True waveform generation by Signal Sources

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GW INSTEK
Made to Measure

GW INSTEK CORPORATION

Contents

- Signal source category
- Waveform generator evolution
- Hints of arbitrary waveform generator selection
- Frequently Asked Questions

Contents

- **Signal source category**
- **Waveform generator evolution**
- **Hints of arbitrary waveform generator selection**
- **Frequently Asked Questions**

Signal Source Category

- **Function Generator. Generate Sine, Triangular, Square, Ramp waveforms. Sweep, AM, FM, usually are available.**

- **DDS Function Generator. The function waveforms are generated by Direct-Digital-Synthesized technology. More modulation is possible.**

Waveform (time domain) generation

- **Arbitrary Waveform Generator. Allows users to edit and generate the arbitrary waveform.**

- **RF Signal Generator. RF signal technically generate sine wave only. The modulations used in communication are generally built-in.**

Waveform generator

- Signal source category
- Waveform generator evolution
- Hints of arbitrary waveform generator selection
- Frequently Asked Questions

Waveform generator evolution

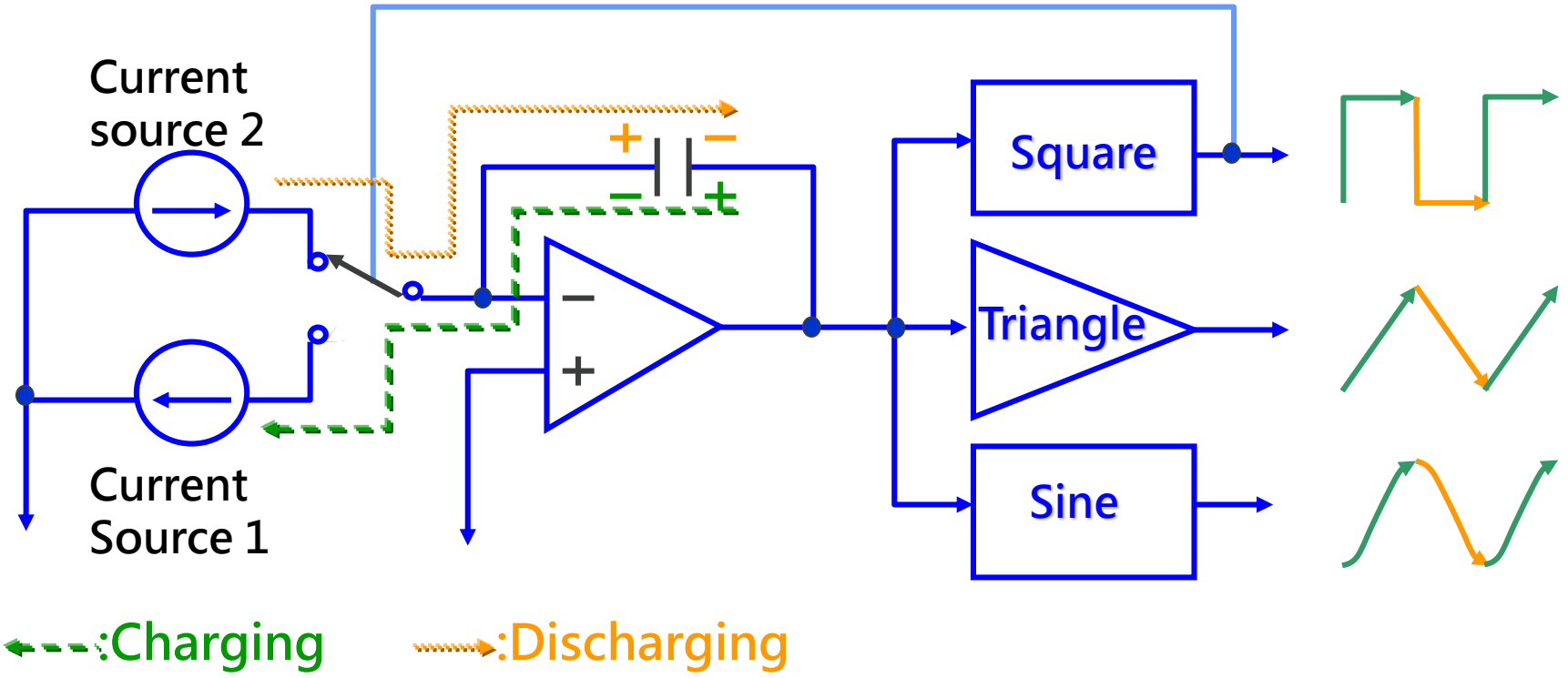
Analog function generator

DDS function generator

Arbitrary waveform generator

How does Conventional FG work?

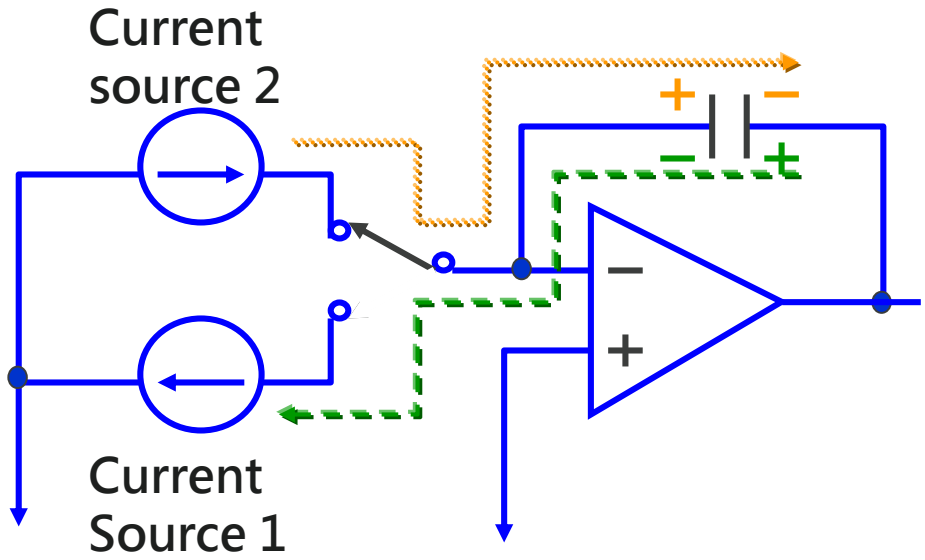
Consists of Current Sources, Current Integrator and waveform shaping circuits.



Problems of conventional FG

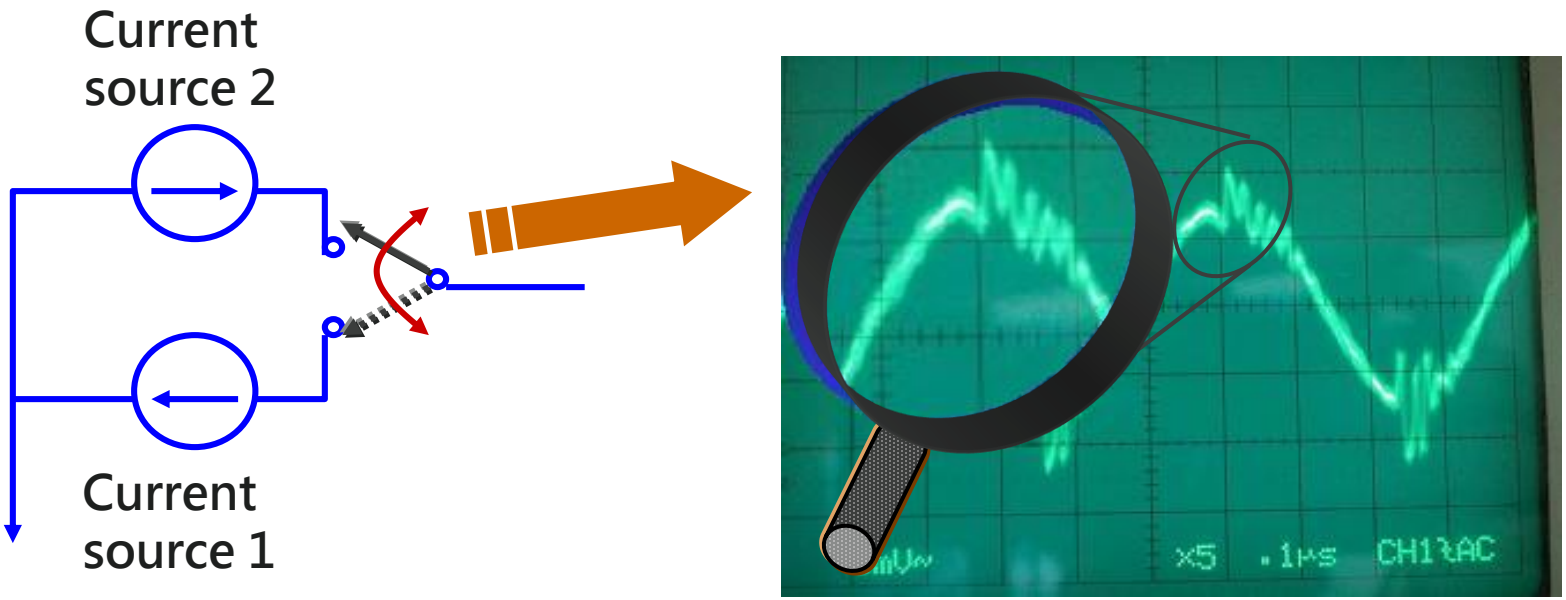
#1. Frequency is unstable. The frequency control components are Current Sources and Capacitor.

The parameters of current source and components vary with temperature, the frequency drifts accordingly.



