AT-AWG-GS

2.5 GS/s 14 Bit - Arbitrary Waveform Generator

User Manual

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use only the power cord specified for this product and certified for the country of use.

Ground the Product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Power Disconnect. The power cord provides Mains disconnect.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Do Not Operate With Suspected Failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Provide Proper Ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Safety Requirements

This section contains information and warnings that must be observed to keep the instrument operating in a correct and safe condition. You are required to follow generally accepted safety procedures in addition to the safety precautions specified in this section.

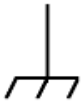
Safety Symbols

Where the following symbols appear on the instrument's front or rear panels, or in this manual, they alert you to important safety considerations.

This symbol is used where caution is required. Refer to the accompanying information or documents in order to protect against personal injury or damage to the instrument.

This symbol warns of a potential risk of shock hazard.

This symbol is used to denote the measurement ground connection.



This symbol is used to denote a frame or chassis connection.

This symbol is used to denote a safety ground connection.

On (Supply). This is the DC power connect/disconnect switch at the back of the instrument.

○	Off (Supply). This is the DC power connect/disconnect switch at the back of the instrument.
⏻	This symbol is used to denote Power. It is located on the front panel and denotes Power On/Off status of the instrument.
⎓	This symbol is used to denote Direct Current.

CAUTION
The **CAUTION** sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause damage to equipment. If a **CAUTION** is indicated, do not proceed until its conditions are fully understood and met.

WARNING
The **WARNING** sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause bodily injury or death. If a **WARNING** is indicated, do not proceed until its conditions are fully understood and met.

CAT I
Installation (Overvoltage) Category rating per EN 61010-1 safety standard and is applicable for the instrument front panel measuring terminals. CAT I rated terminals must only be connected to source circuits in which measures are taken to limit transient voltages to an appropriately low level.

Operating Environment

The instrument is intended for indoor use and should be operated in a clean, dry environment. Before using this product, ensure that its operating environment is maintained within these parameters:

Temperature: 0 °C to 50 °C (**Note**: Power Supply Adapter for AT-AWG-GS is rated for 40 °C max).
Humidity: Maximum relative humidity 80% (non-condensing) for temperatures up to 40 °C decreasing linearly to 50 % relative humidity at 50 °C.
Altitude: Up to 10,000 ft (3,048 m) at or below 30 °C.

AC Power Source

For External AC Adapter: 100 to 240 VAC (+/-10%) at 45-66 Hz; Automatic AC voltage selection; Installation Category: 300V CAT II

No manual voltage selection is required because the external AC Adapter automatically adapts to line voltage.

Power Consumption

</= 60 watts (12 V at 5 amps)

WARNING - Electrical Shock Hazard

Only use the power cord provided with your instrument.

Calibration

The recommended calibration interval is one year. Calibration should be performed by qualified personnel only.

Cleaning

Clean only the exterior of the instrument, using a damp, soft cloth. Do not use chemicals or abrasive elements. Under no circumstances allow moisture to penetrate the instrument.

Abnormal Conditions

Operate the instrument only as intended by the manufacturer.

If you suspect the instrument's protection has been impaired, disconnect the power cord and secure the instrument against any unintended operation.

The instrument's protection is likely to be impaired if, for example, the instrument shows visible damage or has been subjected to severe transport stresses.

Proper use of the instrument depends on careful reading of all instructions and labels.

WARNING

Any use of the instrument in a manner not specified by the manufacturer may impair the instrument's safety protection.

Environmental Considerations

This section provides information about the environmental impact of the product.

Product End-of-life Handling

Observe the following guidelines when recycling an instrument or component.

Equipment Recycling. Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. In order to avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

The symbol shown to the left indicates that this product complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE).

Preface

This manual describes the installation and operation of AT-AWG-GS Series instruments. Basic operations and concepts are presented in this manual.
The following instruments are supported by this manual:

- AT-AWG-GS 2500 USB
- AT-AWG-GS 2500 USB Option D16/32
- AT-AWG-GS 2500 USB Option D8/16
- AT-AWG-GS 2500 USB Option 1M/16M/32M/64M

AT-AWG-GS is a series of high speed and performance Arbitrary Waveform Generators (AWG) consisting of 2 channel models, up to 64 Mpts/ch memory, 14 bit resolution and a maximum real sampling rate of 2.5 GS/s. Some models provide the ability to generate 32 channel digital patterns, 32 Mpts/ch memory and all models can be operated in True Arbitrary Mode or Direct Digital Synthesis (DDS) mode.
The instrument available memory depends on the installed memory option.

Minimum and Suggested System Requirements

Minimum System Requirements

- Operative system Microsoft™ Windows® XP SP2,Windows® 7 32 and 64 Bit Versions, Windows®8 32 and 64 Bit Versions.
- Intel i3 processor.
- 4 GBytes RAM.
- 100 GBytes hard disk available space.
- Video resolution 1024 X 768.
- USB 2.0 or 1.1 connections.

Suggested System Requirements

- Operative system Microsoft™ Windows® XP SP2,Windows® 7 32 and 64 Bit Versions, Windows® 8 32 and 64 Bit Versions.
- Intel i3/i5/i7 processor.
- 8 GBytes RAM.
- 500 GBytes hard disk available space.
- Video resolution 1280 X 1024.
- USB 2.0 connection.

Package Contents

The standard AT-AWG-GS package includes the following:

- AT-AWG-GS Arbitrary Waveform Generator
- Standard USB 2.0 Cable
- Power Supply Adapter
- Power Cord
- Installation CD containing the **AT-AWG-GS Software** setup files and the **User Manual**.
- Performance/Calibration Certificate
- AT-AWG-GS Introduction and Compliance document

Hardware Inputs and Outputs

Front Panel

Numbered callouts on this image correspond with the following descriptions.

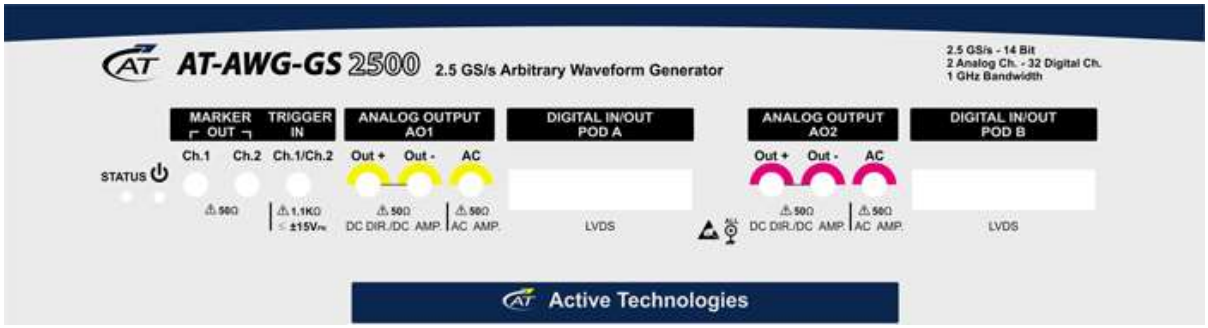


Figure 3-1.

Although digital pods appear on all models, they are only active on AT-AWG-GS with digital option.

1. **DIGITAL POD A / DIGITAL POD B**

   Pod A - Probe connectors for DO[0..15]

   Pod B - Probe connectors for DO[16..31]

   - **Two Infiniband 12x** connectors provide 16 bit LVDS digital outputs each for a total of **32 LVDS outputs**
   - The digital outputs can be software configured to operate in different ways: 32 channels with a max. update rate of 625MSps or with half channels (16) at 1.25Gsps.

2. **TRIGGER**

   Ch.1/Ch.2 Marker Out - SMA output connectors for MARKER OUT.

   Trigger In - SMA input connector for Trigger IN.

   - **Marker Out** output impedance is 50 Ohm and the Voh (voltage level in the high state) is programmable in the range 2V-5.5V.
   - **Trigger In** input has an impedance of 1.1kOhm and a programmable threshold level in the range -15V to 15V.

3. **ANALOG OUTPUTS**

AC/DC AO1 – 50 Ohm AC Coupled or DC Coupled Analog output 1 (SMA connector)
AC/DC AO2 - 50 Ohm AC Coupled or DC Coupled Analog output 2 (SMA connector)

- The DC coupled is a differential output (labeled OUT+ and OUT-, SMA connectors) with 50 Ohm output impedance each.
- The AC and DC configurations are mutually exclusive.
- The DC coupled output can be further configured to work in two different configurations: Direct DAC and DC Amplified. Direct DAC has a higher bandwidth (> 1Ghz calculated @ 500mVpp SE) but less dynamic range (800mVpp SE, 1.6Vpp Diff); DC Amplified has lower bandwidth (> 600Mhz calculated @ 1Vpp SE) but more dynamic range (2Vpp SE, 4Vpp Diff).
  The DC Amplified output path has an hardware filter (-3 dB@ 900 MHz) that can be inserted or not through the main application software.
  You can enable that filter to improve harmonic, non-harmonic distortion at higher frequencies rate and to reduce sampling clock spurs.
- When using the DC coupled outputs both the OUT+ and OUT- outputs should be terminate to 50Ohm. **Therefore in case where only one is to be used for single ended applications than the other one output should be closed with a 50Ohm termination plug.**

4. **STATUS LED**

Indicates instrument power status.

5. **POWER-ON LED**

Indicates the power status of the instrument. The status led can be OFF, ON, or Blinking denoting the following conditions:

OFF: The instrument is ON and connected to a PC, but drivers have not been installed.

ON: The instrument is ON, connected to a PC, and correctly configured.

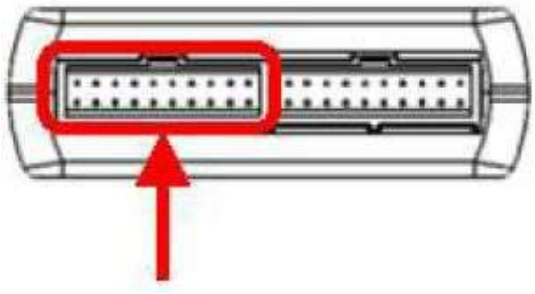
BLINKING: The status led is Blinking when the AT-AWG-GS is uploading firmware for channels.

Probes (Option)

Overview

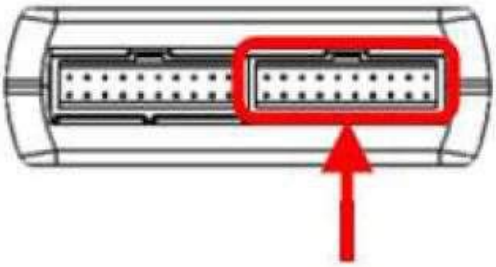
Probes have to be connected to the testing board with suitable connectors. The correspondence between pins and signals is reported in the following tables:

***Bank* 0**



DO[0]	DO[1]	DO[2]	DO[3]	DO[4]	DO[5]	DO[6]	DO[7]	T1	T2
GND	GND	GND	GND	GND	GND	GND	GND	GND	GND

***Bank* 1**

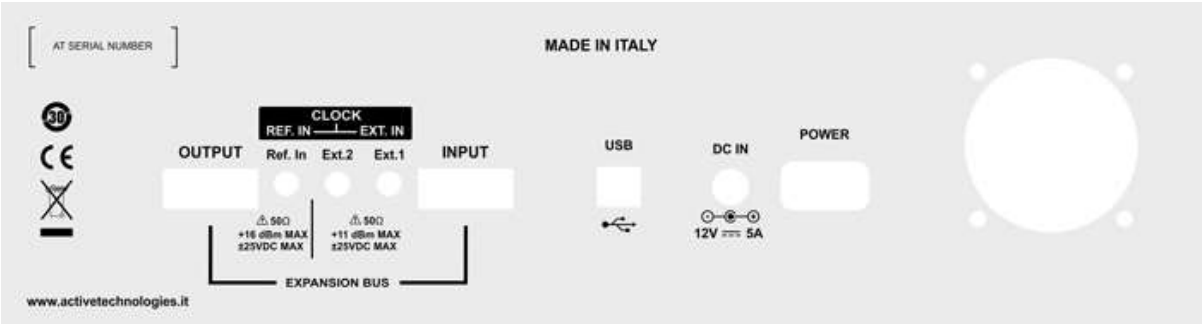


DO[8]	DO[9]	DO[10]	DO[11]	DO[12]	DO[13]	DO[14]	DO[15]	T3	T4
GND	GND	GND	GND	GND	GND	GND	GND	GND	GND

Signal Name	Type	Description	Voltage Level
GND	—	Digital Ground	0V
DO[15..0]	Output	Digital Pattern Output	1.2V ÷ 3.6V
T1,T2,T3,T4	Input	Digital Trigger Input	3.3V

Back Panel

Numbered callouts on this image correspond with the following descriptions.



1. **POWER** - The power switch.
2. **DC IN** - 12 V – 5A DC connector.
3. **USB** - USB 2.0 connector.
4. **EXPANSION BUS (SYNC IN / SYNC OUT)** - The Expansion bus connector is located on the rear panel of the AT-AWG GS. Using the appropriate expansion cable, multiple units may be connected.

PLEASE NOTE THE FOLLOWING:

AT-AWG-GS units sharing the Expansion bus must all be connected to the same controller (PC) via USB or hub. If more than one AT-AWG-GS are connected to the same PC, they must also be linked through the Expansion bus.

Making Expansion Bus Connections

In order to connect several AT-AWG-GS units you must first:

- Connect the AT-AWG-GS units using the Expansion bus.
- Connect all AT-AWG-GS units to a single PC by using an USB connector or by using a HUB.
- Ensure all AT-AWG-GS units are correctly recognized by the operating system.

Removing Expansion Bus Connections

Before disconnecting or switching off the instrument, it must be removed by left clicking the Safely Remove Hardware icon showing in the Windows System Tray on your PC.

When your operating system eventually shows a Safely Remove Hardware screen, select **Safely remove AT-AWG-GS**, and then click the **Stop** button.

5. **EXT. CLK IN CH1/CH2:** SMA input connectors for DAC sampling clock.

- Provide directly the sampling clock to the DAC of each analog output.
- The max. sampling clock frequency is 2.5GHz.
- The input impedance is 50 Ohm, AC coupled.

6. **REF. IN CLK**: SMA input connector for reference clock.

- Gives the possibility to provide externally the low frequency reference clock internally used to synthesize the DAC sampling clock.
- This is very useful in case that it is required to synchronize the signal generation with an external clock source.
- The frequency range is 10Mhz to 105Mhz and it can be multiplied by a fractional number to get the desired sampling frequency (<= 2.5Ghz).
- Input impedance is 50Ohm, AC coupled.

Getting Started with AT-AWG-GS

Overview

This Getting Started section begins by providing essential installation instructions for Drivers and Software. Then, the initial software interfaces are introduced. Finally, Setup Examples and Common Tasks are provided to bring you up to speed as fast as possible.

The **How do I section** of the AT-AWG-GS Welcome screen contains links to step-by-step explanations of standard functions and setups using your new product.

These titles along with others provided here and in other locations of this documentation provide accurate descriptions for regular tasks.

Software and Driver Installation

Insert the installation CD into your CD/DVD reader on your computer.

If the **Welcome** screen is not automatically shown, run the **setup.exe** file on the root directory of the installation files.

The one installer guides you through proper setup of both the AT-AWG-GS software and necessary drivers for your computer as explained in the following topics.

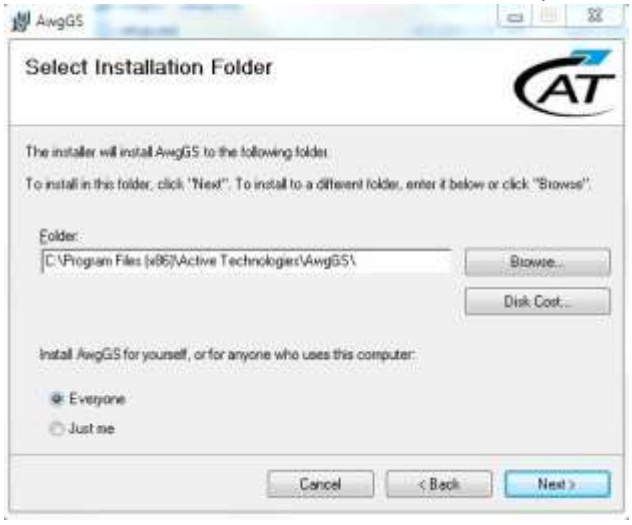
Software Installation

Note: The **Microsoft .NET Framework 4.0 Run-Time Engine** (or greater) is required to run the AT-AWG-GS software properly.

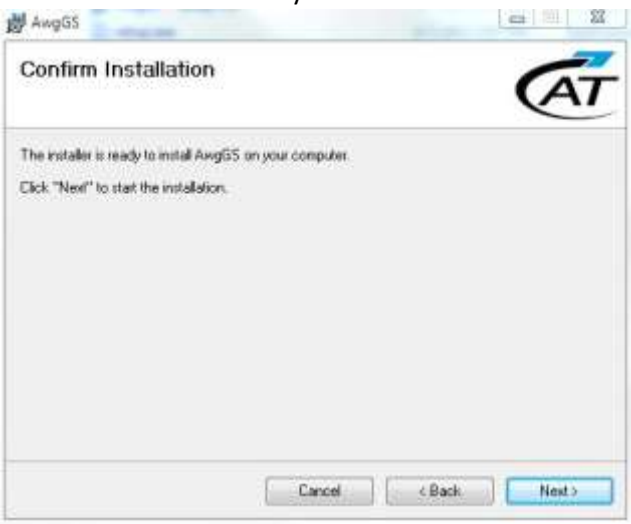
After inserting the installation CD into your CD/DVD reader, the **Welcome** screen is eventually shown, click **Install AT-AWG-GS** to start setting up the software.

The AT-AWG-GS Setup Wizard is then shown. Click **Next** to proceed with the installation.

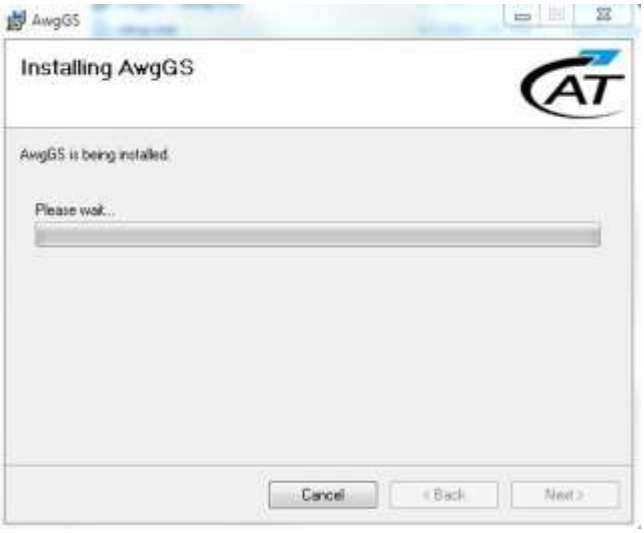
You can leave the default **Installation Folder** path, or specify a new location and click **Next**.



Now the installer is ready to install the AT-AWG-GS software, click **Next**.



Wait until the installer completes the software installation.

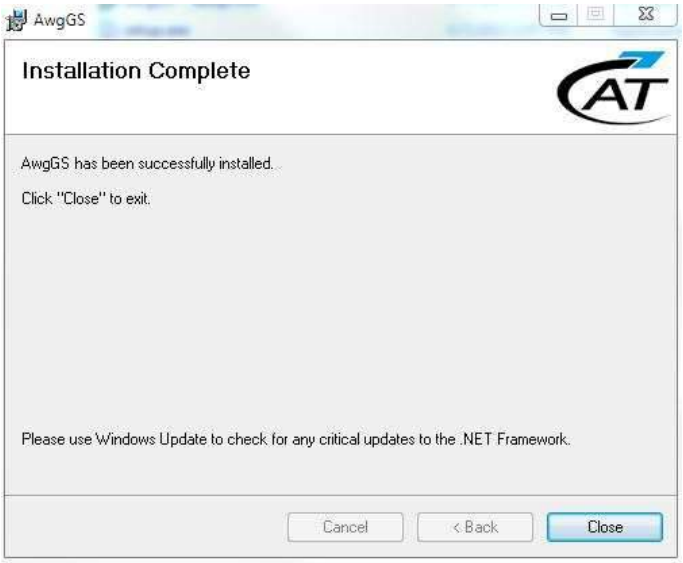


As the installation completes, the Driver Installation starts

Driver Installation

If the Windows Security form appears, click **Install this driver software anyway** to continue with the driver installation.

Now, with correct application software, drivers, and the latest .NET Framework installed, your AT-AWG-GS is ready for use. Click **Close** to exit Setup.



AT-AWG-GS Software Basics

The software is project based. Two type of project exist: Single Sequencer projects or Multi Sequencer projects. The two kind of projects differ in the way the analog/digital resources are managed:

- **Single Sequencer** projects: in this kind of projects all analog/digital resources are managed synchronously, also in the case where multiple board are connected together in a daisy chain configuration.
  This mode is called "Single Sequencer" because there is only one sequencer which manages multiple output channels in contrast with the "Multi Sequencer" where each analog channel has its own sequencer.
- **Multi Sequencer** projects: in this kind of projects each analog output can be configured completely independently each other. Each analog output behaves like a completely independent device with a single output channel.
  This mode is called "Multi Sequencer" because each analog channel has its own sequencer. Even if each channel can be configured independently the channels can share trigger and synchronization signals.

The AT-AWG software can manage two main type of operating modes: **Arbitrary mode** or **Modulation (DDS) mode**.
In Single Sequencer projects the selection of Arbitrary or DDS mode applies to all output channels while in Multi Sequencer mode each output channel can work independently in any of the two modes.

Arbitrary VS DDS technology

Function generators utilize DDS to generate periodic signals at precise frequencies by choosing samples from memory rather than generating all samples of a waveform. By contrast, arbitrary waveform generators (AWGs) generate each sample of a waveform that is stored into memory. While AWGs allow a user to precisely define the waveform that is being generated, they are limited in the frequency precision they can achieve, particularly at high frequencies. By contrast, we illustrate how a function generator is able to generate a 21 MHz sinusoid, even though its frequency is not a direct multiple of the sample rate. This is illustrated in the graph below:

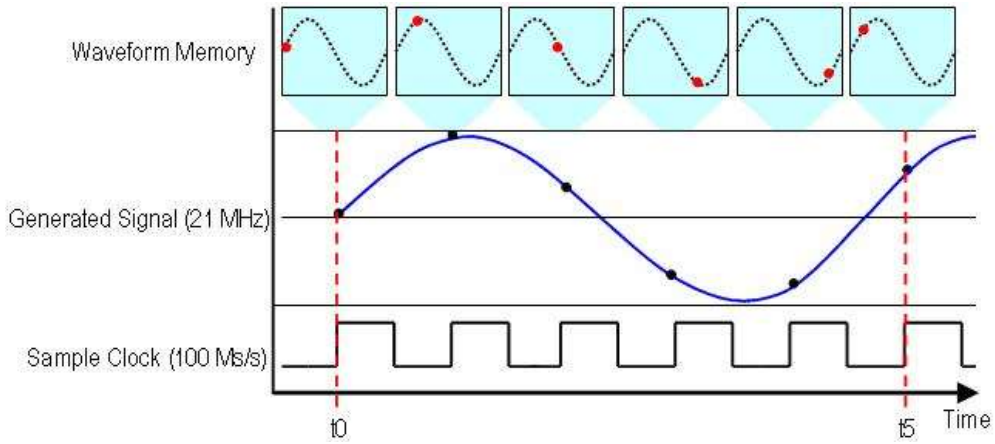


Figure 1: 21 MHz Sine Generation using DDS

From the figure above, we notice that the frequency of the sinusoid is not a divisor of the sampling rate. As a result, generating a 21 MHz sinusoid would be difficult with an AWG sampling at 100 MS/s. Function generators, on the other hand, use DDS to store a 2048 sample waveform in memory. With each clock cycle, the appropriate sample is chosen from a lookup table and then generated. As a result, we are able to generate signals at precise frequencies while supplying the digital-to-analog converter (DAC) with a constant 100 MHz clock.

AT-AWG-GS gives you the best of both worlds because you can setup a channel in **Arbitrary mode** with the possibility of change its sampling rate and/or setup a channel in **DDS mode** defining very long and complex modulation law waveforms.

Arbitrary Mode

In Arbitrary mode it is possible to define different waveforms and decide, by means of a sequencer, the sequence how these waveforms are generated at the outputs of the device.
Since the AT-AWG-GS has both analog and digital outputs there are three different kind of waveforms that can be defined: **analog** waveforms, **digital** waveform or **mixed** (analog/digital) waveforms.
In Arbitrary mode it is possible to define different waveforms and decide, by means of a sequencer, the sequence how these waveforms are generated at the outputs of the device.
Since some constrains must be applied between analog and digital waveform belongings to the same sequencer entry, it is suggested to work with mixed waveforms if there isn't any reason not to do it.

Modulation (DDS) mode

In Modulation (DDS) mode you can generate at the outputs modulated signals. To define the modulated signal you need to define for each analog output both a carrier waveform and the modulation law waveform that will modulate that carrier.

As in Arbitrary mode, multiple modulation law waveforms can be defined and added to the sequencer in order to decide the sequence how these laws will modulate the carrier.
It is possible to simultaneously modulate the **frequency**, **amplitude** and **phase** of the carrier.

For each analog output, in addition to the carrier, a *digital filter* can be defined.
The digital filter can specify the output voltage level versus the output frequency over a programmable bandwidth with a resolution of 10 bits.
This is useful for example to compensate for DDS sinx/x attenuation (or analog bandwidth attenuation) over frequency.

Initial AT-AWG-GS Software Interfaces

The AT-AWG-GS software environment provides access to all product functions.

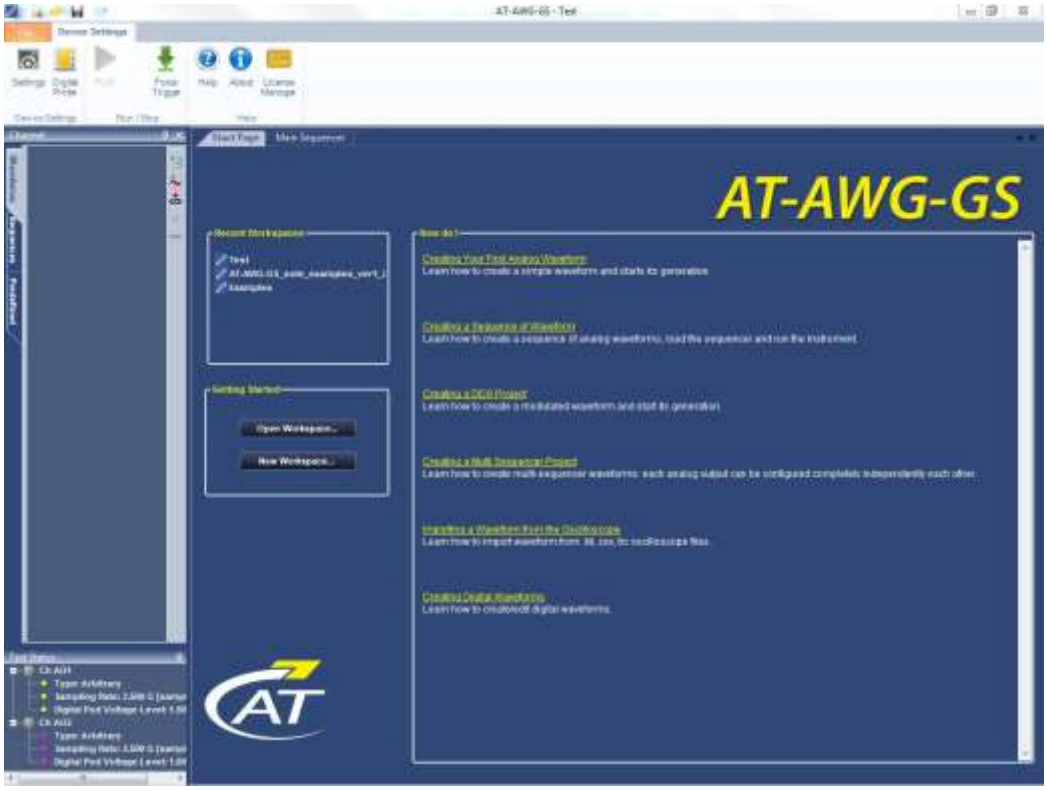
AT-AWG-GS Workspace

The AT-AWG-GS software workspace consists of two main elements:

- The main document editing area, shown on the right side on the following screen-shot.
- The AT-AWG-GS Control Navigation Tree, shown on the left side on the following screen-shot.

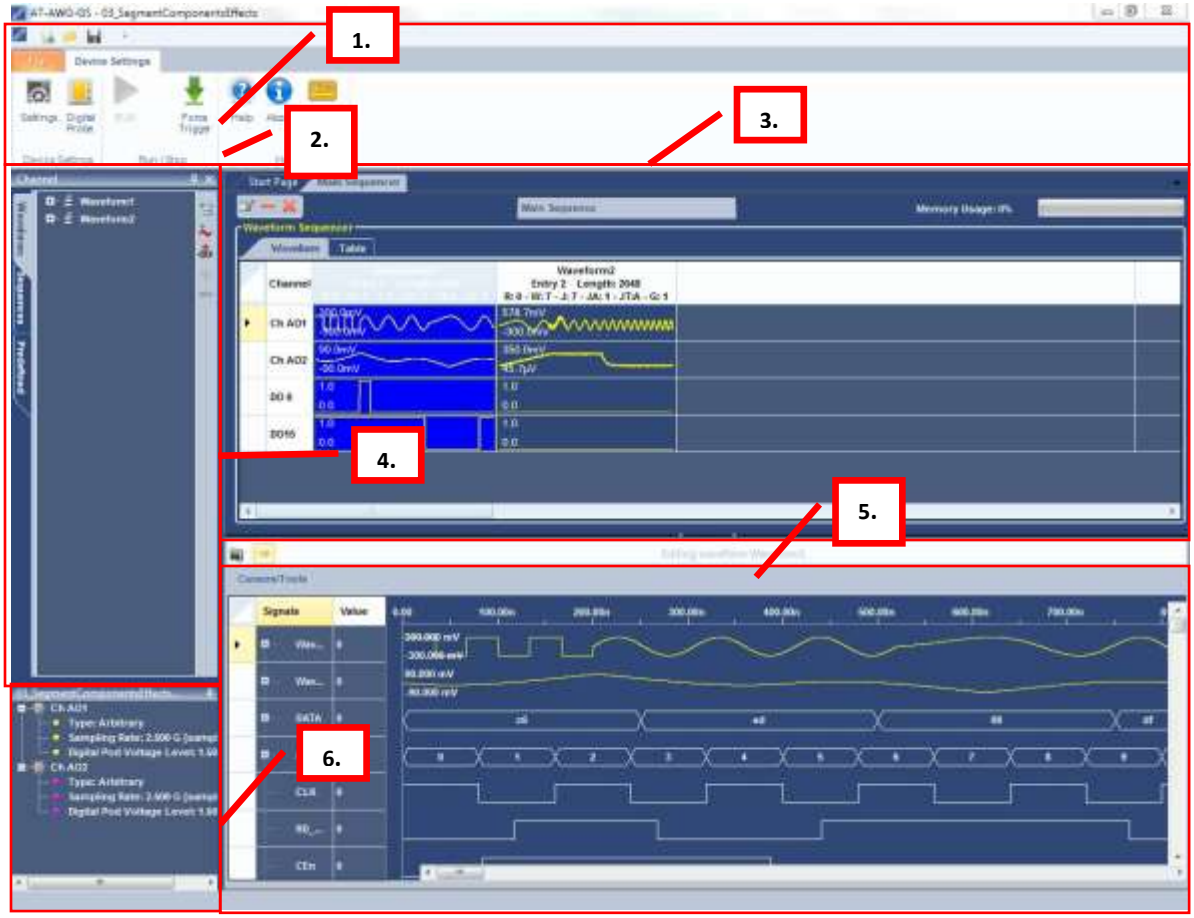
As mentioned, when you open the AT-AWG-GS environment, the most common initial tasks are displayed on the Welcome screen for easy selection in a special view, called the **How do I** section.
The common tasks include the following:

- "How do I" Scenario Details
- Recent Workspaces
- Open Workspace..
- New Workspace..



Interface and Display

The user interface is shown when you **open an existing project** or **create a new one**. Numbered callouts on this image correspond with the following interface section descriptions.



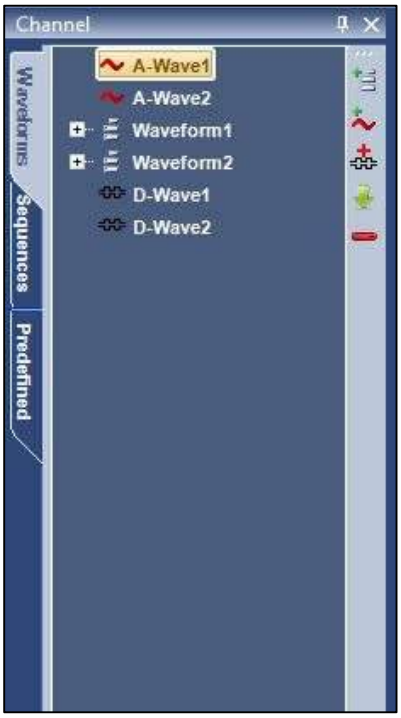
1. **Ribbon Menu Bar and Toolbar-** Provides menu access to device settings, workspace, window management and online help.

	**New Workspace -** Use this button to create a new workspace.
	**Open Workspace** - Use this button to open an existing workspace.
	**Save Workspace** - Use this button to save newly-created or edited workspaces.
	**Settings** - Use this button to access more detailed AT-AWG-GS option settings.
	**Digital Probe** - Use this button to open the Digital Logic Name and Grouping window and manage the names and groups of the Digital Pod signals.
	**RUN/STOP** - This button first loads setting parameters and the waveforms into the instrument, and then it starts/stops the waveform generation for all enabled channels selected from the Channels Selection button.

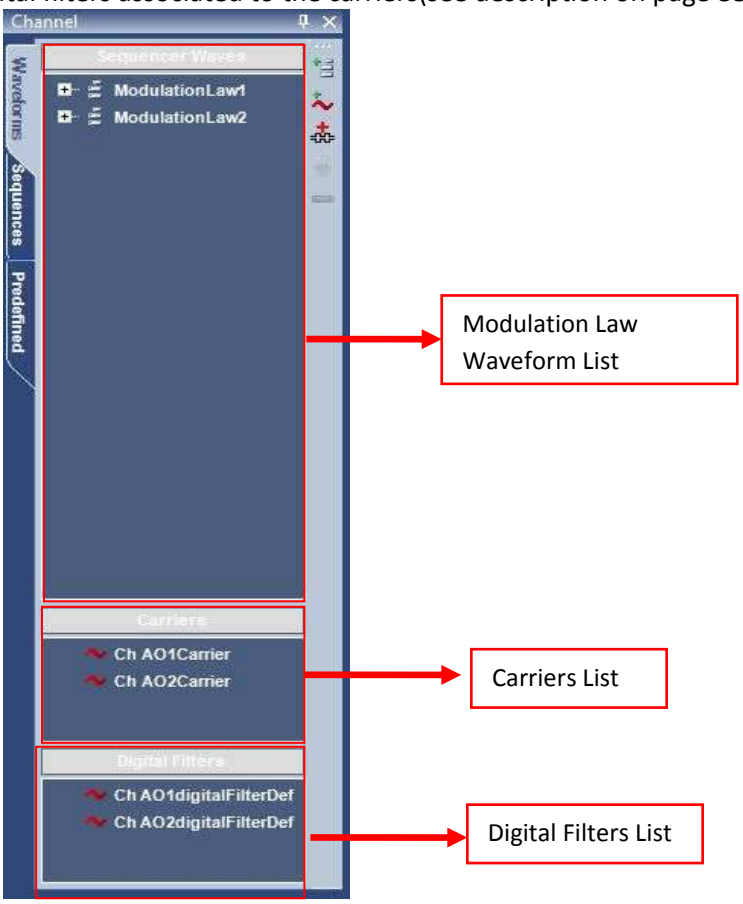
	Force Trigger – Clicking this button makes the instrument generate an internal trigger signal and forces an event on the selected channels/pods.
	Help – Use this button to open the User Manual in pdf format.
	About - Use this button to open the "About" window and retrieve information such as the software, dll and firmware version.

2. **Sequence Area** - This display area mainly provides information on the output sequence.
3. **Channel** – This display area gives access to the User and Predefined waveforms and to the Waveform Sequences.

   - **Waveforms TAB (ARB Mode) –** This TAB contains the list of the arbitrary waveforms that the user added to the project.



- **Waveforms TAB (DDS MODE) -** This TAB contains the list of the Modulation Law waveforms that the user added to the project, a list of the available carriers and a list of the digital filters associated to the carriers(see description on page 88).



Both Waveforms TAB have a toolbar on the aside allowing you to Add, Delete or Copy the waveforms.

Icon	Action	Arbitrary Mode	DDS Mode
	New Mixed Waveform	Use this button to add a Mixed waveform to the list. The waveform editor opens and there you can define at the same time the output waveforms for all the analog and digital available resources.	Use this button to add a Mixed waveform to the list. The waveform editor opens and there you can define for each analog output the amplitude (AM), frequency (FM) and phase (PM) modulation laws as well as the stimulus for the digital outputs.
	New Analog Waveform	Use this button to add and edit an	Use this button to add and edit a modulation

		analog waveform to the list.	law waveform to the list.
	New Digital Waveform	Use this button to add and edit the stimulus for the digital outputs. **Note**: the digital waveform length **must be ½** of the analog waveform length in the same sequencer entry.	Use this button to add and edit the stimulus for the digital outputs. **Note**: the digital waveform length **must be equal** to the analog waveform length in the same sequencer entry.
	Copy To Predefined	Use this button to copy the selected waveform to the Predefined list.	
	Delete Waveform	Use this button to delete an existing waveform.	

QUICK TIPS:

- Double click on an existing waveform to open the **Editing Waveform Window**.
- Double click on a carrier/digital filter to open the Carrier Waveform Editor window/Digital Filter Editor Window.

- **Sequences TAB**
  It is possible to create a subset of waveforms identifying a Subsequence that can be placed into a Sequencer entry by mouse drag & drop.
  This TAB contains the list of the available subsequences and the toolbar on the right allows you to Add/Edit them.

Icon	Action	
	New Subsequence	Use this button to create a Subsequence: the new subsequence opens in the Sequence Area and you can add waveforms to it simply by drag & drop them from the Waveform TAB. Click on the Main Sequence button to exit from Subsequence edit mode; the created subsequence will appear on the Subsequences list.
	Edit Subsequence	Use this button to edit an existing subsequence. Select the Sequence entry from the list and press the button to edit it in the Sequence Area.

- **Predefined TAB**
  This TAB contains the predefined waveforms: predefined waveforms cannot be edited, but once they have been copied to the user waveform list they can be opened and edited.
  Predefined waveforms are available on all the user projects.
  You can add a Predefined waveform to the Sequence Area by drag & drop with mouse.

Icon	Action	
	Copy to Project Waveform	Use this button to copy a Predefined waveform to the user waveform list: the copied waveform can be opened and edited.
	Delete Predefined Waveform	Remove and delete a predefined waveform from the list.

4. **Waveform Display Area** -This area displays the waveform that you selected in the Waveform Table List , in the Sequence Area or in the Carrier graph.
5. **Device Status** - This are of the screen provides channel/pod run mode status information as follows.
    - **Type** - Shows the channel functionality (Arbitrary, DDS).
    - **Voltage Level** - Displays the Pod voltage level.
    - **Sample Rate** - The Sample rate of the Digital Pattern Generator.

PLEASE NOTE THE FOLLOWING:

- All of the panels are dockable; meaning they snap into convenient screen positions adjacent to other panels. Move individual panels by clicking the panel's top side, holding, and dragging with your mouse.

Setup Examples and Common Tasks

The following examples provide a quick way to learn standard AT-AWG-GS signal setups and common tasks:

1. **Arbitrary Mode Single Sequencer Setup Example** (on page 31)

2. **Creating a New Workspace** (on page 37)
3. **Opening an Existing Workspace** (on page 38)

"How do I" Scenario Details

In addition to the **Setup Examples and Common Tasks**, the end of this manual also contains scenarios with detailed steps for performing typical tasks and setups using AT-AWG-GS as shown in the **How do I** section on the Welcome screen (shown when first launching the software).

PLEASE NOTE THE FOLLOWING:

- Before performing any of the scenarios, you must first make sure you've **correctly powered on your instrument**, **connected to your PC**, and **launched the AT-AWG-GS software** as explained in the **Getting Started with AT-AWG-GS** (on page 16) section.
- Some more specific steps are required around Creating a New Workspace for each scenario. Details are provided for those scenarios when necessary.

With the aforementioned prerequisites completed, you can perform the following scenarios:

1. **Creating Your First Analog Waveform** (on page 111)
2. **Creating a Sequence of Waveforms** (on page 115)
3. **Creating a DDS (modulation) Project (AM,FM,PM)** (on page 120)
4. **Creating a DDS Compensated sequence of waveforms** (on page 129)
5. **Creating a Multi Sequencer Project** (on page 135)
6. **Importing a Waveform from an Oscilloscope + Component Usage + Gated Run Mode** (on page 141)
7. **Creating Digital Waveforms** (on page 147)

Arbitrary Mode Single Sequencer Setup Example

After you have powered on the instrument and connected it to the PC, launch the software and use the menu bar to create a **New Workspace**.

1. Type the Workspace name
2. Select **Single** as Sequencer Mode
3. Select **Arbitrary** as Channel Functionality
4. Select **16Ch@1.25 GS/s** as Digital Channel Speed.

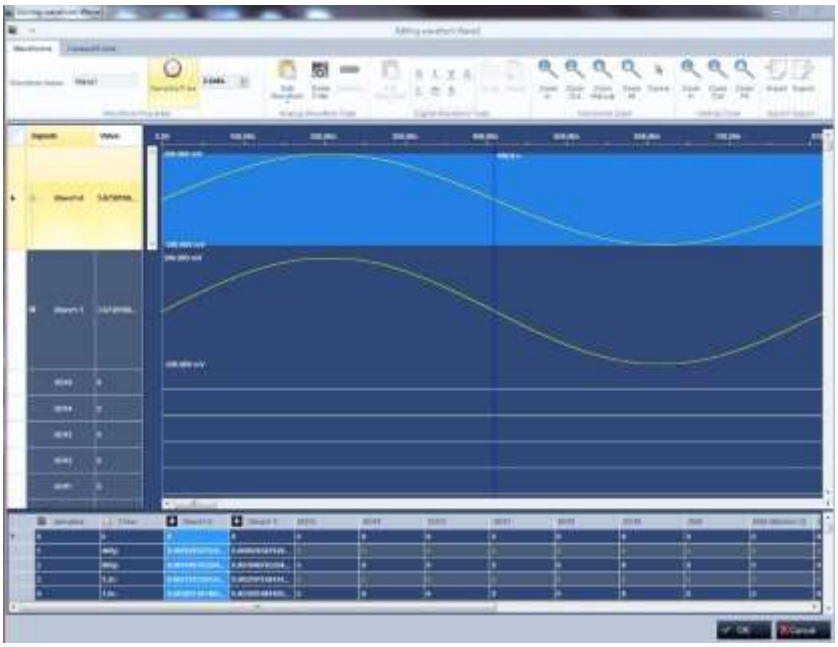
> **Note**: two Infiniband 12x connectors provide 16 bit LVDS digital outputs each for a total of 32 LVDS outputs. These digital outputs can be software configured to operate in different ways. The digital channels are available with Digital Option installed only.
> In ARB mode it is possible to operate with all of the 32 channels with a max. update rate of 625MSps or with half channels (16) at 1.25Gsps.

5. Click **OK**.

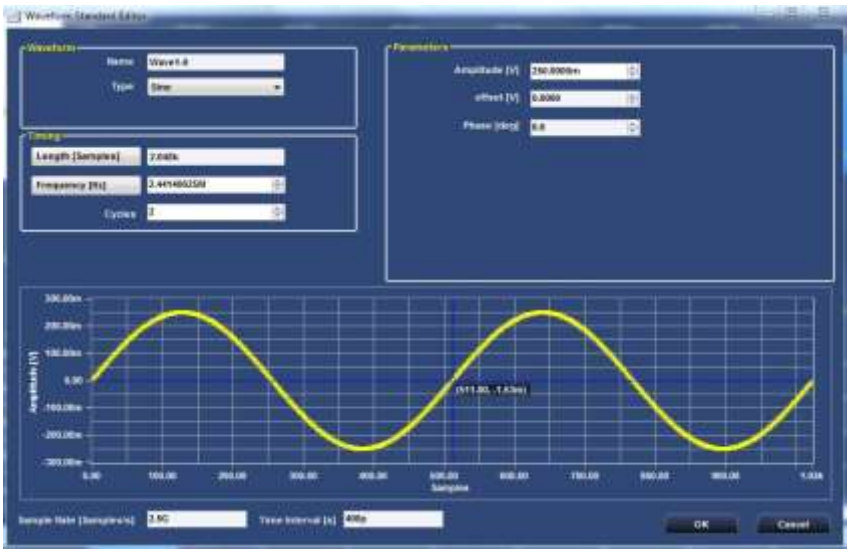
6. Click the **New Mixed Waveform** button.

7. The **New Waveform** window is shown. Type the name of the waveform “Wave1” and choose 2048 for the samples length of the waveform. Click **OK** to confirm.

8. The **Editing Waveform** window is shown. Select the waveform Wave1-0 and click on the **Edit** Edit button

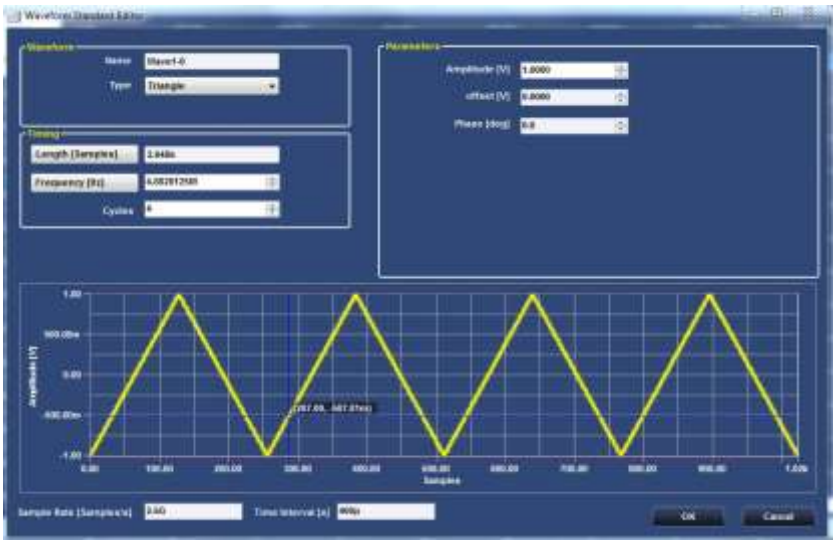


9. The **Waveform Standard Editor** is shown. Choose a sine waveform with the following specs:
   - Cycles: 2
   - Amplitude[V]: 250mV



Press **OK** button.

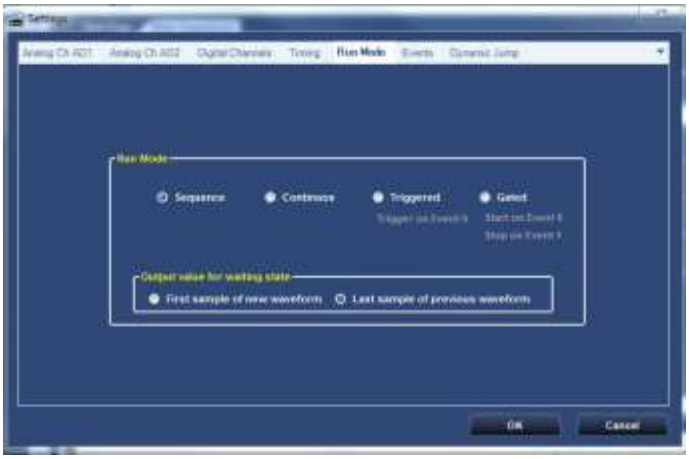
10. Select the waveform Wave1-1 and click on the **Edit** button.
11. The **Waveform Standard Editor** is shown. Choose a triangle waveform with the following specs:
    - Cycles: 4
    - Amplitude[V]: 1V



Press **OK** button.

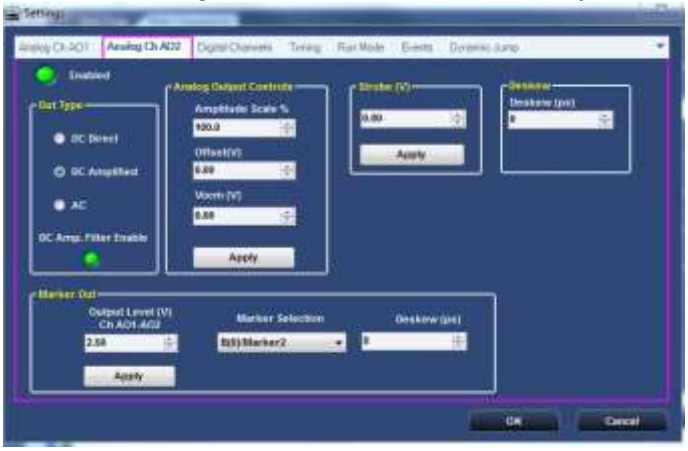
12. Press **OK** button on the **Editing Waveform** window; the *Wave1* will appear on the Waveform TAB.
13. Click the **Settings** button. The Settings window is shown.

