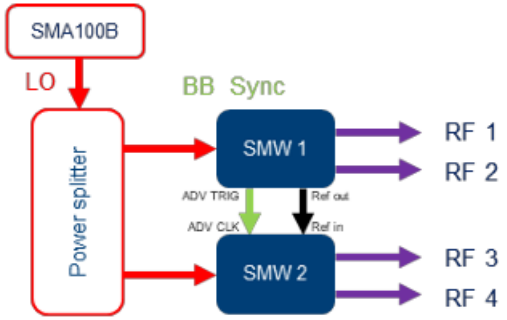
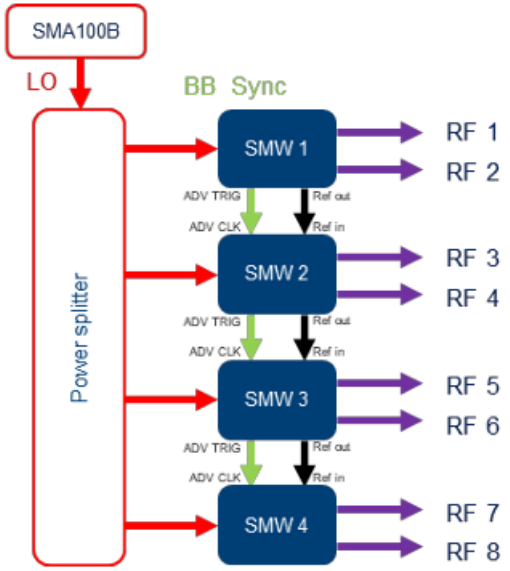
Multi-channel models APVSG vs SMW200A, up to 20 GHz

APVSG-X

APVSGXX - front and rear panel

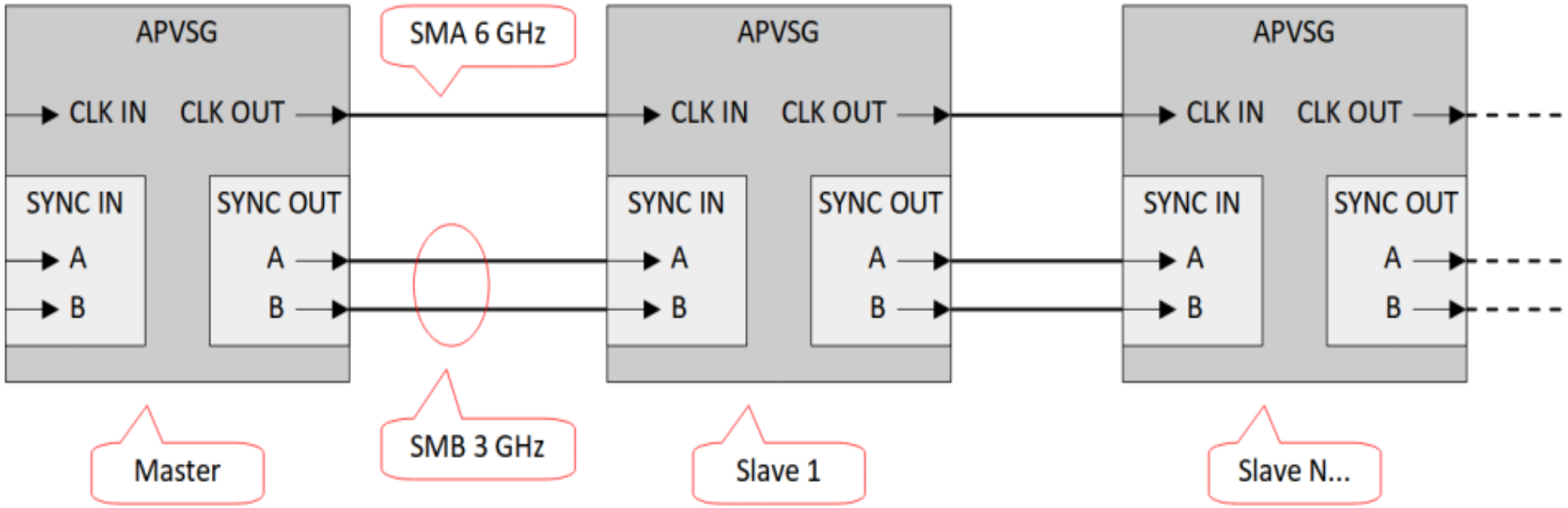
R&S 4 and 8 channels system with star distribution SMA100B





The power splitters need to cover the frequency range from the lowest desired operating frequency (minimum 200 MHz for phase coherence in SMW200A) up to 6.5 GHz (or the highest desired operating frequency, whichever is lower). The most critical signal paths with respect to phase stability are the LO signal distribution (red arrows) the baseband (BB) sync signal distribution (green arrows) and the RF signals (purple arrows).

Multi-channel configuration APVSG-X



The reference clock uses SMA connectors. Connectors and cable must support at least 6 GHz bandwidth. The synchronization signals A, B, C use SMB connectors. Connectors and cables must support at least 3 GHz bandwidth.

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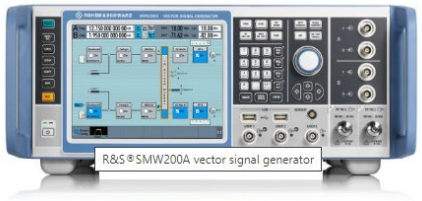

Model	APVSG12-X, APVSG20-X	SMW200A
BASIC SIGNAL QUALITY CHARACTERISTICS		
Frequency range	100 kHz to 12, 20 GHz	100k MHz to 12.75, 20 GHz
Number of channels in one unit	1-2-3-4	2
Scaling	4-8-12-16 channels	8
Aging per year	1 ppm, 0.03 ppm, 0.02 ppm	0.1 ppm, 0.03 pp, B709,B710,B711
Switching speed Analog part	500 µs standard, < 2 µs UFS option	1 ms, 4 ms B711-721 (Low phase noise option)
Switching speed digital part	500 µs standard ,< 1 µs UFS option	Not specified
Min. power	-120 dBm (mechanical attenuator) -55 dBm electronic attenuator	Only mechanical attenuator -120 dBm
Max. power, typical	W/O attenuator/ Attenuator	With internal attenuator
1 GHz	>+20|+18	+18|
6 GHz	>+20|+18	+18|
10 GHz	>+20|+18	+18|
20 GHz	>20|+18 dBm	+18|

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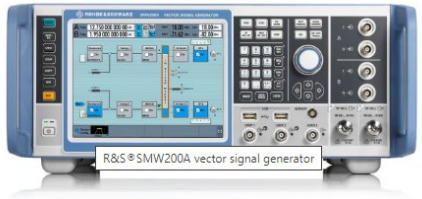

Model	APVSG12-X, APVSG20-X	SMW200A	Remarks
Level accuracy -20 dBm to max	0.7- 1.3 dB	0.5-0.9 dB	
Phase noise 1 GHz-- 10 Hz offset (options) 20 kHz offset	-84 dBc/Hz option LN or LN+ -145 dBc/Hz	Std|B709|B710|B711 Na|-83|-103|-103 dBc/Hz -136|-139|-145|-150 dBc/Hz	In R&S Datasheet phase noise specified without external LO Mode. External LO mode caused degradation of Phase noise especially close in carrier performance. Quality in Non-Harmonics is affected in IQ mode as R&S uses an analogue IQ modulator with high distortion.
Phase noise 10 GHz|20 10 Hz offset (options) 20 kHz offset	-66|-76 dBc/Hz option LN or LN+ -115 dBc/Hz	Std|B709|B710|B711 Na|-63|-83|-83 dBc/Hz -115|-119|-125|-130 dBc/Hz	
Phase noise 20 GHz 10 Hz offset (options) 20 kHz offset	-60|-70 typ. option LN or LN -115 dBc/Hz	Std|B709|B710|B711 Na|-53|-73|-73 dBc/Hz -108|-119|-125|-125	
Non-Harmonics, >10 kHz offset 1|6|10|15|20 GHz	-90|-70|-60|-60 dBc	Std -85|-73|-67|-61 dBc Option B711-B721 -90|-83|-77|-71 dBc	
Harmonics	-45 dBc	-55 dBc	

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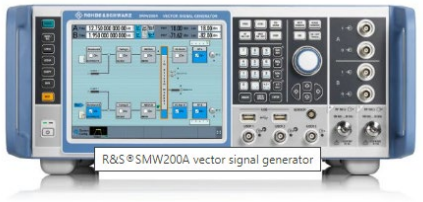

Model	APVSG12-X, APVSG20-X	SMW200A
Phase coherence performance		
Number of channels in one unit	1-2-3-4	2
Phase-coherence between channels	Yes	Yes
Phase coherent frequency switching	Yes	Yes in calibrated bandwidth
Multi-channel baseband synchronization primary/secondary	Yes	Yes
Phase calibration	Yes, option PCM	Yes, RFPAL
Relative phase stability	See plots in the end of presentation	Yes, see plots in the end of presentation

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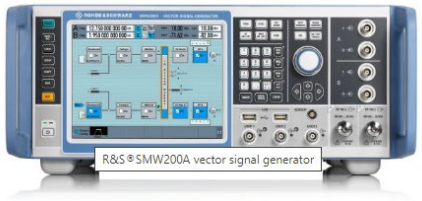

Model	APVSG12-X, APVSG20-X	SMW200A
Pulse modulation Min.width/ Rise time	0-10 ns| 5 ns typ.	20 ns
Minimum pulse width with ALC on	8 ns	20 ns
	PDW	
Pulse Description Word (PDW)	Supported	Supported
Pulse Description Streaming	Internal SSD External Source: FCP	Internal SSD External source LAN
	IQ MODULATOR PARAMETERS	
Bandwidth, IQ	400 MHz	120 MHz to 2 GHz (options)
Frequency response	<± 1,0 dB typ	1.0 dB, 0.3 measured
Carrier Leakage	-90 typ, -70 dBc	-55 dBc
Suppression of Image sideband in modulation bandwidth	-85 typ, -65 dBc	50 dB to 37 dB, depends on modulation bandwidth

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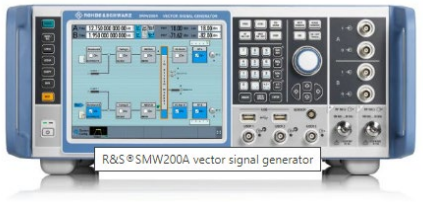

