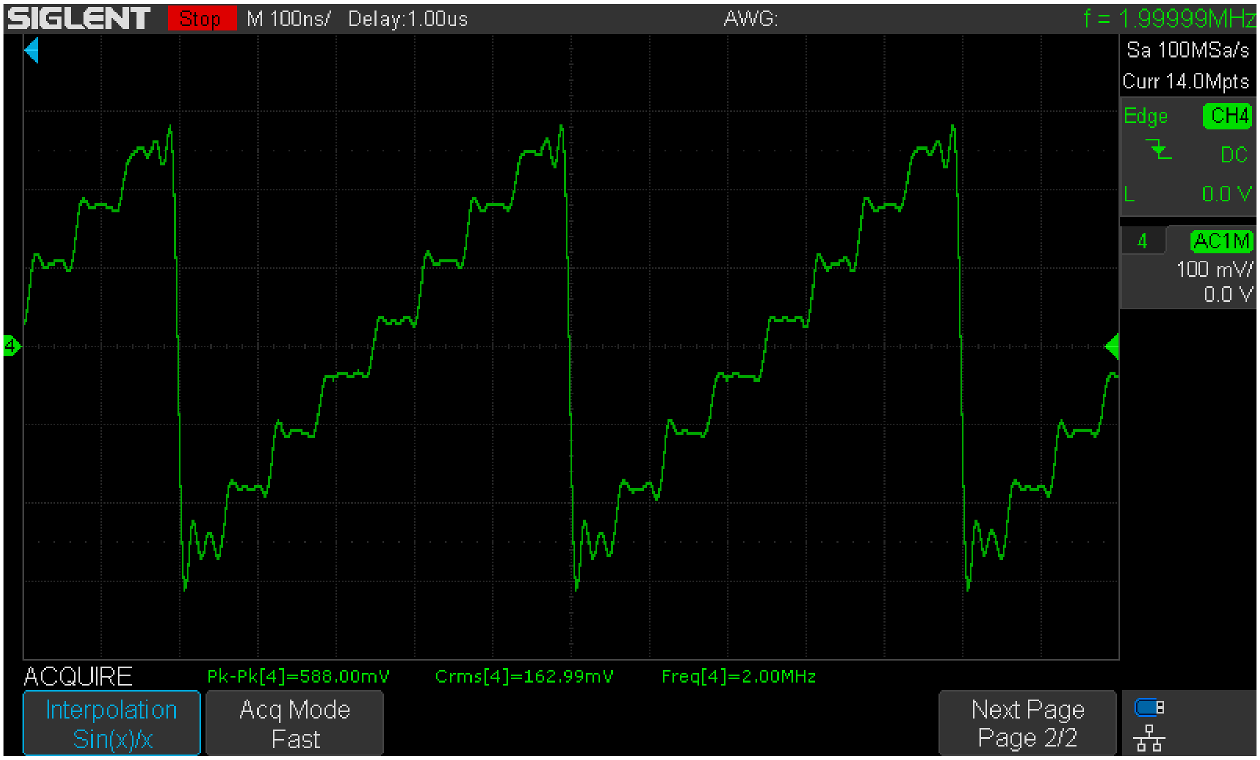
Siglent SDS1104X-E Review



INT_2MHz_stepup_100ns_sinc

Signal Handling

This section deals with the DSO properties related to the frontend design and calibration, hence mainly amplitude accuracy and bandwidth. Even though an oscilloscope is not a precision measurement device, its accuracy specifications are still in the same ballpark as analog meters that were universally used several decades ago – and then as now there are many tasks where we just don't need more than that. Yet we want to be sure that our instrument meets its specifications under all practical circumstances and we can rely upon the test results we're getting out of it.

DC Accuracy

The first test looks at the DC accuracy of the trace display and the automatic measurements for all available vertical gain settings. Environment temperature was 23°C and a self-calibration has been performed after several hours of warm-up one day before the test started.

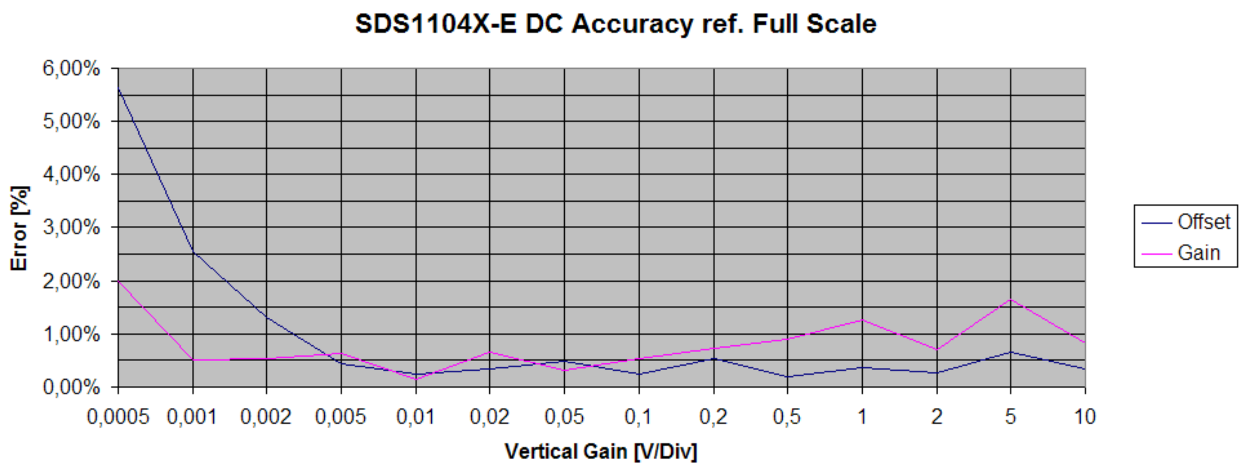
The table below shows the results of all measurements. For each vertical gain setting, measurements have been performed for both polarities and three offsets (zero and ±3 divisions) with and without input signal respectively, resulting in a total of seven measurements per range. The reason why measurements with offset have been included is the probably widely unknown fact that not all DSOs will pass this test, so I wanted to be thorough.

All ranges are well within spec, the green results are even within 25% of the specified error margin. If we look at the error figures, it becomes clear that what we mostly see is nothing more than the inevitable ±1LSB error of the 8-bit ADC and this DSO can indeed compete with the most expensive analog meters.

Below there is also a graph providing a quick overview of the maximum offset and gain errors with respect to the vertical gain setting. The table always shows the worst error figures out of all 7 measurements.

Setting	Signal	Error					
Gain [V/div]	Step [V]	Offset [V]	Offset [%FS]	Gain [%]			
0,0005	0,0015	225,0E-6	5,63%	2,00%			
0,001	0,003	205,0E-6	2,56%	0,50%		Out of spec.	
0,002	0,006	209,0E-6	1,31%	0,54%		Within spec.	
0,005	0,015	174,0E-6	0,44%	0,64%		Error less than 25% spec.	
0,01	0,03	192,0E-6	0,24%	0,14%			
0,02	0,06	540,0E-6	0,34%	0,65%			
0,05	0,15	1,9E-3	0,48%	0,31%			
0,1	0,3	1,9E-3	0,24%	0,54%			
0,2	0,6	8,6E-3	0,54%	0,73%			
0,5	1,5	7,4E-3	0,18%	0,89%			
1	3	28,9E-3	0,36%	1,27%			
2	6	43,7E-3	0,27%	0,71%			
5	15	261,0E-3	0,65%	1,66%			
10	30	276,0E-3	0,35%	0,82%			

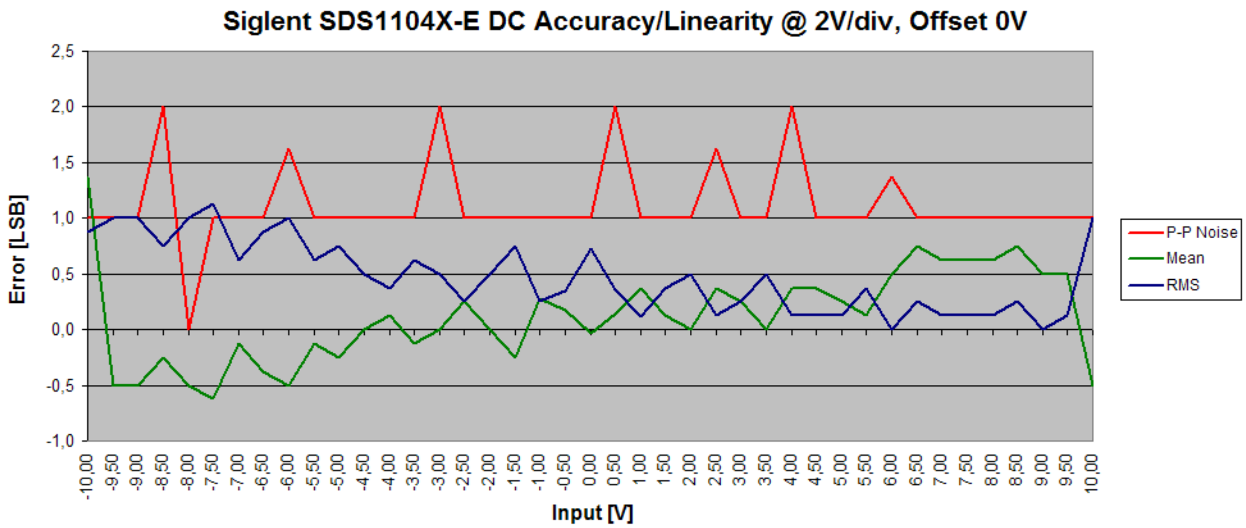
SDS1104X-E_DC_Ranges_Accuracy



SDS1104X-E_DC_Accuracy_FS

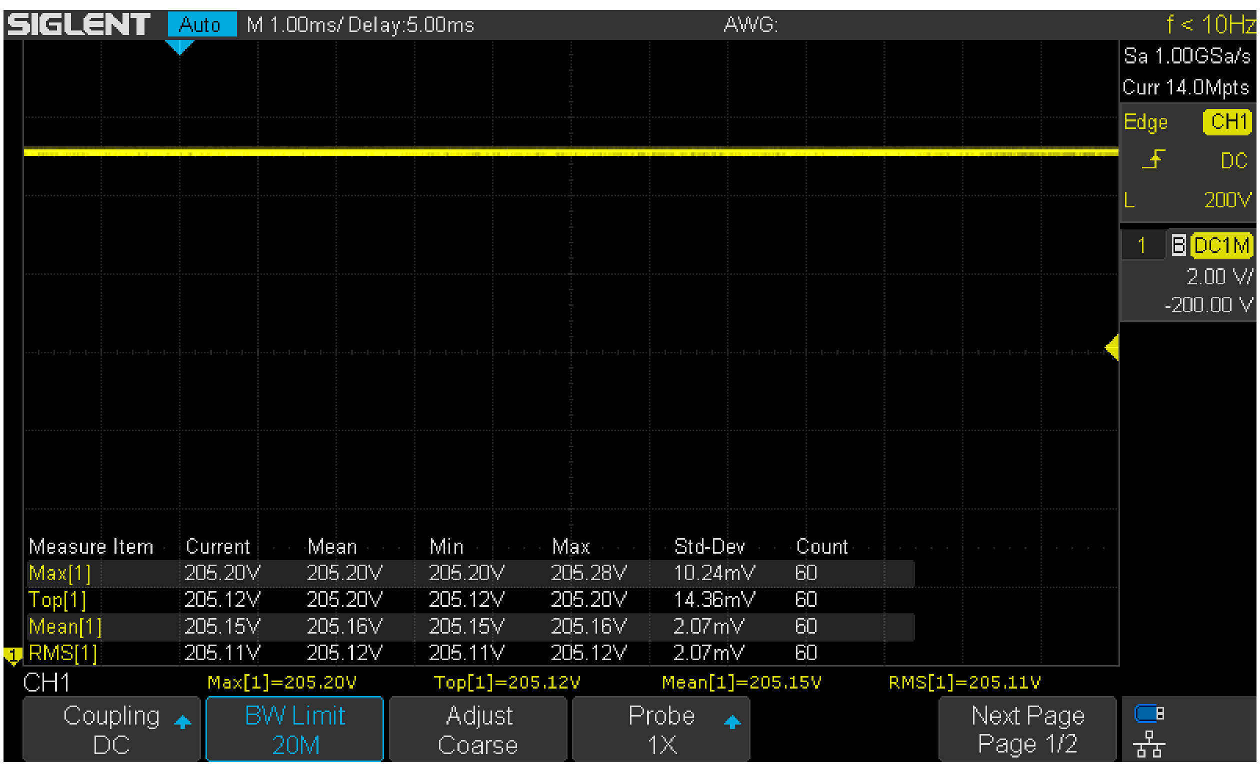
The next test looks at the linearity over the full ADC range. At a vertical gain of 2V/div and with zero offset, an accurate input voltage from -10V to +10V in steps of 0.5V has been applied and measured. Please keep in mind, that the visible display range is only ±8V, according to 200 LSB of the ADC. Consequently, this ±10V test covers 250 LSB, hence almost the entire 8-bit number range and possibly eating into the calibration headroom. Results are shown in LSB instead of %, because that makes immediately clear how close to the physical limits they actually are.