    - Select **Sequence** as Run Mode



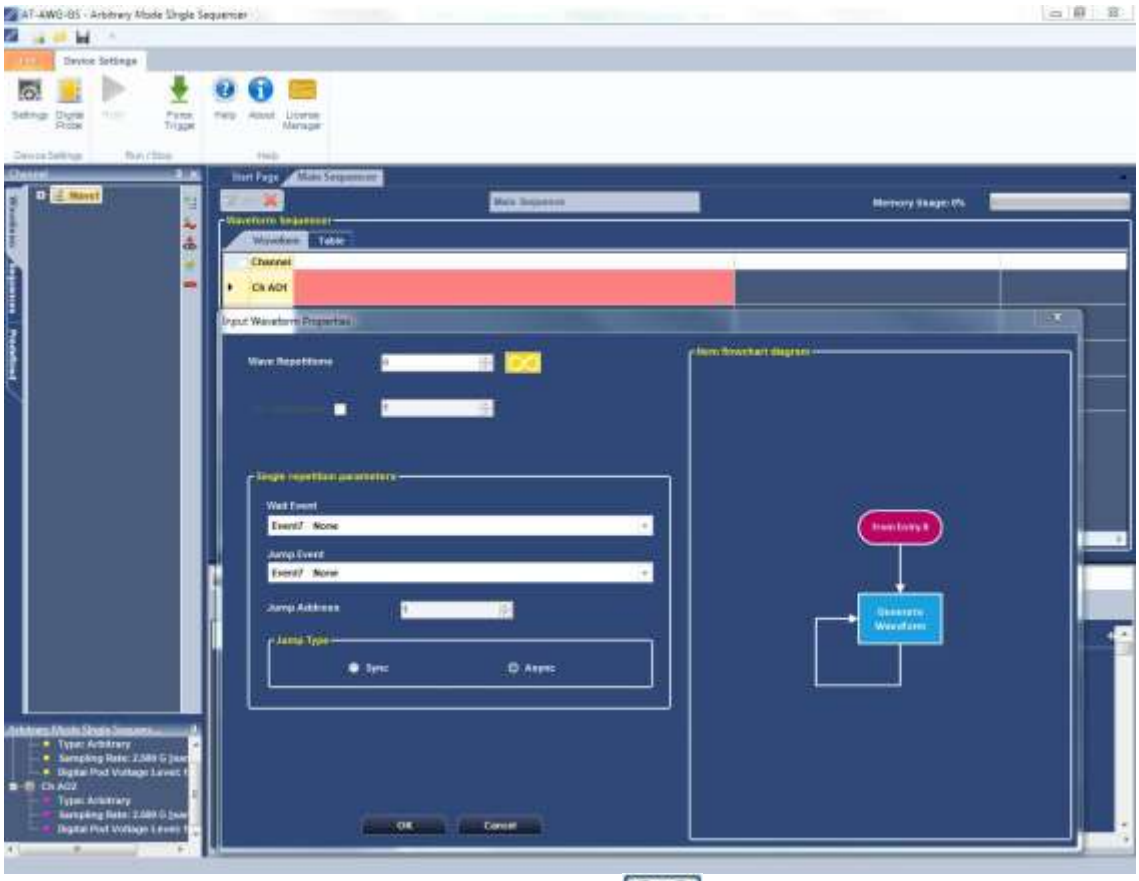
- Select the *Analog Ch AO1* TAB and select **DC Direct** as Out Type

- Select the *Analog Ch AO2* TAB and select **DC Amplified** as Out Type

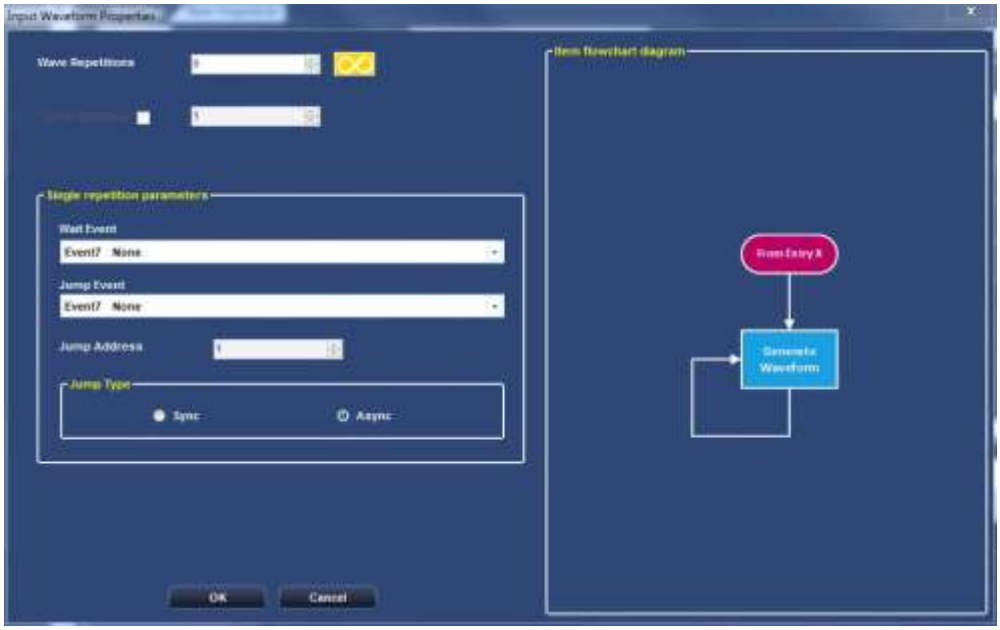


Press **OK** button.

14. Drag the *Wave1* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).



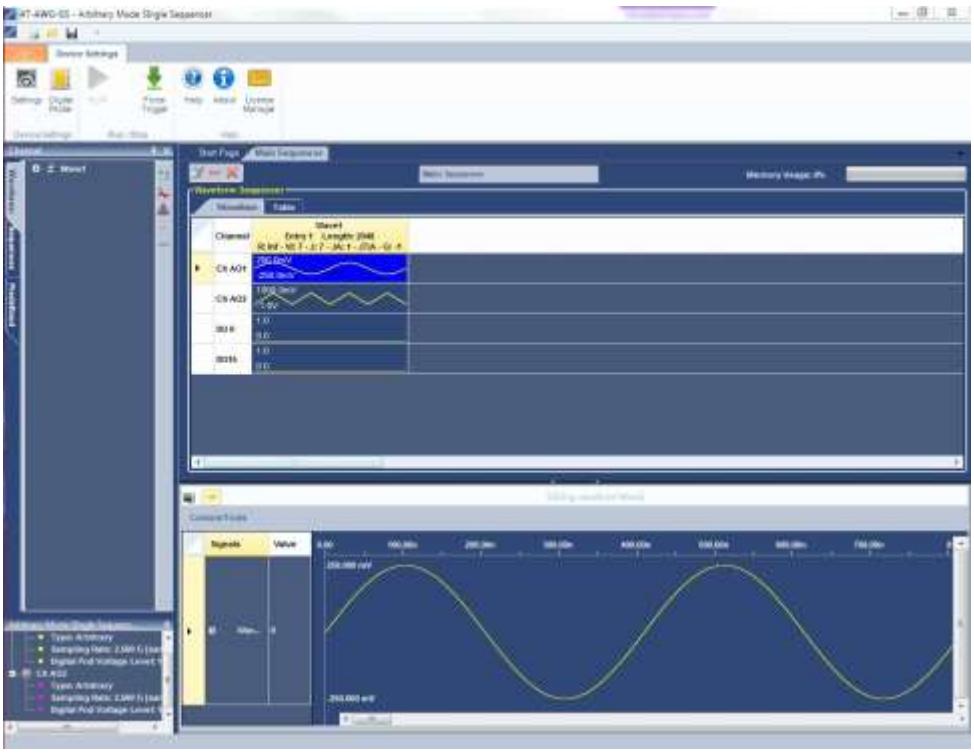
15. The **Input Waveform Properties** is shown. Click the  button to *set infinite repetitions* on Wave1. The item flowchart will help you to understand the correct behavior of the instrument.



Press **OK** button.

16. The Sequence Area will show now the Wave1 inserted in the first cell. Selecting one of the waveform with the mouse, it will appear on the *Waveform Display Area* placed

below.



17. Press the **Run/Stop** toolbar button.

> **Note**: Once the instrument has started, Sequence Run Mode with infinite repetitions, repeats *Wave1* until the **Run/Stop** button is clicked again.

The software loads the waveforms into the AT-AWG-GS hardware and then generates waveforms.

18. **Wave1** ports to the **CH1/CH2 SMA output**, which can be connected to an oscilloscope for signal analysis.

Creating a New Workspace

1. From the Start Page, click the **New Workspace** button.

2. The New Workspace form is shown and displays the connected AT-AWG-GS hardware on the **Connected Devices** section.
3. Now, provide a **Name** and **Description** for your new **Workspace**.

4. Select the **Sequencer Mode**
   - **Single Sequencer** projects: in this kind of projects all analog/digital resources are managed synchronously, also in the case where multiple board are connected together in a daisy chain configuration.
   - **Multi Sequencer** projects: in this kind of projects each analog output can be configured completely independently each other. Each analog output behaves like a completely independent device with a single output channel.

5. Select the **Channel Functionality:**
   - **Arbitrary:** in Arbitrary mode it is possible to define different standard/complex waveforms and decide, by means of a sequencer, the sequence how these waveforms are generated at the outputs of the device generating different scenarios.
   - **Modulation (DDS):** If you need an amplitude, frequency or phase modulated signal choose DDS mode.
     It is also possible to generate very complex AM,FM,PM modulation law waveforms and decide their sequence by means of a sequencer.
6. Select the **Digital Channel Speed**: in ARB mode it is possible to operate with all of the 32 channels with a maximum update rate of 625MSps or with half channels (16) at 1.25Gsps.
   In DDS mode the update rate is fixed at 625MSps on all channels.

Opening an Existing Workspace

1. Open preexisting workspaces by clicking the **Open Workspace** toolbar button. The Open Workspace screen is shown.
2. The Open Workspace screen automatically navigates to the AwgGSProjects folder. Select the desired workspace and click **Open**.

Examples Project

1. The AT-AWG-GS setup automatically installs under the folder \Program Files (x86)\Active Technologies\AT-AWG-GS\DemoProjects several demo projects that can help you to understand more in depth all the instrument features.
2. Please note that the Demo Projects are configured for a full optional instrument (64MS/CH and 32 DIOs), so if you try to open them with a connected instrument with less options, you will receive an error message.
   In that you can open them in DEMO Mode turning off the AT-AWG-GS.

Settings

Use **Settings** to control the channel settings of the instrument. Access Settings by double clicking on the  button in the main toolbar.
The **Settings** screen is divided into the following tabs:

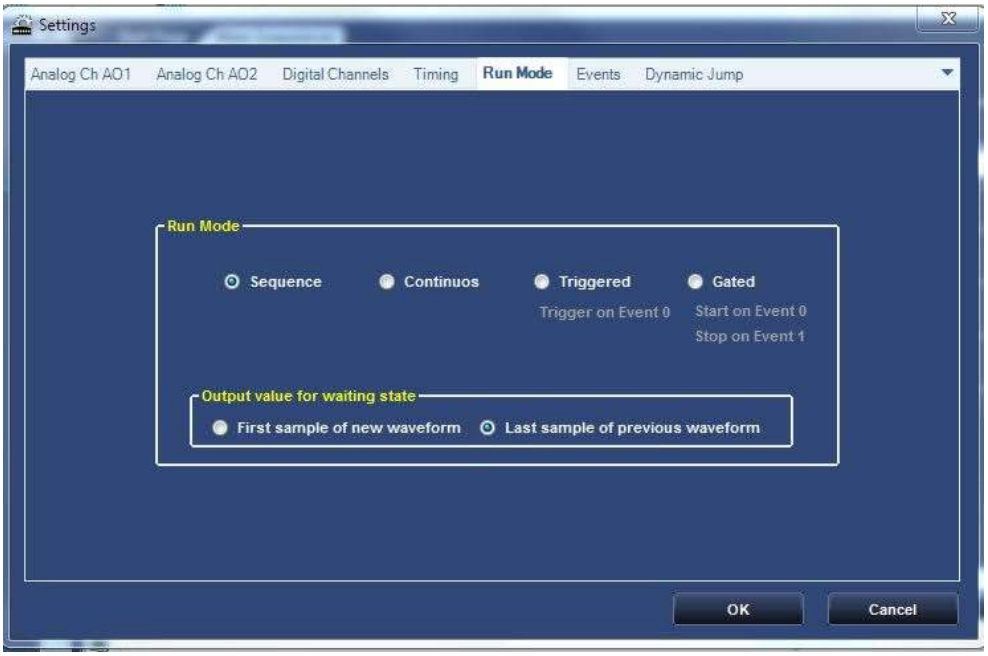
1. **The Analog Ch AO1/AO2 Tab** (on page 41)
2. **Digital Channels Tab** (on page 45)
3. **The Timing Tab** (on page 46)
4. **The Run Mode Tab** (on page 39)
5. **The Events Tab** (on page 47)
6. **The Dynamic Jump Tab**(on page 49)

PLEASE NOTE THE FOLLOWING:

- In Single Sequencer projects, one Settings panel is available to manage all the channels capabilities.
- In Multi Sequencer projects, one Settings panel per analog channel is available to manage the single channel capabilities: those control panels are called the *Master Settings* and the *Slave Settings* panels.

Settings - The Run Mode Tab

The **Run Mode** tab is shown by default when the **Settings** screen is opened.
Use the Run Mode tab to define the generation mode for the edited sequence.



The AT-AWG-GS supports the following four run modes:

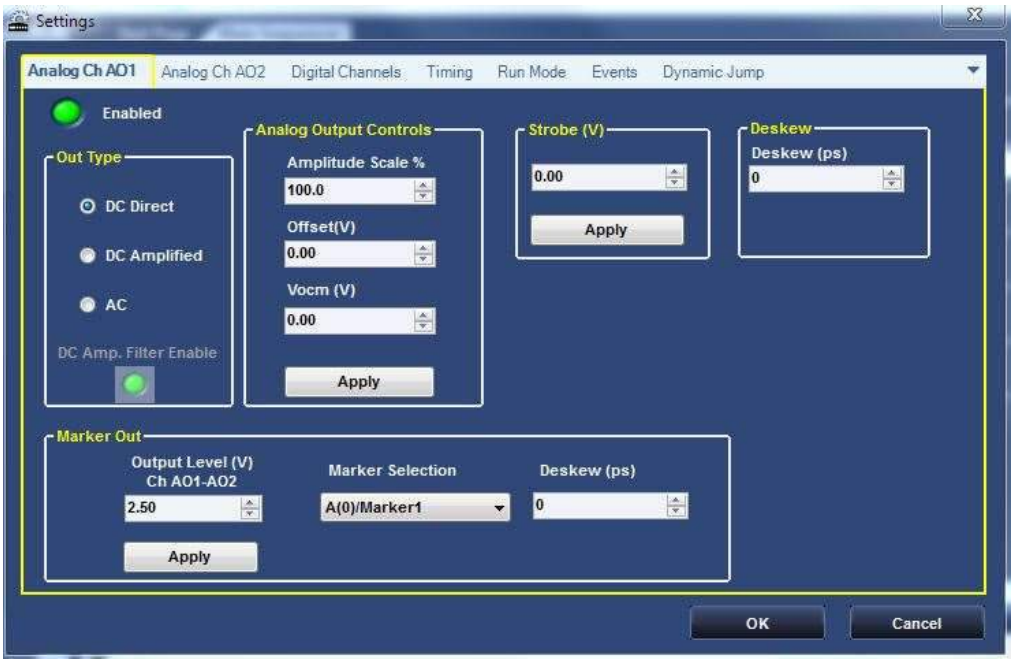
- **Sequence** – Multiple waveforms can be output in the order specified in the Sequence Window.
- **Continuous** – A continuous waveform is output. Only one entry is allowed in the Sequence Window.
- **Triggered** – A waveform is output once when the instrument receives a trigger signal. The instrument will wait for the next trigger signal after outputting the waveform. Only one entry is allowed in the Sequence Window.
  The *Event 0* is the trigger signal and it can be set in the Events Tab.
- **Gated** – The waveform is generated when Event 0 occurs (by default Event 0 = Force Trigger button is pressed) and stopped when Event 1 occurs (by default Event 1 = Force Trigger button is released). Only one entry is allowed in the Sequence Window.
  The *Event 0 and Event 1* are the gate signals (Start/Stop) and they can be set in the Events Tab.

PLEASE NOTE THE FOLLOWING:

- In Sequence and Triggered mode the instrument can wait for an event before a waveform is output: it is possible to select the output value for the waiting state between the *last sample of the current* waveform or *the first sample of the next* waveform.

Settings - The Analog Ch Tab (ARB Mode)

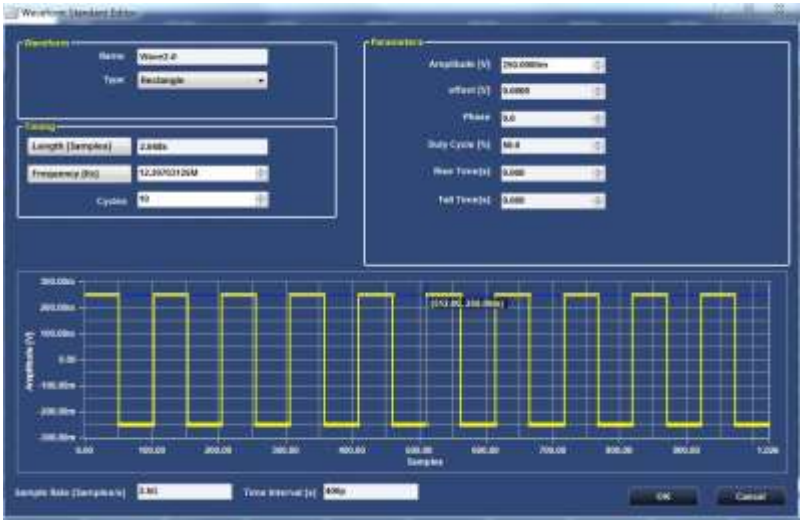
Use the **Analog Ch AO1/AO2** tab to quickly access the output type, amplitude, de skew and trigger out parameters of the selected channel.



- **Enabled**: to enable a channel output, click the **Enabled** button.
- **Out Type**: select the output type (DC Direct, DC Amplified or AC) of the selected channel.
- **DC Amp. Filter Enable**: enables/disables the hardware filter of the DC Amplified output.
- **Analog Output Controls**: you can set parameters for the amplitude scale in %, offset and Vocm. Press the Apply button to confirm the changes.
- **Strobe(V):** use this field to set the DC Output voltage for the selected channel. Press the Apply button to confirm the changes.
- **Deskew(ps):** this parameter can set a fine delay between the output channels in order to realign the outputs with a resolution of about 10 ps.
  The skew between analog/digital channels depends over the sampling frequency.
  The AT-AWG-GS factory deskew calibration has been performed at 2.5GHz; if you change the instrument sampling rate the calibration of analog channels alignment should be perfomed manually (please see below the alignment procedure).
- **Marker Out**: set the Marker Out *output level (V)* and the *Marker Selection* associated to the Marker Out. The drop-down list contains Marker / Low / High: it means that you can associate to the Marker Out connector the marker digital signal you can edit in the Waveform Editor Window or an always low/high level signal.
  Press the Apply button to confirm the changes.

ANALOG CHANNELS ALIGNMENT PROCEDURE:

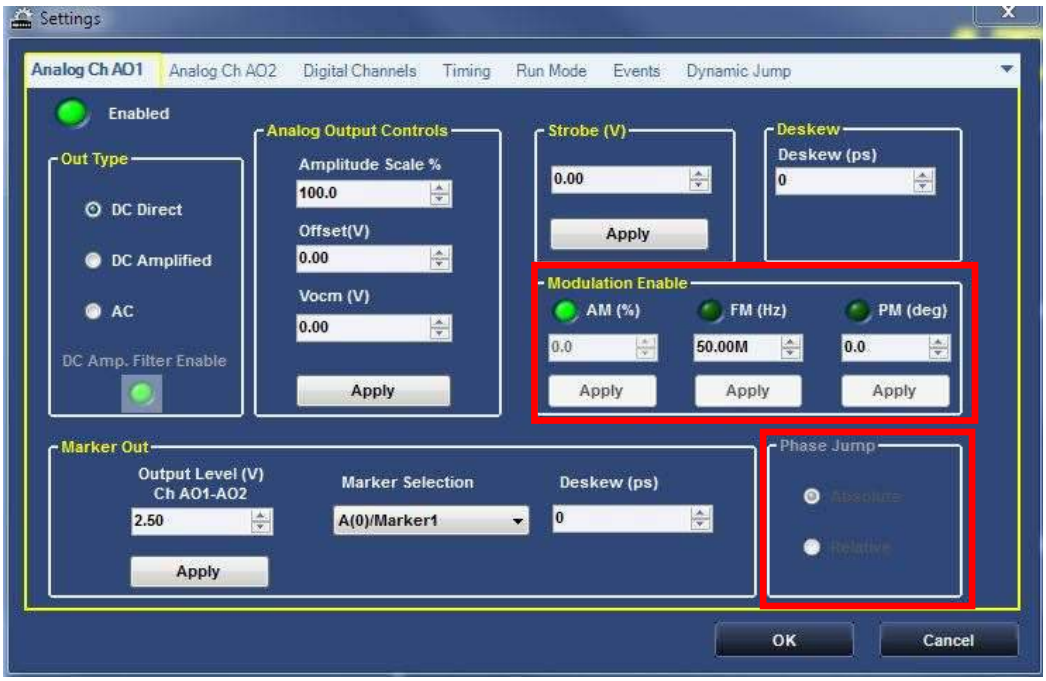
1. Connect the AO1+ and AO2+ outputs to the oscilloscope.
2. Tap the unused outputs with 50 Ohm load.
3. De skew the oscilloscope channels (please follow the procedure on your oscilloscope).
4. Refer to the ***Creating Your First Analog Waveform*** tutorial on page 111 to set up a New Workspace and to create two analog waveforms.
5. In the step 4 of the tutorial create a Rectangle waveform for **each** channel (Wave1-0 and Wave1-1).



Amplitude[V]: 250m
Cycles: 10

6. Follow the tutorial until the step 10.
7. On the main toolbar, press the Settings button and go to the Analog Ch AO1 tab: select the Direct DAC output.
8. Go to the Analog Ch AO2 tab: select the Direct DAC output. Click **OK**.
9. Press the **Run** button to start the waveform generation.
10. Measure on the oscilloscope the delay between the AO1+ waveform rise and the AO2+ waveform rise.
11. Press the **Stop** button.
12. Press the Settings button: if the Delta(AO1+,AO2+) is positive, then go to the Analog Ch AO1 tab and insert the Delta value in the Deskew field; if the Delta(AO1+,AO2+) is negative, then go to the Analog Ch AO2. tab and insert the Delta value in the Deskew field. Click **OK**.
13. Press the **Run** button and repeat the steps 10-12 until the skew between the channels is about 10 ps.

Settings - The Analog Ch Tab (DDS Mode)



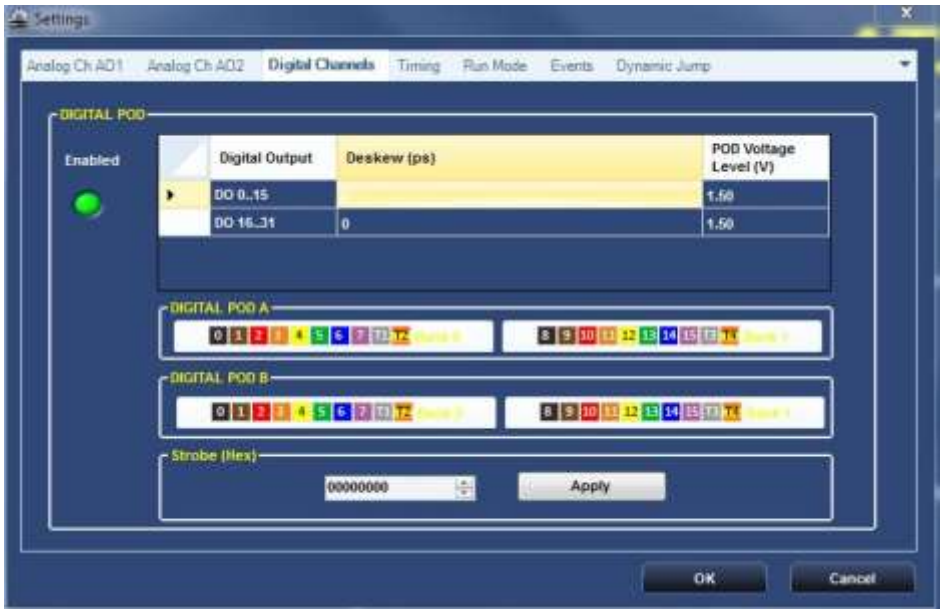
In DDS mode the Analog Ch TAB parameters are the same of the ARB mode except for *Modulation Enable* and *Phase Jump* controls.

- **Modulation Enable**: you can enable or disable AM,FM,PM modulation.
  Disabling the modulation laws, you will enter in *manual modulation* mode.
  The *manual modulation* is useful when you need to change the modulation parameters on run-time.
  For example if you disable AM modulation by turning off the AM(%) led button in the *Settings tab*, the AM modulation law waveform will disappear from the Sequencer/Waveform Editor and you can manually adjust the AM(from -200% to 200%) when the instrument is on running state.
  AM range: -200% to 200%.
  FM range: 0 to 1.25 GHz.
  PM range: -360° to 360°.
- **Phase Jump:** if the phase jump is **Absolute**, the modulated waveform changes the phase at each value change of the Modulation Law waveform.
  If the phase jump is **Relative**, the modulated waveform changes the phase at each point of

the Modulation Law waveform.
When the PM is *on manual modulation mode,* the Phase jump is always Absolute.

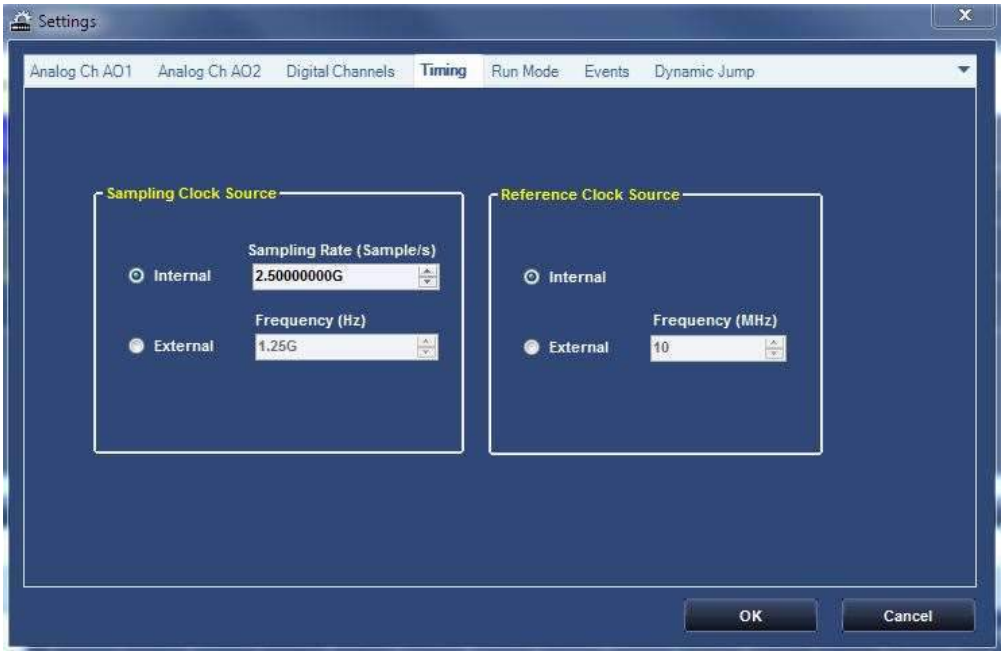
Settings - Digital Channels Tab

Use the **Digital Channels** tab to set a fine de skew on the digital lines and assign values to the output pins.
You can generate a digital pattern to test digital devices such as serial and parallel DACs or to emulate protocols. Two Infiniband 12x connectors provide 16 bit LVDS digital outputs each for a total of 32 LVDS outputs.



- **Enabled**: to enable the digital output channels, click the **Enabled** button.
- **Fine Deskew(ps) :** this parameter can set a fine delay between the digital channels in order to realign the analog and digital outputs with a resolution of about 78 ps.
  The skew between analog/digital channels depends over the sampling frequency.
- **Pod Voltage Level(V):** this parameter sets the output voltage level (in Volt) of the Digital Probe. Please note that it will take effect on the AT-AWG-GS instruments with installed Digital Option and with the probe connected.
- **Strobe (Hex):** allows the assignment of values to Digital Output bus.
  By pressing the Apply button, the output pins change their logic levels to the ones assigned.

Settings - Timing Tab

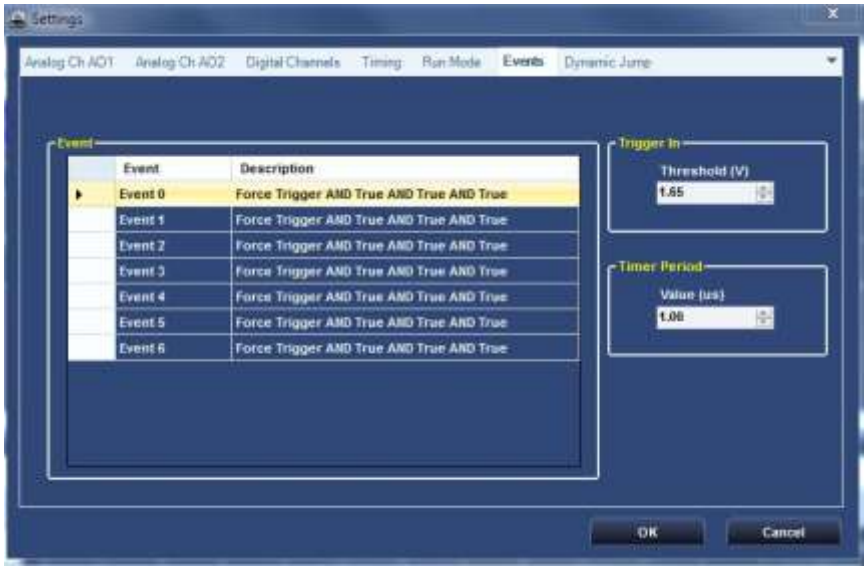


1. **Sampling Rate:** the sample rate can be set to the following ranges
   - The 7.4MS/s to 2.5 GS/s for Arbitrary mode channels
   - Up to 312.5 MS/s for DDS mode channels
2. **Sampling Clock Source**: it may be set to Internal or External.
   If **Internal** is selected, the sampling clock signal is generated internally.
   If **External** is selected, the clock signal from the EXT. CLOCK IN SMA connector is used. When the External Clock is selected, an External Clock Frequency must be set for your clock signal (1.25 GHz to 2.5 GHz).
   PLEASE NOTE THE FOLLOWING:
   - In the Single Sequencer project, the AO1 is the Master channel and it propagates the sampling clock to the slave channel AO2, so the EXT. CLOCK IN CH1 is the **only one input available** as External clock.
   - In a Multi Sequencer project, both EXT. CLOCK IN SMA inputs are available as External clock, because the two channels works independently.
3. **Reference Clock Source**: you can select the Reference Source (Internal or External), the Reference Source is selectable only when the Clock Source is set to Internal.

Settings - Events Tab (Single Sequencer)

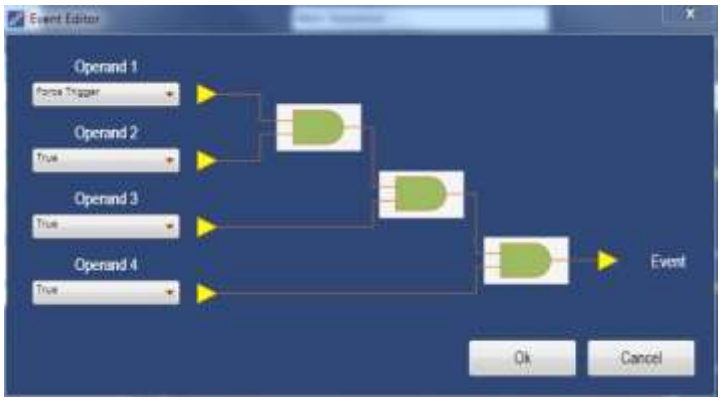
The AT-AWG-GS has Event Jump and Wait Event (*Input Waveform Properties window*) functions which change the generation sequence using an event signal.
Additionally Triggered and Gated run mode execution depend on Event 0 and Event 1.

Use the **Events** tab to set the Events, Trigger IN and Timer parameters.



- **Event**: you can configure up to seven events (Event 0…Event 6) and each event is a logic combination between four operands (*Operand 1..Operand 4*) and three operators(*Operator 1..Operator 3*).

  The *Event table* contains the event columns and the description columns that gives a summary of the event setting.
  Double click on an Event table row to open the *Event Editor*; the editor gives you access to the available operands and operators.



The logic combination evaluation formula is:
EventN= (Operand1 ***Operator1*** *Operand2)****Operator2*** *Operand3)****Operator3*** *Operand4)*

The possible operations include **AND**, **OR**, **XOR**, **NAND**, **NOR**, and **XNOR** and the possible operands include **False, True, Trigger IN, Timer, Force Trigger, DO, Not Trigger IN, Not Timer, Not Force Trigger, Not DO**.
Right-click on the Operator icon to select the operation type.

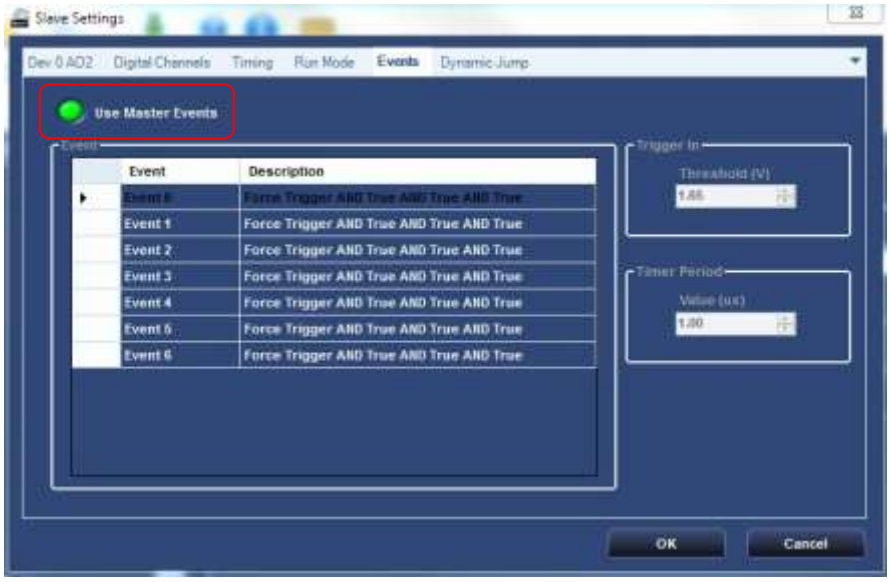
PLEASE NOTE THE FOLLOWING:

- **Trigger IN**: the event is received by the dedicated SMA Connector on the instrument front panel.
- **Timer**: the event is generated by a time counter you can set in the Event Tab.
- **Force Trigger**: the event is generated by a software trigger pressing the button in the main toolbar.
- **DO**: the event is generated by one of the available digital lines in the Operand drop down list (it depends on the Channel Functionality / Digital Channel List selection). It can be a logical high level (DO) or logical low level (NOT DO).

- **Trigger IN - Threshold(V):** use this field to select the Trigger IN threshold voltage level.
- **Timer Period - Value (uS):** use this field to set the value of the time counter in microseconds.

Settings - Events Tab (Multi Sequencer)

In Multi Sequencer projects, the Event TAB parameters are the same of the Single Sequencer projects except for *Use Master Event* led placed on the Slave Settings panel.



If you enable the *Use Master Events* control, the Slave event list will be disabled and the Slave channel will use the events of the master channel to control the generation sequence.

Settings - Dynamic Jump

Use this Tab to modify the execution flow of the sequencer by forcing a specific entry to be executed.

This can be done by following these guidelines:

1. Specify the relationship between the "Strobe" value and the entry of the sequencer in the *Dynamic Jump* table.
2. Use the Strobe field to select one of the available entries in the JumpBit column.
3. Press the Apply button.
4. The **Enabled** button enable/disable the dynamic jumps.

Editing Waveform Window

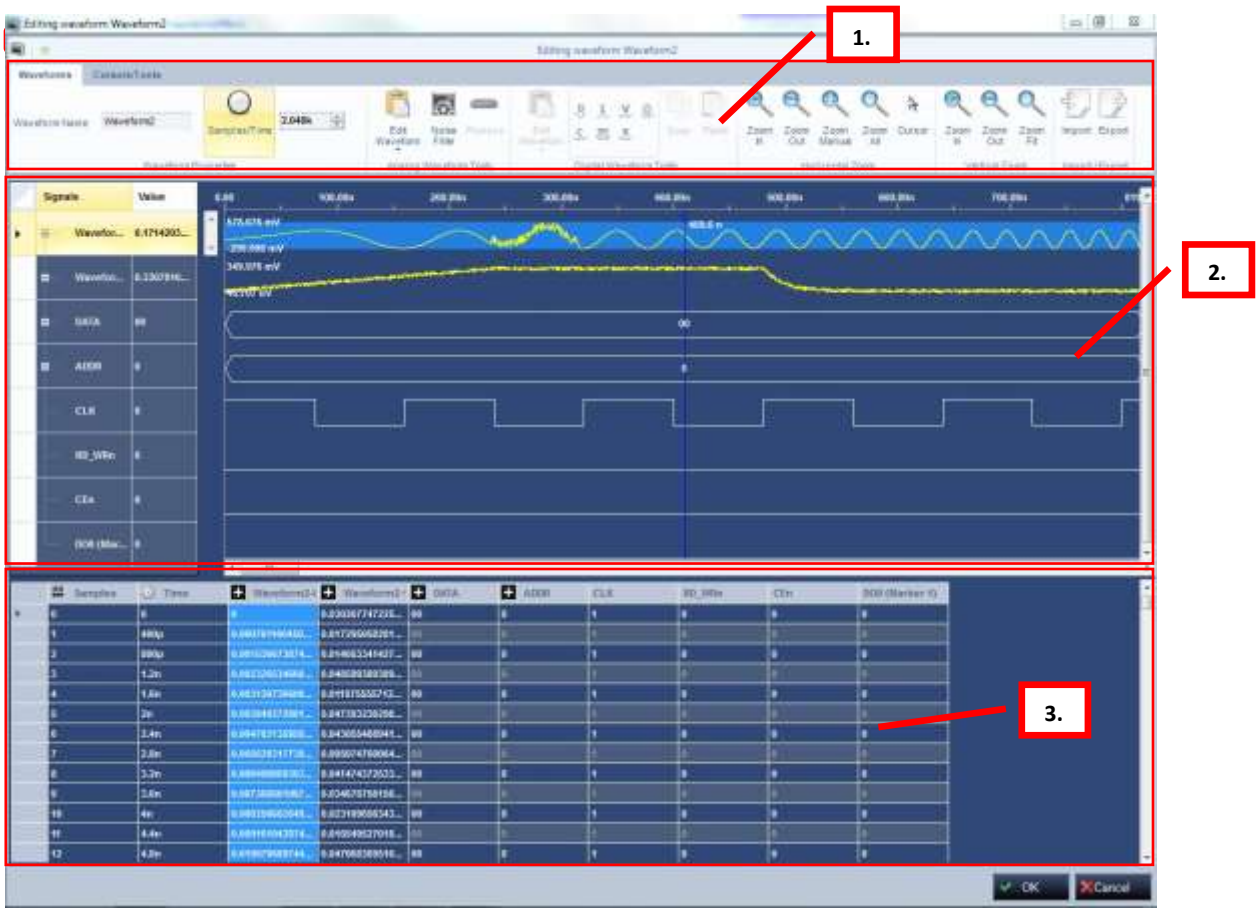
Use the **Editing Waveform Window** menu to create a new analog/digital waveform or modify an existing waveform.
The AT-AWG-GS has two analog outputs and up to 32 digital channels that the user can configure according at his needs.

1. Use the Waveforms TAB toolbar buttons to create a New Mixed / Analog / Digital Waveform .
   PLEASE NOTE THE FOLLOWING:
   - The *Mixed Waveform* is the easiest way to create a new entry for the Sequencer because it inserts in the same entry both analog and digital channels correctly formatted.
   - If you want to modify an existing waveform you can double click it on the *Waveforms TAB* to open **the Editing Waveform** window.

2. The **New Waveform** window is shown. Type the name of the waveform and choose the samples length. You can insert the Length in *Samples* or *Time*.Click **OK** to confirm.

3. The **Editing Waveform Window** is shown. Numbered callouts on this image correspond with the following interface section descriptions.

   1. **Analog/Digital Waveform Graph Tools**
   2. **Mixed Signal Waveform Editor**
   3. **Data Editor**



Waveform Graph Tools

When viewing a waveform in the Waveform Editor, AT-AWG-GS main toolset is provided and gives you access to the following functions:

	*Cursors/Tools TAB:* This button allows changes the mouse function for the graphic area to cursors/markers movement.
	*Cursors/Tools TAB:* The hand tool allows you to dragging inside the graph area.
	*Waveforms TAB:* Auto zoom in function.
	*Waveforms TAB:* Auto zoom out function.
	*Waveforms TAB:* This button allows zooming in on a selected rectangle of the graph. Click and drag inside the graph area to create your zoom rectangle.
	*Waveforms TAB:* This button resets all activated zooms
	*Cursors/Tools TAB:* You can change the properties of the graph display area. Click the **Waveform View Settings** button and the **Graph Property** screen is shown.

Changes can be made as follows:

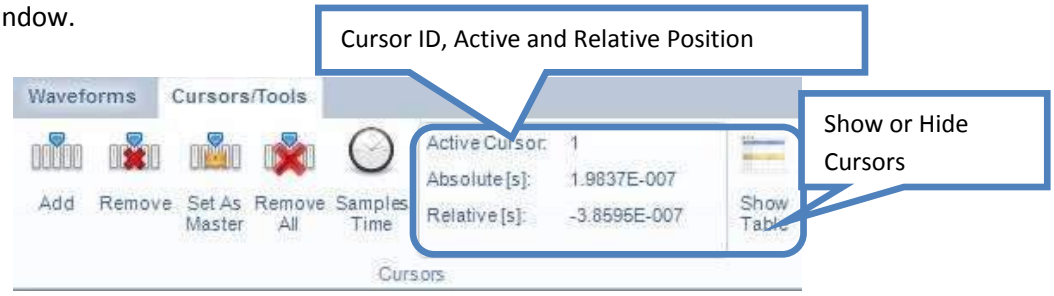
- The **Background Color** can be changed as desired.
- Change colors and turn the **Major** and **Minor Grids** on or off and change their line coloring.
- **Cursor Position** indicators can be turned on or off.

This button switches the X-axis representation between **number of samples** to **seconds**. Default values are optimized based on the selection made.

Cursors

Cursors are useful to identify and enlighten waveform data for improved organization and viewing.

Clicking the Cursors Markers button on the *Editing Waveform main toolset* shows or hides the marker window.



Other field values on the toolbar show the **Active** (or ID) of the currently selected cursor, and its **Absolute** and **Relative** positions.

When Cursors are turned on, all of the cursors present in the *Waveform Editing Window* are listed inside the **Cursor** screen.

Master	Id	Abs Pos	Rel Pos	Sync
	0	409.60...	0	
	1	409.60...	0	
	2	675.02...	265.420...	
	3	174.48...	-235.11...	
	4	409.60...	0	

The **Master Cursor** is the one labeled with the following icon.

Relative positions are calculated from the master cursor position.
The master cursor automatically moved during a data search operation to show relative results.
Change the master cursor by selecting the new marker in the cursor window and clicking the Master Cursor icon in the *Waveform Editing Window* toolbar.

Cursor screen columns show the progressive cursor identifiers, the absolute time position (the time distance between the cursor position and the start of the acquisition) and the relative time position (the time distance between the cursor and the master cursor). Any time one of the cursor is moved, all the values are automatically updated and shown.

The following functions are used on Cursor.

	The **Add** button puts a new **cursor** in the visualization area.
	The **Remove** button eliminates the marker selected in the Cursor screen.
	Move a marker by clicking and dragging a selected cursor.
	Remove all cursor by clicking the **Clear all cursor** button.

PLEASE NOTE THE FOLLOWING:

- You can also perform many of the aforementioned functions by right clicking inside the Cursor screen and choosing from the list of functions shown.
- You can remove all cursors except for one.
- You can create as many cursors as needed.

Go To a Selected Target

The Go to field on the *Editing Waveform main toolset* contains multiple functions on its right side drop-down. The functions allow you to select the position where the master marker is going to be moved within the visualization area.
The Go to functions include:

	**Go to time** - Moves the master cursor to the time position specified in the text field to the left of the control.
	**Go to start samples** - Moves the master cursor and visualization area to the start of the acquisition.

	Go to end samples - Moves the master cursor and visualization area to the end of the acquisition.
	Cursor n - Centers the visualization area on the cursor/marker n (position specified in the text field to the left of the control).
	You can move the selected cursor to the middle of the current visualization by clicking the **Move active cursor here** button.

Search

Searching can be done from the *Editing Waveform Window*. It also is available in the aforementioned search section regarding the **Waveform View** screen.
You can search for a specific bus, signal, rising, or falling edge value.

Activate the search option by clicking the **Search Settings** button .
The *Search Settings* window is shown and used to provide your search criteria

In the **Signal Type** search list on the right side of the Search Settings window, all defined analog/digital signals and busses are shown. Select the signal or bus and then provide a specific value for the search.

> **Note**: Depending on the Signal Type selected in the search list, the **Compare** and **Value** fields contains different options.

Use the Compare field to select between the following search logic operators:

- **=** or **Is** - Find the equivalent value.
- **!=** or **Is not** - Find the unequal value.
- **>** - Find values greater than the one specified (on digital channels only available if a bus is selected).
- **<** - Find values less than the one specified (on digital channels only available if a bus is selected).

On digital channels use the **Value** field to provide the specific value or edge on which to search. If one channel is selected, the **Value** field has the following options:

- **0** - Searches for a logic **0**.
- **1** - Searches for a logic **1**.
- **Rise** - Searches for a Rising Edge trigger. 
- **Fall** - Searches for a Falling Edge trigger. 
- **Change** - Searches for any trigger edge. 

The **From Start** button can be used to specify where the search starts within your data generation. Possible options include:

- **From Start** - Starts the search from the beginning of the waveform.
- **From End** - Starts the search from the end of the waveform.
- **Master Marker** - Starts the search from the Master Marker position.

Select criteria on the Search Settings screen and click the **OK** button. The results are then shown on the **Editing Waveform Window**.
Use the **Search Backward** or **Search Forward** buttons to navigate through your search results.

> **Note**: As you navigate through your search results, the master cursor is updated to the subsequent values in your results.

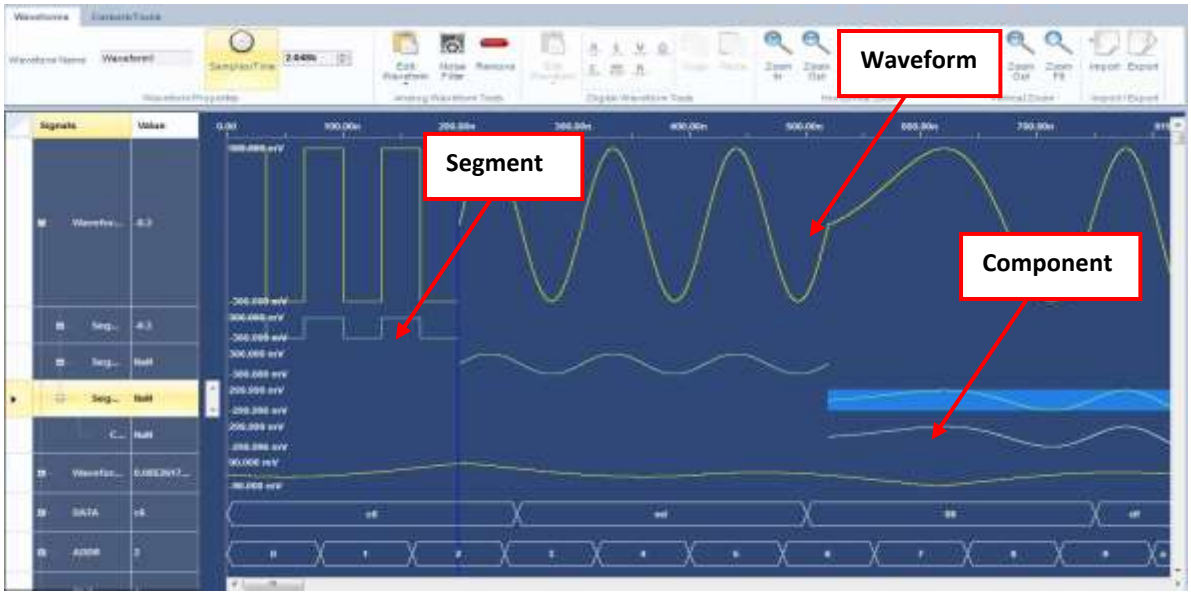
Analog Waveform Graph Tools

AT-AWG-GS handles Analog Waveforms, Segments, and Components in the following manner.

Analog Waveform

An analog waveform is a sequence of elementary segments and it contains the temporal order by which the segments are generated.
You can add a standard waveform simply by pressing the **Edit** button and choose a basic waveform like DC Level, Sine, Increase Ramp, Triangle, Sawtooth, Rectangle etc. The AT-AWG-GS software will display a waveform made of one segment.
If you need to generate more advanced waveforms, you should add more segments to your

waveform (see section on page 74).



Segment

A Segment contains one or more Components, all of the same length, combined by means of the elementary Add, Subtract, Multiply, Divide operations.

Component

A Component is the basic element for the construction of a Segment. Each Component may be represented by a standard waveform (DC Level, Sine, Cosine, Exponential, Triangle, Rectangle, Ramp, Pulse, Sync, Sawtooth, Sweep), by a Formula, or its component samples can be loaded from a text file.

In any case, the samples of a Component are calculated/loaded as a function of the AT-AWG-GS frequency (sample rate) and of the length of the component itself (number of points).

	This button allows changes the waveform length. Click on the Samples/Time button to change the waveform length visualization from samplers to time. **PLEASE NOTE THE FOLLOWING:** • In Arbitrary Mode the allowed waveform length is 64 to 64M samples in multiple of 64 for < 320 samples or in multiple of 16 for >= 320 samples. • In DDS Mode the allowed waveform length is 8 to 8M samples in multiple of 8. • All segments and components will be re sampled.
	*Vertical Zoom Auto scale* function for the selected analog waveform.
	*Vertical Zoom Auto zoom in* function for the selected analog waveform.

	*Vertical Zoom Auto zoom out* function for the selected analog waveform.
	Press the **Edit** button to open the *Waveform Standard Editor Window* and create a basic waveform like DC Level, Sine, Increase Ramp, Triangle, Sawtooth, or Rectangle. Click the arrow to open the pop-up menu: select the standard waveform (Sine, Triangle, Square,etc.) as short-cut for the Waveform Standard Editor Window.
	Press the **Remove** button to remove the selected Segment / Component of the waveform. This button is active only if more than one segment/component exists in the current waveform.
	Right-click on the Waveform/Segment/Component to open the context menu. Select **Properties** to open the waveform/segment properties window and change the waveform display parameters like color, plot height or resize the segment length. 
	Press the **Effect** button to open the *Effects Settings and Parameters* window and add noise, filtering to your analog waveforms.

Waveform Standard Editor Window

Press the **Edit** button and the Waveform Standard Editor Window is shown.

This window allows editing standard waveforms, segments and components parameters.