Model	APVSG12-X, APVSG20-X	SMW200A	Remarks
BASEBAND GENERATOR			
Bandwidth	400 MHz- Standard	120 MHz to 2000 GHz	In Multi-channel mode SMW200A not always support 2 GHz Bandwidth, depends of number calibration points Explanation on the next page.
Sample-rate	500 MHz	600 MHz to 2400 MHz	
Memory of BB Generator (Playback)	512 MSample-Standard	256 Msample standard 2 Gsample options	
EVM 16QAM 2.5 GHz, 0 dBm	0,4% typ	0,2% typ	
BASEBAND GENERATOR (SEGMENTED MEMORY MODE)			
Number of segments	1 to 65 k	1 to 1024, 65k options	
Sequencer Play List Length	1 to 2048	1024	
Sequence Segment Repetitions	1 to 10 M	1 Mill	

Explanation to IQ Band limitation of SMW200A in Multi-channel mode

1. Phase-calibration are possible within IQ bandwidth of signal generator, figure 2.3.
2. User have to set up power level and frequency range of calibration (Blue region picture 3.8)

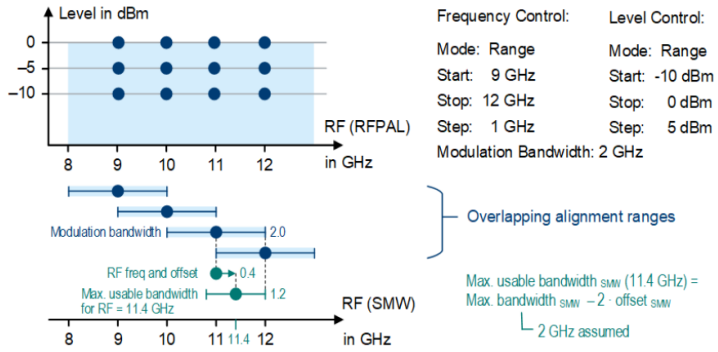

Figure 3-8: Calibration set and relations to the RF signal at the R&S SMW

3. ***Maximum Usable bandwidth SMW (f) = Maximum Bandwidth SMW – 2*offset to calibration frequency.***

To calibration frequency. For 11.4 GHz bandwidth 1.2 GHz.
Figure 3-9 Explain formula.

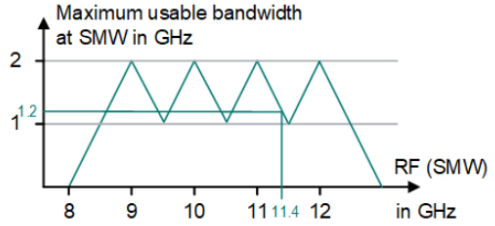

Figure 3-9: Maximum usable bandwidth for the RF signal at the R&S SMW

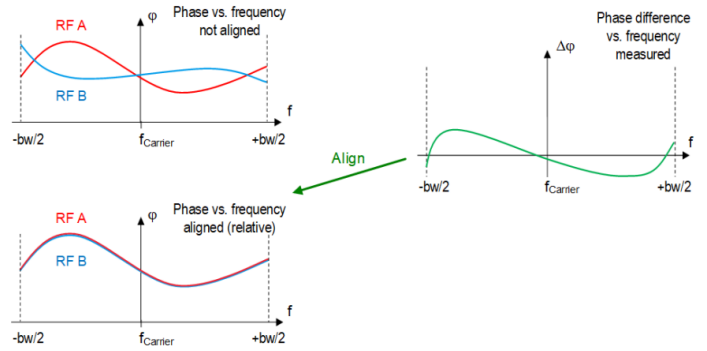

Figure 2-3: Phase responses and relative compensation

bw = Modulation bandwidth

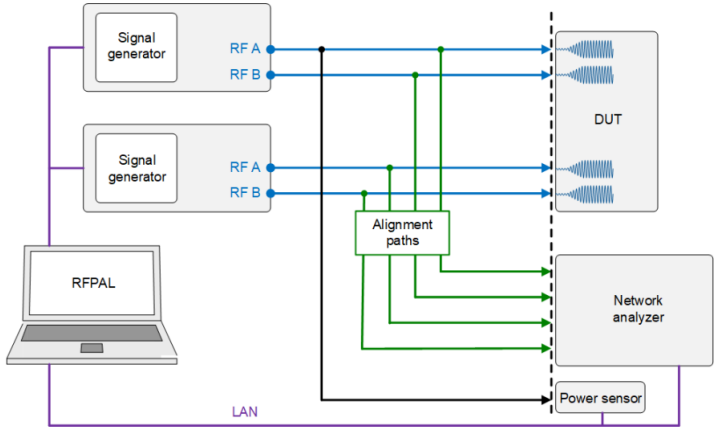

Figure 3-1: RF paths to be aligned

User can not use 2 GHz IQ band at all frequencies in multi-channel mode. Increasing number of calibration points will be time consuming.

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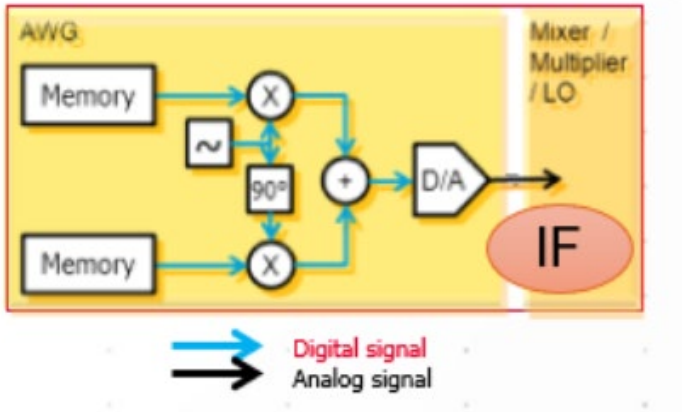
Model	APVSG12-X, APVSG20-X	SMW200A
Multi-tone mode		
Number of carriers	1 to 1 000	512
Frequency offset	-200 to 200 MHz	160 MHz
Power offset	-60 dB to 0 dB	-80 to 0 dB
Additive White Gaussian Noise		
Crest Factor	≤ 21.07 dBm	15 dB
Carrier to Noise Ratio C/N	-60 to 90 dB	-50 to +45 dB
Software		
Digital modulations	Supporting alternative libraries in the format .qid, .qim, .qis, .qi	All digital standards.

Comparison of Technologies

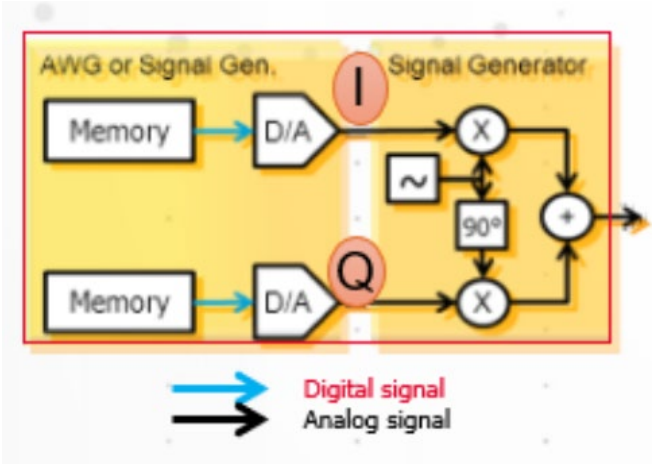
	AnaPico APVSG-X	R&S SMW200A + SMA100B	Remarks
Type of signal sources	DDS+Analog VCO	YIG	*YIG signal generators have excellent performance, the only exception being the frequency hopping speed.*
Method of creating phase coherence system 4 channel	4 Channels in one enclosure with shared reference and phase feedback loop	SMA100B provide shared LO for 2 or more SMW200A	The R&S Shared LO techniques had some strong minus. 1) *Although a common LO signal minimizes the phase drifts between the RF carriers, there are still drifts in other components of the signal generation chain such as the DACs, the I/Q modulator, the power amplifier and the electronic step attenuator* 2) *In addition, temperature effects on the LO connection cables remain. Temperature changes cause a change of the effective electrical length of the cable. For this reason, LO daisy-chaining has the disadvantage that the last instrument in the chain suffers generally most from temperature induced phase drifts (because it has the longest effective LO cable length).* *Temperature the major factor on the phase stability and limitation in building 4-8 and more channels. For example in X-band changing temperature of units in 1 Deg caused relative phase change in 2 Deg. And this example only for 2 ch system.* Plus of shared LO-system 1) *Performance better than shared reference 10/100 MHz* 2) *Phase-noise of synthesiser (LO) is correlated*

Comparison of Technologies

	AnaPico APVSG-X	R&S SMW200A + SMA100B	Remarks
Method of creating phase coherence system 4 channel	4 Channels in one enclosure with shared reference and phase feedback loop	SMA100B provide shared LO for 2 or more SMW200A	AnaPico 4 channel unit with internal shared reference and phase control digital loop *Plus* *1) Best in class phase-coherence, specified in Datasheets between channels and between units.* *2) Possible synchronisation of 12 and more channels.*
Baseband Architecture	Digital	Analog	Digital baseband architecture provides better in Band-Distortion like Carrier Leakage, Image side-band rejection.