Peak-peak ADC noise is a little on the high side with up to 2 LSB in several spots, yet mean and RMS values stay within ±1 LSB pretty much throughout the range.



SDS1104X-E DC_Linearity@G2V

Finally, a practical test measuring an accurate DC voltage of +205V ±20ppm at the scope input directly is shown. To do this, the vertical gain has been selected as 2V/div, because this is the most sensitive range that allows an offset up to ±200V. And that's exactly what has been used here. With an offset of -200V, the +205V input voltage causes a deviation of +2.5 divisions from the center, and automatic measurements should indicate a voltage of +205V. As this is pure DC, Max, Top, Mean and RMS measurements should all give pretty much identical results – and they certainly do. The error of the mean measurement is <0.08%!

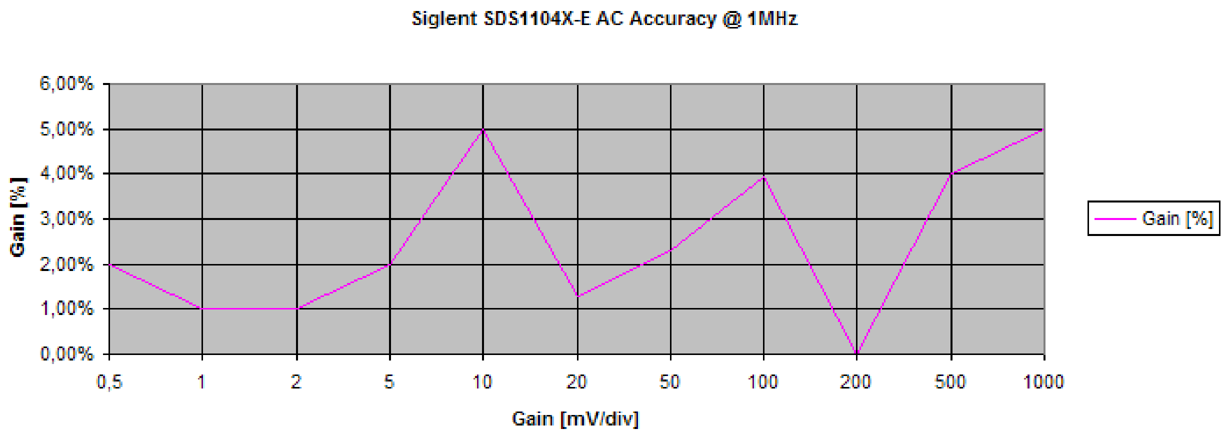


DCOS_200V_205

AC Accuracy

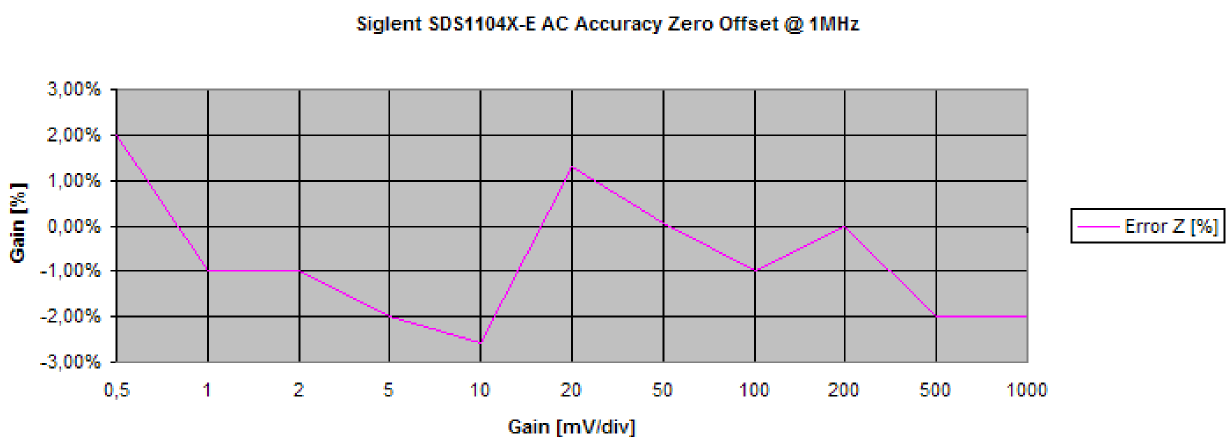
This test looks at the AC accuracy of the trace display and some automatic measurements for most of the available vertical gain settings. Environment temperature was 23°C and a self-calibration has been performed after several hours of warm-up one day before the test started.

The graph below shows the results of all measurements. For each vertical gain setting, measurements have been performed for three offsets (zero and ±2 divisions) , with and without input signal respectively, resulting in a total of 7 measurements for each gain setting. The reason why measurements with offset have been included is the probably widely unknown fact that not every DSO will pass this test.



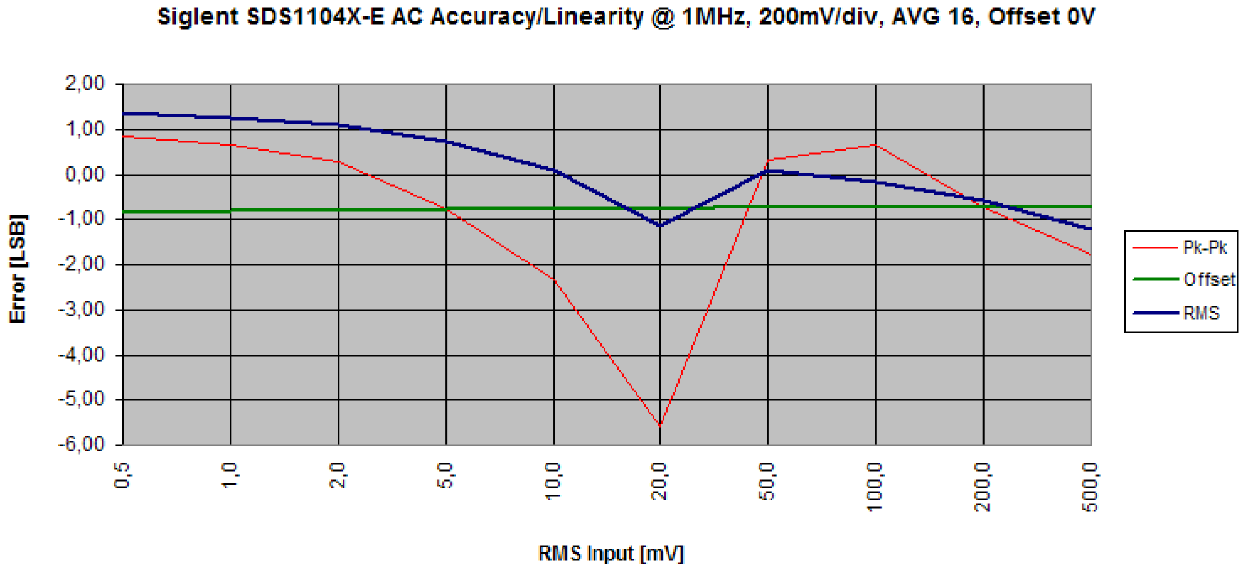
SDS1104X-E_AC_Accuracy@1MHz

With a maximum error of 5%, all tested ranges are well within spec, which would be 1dB or approximately 10.9%. If results are limited to the tests with zero offset, the error never exceeds 2.5% as can be seen in the diagram below.

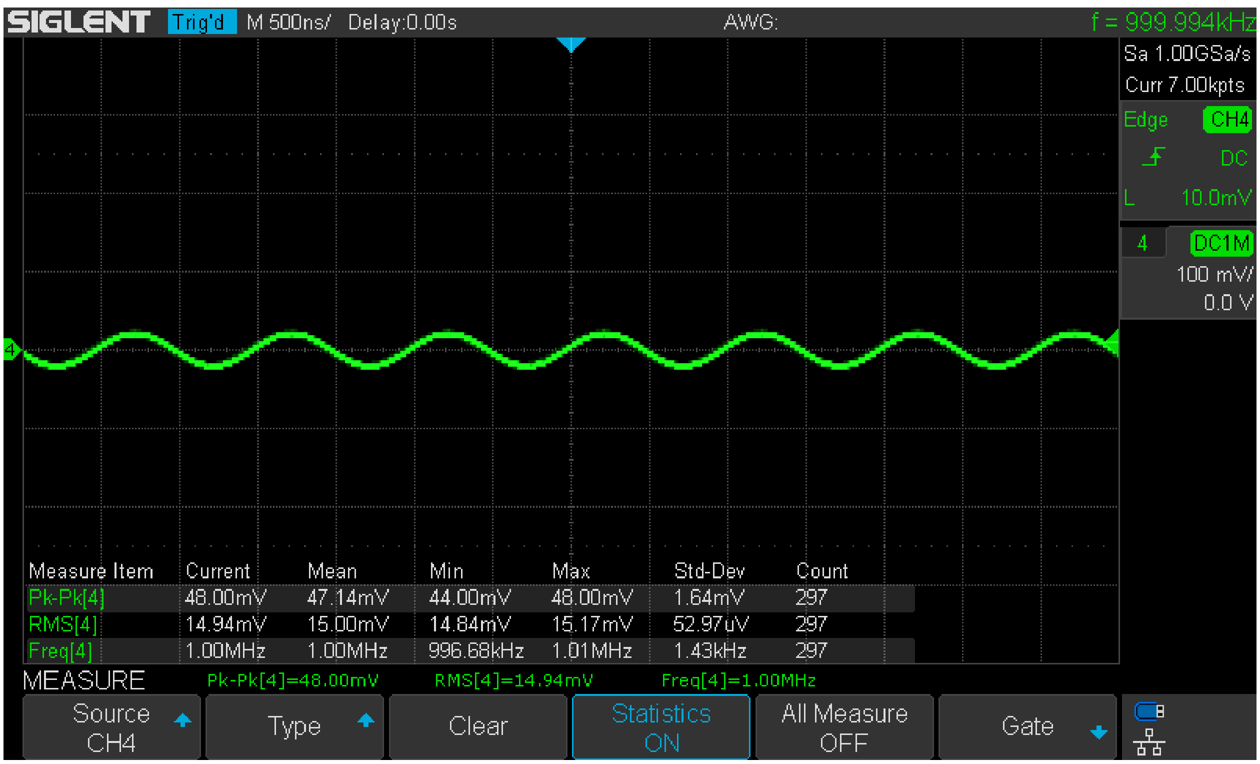


SDS1104X-E_AC_Accuracy_Zero_Offset@1MHz

Next is the AC linearity test which should answer the question how low a signal can be measured with reasonable accuracy. The graph looks odd because the error is measured in LSBs of the ADC and the test covers an absolutely unrealistic 60dB range, whereas only some 26dB are actually usable. This is still a very respectable result, as it actually means we can measure a signal with just 0.5 divisions peak to peak amplitude pretty accurately. A screenshot has been added to demonstrate just this. The automatic measurement of the 15mVrms input signal is pretty much spot-on despite the low amplitude of only half a division peak to peak.