The **Type** menu allows selecting the waveform among a list of possible signals or functions. Depending on the selected Type, different parameter may be edited. The different possibilities include the following:

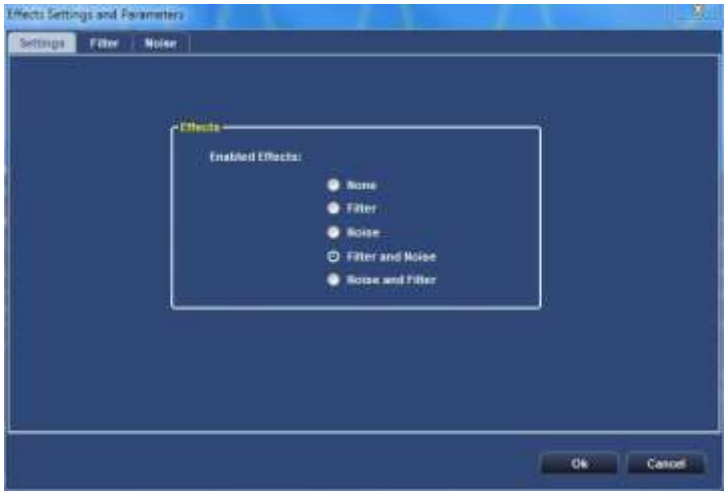
Type	Available Parameters
DC Level	Offset [V]
Sine	Frequency[Hz/cycles], Amplitude[V], Phase[°], Offset[V]
Cosine	Frequency[Hz/cycles], Amplitude[V], Phase[°], Offset[V]
Triangle	Frequency[Hz/cycles], Amplitude[V], Phase[°], Offset[V]
Rectangle	Frequency[Hz/cycles], Amplitude[V], Phase[°], Offset[V], Duty Cycle [%]

Saw tooth	Frequency[Hz/cycles], Amplitude[V], Phase[°], Offset[V]
Increase Ramp	Amplitude[V], Offset[V]
Decrease Ramp	Amplitude[V], Offset[V]
Pulse	Amplitude[V], Delay[s], Width[s], Offset[V]
Sinc	Amplitude[V], Offset[V], Peak Position[s], Lobe Width[s],
Exponential	Frequency[Hz/cycles], Vo[V], Vinf[V], Time Constant[s]
Sweep	Amplitude[V], Offset[V], Start Frequency[Hz], Stop Frequency[Hz]
Formula	Calculator Window
From File	Explorer Window
Custom	Insert the sample values by editing the table entries 
Composite	It indicates the waveform is made of the composition of multiple segments and/or components.

The Formula type allows defining the waveform by means of a mathematical expression.
The waveform is edited by using the Formula Editor window that can be activated by clicking the Edit Formula button. The mathematical expression can be a function of time or a function of samples by using the **t** or **x** variables, respectively. The software verifies, in run time, that the component to be edited does not exceed the limits for the selected output and that the formula syntax is correct. In case of error, an error indication is shown in the Error message indicator.

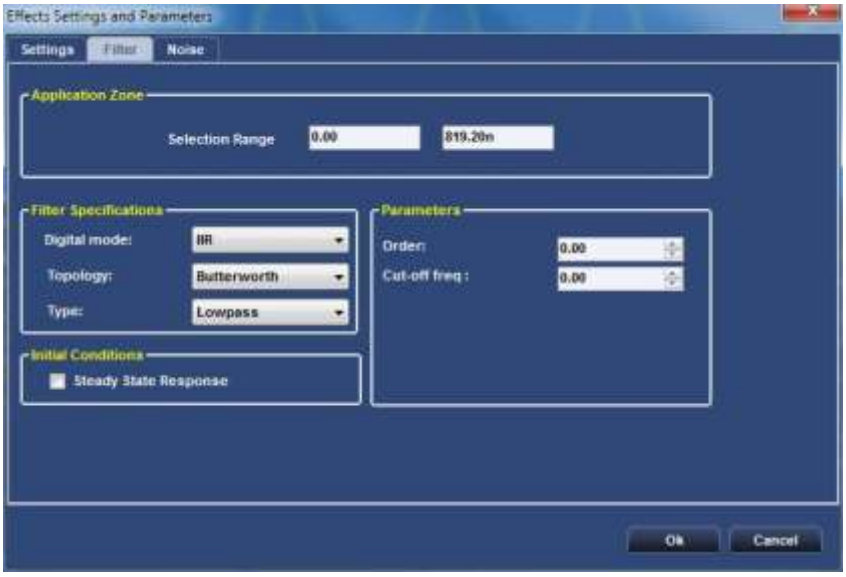
Effects Settings and Parameters Window (Analog Waveforms Only)

Press the **Effect** button and the *Effects Settings and Parameters Window* is shown.
On the *Settings* Tab for each waveform you can select to add a noise effect, a filter, noise then filter (noise and filter), filter then noise (filter and noise) .



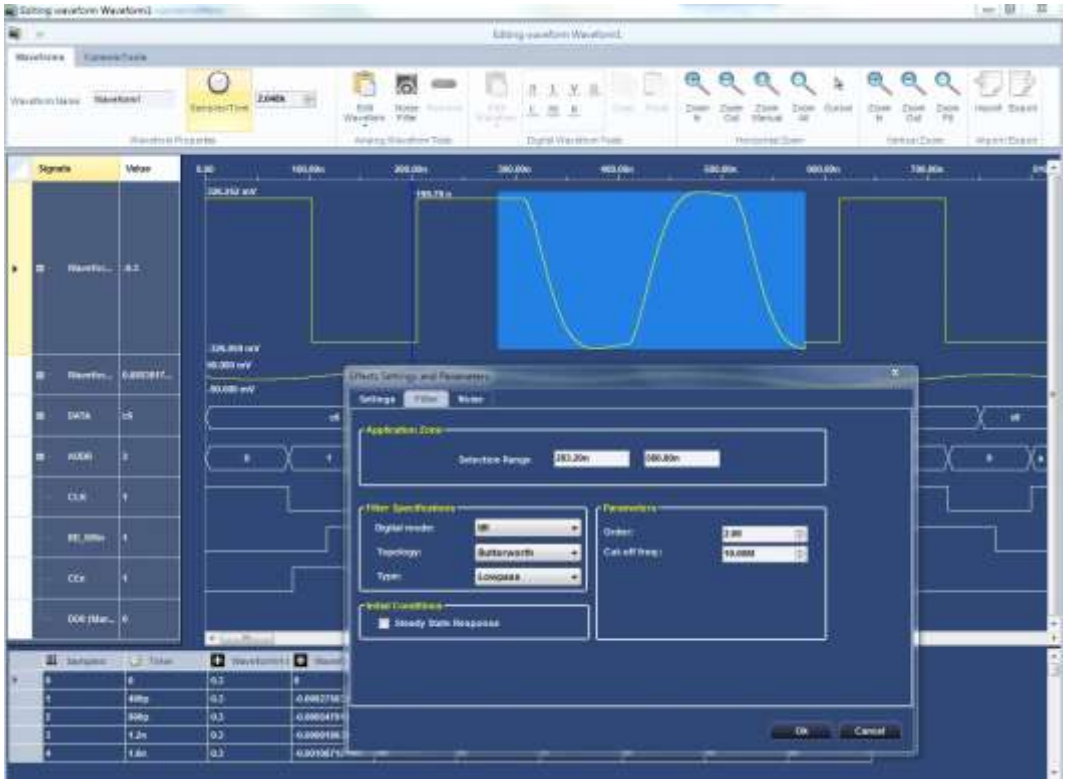
Filter Settings TAB

This tab allows applying a digital filter to the selected waveform.



FILTER

This section allows selecting whether the digital filtering is to be applied to the entire waveform or to a limited part.
If you click on the waveform name in the *Analog Waveform Graph* Viewer/Editor, the selection range indicators will display the entire waveform limits.
If you need to apply the filter to a limited part, click and drag inside the graph area to create a rectangle delimiting the waveform section to be filtered. Their position is shown in the same Application Zone section.



FILTER Specifications

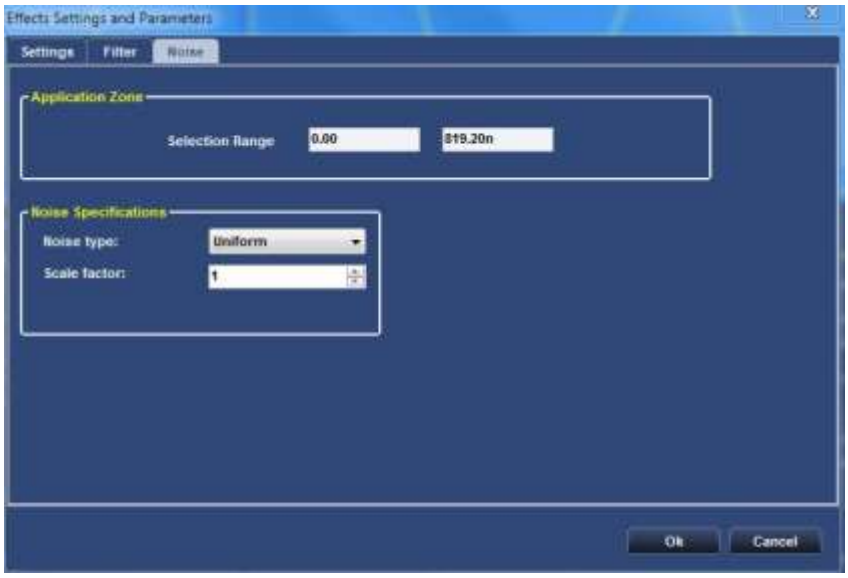
This section allows setting all the characteristics of the filter.

- **Digital Mode IIR (Infinite Impulse Filter)** - Bessel, Butterworth, Chebyshev, Inverse Chebyshev, and Elliptic.
- **Digital Mode FIR (Finite Impulse Filter)** - EquiRipple, Kaiser, and Windowed.
- **Type** - Low Pass, High Pass, Band Pass, Band Stop, and General.
- **Initial Condition** – Steady State Response means the output is in *steady-state*, since the input has fully engaged the filter.

Type, Topology and filter Order options depend on the specific filter characteristics.
Click the **OK** button and the set filtering options are applied to the waveform. A preview of the filter/noise effects on the waveform is shown in the graph area.
You can remove a filter by clicking the current waveform and selecting the **None** option on the Setting tab.

NOISE Settings TAB

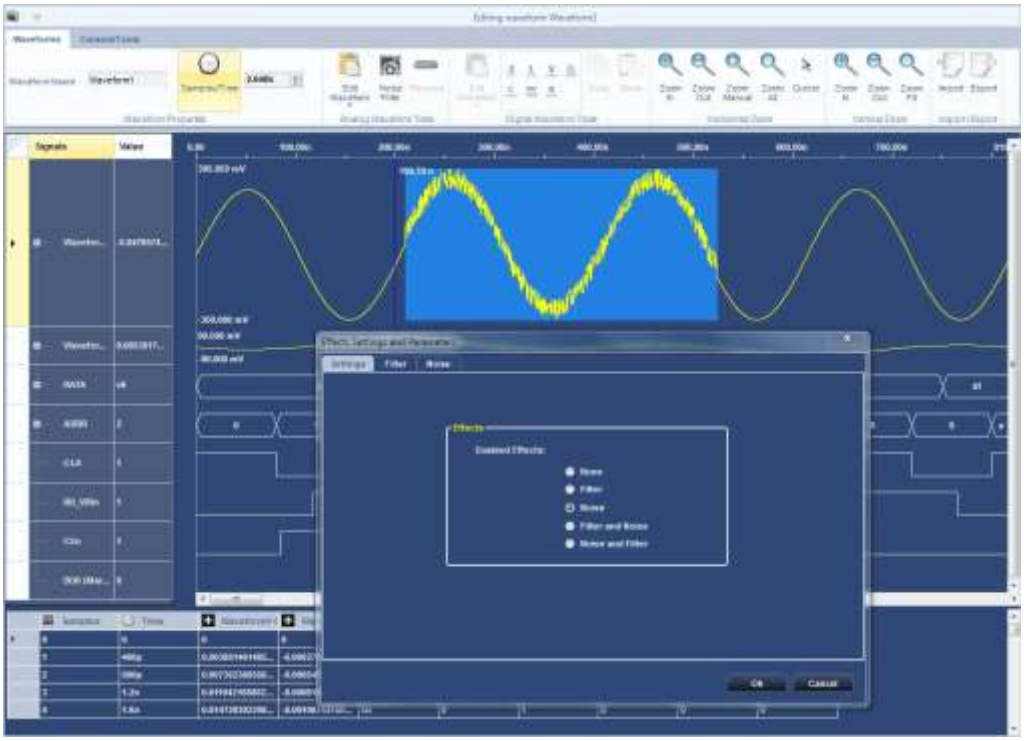
This TAB allows applying a digital noise to the selected waveform.



The Noise setting tab is divided into Application Zone, Noise Specification, and Parameters sections.

NOISE Application Zone

This section allows selecting whether the digital noise is to be applied to the entire waveform or to a limited part of it.
If you click on the waveform name in the *Analog Waveform* Editor, the selection range indicators will display the entire waveform limits.
If you need to apply the noise to a limited part, click and drag inside the graph area to create a rectangle delimiting the waveform section. Their position is shown in the same Application Zone section.



NOISE Specifications

This section allows setting all the noise characteristics.
Noise Type - Use this drop-down to select the noise type applied to the waveform. Options include **Gaussian**, **Uniform**, and **White**.
Depending on the selected noise type, specific parameters (**Standard Deviation** or **Amplitude**) are enabled together with the **Scale Factor** field, for increasing/decreasing noise intensity.
Click the **OK** button and the noise options set are applied to the waveform. A preview of the noise effects on the waveform is shown in the graph area.
Remove a filter by clicking the current waveform and selecting **None** on the **Settings** Tab.

IMPORT/EXPORT of Analog Waveform

The Import/Export file format for analog waveforms is a comma separated value file (only one column) where the column represent the samples of the selected analog channel.
The first two rows of the exported file is a header that represent the sample rate and the number of samples (# Sample rate: 2500000000 # Samples: 2048).
The exported values representation is double.

Select the analog waveform and press the Import  or Export  button to import/export the values associated to all the digital lines.

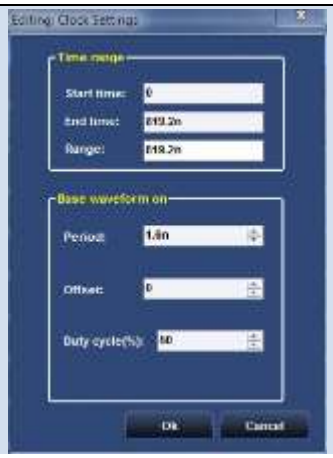
Please note that the import/export functions can become slow with large amount of data to import or export.

Please go to page 141 of the manual for import usage example.

Digital Waveform Graph Tools

This toolbar contains several commands for use on digital waveforms as follows:

	Signal/bus to 0.
	Signal/bus to 1.
	Signal/bus to Arbitrary Value. Arbitrary Value allows overwriting a node value over the selected waveform, waveform interval, or across one or more nodes or groups. Overwrite a node value using the following steps: 1. Select a node or a bus and click the **Value** button on the Digital Editor toolbar. The **Arbitrary Value** dialog box appears.  2. In the Radix list, select the radix type. 3. Specify the new value you want overwritten in the Numeric or named value box. 4. Click OK.
	Clock Editor for selected signal. The Clock feature can be used to automatically generate the clock wave, rather than drawing each clock triggering pulse. The start and end time of a clock signal can also be selected.



Counter Editor for selected bus.
The counter editor applies a count value to a bus which increments the value of the bus by a specified time interval.

Instead of manually editing the values for each node, the Counter editor automatically creates the counting values for buses.

You can also specify a starting value for a bus and the time interval for increments.

Random Value for signal/bus.
Random Value allows generating random node values over the selected waveform, waveform interval, or across one or more nodes or groups.
Random node values can be generated for each grid interval, a specified time, or at fixed intervals.

	
	Invert signal/bus value.
	Copy Waveform. Select the entire waveform clicking on the signal/bus name on the left column or select a portion of it with mouse selection. Press the **Copy Waveform** button to copy the waveform.
	Paste Waveform. Paste the copied waveform into a selected area of the graph (mouse selection) or from the start of another waveform.

IMPORT/EXPORT of Digital Waveforms

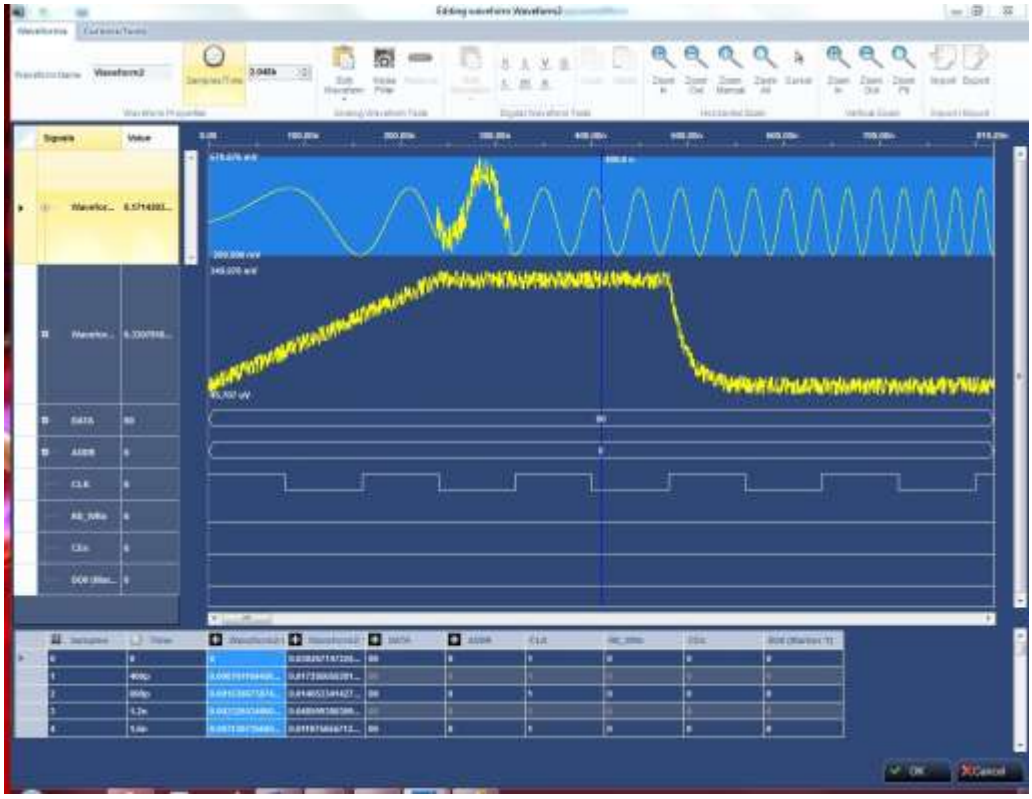
The Import/Export file format for digital waveforms is a comma separated value file where each column represent the samples of one digital channel.
The first row of the file is a header that represent the number of the digital channel (#0,#1,#2……..,#15) associated to the logical name.

Select a digital line and press the Import  or Export  button to import/export the values associated to all the digital lines.

Mixed Signal Waveform Editor

The **Mixed Signal Waveform Editor** screen is used to create or edit *analog* and *digital* waveforms in a graphic or tabular format.
Single signals are visualized as analog or digital signals, while grouped signals are

represented as buses.



Analog Waveform Editor

Depending on Arbitrary or DDS project type mode, edited waveforms acquire different meanings.

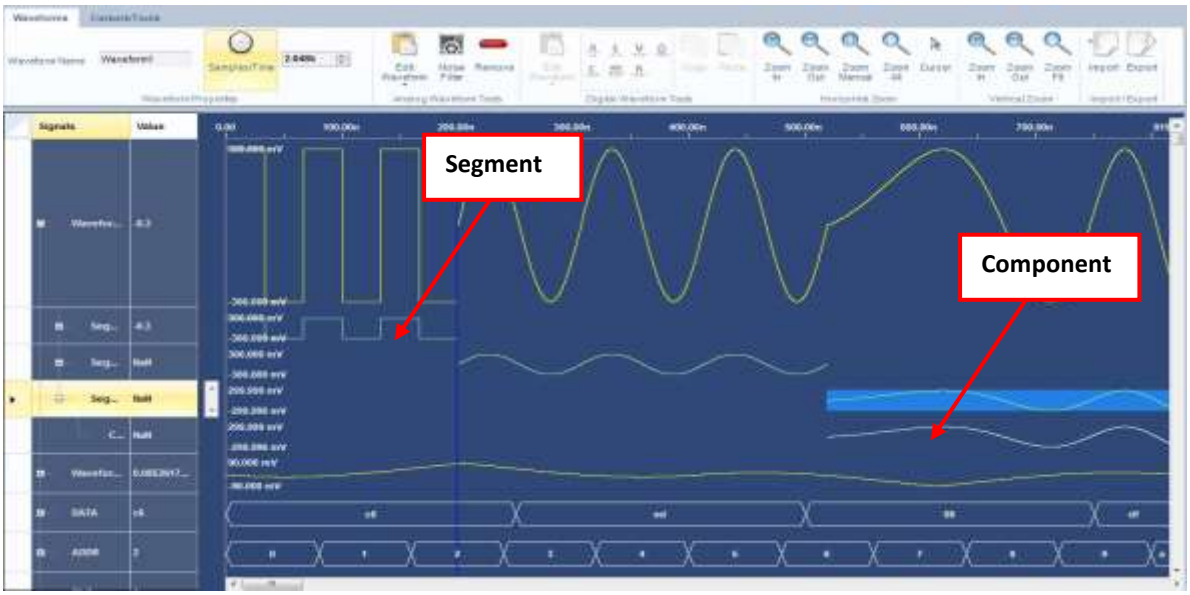
- **Arbitrary** - Edited waveforms can be generated as they have been set.
- **DDS** - Edited waveforms represent the *Modulation Law Waveform*.

Think of a waveform as a list of **Segments**, where each segment can contain one or more **Components**, all of the same length, combined by means of the elementary Add, Subtract, Multiply, Divide operations.

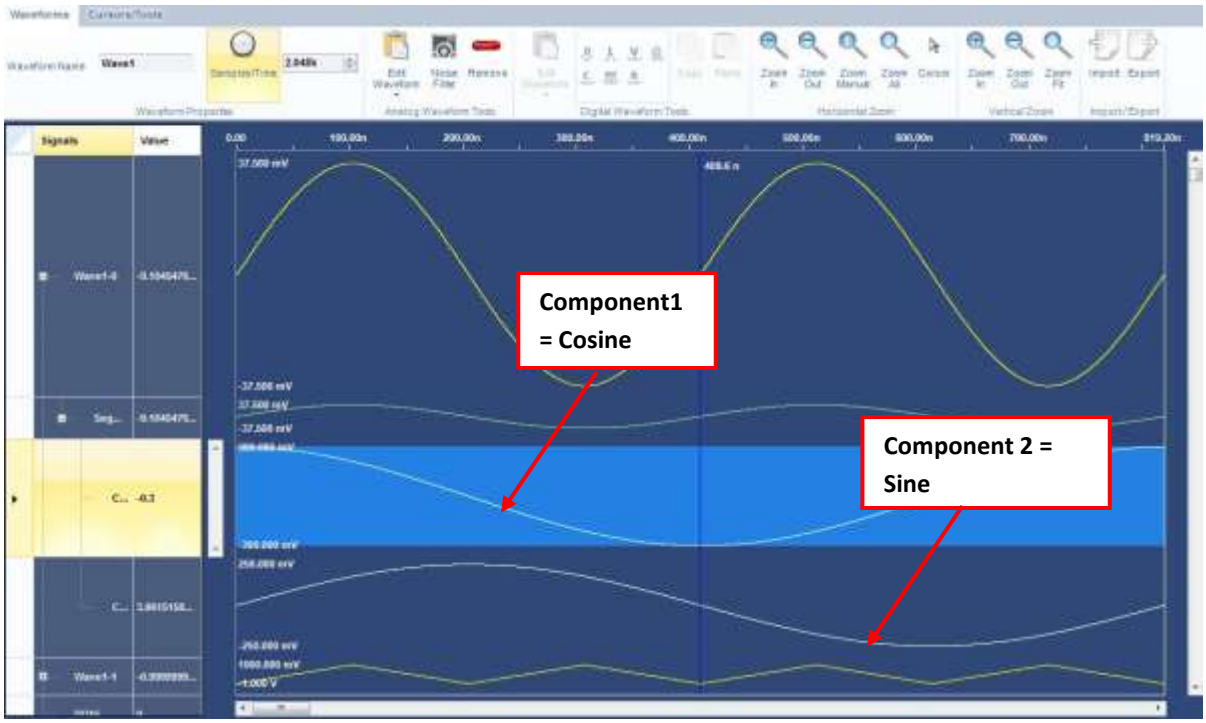
Each waveform may be constituted by an arbitrary number of segments and each segment can have its own length.

PLEASE NOTE THE FOLLOWING:

- The maximum number of samples for all waveforms is fixed in Arbitrary Mode is 64M. In DDS mode, the maximum number is 8M samples.
- In Arbitrary mode each waveform must be constituted by a multiple number of samples of 64 for <320 samples length or in multiple of 16 for >= 320 samples.
  In DDS mode each waveform must be constituted by a multiple number of samples of 8.



The waveform in the picture above is the composition of four segments. Each segment is made of one component.



The waveform in the picture above is made of one segment. The segment is the composition of two Components multiplied together: Segment1 = Component1 * Component2.
You can use this technique for example to generate **IQ** modulated signals.

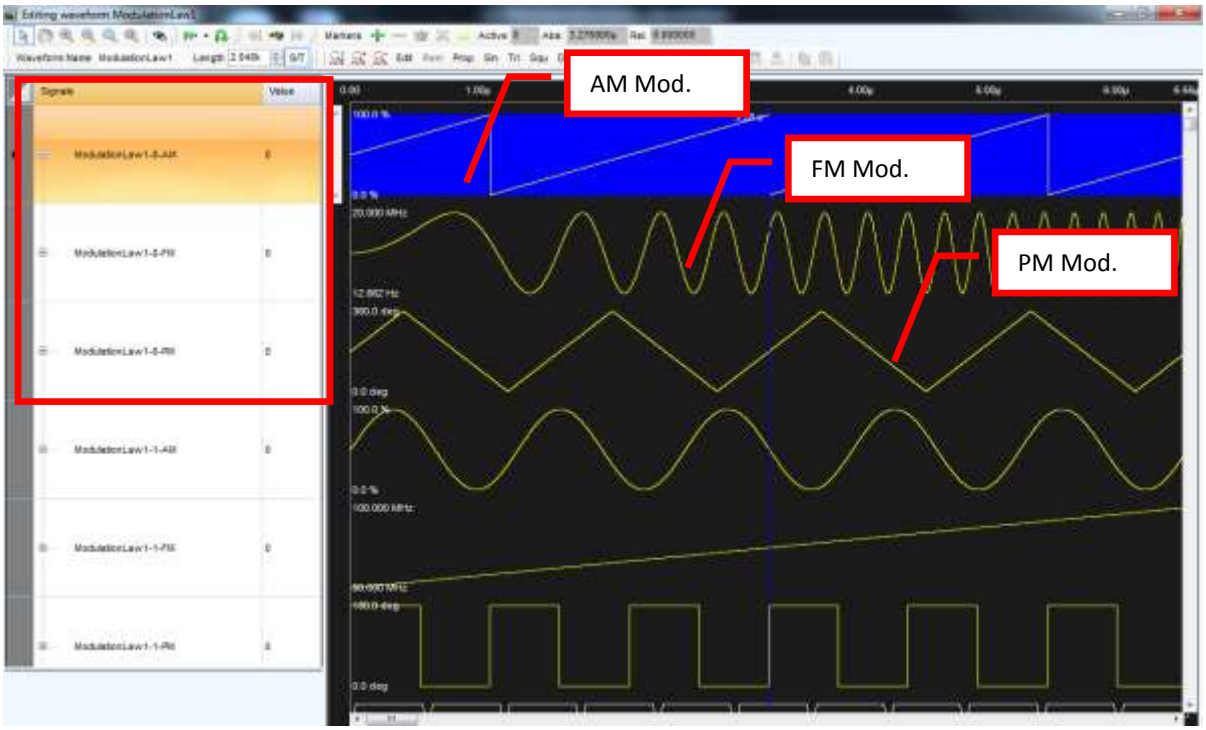
In **DDS mode** the Mixed Waveform Editor can contain up to three modulation law waveforms per channel: AM, FM and PM Modulation Law you can use to obtain powerful modulated signals.

Modulation Type (DDS Mode only)

- **Amplitude (AM)** - The samples constituting the Modulation Law waveform may assume values between -200% and +200%.These values are the multiplying factors of the signal carrier amplitude.
- **Frequency (FM)** - The samples constituting the Modulation Law waveform may assume values between 18µHz to 600 MHz.The window allows setting the time/frequency behavior to be assumed by the carrier signal. The maximum frequency depends on the selected waveform.
- **Phase (PM)** - The samples constituting the Modulation Law waveform may assume values from 0° to 360°.The window allows setting the phase shifts to be assumed by the carrier signal and the time instants at which they occur.

The carrier signal is generated at a frequency set by the sampling clock (2.5 GHz if internal).
PLEASE NOTE THE FOLLOWING:

- You can enable or disable AM,FM,PM modulation by turning on/off the leds on the Settings-Analog Ch TAB; if you disable a modulation (entering in manual modulation), the corresponding Modulation Law waveform will disappear from the Sequencer and from the *Editing Waveform Window*.



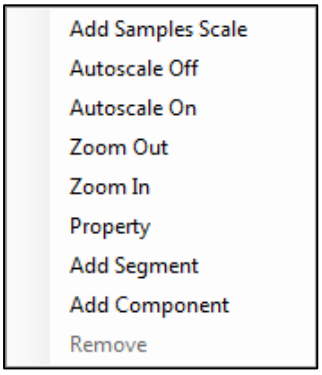
Common operations can be directly performed on waveforms, segments and components (**Selection**, **Left Click**, **Right Click**). Drag and Drop operation between analog waveforms is not allowed.

LEFT CLICK AND SELECTION

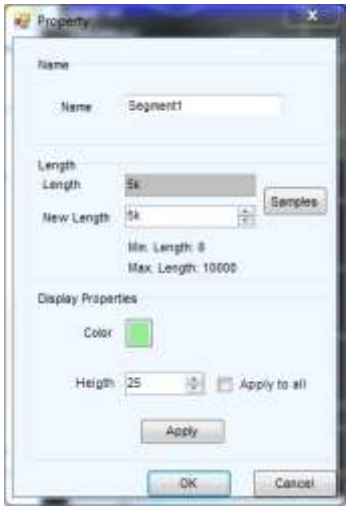
- Left Click on the analog *Signals cell* to select the entire waveform that will be enlightened in blue.
- Click and drag inside the graph area to create a rectangle delimiting the waveform section. You can add *Effects* on the selection.
- Left Click on the Signals cell tree item to open/close the Segments of the waveform.
- Left Click on the Segment tree item to open/close the Components of the single segment.
- Resize the signal amplitude by dragging the line between a signal name cell.
- To the right of every analog signal, a number indicates the value the signal at the time position of the master cursor.

RIGHT CLICK

A Right Click on a Waveform tree item activates a pop-up menu, with functions depending on a Waveform or Segment selection as follows.



- **Add Samples Scale** - Select this option to add a signal with a series of segments that represents the number of samples.
- **Autoscale Off** – Select this option to disable the waveform auto scale; it will appear a vertical scrollbar on the right side of the Signals cell you can use to scroll up and down the selected waveform.
- **Autoscale On** – Enable the auto scale function .
- **Zoom Out** - Auto zoom out function.
- **Zoom In** – Auto zoom in function.
- **Add Segment** – To add a segment you have to increment the waveform length or resize/delete the existing segments.
  For example if you have a 10k samples waveform made of one segment and you need to add a second segment to it, you can perform the following operations:
  - Right click on the existing segment to activate the pop-up menu and select *Property*. The Segment1 Property window is shown: resize the Segment1 length from 10K to 5K.

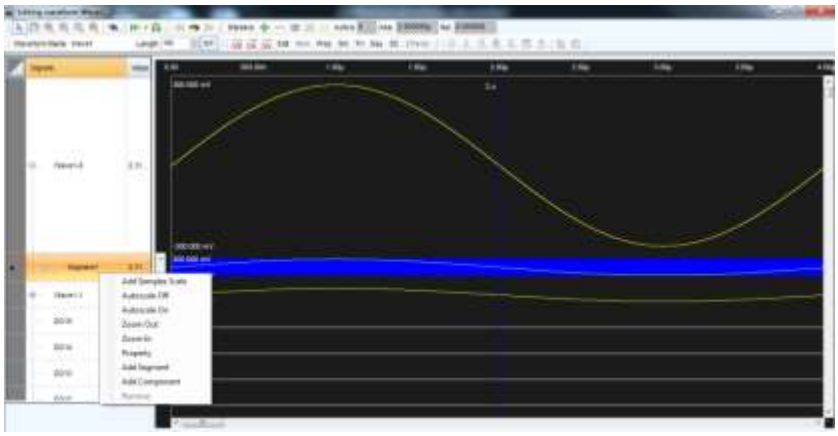


- Right click on the Waveform or on the existing Segment to activate the pop-up menu and select Add Segment.
  The Segment2 Property window is shown, insert the new segment length and press OK to add it to the waveform.
  PLEASE NOTE THE FOLLOWING:
  If you select the *Add Segment* option from the Segment pop-up menu, the new one will be added at the end; if you select the *Add Segment* option from the Waveform pop-up menu, the new one will be added at the beginning.
- **Add Component –** Add a Component at the selected Segment.
- **Remove –** Remove the selected Segment or the Component.

How to create an Advanced Analog Waveform

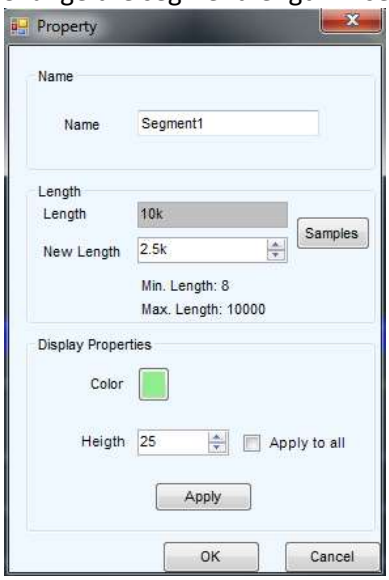
- Follow the steps 1-6 of the Arbitrary Mode Single Sequencer Setup Example on page 31
- The **New Waveform** window is shown. Type the name of the waveform "Wave1" and choose 10k for the samples length of the waveform. Click **OK** to confirm.

- The **Editing Waveform Window** is shown. Right click on Segment1 of the Wave1-0 to open the pop-up menu.

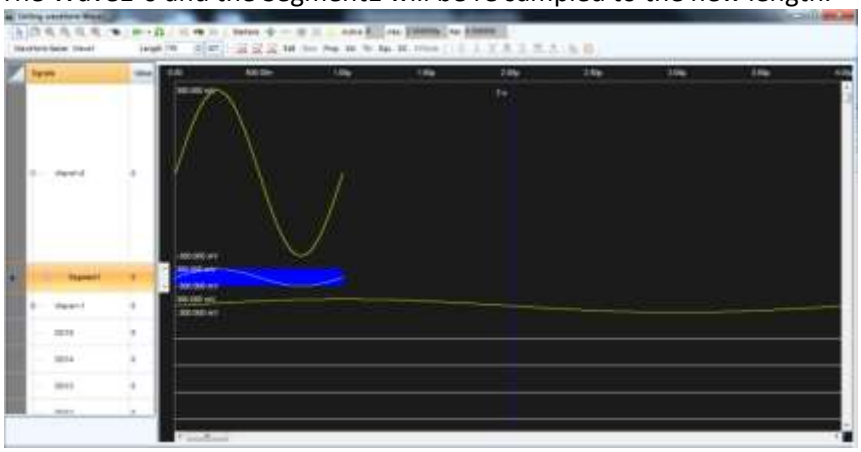


Select **Property** on the pop-up menu.

- Change the segment length: insert 2.5k in the New Length field.



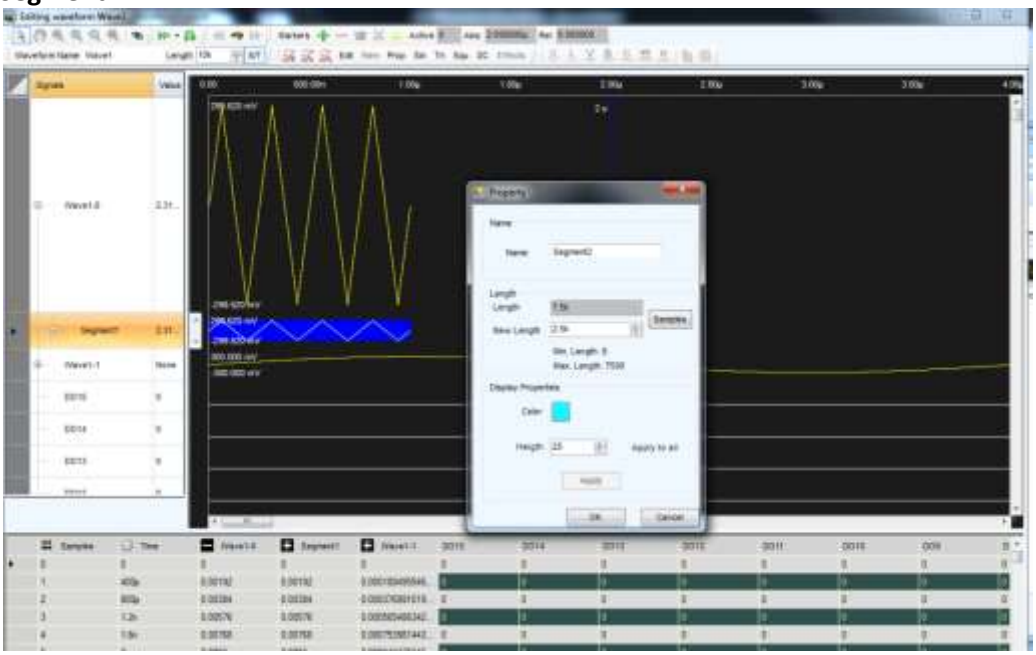
- The Wave1-0 and the Segment1 will be re sampled to the new length.



- Select the Segment1 and click the **Edit** button on the toolbar.
- The Standard Waveform Editor window is shown.

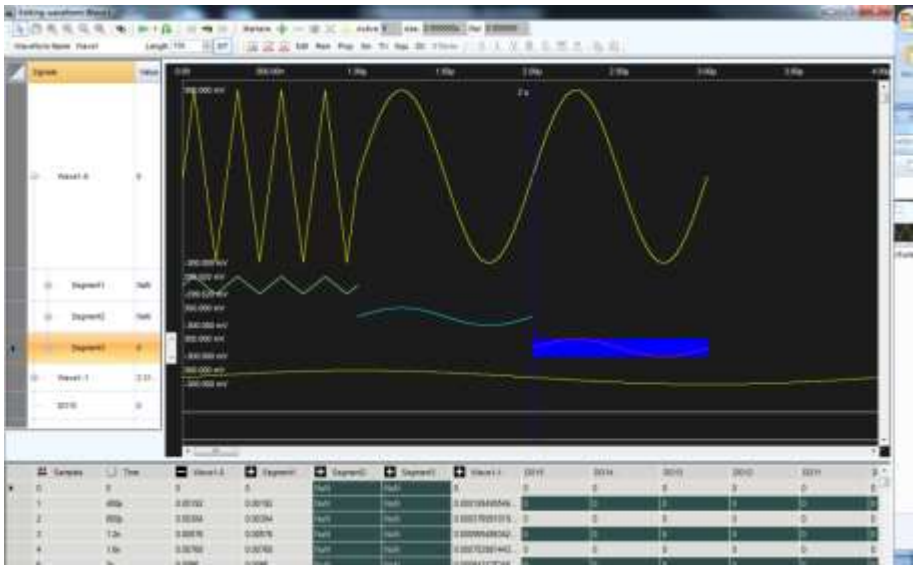
Select Triangle as waveform Type and 4 as number of Cycles.
Click **OK**.

- Right click on the Segment1 of Wave1-0 to open the pop-up menu and select **Add Segment**.

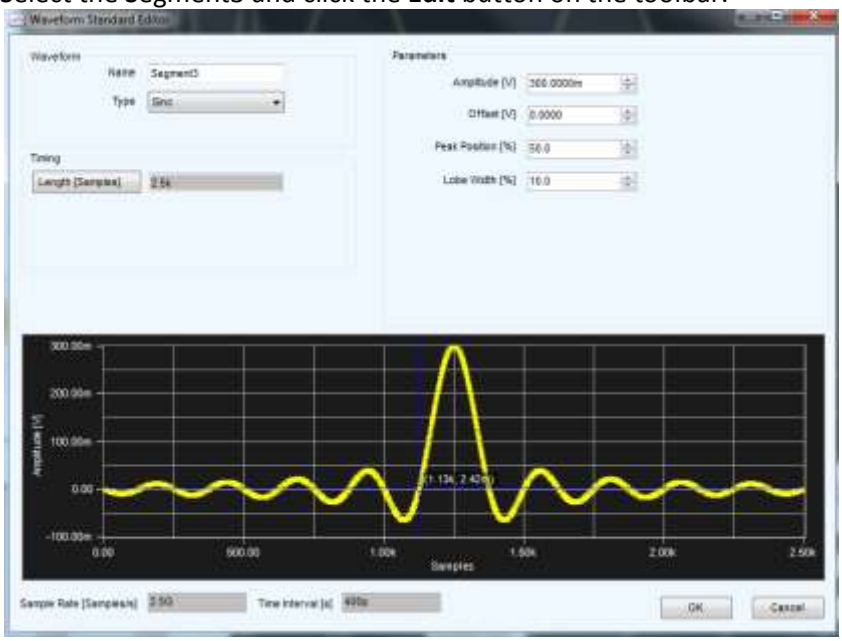


The Property window is shown. Select 2.5k as Segment2 length and change the color.
Click **OK**.

- Right click on the Segment2 of Wave1-0 to open the pop-up menu and select **Add Segment**.
  The Property window is shown. Select 2.5k as Segment3 length and change the color.
  Click **OK**.



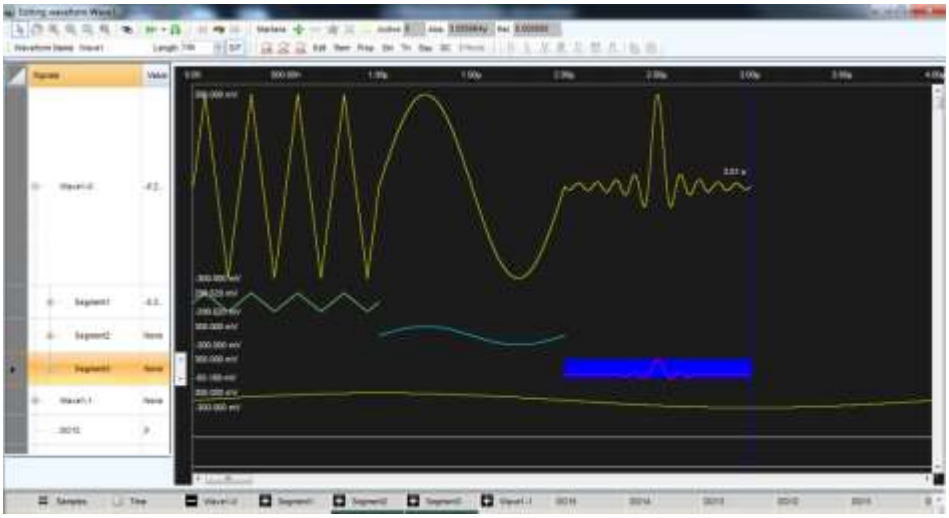
- Select the Segment3 and click the **Edit** button on the toolbar.



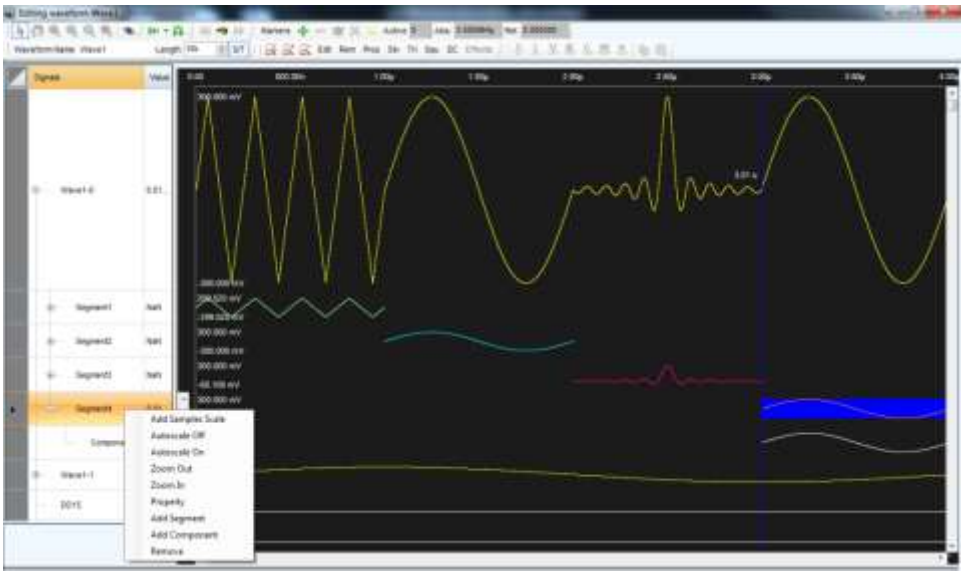
The Waveform Standard Editor is shown. Select Sinc as waveform Type. Click **OK**.

- Right click on the Segment3 of Wave1-0 to open the pop-up menu and select **Add Segment**.

  The Property window is shown. Select 2.5k as Segment4 length and change the color. Click **OK**.



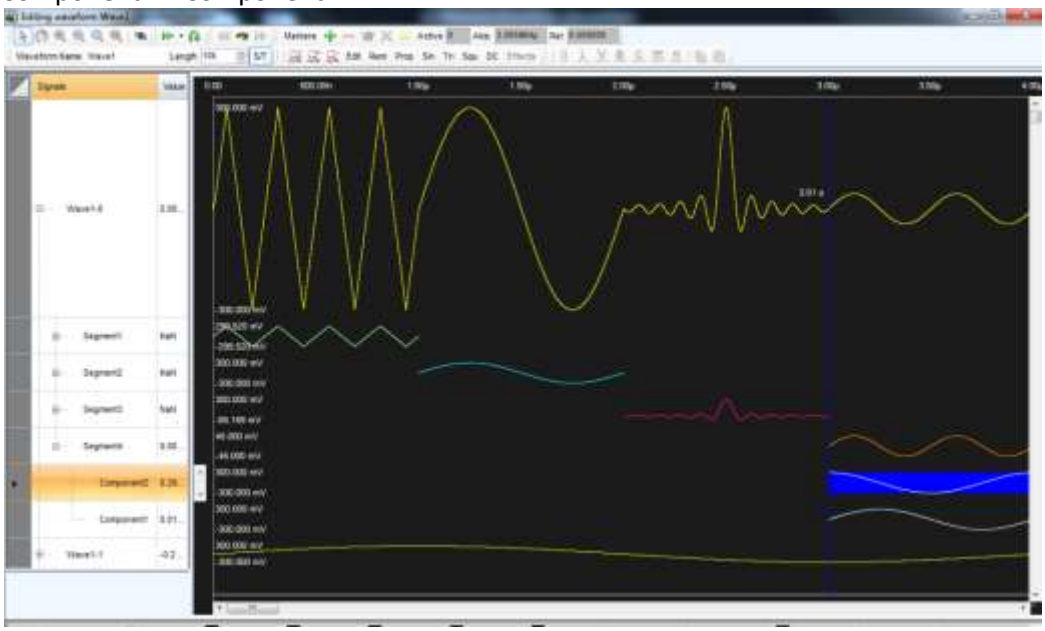
- Right click on the Segment4 of Wave1-0 to open the pop-up menu and select **Add Component**.
  The Property window is shown. Select 2.5k as Component2 length.
  Click **OK**.



- Select theComponent2 and click the **Edit** button on the toolbar.
- The Standard Waveform Editor window is shown.

Select **Cosine** as waveform Type and **Multiply** as Operation.
Click **OK**.

- The Segment4 is the composition of two Components multiplied together: Segment4 = Component1 * Component2.



- The **Advanced Waveform** is ready to use and can be inserted in the Sequencer.

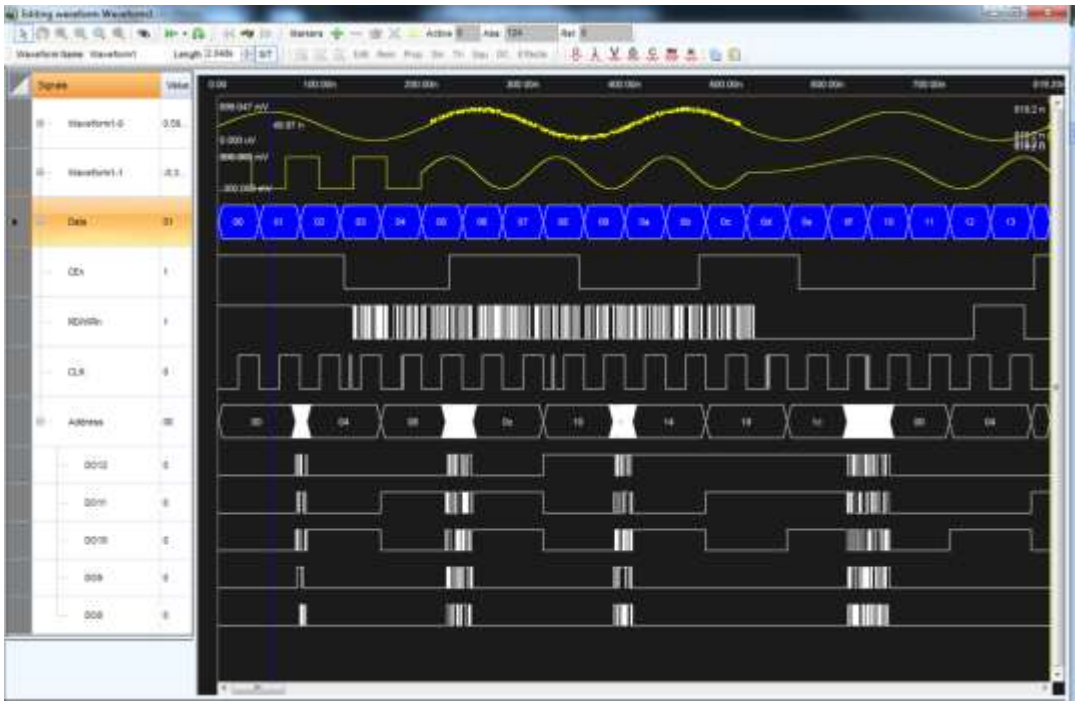
Digital Waveform Editor

AT-AWG-GS can be configured to work as a powerful Digital Pattern Generator.

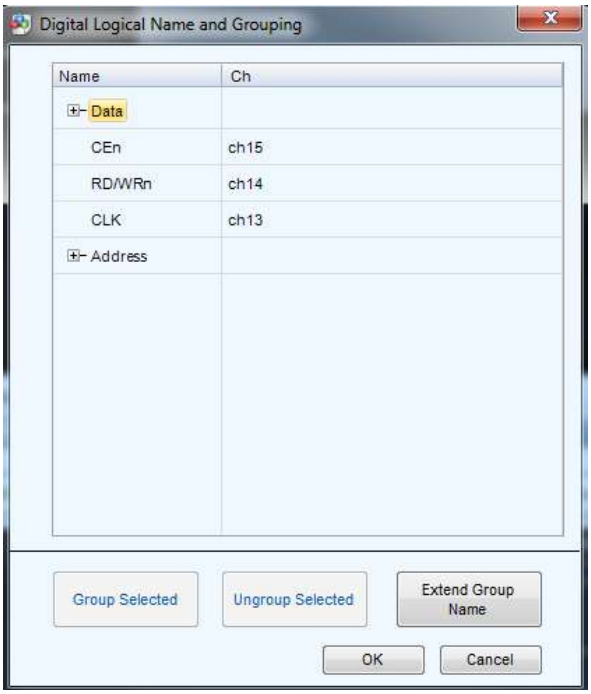
In this working mode AT-AWG-GS provides the capability to emulate standard serial or parallel bus transitions or custom digital interfaces for system debugging and characterization.