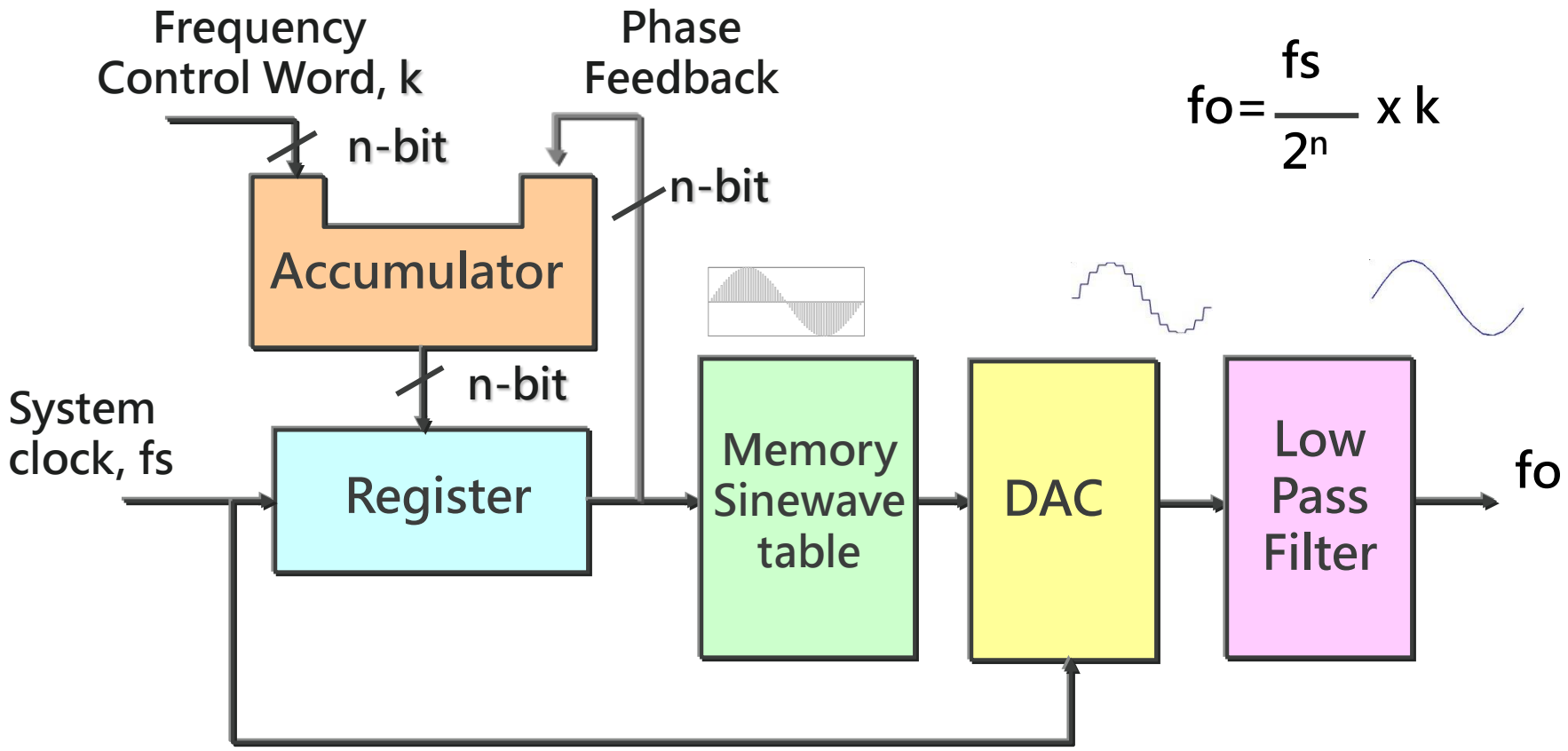
Problems of conventional FG

#2. The ringing noise on the top is caused by the switching between two current sources.



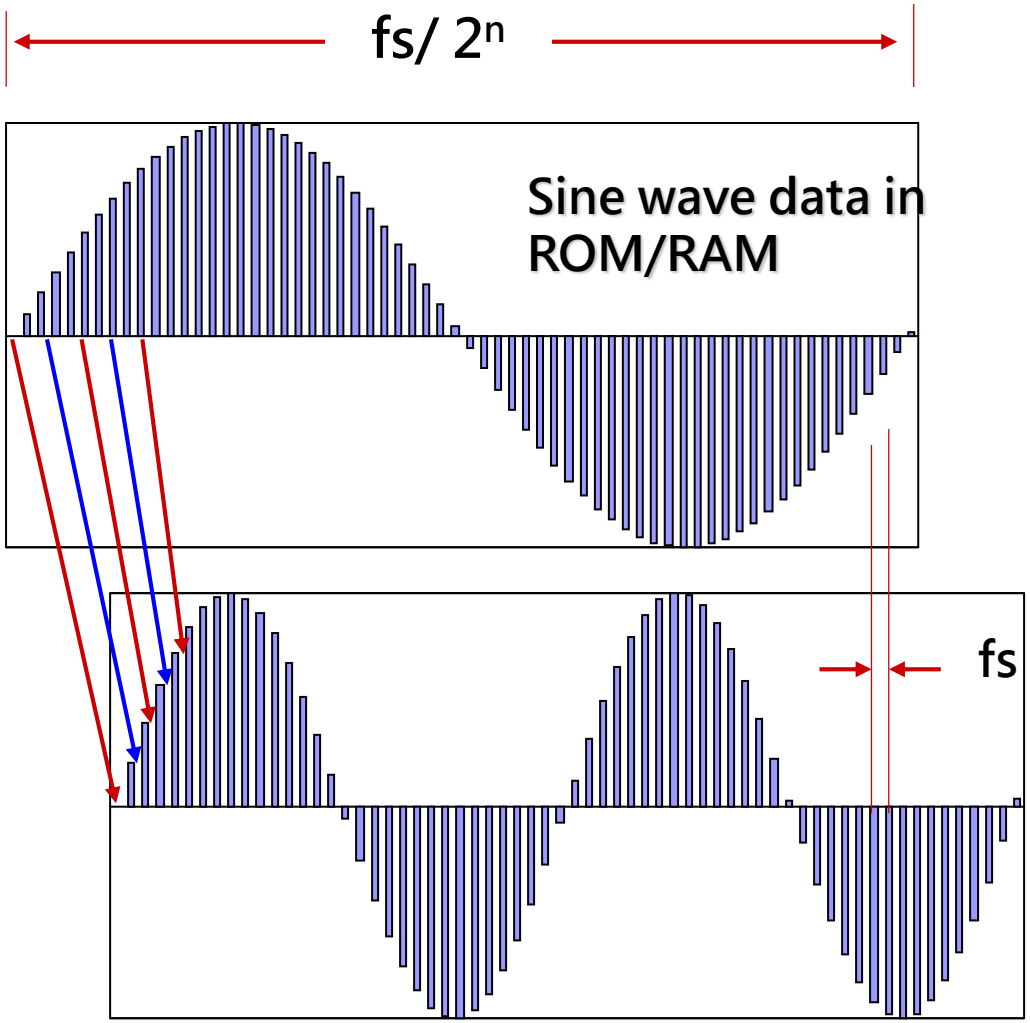
Direct Digital Synthesis (DDS)