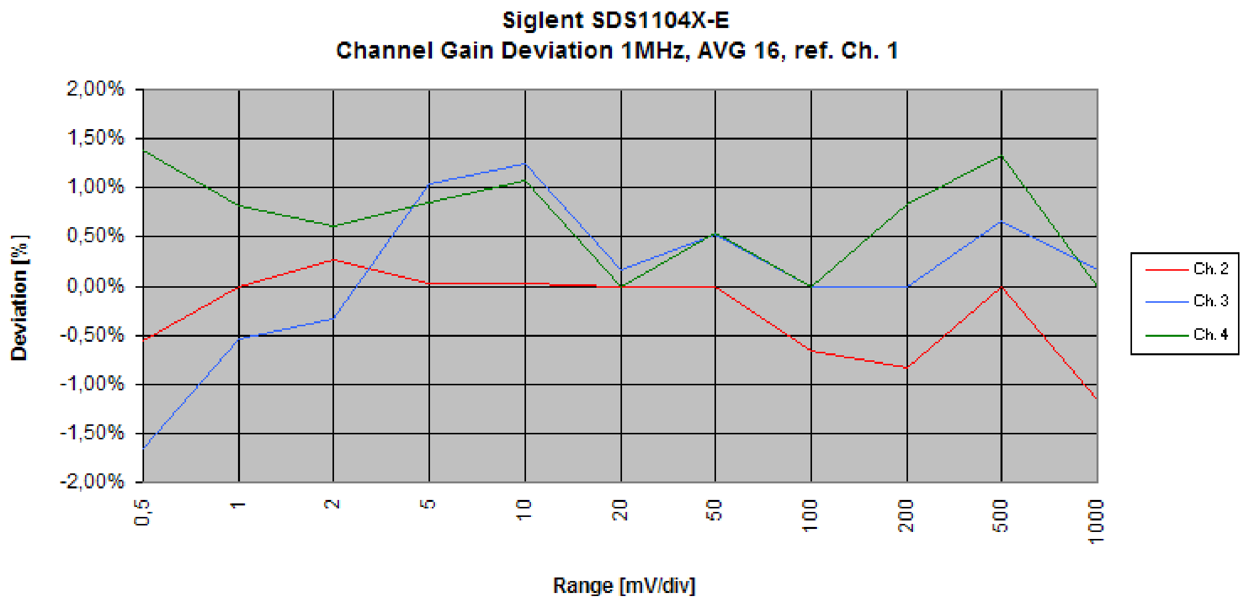


SDS1104X-E AC_Lin@1MHz_200mV_Avg16



SDS1104X-E_AC_Accuracy_1MHz_05div

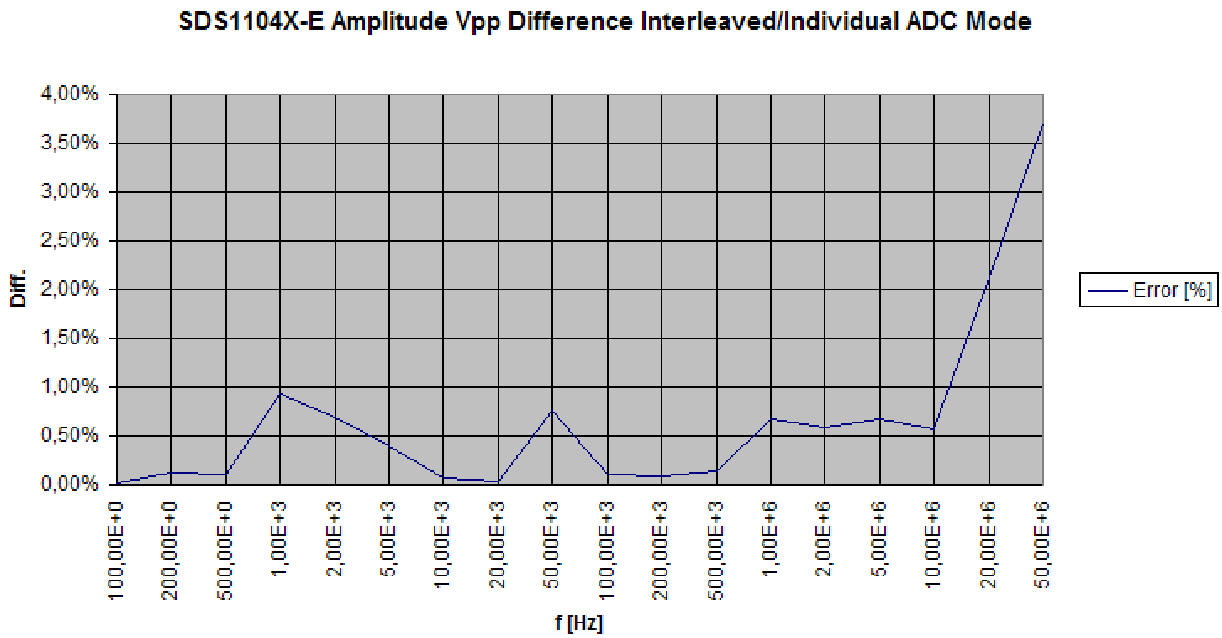
We also want to check the vertical gain deviation of channels 2 to 4 with reference to channel 1. The test is done at a frequency of 1MHz for all vertical gain settings up to 1V/div. The differences are fairly low and certainly acceptable, particularly for a cheap entry level scope like this. Except for Ch.2 at 500µV/div, the error does not exceed 1.5%.



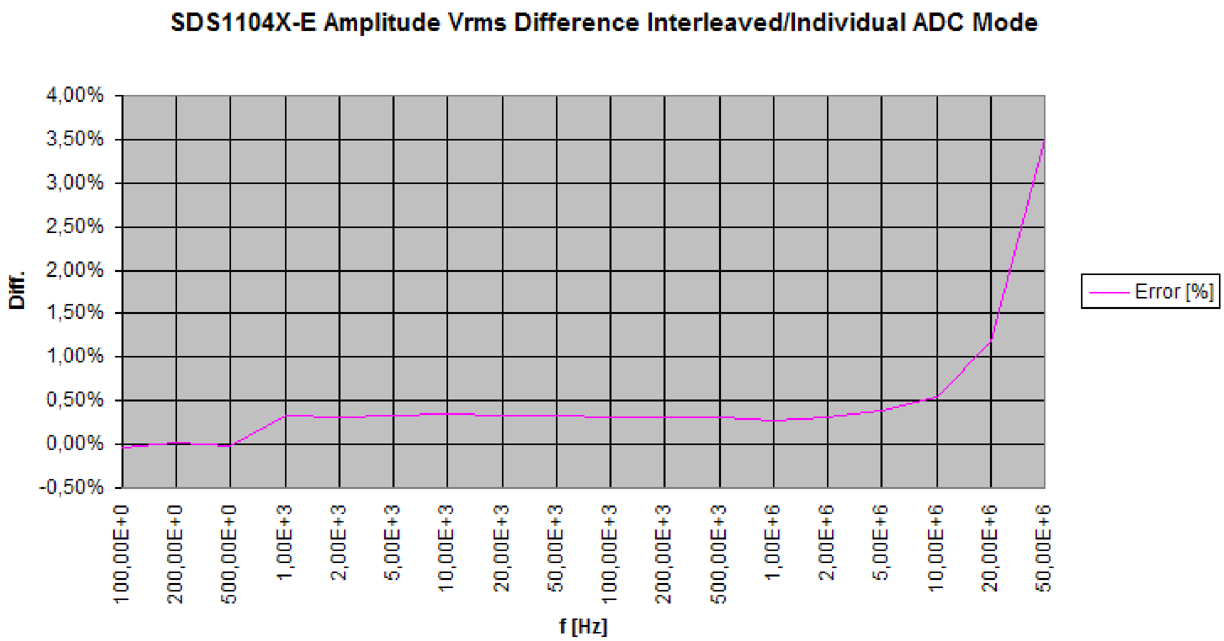
SDS1104X-E_Channel_Gain_Deviation@1MHz

Finally we want to see the impact of the ADC mode (interleaved/individual) on the signal amplitude. The key for this is the number of active channels. With only one active channel per channel group, the ADC and memory resources that would normally be used for the second channel are now associated with that single active channel (interleaved mode), thus giving us twice the sample rate and acquisition memory. Of course this affects the measured signal amplitude, particularly at high frequencies.

The following graphs show the deviation of peak to peak and rms measurements between one and two channels per group for frequencies from 100Hz up to 50MHz.



SDS1104X-E_Amplitude_Vpp_Difference



SDS1104X-E_Amplitude_Vrms_Difference

The deviation is pretty much negligible for frequencies up to some 10MHz and still well within specifications above that. It comes as little surprise that the deviation rises significantly at high frequencies, where the difference in sample rate has indeed a substantial impact on measurement accuracy. But this is also the area where a +2/-3dB error is specified, so there's still no reason to complain.

Bandwidth

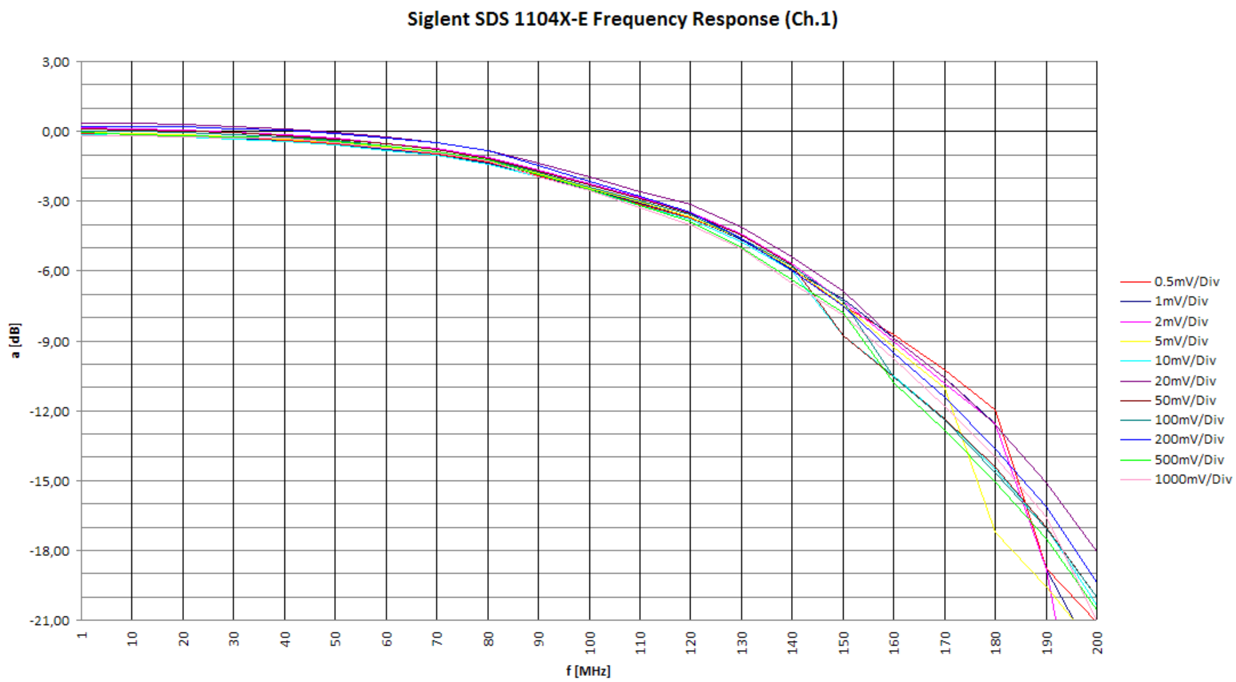
For this test, only the 100MHz SDS1104X-E was available. The table below shows the measurement results for all vertical gain settings up to 1V/div.