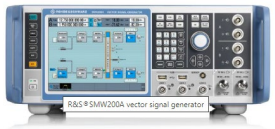


Digital BB Architecture



Analog BB Architecture

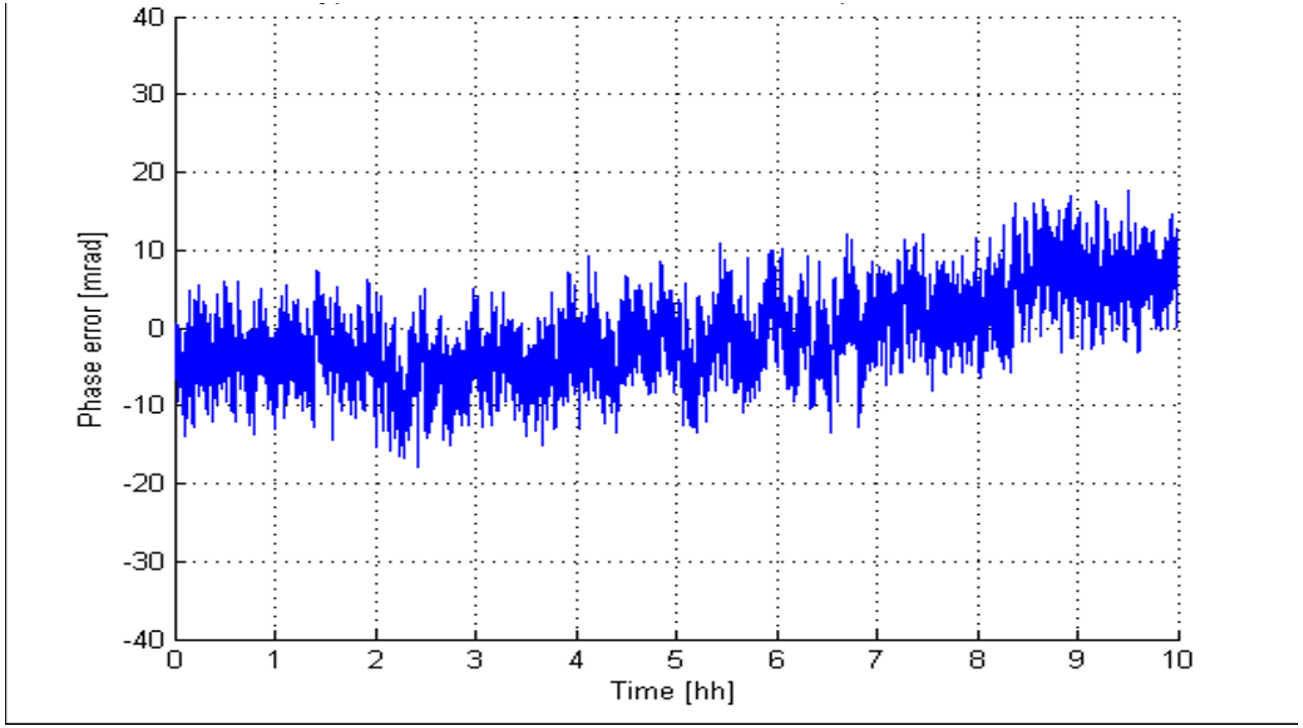
Comparison of Technologies



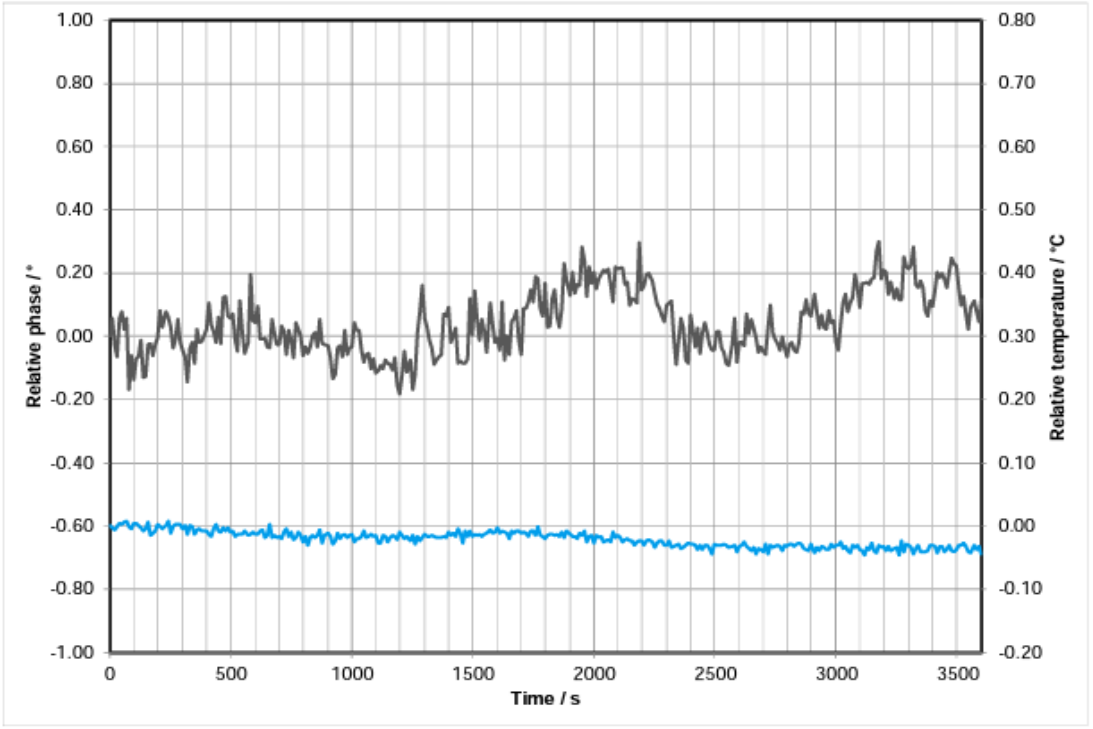
	AnaPico APVSG-X	R&S SMW200A +SMA100A	Remarks
Attenuator	Electronic PE4 Mechanical PE2	Only Mechanical	Electronic attenuator used for fast amplitude setting time. Mechanical step attenuator not allow to make fast amplitude setting, but has dynamic range up to -120 dBm.

Phase coherence at 38 GHz and 40 GHz. Test 1

AnaPico APVSG40-X at 38 GHz



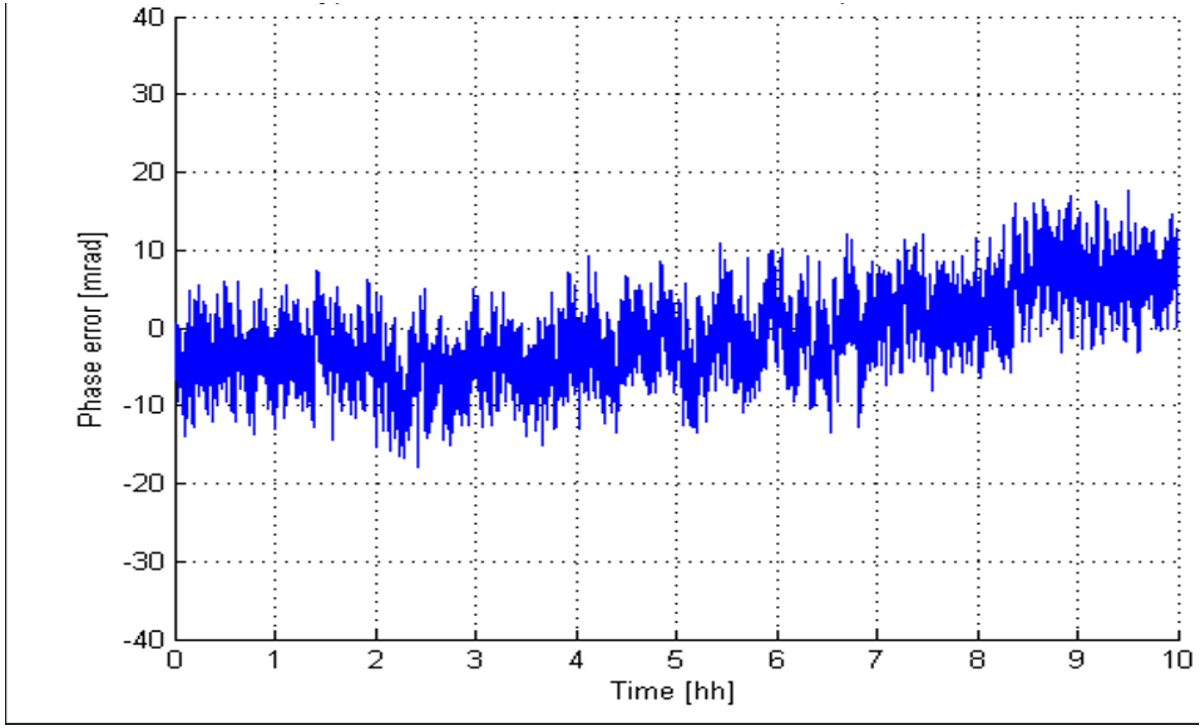
SMW200A.



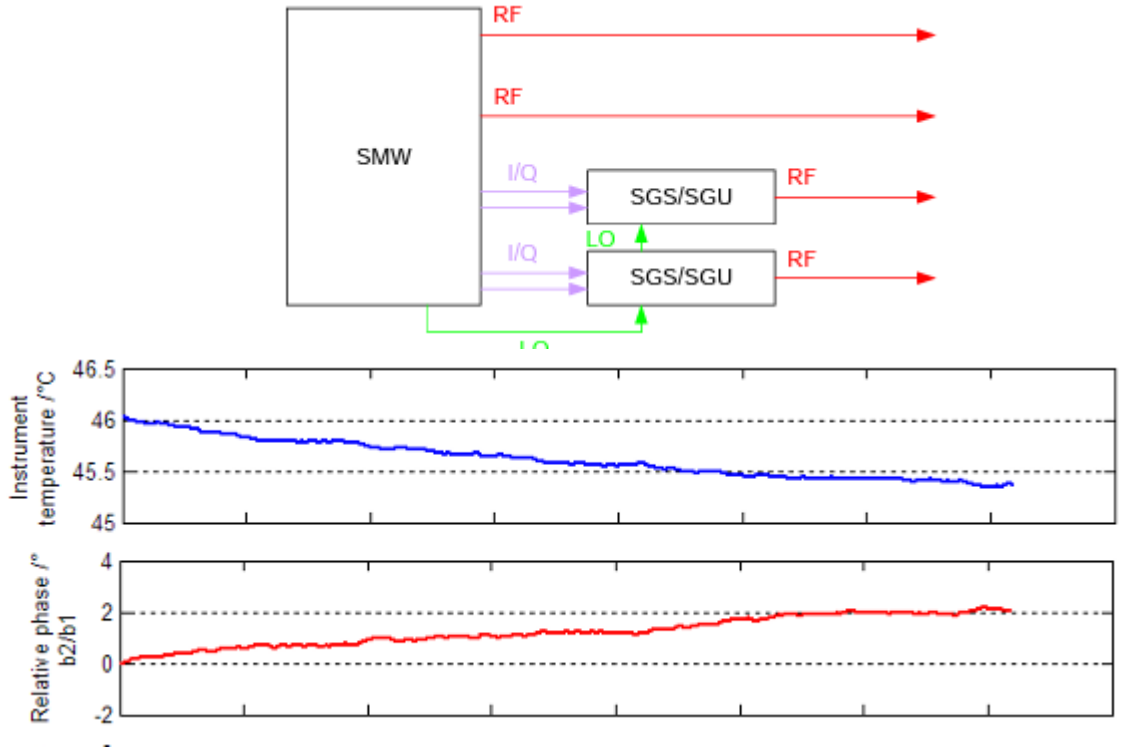
The Maximum amplitude of phase deviation AnaPico APVSG at 38 GHz within 10h 25 mrad is it 1,43 Degree. R&S declares only 1h of operation and with non-realistic temperature stability. In Real conditions 1 deg temperature variations, highly possible that relative phase deviation will be much higher in SMW200A.