PLEASE NOTE THE FOLLOWING:

- The vector memory depth is 32Mpoints /Ch.
- In Arbitrary Mode the maximum update rate is 1.25GS/s on 16 channels projects and 625 MS/s on 32 channels projects.
- In DDS Mode the maximum update rate is 312.5 MS/s on 32 channels.
- Alignment between Digital and Analog Channels: by using the de skew controls on the *Settings Tab* (on page 45) it is possible to realign the analog channels with a resolution of about 10ps and the digital channels with a resolution of about 78ps.



Single signals are visualized as digital signals, while grouped signals are represented as buses. When you create a New Mixed or Digital Waveform you have single digital signals at your disposal; the number and the names of those signals depend on the initial Project setup.
You can change the name of the signals and create / rename buses pressing the **Logical Name Definition** button on the main software toolbar.



The *Digital Logical Name and Grouping Window* is shown.

- The first column displays the digital channels logical names that can be assigned by the user.
- The second column displays the *digital pod channel* that it is associated to the *digital logical name*.
  "Connected" means that the Digital Probe is connected to the digital channel.
- The third column displays the device name associated to the digital channel.
- Left Click + SHIFT to select multiple DO single digital lines, then press the **Group Selected** button to make a bus.
- Keep pressed the left mouse button on single signal or bus name to rename it.
- Select a bus and press the **Extend Group Name** button to extend the root name to the single lines of the bus.
- Select a bus and press the **Ungroup Selected** button to ungroup a bus into single lines.

Common operations can be directly performed on digital single signals or buses (**Selection**, **Left Click**, **Right Click**). Drag and Drop operation between digital waveforms is not allowed.

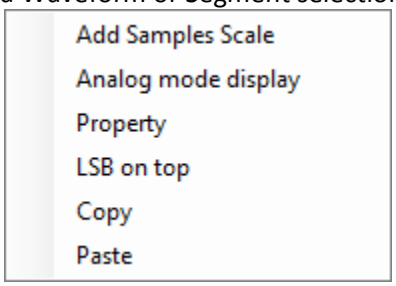
LEFT CLICK AND SELECTION

- Left Click on the analog *Signals cell* to select the entire digital single signal or bus that will be enlightened in blue.
- Click and drag inside the graph area to create a rectangle delimiting the digital waveform section. You can apply one of the operations described in the Digital Waveform toolbar on the current selection or on the entire waveform.
- Left Click on the Signals cell tree item to open/close the bus.
- Resize the digital signal amplitude by dragging the line between a signal name cell.
- To the right of every analog signal, a number indicates the value the signal or bus at the

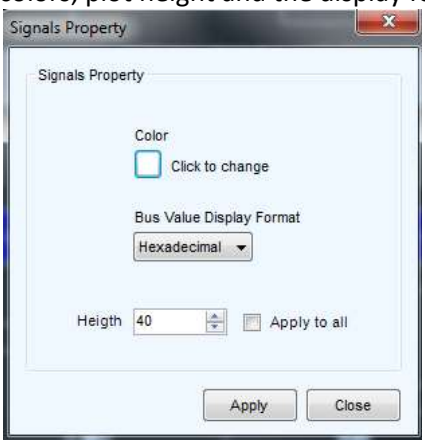
time position of the master cursor.

RIGHT CLICK

A Right Click on a Digital Waveform tree item activates a pop-up menu, with functions depending on a Waveform or Segment selection as follows.



- **Add Samples Scale** - Select this option to add a signal with a series of segments that represents the number of samples.
- **Analog mode display** - This option (available only for the buses) will represent a bus as an analog waveform. This is useful for example if an ADC or a DAC has to be tested.
- **Property -** Open the digital waveform Property Window. You can use it to change signals/buses colors, plot height and the display format of the bus value.



- **LSB on Top** - Bus values are calculated with MSB (Most Significant Bit on Top) by default. Select LSB to have the Least Significant Bit on Top instead.
- **Copy -** Copy Waveform. Select the entire waveform clicking on the signal/bus name on the left column or select a portion of it with mouse selection.
- **Paste -** Paste Waveform. Paste the copied waveform into a selected area of the graph (mouse selection) or from the start of another waveform.

Digital Channel as Marker

In Arbitrary mode a Marker identifies univocally a waveform sample.

In general when you use a marker in Arbitrary mode, you can trigger others channels or others instruments at a specified time while a waveform generation is in progress.

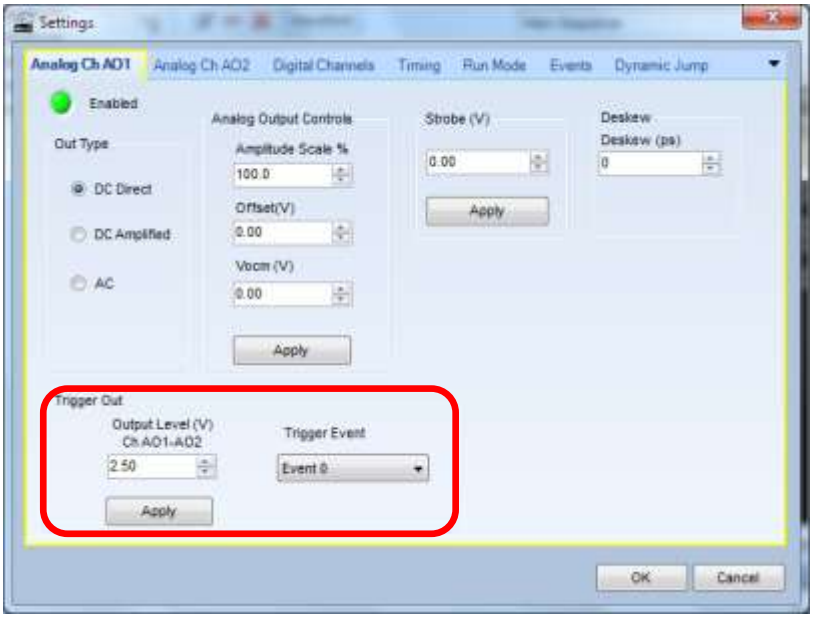
During the waveform generation the marked samples generates a signal pulse that may provoke a level change on the instrument Marker Out, or that may send a synchronous signal Event to the

Sequencer (Wait Event, Jump if Event) .

To configure a Digital channel as Marker in Arbitrary mode please refer to the following example. In this example the A(0)/Marker1 is used as Marker and redirected on the instrument Trigger Out as Event 0.

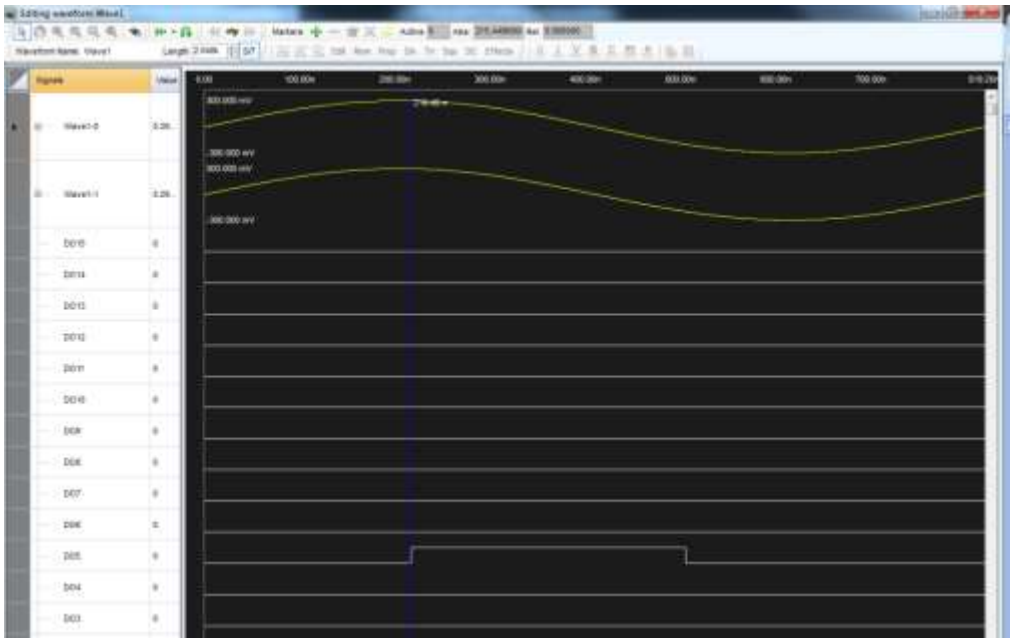
1. Open the Settings → Event Tab
2. Double Click on Event 0

3. Select A(0)/Marker1 as Operand1. The Digital lines available on the drop down list depend on the Project setup.
4. Open Settings→Analog Ch AO1



Set the Marker Out *output level (V)* and A(0)/Marker1 as digital signal associated to the Marker Out.

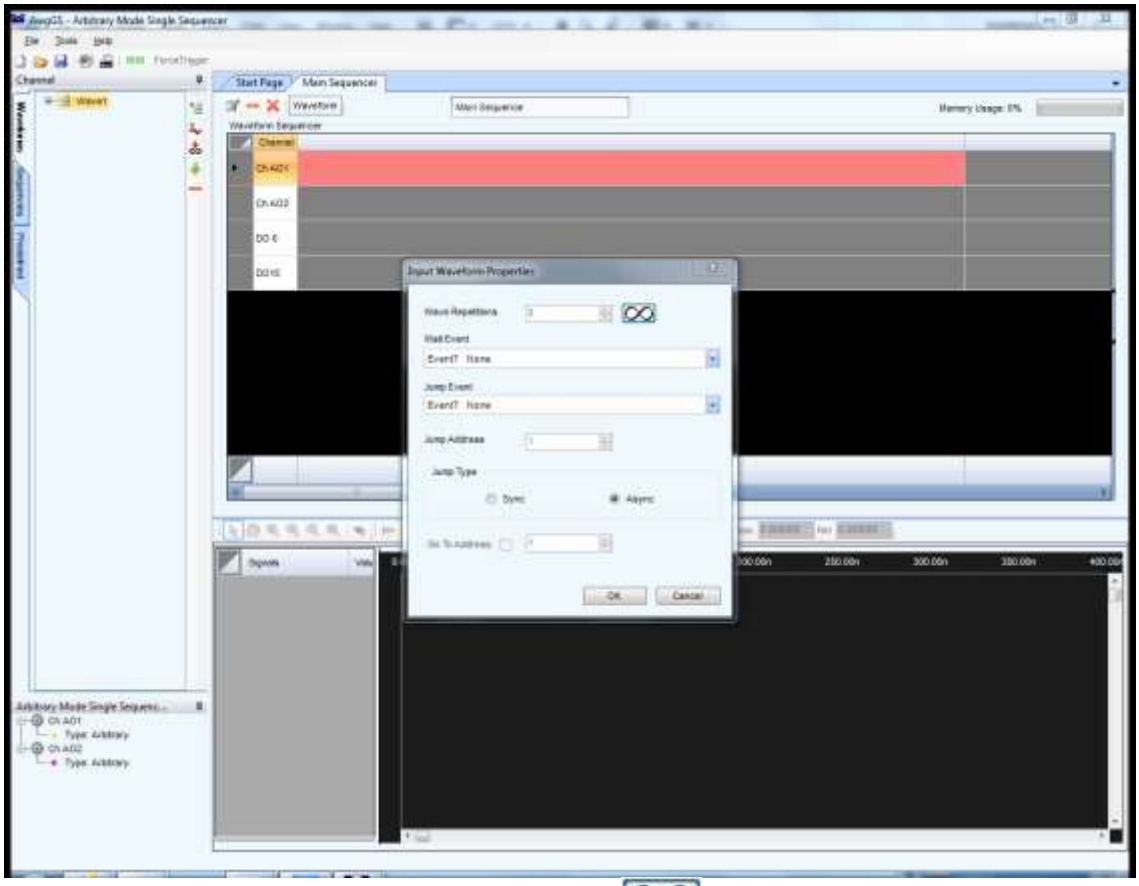
5. Add a new Mixed Waveform to your project and open the *Editing Waveform Window*.



Edit the digital channel A(0)/Marker1 as in the picture above. The A(0)/Marker1 represents now your Marker on the Analog Waveforms.

6. Click OK to confirm and close the Editing Waveform Window.

19. Drag the *Wave1* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).



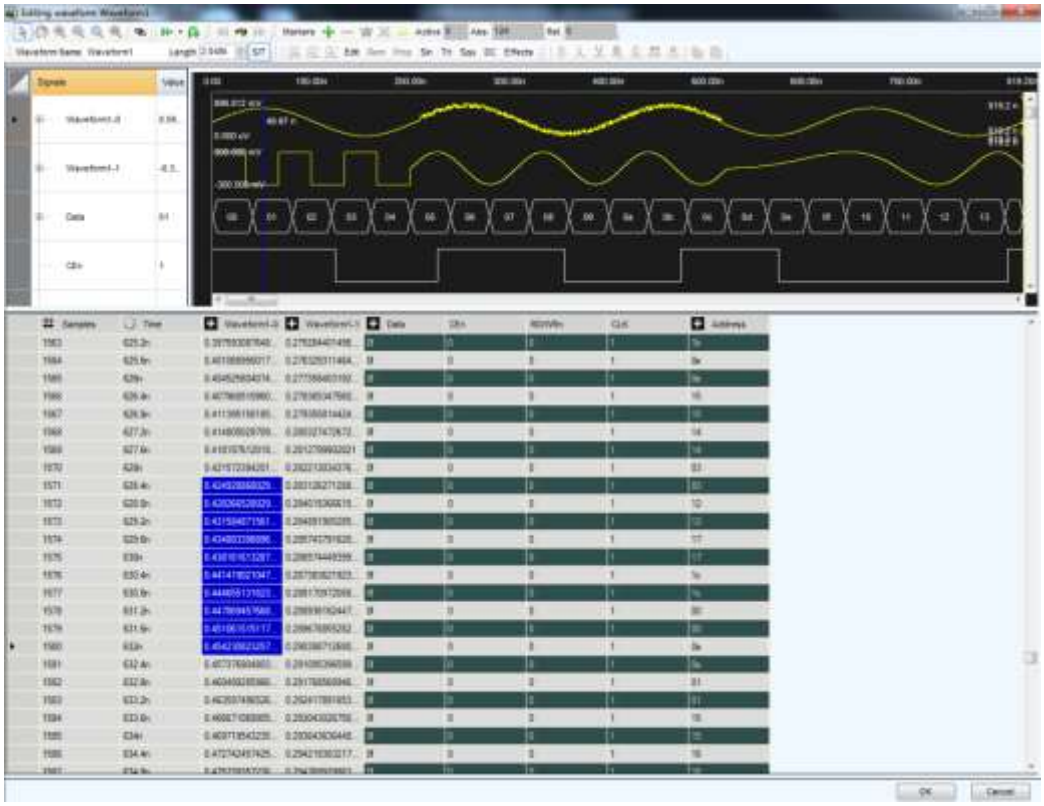
7. The **Input Waveform Properties** is shown. Click the  button to *set infinite repetitions* on Wave1.
8. Press the Run button to start the generation.

PLEASE NOTE THE FOLLOWING:

- In DDS mode a Marker identifies univocally a Modulation Law Waveform sample.
- In DDS mode there is not relationship between the Modulation Law duration and the carrier period, so the Marker does not identify a timestamp on the generated output but just a timestamp on the Modulation Law.

Data Editor

The Data Editor can be used to edit analog/digital signals and bus values in tabular format. Data is visualized numerically in columns when using the Data Editor.



The Data Editor contains the following two additional columns:

- **Samples** - Contains the progressive number of the samples generated.
- **Time** - Contains the progressive absolute time of every sample.

BUSSES

A bus node is indicated by the **Expandable Bus** icon shown to the left of the bus name (in the columns on the right of the screen).
Expanding an *analog waveform*, the Segments are shown. Expanding a Segment, the Components are shown.
Expanding a *digital waveform*, the single digital lines are shown.

Double click the bus name to open the bus.

Once a bus node is opened, the **Expanded Bus** icon is shown instead of the **Expandable Bus** icon.

Double click the bus name again to close the bus.

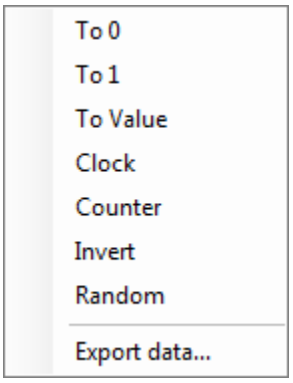
Common operations can be directly performed on table values (**Selection**, **Left Click**, **Right Click**). Drag and Drop operation between table columns is not allowed.

LEFT CLICK AND SELECTION

- Left Click on the signal name to select the entire analog/digital single signal or bus that will be enlightened in blue.
- Click and drag inside the table cells to create a rectangle delimiting the analog/digital waveform section.
  You can apply one of the operations described in the Analog/Digital Waveform toolbar on the current selection or on the entire waveform.
- Keep pressed the left mouse button on single cell to edit the value.
- Resize the column amplitude by dragging the line between a signal name.

RIGHT CLICK

A Right Click on a table cell activates a pop-up menu, with functions depending on a Analog/Digital Waveform selection as follows.



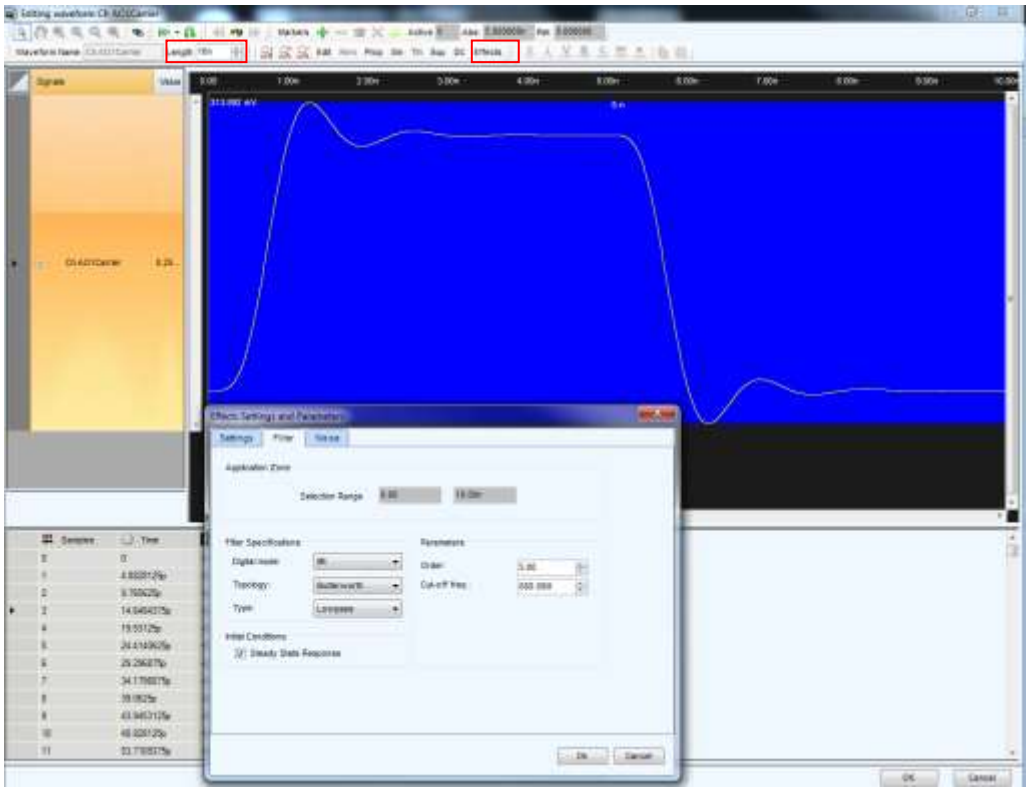
You can change table values by pressing Analog/Digital Editor Waveform toolbar buttons or right clicking on a table item to open the context menu.
To Export data, select the **Export data…** right click menu item or click on the export menu icon  .
The digital data will be exported into a .csv file; the file is comma separated with an header on the first line.
PLEASE NOTE THE FOLLOWING:

- The disabled cells in the Digital single signals/buses are not editable.
- The changes made on the table cells are also shown on the Mixed Waveform Editor directly above it.

Carrier Waveform Editor (DDS Mode)

A carrier wave or carrier is a waveform that is modulated (modified) with an input signal for the purpose of conveying information. In the AT-AWG-GS software, the input signal is the Modulation Law Waveform.
This tool, available only in DDS mode, allows editing the carrier waveform of the modulated signal; the carrier has a fixed length of 2048 samples and it can be modified through an editor with the same features and capabilities of the Editing Waveform Window (on page 51).

Double Click on the Waveforms TAB → Carrier List to open the Carrier Waveform Editor Window.

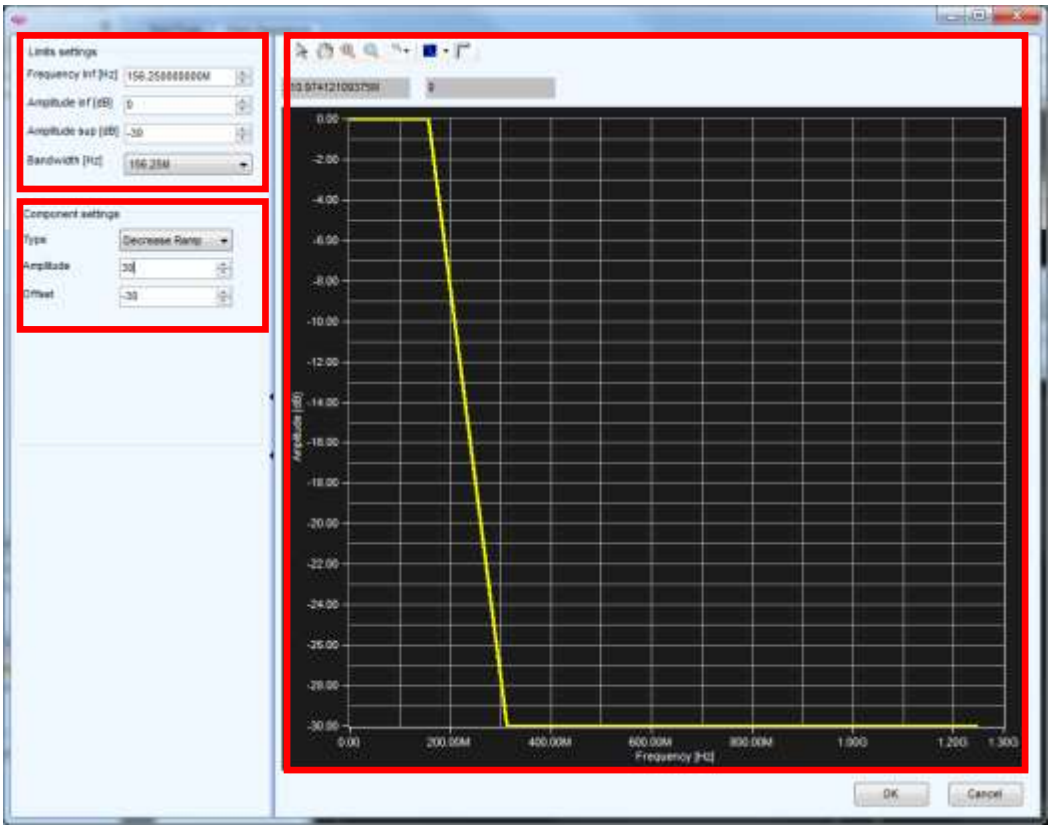


- **Length**: the carrier length is fixed at 2048 samples. The user can change its length (in time only) for calculation purposes in Effects window form.

Digital Filter Editor

Use the Digital Filter Editor to set an amplitude profile applied to the carrier waveform as a function of its frequency.

- For a given frequency of the carrier signal, its amplitude is multiplied by the corresponding value of the filter profile.
- The filter profile is divided in three frequency intervals: Low Frequency constant value, Intermediate Segment and High Frequency constant value.
- The window is divided in two main sections: the Limits settings section and the visualization area.



Limits Settings

The frequency interval for the Intermediate Segment is described by **Frequency** Inf [Hz] and **Bandwidth** [Hz].

- The upper frequency for the Intermediate Segment is Frequency Inf + Bandwidth.
- Frequency Inf must be set to a multiple of the Bandwidth value.

- The samples constituting the segment can be edited as a standard segment, by editing its component.

The constant value amplitudes for the lateral interval are set by means of the Amplitude Inf and Amplitude Sup indicators for the Low Frequency constant value and the High Frequency constant value intervals, respectively.

Component Settings

- **Type:** allows selecting the waveform among a list of possible signals or functions. Depending on the selected Type, different parameters may be edited.
- **Amplitude:** sets the amplitude in dB of the Intermediate Segment.
- **Offset:** sets the offset in dB of the Intermediate Segment.

Digital Filter Toolbar

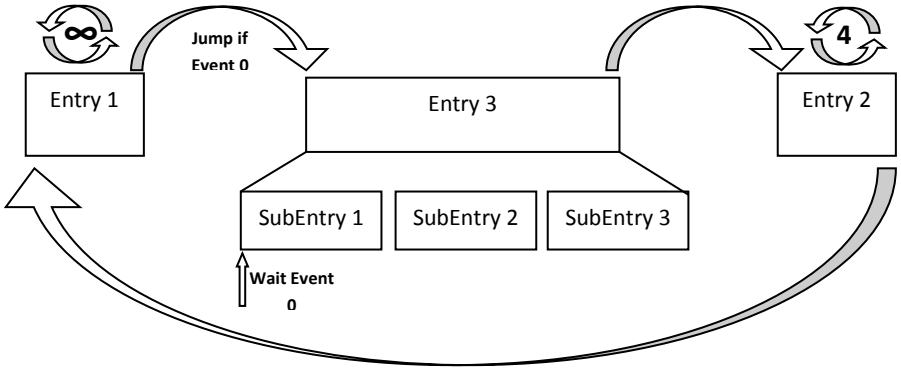
	This button allows changes the mouse function for the graphic area to cursors/markers movement.
	The hand tool allows you to dragging inside the graph area.
	This button allows zooming in on a selected rectangle of the graph. Click and drag inside the graph area to create your zoom rectangle.
	This button resets all activated zooms.
	This button activates the Zoom X / Zoom Y pop-up menu. Zoom X allows zooming in on a selected rectangle around X-axis. Zoom Y allows zooming in on a selected rectangle around Y-axis.
	This button allows changing the plot display (line and plot style) and colors (line and plot color).
	Shows the measurement cursor on the graph.

Sequence Window

It is sometimes necessary to create long waveform files to fully implement a DUT test. Where portions of the waveforms are repeated, a waveform sequencing function can save you a lot of memory-intensive waveform programming.
The Sequencer allows you to select which edited waveforms are generated, their sequence, number of repetitions and the generation conditions.

Sequencer is used for mainly the following two purposes:

- Output longer waveform than hardware memory.
- Change the output waveform quickly following conditions.

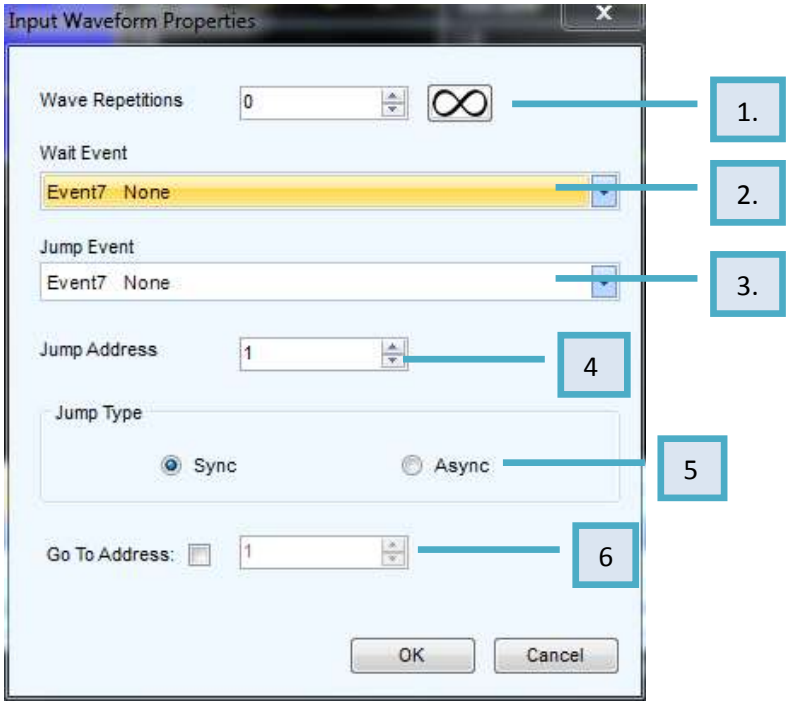


A sequence is made of multiple entries; each **entry** contains analog and digital signals properly formatted.
It is possible to create a subset of entries identifying a Subsequence that can be placed into the Sequencer entry by mouse drag & drop. In the picture above the entry 3 of the sequencer is replaced by a SubSequence with 3 entries.

- In **ARB Mode** the digital waveform length **must be ½** of the analog waveform length in the same sequencer entry.
- In **DDS Mode** the digital waveform length **must be equal** to the analog waveform length in the same sequencer entry.
- A subsequence can be placed into the sequencer in the same way as a waveform by dragging and dropping the SubSequence from the Subsequences TAB into the sequencer.
- To create a new SubSequence press the “NewSubsequence” button located in the toolbar aside the SubSequences tab.
- A SubSequence can be edited exactly in the same way as the main sequence.
- It is not possible to have a SubSequence with just one entry.

When the waveform or the subsequence is dropped into the sequencer a dialog box opens called *Input Waveform Properties* to specify the properties of the new sequencer entry that is going to be

created.

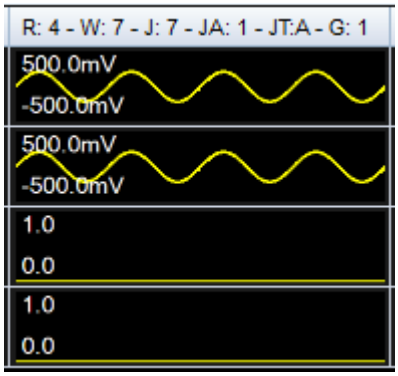


Input Waveform Properties

1. An entry can be repeated if the **Wave Repetitions** is specified.
   Zero repetitions means the entry is once repeated. The maximum number of repetitions is 2097150.
   Press the ∞ button for *infinite* repetions.
2. If an event is selected in the **Wait Event** drop-down list (Event0..Event7 are available), the sequencer will wait for the Event N before generating a waveform.
3. **Jump Event** changes the sequencing of the waveform by the event specified in the *Jump Event* drop-down list. Event0..Event7 are available.
   If the Jump Event has been set inside a *Subsequence entry*, when the event occurs the Sequencer will exit from the Subsequence and it will continue the entry generation in the main sequence.
4. **Jump Address** sets the number of the entry at which the Sequencer will jump when the event occurs.
5. **Jump Type:** if Sync is selected and the event occurs, the sequencer waits for the end of the current waveform before executing the Jump.
   If Async is selected, the sequencer executes the Jump as soon as the event occurs.
6. **Go to Address:** if Jump Event is not selected (Event7 None), the sequencer will execute the next entry after the completion of the current one.
   You can change the execution order pressing the checkbox to activate the Go to Address control and type the next entry address.

PLEASE NOTE THE FOLLOWING:

- The infinite repetitions have the priority over the Go To Address.
- It is possible to set Wait Event AND Jump If Event conditions in the same entry; the Jump If condition is evaluated **after** that the Wait Event has occurred.
- The Jump instruction cannot be evaluated during the transition between the current and the next entry.
- The header of the entry contains the settings of the Input Waveform Properties window.

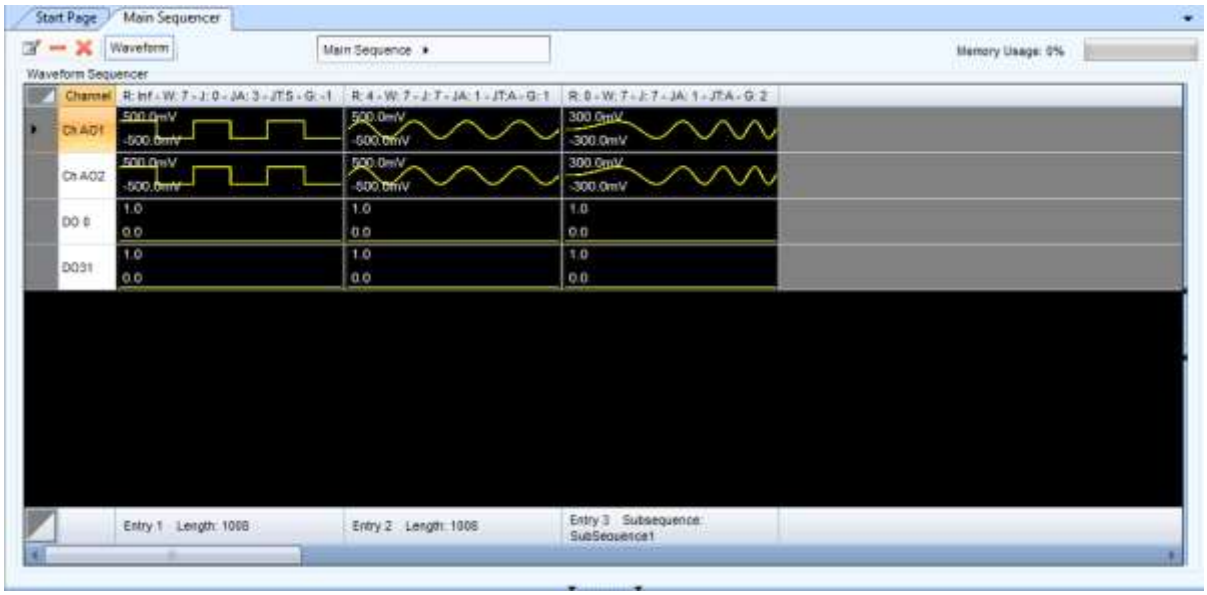


R :4 = 4 repetitions
W :7 = Wait for Event 7 (None)
J: 7 = Jump if Event 7 (None)
JA:1 = Jump Address 1
JT:A = Jump Type Asynchronous
G:1 = Go To Address 1

Sequence in Arbitrary and DDS mode

When Sequence is selected in the Run Mode, multiple waveforms can be output in the order specified in the Sequence Window.
In **Arbitrary mode** the Sequence Window displays the analog and digital waveforms that will be

generated.

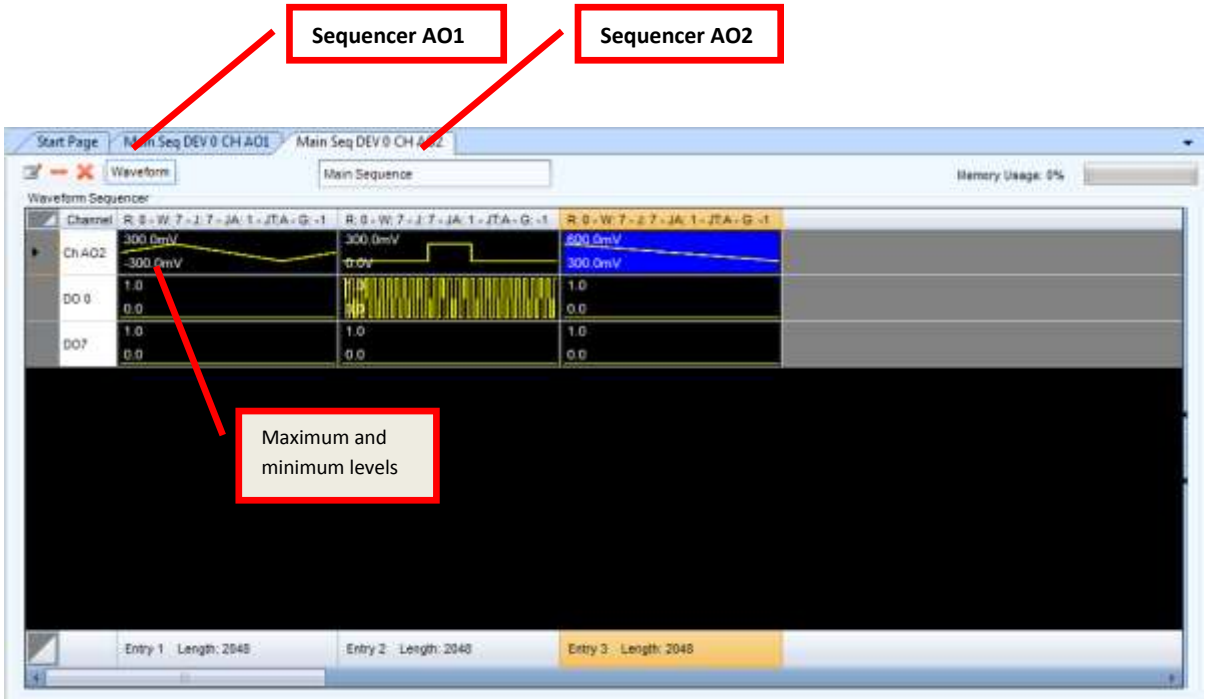


In **DDS mode** the Sequence Window is divided in two parts: on the left the *Modulation Sequencer* displays the Modulation Law waveforms (AM,FM,PM) and the digital channels; on the right the *Carrier Graph* contains the carriers and the digital filters associated with them.
The modulation law waveform and the carrier define the modulated waveform that is generated on the SMAs output connectors.

Single Sequencer projects have one sequencer called Main Sequencer that controls all analog/digital channels waveform generation.

Multi Sequencer projects have two Sequence Windows: the first one is relative to the Analog Output 1, the second one is relative to the Analog Output 2.

Each one works independently by the other and has its own list of available waveforms in the Waveform TAB.



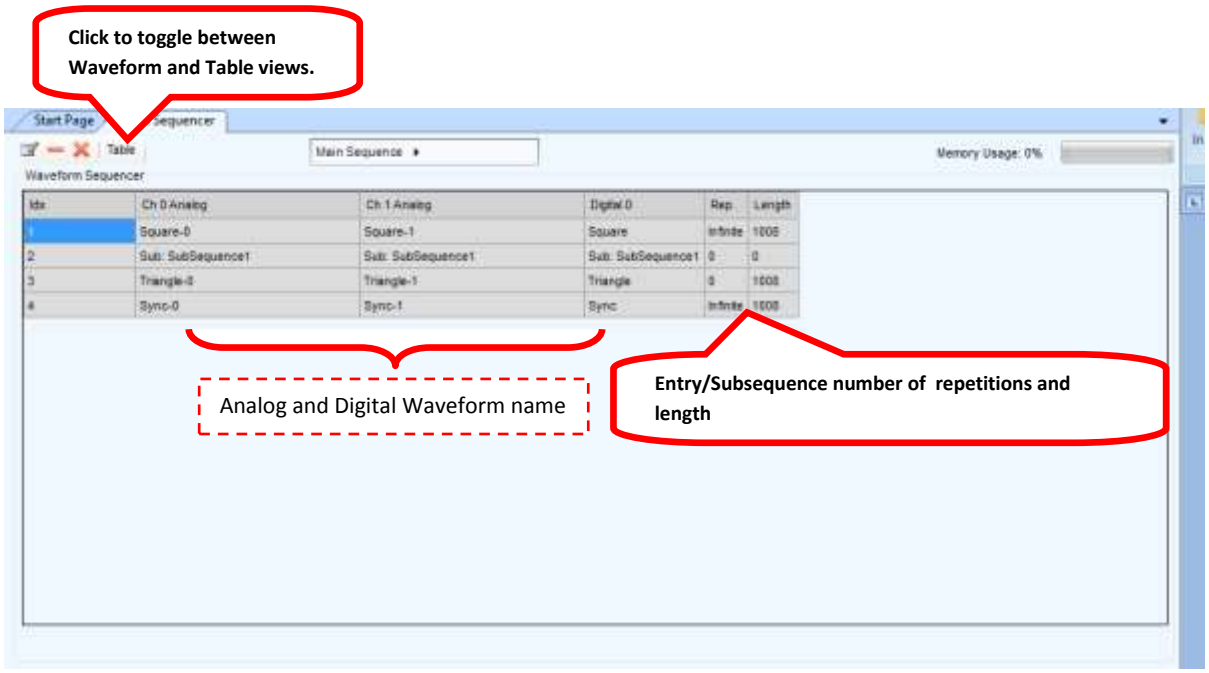
PLEASE NOTE THE FOLLOWING:

- If you click on a cell in the Sequence window, the selected waveform is displayed in the Waveform View window. The background color of the selected cell changes in blue.
- If you click on the header of the cell in the Sequence window, the entry is selected and all the waveforms inside it are displayed in the Waveform View window. The background color of the selected entry changes in blue.
- Drag a waveform from the Waveform List window and drop it to a cell of the Sequence window to insert it in the sequencer.
- To edit a waveform: after selecting a cell in the Sequence window, right click to open the pop-up menu and select *Edit Waveform* to open the *Editing Waveform Window.*
- When you insert a waveform in a sequencer cell, its maximum and minimum levels are displayed on the left margin of the cell.
- In **DDS mode** at each analog output channel are associated three Modulation Law waveforms (AM,FM,PM). You can enable or disable AM,FM,PM modulation by turning on/off the leds on the Settings-Analog Ch TAB; if you disable a modulation (entering in manual modulation), the corresponding Modulation Law waveform will disappear from the Sequencer and from the *Editing Waveform Window*.
- When Continuous, Triggered, or Gated is selected in the Run mode, the Sequence window contains one waveform only.

Waveform View of the Sequencer

> **Note**: The sequencer provides both a **Waveform** and **Table** view of your sequenced waveforms. Both views provide the same data; however, Waveform provides a graphical representation of your sequence, while the Table shows a list.

Table View of the Sequencer



Editing a Sequence

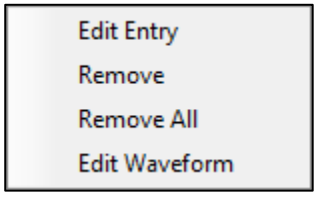
The Sequence Window allows you to select waveforms from the Waveforms TAB for generation by the AT-AWG-GS instrument.

Drag a waveform from the Waveform TAB to a cell of the Sequence window to insert it in the sequencer. **Remove** waveforms to the Sequencer using the Sequence Window Toolbar.

Sequence Window Toolbar

	Edit Entry – opens the *Input Waveform Property window*
	Remove selected entry – removes all the waveforms in the selected entry from the sequencer.
	Remove all – removes all the entries from the sequencer.
Waveform	**Waveform/Table** – switches the sequencer visualization from waveform to table style.
Main Sequence	**Sequence/Subsequence** - press the arrow button to have a list of the subsequences inserted in the sequencer. Select one of them to switch from sequence to subsequence visualization.
Memory Usage: 0%	**Memory Usage** – indicates the percentage of available memory for waveform generation.

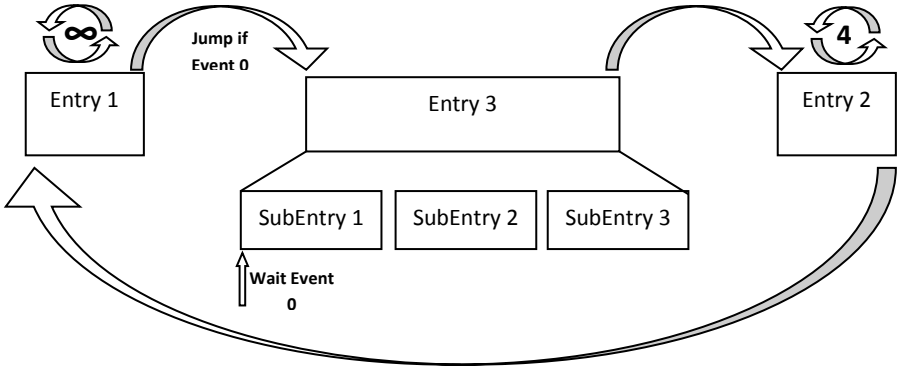
A Right Click on a Waveform cell activates a pop-up menu



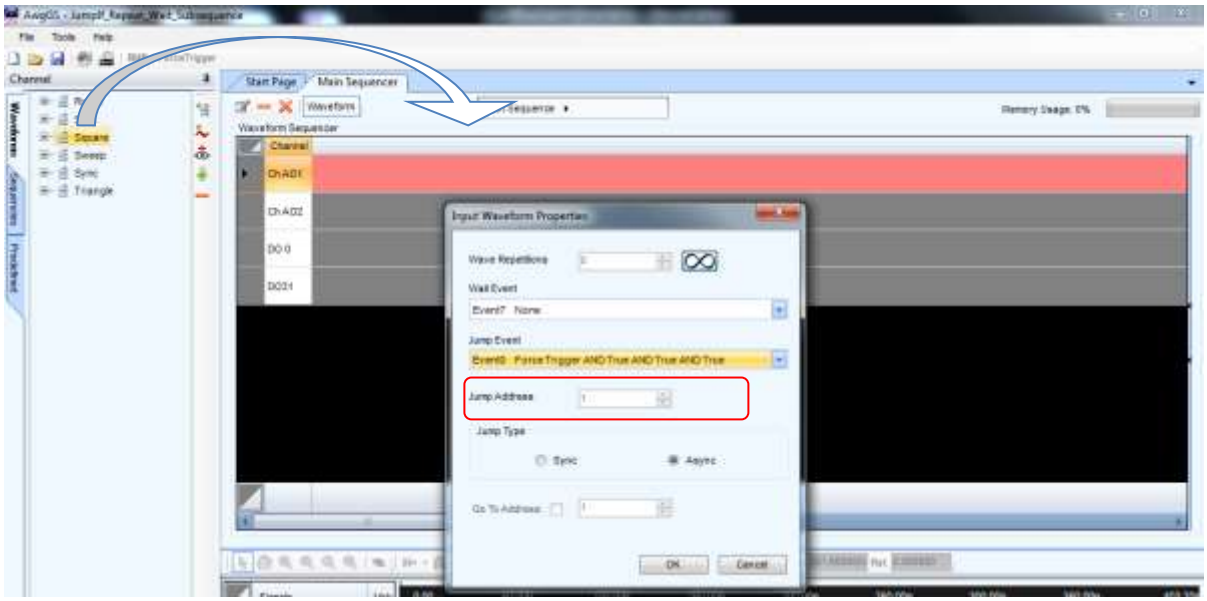
- **Edit Entry**: opens the *Input Waveform Properties* window to change the current entry properties.
- **Remove:** removes all the waveforms in the selected entry from the sequencer.
- **Remove all:** removes all the entries from the sequencer.
- **Edit Waveform:** opens the *Editing Waveform Window* to make changes on the selected waveform.

How to Create a Sequence

Prerequisites: JumpIf_Repeat_WaitSubsequence project



1. Open the JumpIf_Repeat_WaitSubsequence project
2. Press the  button in the Sequence Window toolbar to remove all the sequencer entries.
3. On the Waveforms TAB, drag the Square waveform and drop it in the first entry of the sequencer.

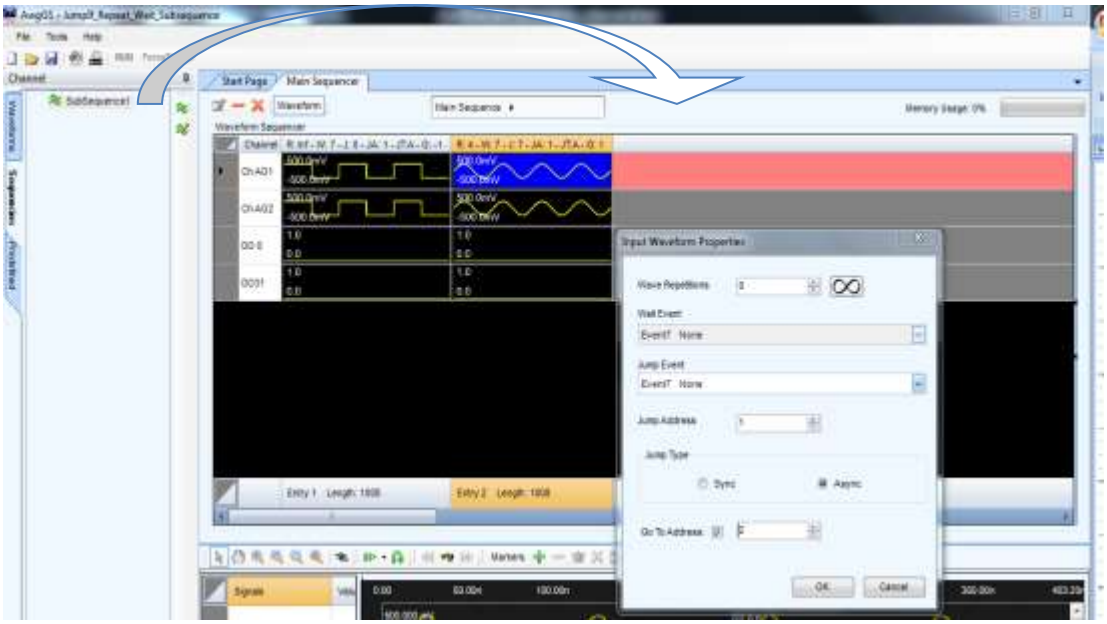


On the *Input Waveform Properties* window select infinite repetitions and Event0 (Force Trigger AND True AND True AND True) in the Jump Event drop-down list.
The Jump Address control is disabled because there are not entries in the sequencer yet.
Press OK to confirm.