Vert. Gain	BW [MHz]		
	1 dB	3 dB	6 dB
0.5mV/Div	74,00	110,00	141,00
1mV/Div	74,00	110,00	141,00
2mV/Div	74,00	110,00	141,00
5mV/Div	74,00	110,00	141,00
10mV/Div	74,00	109,00	141,00
20mV/Div	74,00	111,00	141,00
50mV/Div	74,00	109,00	141,00
100mV/Div	74,00	109,00	141,00
200mV/Div	78,00	109,00	139,00
500mV/Div	76,00	109,00	138,00
1000mV/Div	78,00	109,00	138,00

SDS1104X-E_BW

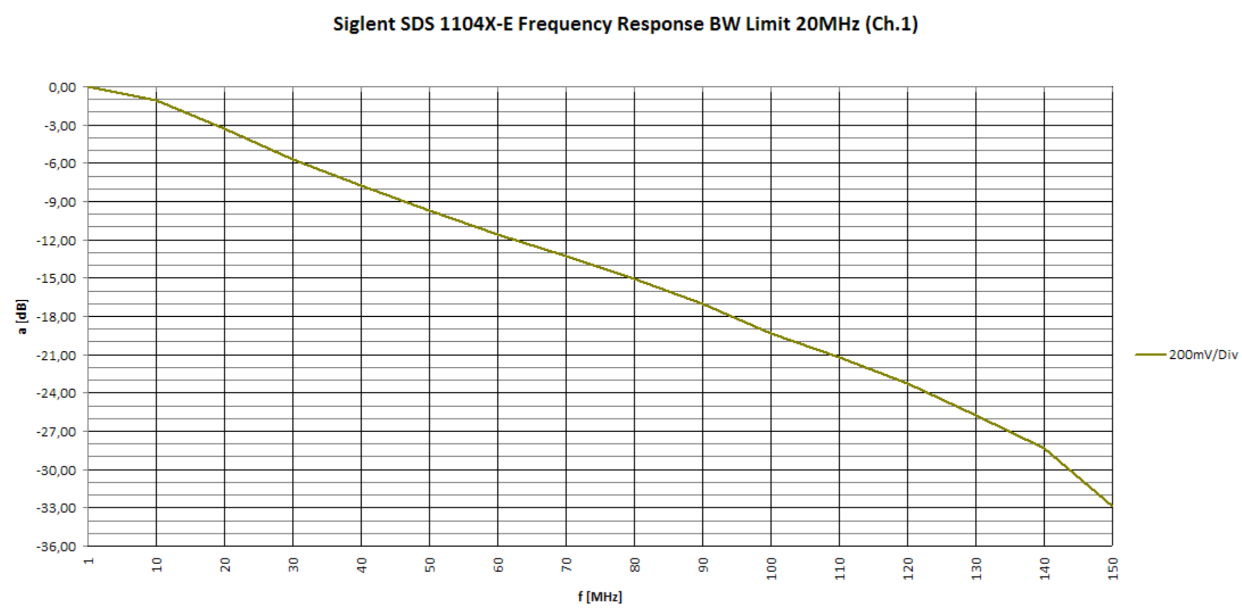
Since there has to be an explicit bandwidth limiter somewhere in this scope, it comes as no surprise that the actual bandwidth is only slightly higher than specified.

The graph below shows the individual frequency responses up to 200MHz for all tested vertical gain settings from 500µV/div to 1V/div.



SDS1104X-E_BW_Graph

The next graph shows the frequency response at 200mV/div with 20MHz bandwidth limit activated.



SDS1104X-E_Frequency_Response_BW_Limit_20MHz

Actual 3dB bandwidth limit has been measured as 18.6MHz, which is well within the specified tolerance of ±40%.

I do not have any data for the SDS1204X-E, but its frontend is most likely pretty much identical to the SDS1202X-E whose bandwidth measurement data can be found in the table below.

Vert. Gain	BW [MHz] 1 dB	3 dB	6 dB
0.5mV/Div	204,00	240,00	290,00
1mV/Div	204,00	240,00	290,00
2mV/Div	203,00	240,00	289,00
5mV/Div	200,00	236,00	285,00
10mV/Div	199,00	236,00	285,00
20mV/Div	201,00	237,00	285,00
50mV/Div	198,00	233,00	283,00
100mV/Div	192,00	227,00	280,00
200mV/Div	200,00	243,00	314,00
500mV/Div	196,00	238,00	310,00

SDS1202X-E_BW

Input Impedance

Bandwidth measurements are always compromised by parasitic impedances, which we'll take a closer look at in this section.

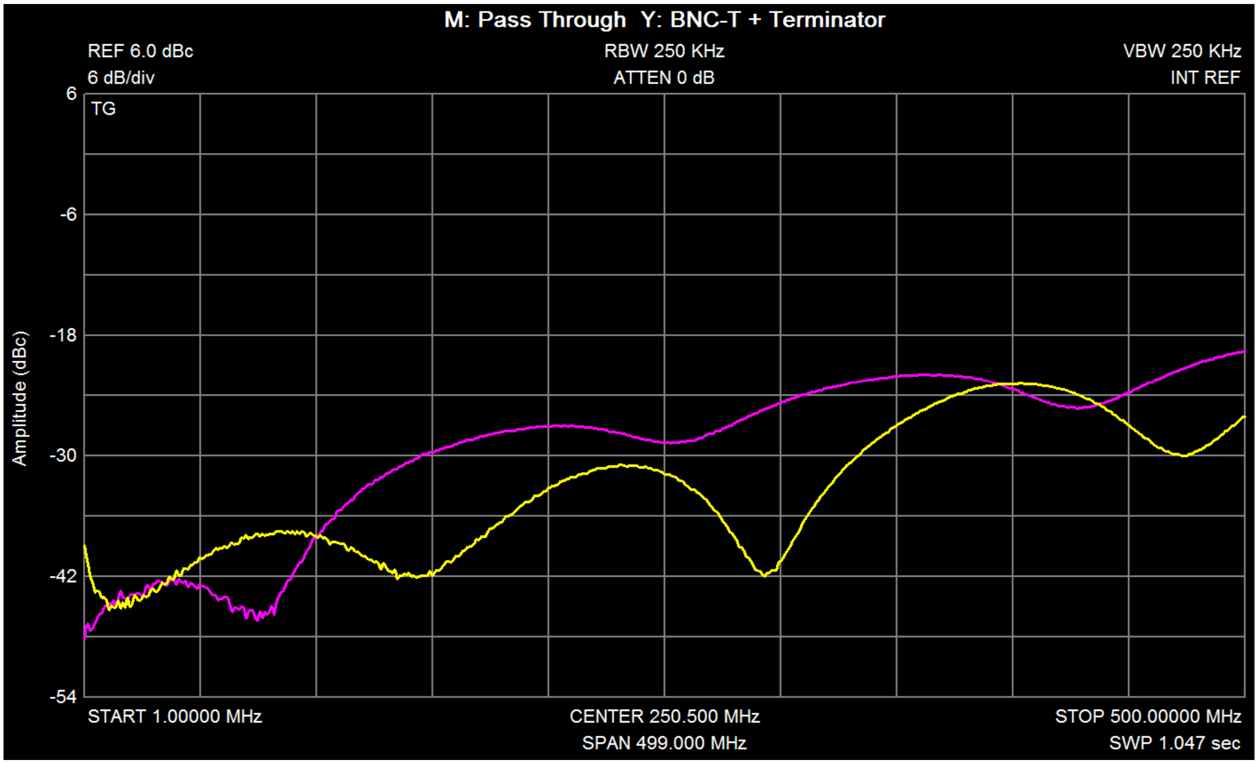
If we use the probes, then the input capacitance of the probe will present an increasing load to the signal source at higher frequencies, which lets the amplitude drop and might even cause signal distortion. In most cases, the stray inductance of the ground connection adds to that and turns the probe into a series resonance circuit. This is why it is essential to use the probe BNC adaptor whenever the probe bandwidth is to be determined.

For the majority of tests, a direct BNC connection is used and this has it's pitfalls as well. In general purpose high frequency test & measurement instruments, 50Ω impedance for the inputs is common. The same is true for coax cables e.g. RG58 used in the lab. A flat frequency response, thus high signal fidelity can only be obtained if the entire connection from the signal source to the scope input is precisely 50Ω throughout. Signal generators usually have a 50Ω output, laboratory coax cables and connectors are 50Ω, but scope inputs are often not – particularly not in low cost general purpose scopes. Better general purpose scopes provide a switchable 50Ω input impedance, but e.g. the SDS1000X-E does not.

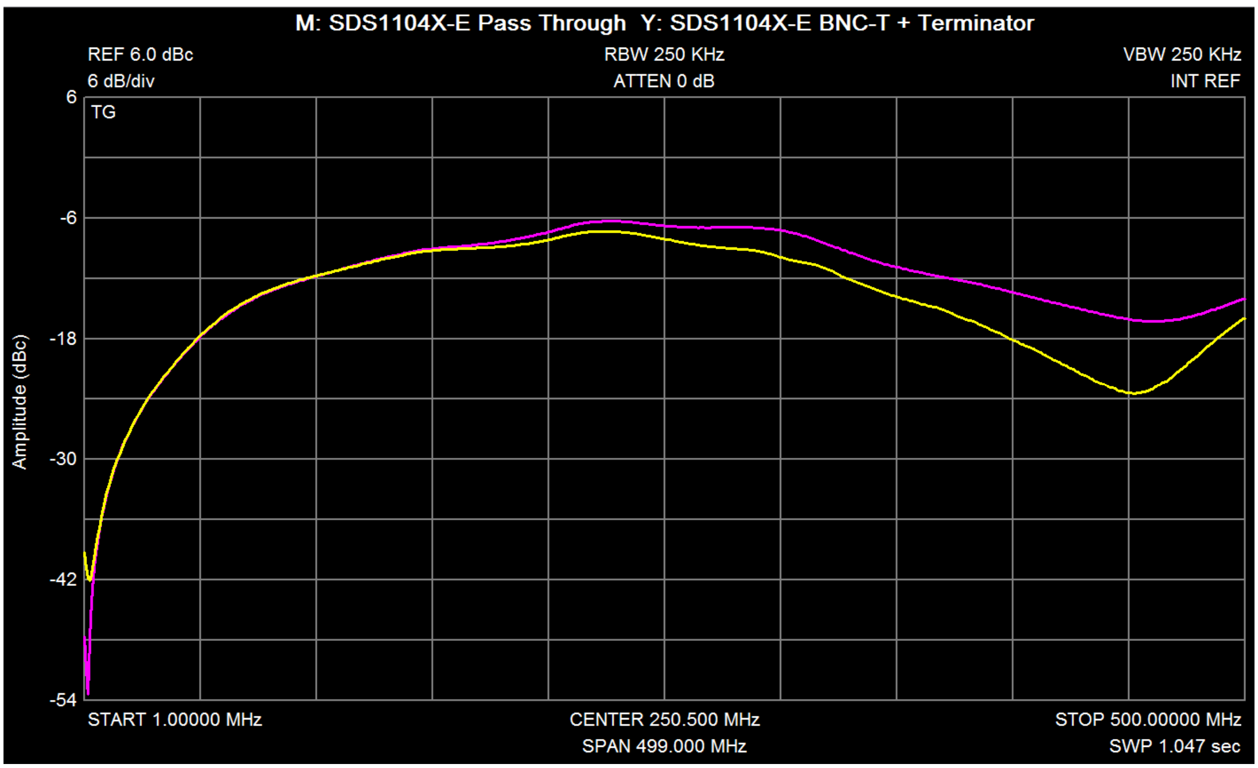
In theory, we can use an external 50Ω pass-through terminator to make any scope 50Ω compatible. The 1MΩ Input resistance would be negligible in this case, but the input capacitance (15pF for the SDS1104X-E) is not. The 3dB corner frequency of this combination is 212MHz. There are several adverse effects because of the input capacitance of the scope:

1. Additional attenuation at higher frequencies because of the capacitive loading. It would be -3dB at 212MHz for the SDS1104X-E.
2. The end of the BNC cable is not properly terminated anymore at higher frequencies. Depending on the cable length this will cause ripple in the overall frequency response.
3. The two topics mentioned above would apply for most scopes that can set the input impedance to 50Ω internally. For an external pass-through termination, there is some distance between the 50Ω resistor and the input capacitance, causing an even worse mismatch and making matters all the more obscure, but this most likely only plays a role at really high frequencies >1GHz.