Phase coherence at 38 GHz and 40 GHz. Test 2

AnaPico APVSG40-X at 38 GHz



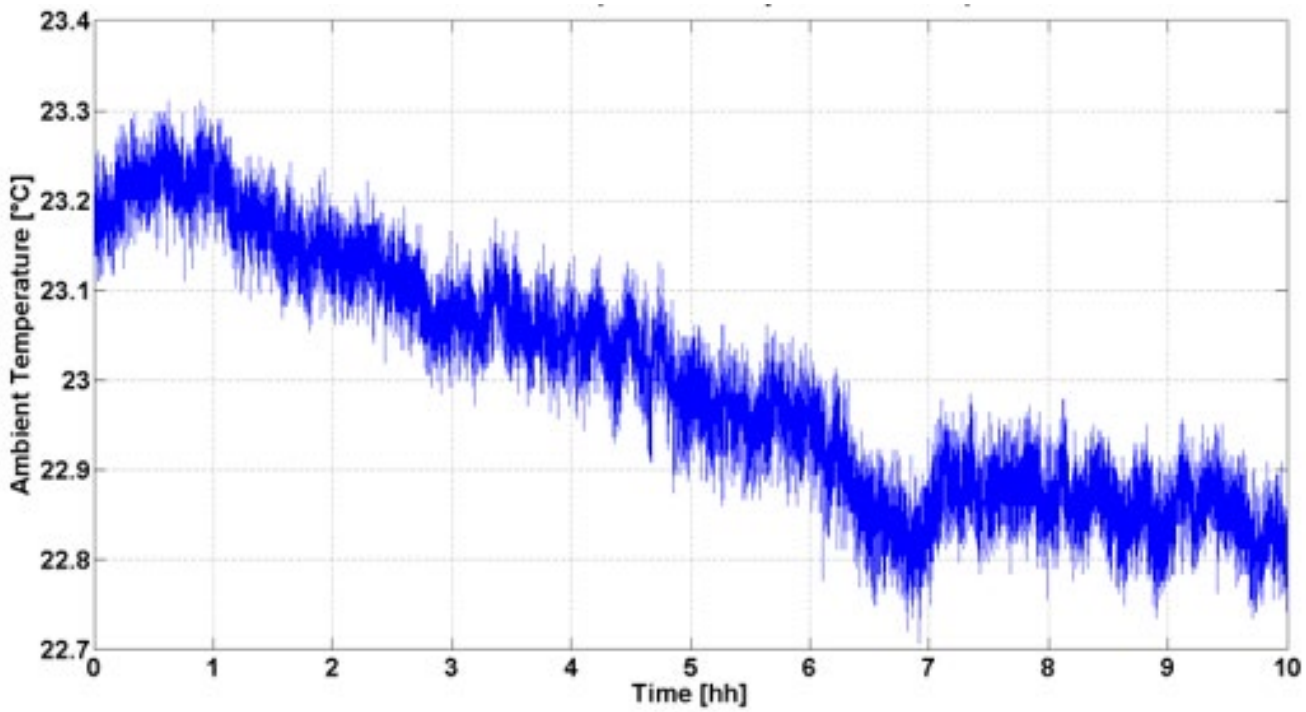
SMW200A ch1 vs Ch2.



If temperature changed by 0.8 Deg, which is realistic. Relative phase between 2 Channels SMW200A become 2 deg, cascade SMW200A system caused degradation of the relative phase behaviour. AnaPico 4 channels unit has relative phase stability in same temperature conditions <1.5 deg.

AnaPioco temperature stability during the test 38 GHz

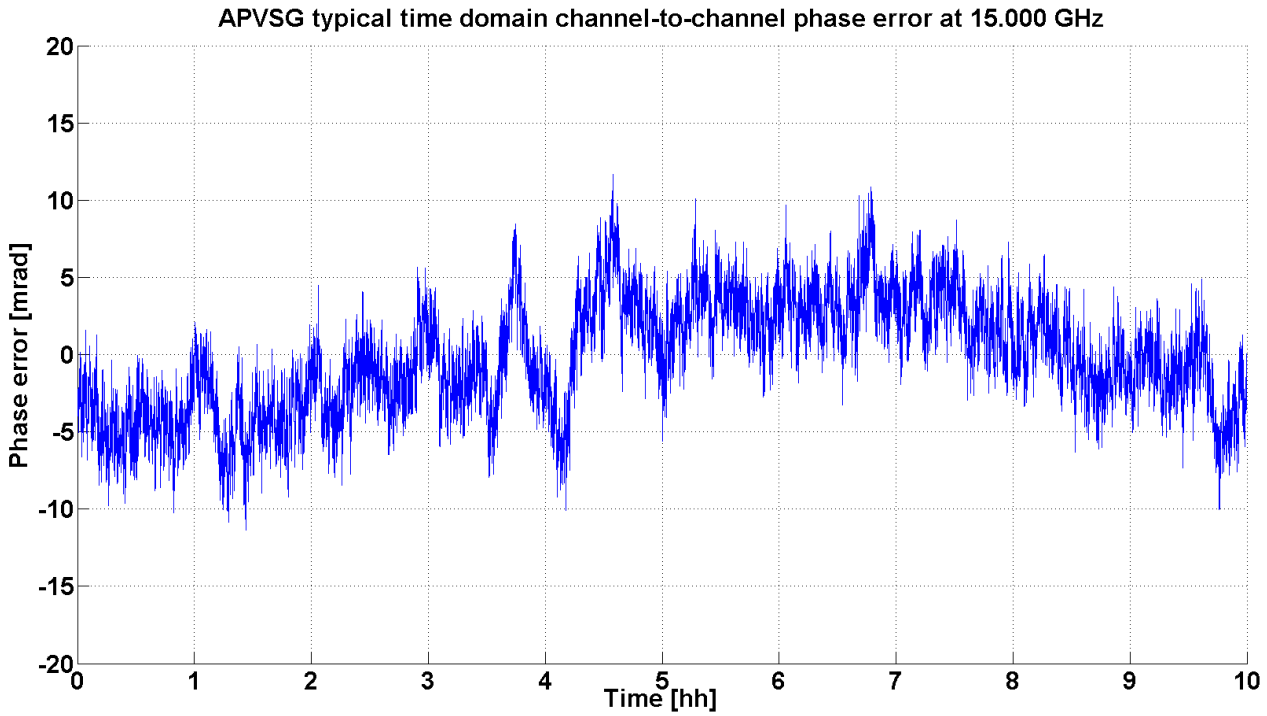
AnaPico APVSG40-X at 38 GHz



During the test of phase stability APVSG-G temperature changed within 1 deg, which is accomplish to realistic conditions.

Phase coherence at 15 GHz

AnaPico APVSG20-X at 15 GHz



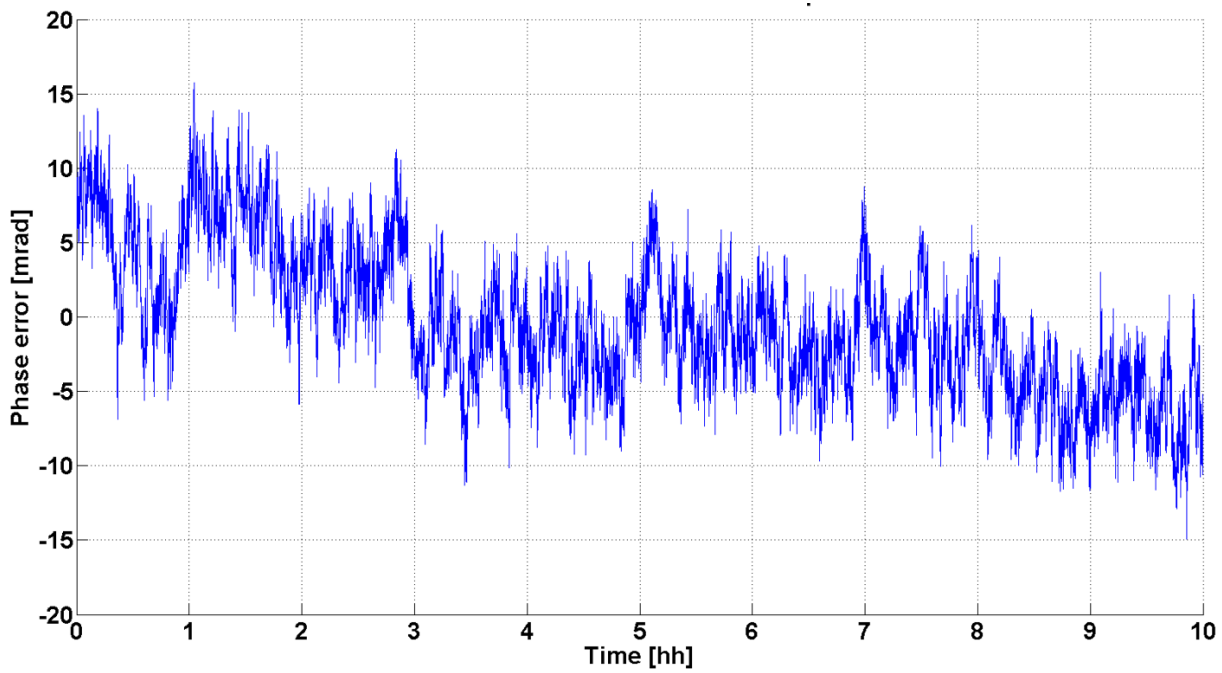
SMW200A

NO DATA

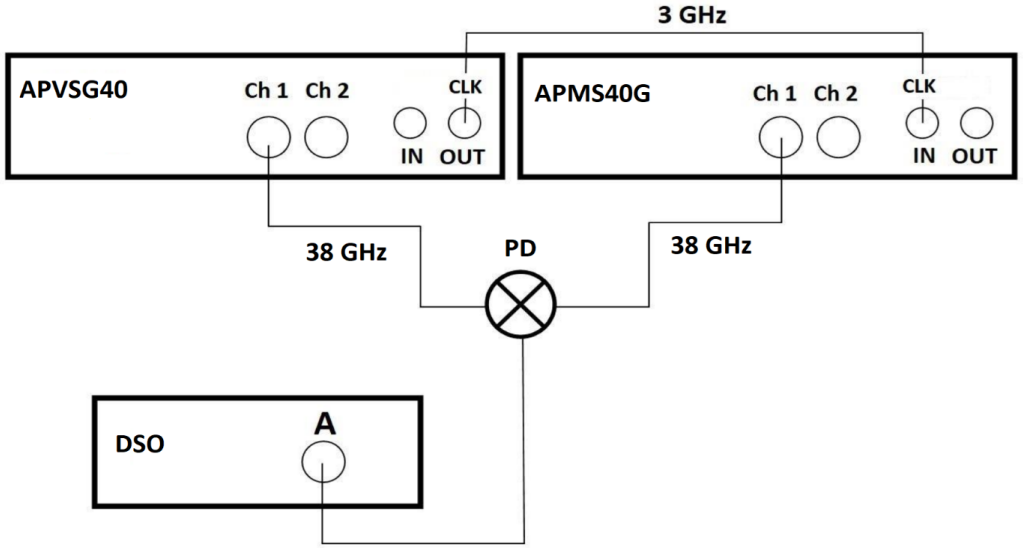
The Maximum amplitude of phase deviation AnaPico APVSG20 at 15 GHz within 10h 20 mrad is it 1,15 Deg.

