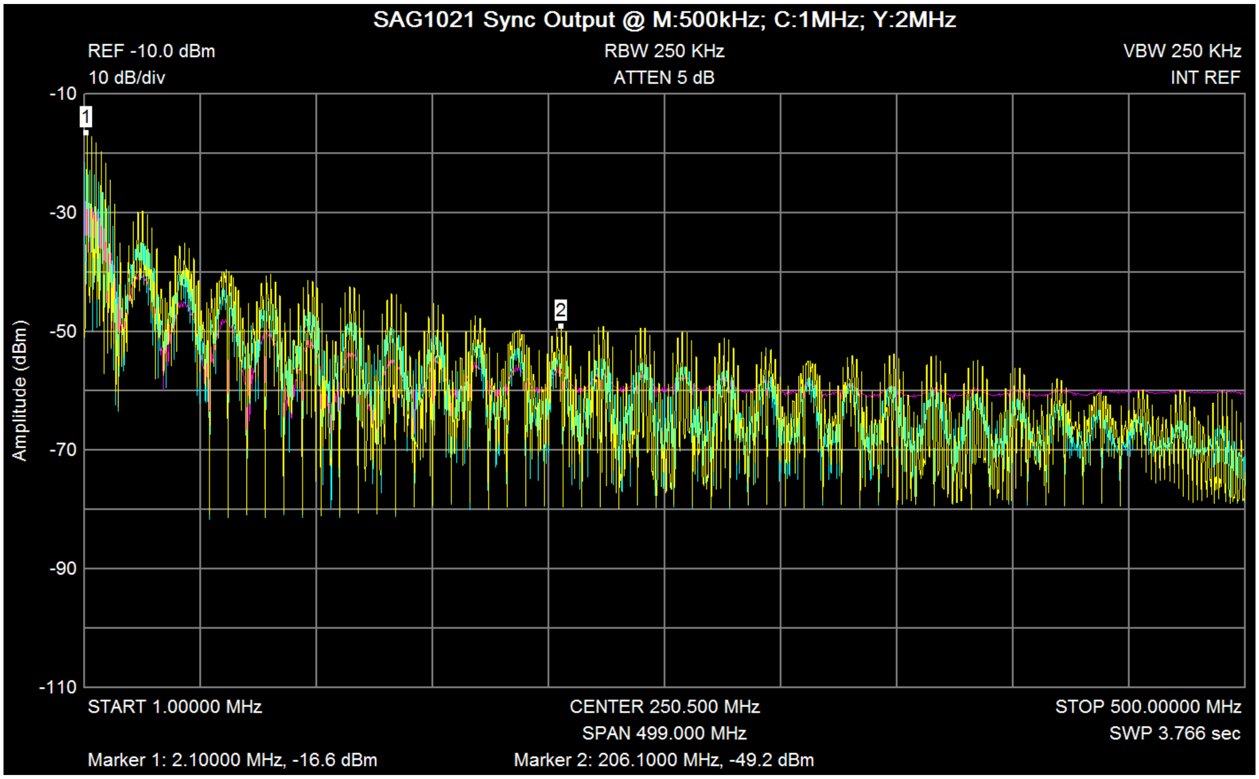
Siglent SAG1021 Review

Just for fun, here's the spectrum of the sync pulse up to 500MHz for repetition rates of 500kHz (magenta), 1MHz (cyan) and 2MHz (yellow):



SAG1021_Sync_500kHz_1MHz_2MHz

Frequency Accuracy

The frequency accuracy is specified as ±50ppm which marks about the bottom of the barrel for all synthesized function generators. Fortunately, the actual accuracy appears to be much better than that.

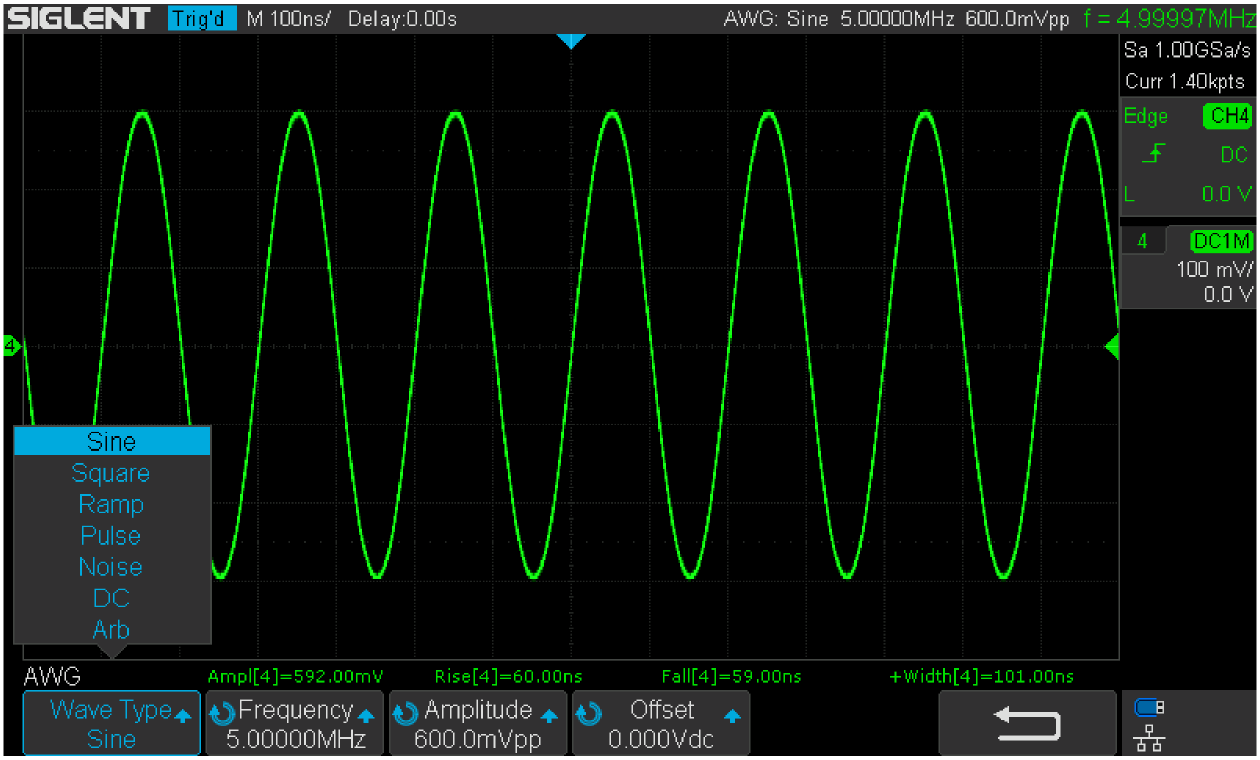
For a 10MHz output, I got a measurement stable to 7 digits that was 9.999997MHz, hence a frequency error of <0.3ppm. The 7 digits mean that the short term stability is better than 1Hz or 0.1ppm. Of course this test cannot be representative for all devices, but it still indicates that the SAG1021 is likely to use a decent TCXO and the ±50ppm specification is just a copy & paste error. In fact, frequency accuracy of my SAG1021 is considerably better than that of the SDS1104X-E!

Waveforms

There are 5 standard waveforms (sine, square, ramp, pulse, noise) available, plus DC and arbitrary. This covers the majority of applications, but we don't get swept, gated and/or triggered waveforms and there is also no modulation capability.

We can adjust the frequency from 1µHz up to 25MHz for sine waves (10MHz for square and pulse, 300kHz for ramp) and the amplitude from 1mVpp to 3Vpp into a 50Ω load (or 2mVpp to 6Vpp into high-Z). We can also have a DC offset within this range and get an additional parameter for some waveforms, like symmetry for ramp, duty cycle for square and pulse width for pulse.

The available waveforms will be closely examined in the following sections.



SAG1021_Waveforms

Sine

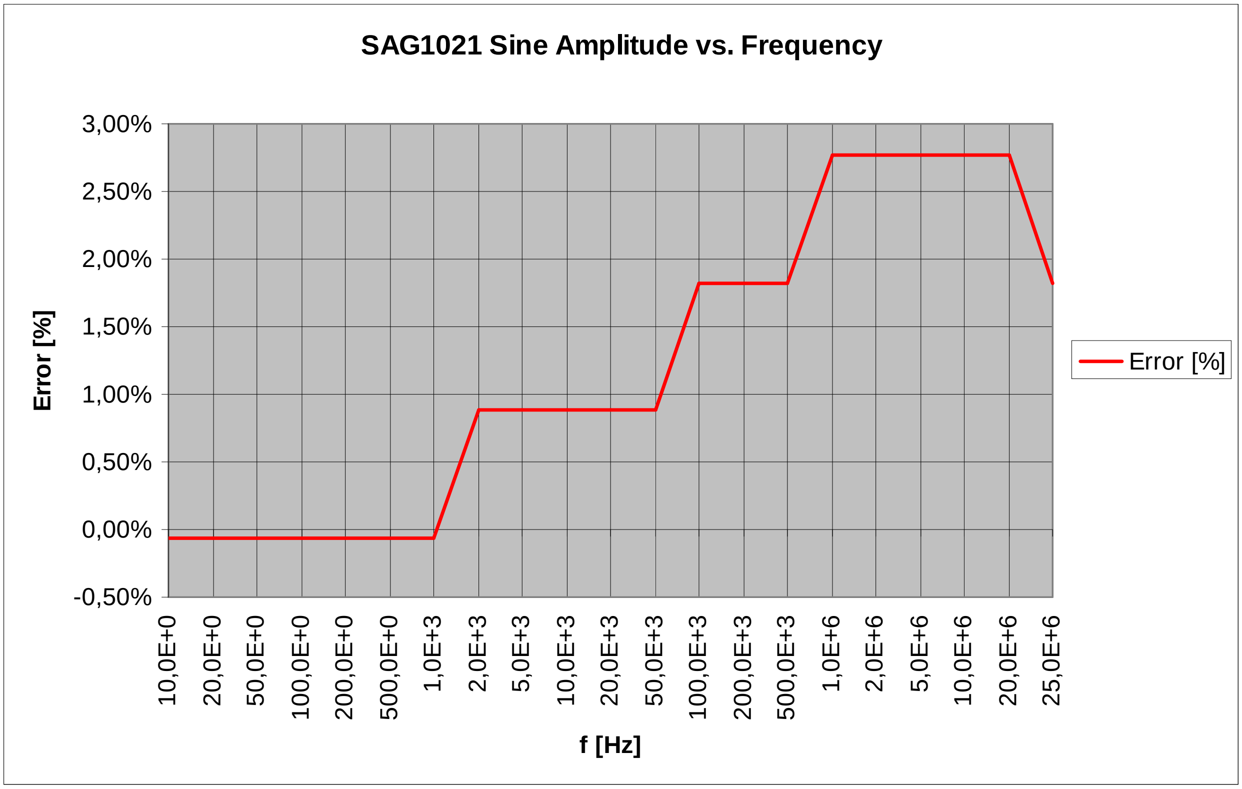
A perfect sine wave is unique in that it has just one single frequency component. Consequently spectral purity is an important feature that we'll have a look at, but we also want decent amplitude accuracy, so let's check that first.