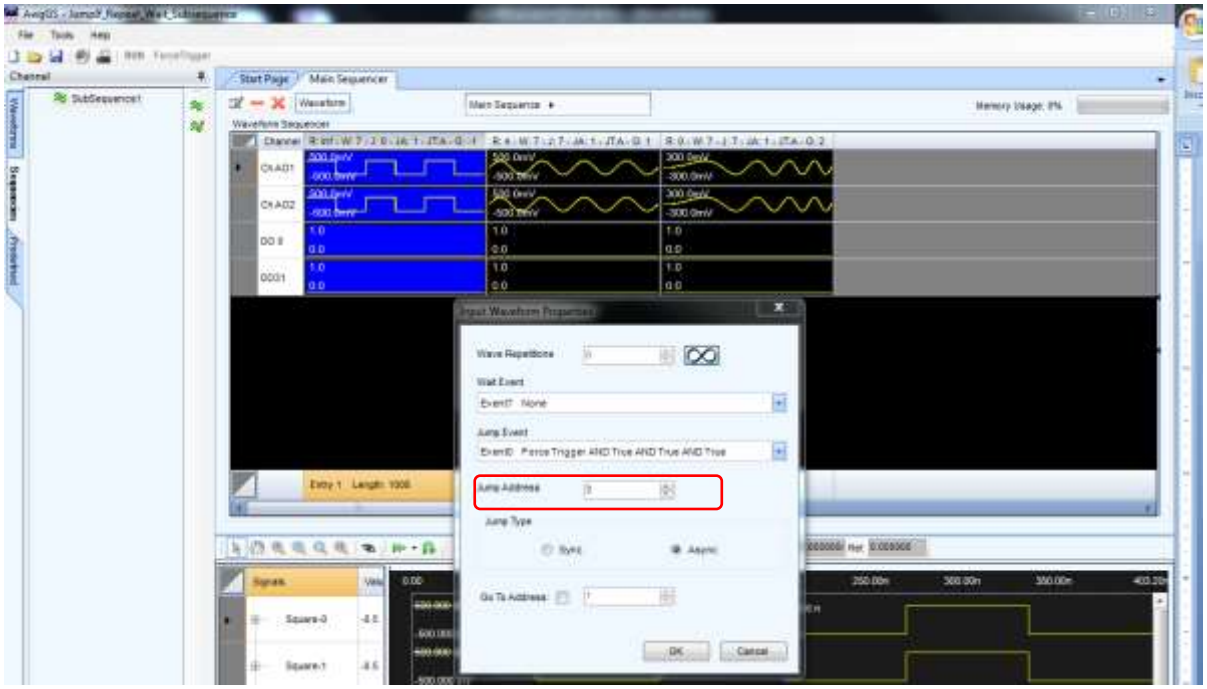
4. On the Waveforms TAB, drag the Sine waveform and drop it in the second entry of the sequencer.

On the *Input Waveform Properties* window select 4 repetitions, mark the Go To Address checkbox and type 1 as Go To Address value. Press OK to confirm.

5. On the Subsequences TAB, drag the Subsequence1 and drop it in the third entry of the sequencer.



6. Now the sequence is complete but you need to modify the properties of the Entry 1; double click on the Entry 1 or right click to open the pop-up menu and select Edit Entry.

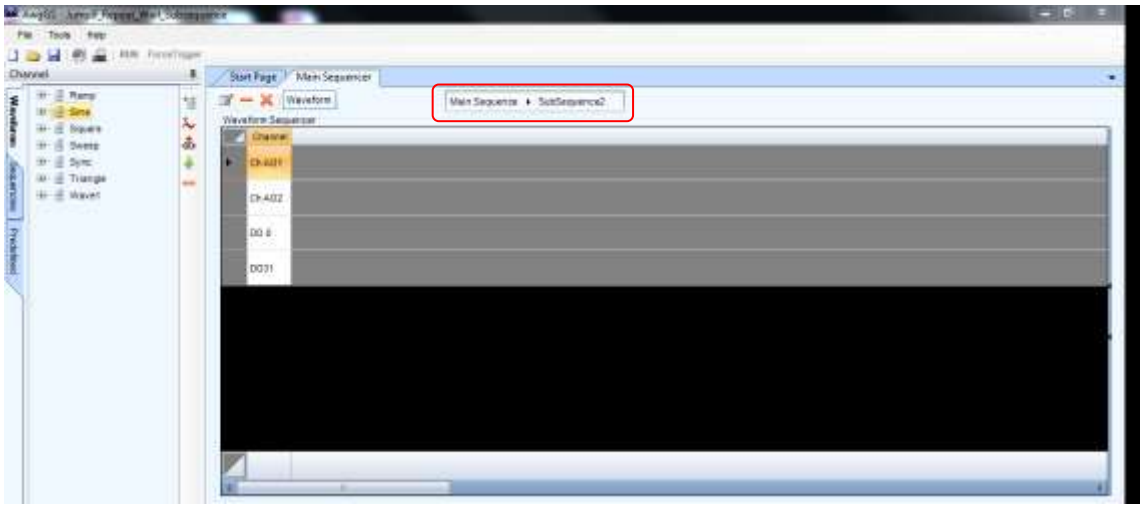


Modify the Jump Address field and type 3 as address of the jump. Press the OK button.

How to Create a Subsequence

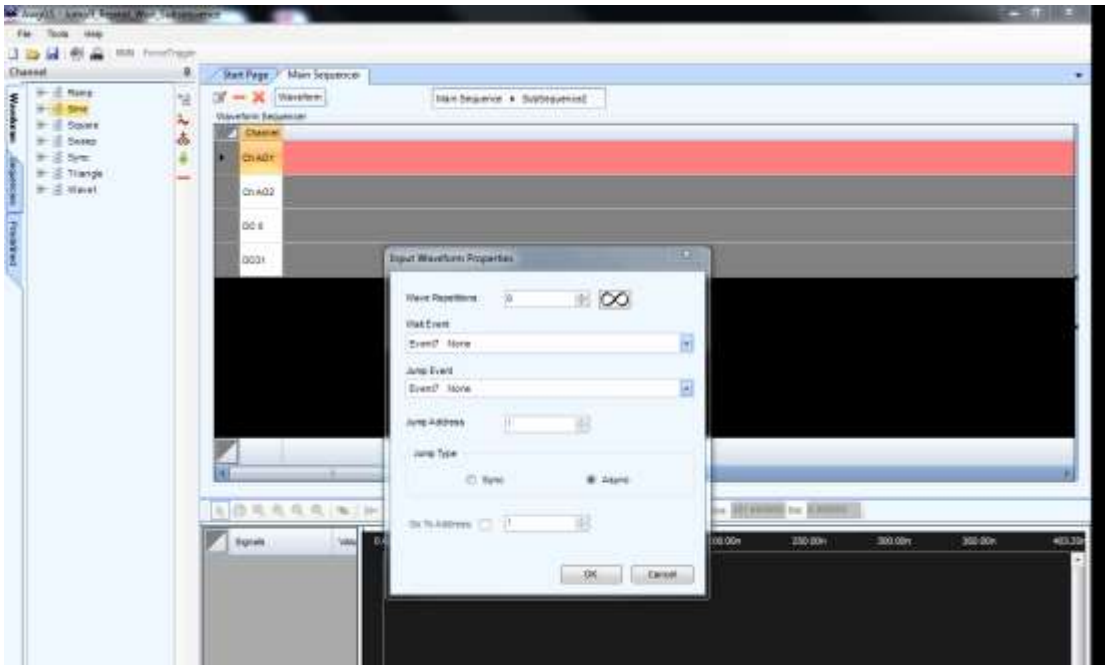
Prerequisites: JumpIf_Repeat_WaitSubsequence project

- Open the JumpIf_Repeat_WaitSubsequence project
- On the Sequences TAB press the  New Subsequence button.
- The new empty subsequence is shown on the Main Sequencer Window

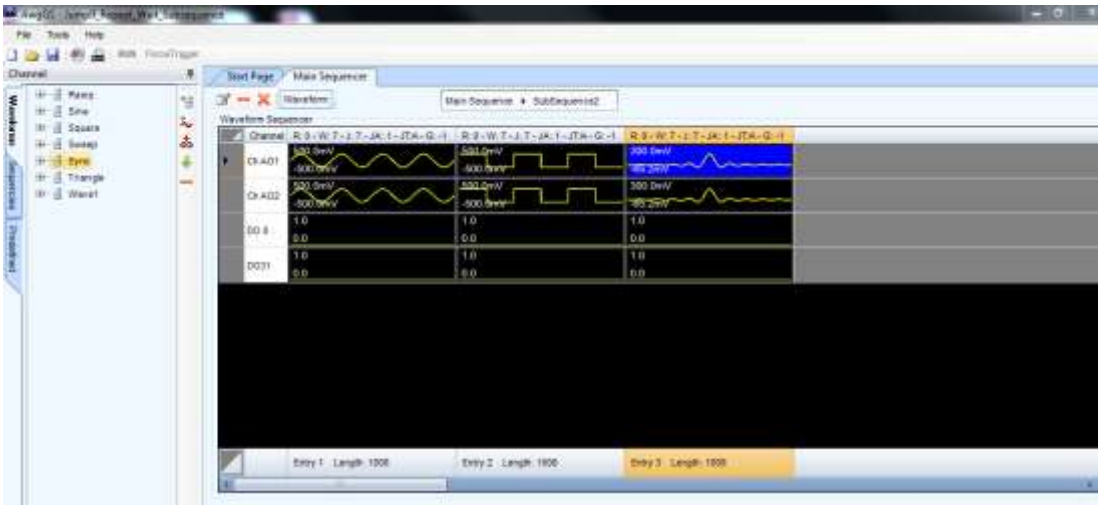


- Drag a waveform from the Waveform TAB to a cell of the Sequence window to insert it in the sequencer. The destination sequencer cell of the selected waveform will be enlightened

in red.



- Repeat the last step Square and Sync waveforms. The Subsequece2 is made of three entries: Sine, Square and Sync Mixed waveforms.



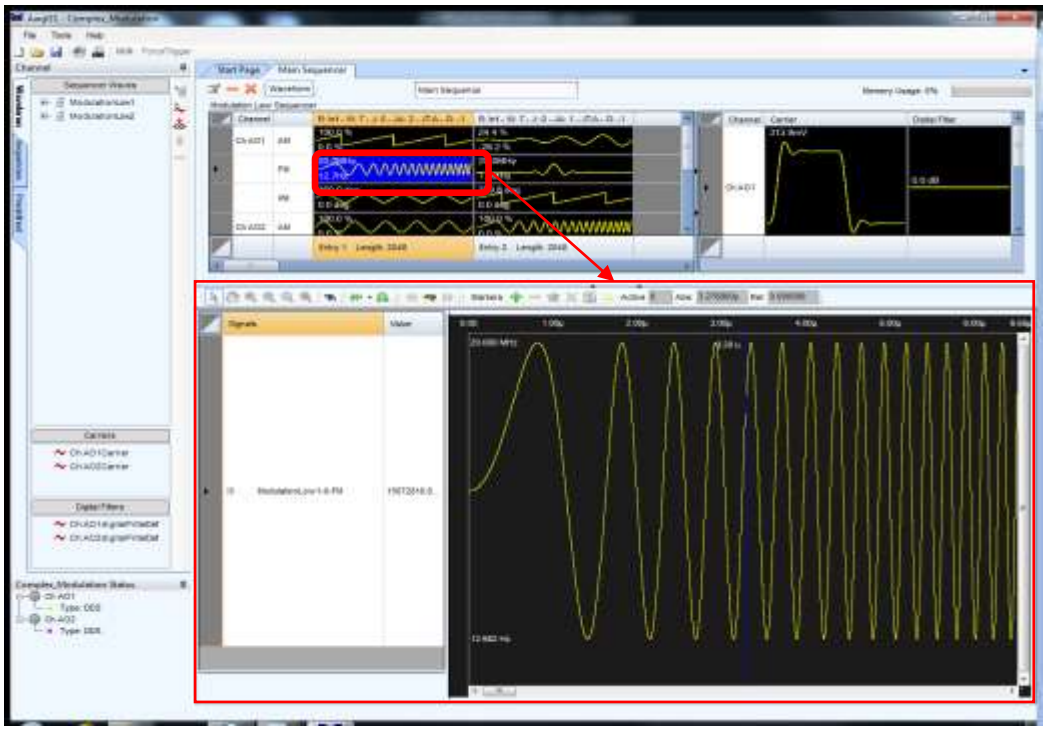
- Press the 

Sequence/Subsequence button to close the subsequence, confirm the changes and return to the main sequencer.
The Subsequence2 will appear in the Sequences TAB and now you can insert it into the Main Sequencer.

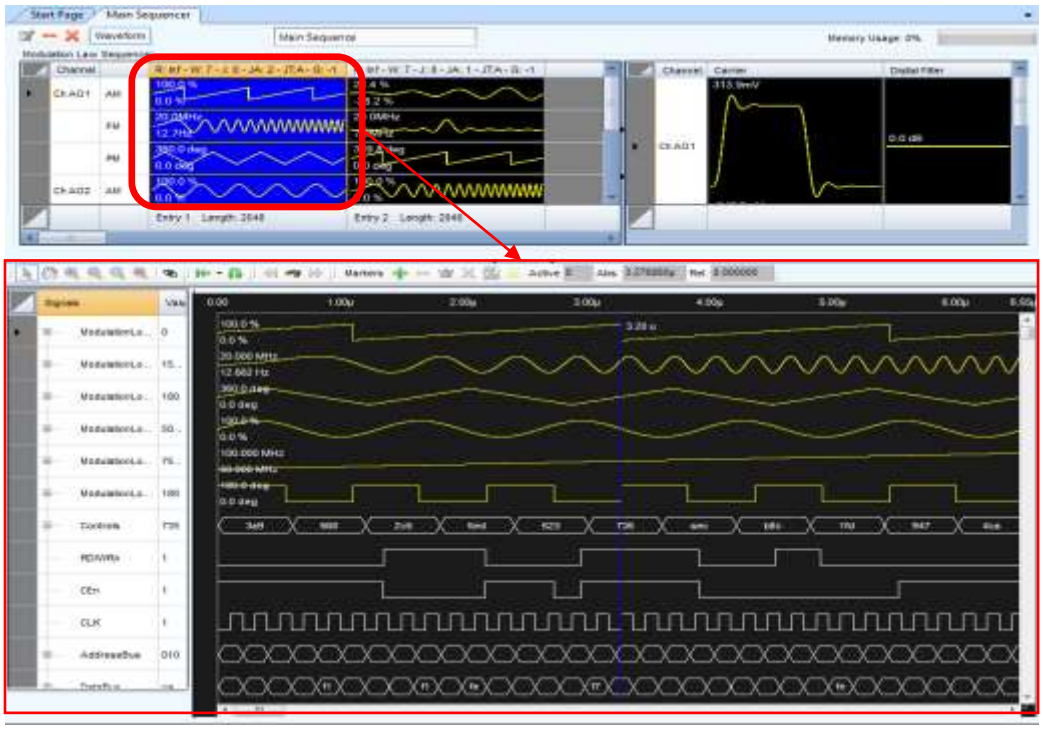
Waveform View Window

A selected element in the Sequence Window or in the Carrier Graph is displayed in the *Waveform View* window.
To the right of every signal, there are two columns: the first one called *Signals* displays the name and the root icon to open/close the segment/component/bus elements, the second one called *Value* displays a number indicating the value the signal at the time position of the master cursor.

- If you select a single cell, you can use the Waveform View window to display analog and digital waveforms, the carrier and the digital filter associated to the carrier.



- If you click on the header of the cell in the Sequence window, the entry is selected and all the waveforms inside it are displayed in the Waveform View window.



Waveform View Window Tools

When viewing a waveform in the Waveform View Window, you have access to the following functions:

	This button allows changes the mouse function for the graphic area to cursors/markers movement.
	The hand tool allows you to dragging inside the graph area.
	Auto zoom in function.
	Auto zoom out function.
	This button allows zooming in on a selected rectangle of the graph. Click and drag inside the graph area to create your zoom rectangle.
	This button resets all activated zooms
	You can change the properties of the graph display area. Click the **Waveform View Settings** button and the **Graph Property** screen is shown.

Changes can be made as follows:

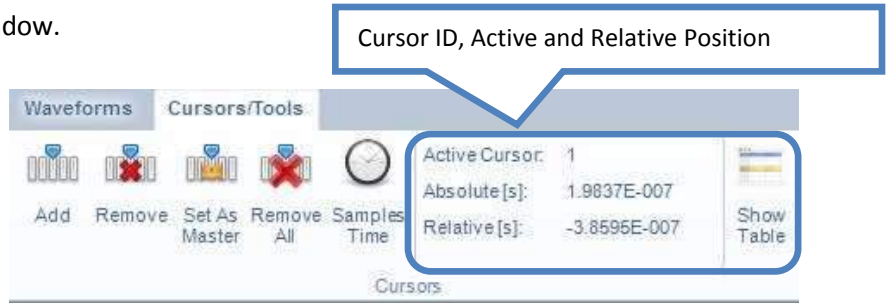
- The **Background Color** can be changed as desired.
- Change colors and turn the **Major** and **Minor Grids** on or off and change their line coloring.
- **Cursor Position** indicators can be turned on or off.

This button switches the X-axis representation between **number of samples** to **seconds**. Default values are optimized based on the selection made.

Cursors

Cursors are useful to identify and enlighten waveform data for improved organization and viewing.

Clicking the Cursors Markers button on the *Editing Waveform main toolset* shows or hides the marker window.



Other field values on the toolbar show the **Active** (or ID) of the currently selected cursor, and its **Absolute** and **Relative** positions.

When Cursors are turned on, all of the cursors present in the *Waveform View Window* are listed inside the **Cursor** screen.

Master	Id	Abs Pos	Rel Pos	Sync
	0	409.60...	0	
	1	409.60...	0	
	2	675.02...	265.420...	
	3	174.48...	-235.11...	
	4	409.60...	0	

The **Master Cursor** is the one labeled with the following icon.

Relative positions are calculated from the master cursor position.
The master cursor automatically moved during a data search operation to show relative results.
Change the master cursor by selecting the new cursor in the cursor window and clicking the Master Cursor icon in the *Waveform View Window* toolbar.

Cursor screen columns show the progressive cursor identifiers, the absolute time position (the time distance between the cursor position and the start of the acquisition) and the relative time position (the time distance between the cursor and the master cursor). Any time one of the cursor is moved, all the values are automatically updated and shown.

The following functions are used on Cursor.

	The **Add** button puts a new cursor in the visualization area.
	The **Remove** button eliminates the cursor selected in the **Cursor** screen.
174.49 n	Move a cursor by clicking and dragging a selected cursor.
	Remove all cursors by clicking the **Clear all cursors** button.

PLEASE NOTE THE FOLLOWING:

- You can also perform many of the aforementioned functions by right clicking inside the **Cursor** screen and choosing from the list of functions shown.
- You can remove all cursors except for one.
- You can create as many cursors as needed.

Go To a Selected Target

The Go to field on the *Waveform View Window toolset* contains multiple functions on its right side drop-down. The functions allow you to select the position where the master marker is going to be moved within the visualization area.
The Go to functions include:

	Go to time - Moves the master cursor to the time position specified in the text field to the left of the control.
	Go to start samples - Moves the master cursor and visualization area to the start of the acquisition.
	Go to end samples - Moves the master cursor and visualization area to the end of the acquisition.
	Cursor n - Centers the visualization area on the cursor/marker n (position specified in the text field to the left of the control).
	You can move the selected cursor to the middle of the current visualization by clicking the **Move active cursor here** button.

Search

Searching can be done from the *Waveform View Window*. It also is available in the aforementioned search section regarding the **Waveform View** screen.
You can search for a specific bus, signal, rising, or falling edge value depending on the selected waveform is analog or digital.

Activate the search option by clicking the **Search Settings** button .
The *Search Settings* window is shown and used to provide your search criteria

Note: Depending on the Signal Type selected in the search list, the **Compare** and **Value** fields contains different

Select the signal or bus and then provide a specific value for the search

Use the Compare field to select between the following search logic operators:

- **=** or **Is** - Find the equivalent value.
- **!=** or **Is not** - Find the unequal value.
- **>** - Find values greater than the one specified (on digital channels only available if a bus is selected).
- **<** - Find values less than the one specified (on digital channels only available if a bus is selected).

On digital channels use the **Value** field to provide the specific value or edge on which to search. If one channel is selected, the **Value** field has the following options:

- **0** - Searches for a logic **0**.
- **1** - Searches for a logic **1**.
- **Rise** - Searches for a Rising Edge trigger.
- **Fall** - Searches for a Falling Edge trigger.
- **Change** - Searches for any trigger edge.

The **From Start** button can be used to specify where the search starts within your data generation. Possible options include:

- **From Start** - Starts the search from the beginning of the waveform.
- **From End** - Starts the search from the end of the waveform.
- **Master Marker** - Starts the search from the Master Marker position.

Select criteria on the Search Settings screen and click the **OK** button. The results are then shown on the **Waveform View Window**.
Use the **Search Backward** or **Search Forward** buttons to navigate through your search results.

Note: As you navigate through your search results, the master cursor is updated to the subsequent values in your results.

Tutorials

Scenarios with detailed steps for performing typical tasks and setups using AT-AWG-GS are shown in the **Examples.**

PLEASE NOTE THE FOLLOWING:

- Before performing any of the scenarios, you must first make sure you've **correctly powered on your instrument**, **connected to your PC**, and **launched the AT-AWG-GS software** as explained in the **Getting Started with AT-AWG-GS** (on page 16) section.
- Some more specific steps are required around Creating a New Workspace for each scenario. Details are provided for those scenarios when necessary.

With the aforementioned prerequisites completed, you can perform the following scenarios:

1. **Creating Your First Analog Waveform** (on page 111)
2. **Creating a Sequence of Waveforms** (on page 115)
3. **Creating a DDS (modulation) Project (AM,FM,PM)** (on page 120)
4. **Creating a DDS Compensated sequence of waveforms** (on page 129)
5. **Creating a Multi Sequencer Project** (on page 135)
6. **Importing a Waveform from an Oscilloscope + Component Usage + Gated Run Mode** (on page 141)
7. **Creating Digital Waveforms** (on page 147)

Setup Examples and Common Tasks

In addition to these **How do I Scenario Details**, the **Setup Examples and Common Tasks** section at the beginning of this manual contains the following additional examples:

1. **Arbitrary Mode Single Sequencer Setup Example** (on page 31)
2. **Creating a New Workspace** (on page 37)
3. **Opening an Existing Workspace** (on page 38)

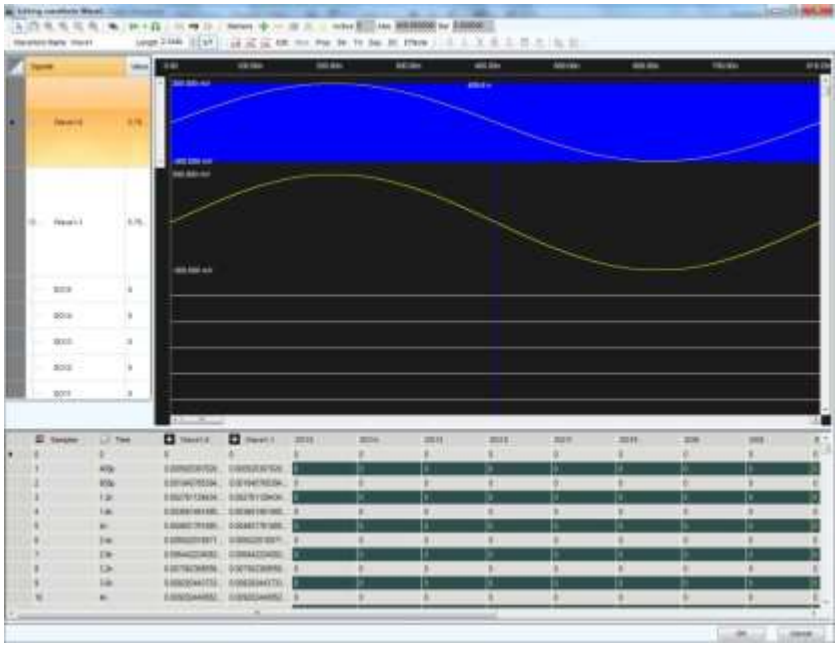
Creating Your First Analog Waveform

To create your first Analog Waveform, you must first create a single sequencer project with Arbitrary Waveform Generator as the Operating Mode. See steps 5 and 6 in **Arbitrary Mode Single Sequencer Setup Example** (on page 31) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

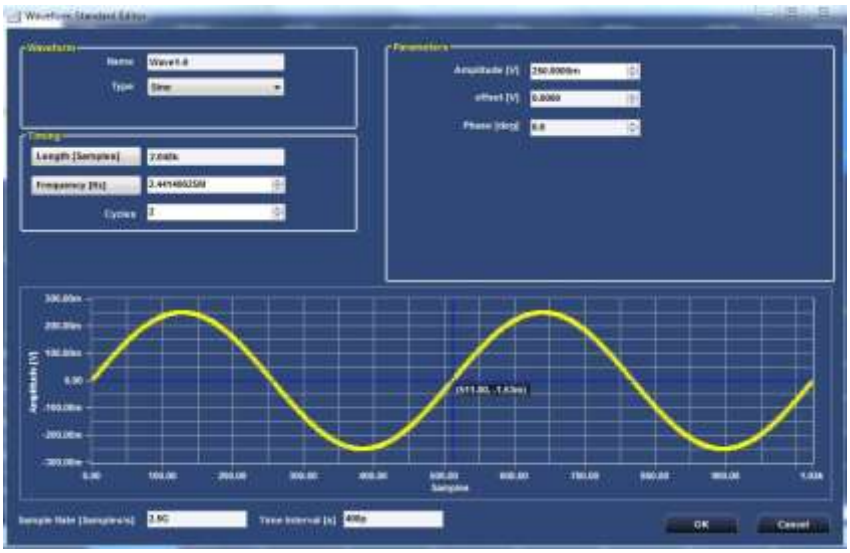
1. Click the **New Mixed Waveform** button.

2. The **New Waveform** window is shown. Type the name of the waveform “Wave1” and choose 2048 for the samples length of the waveform. Click **OK** to confirm.

3. The **Editing Waveform** window is shown. Select the waveform Wave1-0 and click on the **Edit** Edit button

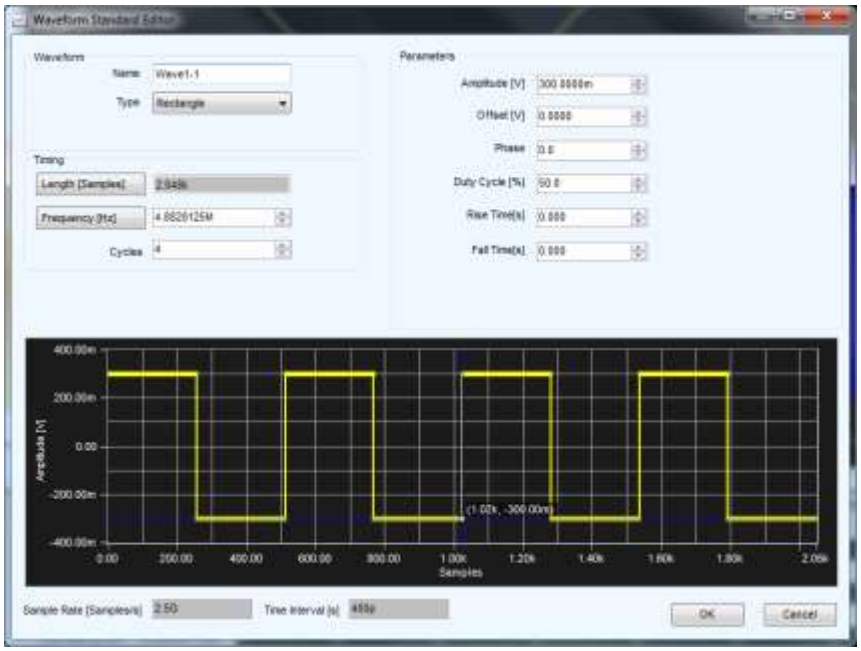


4. The **Waveform Standard Editor** is shown. Choose a sine waveform with the following specs:
   - Cycles: 2
   - Amplitude[V]: 250mV



Press **OK** button.

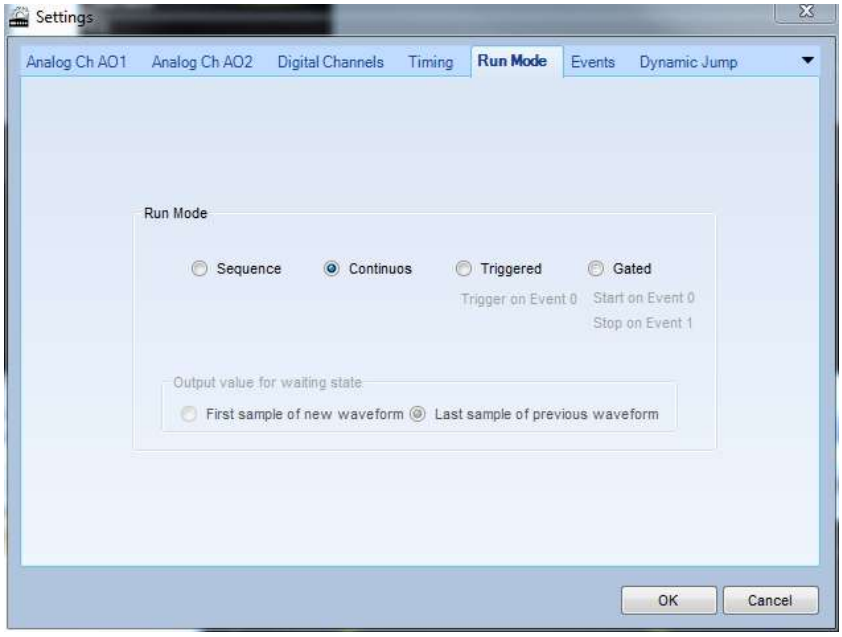
5. Select the waveform Wave1-1 and click on the **Edit** button.
6. The **Waveform Standard Editor** is shown. Choose a rectangle waveform with the following specs:
   - Cycles: 4
   - Amplitude[V]: 300m



Press **OK** button.

7. Press **OK** button on the **Editing Waveform** window.
8. On the main toolbar, press the Settings button. The *Wave1* will appear on the Waveform TAB.
9. On the Settings pop-up screen's Run Mode tab, select **Continuous**.

Click **OK**.



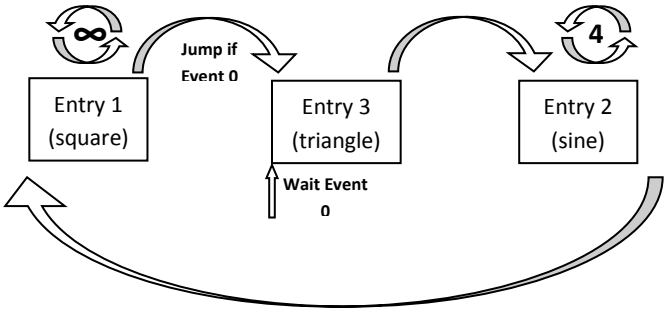
10. Drag the *Wave1* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).

11. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

The software loads the waveforms into the AT-AWG-GS instrument and starts generating the waveforms. Wave1 is generated on the AO1 and AO2 SMA outputs. You can connect an oscilloscope to this output and analyze the signals.
Stop generating waveforms by pressing the **Run/Stop** button again.

Creating a Sequence of Waveforms

To create your first Sequence of Waveforms, you must first create a single sequencer project with Arbitrary Waveform Generator as the Operating Mode. See steps 5 and 6 in **Arbitrary Mode Single Sequencer Setup Example** (on page 31) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

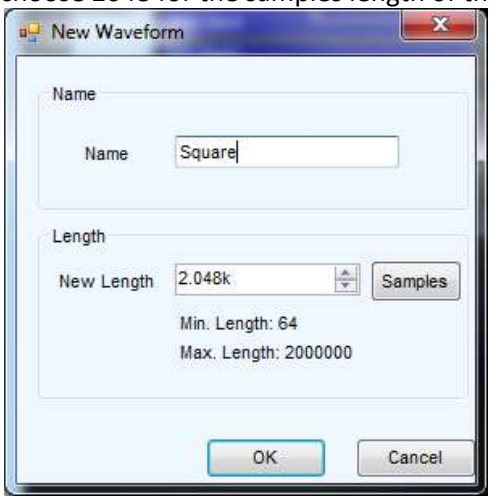


1. Now, we'll add three waveforms to our Waveforms TAB list. Do this by repeating the steps 2,3 and 4 and providing the following specifications for waveforms 1, 2, and 3 on the **Waveform Standard Editor** dialog box each time.

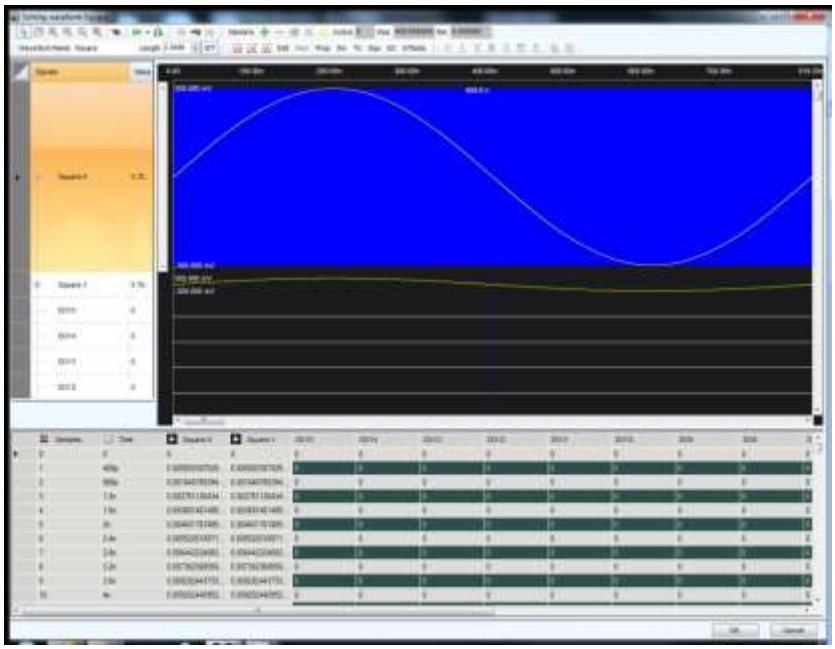
   Waveform 1 - Square waveform Type, 2048 Samples, 1 Cycle and 300 mVolt Amplitude.
   Waveform 2 - Sine waveform Type, 2048 Samples, 1 Cycle and 300 mVolt Amplitude.
   Waveform 3 – Triangle waveform Type, 2048 Samples, 1 Cycle and 300 mVolt Amplitude.

   Click the **New Mixed Waveform** button. 
   The **New Waveform** window is shown. Type the name of the waveform “Square” and

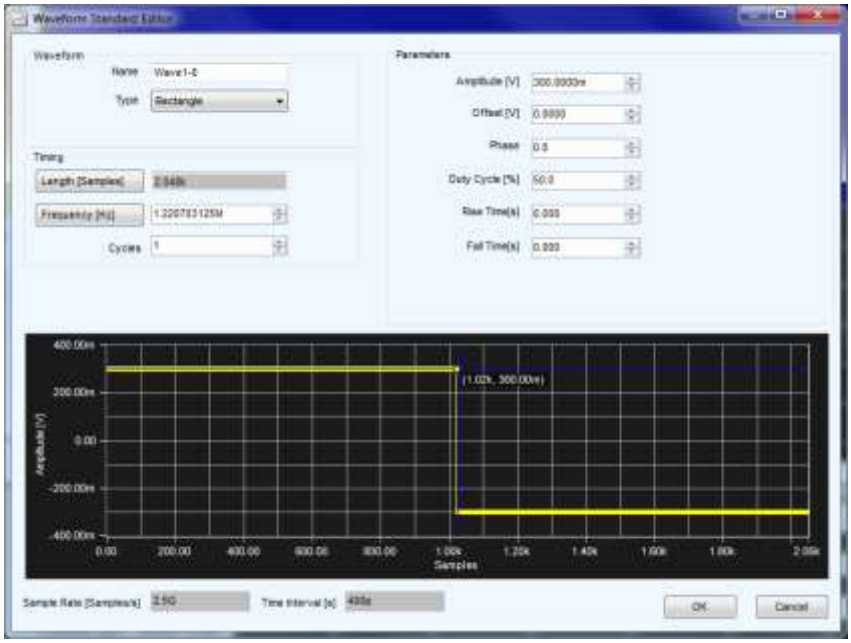
choose 2048 for the samples length of the waveform. Click **OK** to confirm.



2. The **Editing Waveform** window is shown. Select the waveform Square-0 and click on the **Edit**  button

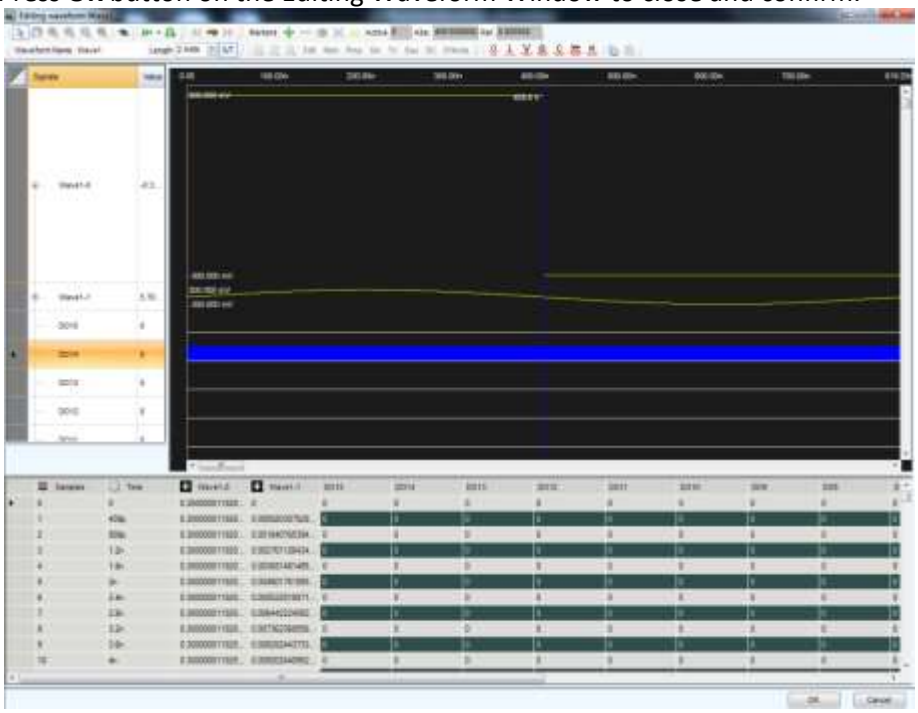


3. The **Waveform Standard Editor** is shown. Choose a rectangle waveform with the following specs:
   - Cycles: 1
   - Amplitude[V]: 300mV

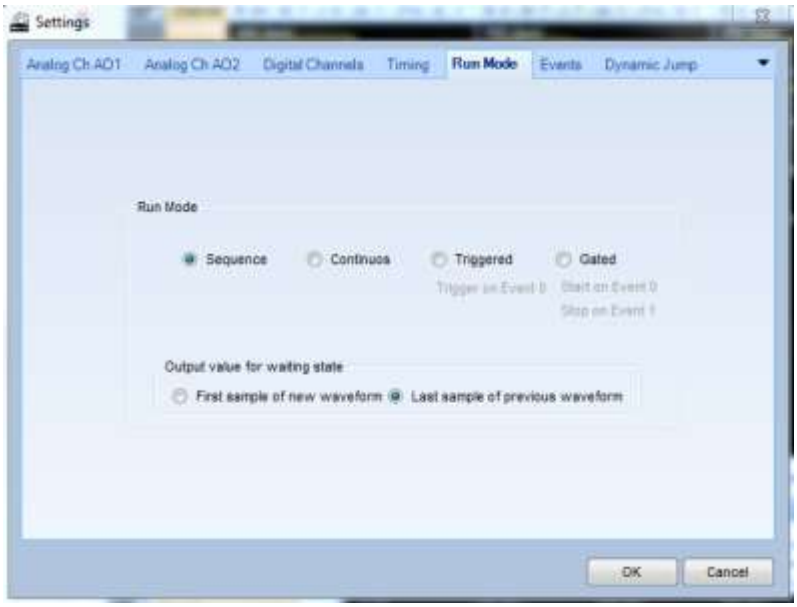


Press **OK** button.

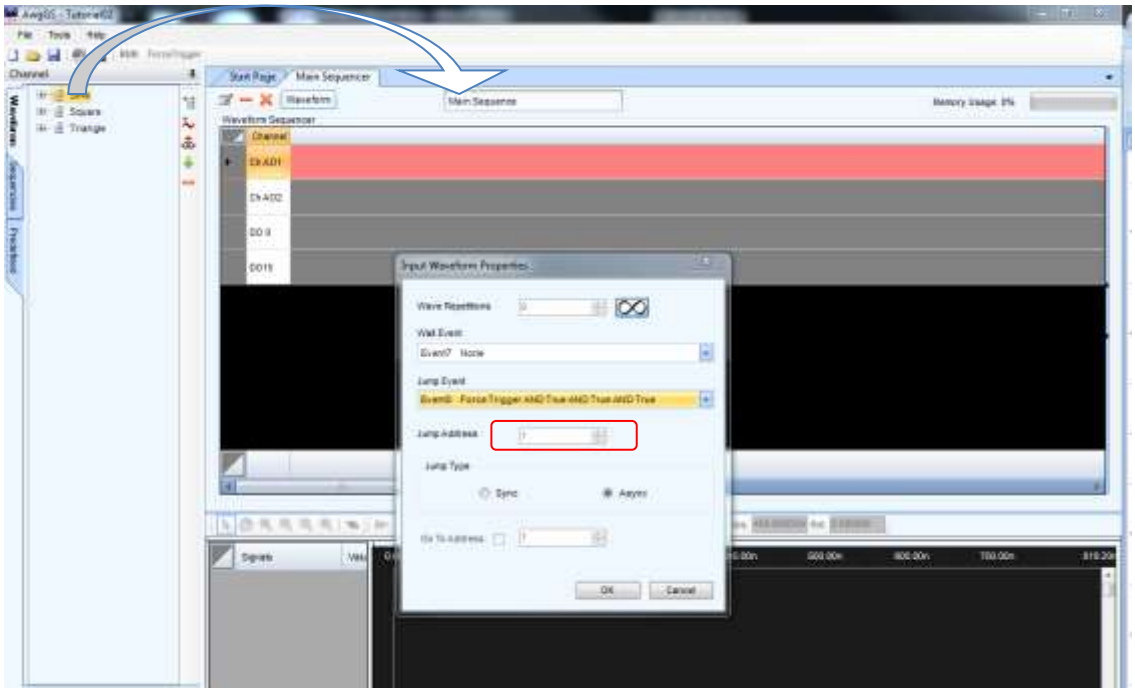
4. Press **OK** button on the Editing Waveform Window to close and confirm.



5. Repeat the steps 2,3 and 4 to create the Sine and Triangle waveforms.
5. On the main toolbar, press the Settings button. The *Square, Sine* and *Triangle* will appear on the Waveform TAB.
6. On the Settings pop-up screen's Run Mode tab, select **Sequence**.
   Click **OK**.



7. On the Waveforms TAB, drag the Square waveform and drop it in the first entry of the sequencer.



On the *Input Waveform Properties* window select infinite repetitions and Event0 (Force Trigger AND True AND True AND True) in the Jump Event drop-down list.
The Jump Address control is disabled because there are not entries in the sequencer yet.
Press **OK** to confirm.

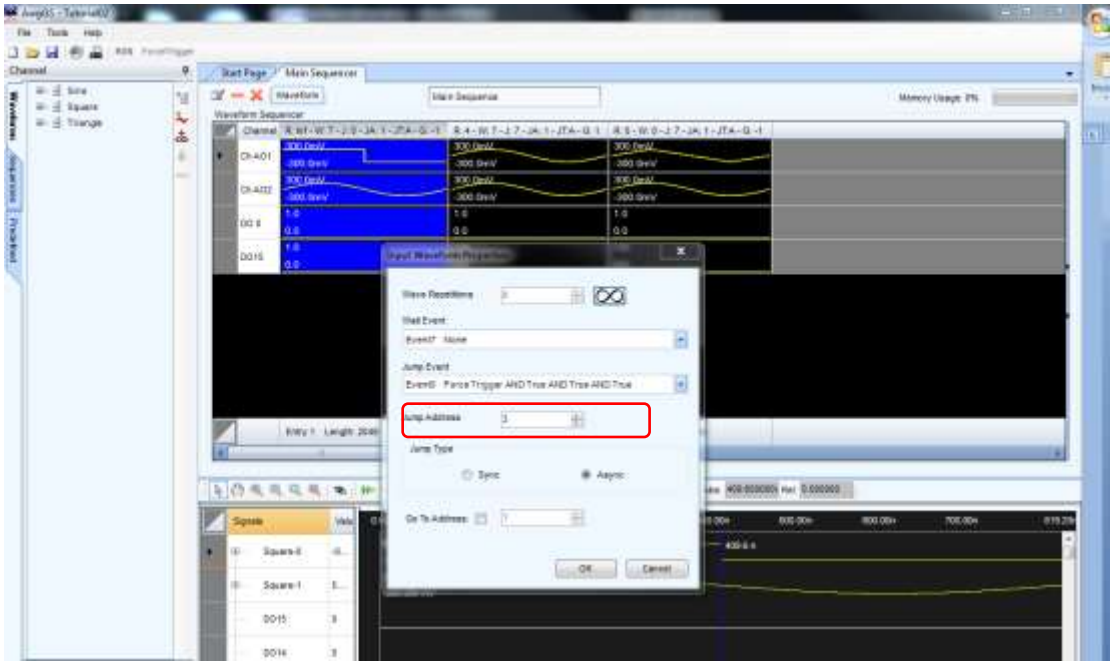
8. On the Waveforms TAB, drag the Sine waveform and drop it in the second entry of the sequencer.

On the *Input Waveform Properties* window select 4 repetitions, mark the Go To Address checkbox and type 1 as Go To Address value. Press **OK** to confirm.

9. On the Waveforms TAB, drag the Triangle waveform and drop it in the third entry of the sequencer.

On the *Input Waveform Properties* window select Wait Event0 and mark the Go To Address checkbox and type 2 as Go To Address value. Press **OK** to confirm.

10. Now the sequence is complete but you need to modify the properties of the Entry 1; double click on the Entry 1 or right click to open the pop-up menu and select Edit Entry.



Modify the Jump Address field and type 3 as address of the jump. Press the **OK** button.

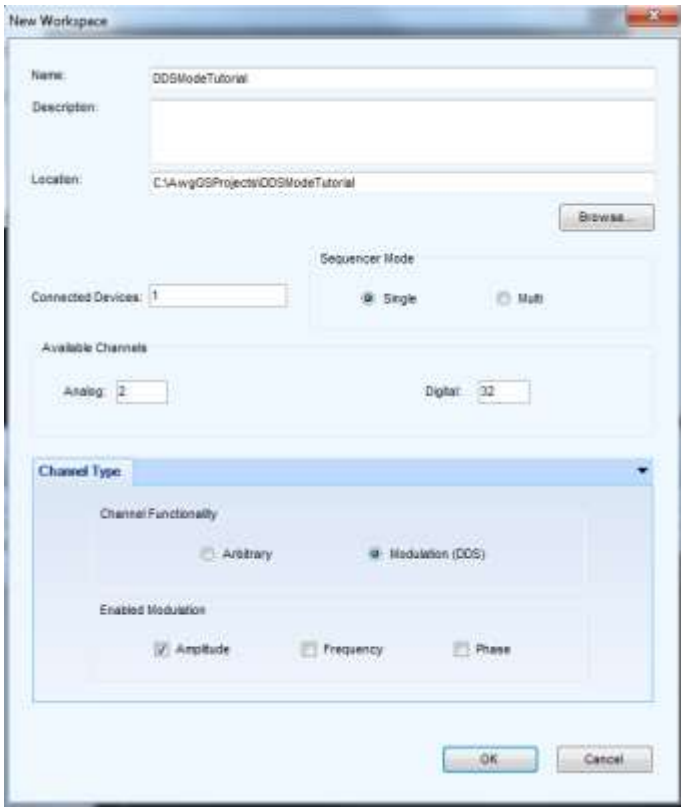
11. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

The software loads the waveforms into the AT-AWG-GS instrument and starts generating the waveforms. The sequence is generated on the AO1 SMA output. You can connect an oscilloscope to this output and analyze the signal.
Stop generating waveforms by pressing the **Run/Stop** button again.

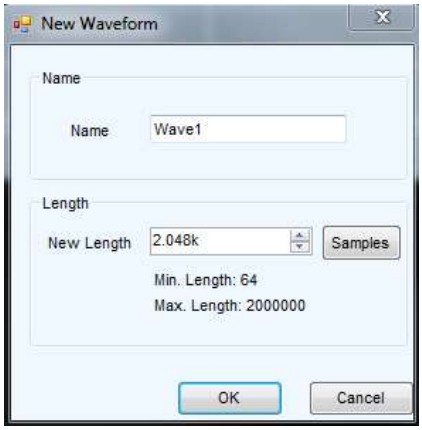
Creating a DDS Project

After you have powered on the instrument and connected it to the PC, launch the software and use the menu bar to create a **New Workspace**.

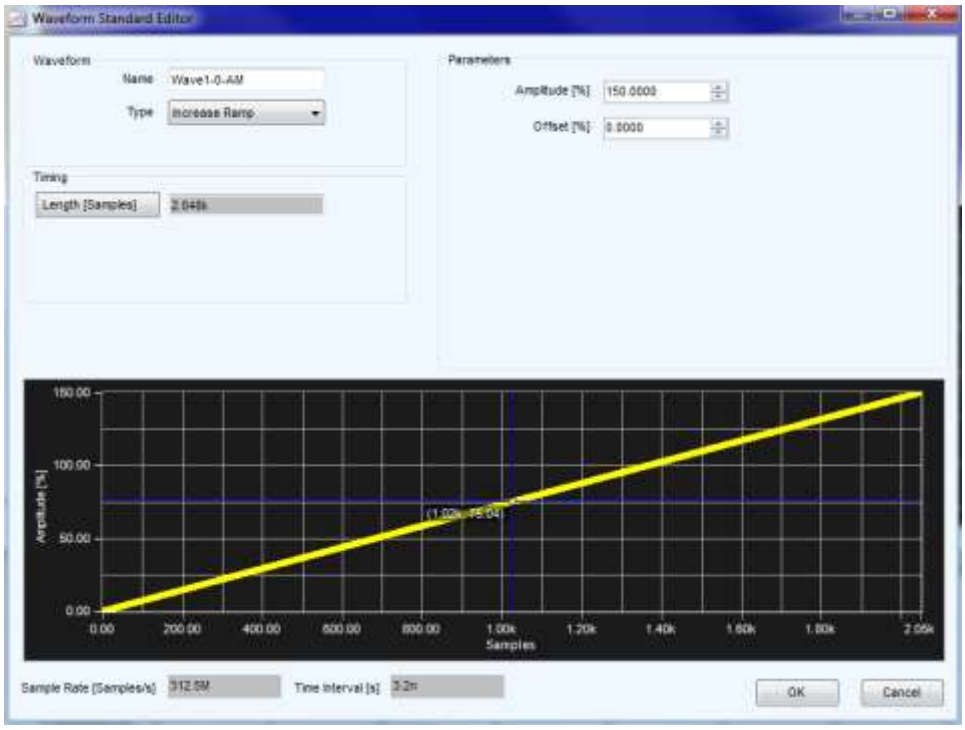
1. Type the Workspace name
2. Select **Single** as Sequencer Mode
3. Select **Modulation(DDS)** as Channel Functionality and **Amplitude** as Enabled Modulation. Click **OK**.



4. In the *Main Sequencer*, click the **New Mixed Waveform** button. 
   The **New Waveform** window is shown. Type the name of the waveform "Wave1" and choose 2048 for the samples length of the waveform. Click **OK** to confirm.