Phase error between Synchronized AnaPico Analog and Vector multi-channel SG

AnaPico APVSG40-x vs APMS40-X



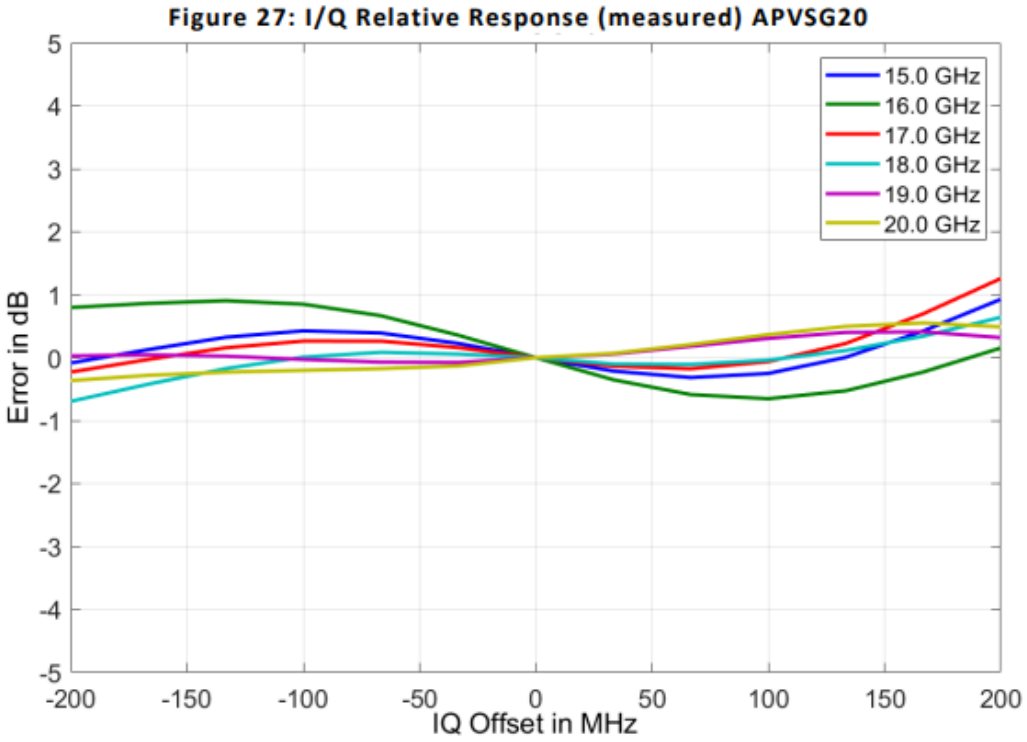
Measurement setup



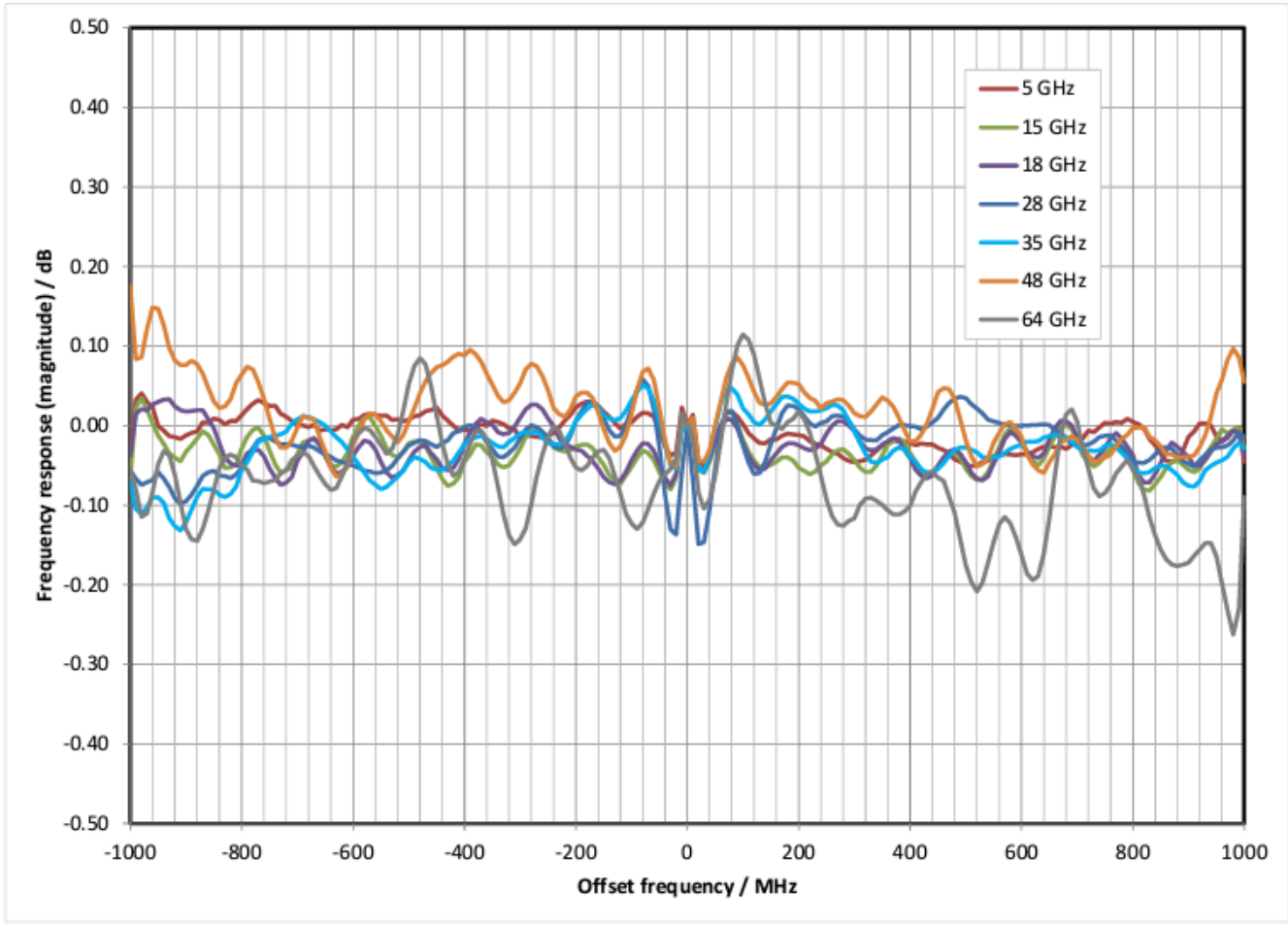
Analog and vector signal sources could be combined in the Multi-channel phase coherent system.