Block Diagram of DDS generator



DDS FG Basics

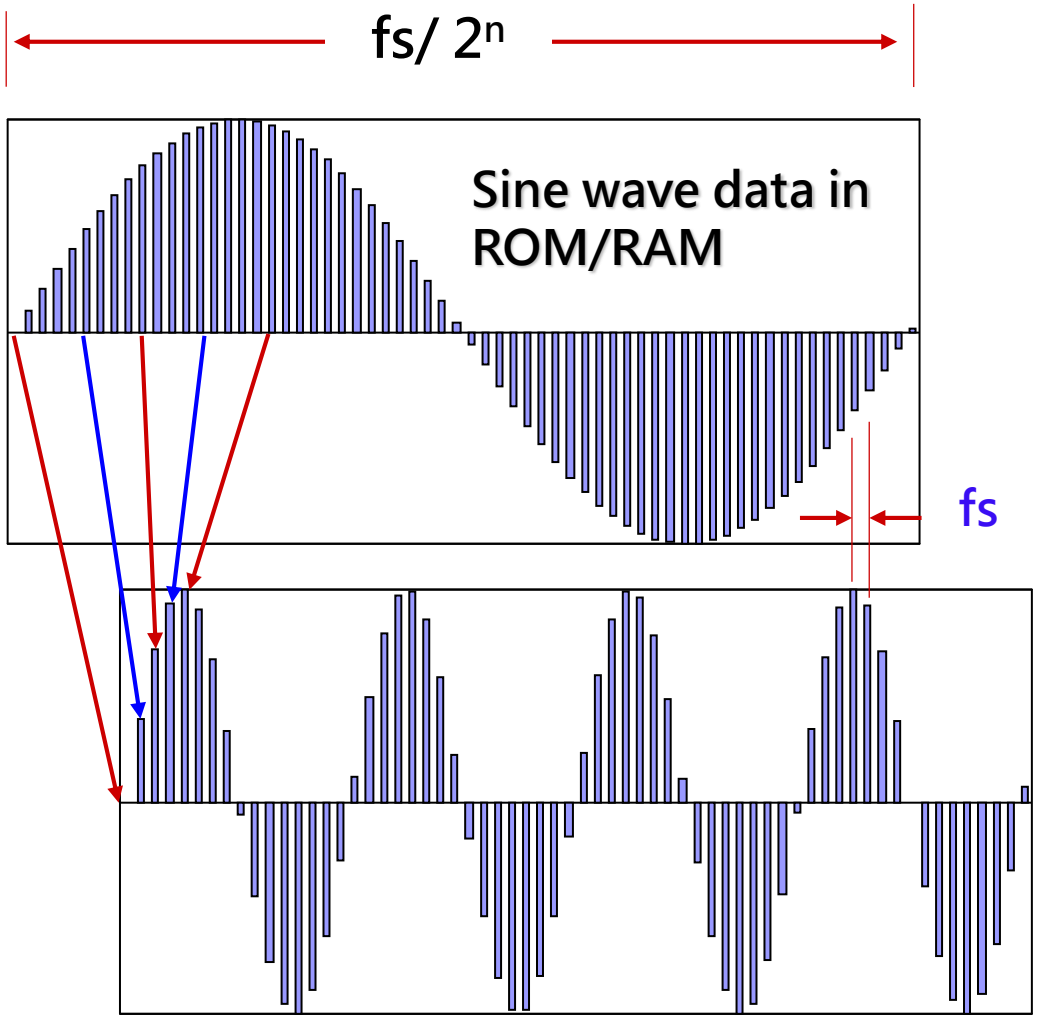
Ex. k=2



$$fo = \frac{fs}{2^n} \times k$$

DDS FG Basics

Ex. k=4

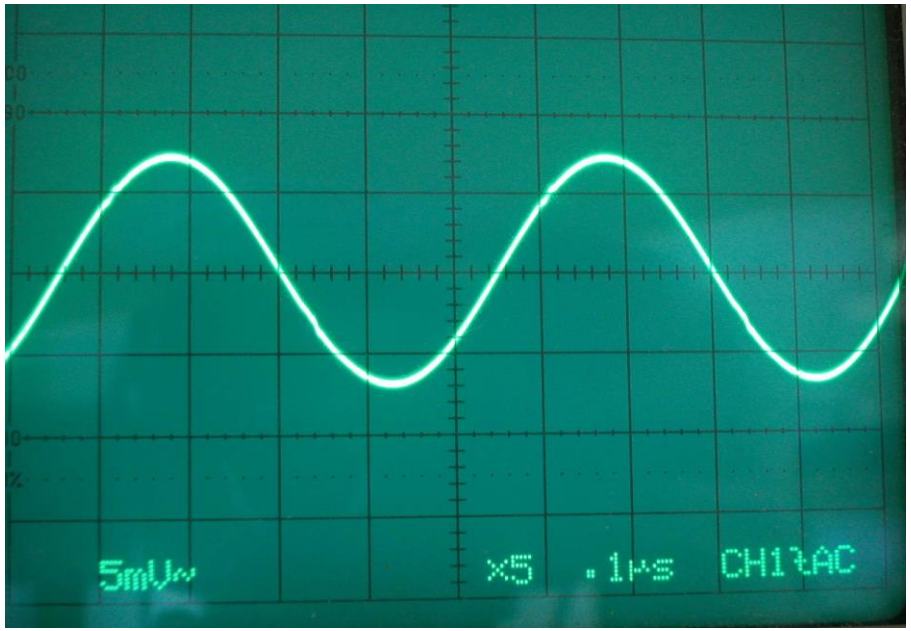


$$fo = \frac{fs}{2^n} \times k$$

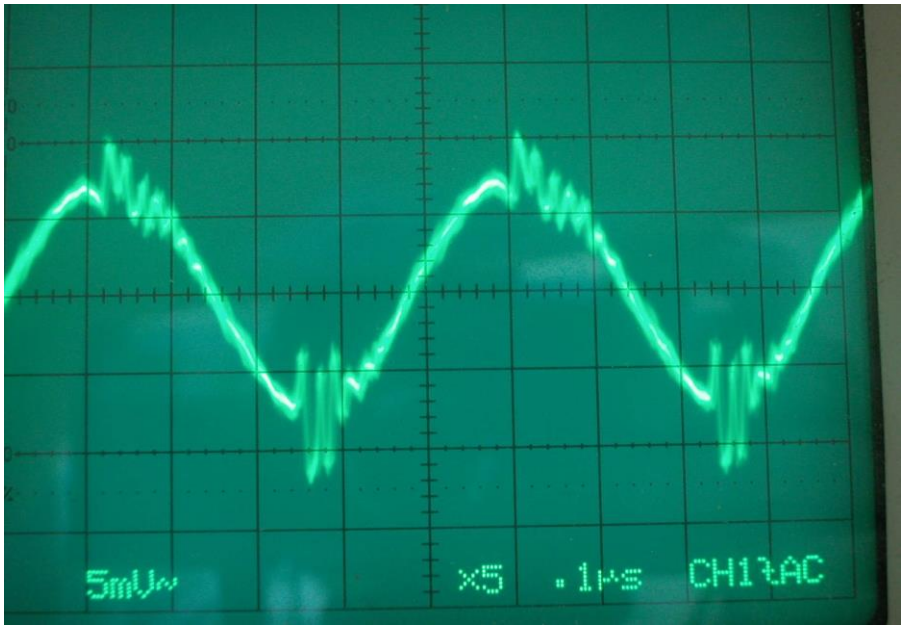
DDS vs. Conventional - Distortion

Small Signal - Sine wave

DDS FG



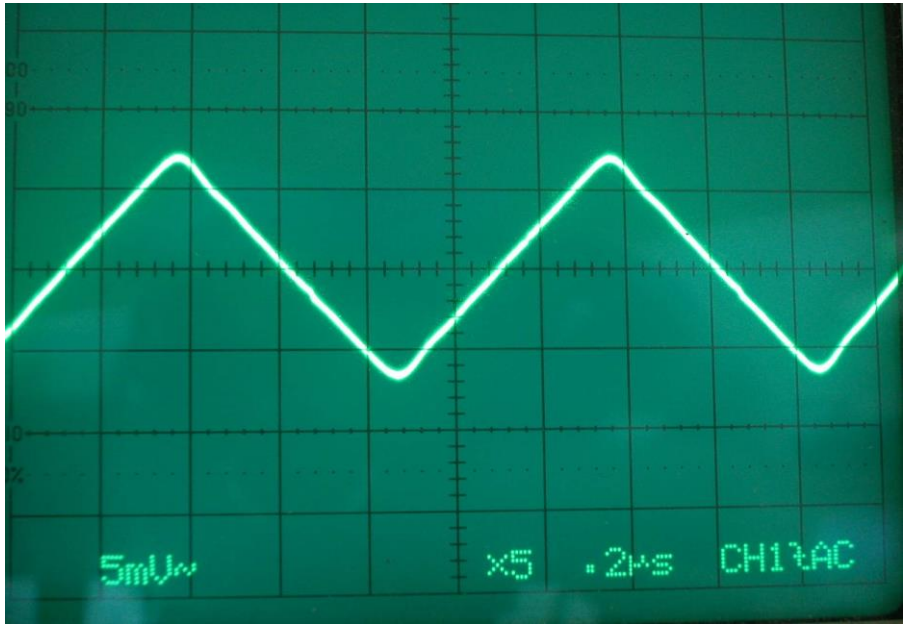
Conventional FG



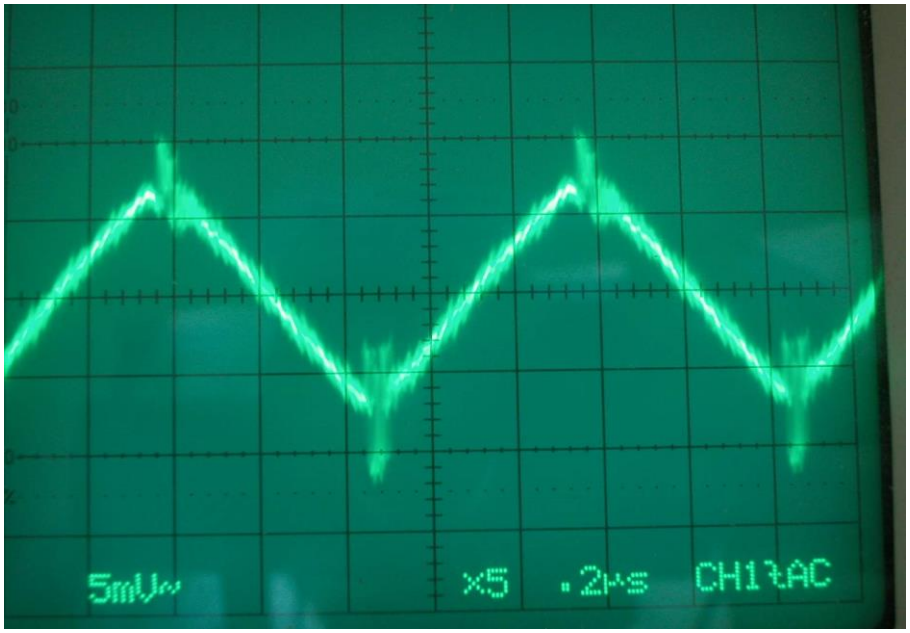
DDS vs. Conventional - Distortion

Small Signal - Triangular wave

DDS FG



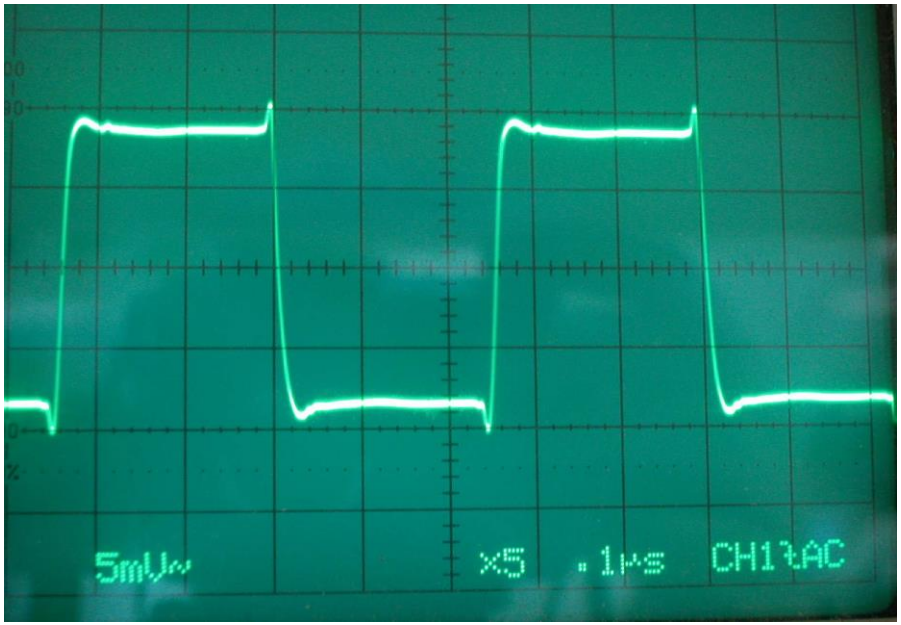
Conventional FG



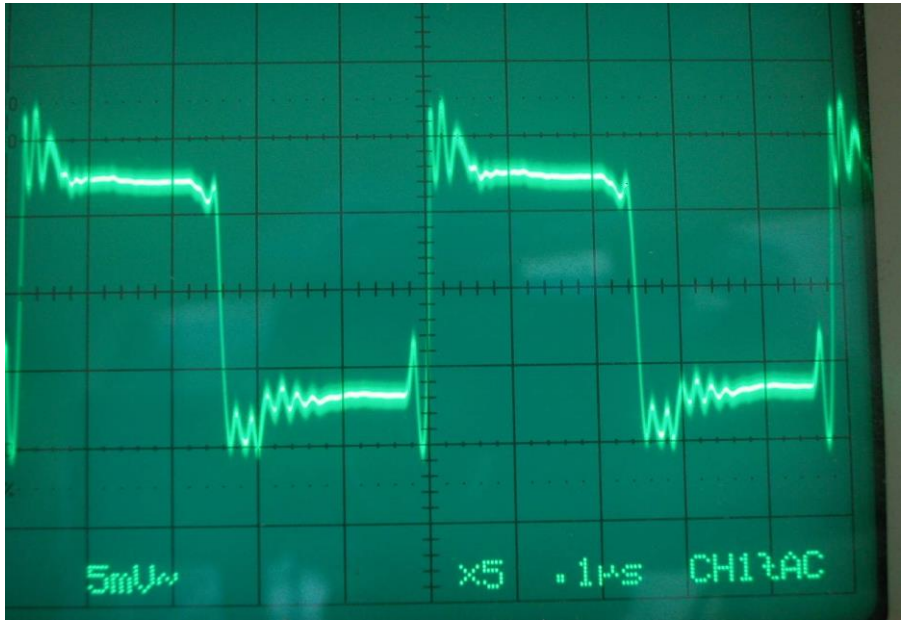
DDS vs. Conventional - Distortion

Small Signal - Square wave

DDS FG



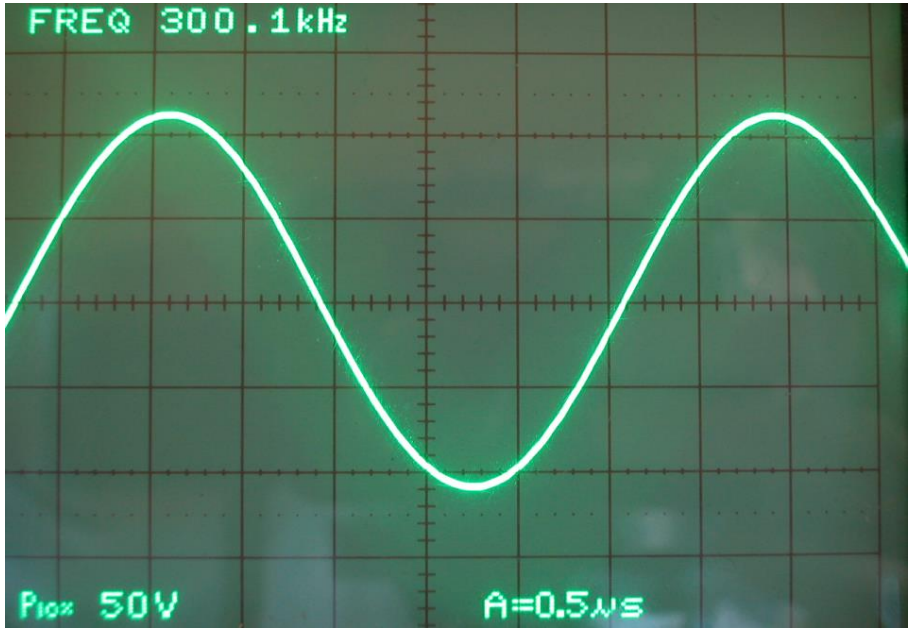
Conventional FG



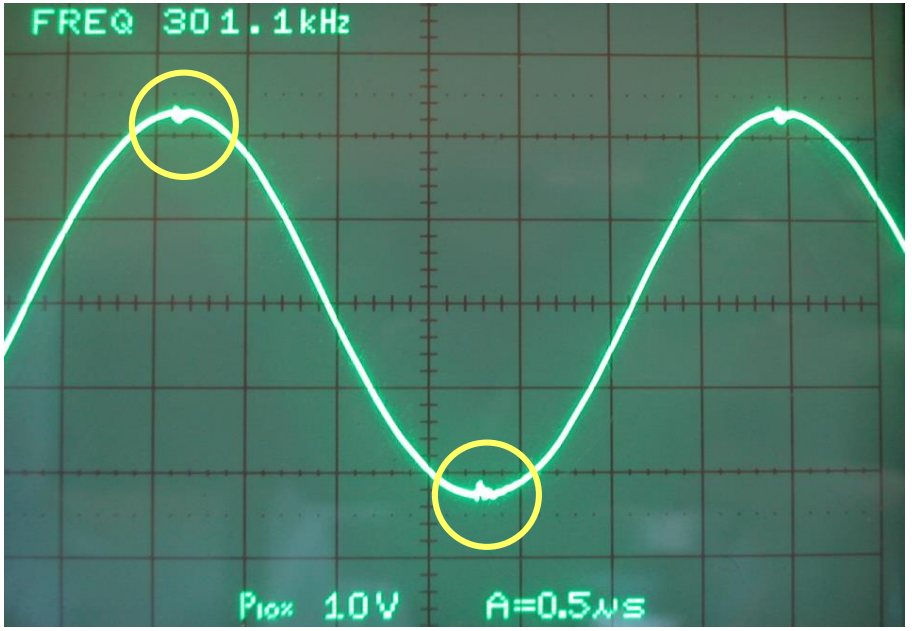
DDS vs. Conventional - Distortion

Large Signal

DDS FG



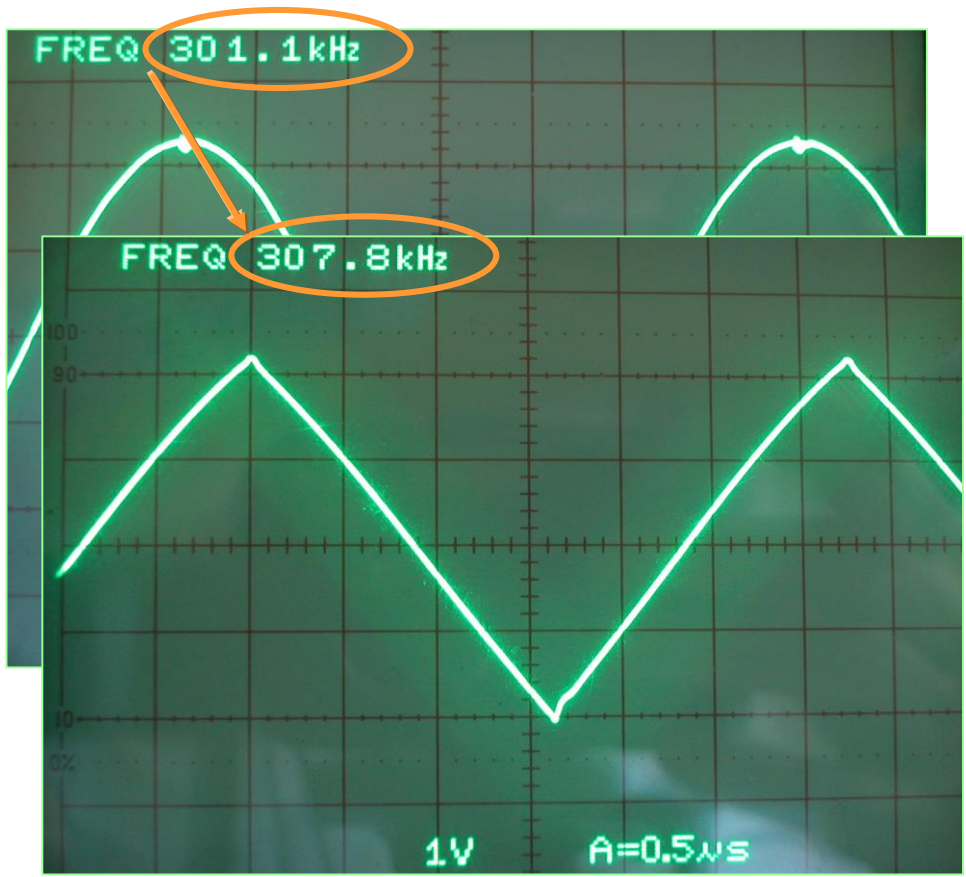
Conventional FG



DDS vs. Conventional – Frequency Stability

DDS FG

Conventional FG

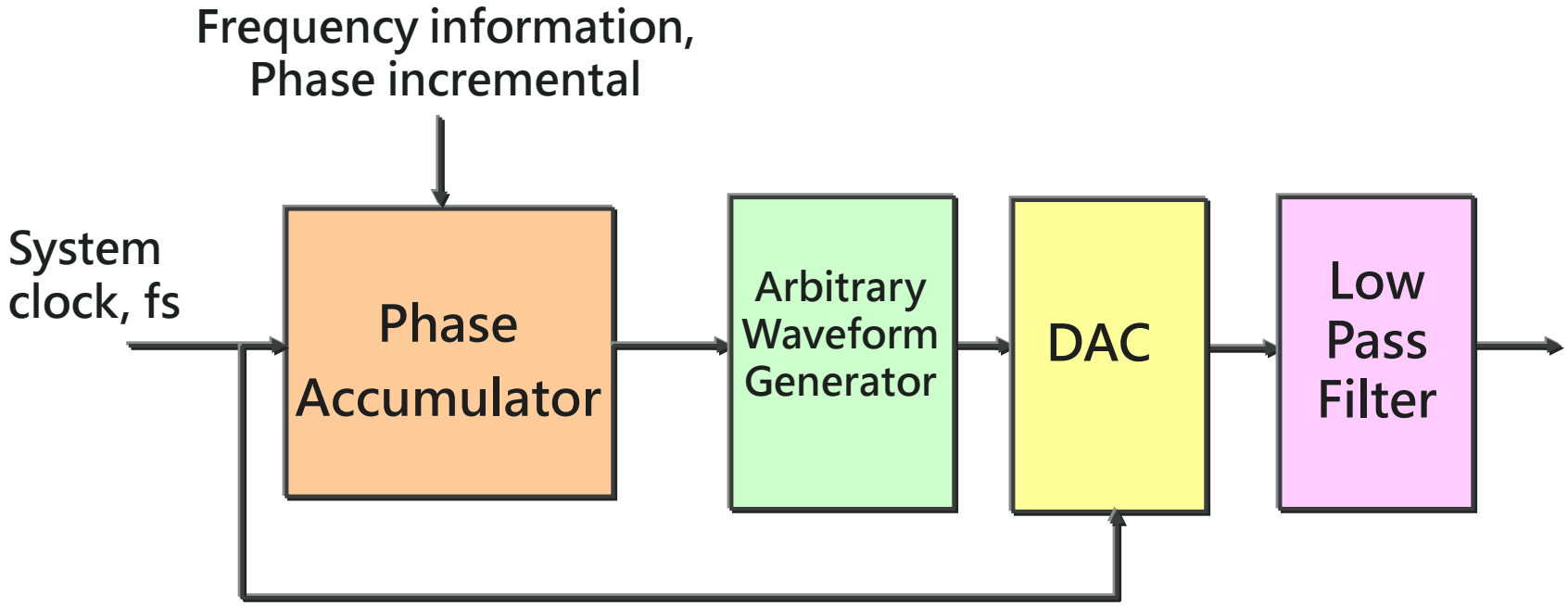


Features of DDS Function Generator

- High Frequency Stability
- Lower Distortion achieved by good filtering
- Extremely high frequency resolution
- Programmable frequency control