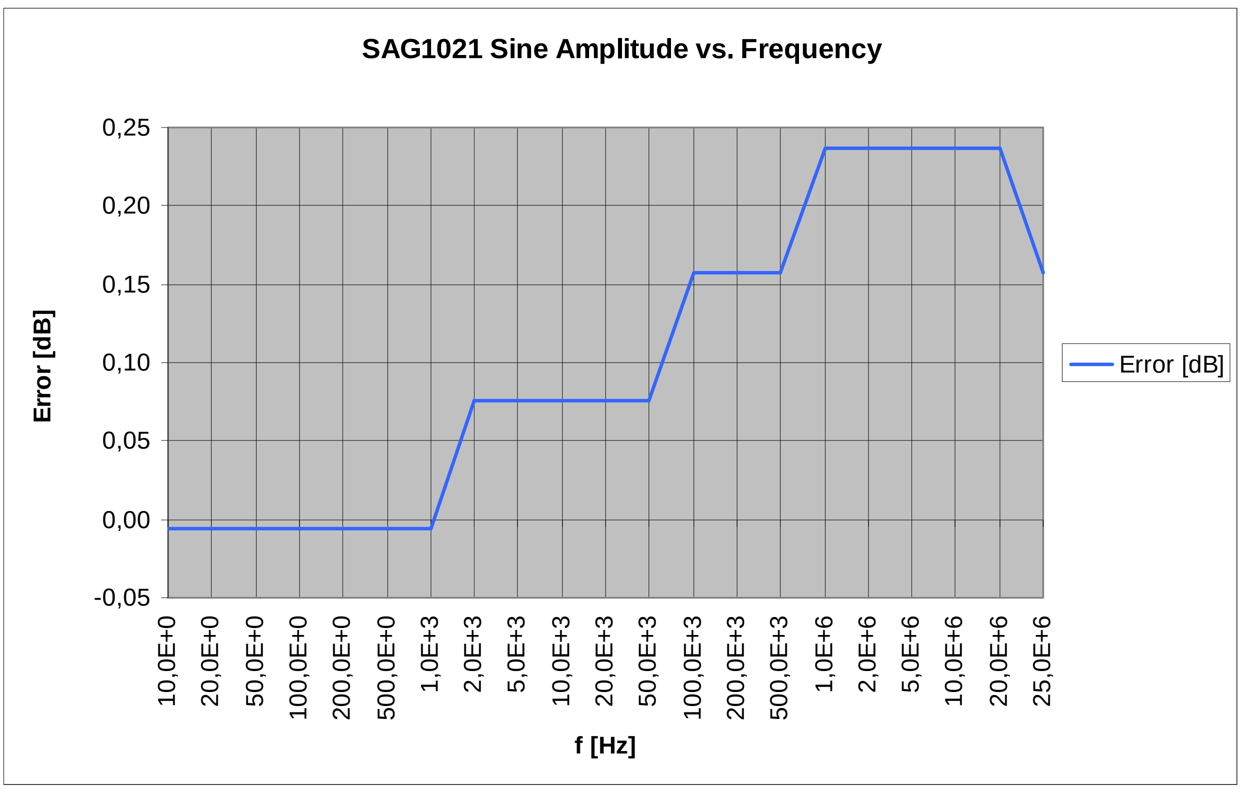
Amplitude Accuracy

An initial check was done using a sine wave at 10kHz measured with a Fluke 8842A DMM and confirmed by a Keithley 2001. At 6Vpp (=2.121Vrms) output amplitude, the measured RMS voltage was 2.1206V, so this is only -720µV or 0,034% difference. With 50Ω termination, the expected voltage would be 3Vpp (=1.061Vrms) and was measured as 1.05969Vrms, which is an error of -970µV or -0.091%.

The frequency response has been measured for a range of 10Hz to 25MHz using the SDS1104X-E itself, as this DSO has proven to provide a decent flatness up to 25MHz.

The graphs below show the combined amplitude error of the SAG1021/SDS1104X-E test setup as percent of the output value as well as dB. Please note that the absolute error includes not only the amplitude errors of both the SAG1021 and SDS1104X-E, but also the tolerances of the 50Ω through termination and the source impedance of the SAG1021. Even more importantly, the limited resolution of 8 bits in conjunction with a peak to peak signal amplitude of 6 divisions can't guarantee an accuracy better than 0.67% from the outset. As a sanity check the10kHz measurement has been performed with the SDS1104X-E and external 50Ω termination and the result was 1.07Vrms, or 0.88% error.