Sometimes people don't have an external pass-through terminator available and use a BNC-T + BNC Termination. Let's compare the two methods. The pass-through terminator is a RS-456-150-50Ω which is the Tyco part B35 X13 • 999 X99 – unfortunately there's no specification. The equivalent end terminations are specified with a VSWR of 1.1 up to 1GHz. The terminator on the BNC-T is not specified either, but at one point I have bought a bunch of different BNC terminators, kept the best and threw away the rest. So it is a good one. Now let's see how the two solutions compare – just the through termination, not plugged into the scope. Magenta is the RS-456-150-50Ω, yellow the BNC-T with selected terminator at one end. Both solutions work fine up to 500MHz, with a return loss >20dB, equivalent to a VSWR <1.25. The 2nd screenshot shows the return loss of both solutions when plugged into the scope input.



RL_Ext_Comp



RL_SDS_Ext_Comp

As expected, this is significantly worse, but still not quite as bad as suspected. It is interesting though that the BNC-T works slightly better than the dedicated pass-through terminator. Return loss is particularly bad at 220MHz, where it is almost down to 6dB, equivalent to a VSWR of 3. Interestingly, it gets better again at higher frequencies.

Particularly for the SDS1104X-E we get a return loss of some -9dB and VSWR <2.2 at 100MHz. The situation is only really satisfactory for frequencies up to some 50MHz.

Low Frequency Response

There are at least two concerns about the low frequency response in an oscilloscope:

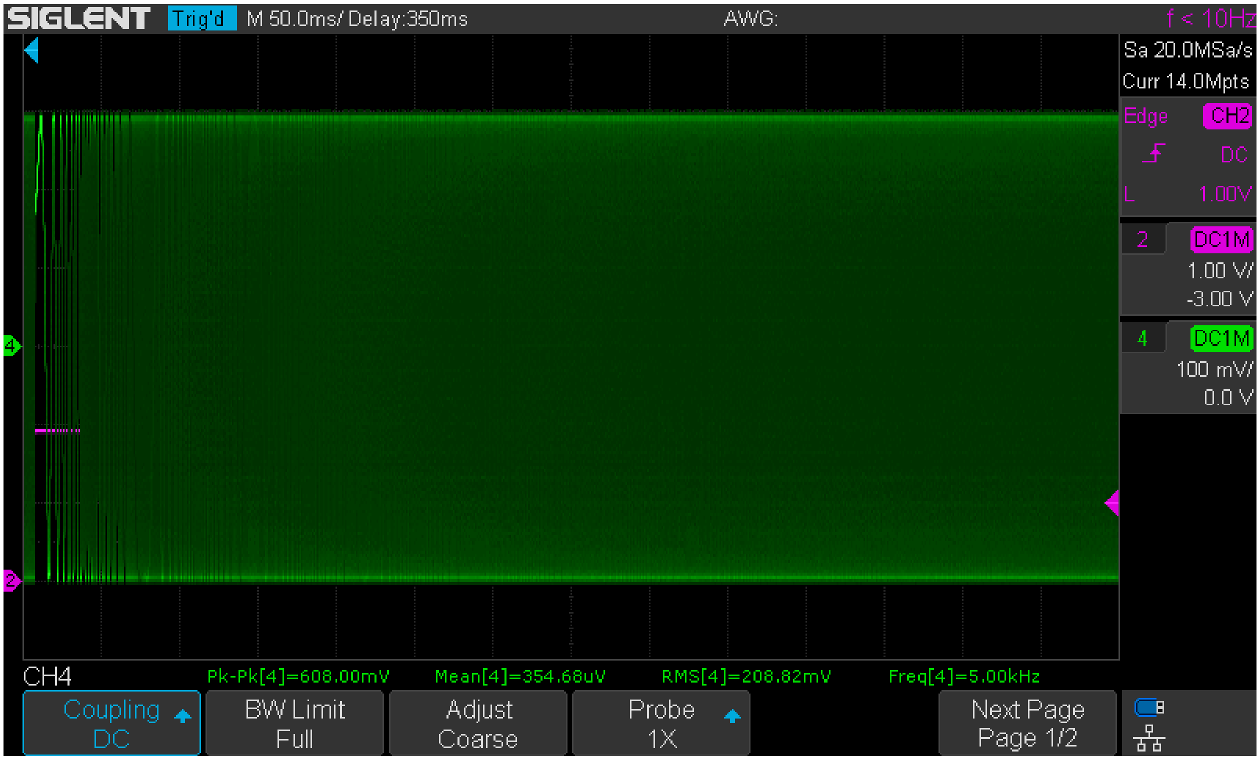
- Lower bandwidth limit with AC input coupling
- Gain flatness at the crossover region in the split path input buffer

The first topic is easily measured and the Siglent 1104X-E has its lower bandwidth limit at about 1.2Hz for -3dB and 3Hz for -1dB. This is a good choice, as with these values AC coupling covers most practical AC signal applications, while response to DC offset voltage changes is still reasonably fast.

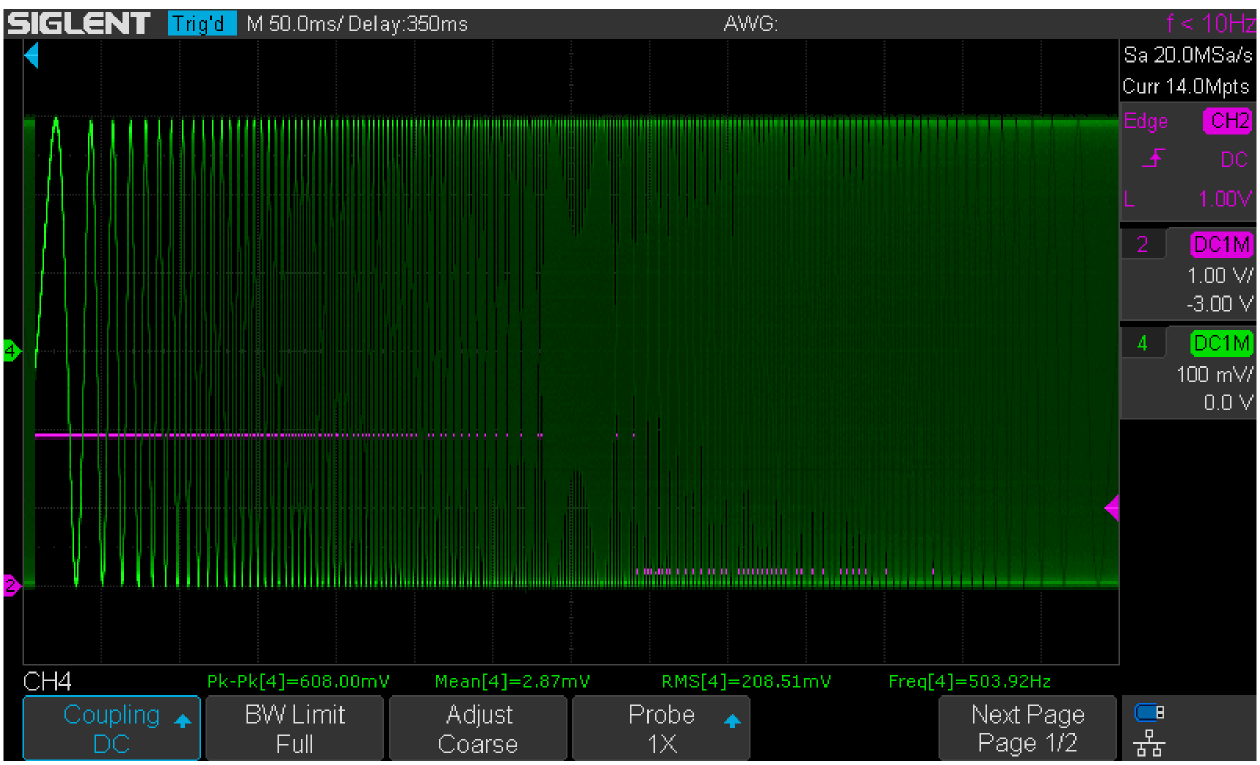
A quick check of the proper design and adjustment of the crossover networks for the split path input buffer can be done by viewing a 100Hz square wave. This is independent of input coupling, so DC coupling is used again.

SDS1104X-E_LF_Square_100Hz

This doesn't look particularly bad, though not 100% perfect, but this could also be the signal source. Another test method is just checking the frequency response in the ranges 10Hz to 10kHz and 1kHz.



SDS1104X-E_LF_SWEEP_10Hz-10kHz



SDS1104X-E_LF_SWEEP_10Hz-1kHz

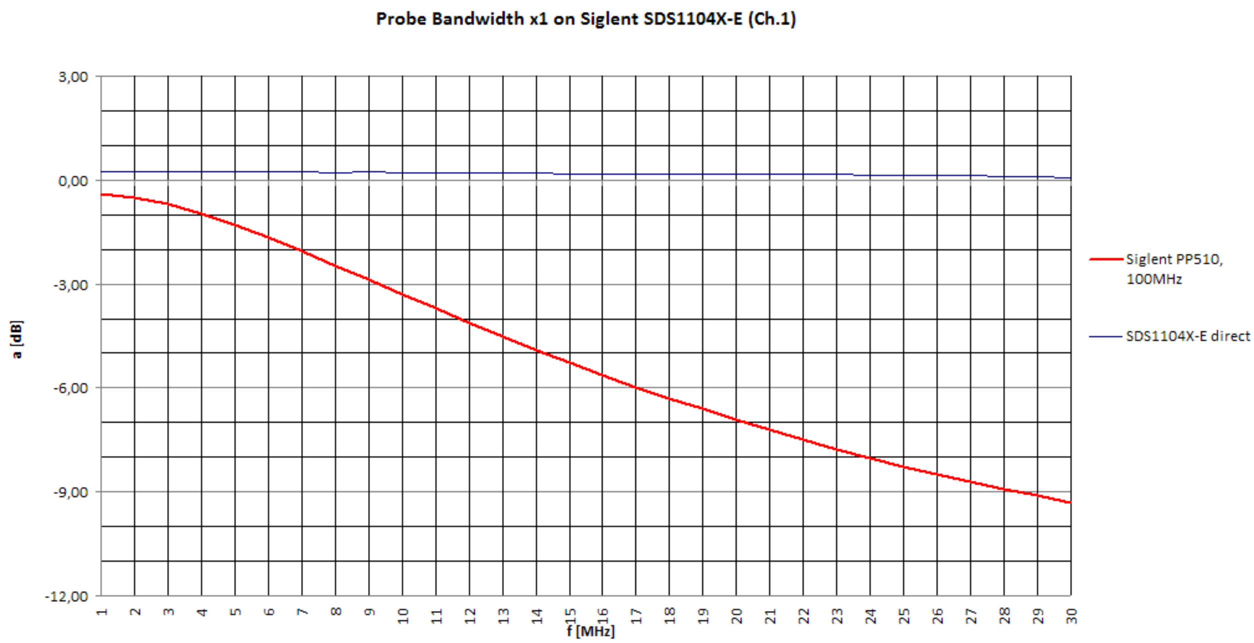
Frequency response is certainly flat. So the split path input buffer is well designed and properly adjusted.

Probe Bandwidth PP510

The Siglent SDS1104X-E came with slim 100MHz probes PP510 with switchable attenuation x1 and x10.