- Relatively fast frequency switching speed (compare to PLL)
- Analog/digital modulation, PWM, trigger, sweep, burst… functions all can be done by DDS.

Arbitrary waveform generator

- Similar idea like DDS except the arbitrary waveform data, in stead of sine waveform, is loaded in the memory.



Block Diagram of DDS based arbitrary waveform generator

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Key Factors of ARB selection

- Sample Rate
  Higher sample rate can generate higher output frequency signal.
- Vertical Resolution
  More DAC bits create low distortion signal.
- Memory Length
  Especially important for high sample rate and long period signal.

Sample Rate vs. Repetition Rate

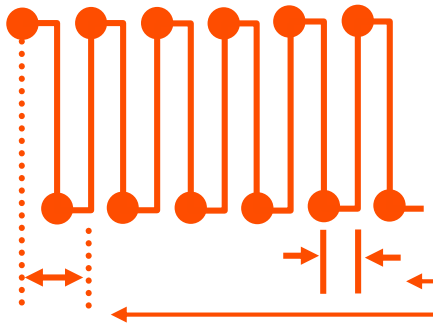
Technically two points form a repetitive waveform.

Arbitrary Waveforms	
ARB Function	Built in
Sample Rate	200 MSa/s
Repetition Rate	100MHz
Waveform Length	1M points
Amplitude Resolution	16 bits
Non-Volatile Memory	Ten 1M waveforms(1)
User define Output Section	Any section from 2 to 1M points
User define Mark Output	Any section from 2 to 1M points

Arbitrary	
Waveform length	1 to 64K points
Amplitude resolution	12 bits (including sign)
Repetition rate	1 µHz to 25 MHz