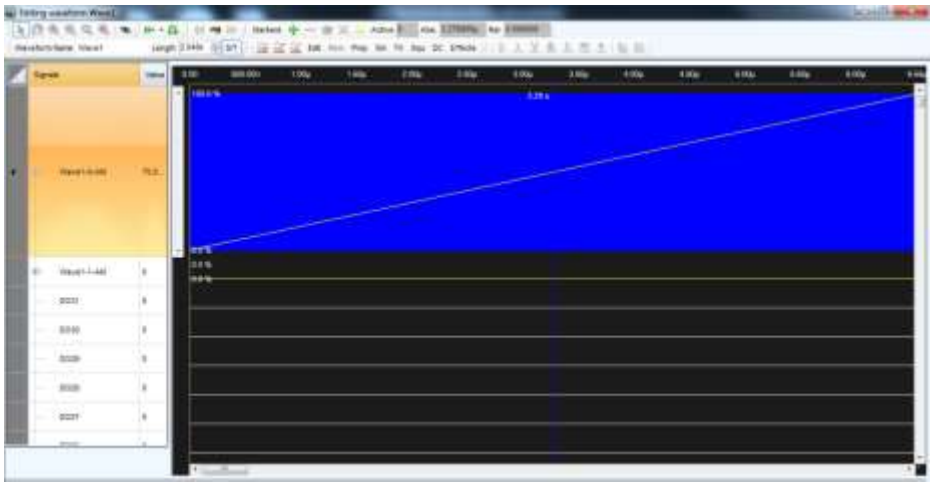
5. The **Editing Waveform Window** is shown. Select the waveform Wave1-AM and click on the **Edit**  button.



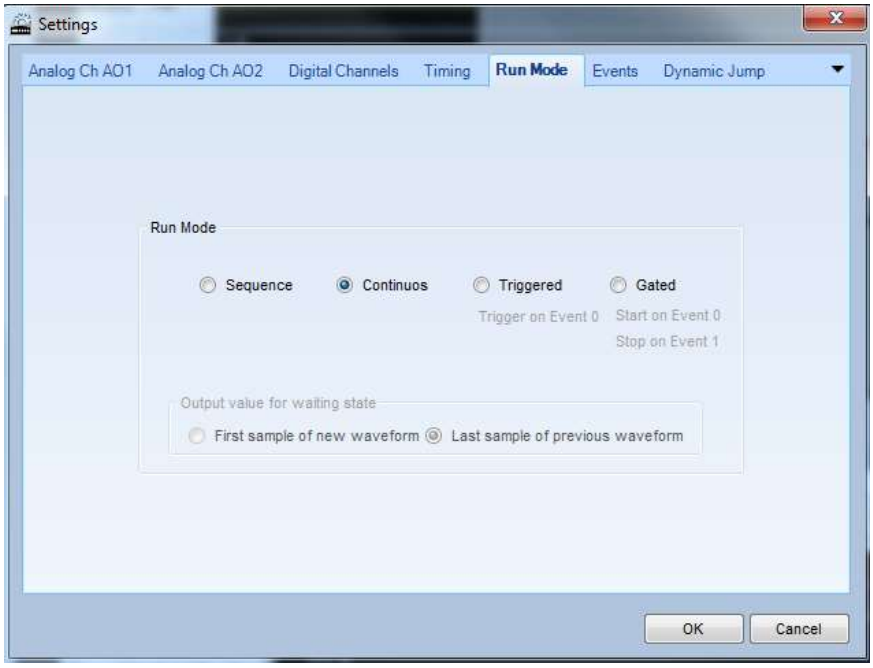
On the **Type** drop-down list select *Increase Ramp* and type 150 as Amplitude[%], Offset[%] = 0.

Click **OK** to confirm.

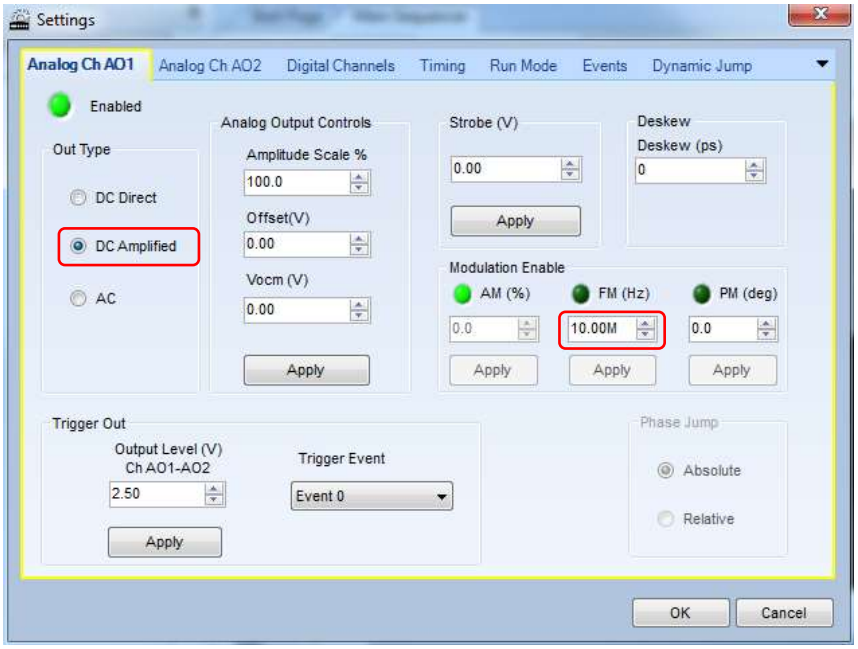
6. Click OK in the Editing Waveform Modulation window to confirm the profile of the amplitude modulation law.



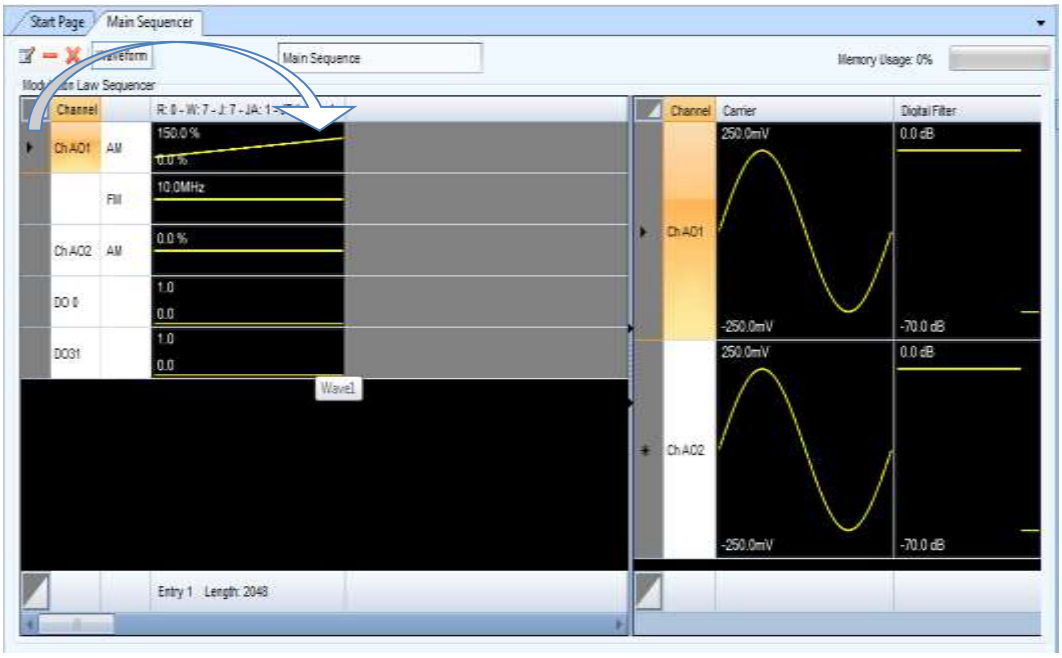
7. On the Settings pop-up screen's Run Mode tab, select **Continuous**.
   Click **OK**.



8. On the Settings pop-up screen's Analog Ch AO1 tab, select **DC Amplified** as Out Type and type 10M in the FM(Hz) field.
   The FM modulation mode is *manual*, so you should type the frequency of the output waveform.



9. Drag the *Wave1* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).

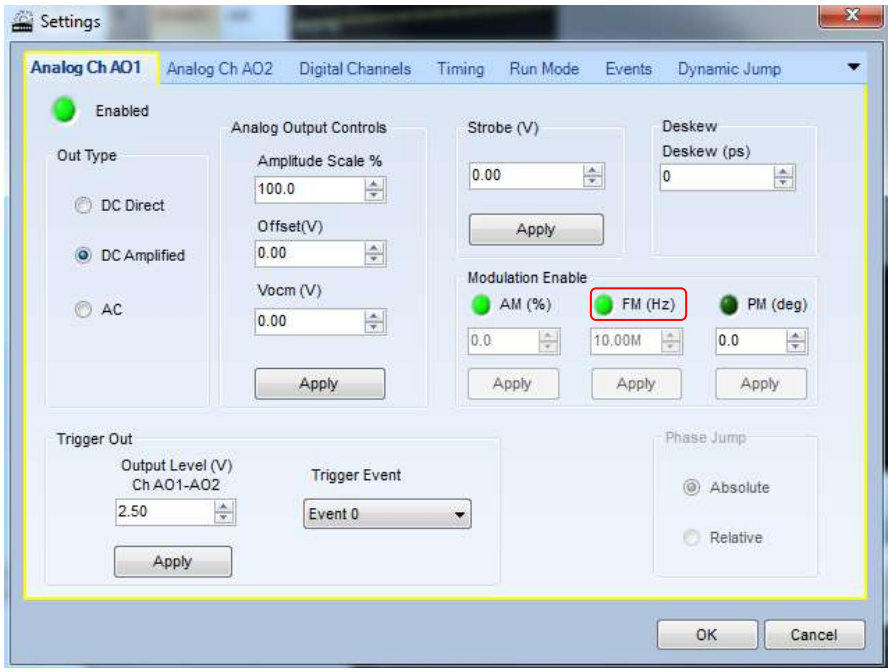


10. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

The software loads the waveforms into the AT-AWG-GS instrument and starts generating the waveforms. Wave1 is generated on the AO1 SMA output. You can connect an oscilloscope to this output and analyze the amplitude modulated signal.
Stop generating waveforms by pressing the **Run/Stop** button again.

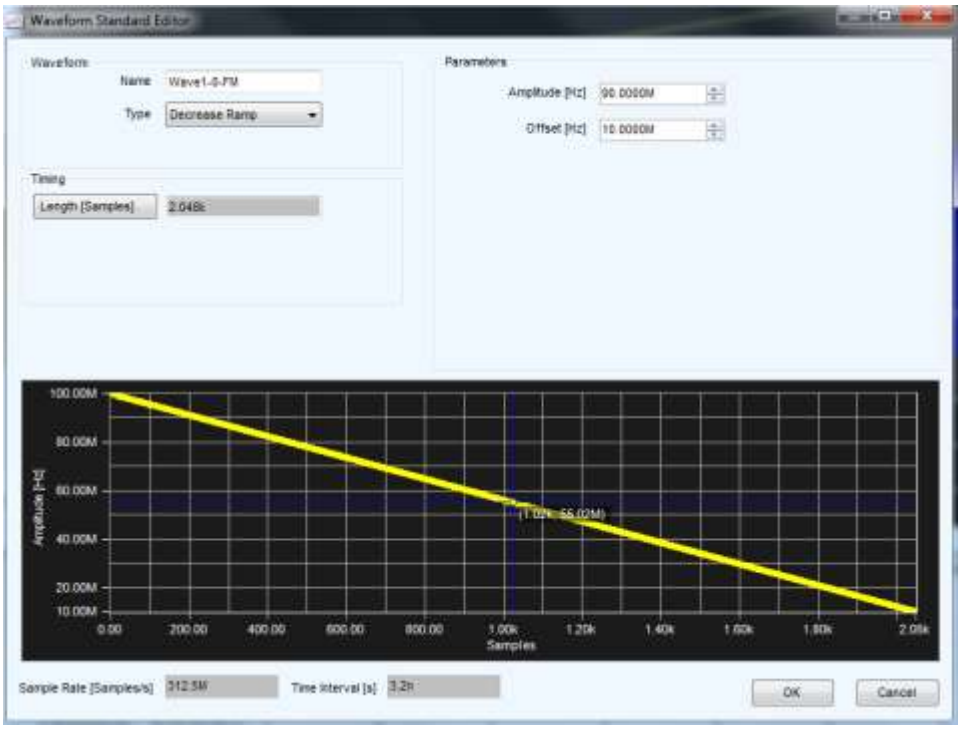
11. Now we will add the Frequency Modulation Law to the Wave1. In this way we will obtain at the output a waveform modulated in amplitude and frequency.

12. On the Settings pop-up screen's Analog Ch AO1 tab, **enable** the FM.



Click **OK** to confirm.

13. Double click on Wave1 in the Waveforms Tab list to open the Editing Waveform Window.
14. The **Editing Waveform Window** is shown. Select the waveform Wave1-FM and click on the **Edit** Edit button.

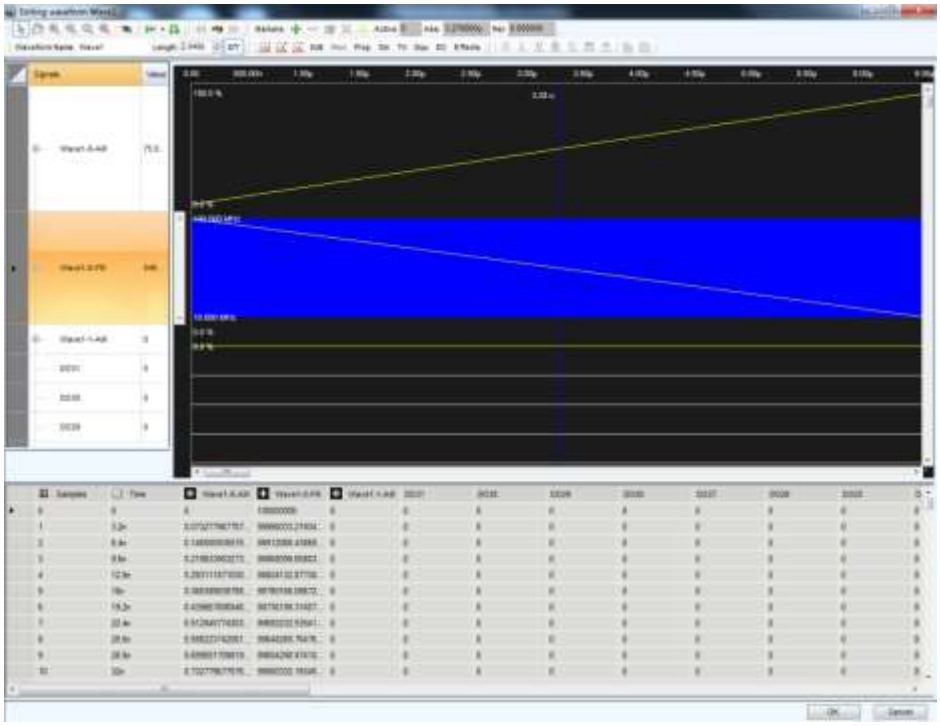


On the **Type** drop-down list select *Decrease Ramp* and type 90M as Amplitude[Hz],

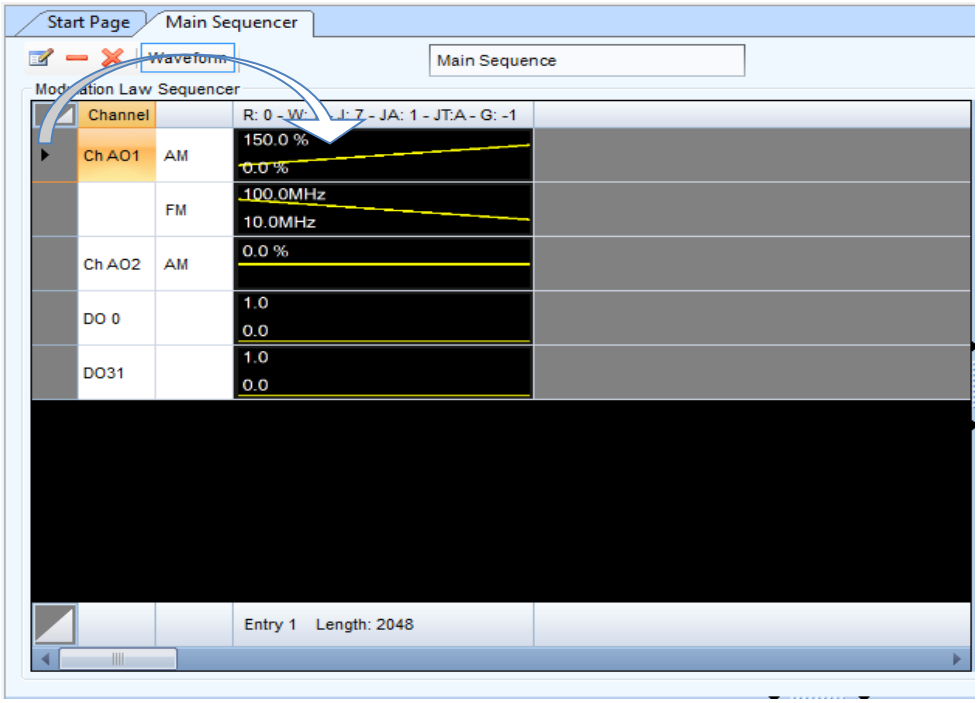
Offset[Hz] = 10M.

Click **OK** to confirm.

15. Click **OK** in the Editing Waveform Modulation window to confirm the profile of the frequency modulation law.



16. The *Wave1* in the Waveform Area is updated with the FM Modulation Law waveform.

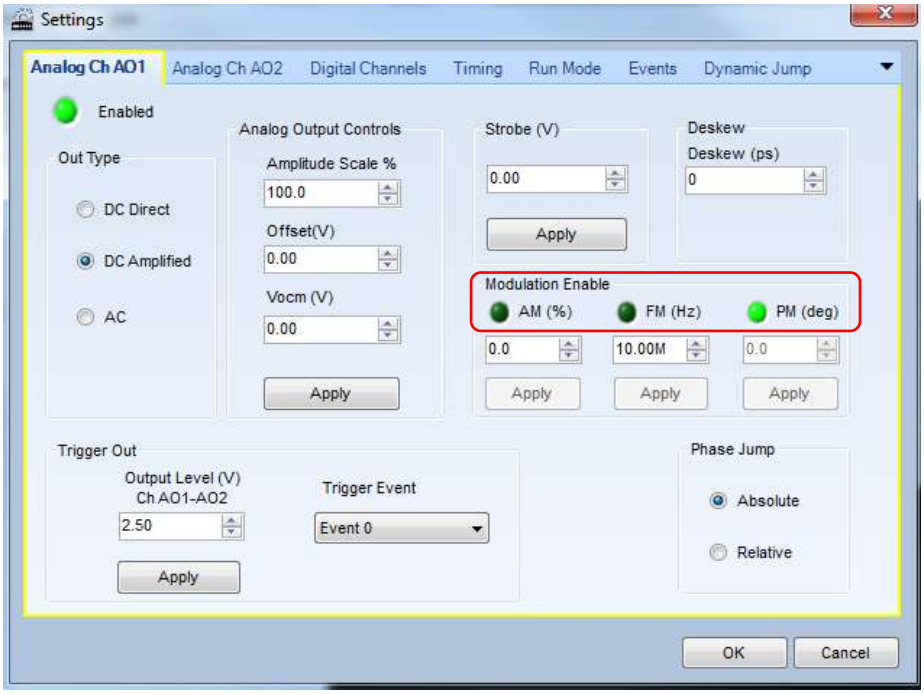


17. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

Wave1 is generated on the AO1 SMA output. You can connect an oscilloscope to this output and analyze the amplitude and frequency modulated signal.

Stop generating waveforms by pressing the **Run/Stop** button again.

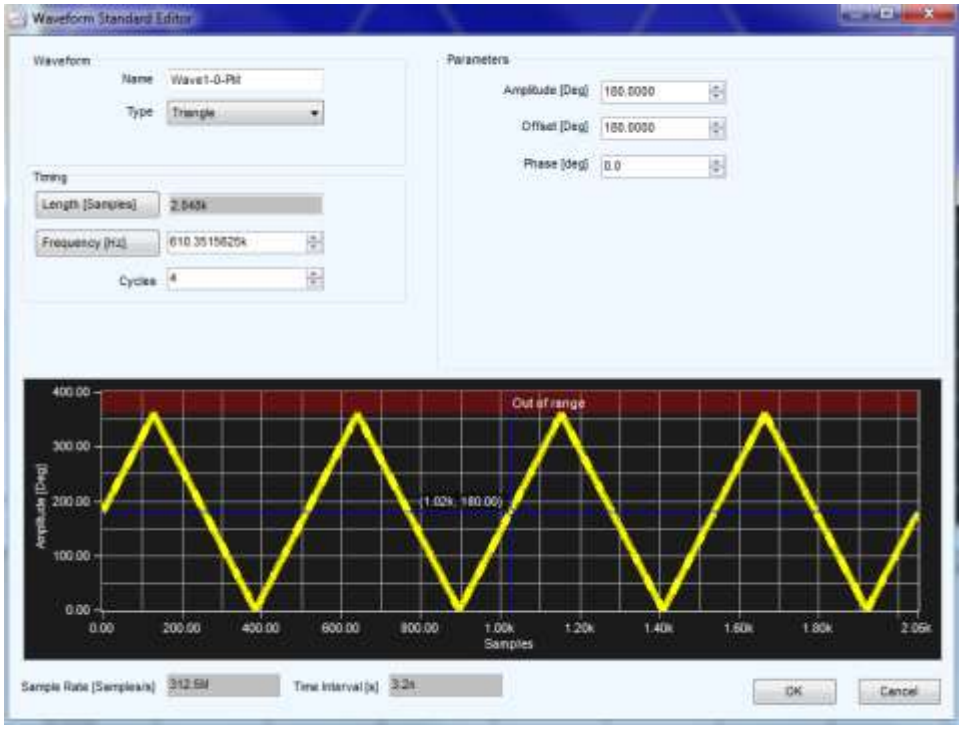
18. Now we will generate a phase modulated signal. First of all we will disable AM and FM modulation and we will enable PM Modulation Law Waveform.
19. On the Settings pop-up screen's Analog Ch AO1 tab, **enable** the PM and **disable** AM,FM.



Click **OK** to confirm.

20. Double click on Wave1 in the Waveforms Tab list to open the Editing Waveform Window.
21. The **Editing Waveform Window** is shown. Select the waveform Wave1-PM and click on the **Edit** 

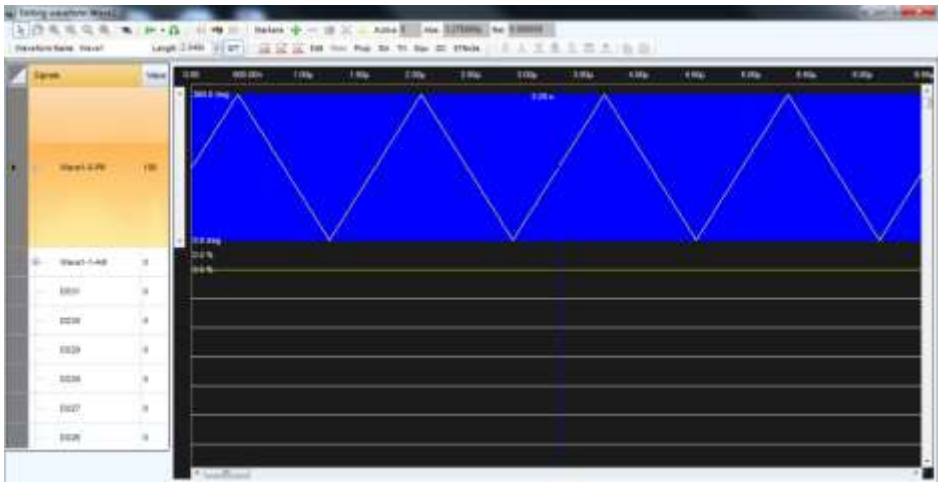
button.



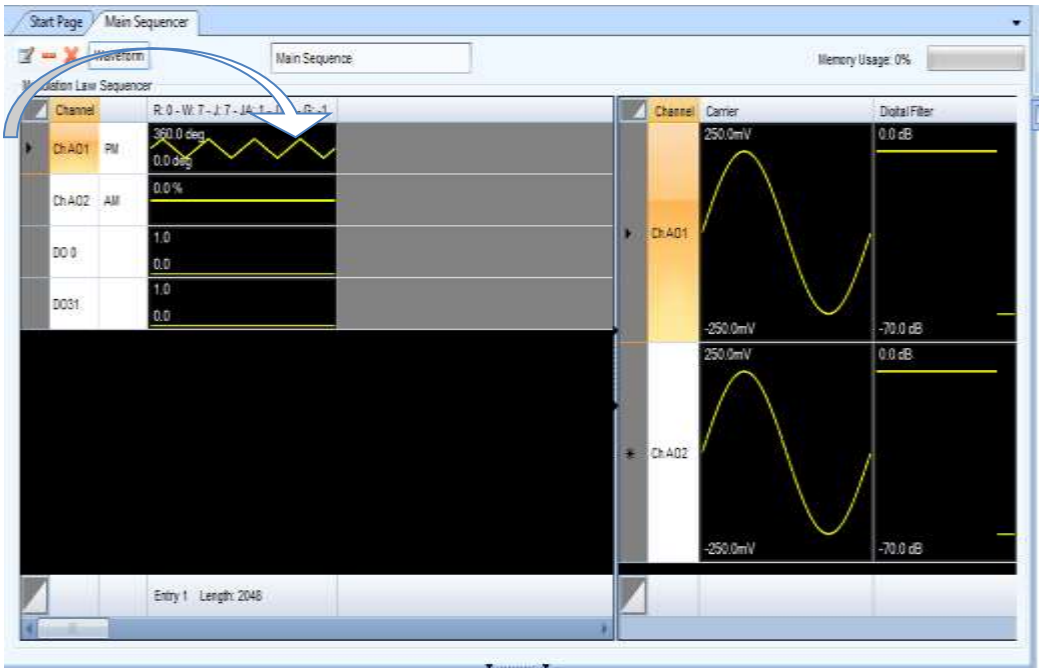
On the **Type** drop-down list select *Triangle* and type 180 as Amplitude[Deg], Offset[Deg] = 180.

Click **OK** to confirm.

22. Click **OK** in the Editing Waveform Modulation window to confirm the profile of the phase modulation law.



23. The *Wave1* in the Waveform Area is updated with the PM Modulation Law waveform only.



24. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

Wave1 is generated on the AO1 SMA output. You can connect an oscilloscope to this output and analyze the phase modulated signal.
Stop generating waveforms by pressing the **Run/Stop** button again.

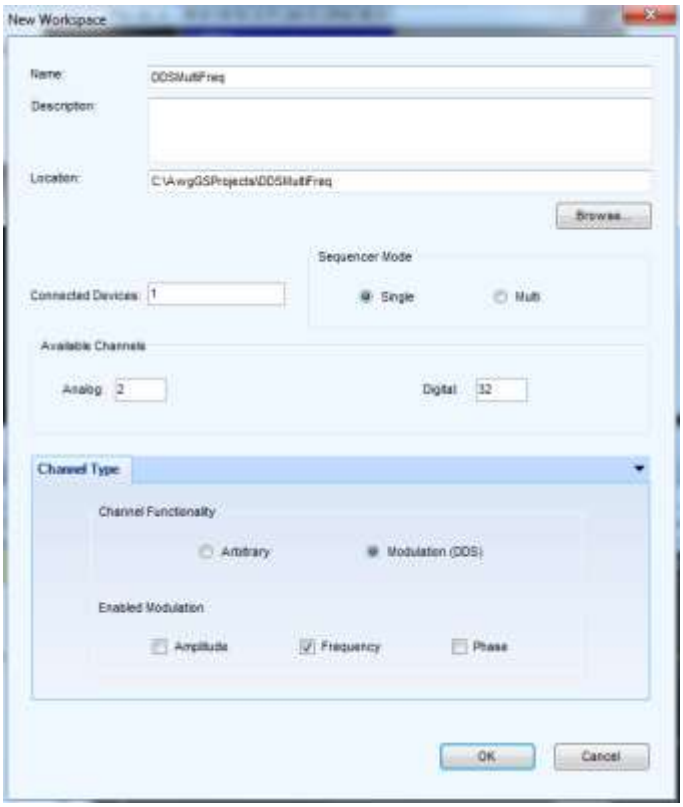
Creating a DDS Compensated sequence of waveforms

- Setup for the tutorial: : connect the external coaxial low pass filter (Minicircuits SBLP-933+) at the OUT+ connector of the AO2 and then connect the output of the filter to the input of a spectrum analyzer through a high bandwidth coaxial cable.
- Target of the example: sine waves with different frequencies are generated.
- In this example the Digital Filter of analog output 2 is loaded with a profile that compensates for the attenuation of the output power versus frequency. In this way the output power level is kept flat up to 600MHz with a tolerance of about ±0.5dB[1].
- Description: each entry of the sequencer contains a wait event that waits for the "Force Trigger" button to be pressed before executing the modulation low contained in it. So when the RUN button is pressed the first entry of the sequencer is executed and it waits for the "Force Trigger" button to be pressed.

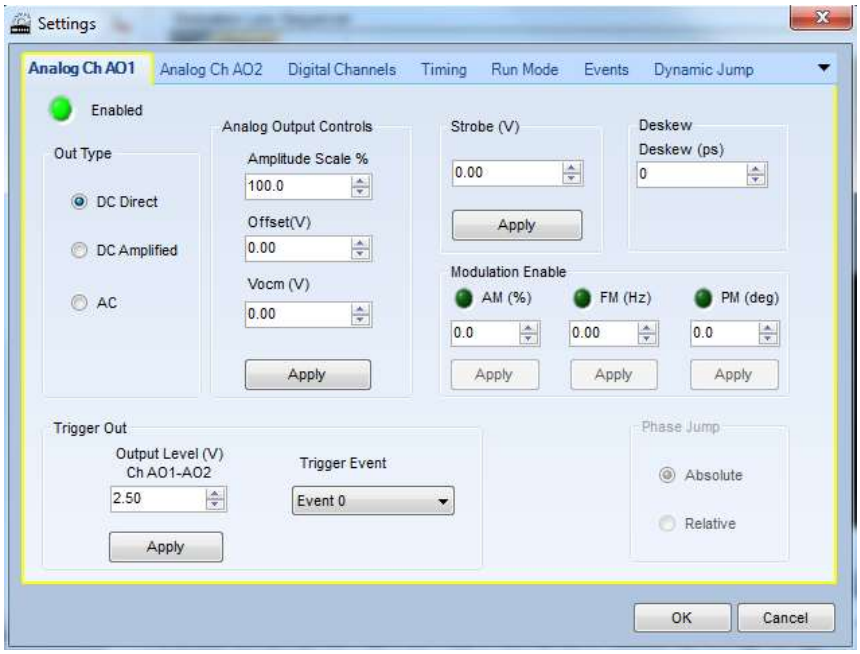
[1] The compensation profile depends on the coaxial cable from the filter to the input of the spectrum analyzer. Therefore the absolute output power level can slightly differ from 4dBm depending on the cable bandwidth.

- When the button is pressed it generates at the output a 4dBm sine wave at 600.1MHz. After that, each time the “Force Trigger” button in the main toolbar is pressed, the next entry of the sequencer is executed and it generates a new frequency according with the waveform contained in it. The sequencer execution restarts form the first entry when the last one is reached.

1. Type the Workspace name
2. Select **Single** as Sequencer Mode
3. Select **Modulation(DDS)** as Channel Functionality and **Frequency** as Enabled Modulation. Click **OK**.

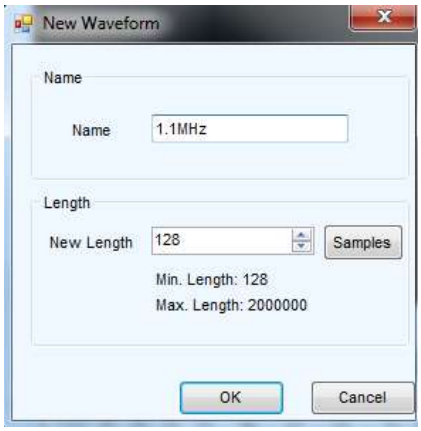
a. 

4. Click on the **Settings** icon in the main toolbar and select the Analog CH AO1 Tab.

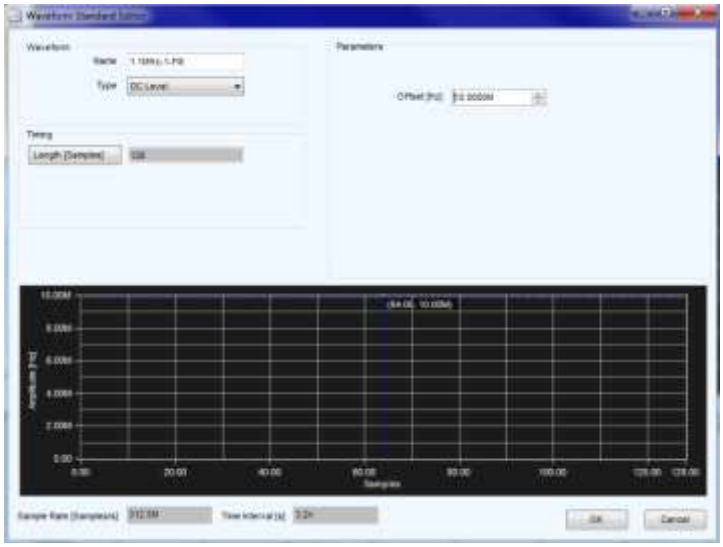


Disable FM(Hz) Modulation on CH1.

5. In the *Main Sequencer*, click the **New Mixed Waveform** button. 
The **New Waveform** window is shown. Type the name of the waveform "1.1MHz" and choose 128 for the samples length of the waveform. Click **OK** to confirm.

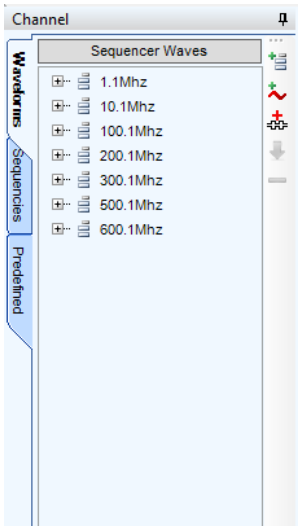


6. The **Editing Waveform Window** is shown. Select the waveform 1.1MHz-1-FM and click on the **Edit**  button.

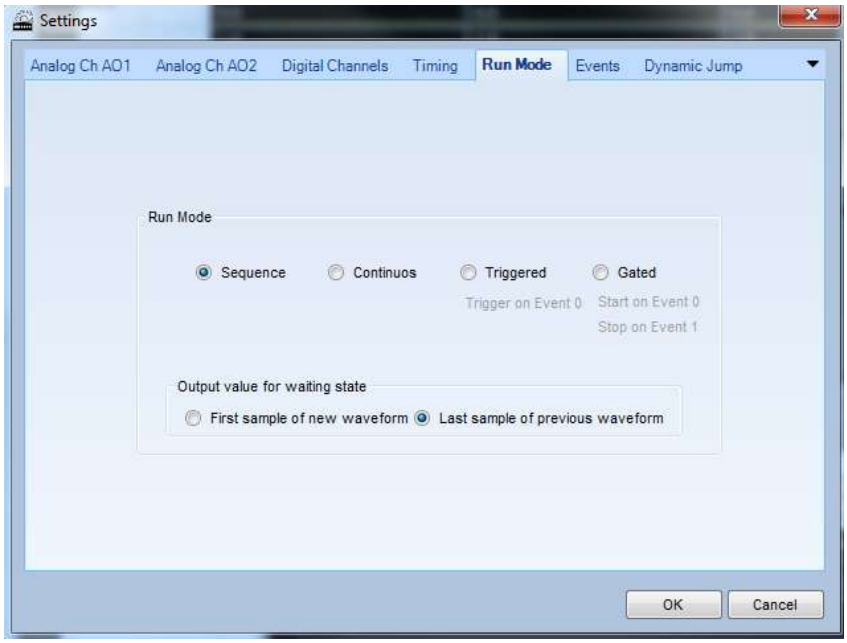


On the **Type** drop-down list select *DC Level* and type 10MHz as Offset[Hz] parameter. Click **OK** to confirm.

7. On the Editing Waveform Window click **OK** to confirm.
8. Repeat the steps from 1 to 7 and add the 10.1MHz, 100.1MHz, 200.1MHz,300.1MHz,400.1MHz,500.1MHz,600.1MHz frequencies.
9. The Waveform Tab list contains now the added waveforms.

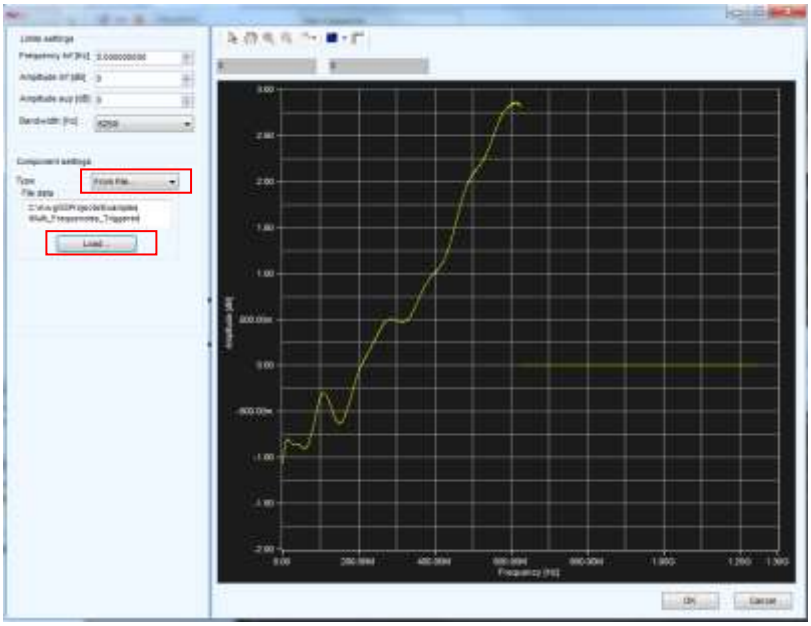


10. Click on the **Settings** icon in the main toolbar and select the Run Mode Tab.



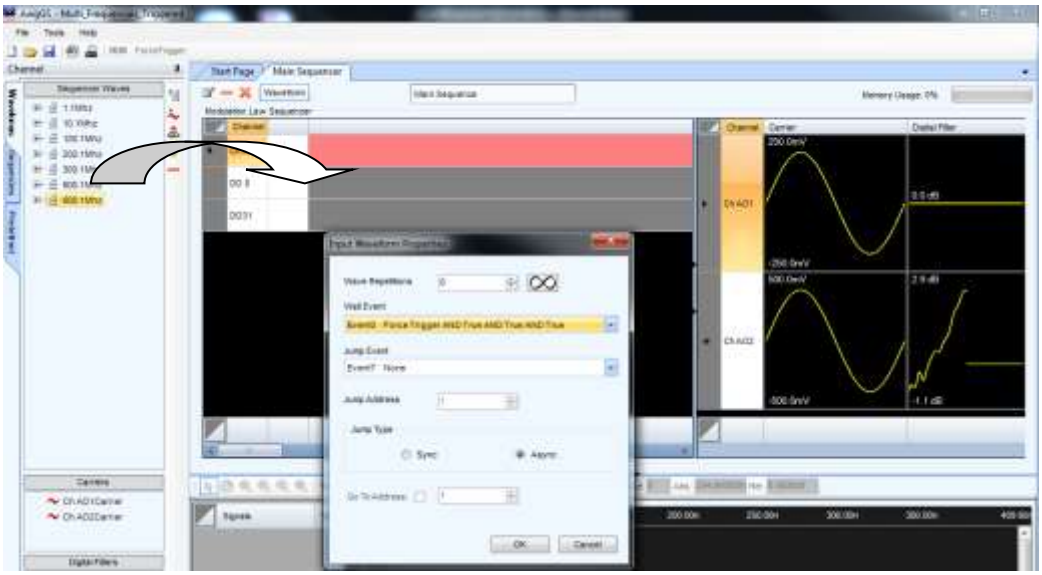
Select **Sequence** and click **OK** to confirm.

11. Double click on the *CHAO2DigitalFilter* to open the Digital Filter editor.



Select *From File… ,* click the *Load…* button and choose the flatness compensation filter Click **OK** to confirm.

9. Drag the *600.1MHz* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).



On the *Input Waveform Properties* window select Event0 in the Wait Event drop-down list.

10. Press **OK** to confirm.
11. Repeat the steps 9 and 10 for all the other waveforms in the Waveform Tab List; in the 1.1 MHz Input Waveform Properties type 1 as Go To Address.

Press **OK** to complete the sequence.

12. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

600.1MHz is generated on the AO2 SMA output when you press the **Force Trigger** button. You can connect an oscilloscope to this output and analyze the phase modulated signal. Press again the **Force Trigger** button to generate the next waveform on the sequence

13. Stop generating waveforms by pressing the **Run/Stop** button again.

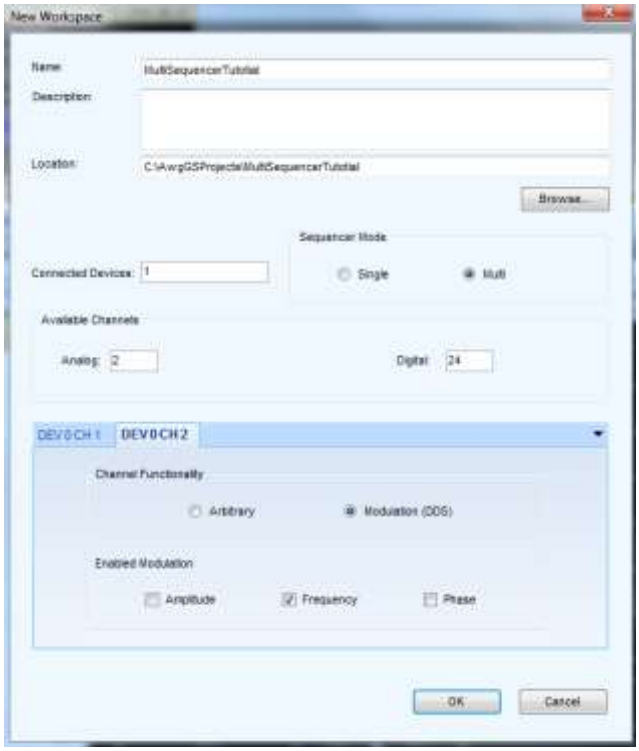
Creating a Multi Sequencer Project

Multi Sequencer projects: in this kind of projects each analog output can be configured completely independently each other
This mode is called “Multi Sequencer” because each analog channel has its own sequencer.

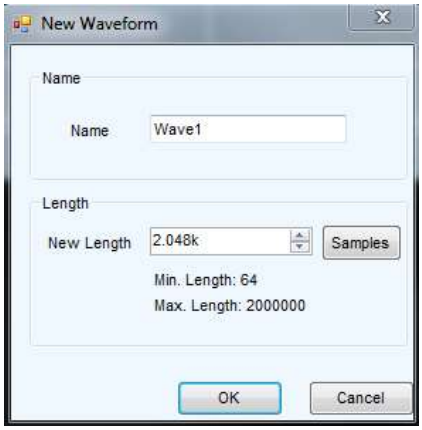
After you have powered on the instrument and connected it to the PC, launch the software and use the menu bar to create a **New Workspace**.

1. Type the Workspace name
2. Select **Multi** as Sequencer Mode
3. On the **DEV 0 CH1** Tab select **Arbitrary** as Channel Functionality and **16Ch@625 MS/s** as Digital Channel Speed.

4. On the **DEV 0 CH2** Tab select **Modulation(DDS)** as Channel Functionality and mark the Frequency box for the Enabled Modulation field. Click **OK**.

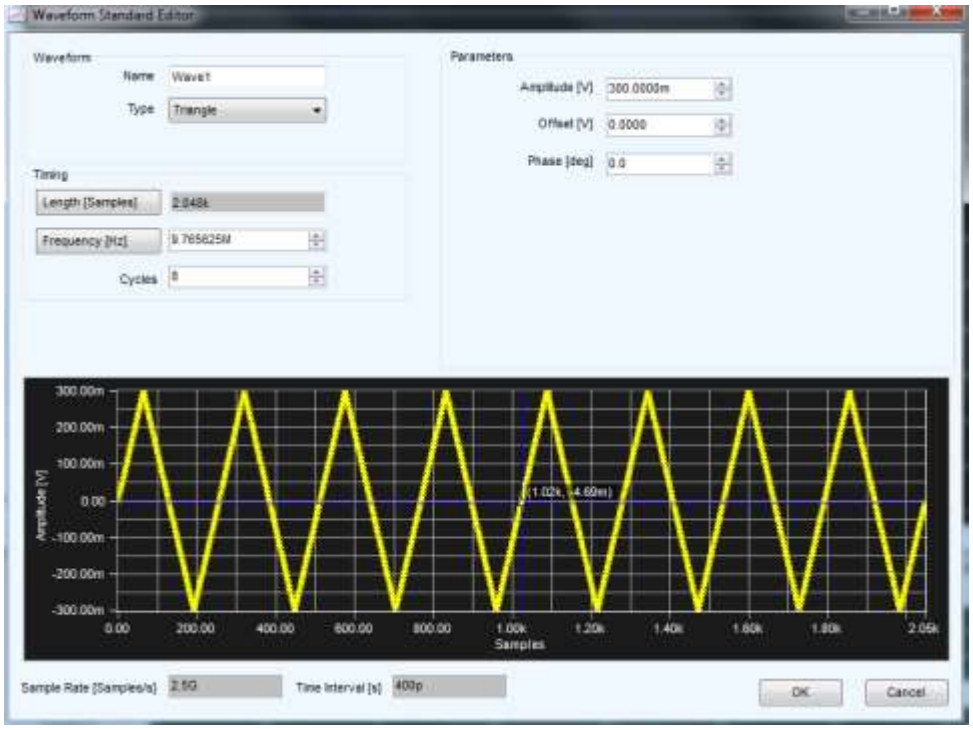


5. In the *Main Seq DEV0 CH1*, click the **New Mixed Waveform** button. 
   The **New Waveform** window is shown. Type the name of the waveform "Wave1" and choose 2048 for the samples length of the waveform. Click **OK** to confirm.



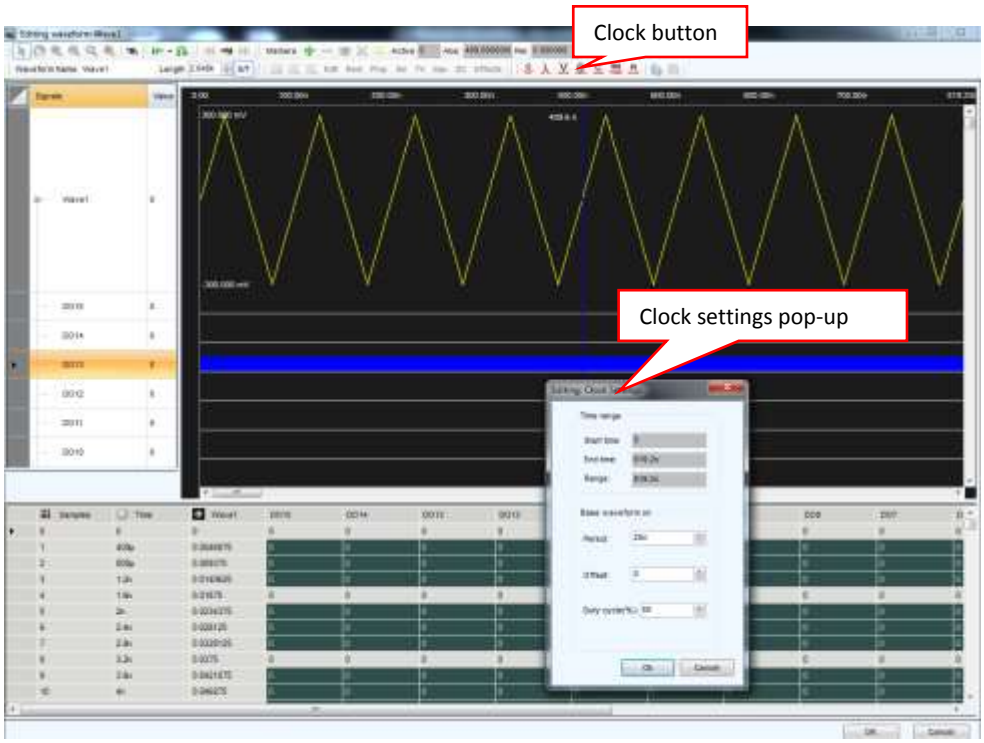
6. The **Editing Waveform Window** is shown. Select the waveform Wave1 and click on the **Edit** 

button.



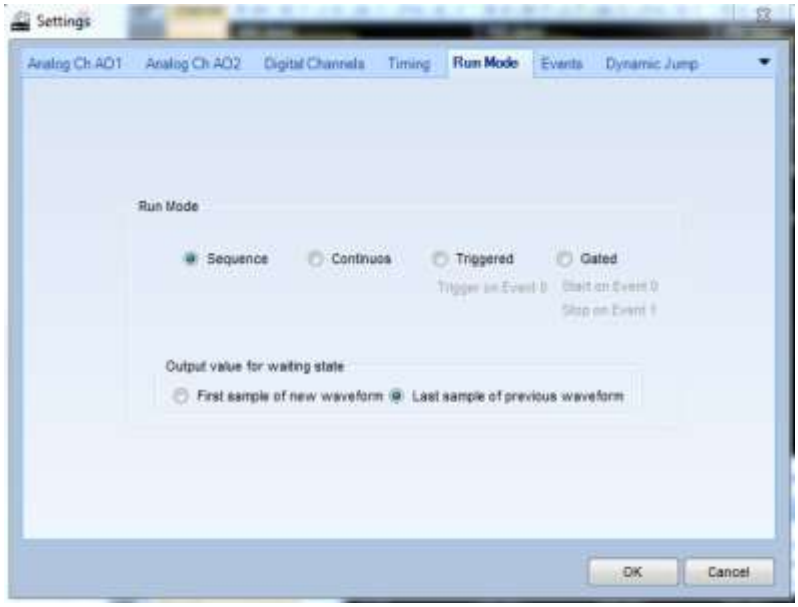
On the **Type** drop-down list select *Triangle* and type 8 cycles (Frequency = 9.765625 MHz). Click **OK** to confirm.

7. Select the DO13 in the Editing Waveform window and use the **Clock Button** to modify settings on the corresponding pop-ups. Click **OK** to confirm.