IQ Modulation Frequency response

AnaPico APVSG-X

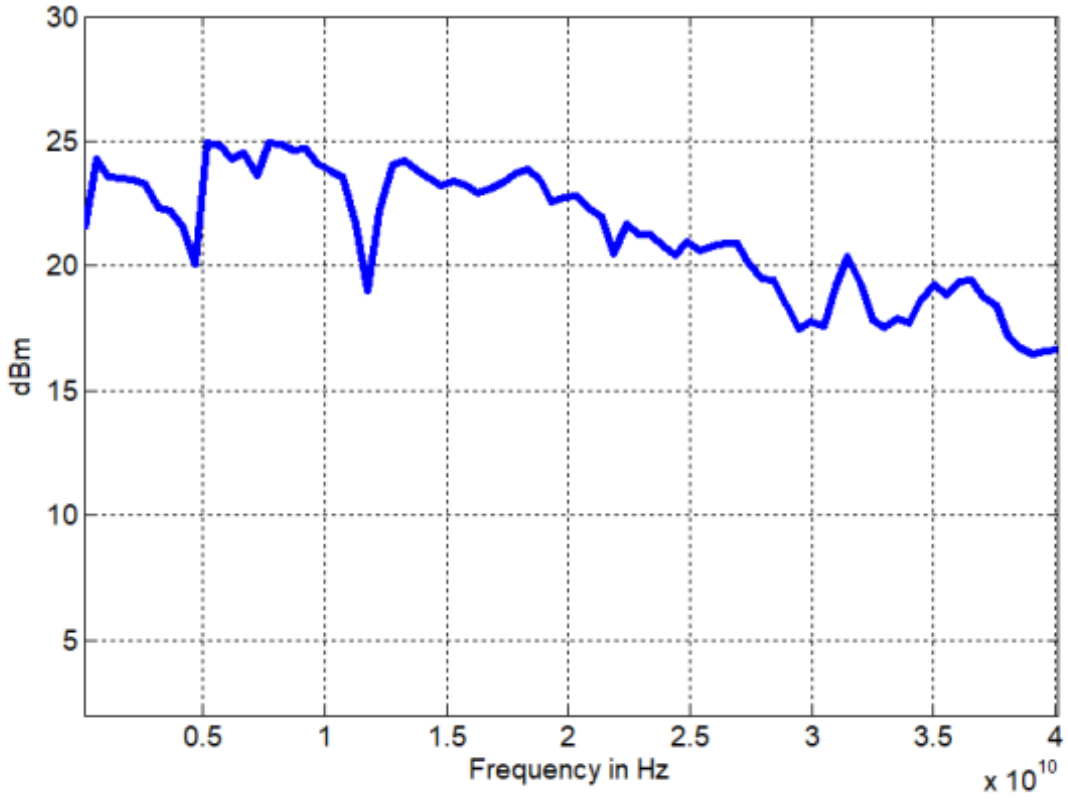


SMW200A

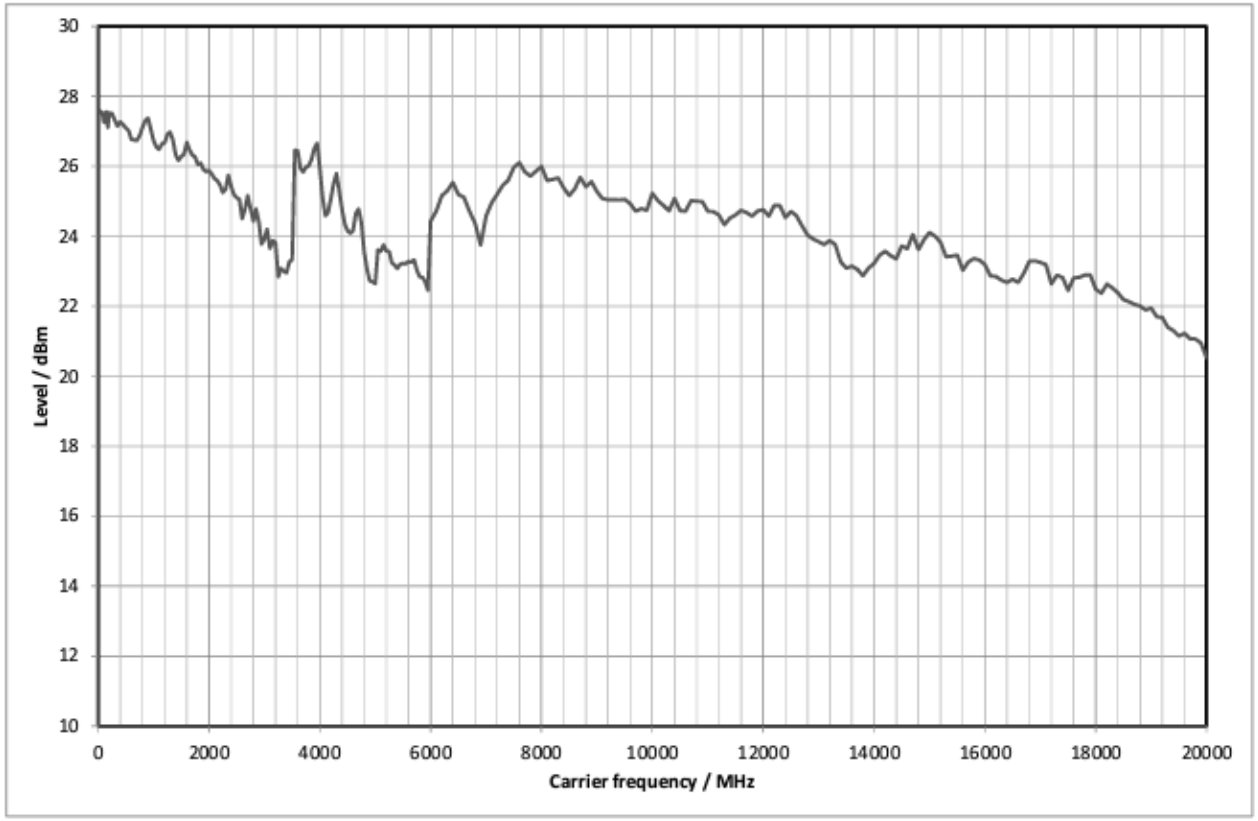


Max. power AnaPico APVSG-X vs R&S SMW200A

AnaPico APVSG20

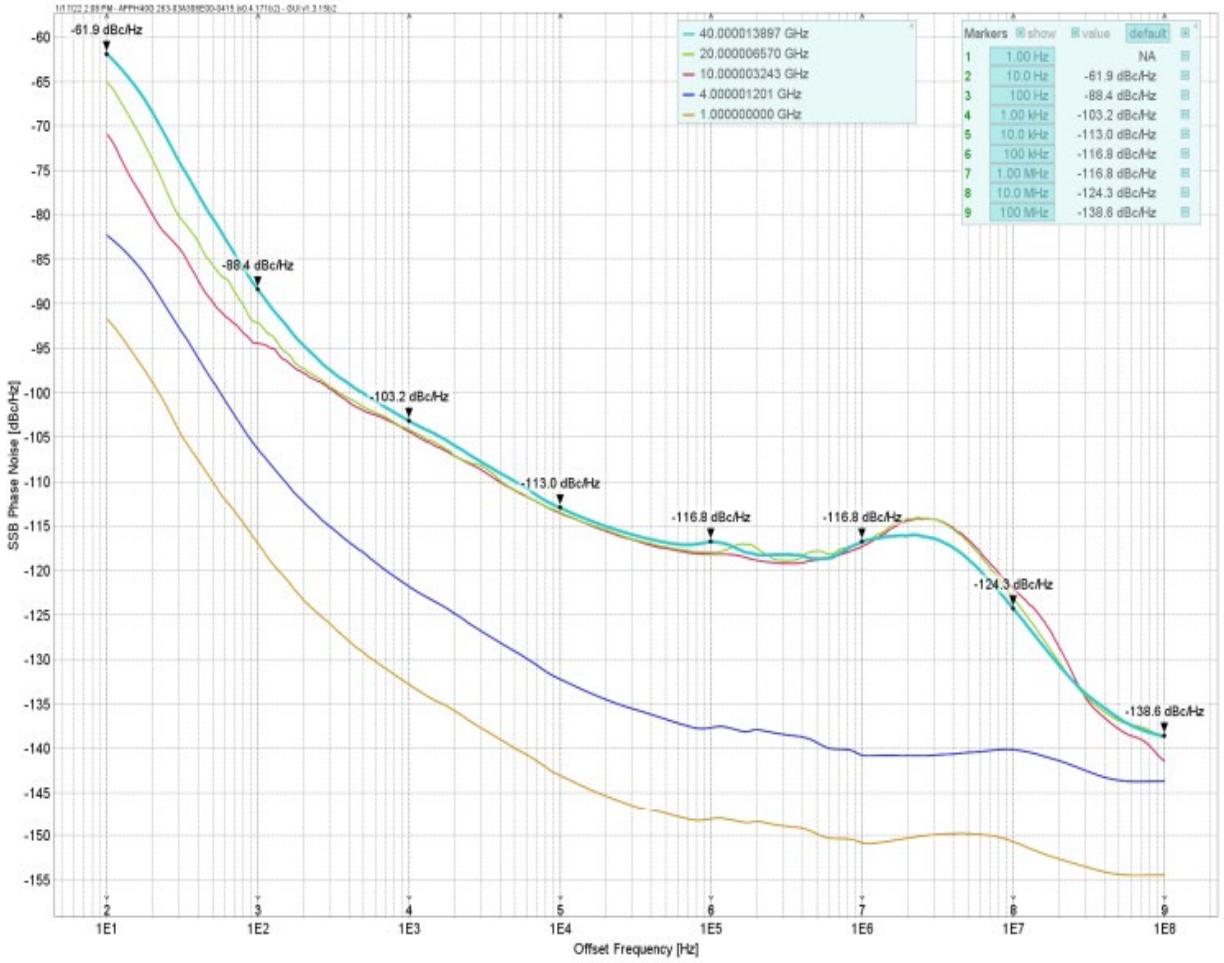


R&S SMW200A

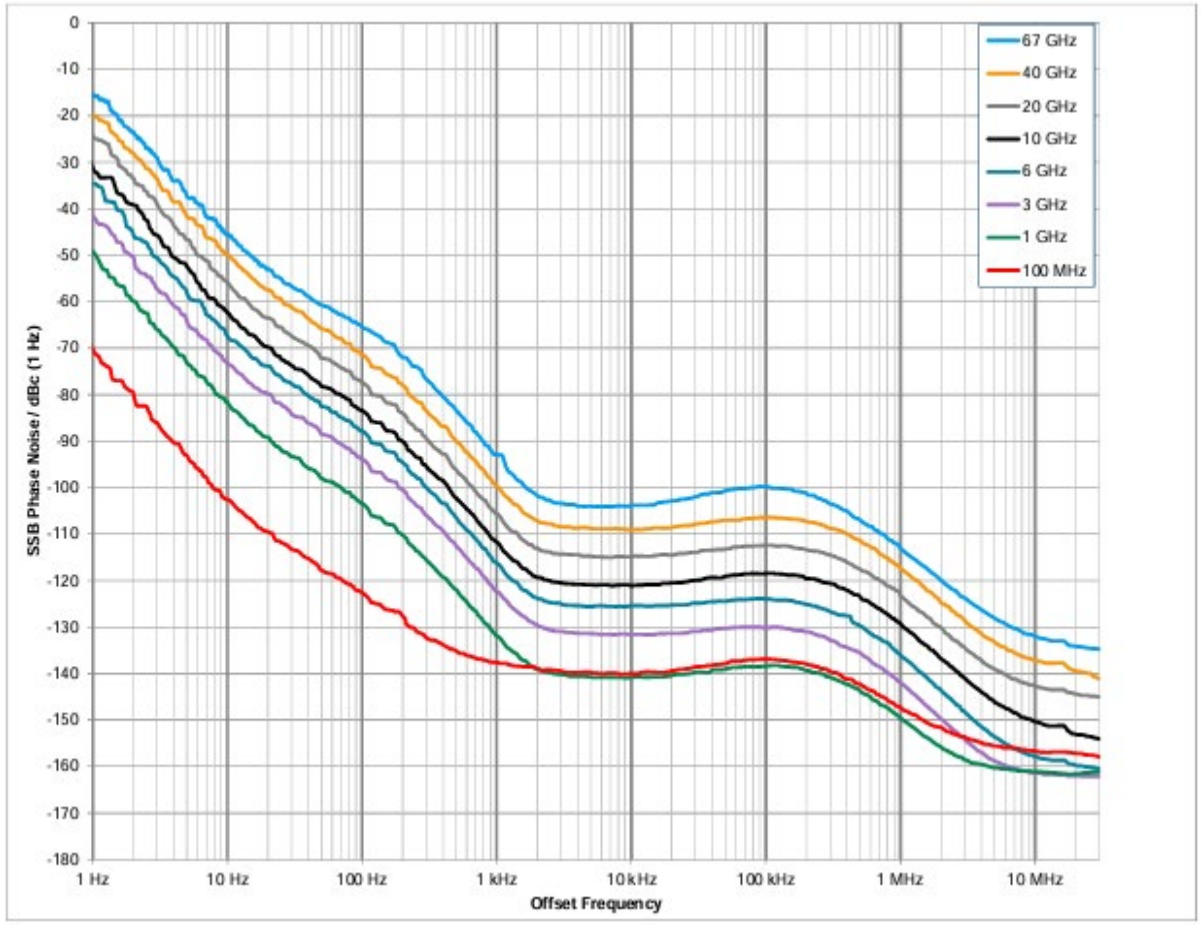


Phase noise APVSG-X vs R&S SMW200A

AnaPico APVSG, without LN

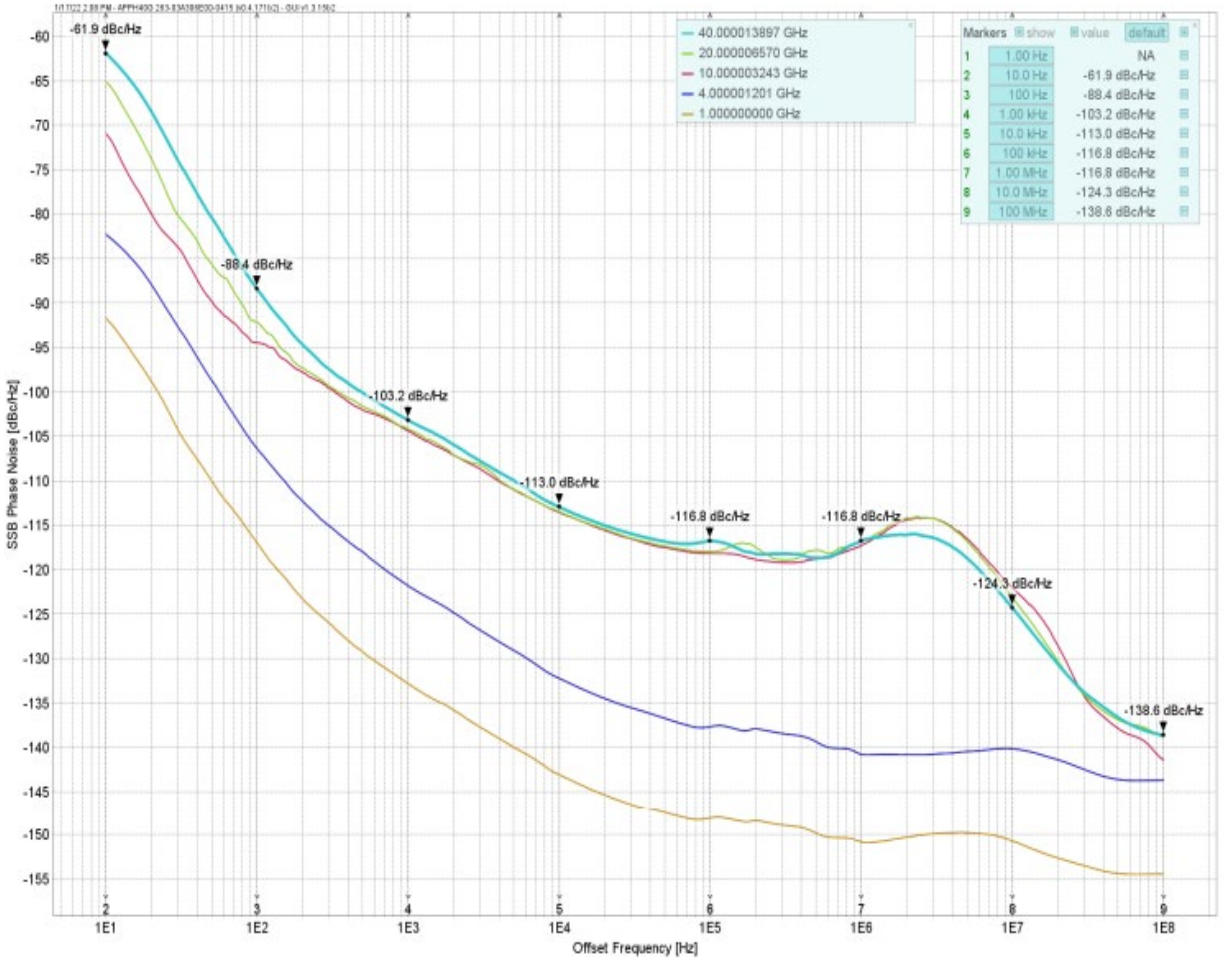


R&S SMW200A standard

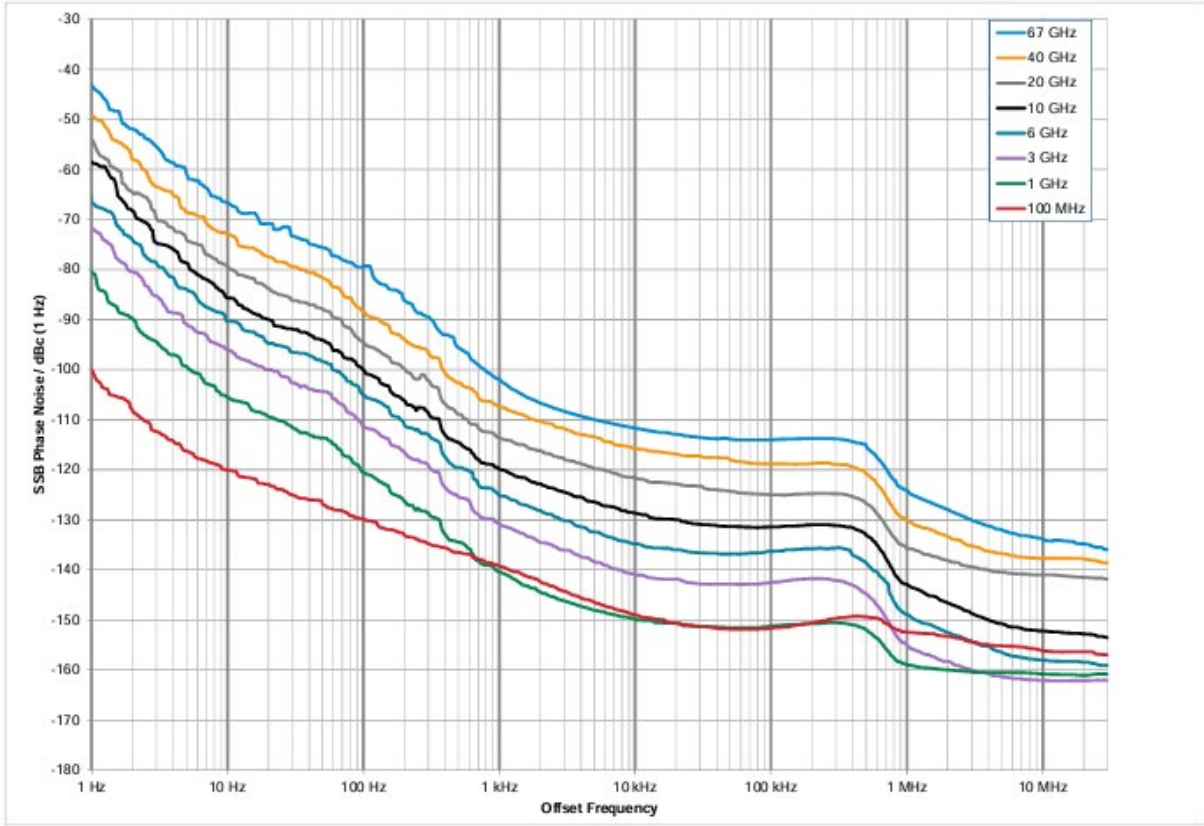


Phase noise APVSG-X vs R&S SMW200A

AnaPico APVSG, without LN

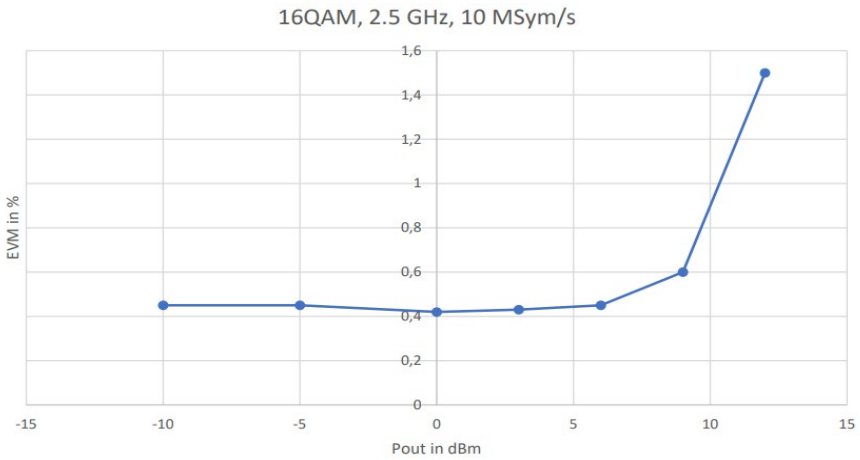


R&S SMW200A options B711/721

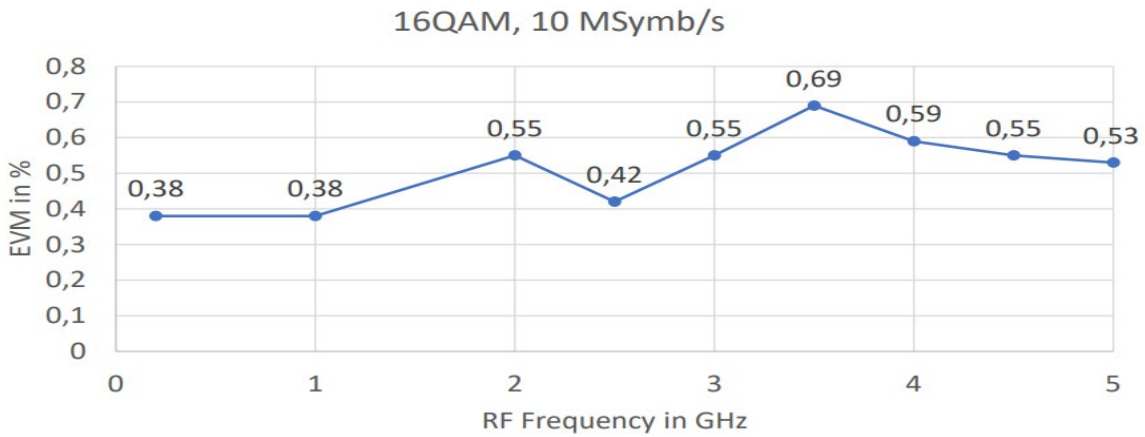


EVM 16QAM AnaPico vs R&S

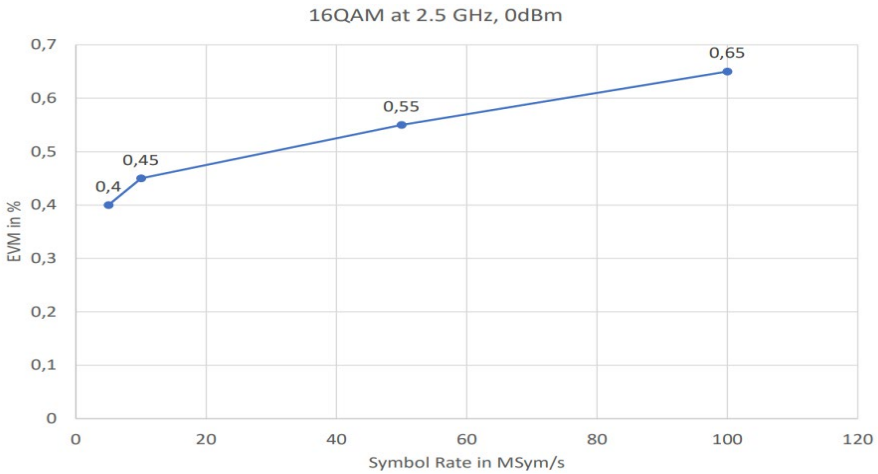
AnaPico APVSG



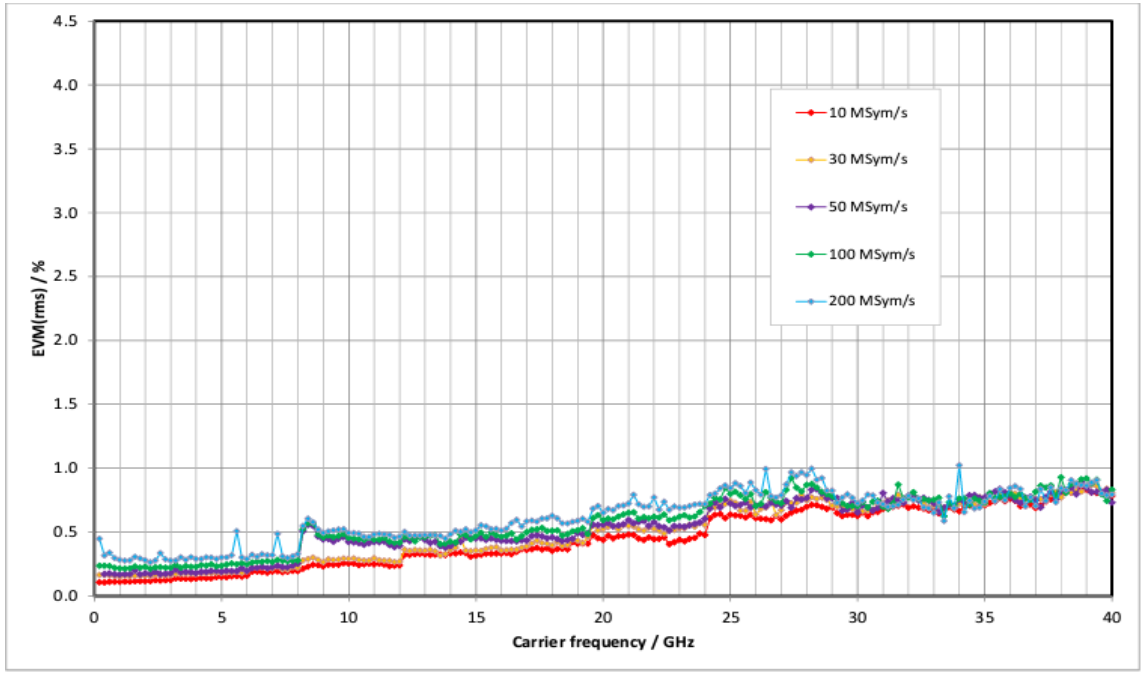
AnaPico APVSG



AnaPico APVSG



SMW200A Measured EVM versus carrier frequency for 16QAM



Pulse modulation AnaPico vs R&S

AnaPico APVSG

Figure 22: Pulse modulation 16 ns at 10 GHz

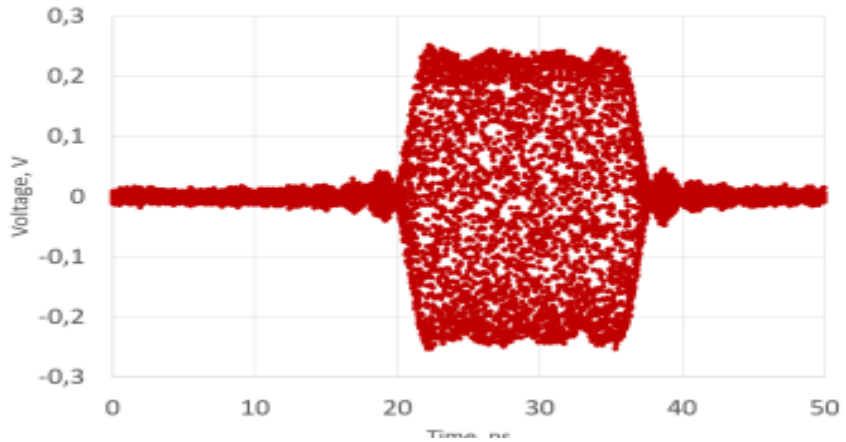
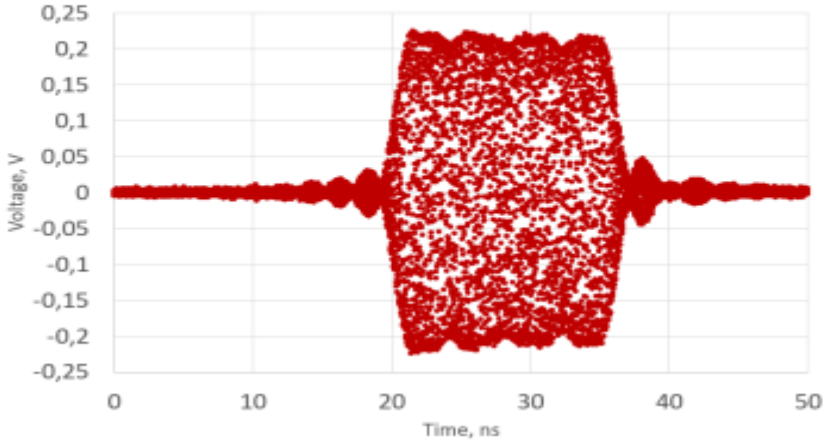


Figure 23: Pulse modulation 16 ns at 40 GHz



R&S SMW200A

Minimum pulse width	50 %/50 % of RF amplitude, transition type = fast	
	with R&S®SMW-B1003, R&S®SMW-B2003, R&S®SMW-B1006, R&S®SMW-B2006, R&S®SMW-B1007, R&S®SMW-B2007, R&S®SMW-B1012, R&S®SMW-B2012, R&S®SMW-B1020, R&S®SMW-B2020, R&S®SMW-B1031, R&S®SMW-B2031, R&S®SMW-B1040, R&S®SMW-B1044, R&S®SMW-B2044, R&S®SMW-B1056, R&S®SMW-B1067 frequency options	20 ns