Sample rate	200 MSa/s
Filter bandwidth	50 MHz
Non-vol. memory	Four (4) 64K waveforms

Sample Rate vs. Repetition Rate

True point-by-point will get Repetition Rate the half of Sample Rate.



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ARB Function	Built in
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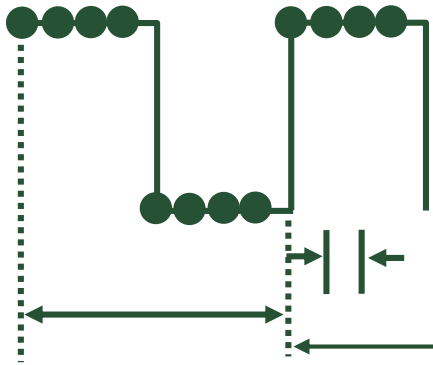


Arbitrary

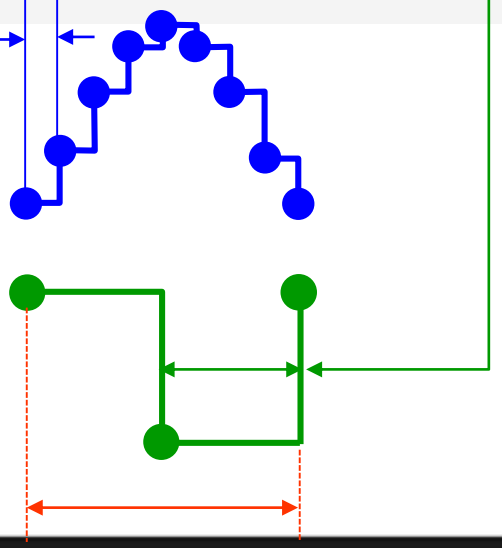
Waveform length	1 to 64K points
Amplitude resolution	12 bits (including sign)
Repetition rate	1 μHz to 25 MHz
Sample rate	200 MSa/s

Sample Rate in different definition

Example 2:

Product Model	SDG2042X	SDG2082X	SDG2122X
Bandwidth	40MHz	80 MHz	120 MHz
Sampling rate	1.2 GSa/s (4X Interpolation)		

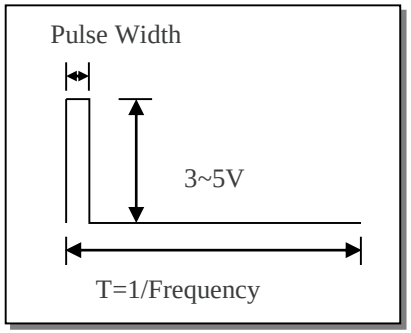
Arbitrary Wave characteristics					
Parameter	Min.	Typ.	Max.	Unit	Condition
Frequency	1μ		20M	Hz	
Waveform length	8		8M	pts	
Sampling rate	1μ		75M	Sa/s	TrueArb mode
	300			MSa/s	DDS mode

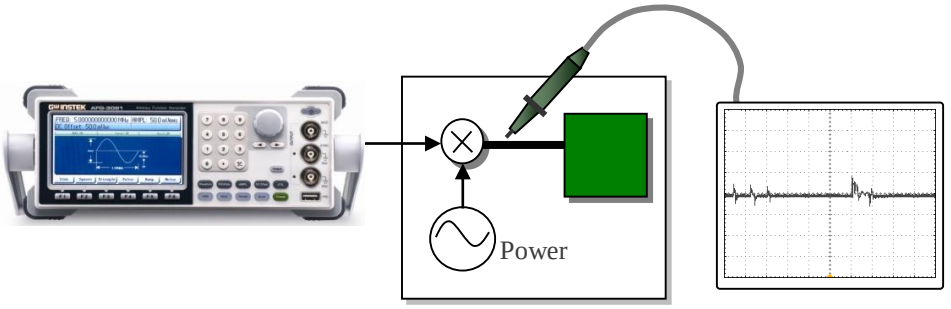


Repetition Rate=37.5MHz

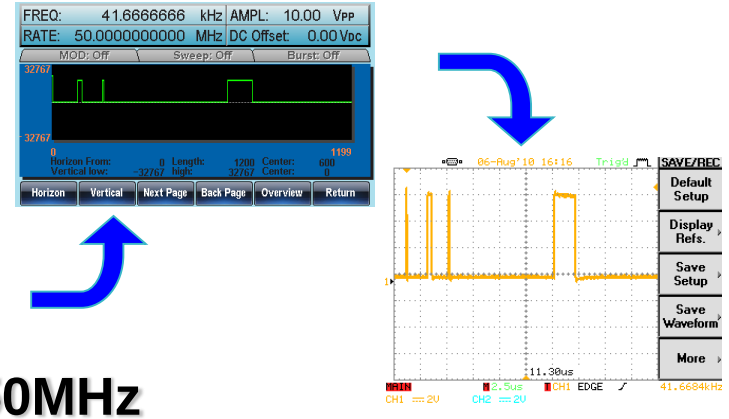
True Point-by-Point ARB Application

Pulse noise source of Power supply. Pulse width is required from 1%~20%, frequency is up to 1MHz.