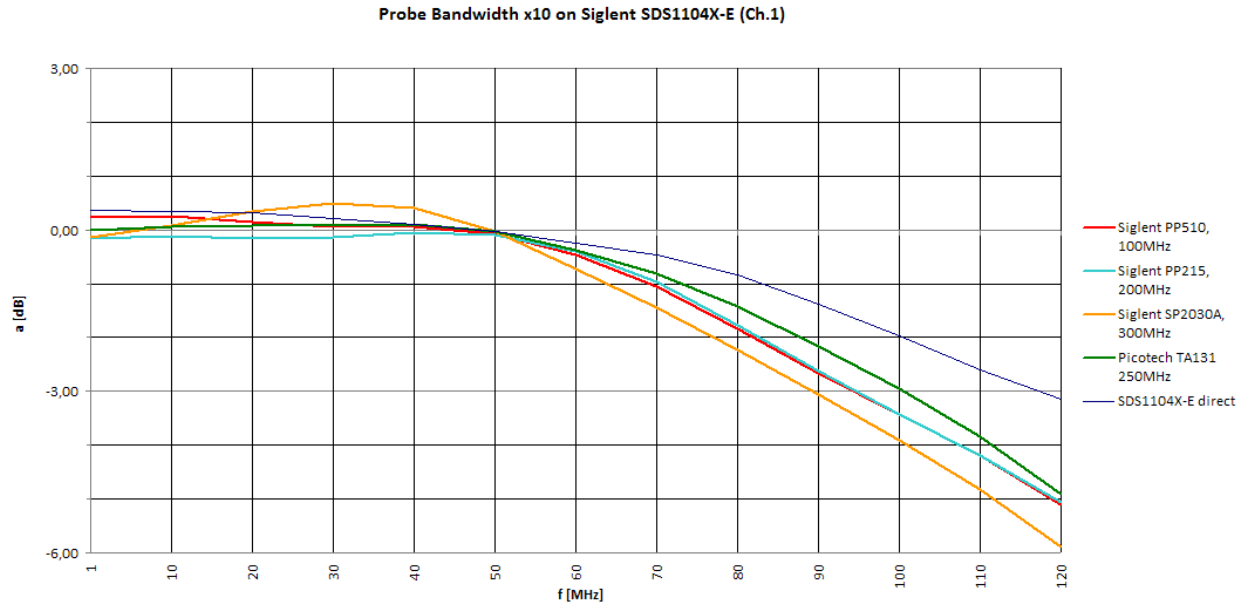
As we all know, x1 mode is of limited use because of the high capacitive loading (approx. 100pF) and limited bandwidth. The most common application would be checking power supply rails for ripple and noise.

The following graph shows the frequency response with a 3dB bandwidth slightly above 9MHz for 50 ohms source impedance.

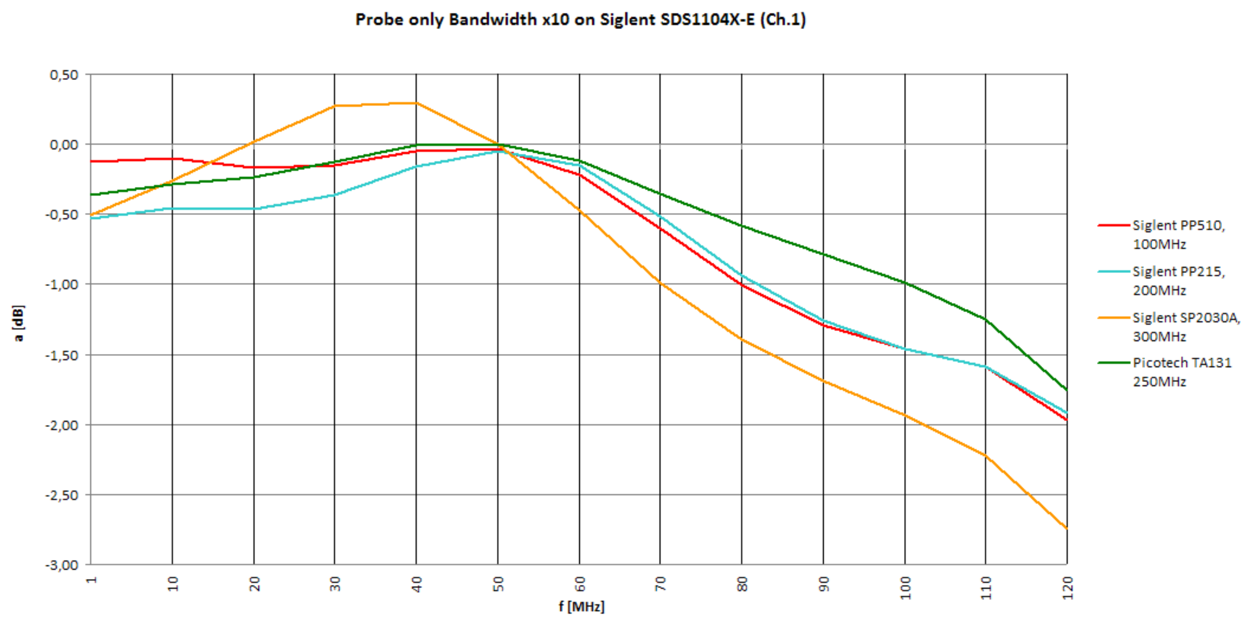


SDS1104X-E_Probe_x1_BW

The following screenshot shows the frequency response of the SDS1104X-E with 4 different x10 probes and with direct coax connection as a reference.



SDS1104X-E_Probe_x10_BW



SDS1104X-E_ProbeOnly_x10_BW

The screenshot above shows the difference between each probe and the direct connection. The following probes have been tested:

- Siglent PP510, 100MHz
- Siglent PP215, 200MHz
- Siglent SP2030A, 300MHz
- Picotech TA131, 250MHz

It can be seen that the supplied standard probe PP510 is not bad at all; up to 50MHz it is clearly the best choice. Above that frequency, the Picotech TA131 performs a little better, but the difference is still just 0.5dB @ 100MHz.

Some might think a faster probe is always better, but that's clearly not the case when looking e.g. at the SP2030A. At the same time, this very same probe works perfectly fine together with an SDS2304X scope and extends its bandwidth up to 450MHz! Probes should be matched with the particular scope input characteristics and the Siglent PP510 certainly is a pretty good match for the SDS1104X-E. Yet it should be noted that the differences are not huge and probe matching is generally a less critical issue for slower scopes.

Noise

This scope provides an exceptional high input sensitivity of 500µV/div at full bandwidth. Of course the actual sensitivity is limited by the input noise of the scope – which cannot be low in an overvoltage-protected high impedance input amplifier. This also shows by the fact that the scope noise is more or less independent of the external load impedance. In other words, it remains the same, whether the input is shorted to ground or left open.

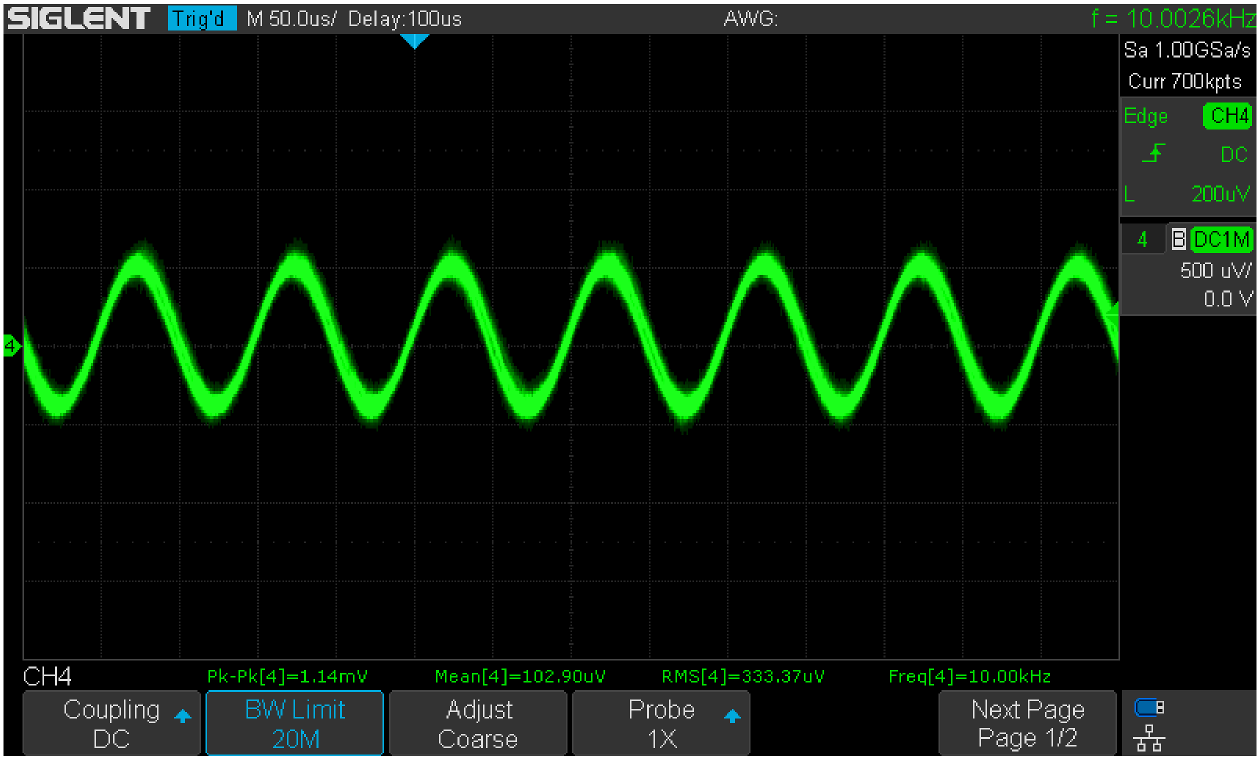
Whenever screenshots are published to demonstrate the low noise of a scope, we usually can assume that the scope settings have been carefully selected to make the results look good. Noise performance is affected by so many parameters, like bandwidth, memory depth, sample speed and screen update rate, which are all directly proportional to the exhibited noise amplitude.

In this review, we do the opposite by using a fairly slow timebase, where the 1/f noise already takes its toll and we can see 700kpts mapped to the screen, yet some 300 waveforms per second, resulting in a total of about 7.7Mpts per screen refresh – which is quite a lot of data to look at in a single picture.

The screenshot below shows a 10kHz sine with only 1mVpp amplitude. The trace is fat and noisy, the peak to peak measurement reads much too high (+38%) because of the noise, but Vrms and frequency measurements are pretty close and overall, this is still a fairly decent result.

Noise_10kHz_1mVpp_normal_full

With the 20MHz bandwidth limit, noise is significantly reduced already. Even the very sensitive peak to peak voltage measurement gets much closer and exhibits only 14% error now.



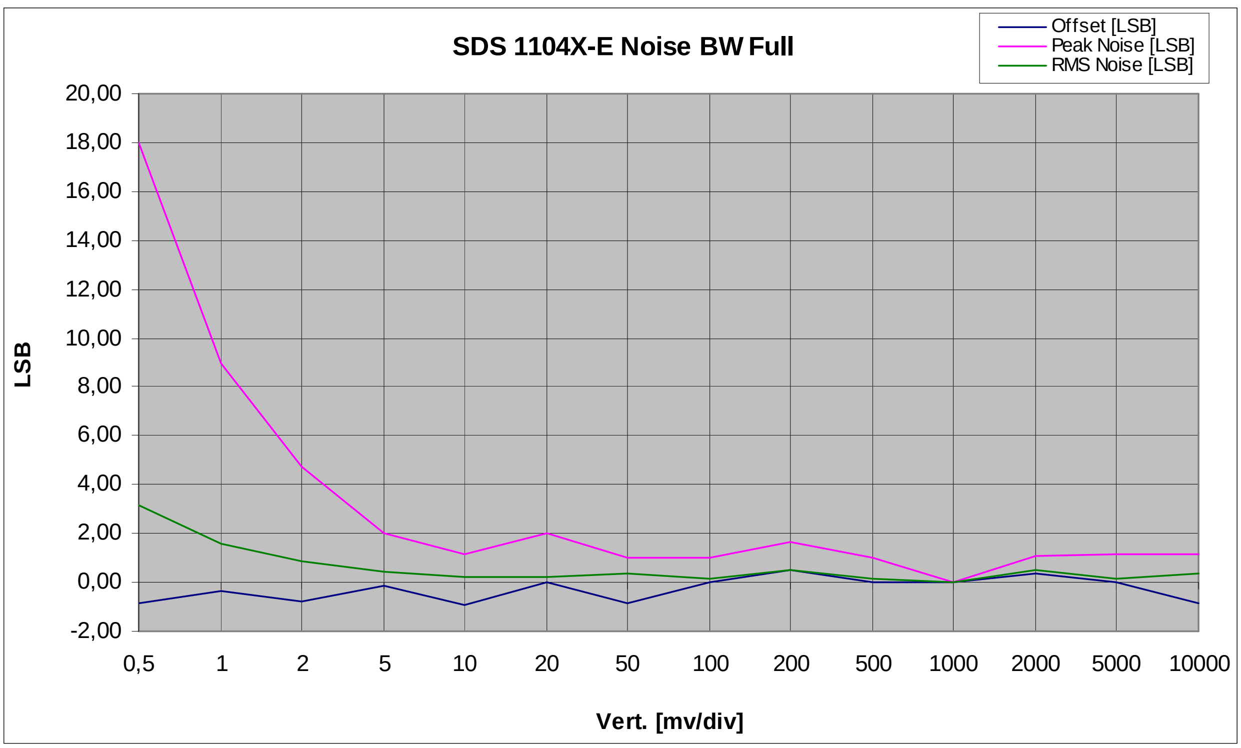
Noise_10kHz_1mVpp_normal_limit

Instead of an input bandwidth limit, we can use the average acquisition mode. With just 16 averages, noise isn’t an issue anymore and all automatic measurements are pretty much spot-on.