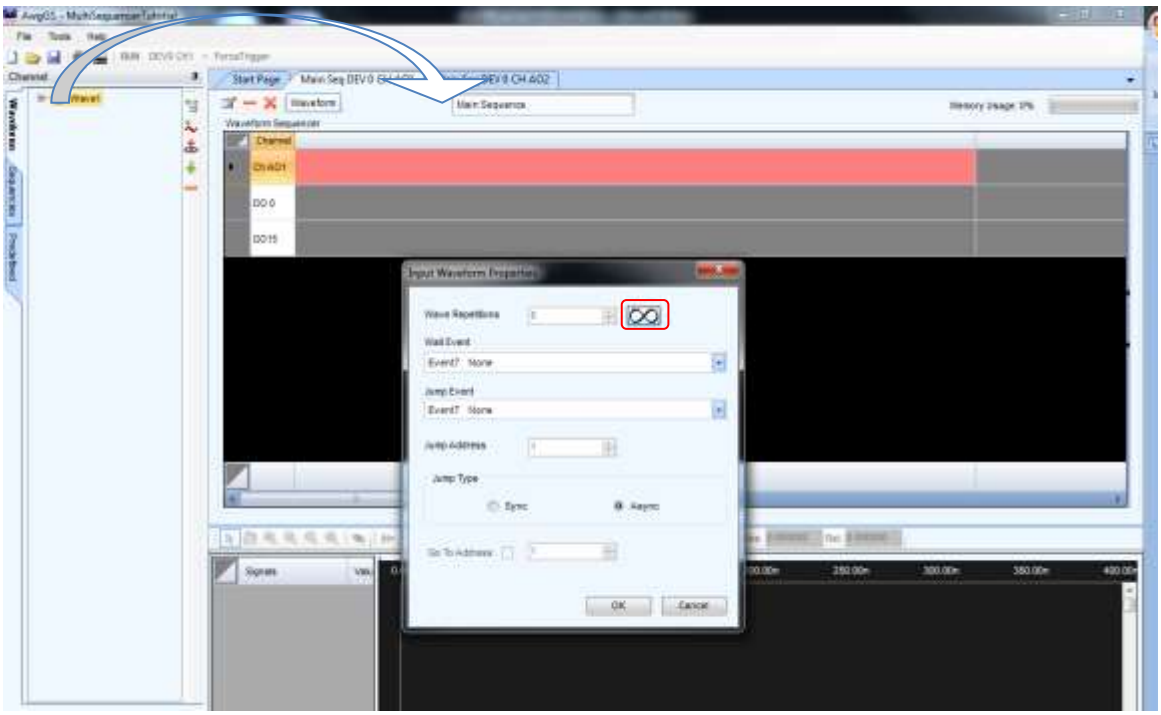


8. On the Settings pop-up screen's Run Mode tab, select **Sequence**.

Click **OK**.



9. On the Waveforms TAB, drag the Wave1 and drop it in the first entry of **the Main Seq Dev 0 CH1 sequencer**.

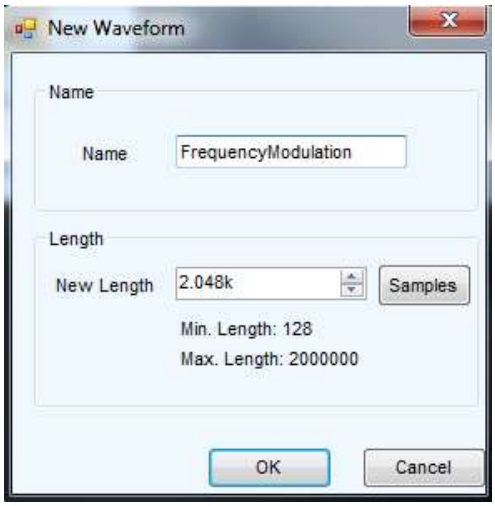


On the *Input Waveform Properties* window select infinite repetitions.
Press **OK** to confirm.

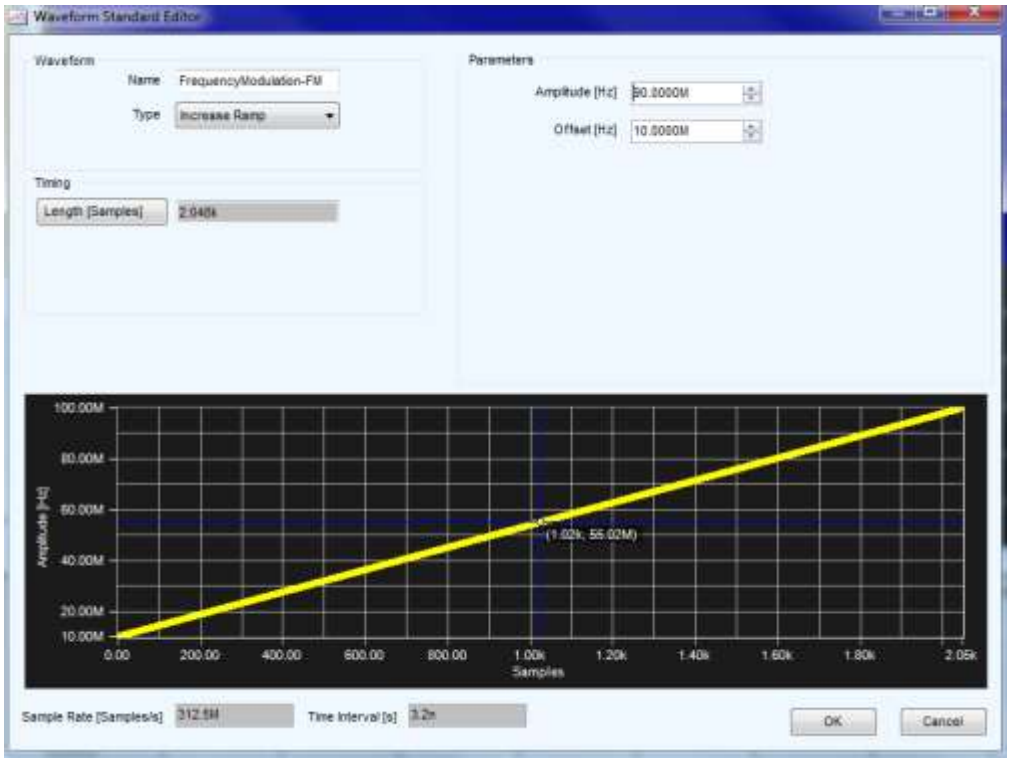
10. Change the sequencer TAB and select **Main Seq Dev 0 CH AO2**.

In the *Main Seq DEV0 CH AO2*, click the **New Mixed Waveform** button. 

The **New Waveform** window is shown. Type the name of the waveform "FrequencyModulation" and choose 2048 for the samples length of the waveform. Click **OK** to confirm.



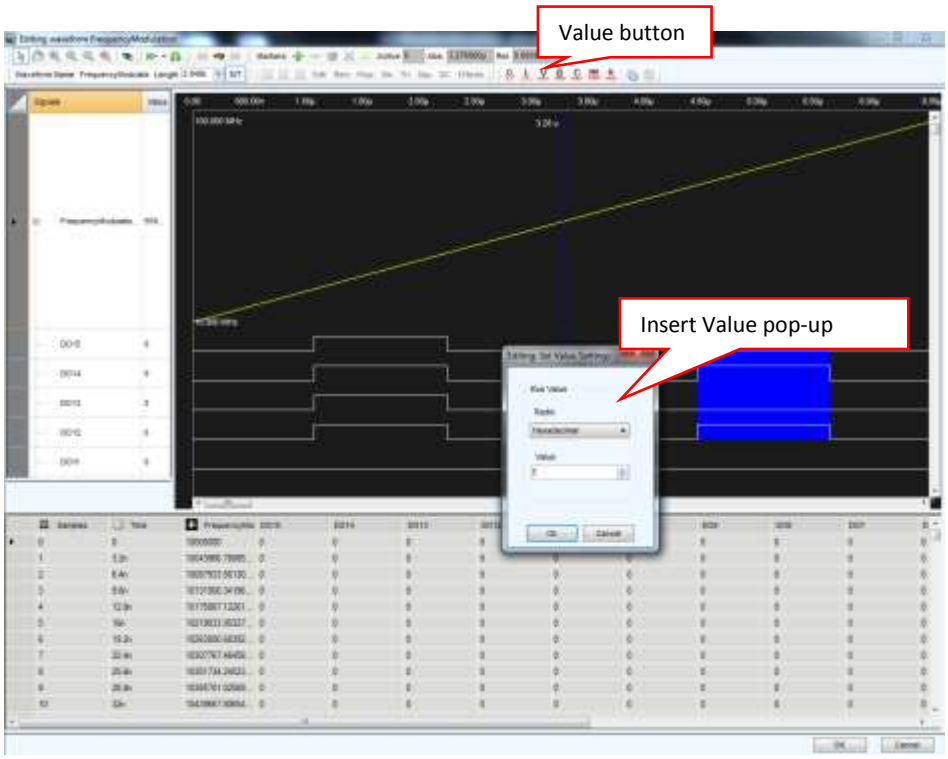
11. The **Editing Waveform Window** is shown. Select the waveform FrequencyModulation and click on the **Edit** Edit button.



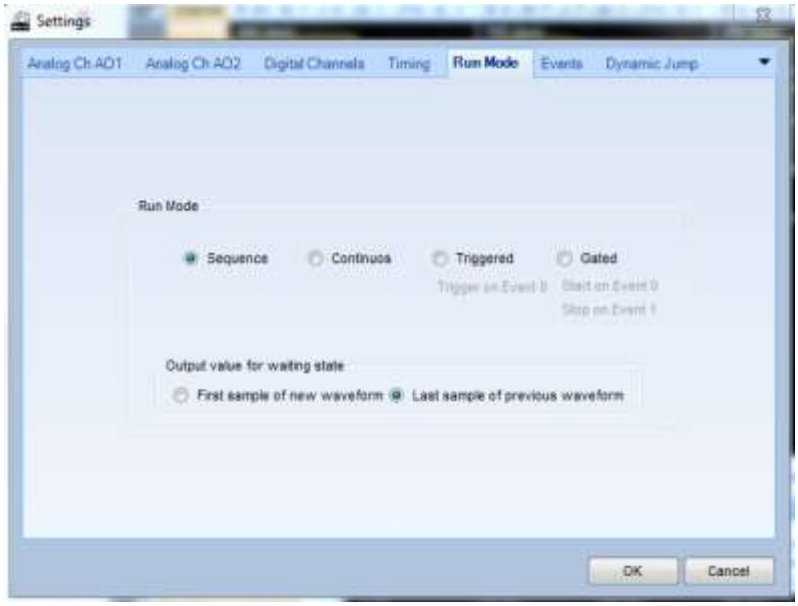
On the **Type** drop-down list select *IncreaseRamp* and type 10MHz in the Offset field and 90MHz in the Amplitude field to obtain a frequency sweep from 10 MHz to 100 MHz. Click **OK** to confirm.

12. Select the DO12..DO15 in the Editing Waveform window and use the **Value Button** to

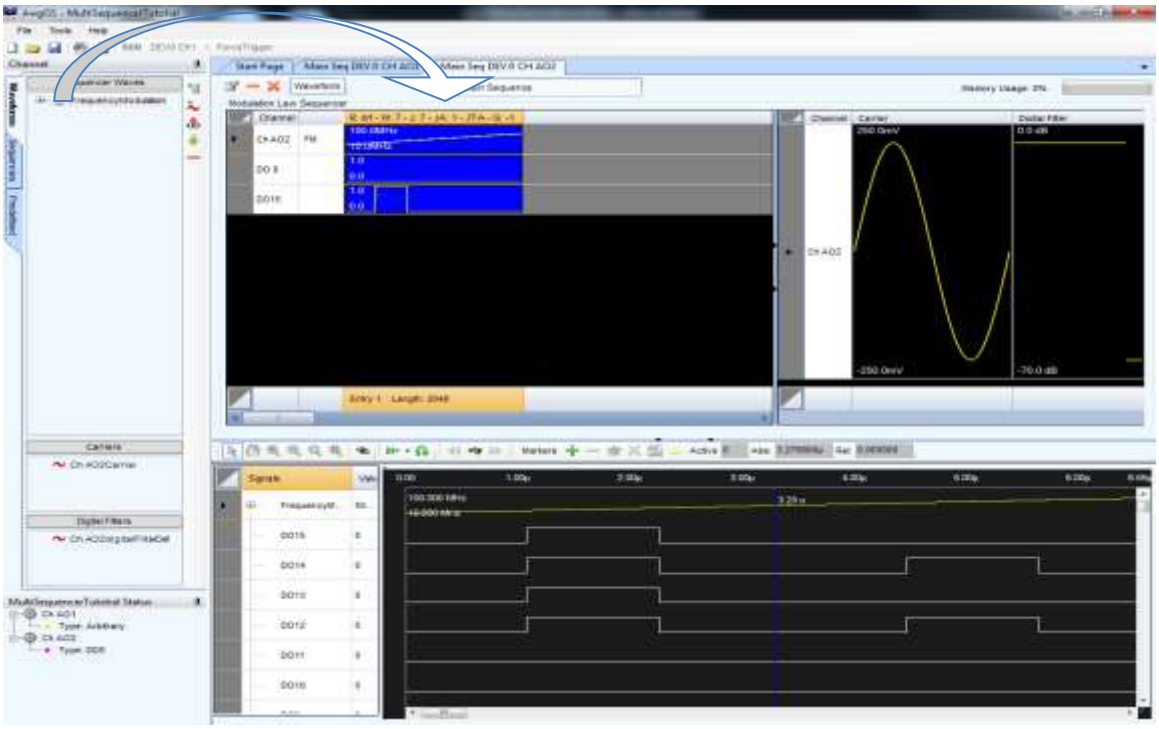
modify settings on the corresponding pop-ups. Click **OK** to confirm.



13. On the Settings pop-up screen's Run Mode tab, select **Sequence**. Click **OK**.



14. On the Waveforms TAB, drag the *FrequencyModulation* waveform and drop it in the first entry of **the Main Seq Dev 0 CH AO2 sequencer**.



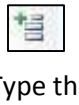
On the *Input Waveform Properties* window select **infinite** repetitions.
Press **OK** to confirm.

15. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

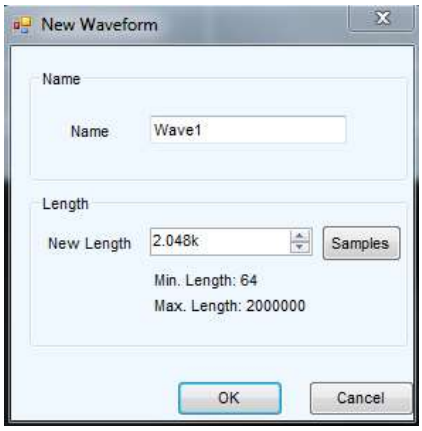
The software loads the waveforms into the AT-AWG-GS instrument and starts generating the waveforms. The two waveforms are generated on the AO1 and AO2 SMAs output. You can connect an oscilloscope to this output and analyze the signals.
In **MultiSequencer** mode the two sequencers work independently so the channels don't start/stop in the same time.
Stop generating waveforms by pressing the **Run/Stop** button again.

Importing a Waveform from an Oscilloscope + Component Usage + Gated Run Mode

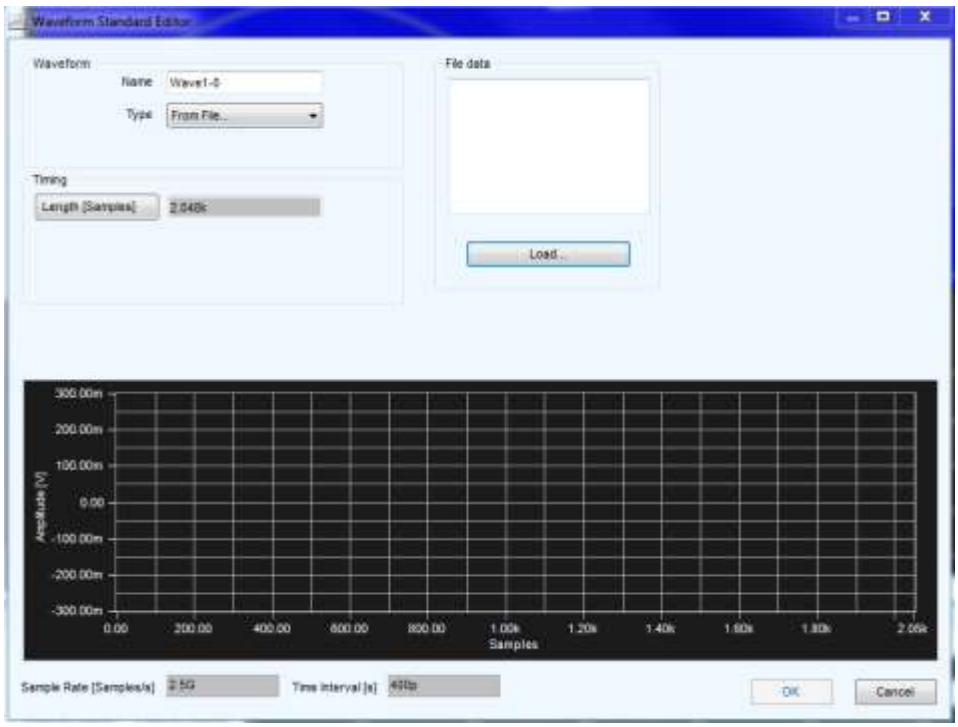
Import a Waveform from an Oscilloscope by first creating a project with Arbitrary Waveform Generator Mode. See steps 5 and 6 in **Arbitrary Mode Single Sequencer Setup Example** (on page 31) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

1. Click the **New Mixed Waveform** button. 
   The **New Waveform** window is shown. Type the name of the waveform "Wave1" and

choose 2048 for the samples length of the waveform. Click **OK** to confirm.

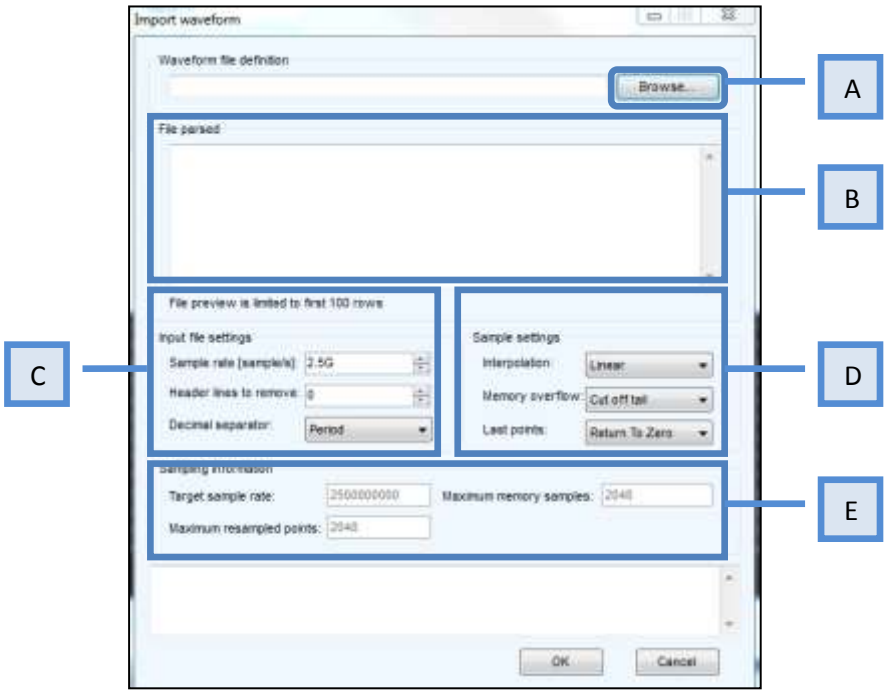


2. The **Editing Waveform Window** is shown. Select the waveform Wave1 and click on the **Edit** Edit button.



On the **Type** drop-down list select *From File…* and press the Load… button.

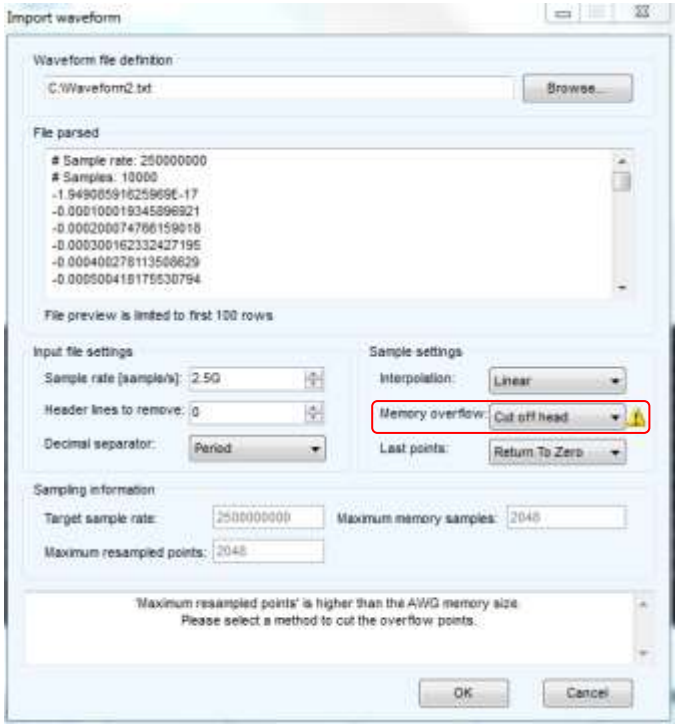
The Import waveform pop-up screen is shown.



Labels A-E on this image corresponds with the following descriptions:

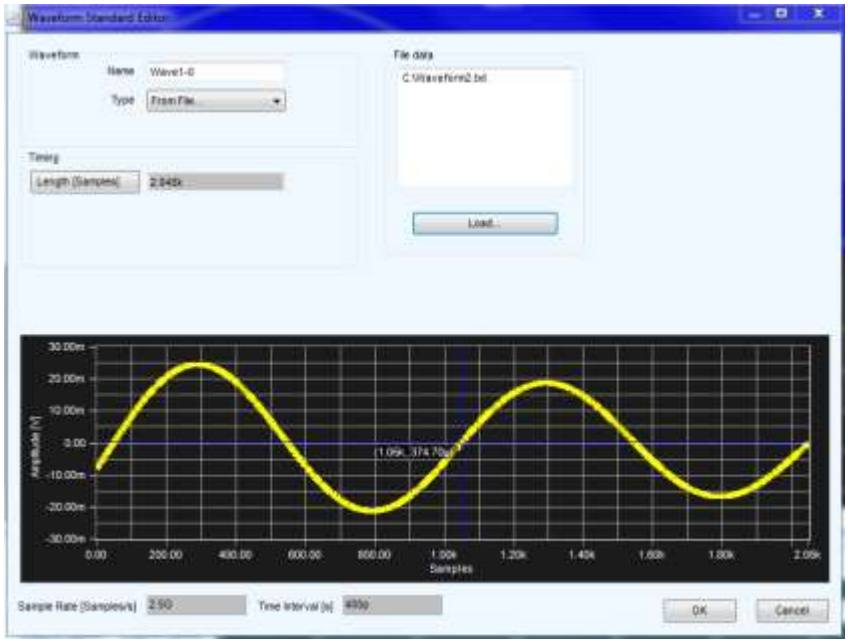
A. Click the **Browse** button and locate your desired .txt,.csv or .trc (LeCroy oscilloscope file format) file for import.
   AT-AWG-GS prompts you to convert the file format from **.trc** to **.txt**.
B. The **File parsed** section then shows the first 100 samples of the imported waveform.
C. If desired, **Input file settings** allow for **Sample rate**, **Header lines to remove**, and **Decimal separator** changes to the imported file.
D. Use the **Sample setting** fields to adjust parameters and rules.
E. If the imported waveform has a sample rate greater than the AT-AWG-GS target sampling rate (2.5 GS/s), the waveform points are re-sampled and shown on the **Sampling information** fields.

Browse for the Waveform2.txt file



Select *Cut off head on Memory overflow* and remove the first two lines of the file header. Click **OK** to confirm.

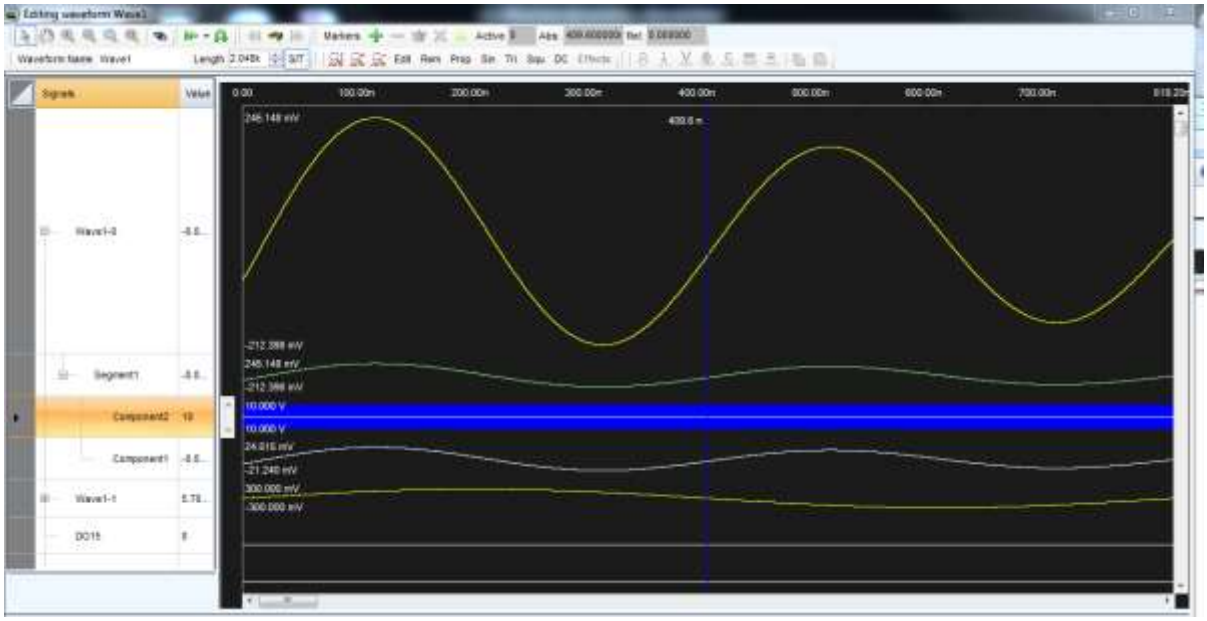
3. Waveform Standard Editor window is shown and it displays the imported waveform.



As you can notice the waveform amplitude is very low, so in the following steps we will use

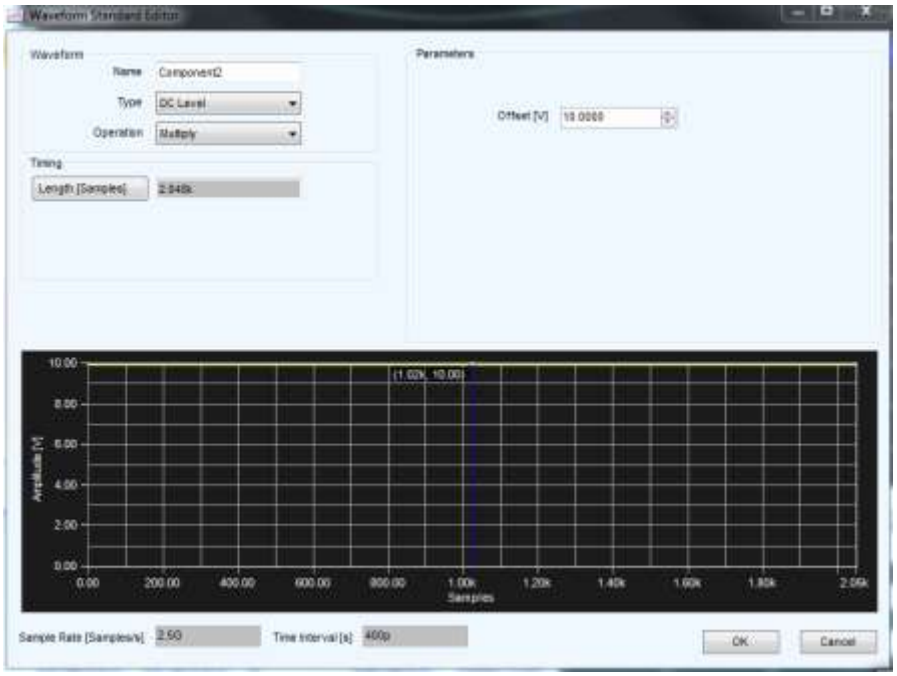
a DC component to multiply it by a constant and obtain a higher voltage output waveform. Click **OK** to confirm.

4. Right click on the Wave1 Segment to display the pop-up menu and select *Add Component*.



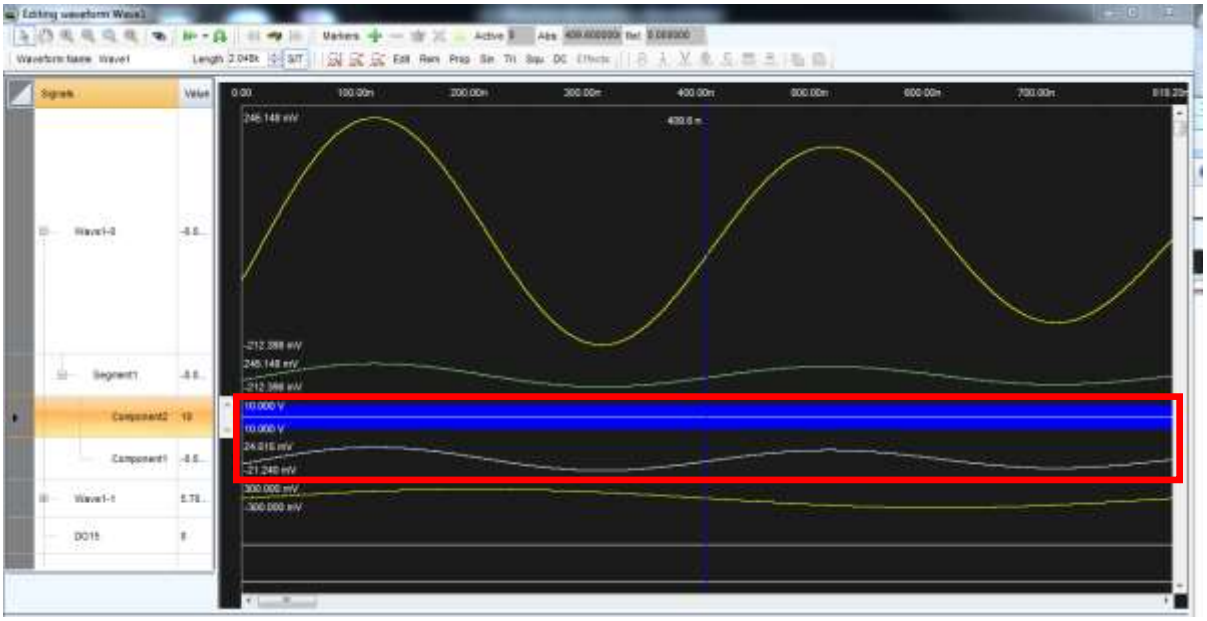
Component2 is added to Wave1-0

5. Select DC Level as **Type** and Multiply in the **Operation** field; type 10 in the **Offset[V]** field as multiplication factor.



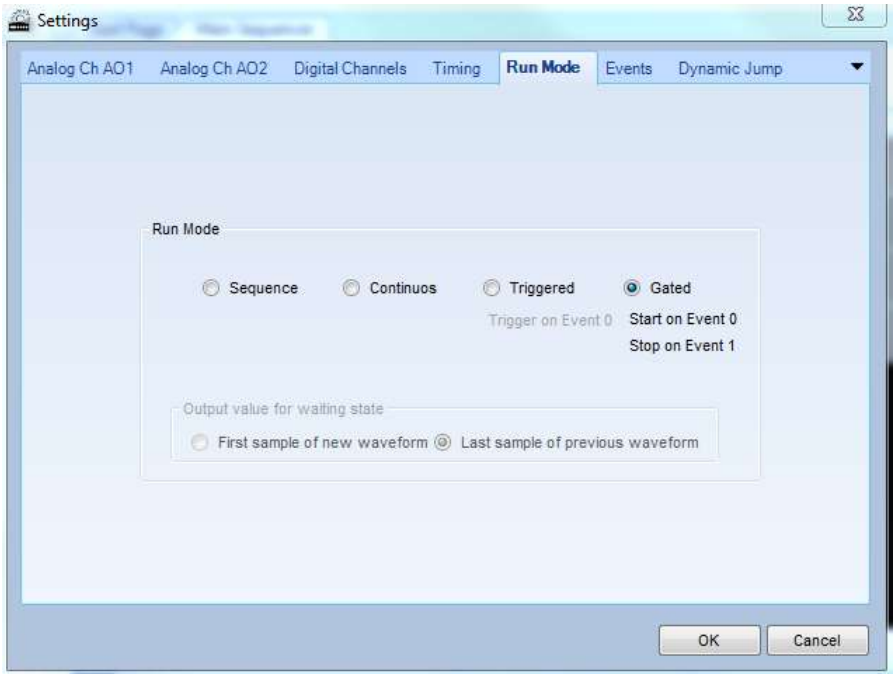
The Wave1-0 = Component1*Component2

6. The waveform amplitude of Wave1-0 has been increased by a 10x factor.

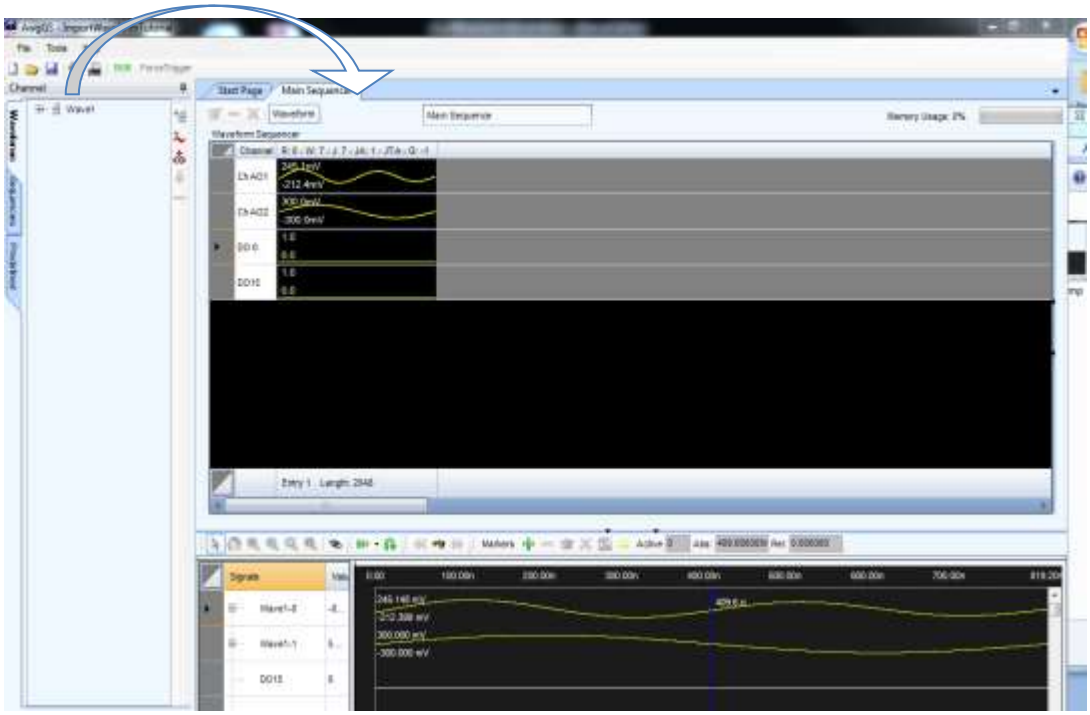


Click **OK** to confirm.

7. On the Settings pop-up screen's Run Mode tab, select **Gated**.
   Click **OK**.



8. Drag the *Wave1* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).



9. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

The software loads the waveforms into the AT-AWG-GS instrument.

Keep pressed the ForceTrigger button to start the waveform generation. Wave1 is generated on the AO1 and AO2 SMA outputs.

Release the ForceTrigger button to stop the waveform generation.
You can connect an oscilloscope to this output and analyze the signals.
Stop the instrument by pressing the **Run/Stop** button again.

Creating Digital Waveforms

The AT-AWG-GS may optionally be configured to work as a powerful Digital Pattern Generator. When the AT-AWG-GS runs in this mode it can emulate standard serial or parallel bus transitions or custom digital interfaces for system debugging and characterization.

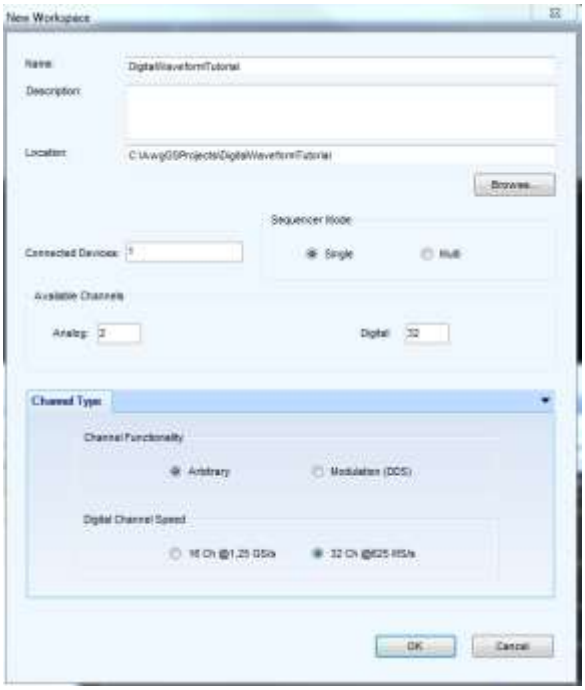
After you have powered on the instrument and connected it to the PC, launch the software and use the menu bar to create a **New Workspace**.

> **Note**: The following steps are done on an AT-AWG GS with the Pattern Generator option enabled.

1. Type the Workspace name
2. Select **Single** as Sequencer Mode
3. Select **Arbitrary** as Channel Functionality
4. Select **32Ch@625 MS/s** as Digital Channel Speed.

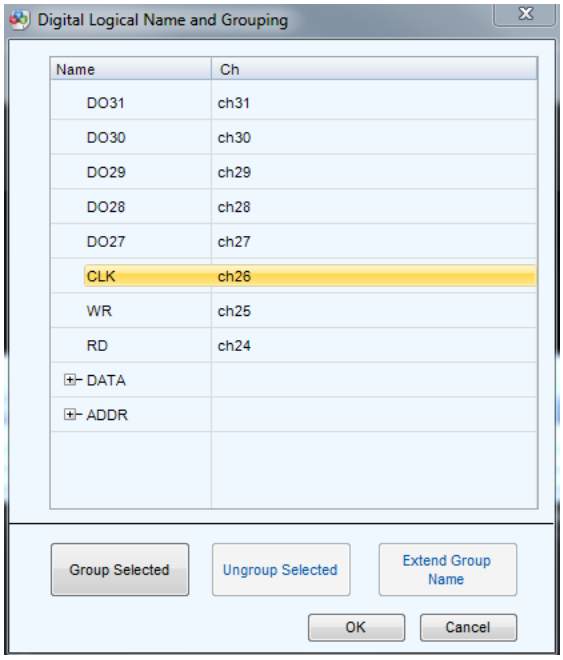
> **Note**: two Infiniband 12x connectors provide 16 bit LVDS digital outputs each for a total of 32 LVDS outputs. These digital outputs can be software configured to operate in different ways.
> In ARB mode it is possible to operate with all of the 32 channels with a max. update rate of 625MSps or with half channels (16) at 1.25Gsps.

5. Click **OK**.



6. Click the **Logical Definition** button.

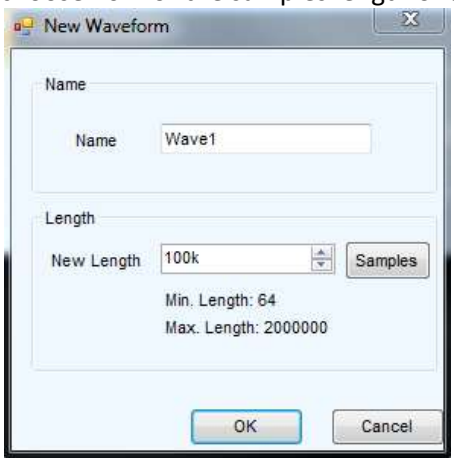
7. The **Digital Logical name and Grouping** window is shown.



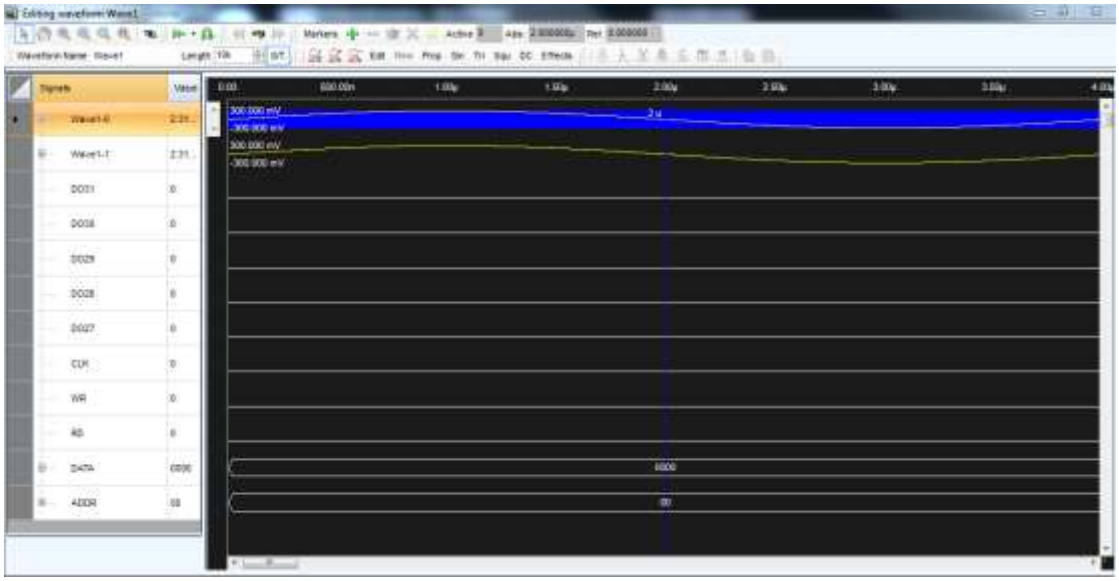
Now, let's make a bus by selecting DO0..DO7 on the channel list on the left, and then clicking the Group Selected. Keep pressed the left mouse button on the bus root name to change its name to ADDR.
Repeat the procedure for DO8..DO23 and change the group name to DATA.
Rename the DO24 to RD, the DO25 to WR and the DO26 to CLK.

8. Click the **New Mixed Waveform** button.

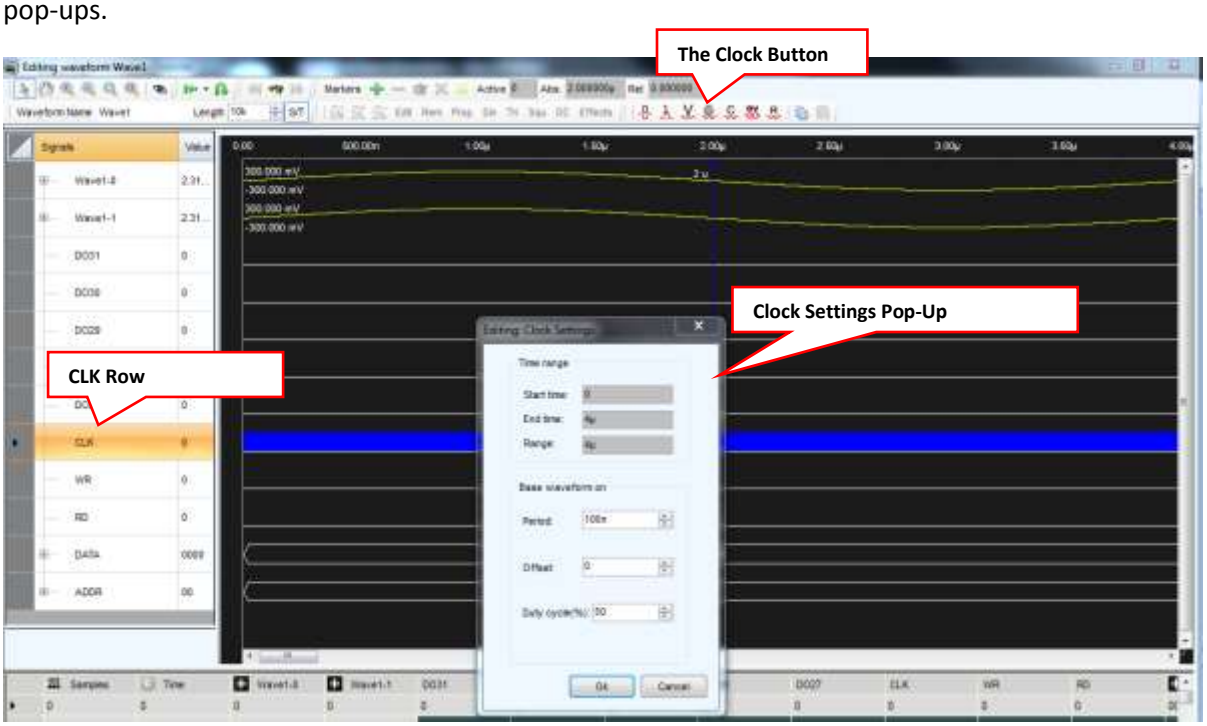
9. The **New Waveform** window is shown. Type the name of the waveform “Wave1” and choose 10K for the samples length of the waveform. Click **OK** to confirm.



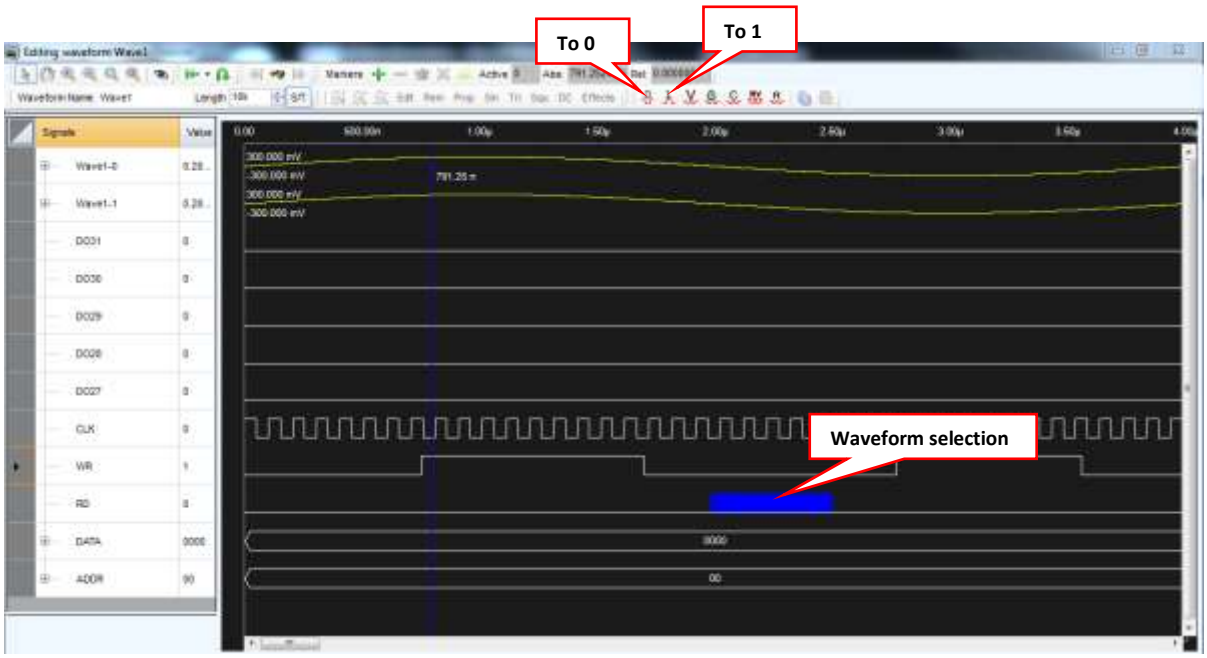
10. The **Editing Waveform Window** is shown.



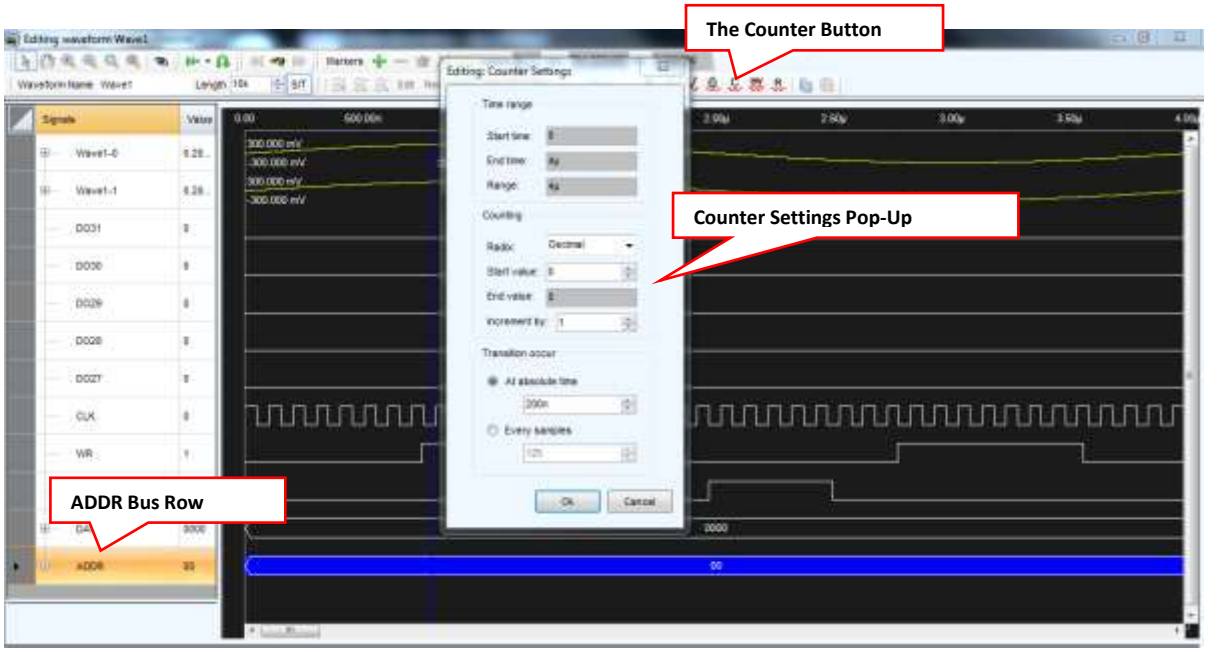
11. Select the **CLK** row and use the **Clock Button** to modify settings on the corresponding pop-ups.