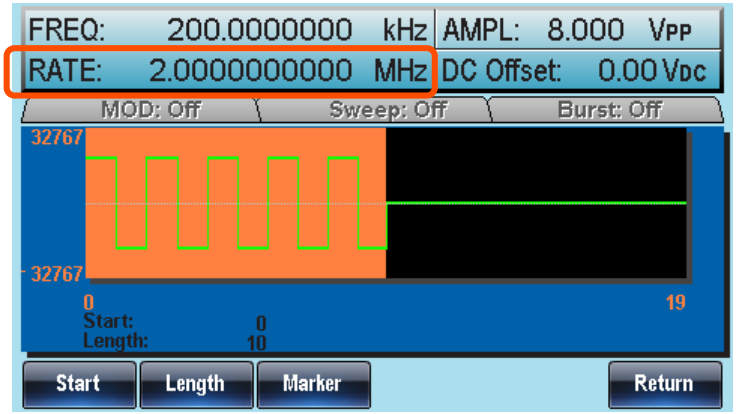
Case	Conditions	Pulse on	Pulse off	Total
1	1MHz, 1%	1 (10ns)	99 (990ns)	100 (1us)
2	1MHz, 20%	20(400ns)	80 (1600ns)	100 (1us)
3	100kHz, 1%	10 (100ns)	990(9900ns)	1000(10us)
4	100kHz, 20%	200(2,000ns)	800(8,000ns)	1000(10us)

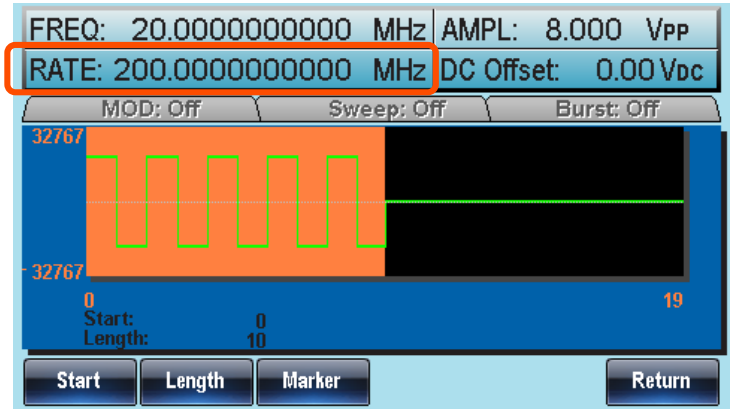


Sample rate: 100MHz, repetition rate=50MHz

Sample Rate

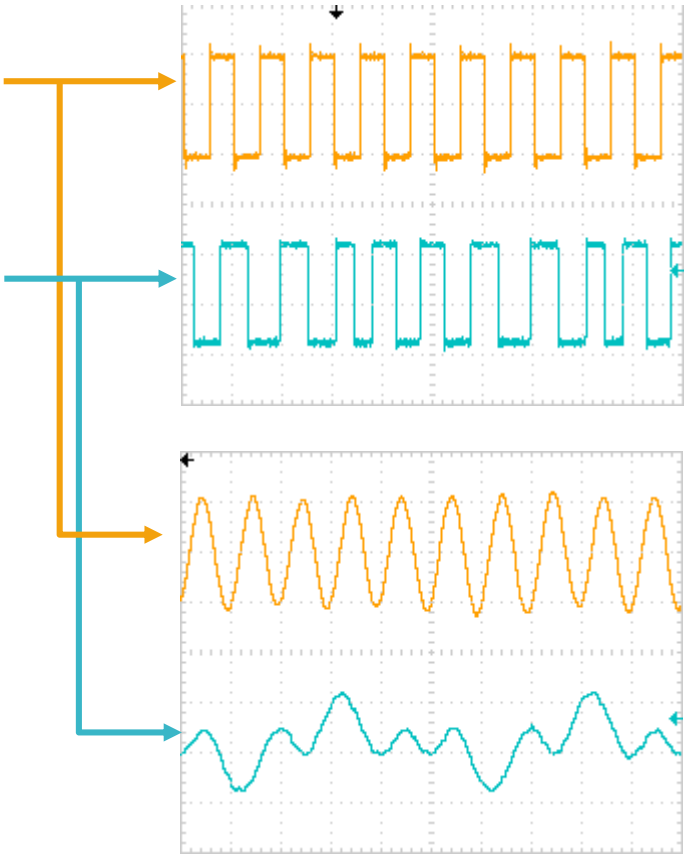
Facts of differences.





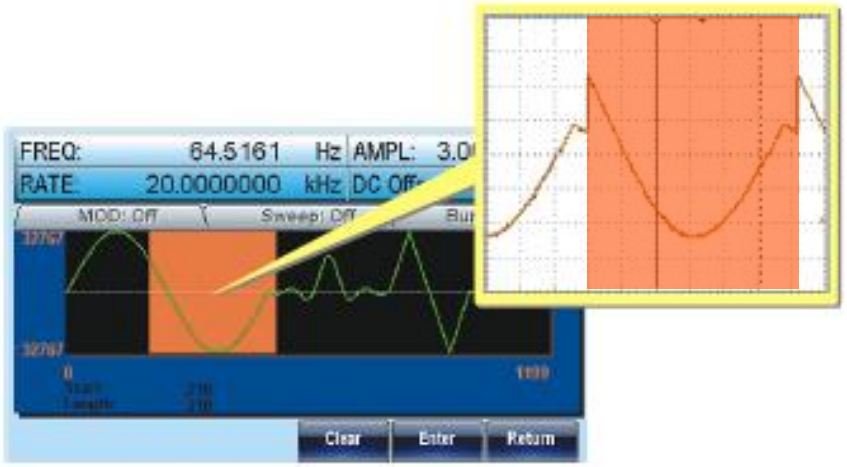
Higher ARB rate

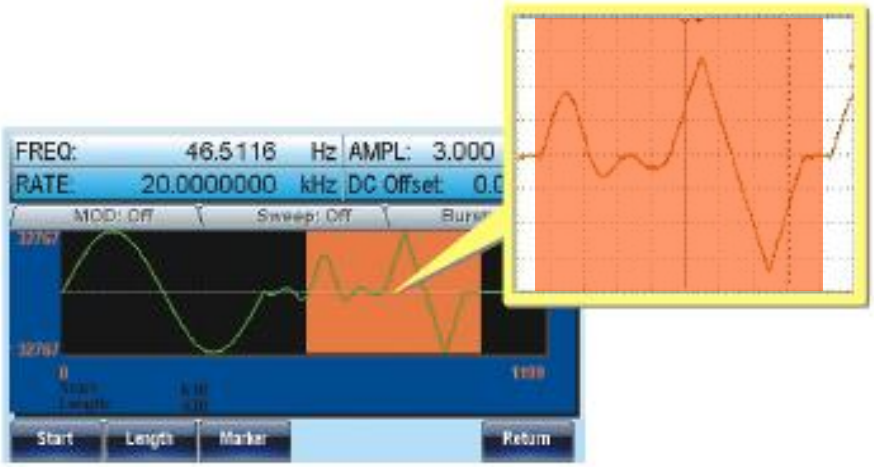
Lower ARB rate



Maximum Waveform Length

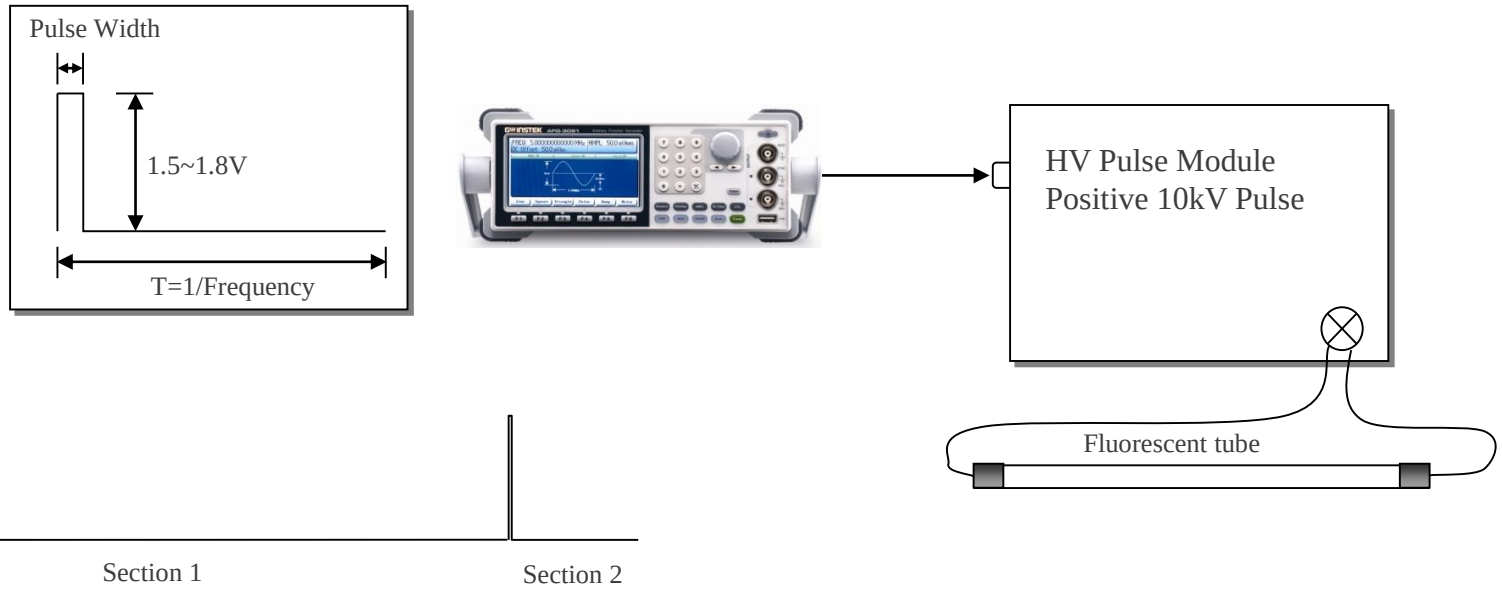
- More memory length (memory) allows more waveform to be stored and applied.
- It is convenient if any of the memory section can be selected to output.





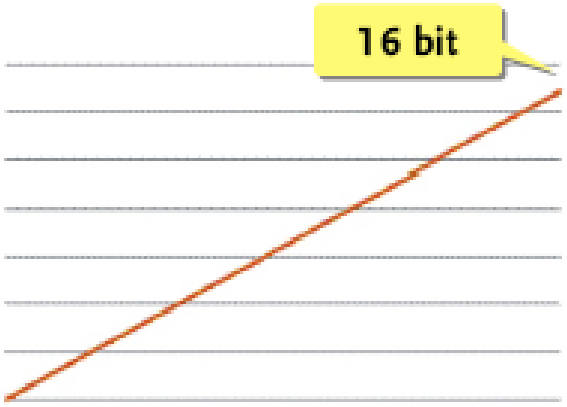
1M Points Waveform Length Application

Stimulus signal of display backlight light. The pulse width is fixed at 1us, the test frequency varies 10Hz to 100Hz. Total 110k points are required for this test.