Noise_10kHz_1mVpp_avg16_full

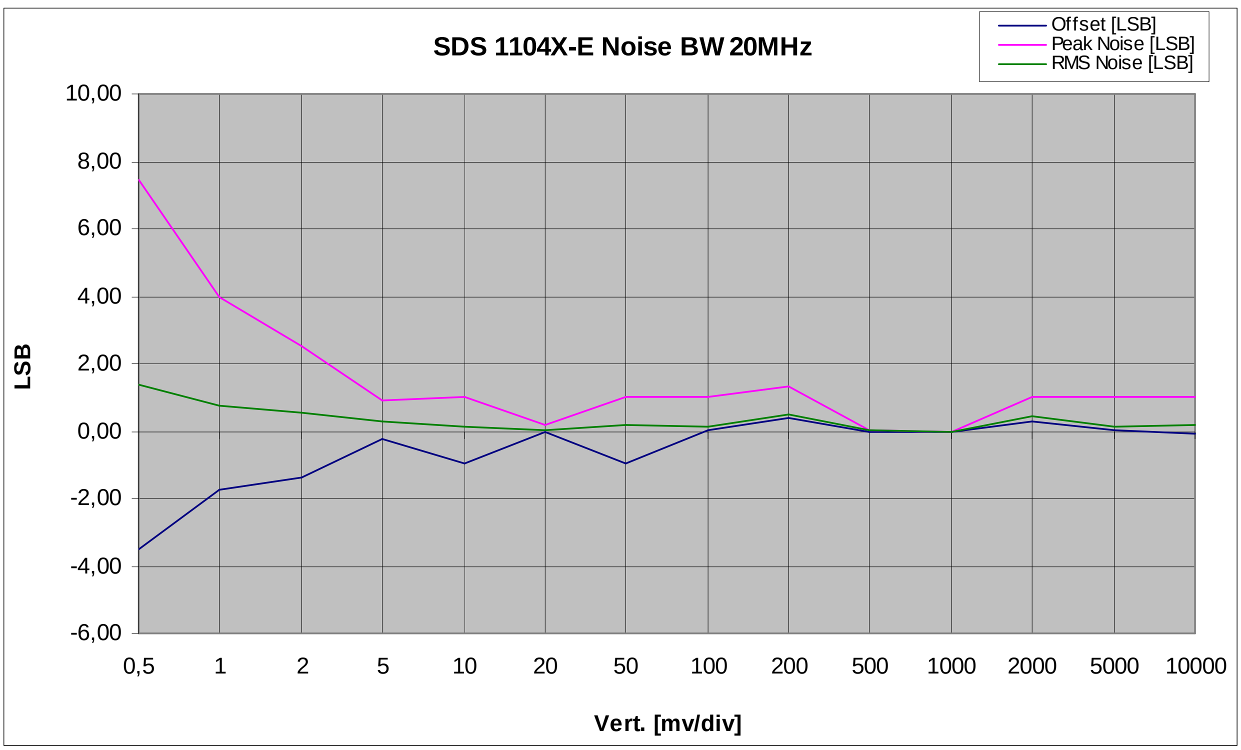
What has been demonstrated before is just one isolated use case – and with a signal frequency of just 10kHz certainly hasn't hit the sweet spot. So a more detailed examination is in order. The following diagrams show offset, peak-peak and RMS noise for all vertical gain settings at 50ns/div, for full bandwidth and also with 20MHz bandwidth limit.

SDS 1104X-E Noise BW Full								
Gain [mV/div]	**Noise [mVpp]**	**Noise [mVrms]**	**Mean [mV]**	**Offset [mV]**	**Offset [LSB]**	**Peak Noise [LSB]**	**RMS Noise [LSB]**	**LSB [mV]**
0,5	0,360	0,063	-0,018	-0,02	-0,88	18,0	3,1	0,020
1	0,360	0,064	-0,015	-0,02	-0,38	9,0	1,6	0,040
2	0,380	0,069	-0,061	-0,06	-0,76	4,8	0,9	0,080
5	0,403	0,084	-0,023	-0,02	-0,12	2,0	0,4	0,200
10	0,464	0,090	-0,377	-0,38	-0,94	1,2	0,2	0,400
20	1,590	0,195	0,022	0,02	0,03	2,0	0,2	0,800
50	2,000	0,702	-1,700	-1,70	-0,85	1,0	0,4	2,000
100	3,980	0,633	0,121	0,12	0,03	1,0	0,2	4,000
200	13,100	4,000	4,120	4,12	0,52	1,6	0,5	8,000
500	19,940	3,030	-0,527	-0,53	-0,03	1,0	0,2	20,000
1000	0,200	0,011	-0,001	0,00	0,00	0,0	0,0	40,000
2000	84,000	38,100	29,100	29,10	0,36	1,1	0,5	80,000
5000	229,000	30,500	5,120	5,12	0,03	1,1	0,2	200,000
10000	468,000	152,000	-328,000	-328,00	-0,82	1,2	0,4	400,000



SDS1104X-E Noise BW_full

SDS 1104X-E Noise BW 20MHz								
Gain [mV/div]	Noise [mVpp]	Noise [mVrms]	Mean [mV]	Offset [mV]	Offset [LSB]	Peak Noise [LSB]	RMS Noise [LSB]	LSB [mV]
0,5	0,150	0,028	-0,070	-0,07	-3,50	7,5	1,4	0,020
1	0,160	0,031	-0,070	-0,07	-1,75	4,0	0,8	0,040
2	0,200	0,044	-0,111	-0,11	-1,39	2,5	0,6	0,080
5	0,180	0,057	-0,051	-0,05	-0,26	0,9	0,3	0,200
10	0,400	0,058	-0,390	-0,39	-0,98	1,0	0,1	0,400
20	0,140	0,008	-0,001	0,00	0,00	0,2	0,0	0,800
50	2,000	0,323	-1,940	-1,94	-0,97	1,0	0,2	2,000
100	3,980	0,618	0,111	0,11	0,03	1,0	0,2	4,000
200	10,730	3,770	3,080	3,08	0,39	1,3	0,5	8,000
500	0,600	0,025	-0,002	0,00	0,00	0,0	0,0	20,000
1000	0,000	0,000	0,000	0,00	0,00	0,0	0,0	40,000
2000	80,000	34,000	22,000	22,00	0,28	1,0	0,4	80,000
5000	200,000	31,000	5,750	5,75	0,03	1,0	0,2	200,000
10000	405,000	80,500	-38,000	-38,00	-0,10	1,0	0,2	400,000



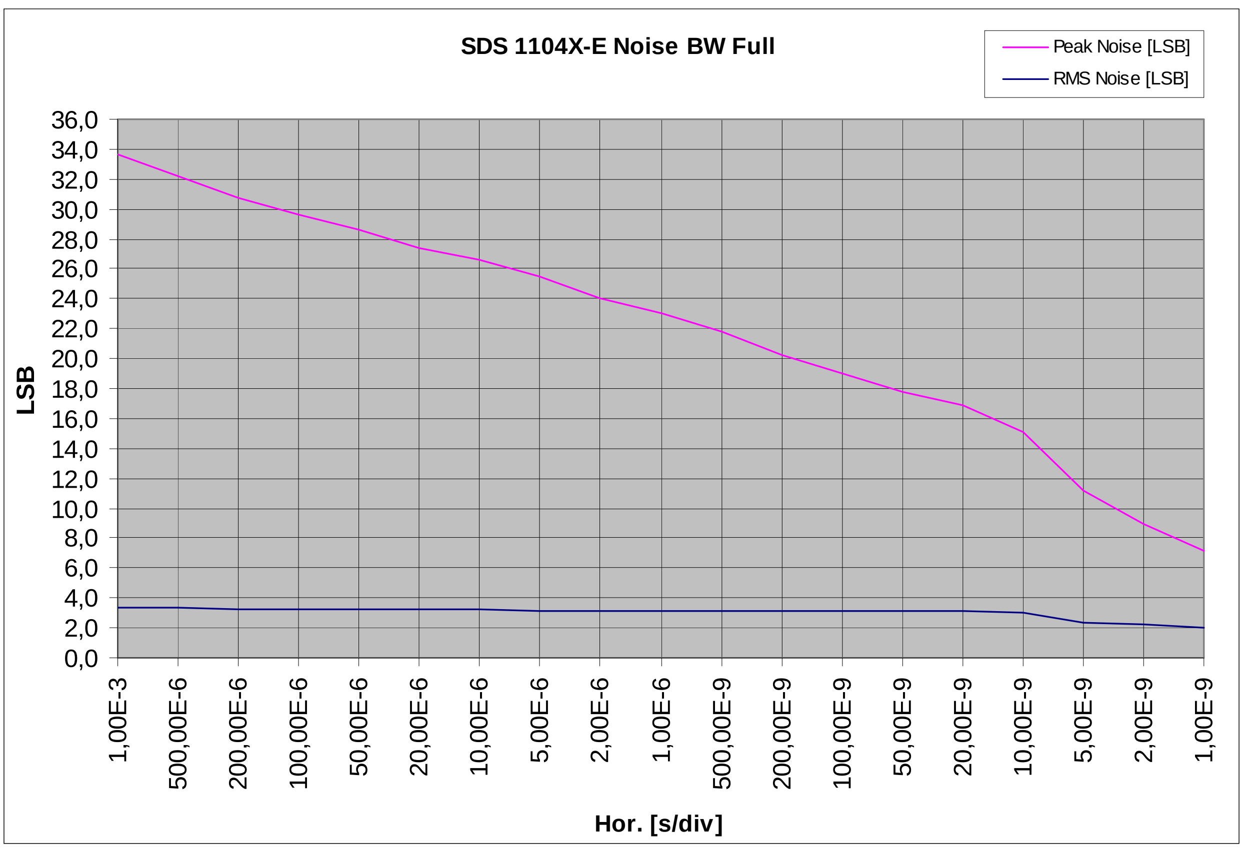
SDS1104X-E Noise BW_20M

It turns out that the ranges 10, 50, 100 and 500mV/div and 1 to 10V/div are really low nose with a peak amplitude of no more than 1ADC LSB. The 1V/div is particularly almost noise-free.

Noise not only depends on the total bandwidth, but also the lower bandwidth limit, for at least two reasons.

