

Low Amplitude Pulse Signals Generation



Introduction

Real-world **millivolt signals** produced by microchannel plate detectors, microchannel plate photomultiplier tubes, fast photodiodes, discrete-dynode photomultiplier tubes, but also cardiac signals require **very low amplitude pulses** to test electronic devices like low signal amplifiers or any other R&D or medical equipment.

The Active Technologies AWG-4000 Arbitrary Waveform Generator has 16 Bits of vertical resolution and a full scale range of 12Vpp 50 Ohms into 50 Ohms: the resolution (DAC step size) is $12Vpp / 2^{16} = 0.1831 \text{ mV}$.

It means that with 3 mVpp waveform amplitude the DAC uses 4 bits only.

The AWG-5000 and AWG-7000 have a full scale range of 5Vpp into 50 Ohms. The resolution is $5Vpp/2^{16} = 0.07629 \text{ mV}$ for AWG-5000 and $5Vpp/2^{14} = 0.305175 \text{ mV}$ for AWG-7000; it means that if you want to generate 6 mVpp waveform amplitude using the AWG-5000 model, the DAC uses 6 bits only.

The PG-1000 Pulse Generator has a full scale of 5Vpp and for this reason when you try to generate a very low amplitude pulse signal, its full range is not optimized.

It is <u>highly suggested</u> to use an **external attenuator** in combination with the Rider Series Waveform and Pulse Generator to reach the best performances in term of very low amplitude pulses, fast rise/fall time, minimum pulse width and high signal fidelity.



Very-Low-Amplitude Pulse Generation with PG-1000

The generation of low-level pulses needs an external attenuator to optimize the signalto-noise ration and to obtain the best overall results.

In the following tests, we used an external 30 dB Attenuator like the one of the following picture.



In this paper we've performed several measurements on very low amplitude pulses using an oscilloscope; you can see the different tests and results in the pictures below.

1. PG-1000 | Pulse wave | 27 mVpp Amplitude | Attenuator 30 dB | Oscilloscope







2. PG-1000 | Pulse wave | 56 mVpp Amplitude | Attenuator 30 dB | Oscilloscope





3. PG-1000 | Pulse wave | 140 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



Very-Low-Amplitude Pulse Generation with AWG-4010

The AWG-4010 Arbitrary Waveform Generator Series has a full scale of 12Vpp into 50 Ohm, so also in this case an external 30 dB Attenuator is needed for optimal results.

1. AWG-4010 | Pulse wave | 15 mVpp Amplitude | Attenuator 30 dB | Oscilloscope







2. AWG-4010 | Pulse wave | 31 mVpp Amplitude | Attenuator 30 dB | Oscilloscope





3. AWG-4010 | Pulse wave | 61mVpp Amplitude | Attenuator 30 dB | Oscilloscope



4. AWG-4010 | Pulse wave | 130 mVpp Amplitude | Attenuator 30 dB | Oscilloscope





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5. AWG-4010 | Pulse wave | 130 mVpp Amplitude | 10 ms Width | Attenuator 30 dB | Oscilloscope



Very-Low-Amplitude Pulse Generation with AWG-5000

The AWG-5000 Arbitrary Waveform Generator Series has a full scale of 5Vpp into 50 Ohm and an analog bandwidth greater than 2 GHz, so also in this case an external 30 dB Attenuator is needed for the optimization of the signal to noise ratio.

1. AWG-5000 | Pulse wave | 8 mVpp Amplitude | Attenuator 30 dB | Oscilloscope







2. AWG-5000 | Pulse wave | 15 mVpp Amplitude | Attenuator 30 dB | Oscilloscope





3. AWG-5000 | Pulse wave | 30 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



4. AWG-5000 | Pulse wave | 60 mVpp Amplitude | Attenuator 30 dB | Oscilloscope





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🖹 File	1 Vertica	I ↔ Timebas	ie i Trigger	Display	Cursors	E Measure	Mati	h 🗠 Analysi	s 🛪 Utilitie	s O Support		Proce	ssing: Ⅱ		
63.2 mV															
53.2 mV								\square							
43.2 mV															
33.2 mV															
23.2 mV															
13.2 mV															
3.2 mV									m						-
-6.8 mV															
-16.8 mV															
	-10 ns	-8 ns	-	6 ns	-4 ns	-21	15	0.08		2 ms	4 ns	6 ns	81	ns	10 ms
Measure		P1.pkpk(C2)	P2 freq(C2)	P3.nse2080(P4 pkpk/C	1) P5 widtl	h(C1)	P6 freq(C2) P			P9 nse2080(P10 ovsh+(M4)	Pit-		212
value				125 ps	58.4 m	V 331.0	05 ps								
mean				124.413 ps	58 2995 m	V 330 8	24 ps								
min				110 05	59.4 m	V 325.4	27 DS								
sdev				3.564 ps	329.2 1	V 1.90	14 ps								
num				528	5	8	528								
status C1 10.0 m -23.2	0050 1V/div 10 mV	+		x			×					Tb Rit 4)	ase 0.00 5 2.00 ns cS 200 C	0 ns Trigga /div Auto SS/s Edge	5.3 mV Positive

5. AWG-5000 | Pulse wave | 140 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



Very-Low-Amplitude Pulse Generation with AWG-7000

The AWG-7000 Arbitrary Waveform Generator Series has a full scale of 5Vpp into 50 Ohm and an analog bandwidth greater than 8 GHz, so also in this case an external 30 dB Attenuator is needed to obtain the optimal results.

Using the AWG-7000, you can obtain very small amplitude pulses with 50 ps of rise and fall time and about 100 ps of minimum pulse width.

1. AWG-7000 | Pulse wave | 16 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



2. AWG-7000 | Pulse wave | 30 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



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3. AWG-7000 | Pulse wave | 60 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



4. AWG-7000 | Pulse wave | 120 mVpp Amplitude | Attenuator 30 dB | Oscilloscope



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80 mV												
60 mV												
40 mV						X						
20 mV												
0 <mark>13</mark> 4 0												
-20 mV												
-40 mV												
-60 mV								~~~~~				
-80 mV	فالتعييين وفاقتهما الشكماني		1 00		Voore							
	.98 nš -3.98	ns -2	98 ns	-1.98 ns	-980 ps	20°ps	1.02 ns	2.0	2 ns	3.02 ns	4.02 ns	5.02 ns
Measure	P1:ampl(C1)	P2:rise2080(P3:width(C1)									
value	120.30 mV	60 ps	118.7 ps									
mean	85.25 mV	60.142 ps	118.982 ps									
min	56.18 mV	50 ps	111.7 ps									
max	121.93 mV	67 ps	124.2 ps									
sdev	29.37 mV	2.593 ps	2.100 ps									
num	533	533	533									
status	×	×	×									
C1 20.0 mV 0.00 mV	/div +									Timeb: 400 S	ase -20 ps Tri 1.00 ns/div St 40 GS/s E	leger CL DD lop 0.0 mV doe Positive

Conclusion

The Active Technologies ARB Rider and Pulse Rider Series first-class hardware architecture coupled with an external attenuator offers the ability to generate unmatched performance and high signal fidelity when you need to generate very low amplitude, fast rise/fall time and very small width pulses , that are needed in the latest advanced R&D challenges.