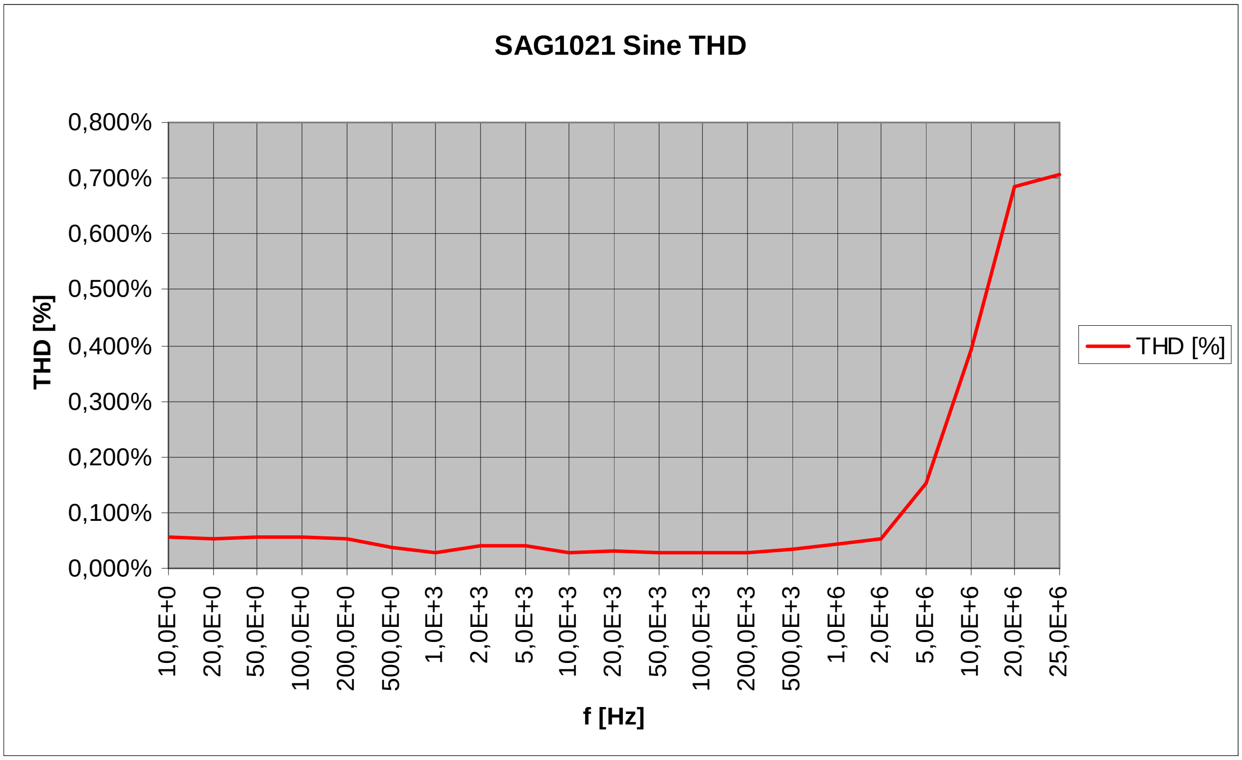


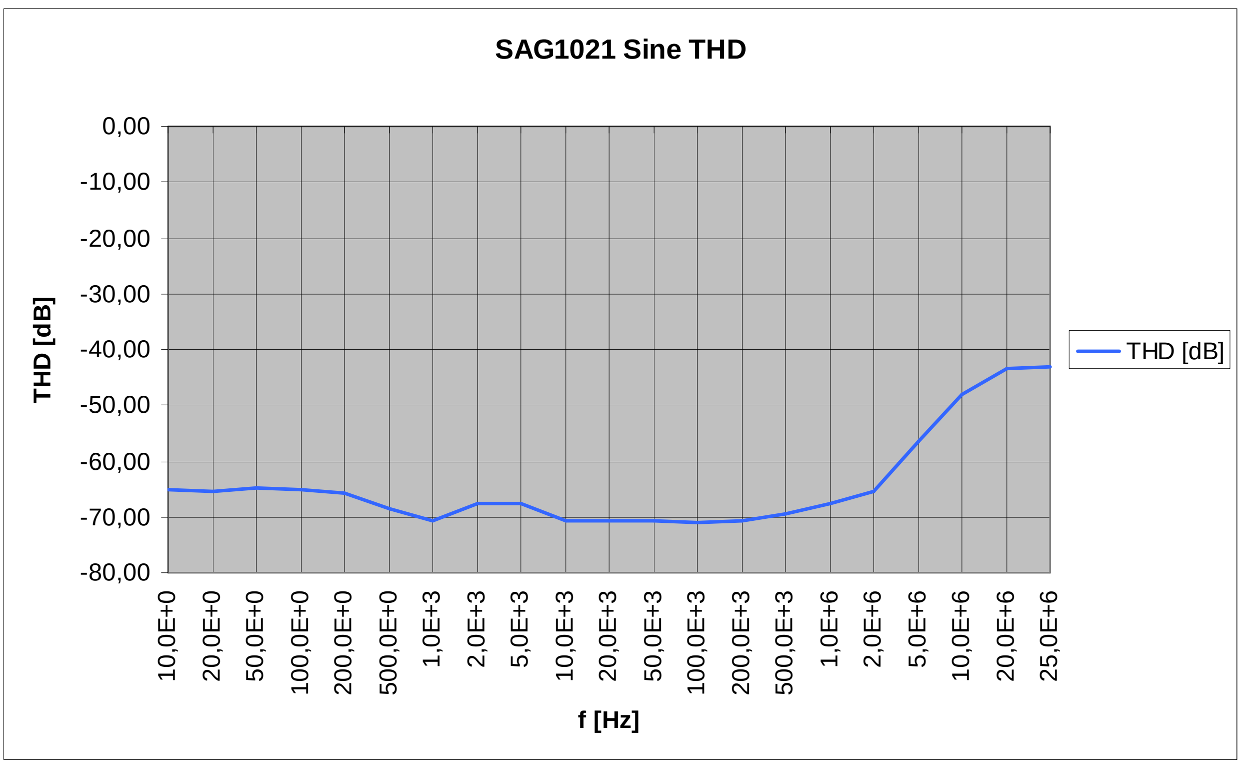


It turns out that the SAG1021 frequency response is flat within 0.25dB over the full frequency range.

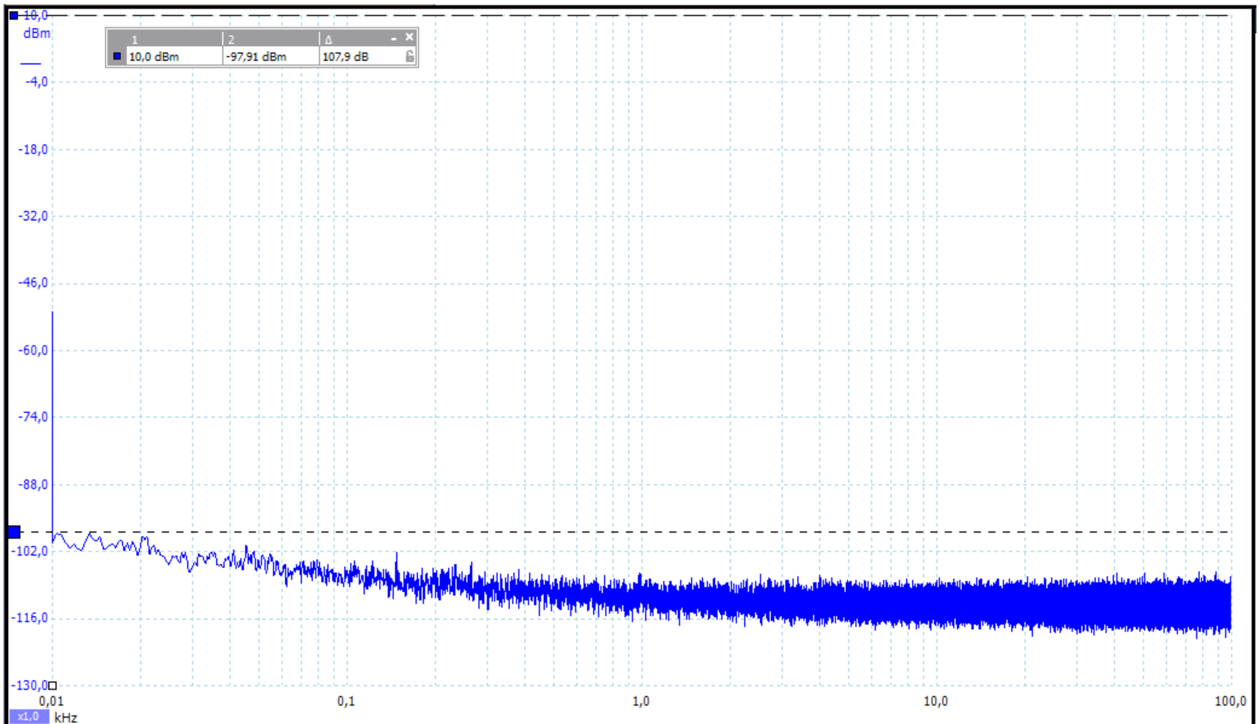
Harmonic Distortion

The harmonic distortion is pretty low up to some 2MHz and remains still decent above that frequency up to the full 25MHz. The graphs below show the THD (total harmonic distortion) over the frequency range from 10Hz to 25MHz as percentage of the signal amplitude as well as in decibels.





The numbers provide a coarse orientation, but the spectrum plots for some selected frequencies would be even more revealing. The screenshot below demonstrates the base noise/spur performance of the analyzer that has been used for these tests.

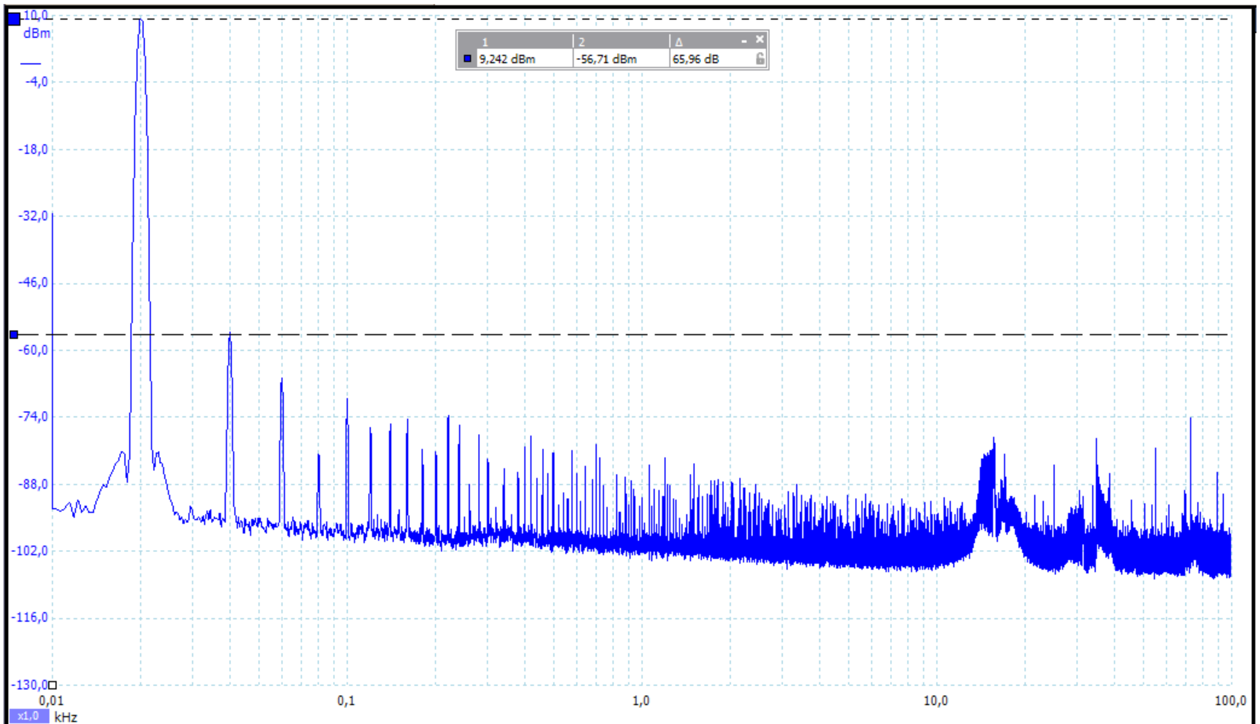


Channel	Name	Value	Min	Max	Average	σ	Capture Count	Span
A	Frequency at Peak	2,415 Hz	1,823 Hz	3,676 Hz	2,573 Hz	676,8 mHz	17	At Peak
A	Amplitude at Peak	-90,54 d...	-94,79 d...	-90,54 d...	-91,98 dBm	1,785 dBm	17	At Peak
A	Average Amplitude at Peak	6,228 µV	3,628 µV	6,228 µV	5,347 µV	1,091 µV	17	At Peak
A	Total Harmonic Distortion (THD) %	73,26 %	72,17 %	107,1 %	81,32 %	11,35 %	17	Whole trace
A	Total Harmonic Distortion (THD) dB	-2,702 dBc	-2,833 dBc	0,594 dBc	-1,869 dBc	1,129 dBc	17	Whole trace
A	Total Harmonic Distortion plus Noise (THD+N)	23,39 dBc	23,18 dBc	25,36 dBc	23,85 dBc	0,649 dBc	17	Whole trace
A	Spurious Free Dynamic Range (SFDR)	5,154 dBc	2,358 dBc	5,82 dBc	4,536 dBc	1,098 dBc	17	Whole trace

SAG1021_Sine_Off_FFT

The noise floor is less than -98dBm or $-108dB_{FS}$, which is some 40dB better than the expected performance of the SAG1021 and would be good enough even for dedicated low distortion audio generators.

For the following measurements for signal frequencies up to 20kHz, a frequency span of 10Hz to 100kHz has been used. We'll see an elevated noise floor and lots of spurious signals and a zoomed view of the measurements will be shown where necessary.