Rise/fall time	with R&S®SMW-B1007, R&S®SMW-B2007, R&S®SMW-B1012, R&S®SMW-B2012, R&S®SMW-B1020, R&S®SMW-B2020, R&S®SMW-B1031, R&S®SMW-B2031, R&S®SMW-B1040, R&S®SMW-B1040N, R&S®SMW-B1044, R&S®SMW-B2044, R&S®SMW-B1044N, R&S®SMW-B2044N, R&S®SMW-B1044O, R&S®SMW-B2044O, R&S®SMW-B1056, R&S®SMW-B1056N, R&S®SMW-B1056O, R&S®SMW-B1067, R&S®SMW-B1067N, R&S®SMW-B1067O frequency options	
	transition type = fast	< 10 ns

In summary qual performance of pulse modulation

Price comparison

Requirements : 20 GHz 4 Channel, phase-coherence performance.

R&S SMA100B + 2 SMW200A	AnaPico APVSG20-4 + options
 The system consist of Analog SG SMA100A as shared LO, 2 units VSG SMW200A + VNA for time and phase calibration. Plus cables adapters and test bench. In order to calibrate unit SMW200A must have option allow RF port alignment K545, K544 User defined frequency response correction.	 All channels in one enclosure, extra LO not required.
Estimated price without VNA and accessories: 600-800 k Depends on SG options.	Minimum 3 times cheaper than R&S

Conclusion

The SMW200A high-end vector generators are not the primary device for generating phase coherent signals. They are high-end generators that have been made phase-coherent using an external heterodyne SMA100B and calibration tools SW. The AnaPico solution is simpler, better phase-stable, has faster frequency tuning and can easily scale to 16 or more channels. More details below.