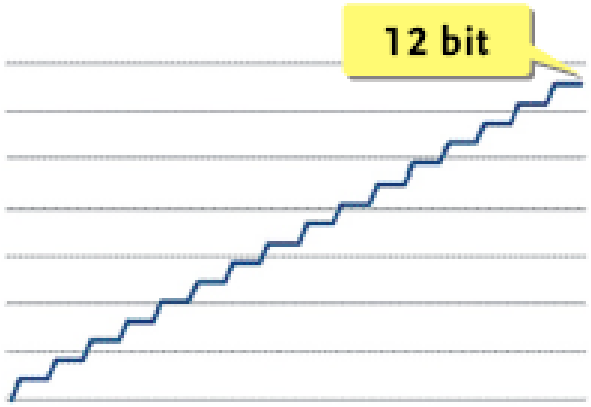


Vertical Resolution

16-bit is capable to create lower distortion waveform than less bits.



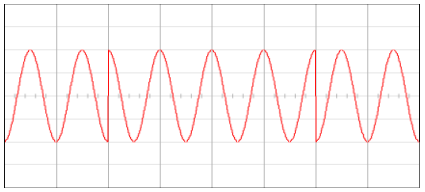
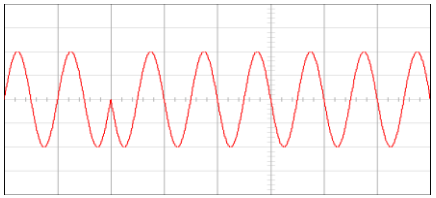
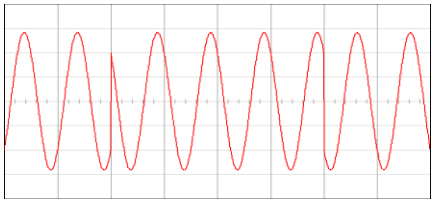
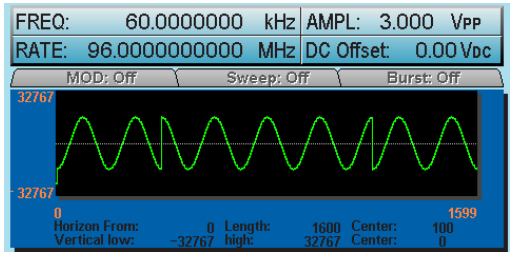
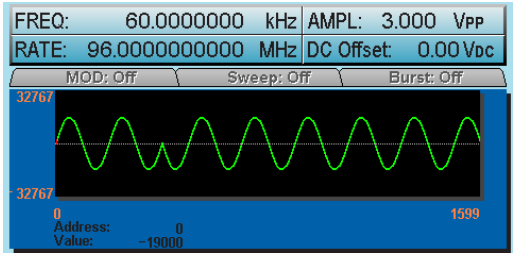
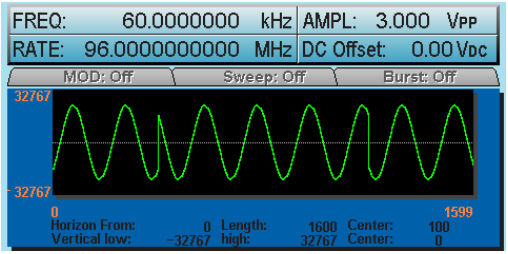
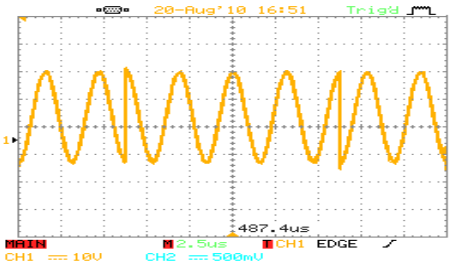
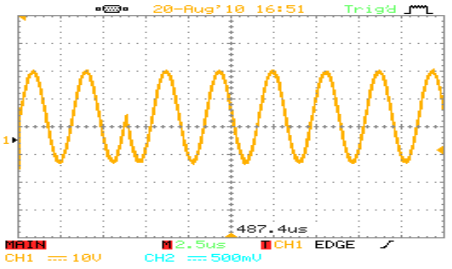
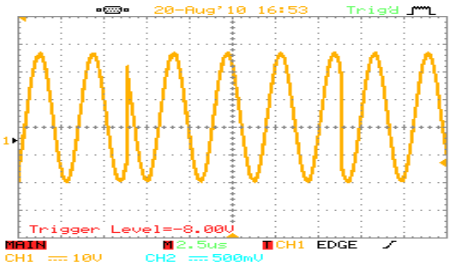
AFG-3081



33250A

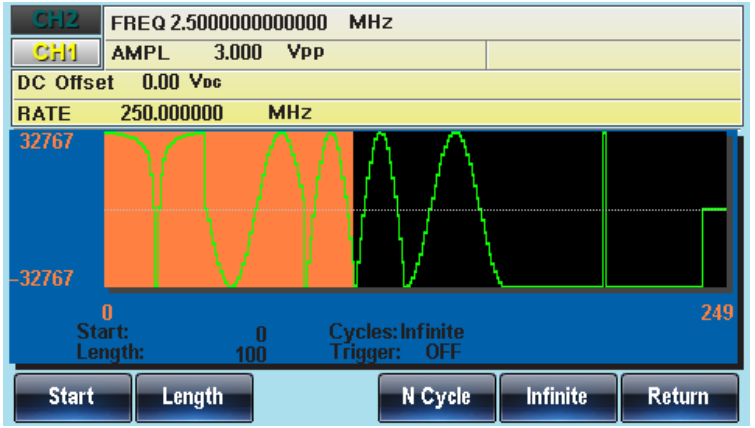
Example of creating QPSK signal

Calculate the QPSK by theory, load into AFG-3000 and measure the output by a DSO.

	I Channel		Q Channel		I+Q Channel
Theory		+		=	
Loaded in AFG					
Results on DSO					

Flexible Arbitrary Waveform Editing

1.Front Panel Operation



2.CSV

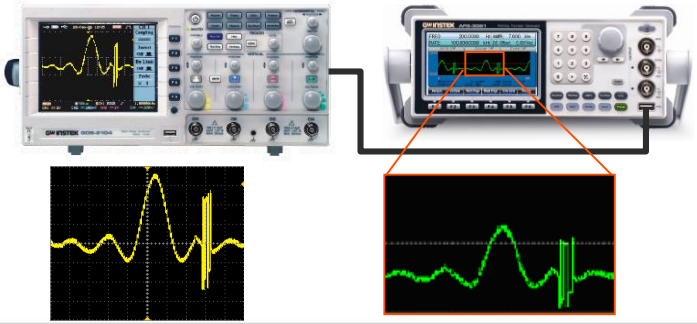
gensin.csv

	A	B	C
1	Start:	0	
2	Length:	629	
3	Sample Rate:	200000000	
4	0		
5	328		
6	655		
7	983		
8	1310		
9	1638		
10	1965		

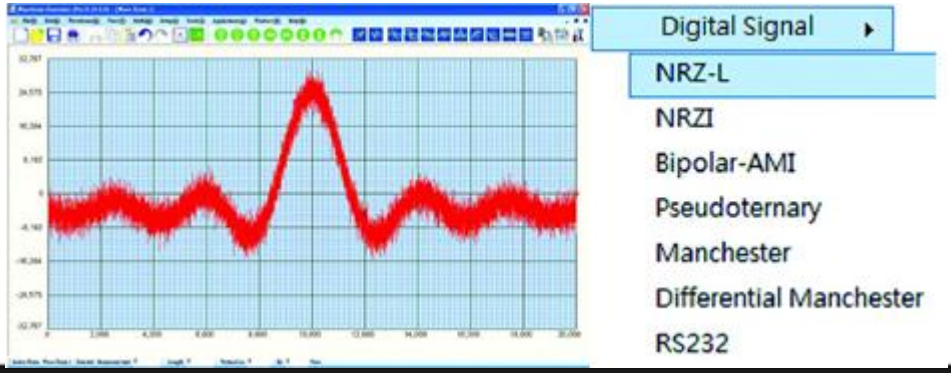
```
% sine wave generation program
result=round(2^15*sin(0:0.01:2*pi))';
save gensin.csv result /ascii;
% end
```

```
Start:,0
Length:,629
Sample Rate:,200000000
0
 328
 655
 983
 1310
 1638
```

3. Direct Waveform Reconstruction



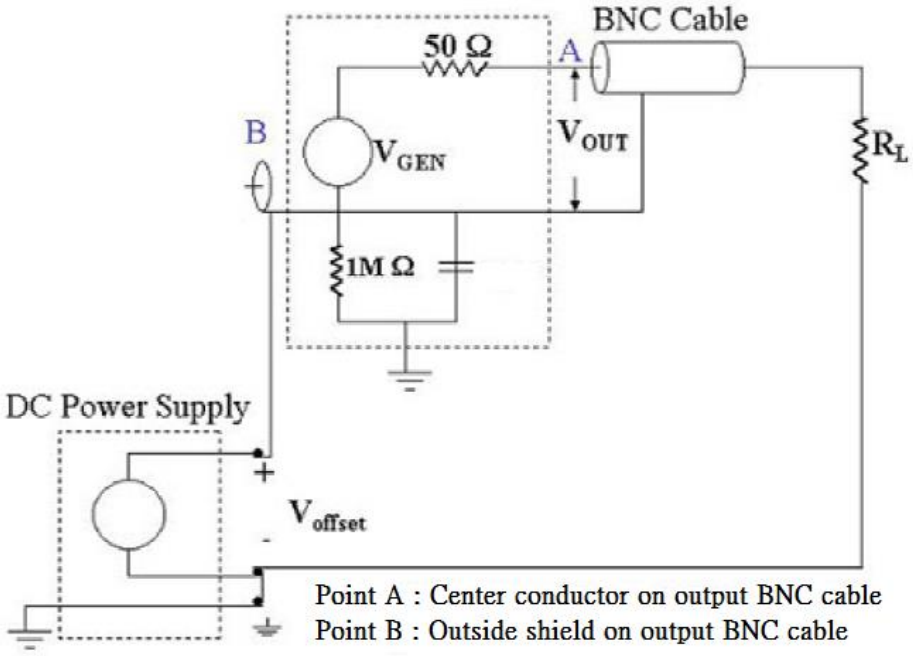
4. Arbitrary Waveform Editing PC Software