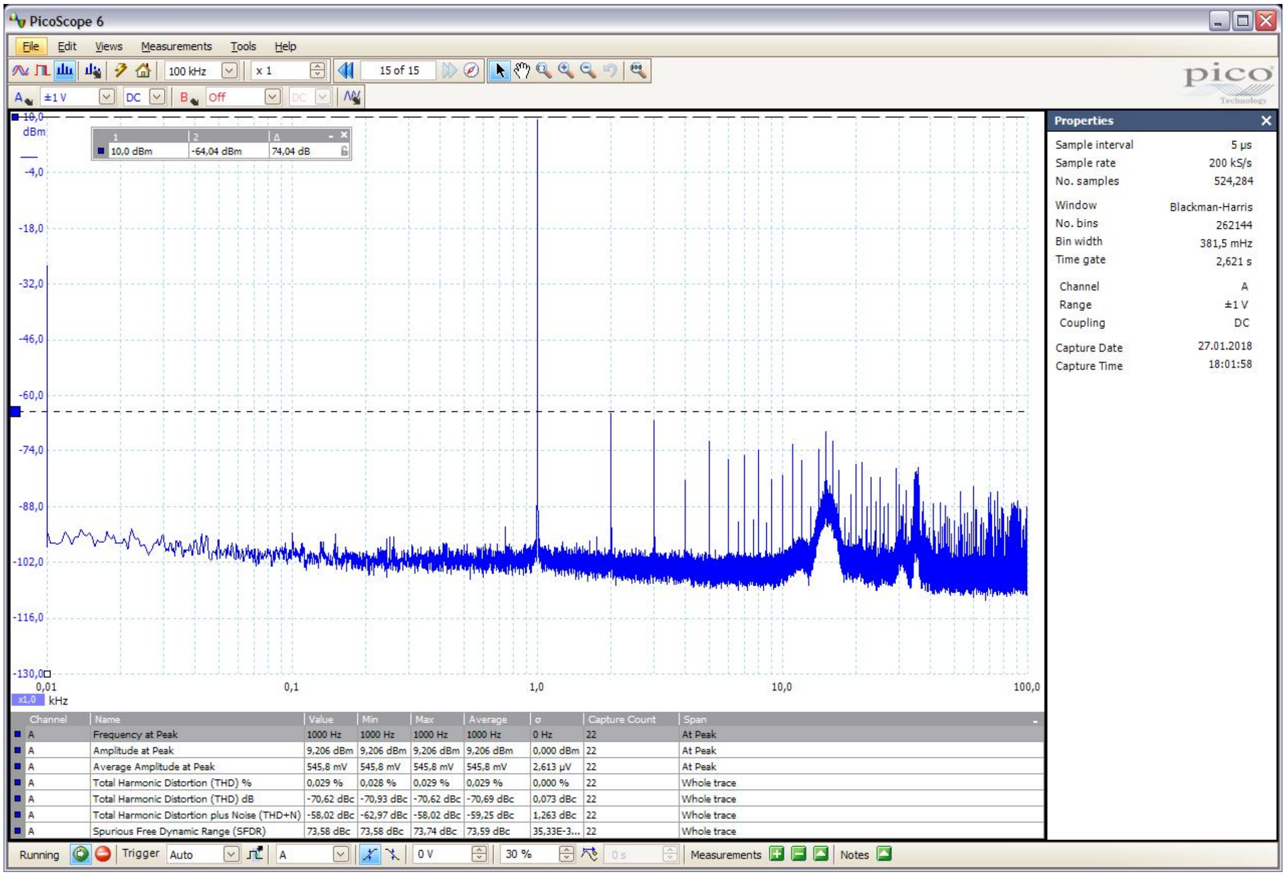


Channel	Name	Value	Min	Max	Average	σ	Capture Count	Span
A	Frequency at Peak	19,99 Hz	19,99 Hz	19,99 Hz	19,99 Hz	1,742 µHz	118	At Peak
A	Amplitude at Peak	9,296 dBm	9,295 dBm	9,298 dBm	9,296 dBm	0,000 dBm	115	At Peak
A	Average Amplitude at Peak	550,1 mV	550 mV	550,1 mV	550,1 mV	25,08 µV	113	At Peak
A	Total Harmonic Distortion (THD) %	0,056 %	0,051 %	0,056 %	0,054 %	0,001 %	110	Whole trace
A	Total Harmonic Distortion (THD) dB	-65,1 dBc	-65,8 dBc	-65,1 dBc	-65,4 dBc	0,204 dBc	106	Whole trace
A	Total Harmonic Distortion plus Noise (THD+N)	-56,27 dBc	-62,04 dBc	-56,27 dBc	-58,81 dBc	2,48 dBc	104	Whole trace
A	Spurious Free Dynamic Range (SFDR)	65,43 dBc	65,43 dBc	66,12 dBc	65,72 dBc	188,6E-3...	101	Whole trace

SAG1021_Sine_20Hz_FFT

Name	Value	Min	Max	Average	σ	Capture Count
Frequency at Peak	19,99 Hz	19,99 Hz	19,99 Hz	19,99 Hz	1,742 µHz	118
Amplitude at Peak	9,296 dBm	9,295 dBm	9,298 dBm	9,296 dBm	0,000 dBm	115
Average Amplitude at Peak	550,1 mV	550 mV	550,1 mV	550,1 mV	25,08 µV	113
Total Harmonic Distortion (THD) %	0,056 %	0,051 %	0,056 %	0,054 %	0,001 %	110
Total Harmonic Distortion (THD) dB	-65,1 dBc	-65,8 dBc	-65,1 dBc	-65,4 dBc	0,204 dBc	106
Total Harmonic Distortion plus Noise (THD+N)	-56,27 dBc	-62,04 dBc	-56,27 dBc	-58,81 dBc	2,48 dBc	104
Spurious Free Dynamic Range (SFDR)	65,43 dBc	65,43 dBc	66,12 dBc	65,72 dBc	188,6E-3...	101

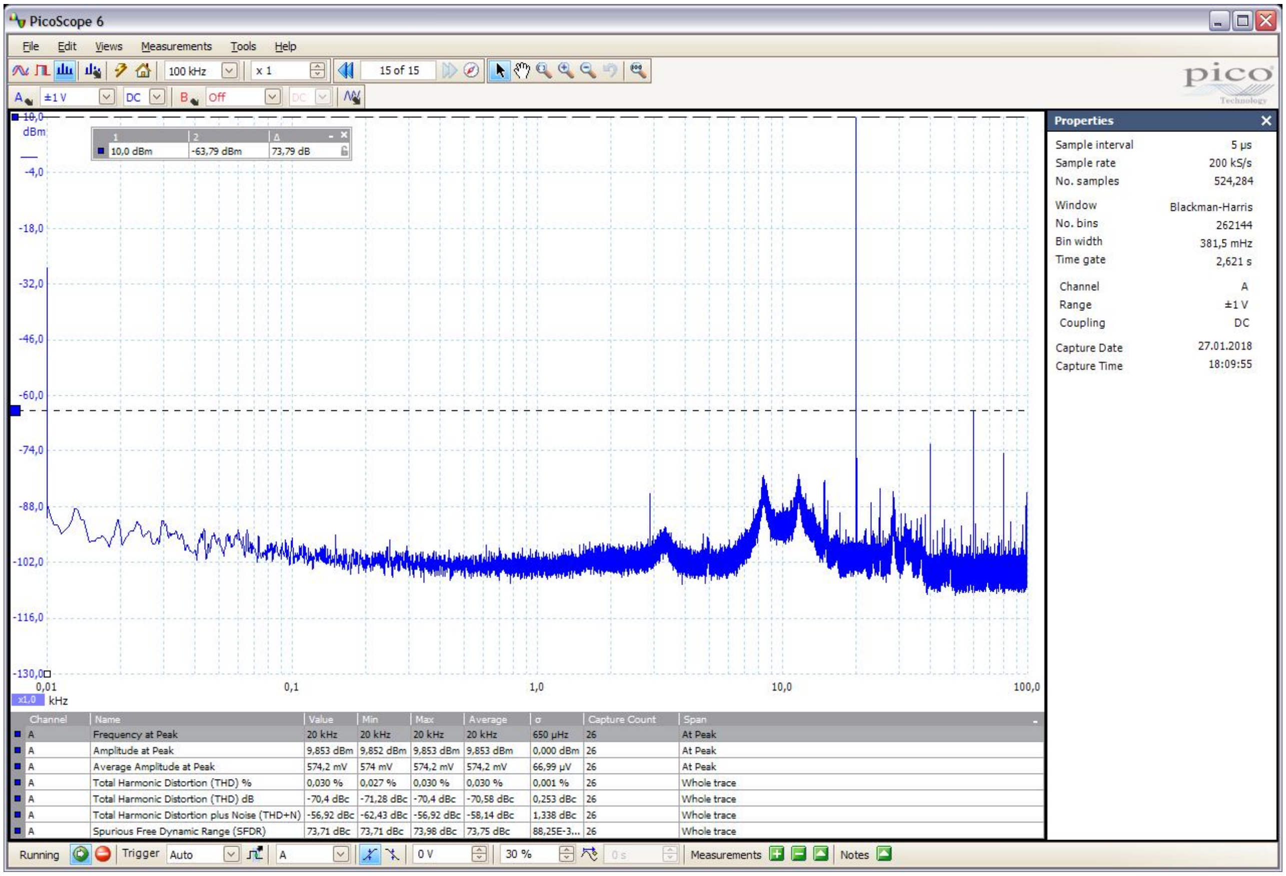
SAG1021_Sine_20Hz_FFT_ZM



SAG1021_Sine_1kHz_FFT

Name	Value	Min	Max	Average	σ	Capture Count
Frequency at Peak	1000 Hz	1000 Hz	1000 Hz	1000 Hz	0 Hz	22
Amplitude at Peak	9,206 dBm	9,206 dBm	9,206 dBm	9,206 dBm	0,000 dBm	22
Average Amplitude at Peak	545,8 mV	545,8 mV	545,8 mV	545,8 mV	2,613 µV	22
Total Harmonic Distortion (THD) %	0,029 %	0,028 %	0,029 %	0,029 %	0,000 %	22
Total Harmonic Distortion (THD) dB	-70,62 dBc	-70,93 dBc	-70,62 dBc	-70,69 dBc	0,073 dBc	22
Total Harmonic Distortion plus Noise (THD+N)	-58,02 dBc	-62,97 dBc	-58,02 dBc	-59,25 dBc	1,263 dBc	22
Spurious Free Dynamic Range (SFDR)	73,58 dBc	73,58 dBc	73,74 dBc	73,59 dBc	35,33E-3...	22