Advantages of AnaPico:

Signal quality

- The number of coherent channels is greater and the system is scalable to 12 or more channels.
- *R&S has a maximum of 4 channels. For channel expansion in the case of the Rhode Schwarz, a more complex calibration is required because the VNA only has 4 ports. And the common SMA100B heterodyne may not have enough power. There are no documents from Rode Schwarz with measurements of more than 4 channels.*
- Better log-term stability 0.02 ppm year
- AnaPico can offer Electronic attenuator for fast amplitude setting.

Phase-Coherence

- AnaPico has better phase-stability within 10h of operation and temperature deviation 1 Deg. If AnaPico has phase error 1.5 Deg R&S has 2-3 deg only between 2 channels.

Switching speed

- APVSG-X from AnaPico better in switching speed 2 µs vs 1 ms SMW200A.

Conclusion

IQ Modulation

- Because of digital IQ Modulator scheme APVSG-X from AnaPico is better in carrier suppression and in image side-band rejection.

Advantages of R&S

- Better phase noise performance up to 10 dB difference
- Better signal harmonics and non-harmonics performance.
- Broader IQ bandwidth and better frequency response of Baseband Generator
- Software for advanced signal simulation
- PDW number of pulsed per second bigger, faster upload speed.

Solution based on AnaPico APVSG-X in average could be 3 times more cheaper for solutions up to 4 channels and more.