Isolated Channel: Higher DC offset

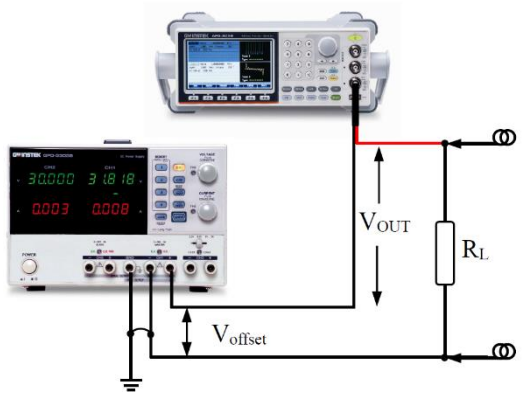
- **Isolated channel: signal ground is isolated to chassis. The additional DC offset/ bias can be cascaded in between.**

2 CH model

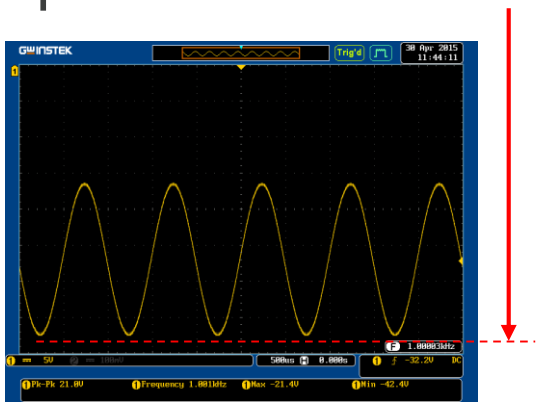


Example: ±42 Vpk (DC + AC peak) output

- Connection illustration



- Output waveform: Vmin=-42V

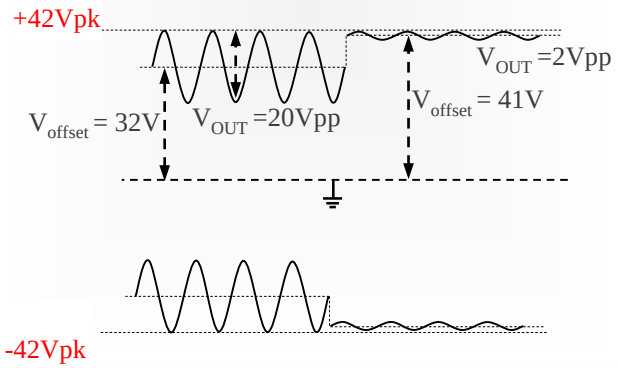


- Example 1

  V_{Offset} = +32V, max V_{OUT} =20Vpp

- Example 2

  V_{Offset} = +41V, max V_{OUT} =2Vpp



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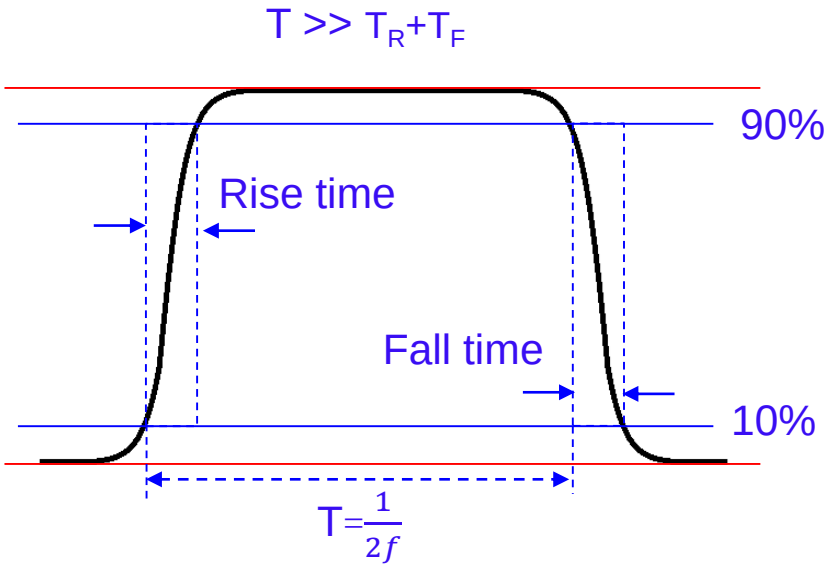
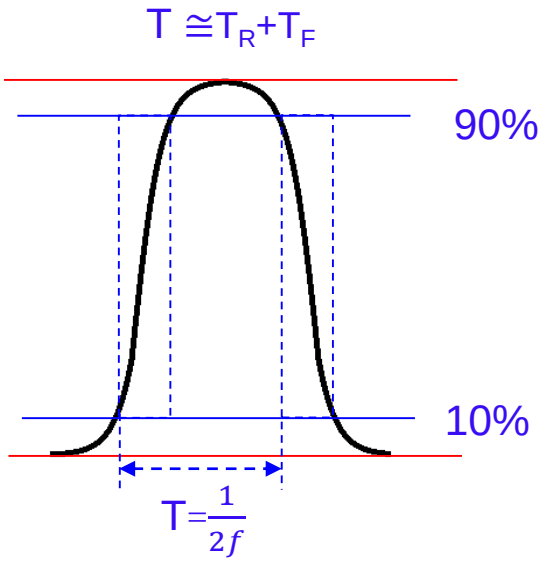
FAQs

- **Why the square waveform looks like sine waveform?**
- **Why the output level is set to 5Vpp but measured 10Vpp on oscilloscope?**

Why the square wave looks like sine?

- **Rise time/ fall time: Due to the physical parameters of electronic parts, the real square edge waveform can't be as sharp as ideal case.**
- **When the frequency is higher, the rise/fall time effect becomes more significant.**



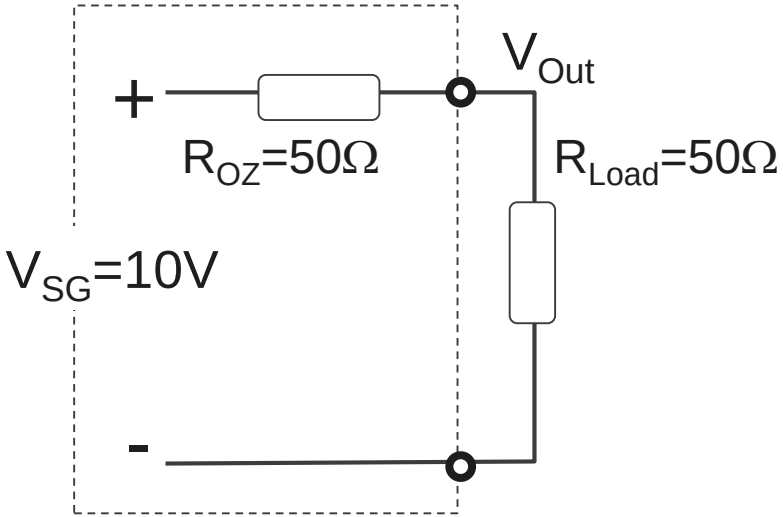


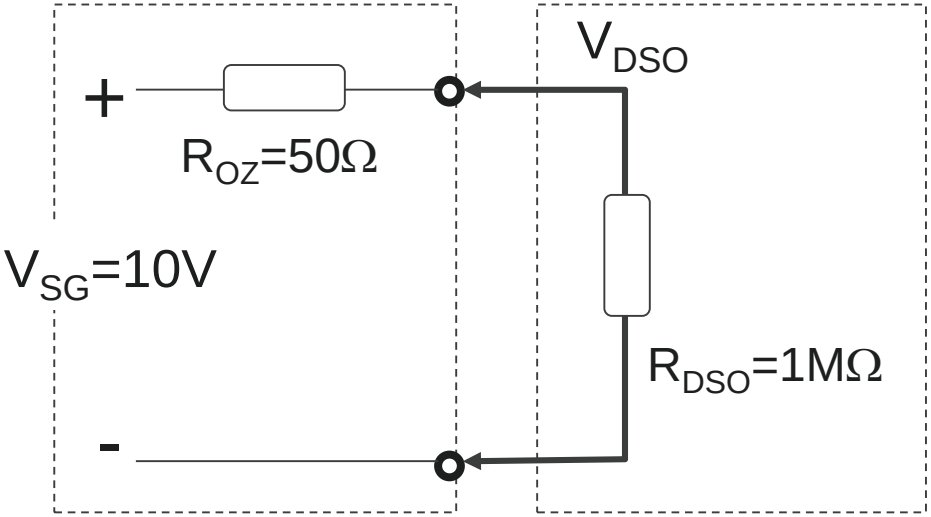
Why 5V output becomes 10V on scope?

- **The signal source output impedance is 50Ω, the output amplitude 5V is set under the assumption of 50Ω load.**
- **The input impedance of scope is 1MΩ, therefore the amplitude tested becomes 10V.**

$$V_{OUT} = V_{SG} \times \frac{R_{LOAD}}{R_{OZ}+RLOA_D} = \frac{V_{SG}}{2}$$

$$V_{DSO} = V_{SG} \times \frac{R_{DSO}}{R_{OZ}+RDS_O} \cong V_{SG}$$





GW Instek Signal Source series

Model	Key Features
AFG-100 series	USB AFG, 25MHz, 1/2 channel
AFG-2000 series	5~25MHz, 1 channel
AFG-2225	25MHz, 2 channel
MFG-2000 series	10~320MHz, multiple channel, isolated
AFG-3000 series	20~30MHz, 1/2 channel, isolated
AFG-3081/3051	80/50 MHz, 1 channel

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