SAG1021_Sine_1kHz_FFT_ZM

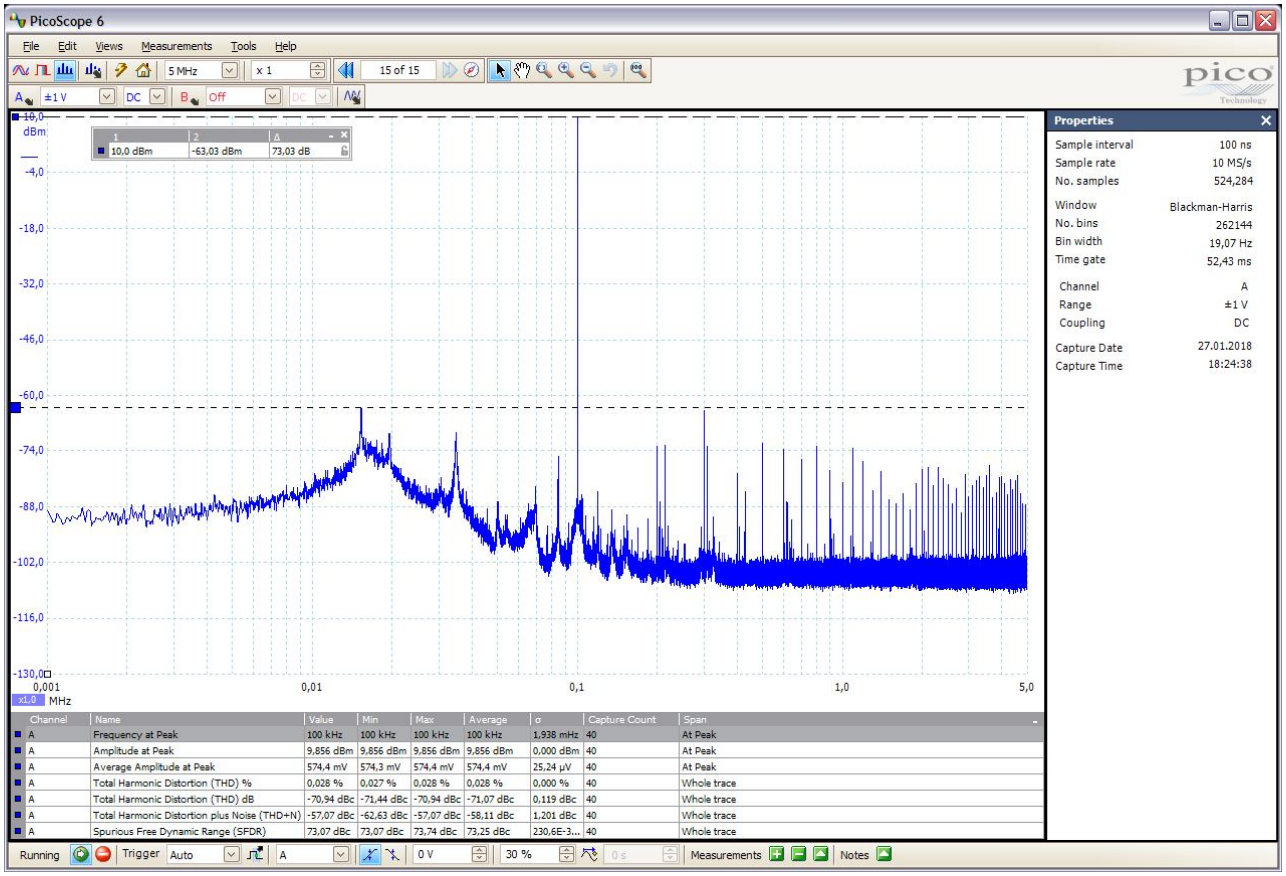


SAG1021_Sine_20kHz_FFT

Name	Value	Min	Max	Average	σ	Capture Count
Frequency at Peak	20 kHz	20 kHz	20 kHz	20 kHz	650 µHz	26
Amplitude at Peak	9,853 dBm	9,852 dBm	9,853 dBm	9,853 dBm	0,000 dBm	26
Average Amplitude at Peak	574,2 mV	574 mV	574,2 mV	574,2 mV	66,99 µV	26
Total Harmonic Distortion (THD) %	0,030 %	0,027 %	0,030 %	0,030 %	0,001 %	26
Total Harmonic Distortion (THD) dB	-70,4 dBc	-71,28 dBc	-70,4 dBc	-70,58 dBc	0,253 dBc	26
Total Harmonic Distortion plus Noise (THD+N)	-56,92 dBc	-62,43 dBc	-56,92 dBc	-58,14 dBc	1,338 dBc	26
Spurious Free Dynamic Range (SFDR)	73,71 dBc	73,71 dBc	73,98 dBc	73,75 dBc	88,25E-3...	26

SAG1021_Sine_20kHz_FFT_ZM

For the following 100kHz measurement, a frequency span of 1kHz to 5MHz has been used.



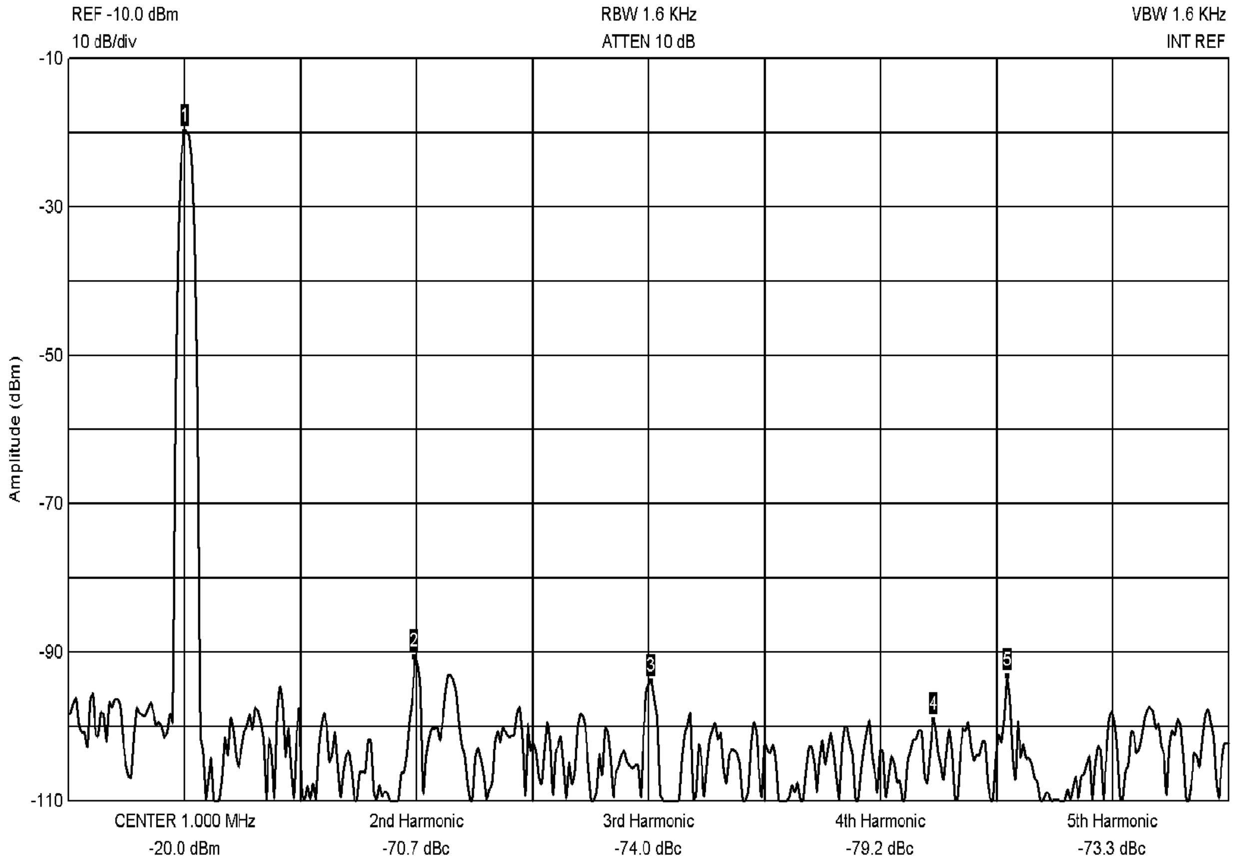
SAG1021_Sine_100kHz_FFT

Name	Value	Min	Max	Average	σ	Capture Count
Frequency at Peak	100 kHz	100 kHz	100 kHz	100 kHz	1,938 mHz	40
Amplitude at Peak	9,856 dBm	9,856 dBm	9,856 dBm	9,856 dBm	0,000 dBm	40
Average Amplitude at Peak	574,4 mV	574,3 mV	574,4 mV	574,4 mV	25,24 µV	40
Total Harmonic Distortion (THD) %	0,028 %	0,027 %	0,028 %	0,028 %	0,000 %	40
Total Harmonic Distortion (THD) dB	-70,94 dBc	-71,44 dBc	-70,94 dBc	-71,07 dBc	0,119 dBc	40
Total Harmonic Distortion plus Noise (THD+N)	-57,07 dBc	-62,63 dBc	-57,07 dBc	-58,11 dBc	1,201 dBc	40
Spurious Free Dynamic Range (SFDR)	73,07 dBc	73,07 dBc	73,74 dBc	73,25 dBc	230,6E-3...	40