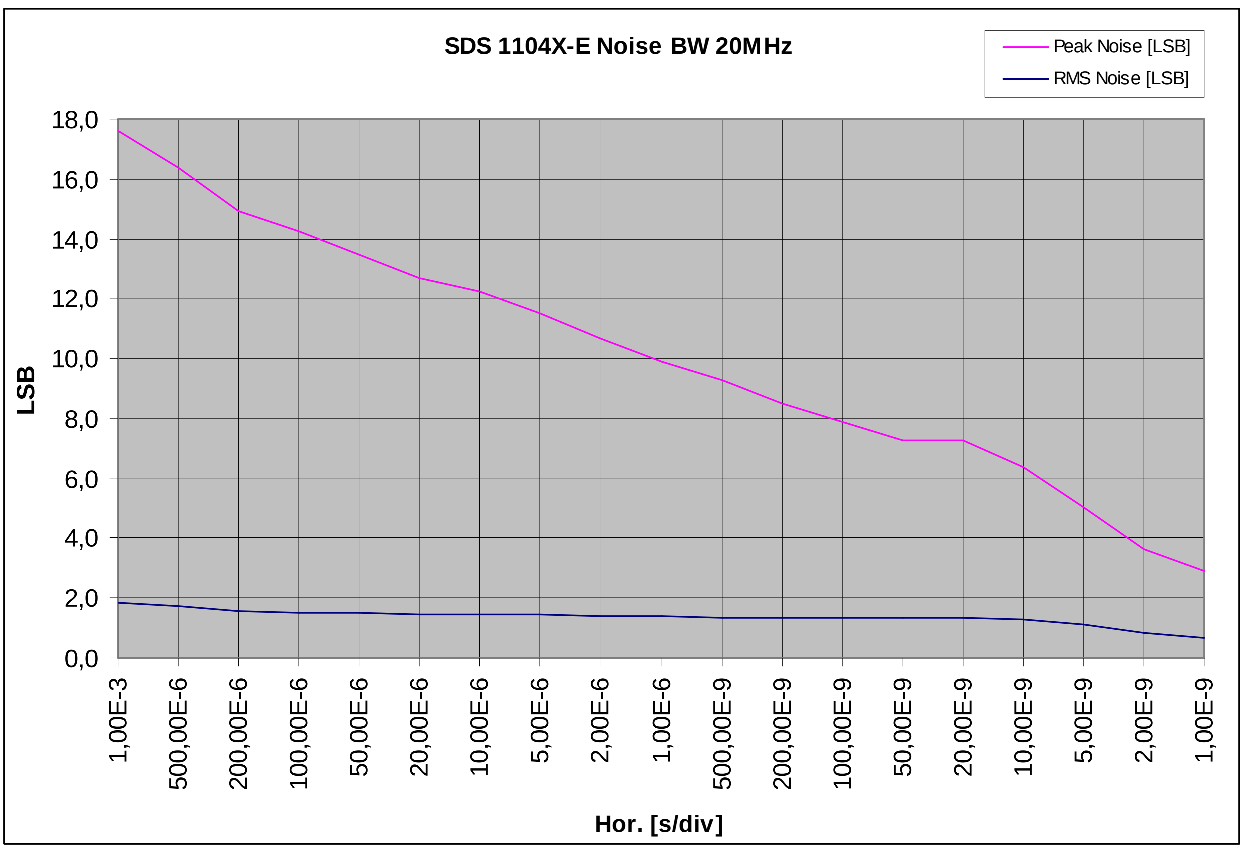
- 1/f noise of the high impedance FET input amplifier
- DC overvoltage protection for the DC path of the input amplifier results in high source impedance and attenuation on top of that, which needs to be compensated by additional amplifier gain.

SDS 1104X-E Noise, Full BW			Max.SR	1,00E+9	Max. Mem	14,00E+6	
Timebase [s/div]	**Noise [mVpp]**	**Noise [mVrms]**	**Peak Noise [LSB]**	**RMS Noise [LSB]**	**LSB [mV]**	**Mem [Pts]**	**NOISE fc_low [Hz]**
1,00E-3	0,673	0,068	33,7	3,4	0,020	14,00E+6	71E+0
500,00E-6	0,643	0,067	32,2	3,3	0,020	7,00E+6	143E+0
200,00E-6	0,615	0,065	30,8	3,2	0,020	2,80E+6	357E+0
100,00E-6	0,592	0,064	29,6	3,2	0,020	1,40E+6	714E+0
50,00E-6	0,573	0,064	28,7	3,2	0,020	700,00E+3	1E+3
20,00E-6	0,548	0,064	27,4	3,2	0,020	280,00E+3	4E+3
10,00E-6	0,533	0,064	26,7	3,2	0,020	140,00E+3	7E+3
5,00E-6	0,509	0,064	25,5	3,2	0,020	70,00E+3	14E+3
2,00E-6	0,480	0,063	24,0	3,2	0,020	28,00E+3	36E+3
1,00E-6	0,460	0,063	23,0	3,1	0,020	14,00E+3	71E+3
500,00E-9	0,435	0,063	21,8	3,1	0,020	7,00E+3	143E+3
200,00E-9	0,405	0,062	20,3	3,1	0,020	2,80E+3	357E+3
100,00E-9	0,381	0,062	19,1	3,1	0,020	1,40E+3	714E+3
50,00E-9	0,356	0,062	17,8	3,1	0,020	700,00E+0	1E+6
20,00E-9	0,337	0,062	16,9	3,1	0,020	280,00E+0	4E+6
10,00E-9	0,302	0,060	15,1	3,0	0,020	140,00E+0	7E+6
5,00E-9	0,223	0,047	11,2	2,4	0,020	70,00E+0	14E+6
2,00E-9	0,180	0,044	9,0	2,2	0,020	28,00E+0	36E+6
1,00E-9	0,143	0,039	7,2	2,0	0,020	14,00E+0	71E+6



SDS1104X-E Noise_vs_time BW_full

SDS 1104X-E Noise, BW 20MHz			Max.SR	1,00E+9	Max. Mem	14,00E+6	
Timebase [s/div]	Noise [mVpp]	Noise [mVrms]	Peak Noise [LSB]	RMS Noise [LSB]	LSB [mV]	Mem [Pts]	NOISE fc_low [Hz]
1,00E-3	0,352	0,037	17,6	1,9	0,020	14,00E+6	71E+0
500,00E-6	0,328	0,034	16,4	1,7	0,020	7,00E+6	143E+0
200,00E-6	0,298	0,031	14,9	1,6	0,020	2,80E+6	357E+0
100,00E-6	0,285	0,030	14,3	1,5	0,020	1,40E+6	714E+0
50,00E-6	0,270	0,030	13,5	1,5	0,020	700,00E+3	1E+3
20,00E-6	0,254	0,030	12,7	1,5	0,020	280,00E+3	4E+3
10,00E-6	0,245	0,029	12,3	1,5	0,020	140,00E+3	7E+3
5,00E-6	0,230	0,029	11,5	1,5	0,020	70,00E+3	14E+3
2,00E-6	0,214	0,028	10,7	1,4	0,020	28,00E+3	36E+3
1,00E-6	0,198	0,028	9,9	1,4	0,020	14,00E+3	71E+3
500,00E-9	0,186	0,027	9,3	1,4	0,020	7,00E+3	143E+3
200,00E-9	0,170	0,027	8,5	1,3	0,020	2,80E+3	357E+3
100,00E-9	0,158	0,027	7,9	1,3	0,020	1,40E+3	714E+3
50,00E-9	0,145	0,027	7,3	1,3	0,020	700,00E+0	1E+6
20,00E-9	0,145	0,027	7,3	1,4	0,020	280,00E+0	4E+6
10,00E-9	0,128	0,026	6,4	1,3	0,020	140,00E+0	7E+6
5,00E-9	0,101	0,023	5,1	1,1	0,020	70,00E+0	14E+6
2,00E-9	0,073	0,017	3,7	0,8	0,020	28,00E+0	36E+6
1,00E-9	0,058	0,014	2,9	0,7	0,020	14,00E+0	71E+6



SDS1104X-E Noise_vs_time BW_20M

The graphs above show input noise for all timebase settings from 1ms/div to 1ns/div at maximum vertical sensitivity of 500µV/div. We can see a continuous 1/f characteristic for the peak to peak noise amplitude. In contrast, the RMS reading is fairly constant and clearly doesn't tell the full story.

Trigger

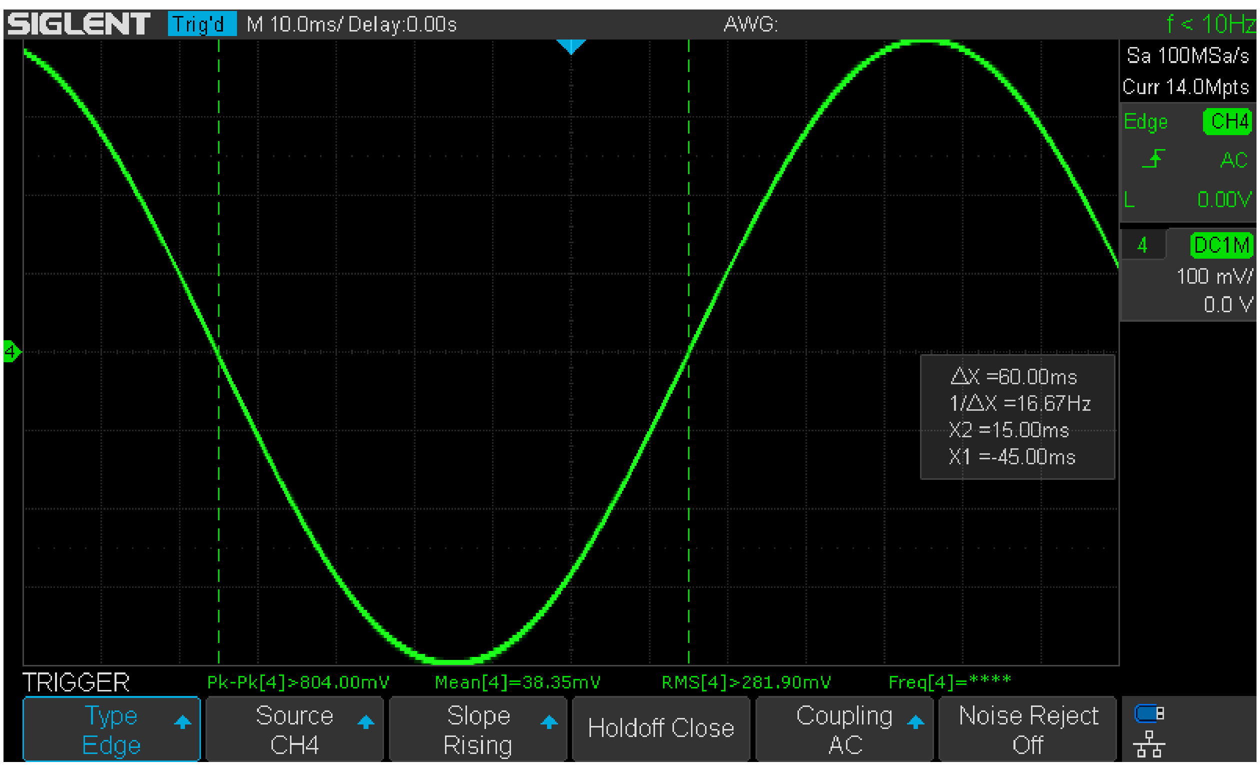
The trigger is one of the most important features of any oscilloscope, since we can only analyze a signal that we are able to trigger in a reliable and stable manner. Consequently, this section deals with the trigger system and its various options in the Siglent SDS1104X-E, which has a modern fully digital trigger system. Expectations are high, because triggering has been excellent on previous Siglent X-series DSOs.

Trigger Coupling

This gives us the opportunity of filtering the sampled input signal data (by means of digital signal processing) before the actual trigger condition is checked. If this is done in a proper way that suits the application, we can often get a stable trigger even on complex and/or noisy signals. There are four choices of trigger signal coupling and consequently filtering:

- DC: The entire input frequency range – no filtering.
- AC: High-pass filter with a lower corner frequency of about 8Hz
- LFRJ (LF-Reject): High-pass filter with a corner frequency of about 2MHz
- HFRJ (HF-Reject): Low-pass filter with a corner frequency of about 2.2MHz

The corner frequency of AC coupling can be determined by the phase shift between trigger point and signal.



SDS1104X-E_Trig_AC_Corner

Cursor measurement is used to determine the phase shift. The difference between both cursors X2-X1 is half the period of the input signal, hence its frequency is 1/(2 x 0.06) = 1/0.12 = 8.33Hz. The easier way is to just divide the frequency calculation of the cursor measurement by two: 16.67Hz/2 = 8.33Hz.