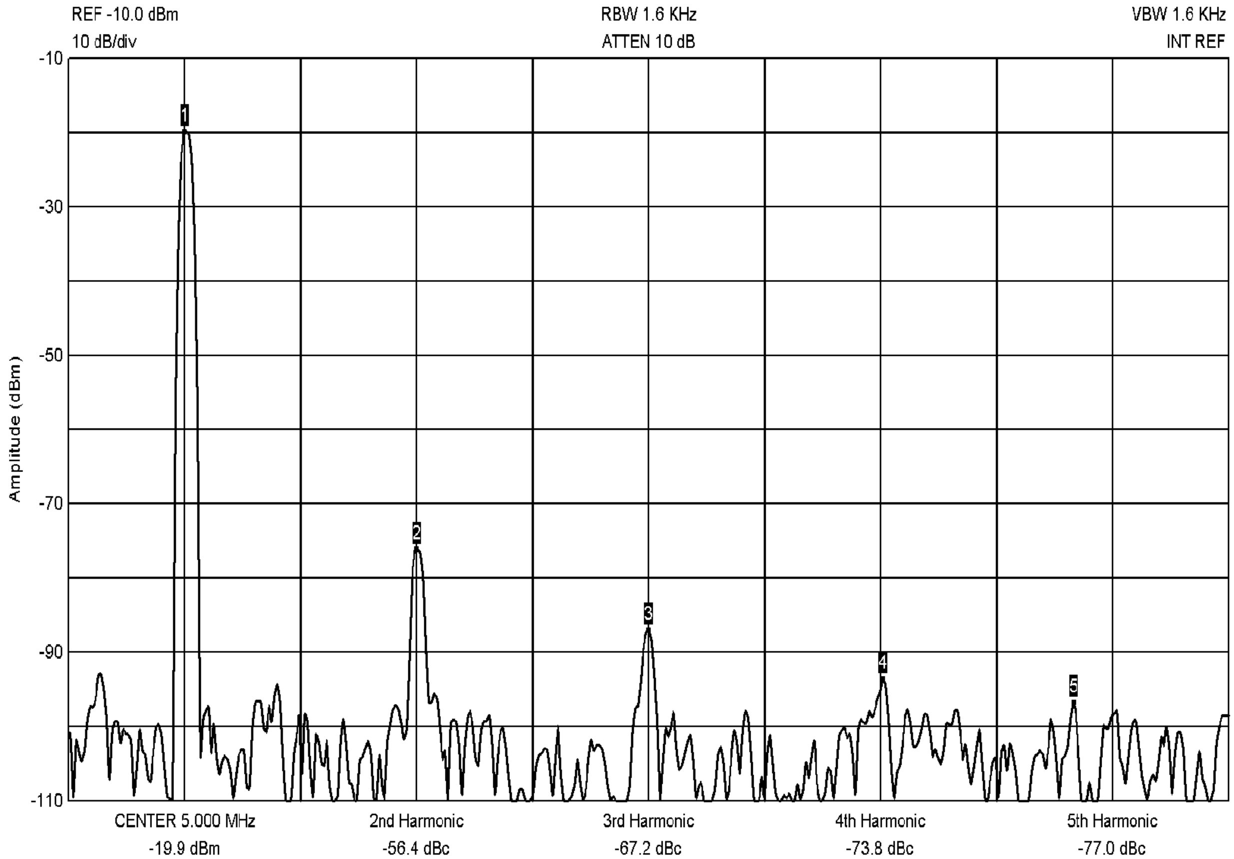
SAG1021_Sine_100kHz_FFT_ZM

For frequencies of 1MHz and up, the “harmonic viewer” on a regular spectrum analyzer has been used in order to examine the harmonic distortions.

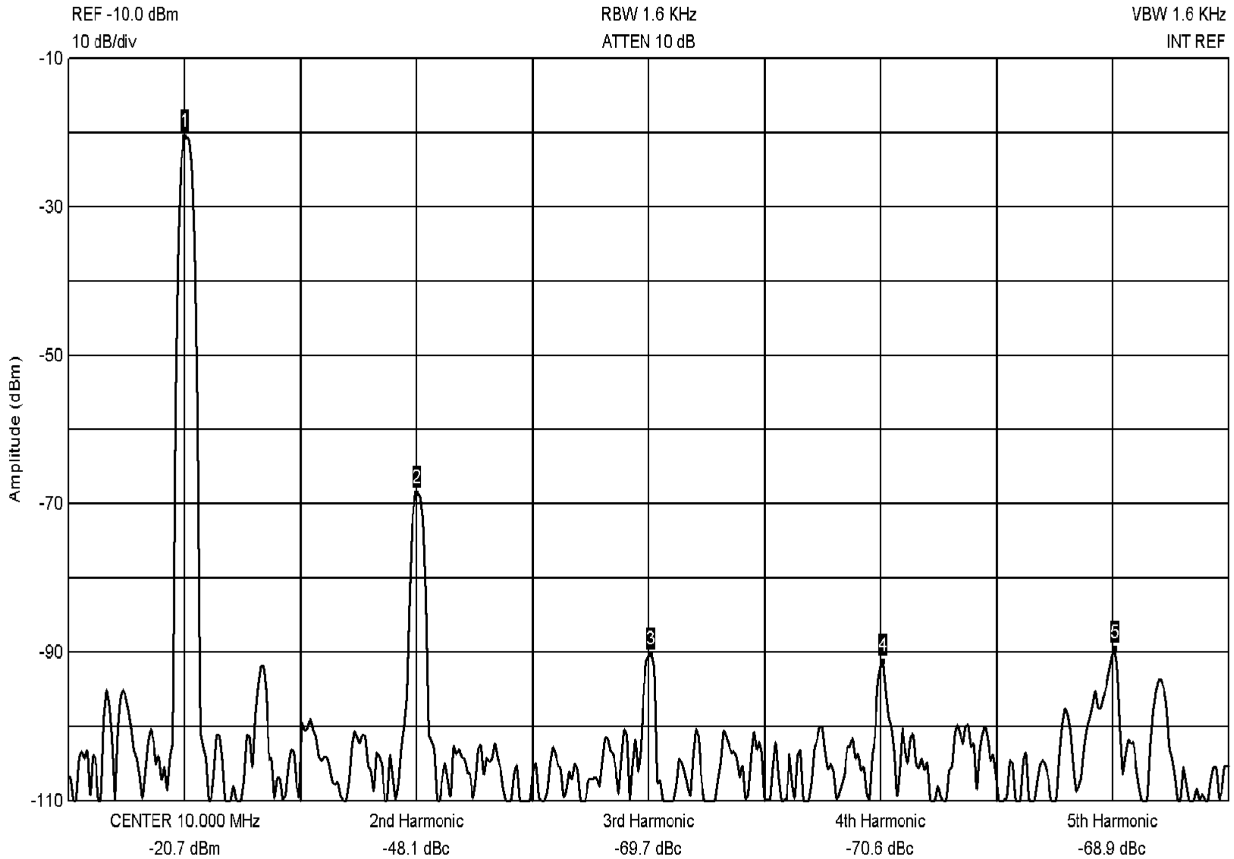
Distortion increases above some 2MHz, but overall performance is still decent and harmonics stay well below -40dBc even at 25MHz.



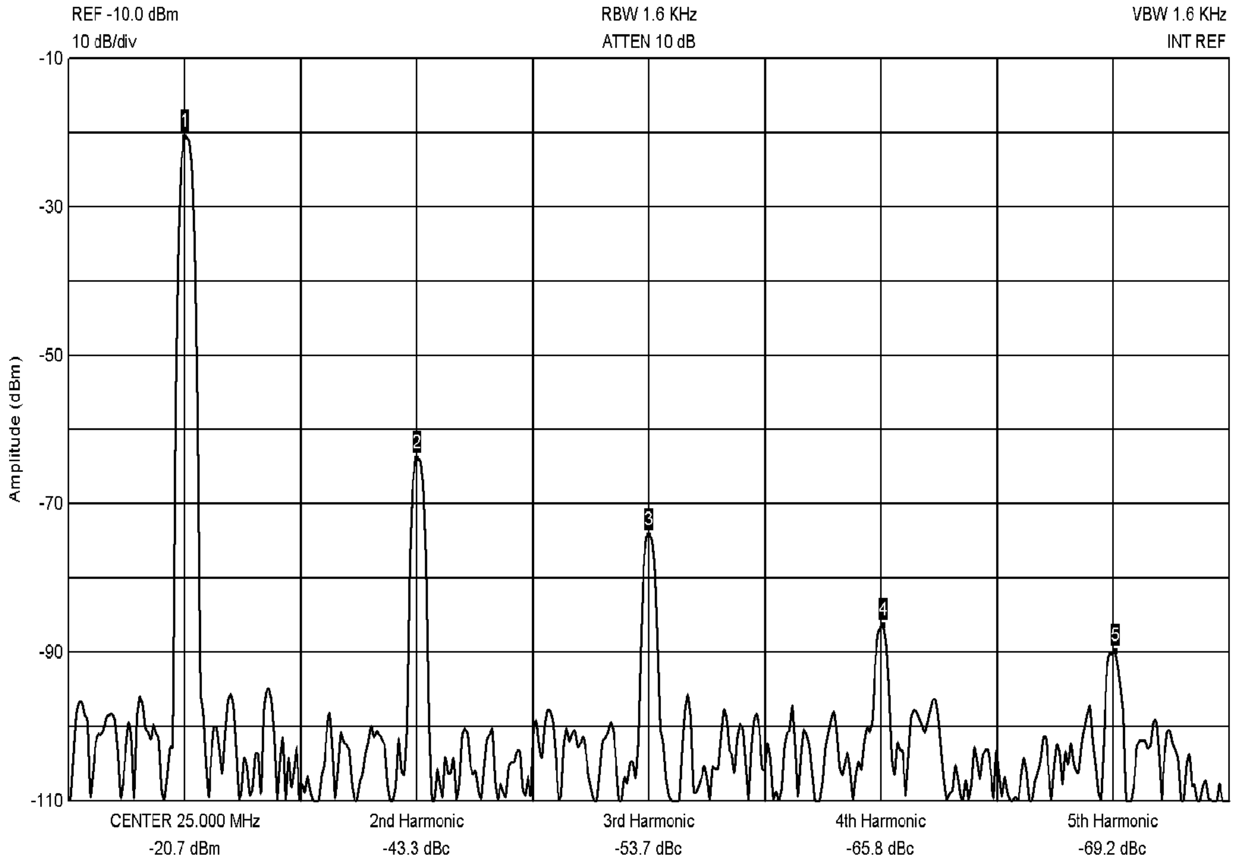
SAG1021_Sine_1MHz_SA



SAG1021_Sine_5MHz_SA



SAG1021_Sine_10MHz_SA



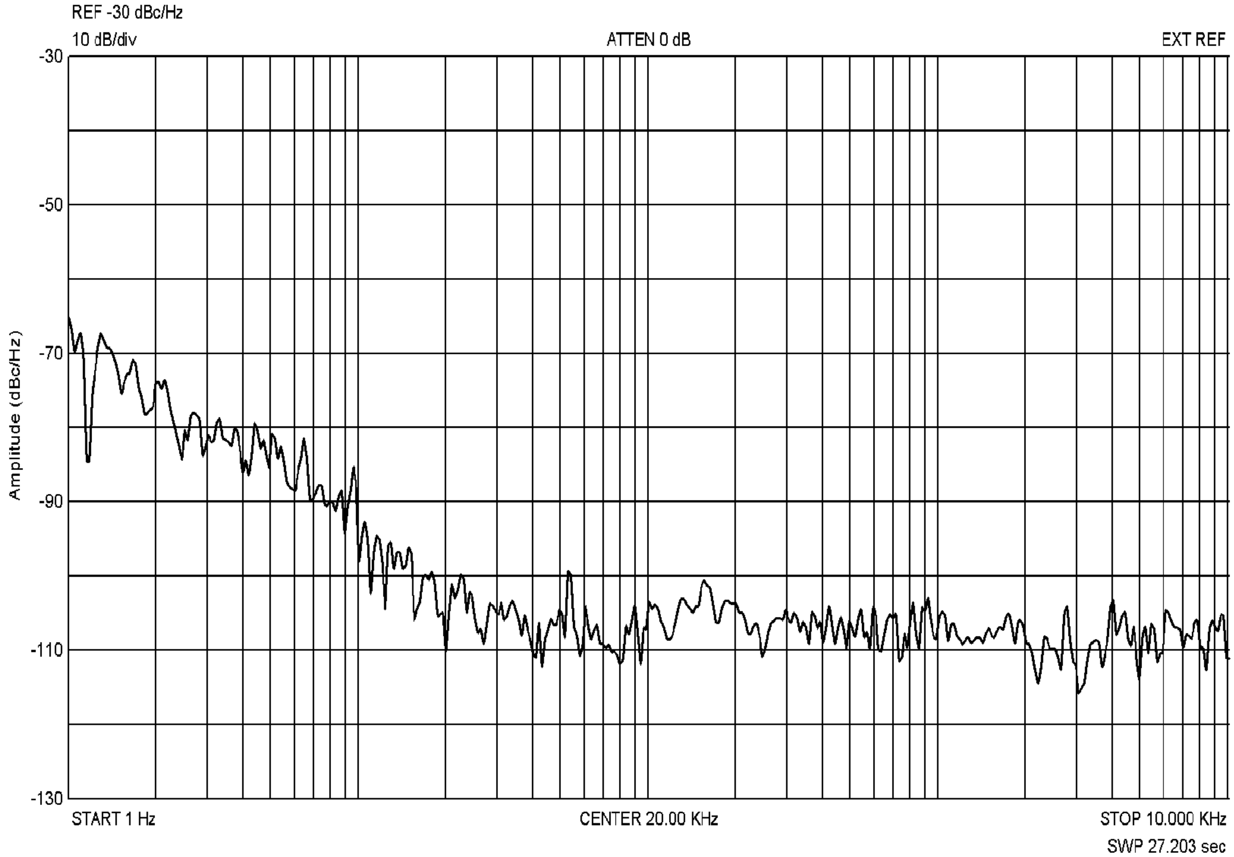
SAG1021_Sine_25MHz_SA

Phase Noise

This is an important property for some (particularly RF) applications. The following screenshots show the phase noise plots for a selection of interesting frequencies, some of them commonly used as intermediate frequencies in traditional communication receivers.

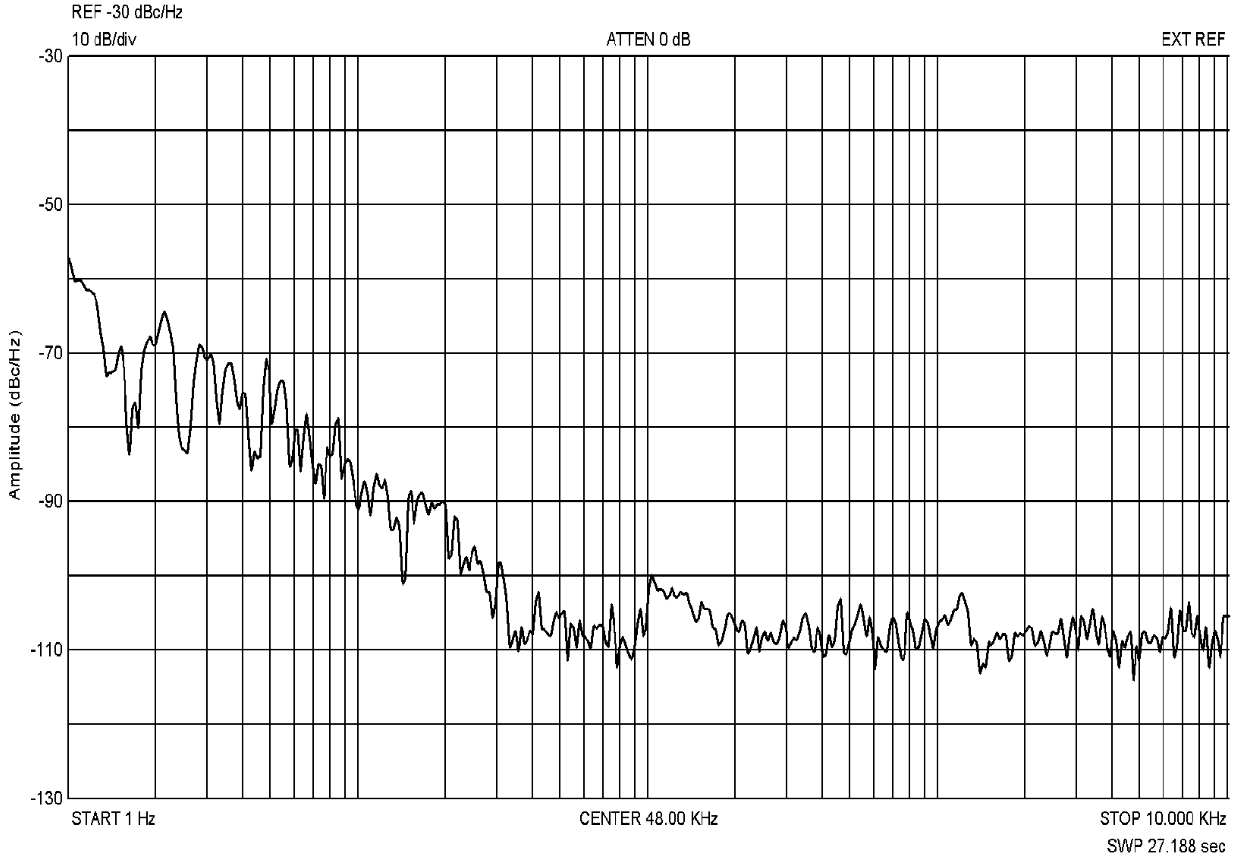
It should be noted that my analyzer doesn't allow reliable phase noise measurements below -100dBc for most carrier frequencies, hence the quality of the signal should be judged by the distance from the carrier where a -100dBc phase noise can be obtained. At greater distances from the carrier, the actual phase noise performance of the SAG1021 might be much better than indicated, but will inevitably be compromised by the spurious signals that might approach an even exceed -70dB_C in some situations.

Even so, the phase noise performance is absolutely decent and with an external step-attenuator, the SAG1021 could certainly be used even for receiver measurements.



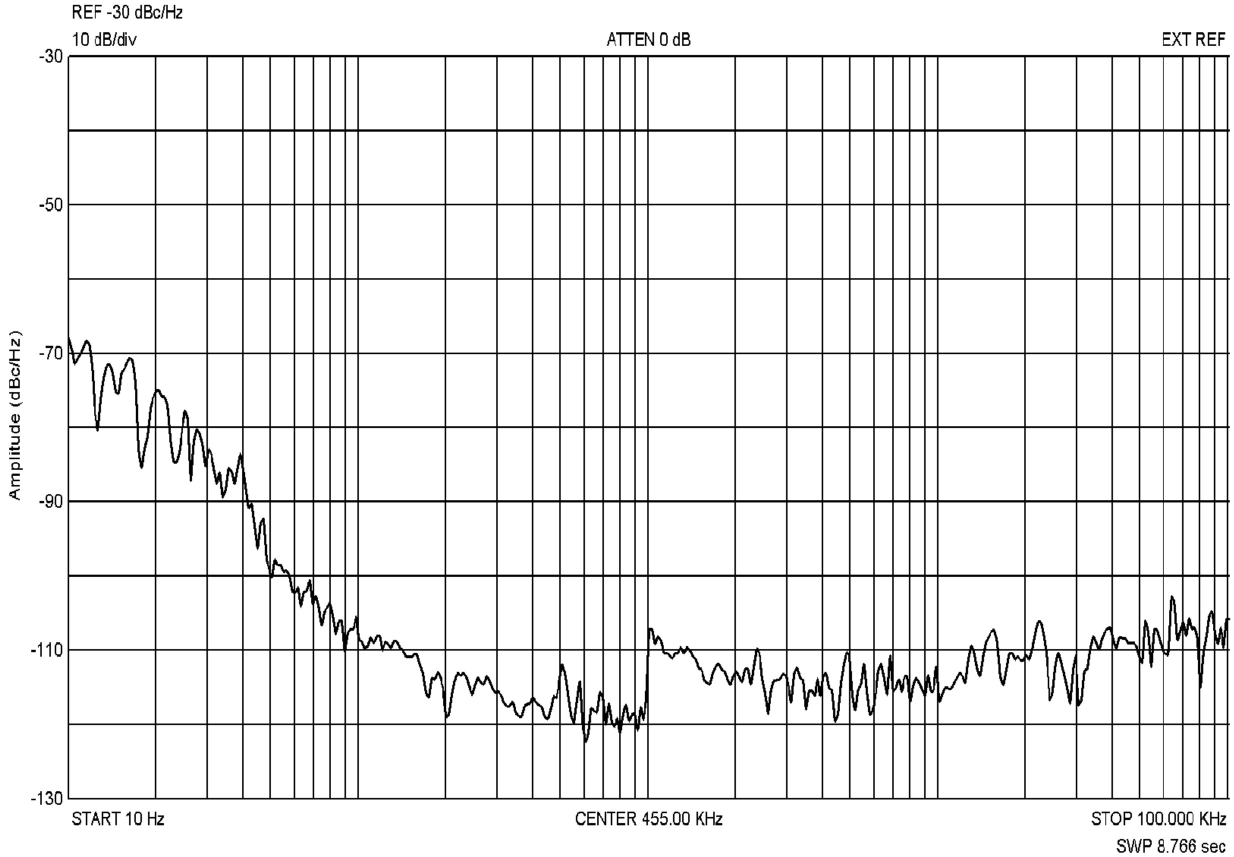
SAG1021_Sine_20kHz_PN

At 20kHz, a phase noise of -100dBc is reached at about 16Hz carrier distance.



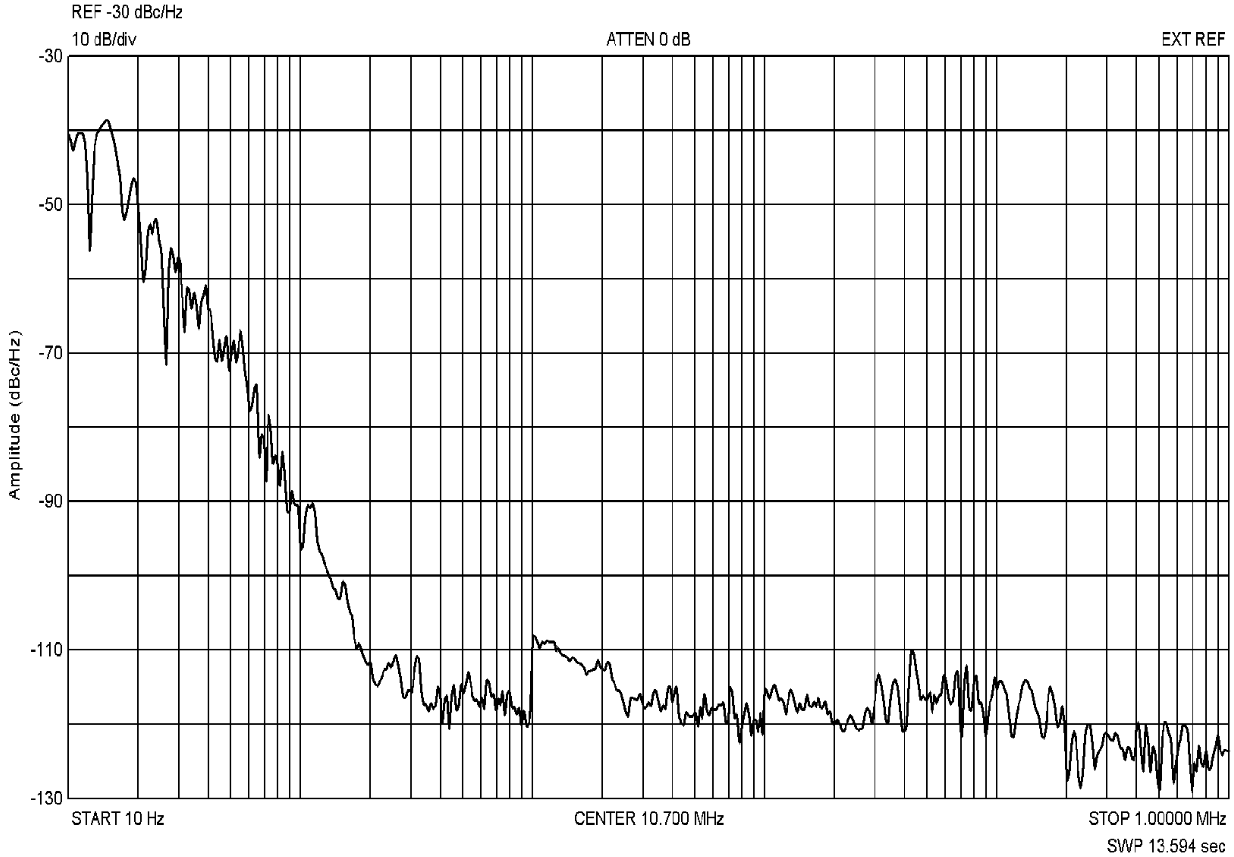
SAG1021_Sine_48kHz_PN

At 48kHz, a phase noise of -100dBc is reached at about 32Hz carrier distance.



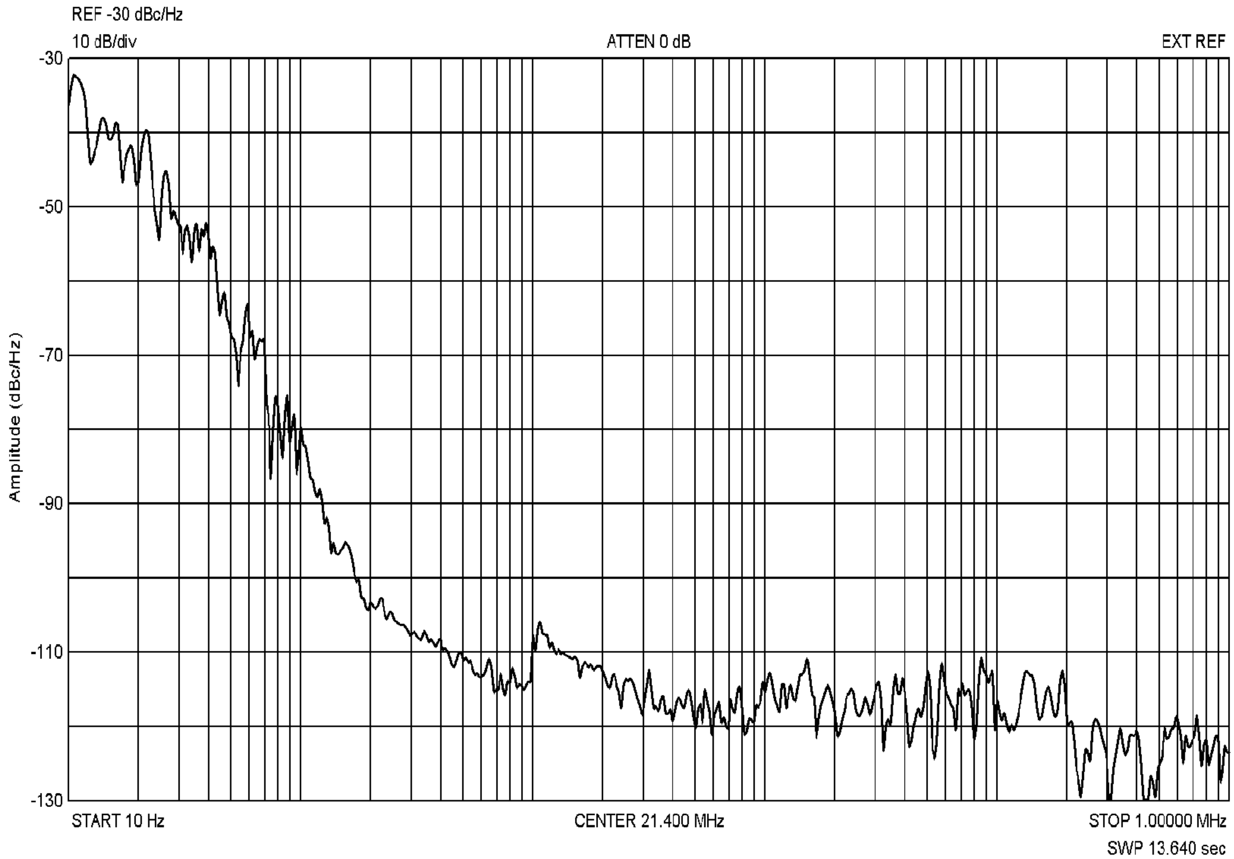
SAG1021_Sine_455kHz_PN

At 455kHz, a phase noise of -100dBc is reached at about 58Hz carrier distance. Also -110dBc @ 130Hz.



SAG1021_Sine_10.7MHz_PN

At 10.7MHz, a phase noise of -100dBc is reached at about 130Hz carrier distance. Also -110dBc @ 180Hz.



SAG1021_Sine_21.4MHz_PN

At 21.4MHz, a phase noise of -100dBc is reached at about 180Hz carrier distance. Also -110dBc @ 420Hz.

Square

Square wave has an additional parameter *Duty* that allows setting the duty cycle from 1 to 99% with 1% resolution.

From a square wave, we'd expect fast transitions with little overshoot and a flat top and bottom. As can be seen from the screenshot below, the 25ns transitions are anything but fast, yet the waveform appears very clean otherwise.

The first screenshot shows the zoomed riding edge and there it appears absolutely clean. But then again, with a rise time as slow as 25ns, we certainly wouldn't expect anything different. In any case this is an ideal signal for LF probe compensation and certainly more versatile than the calibrator output on the scope.

The second screenshot shows the spectrum of the square wave at it maximum frequency of 10MHz. We see lots of spurious signals, but only up to the 5^{th} harmonic of the square wave, which is no surprise given the sample rate of 125MSa/s.