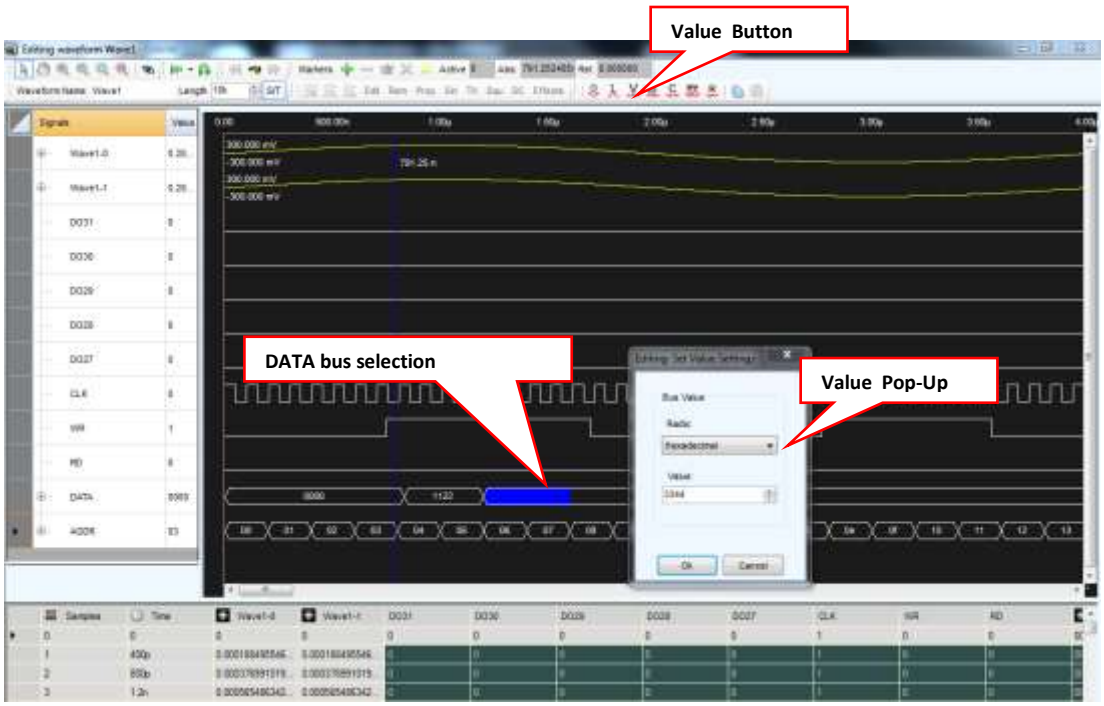
12. Now, define WR and RD signals similarly, by selecting a portion of the digital channel graph, and clicking the desired button from the following choices:



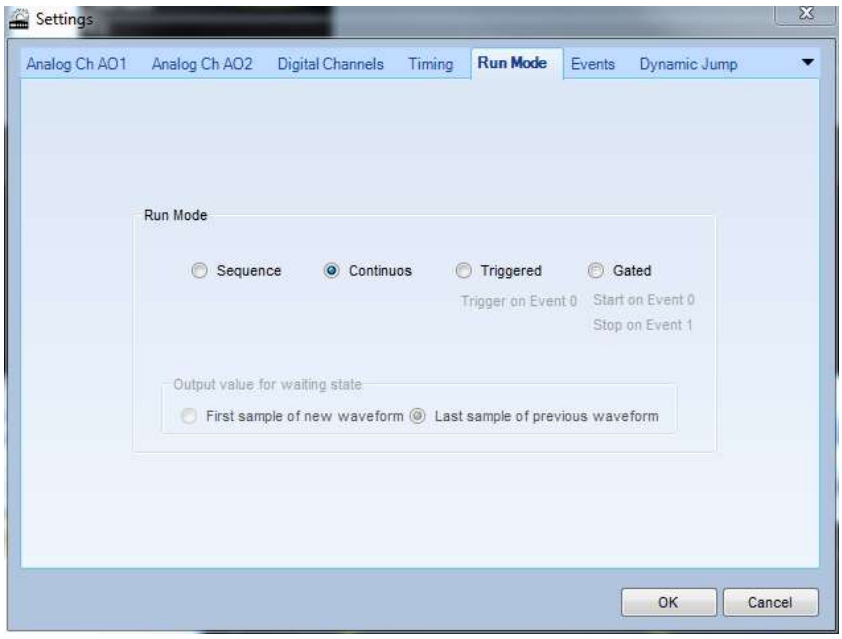
13. Now define the ADDR bus by selecting the ADDR row and use the **Counter Button** to modify settings on the corresponding pop-ups.



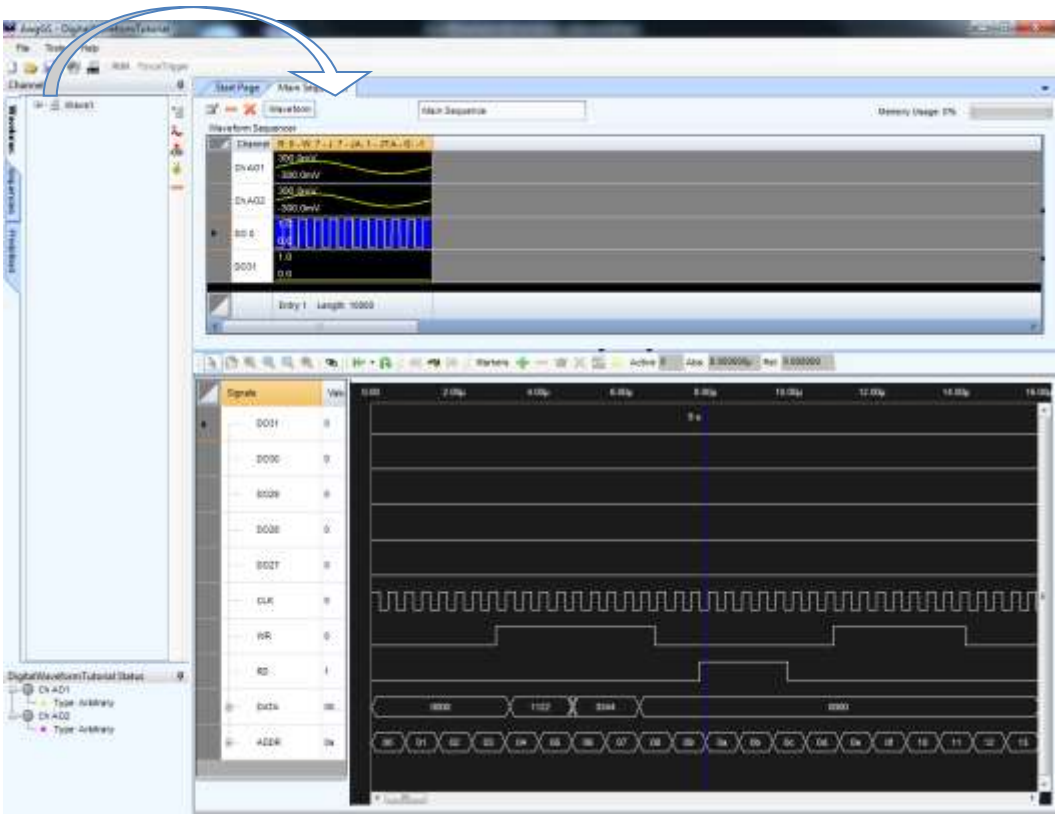
14. Now, define DATA bus signals, by selecting a portion of the data bus graph, and clicking the value button:



15. Click **OK** to close the Editing Waveform Window.
16. On the Settings pop-up screen's Run Mode tab, select **Continuous**. Click **OK**.



17. Drag the *Wave1* from the Waveform Area to the first cell of the Sequence Area (the selected cell is highlighted).



18. Now, press the **Run/Stop** button on the AT-AWG-GS toolbar.

The software loads the waveforms into the AT-AWG-GS instrument and starts generating the waveforms.
Wave1 is generated on the Pod A and Pod B probes. You can connect a logic analyzer and analyze the generated signals.
Wave1 analog signals are generated on AO1 and AO2 SMA outputs.
You can connect an oscilloscope to this output and analyze the signals.

19. Stop generating the waveforms by pressing the **Run/Stop** button again.

Creating Waveforms Using Formulas

Overview

When creating standard analog and digital waveforms, **sine** and **square wave (rectangular)** types are commonly used (alone or in combination with other waveshapes).
However, when waveform creation cannot be accomplished using simple combinations of standard waveform types, importing waveforms from a measurement instrument, file, or creating it analytically using equations or formulae are ideal methods. This section of the manual shows you how to create various waveforms using formulas in AT-AWG GS.

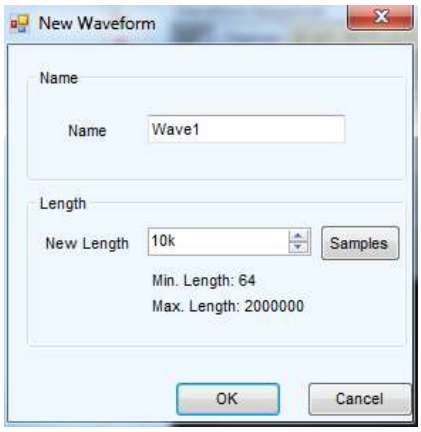
The next topic in this section covers the standard steps used to create an advanced waveform component using formulas. Remaining topics show example formulas producing various waveform types.

Steps to Creating Advanced Waveform Components Using Formulas

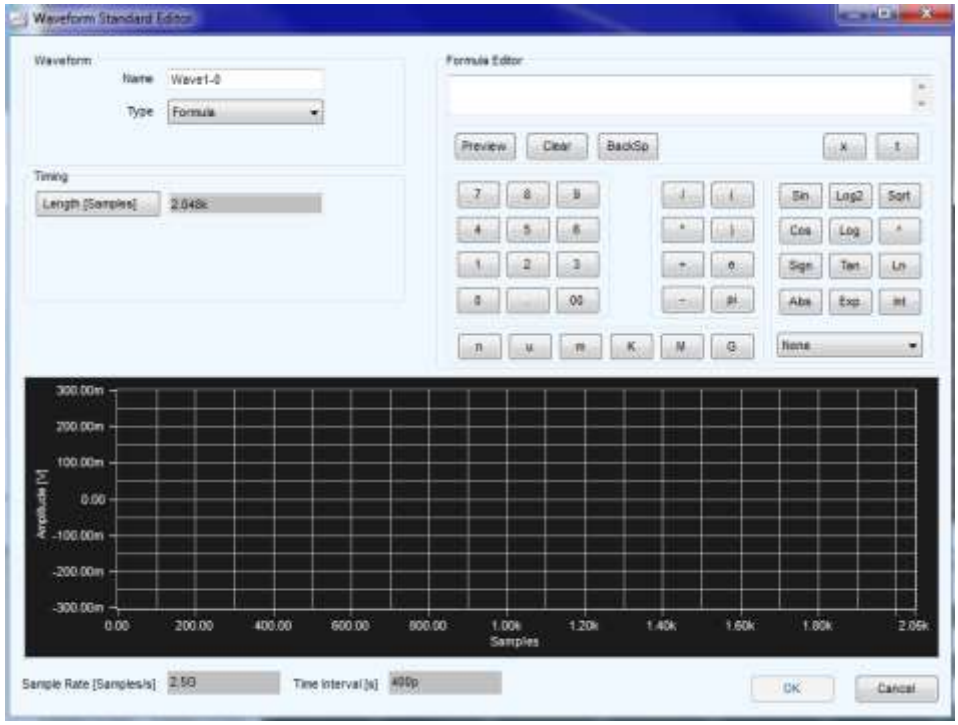
Similar to most other tasks in AT-AWG GS, you must first create a workspace with Arbitrary Waveform Generator as the Operating Mode.

If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

1. Click the **New Mixed Waveform** button. 
   The **New Waveform** window is shown. Type the name of the waveform "Wave1" and choose 10000 for the samples length of the waveform. Click **OK** to confirm.



The Editing Waveform Window is shown. Select the waveform Wave1 and click on the Edit button. 



On the Type drop-down list select *Formula*. The Formula Editor is then shown on the right.
The editor helps building your waveform analytically using equations. Your equation can be based on time(**t**) or samples(**x**).

PLEASE NOTE THE FOLLOWING:

- Your formula is shown in the text box as its built.
- Numeric values can be entered from the keypad along with n (nano), µ (micro), m (milli), K (kilo),M (Mega), and G (Giga) multipliers.
- Equations can be based on the functions **Sin, Cosine, Log base 2, Log Base 10, Pow** (rise to a power**), Square Root, Sign, Tan, Ln** (Natural Log), **Abs, Exp, Integer, ArcSine, Arc Cosine, Arc Tan, Ceiling**, and **Floor** along with the basic arithmetic operators **+** (addition), **-** (subtraction), ***** (multiplication), and **/** (division).
- The **Preview** button compiles your formula and renders it on the graph above the Component Definition dialog.
- The **OK** button saves your formula and exits from the **Waveform Standard Editor** window.

At this point, your newly-created waveform (made using formulas) is now saved as a waveform.
From here you can create additional components and/or add your newly-created component to the sequencer and output your waveform from AT-AWG GS.
The next set of topics show example formulas producing various waveform types.

Exponentially Decaying Sine Wave

An exponentially decaying 2 MHz sine wave.
The actual formula used here is Exp(-t/E6)*Sin(2*3.14592*2*E6*t).

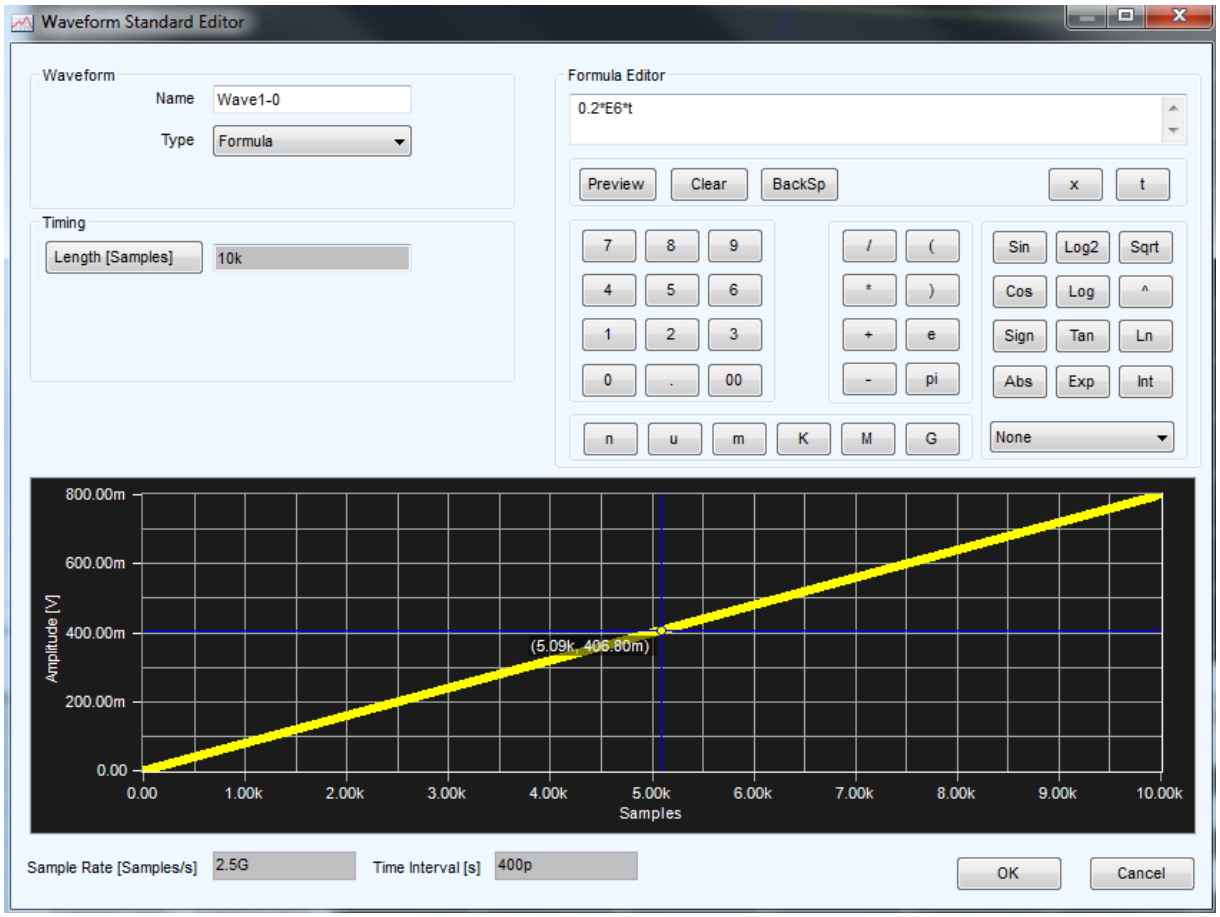
Formula's General Format

$V*Exp(-t/T_c)*Sin(2*pi*t*F_s)$

Where

- T_c – Time Constant in seconds
- F_s - Sine wave frequency in Hertz
- V – Signal amplitude in Volts peak

Ramp



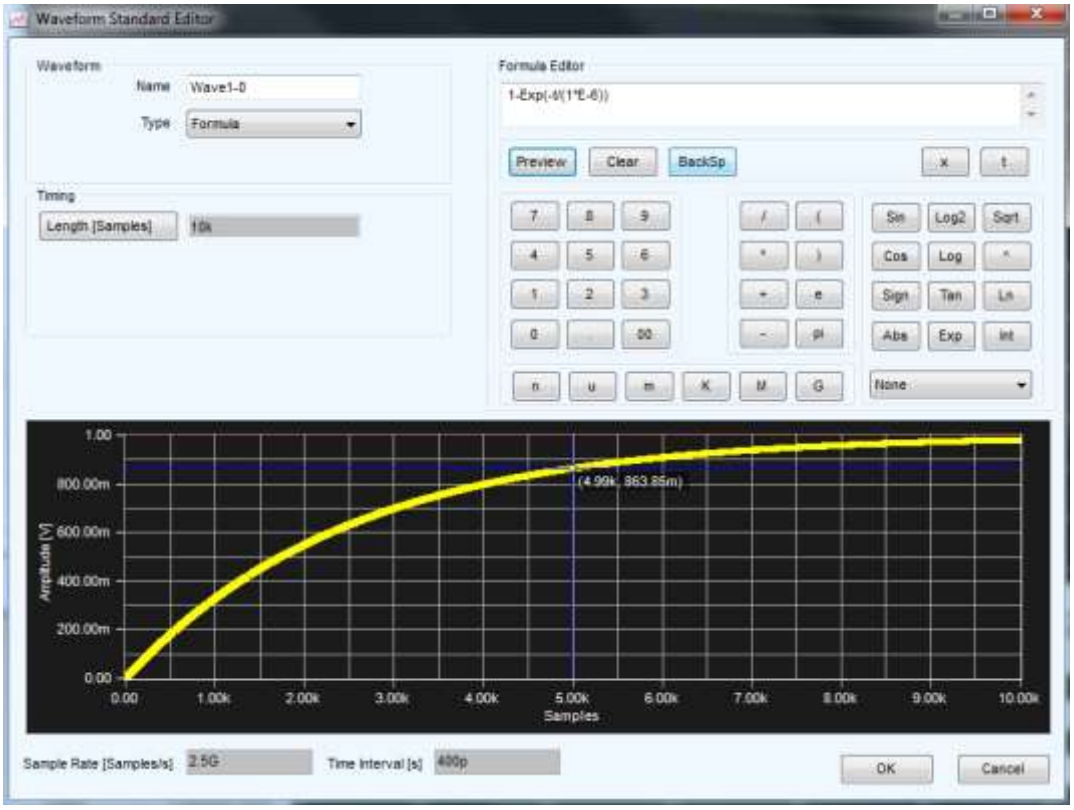
A ramp waveform. The actual formula used here is 0.2*E6*t.

Formula's General Format

$A*t$

Where A – Slope of the ramp in Volts/second.

Rising Exponential



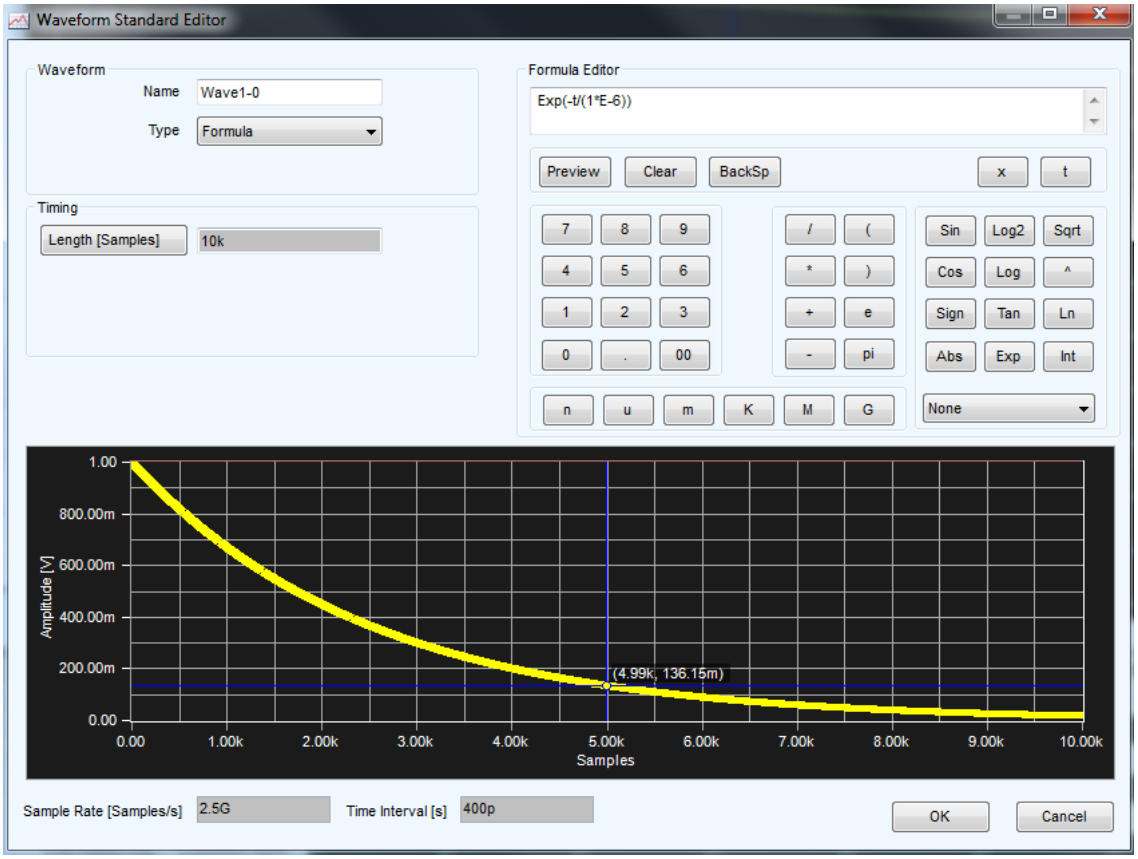
A rising exponential waveform. The actual formula used here is 1-Exp(-t/(1*E-6)).

Formula's General Format

$1\text{-}Exp(-t/T_c)$

Where T_c – Time Constant in seconds.

Decaying Exponential



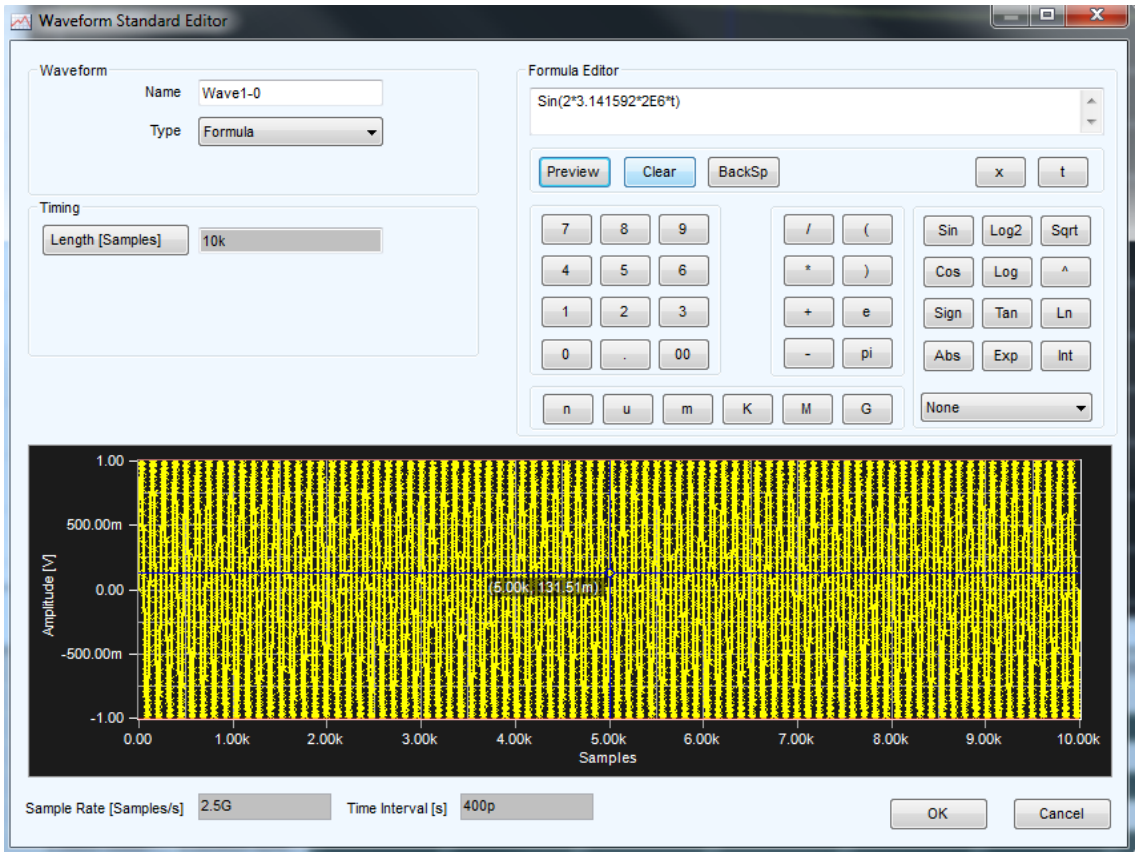
A decaying exponential waveform. The actual formula used here is Exp(-t/(1*E-6)).

Formula's General Format

$Exp(-t/T_c)$

Where T_c – Time Constant in seconds.

Sine



A linear amplitude sweep of a 1 MHz sine waveform. The actual formula used here is Sin(2*3.141592*2E6*t).

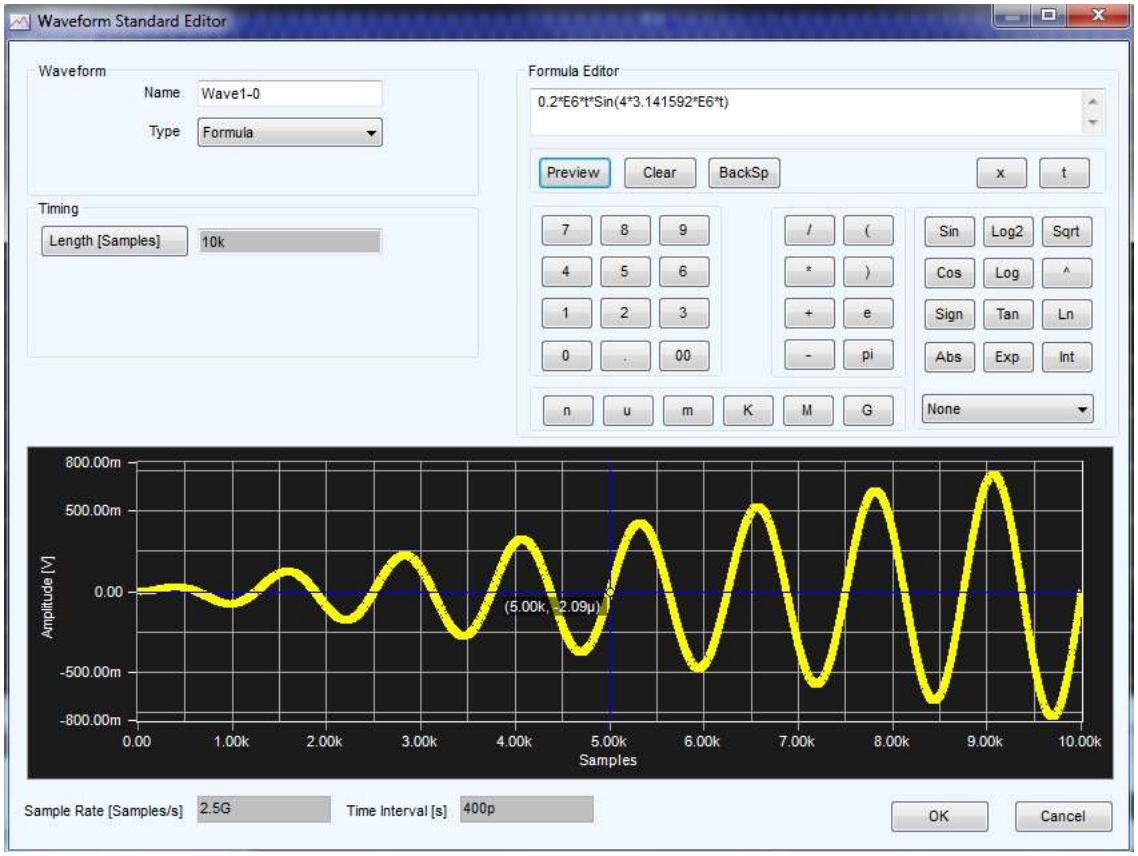
Formula's General Format

$V*Sin(2*pi*t*F_s)$

Where

- F_s – Sine Wave frequency in Hertz.
- V – Signal amplitude in Volts peak.

Linear Amplitude Sweep of a Sine Wave



A Sine waveform. The actual formula used here is 0.2*E6*t*Sin(4*3.141592*E6*t).

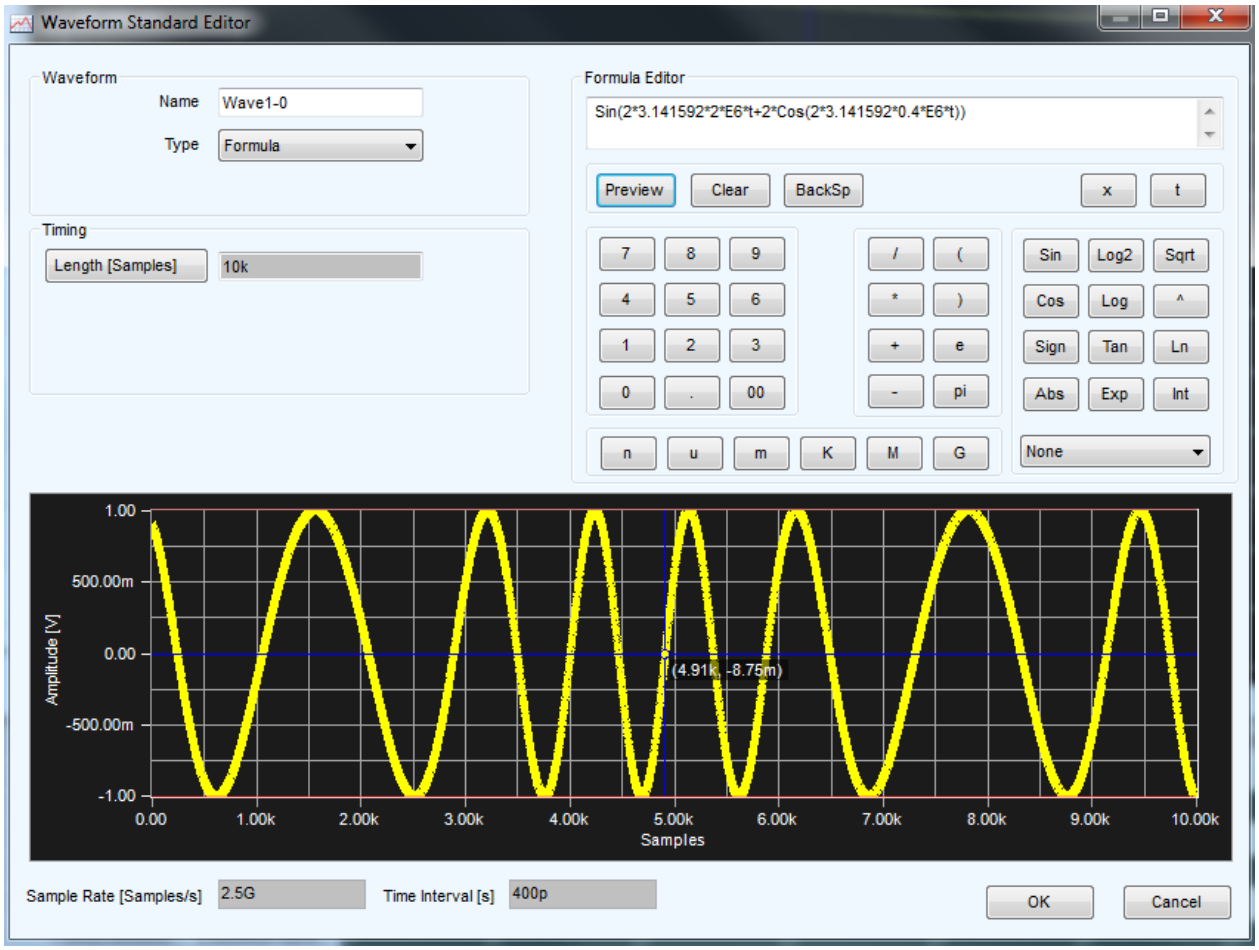
Formula's General Format

$(A*t)\ *Sin(2*pi*t*\ F_s)$

Where

- F_s – Sine Wave frequency in Hertz.
- A – Slope of the ramp in Volts/second.

Frequency Modulation



A frequency modulation waveform. The actual formula used here is Sin(2*3.141592*2*E6*t+2*Cos(2*3.141592*0.4*E6*t)).

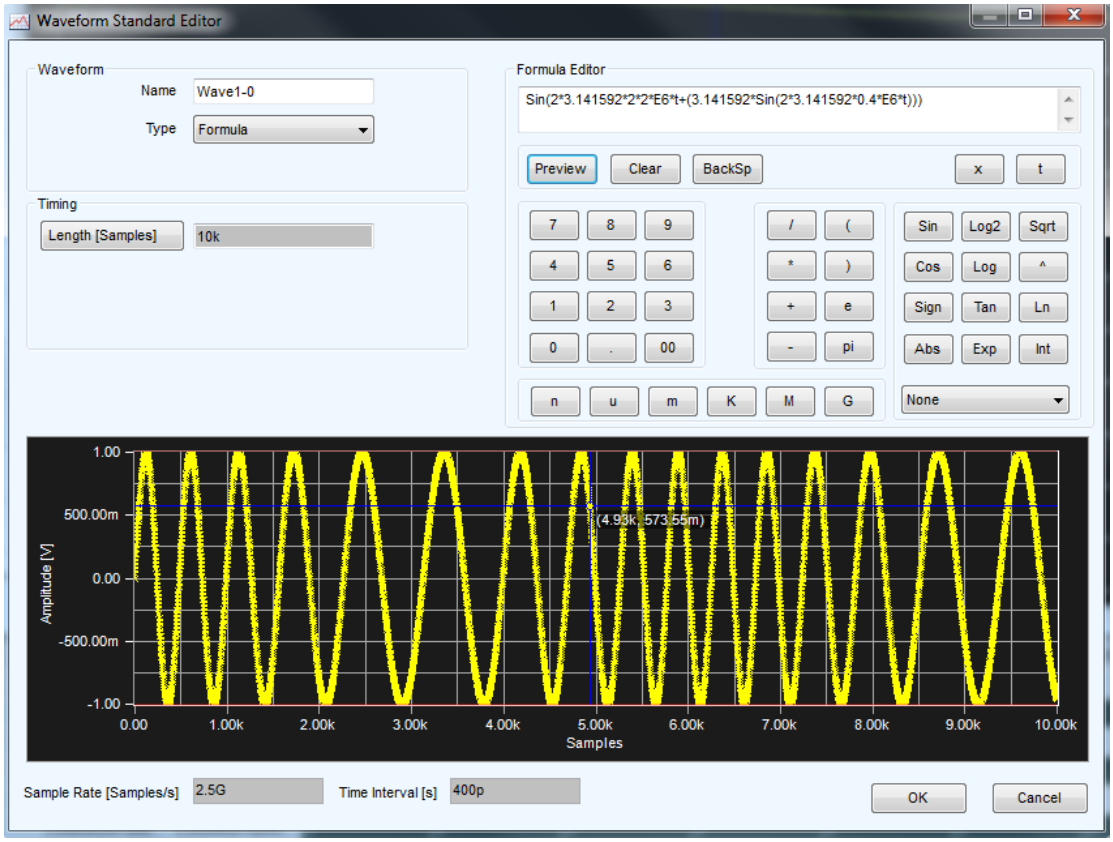
Formula's General Format

$$Sin\ (2*pi*t*F_c+(F_D/F_M)*Cos(2*pi*t*F_M))$$

Where

- F_c – Carrier frequency in Hertz.
- F_D – Frequency deviation in Hertz.
- F_M – Modulation frequency in Hertz.

Phase Modulation



A phase modulation waveform. The actual formula used here is Sin(2*3.141592*2*2*E6*t+(3.141592*Sin(2*3.141592*0.4*E6*t))).

Formula's General Format

$$\mathrm{Sin}((2*pi*t*F_C + K*\mathrm{Sin}(2*pi*t*F_M))$$

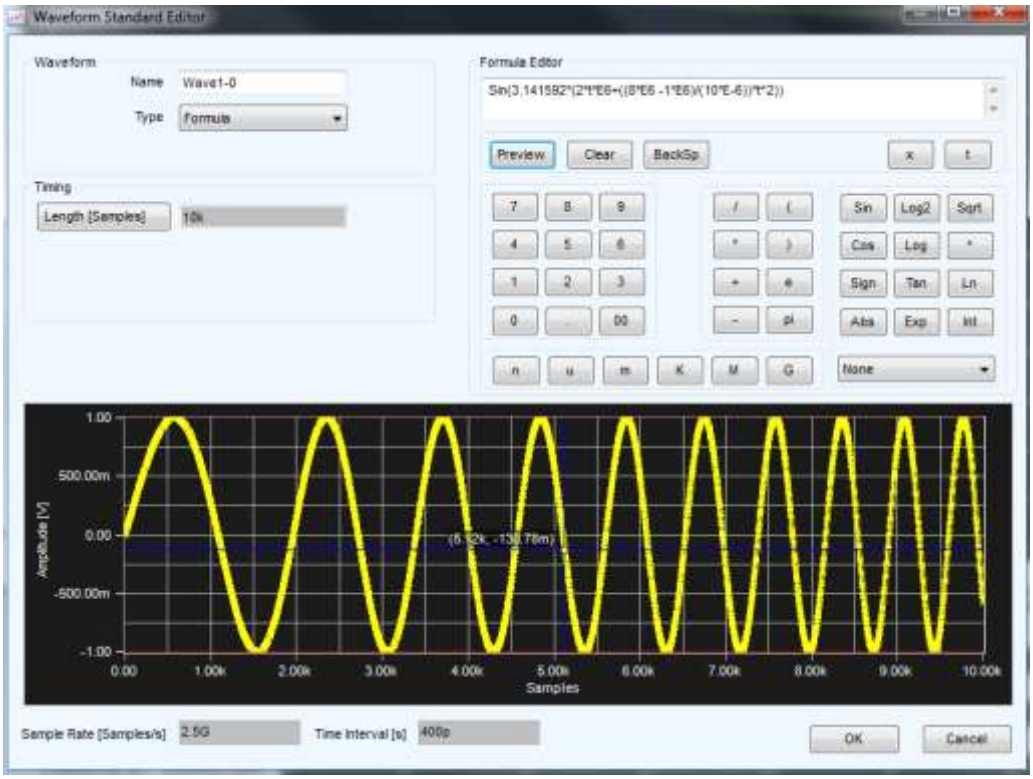
Where

F_C – Carrier frequency in Hertz.

K – Peak phase excursion in radians.

F_M – Modulation frequency in Hertz.

Linear Frequency Sweep



A linear frequency sweep waveform.
The actual formula used here is Sin(3.141592*(2*t*E6+((8*E6-1*E6)/(10*E-6))*t^2)).

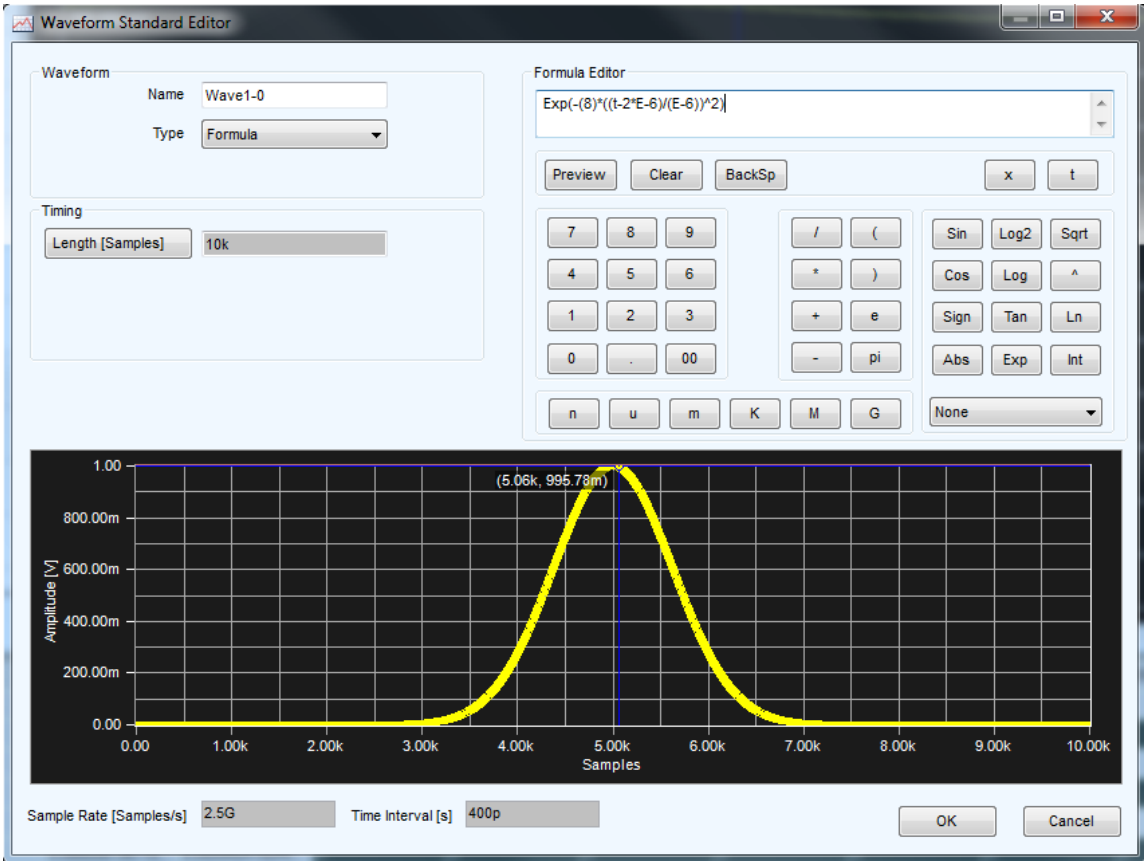
Formula's General Format

Sin(pi*(2*t*F_S+((F_E-F_S)/T_S)*T^2))

Where

- F_S – Start frequency in Hertz.
- F_E – End frequency in Hertz.
- T_S – Sweep duration in seconds.

Gaussian Pulse



A Gaussian pulse waveform. The actual formula used here is Exp(-(8)*((t-2*E-6)/(E-6))^2)).

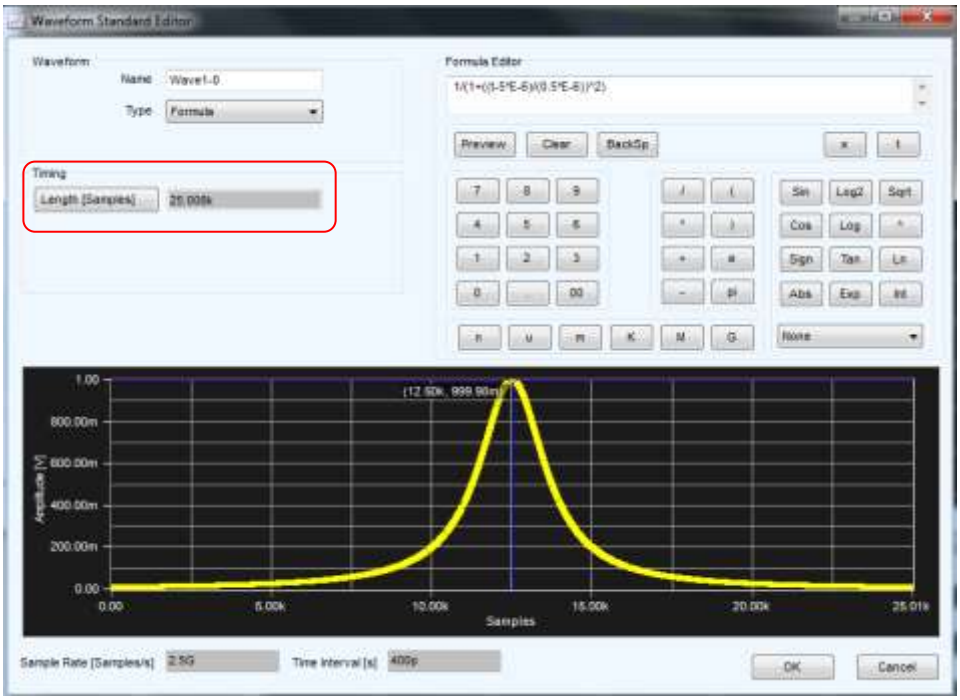
Formula's General Format

$Exp(-(1/2)*((T-T_M)/T_\sigma)\wedge 2$

Where

- T_M – Time location of the mean of the Gaussian pulse.
- T_σ – Half width point of Gaussian pulse corresponds to the standard deviation **σ**.

Lorentzian Pulse



A Lorentzian pulse waveform. The actual formula used here is 1/(1+((t-5*E-6)/(0.5*E-6))^2).

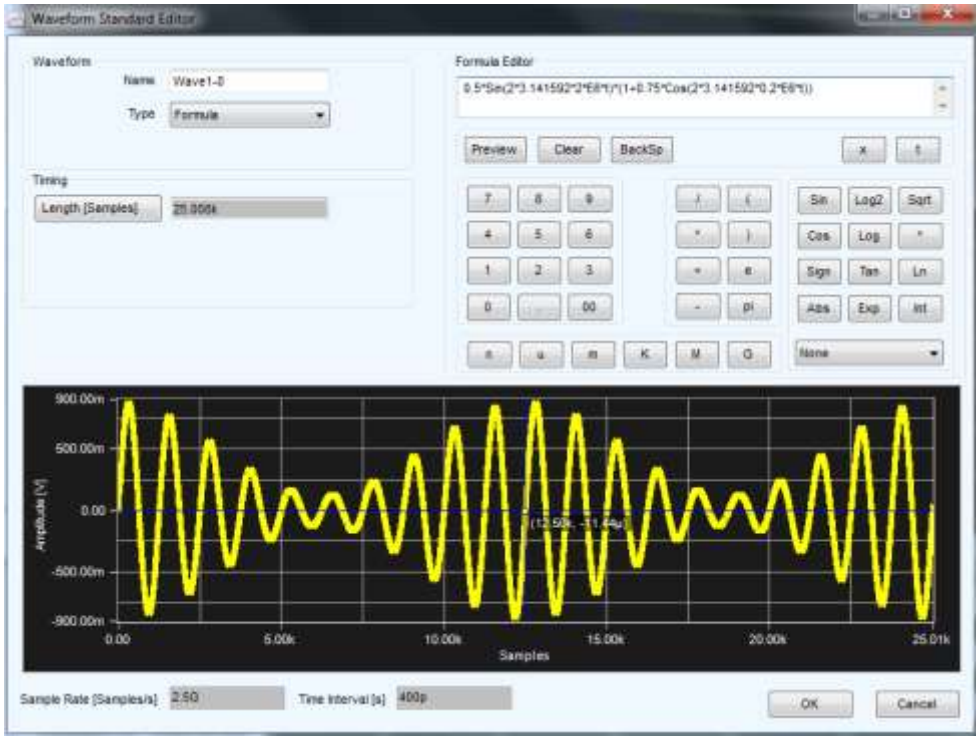
Formula's General Format

$1/(1+((t-5*T_D)/(T_W))\text{^}2)$

Where

- T_D – Time delay in seconds.
- T_W – Half width point of the Lorentzian pulse at 50% amplitude.

Amplitude Modulated Sine



An amplitude modulated sine waveform. The actual formula used here is 0.5*Sin(2*3.141592*2*E6*t)*(1+0.75*Cos(2*3.141592*0.2*E6*t)).

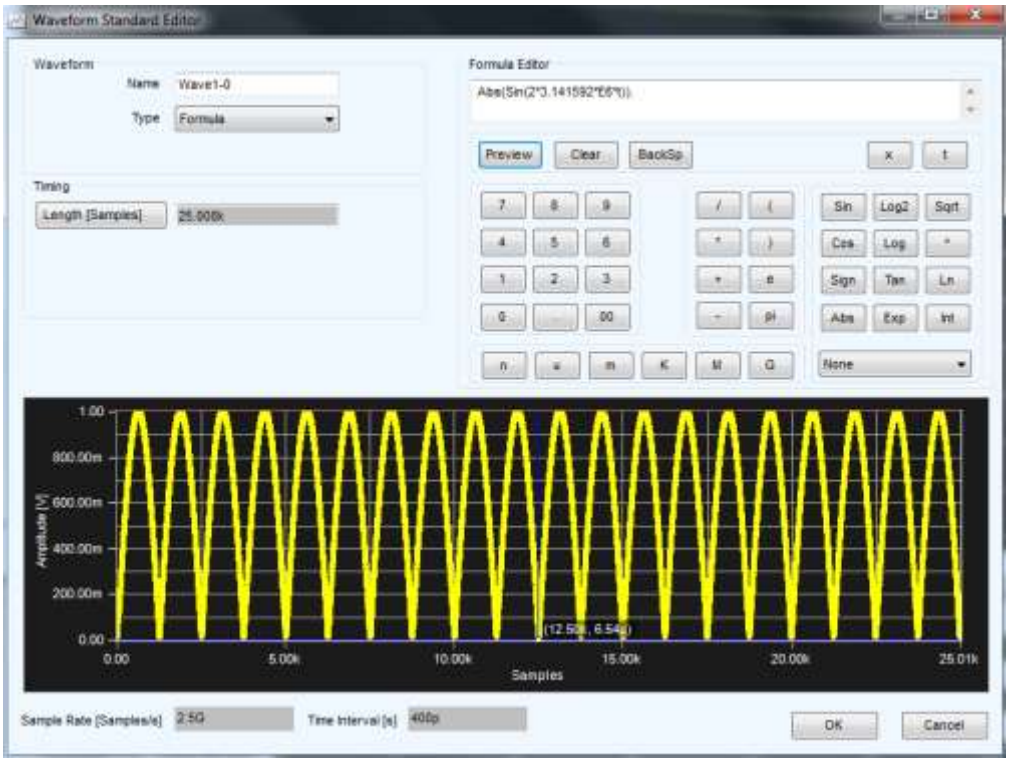
Formula's General Format

$$Sin(2*pi*t*\ F_s)\ *(1+K*Cos(2*pi*t*F_M))$$

Where

- F_s – Sine wave frequency in Hertz.
- F_M – Modulation frequency in Hertz.
- K – Modulation index, 0<K<1.

Full-Wave Rectified Sine



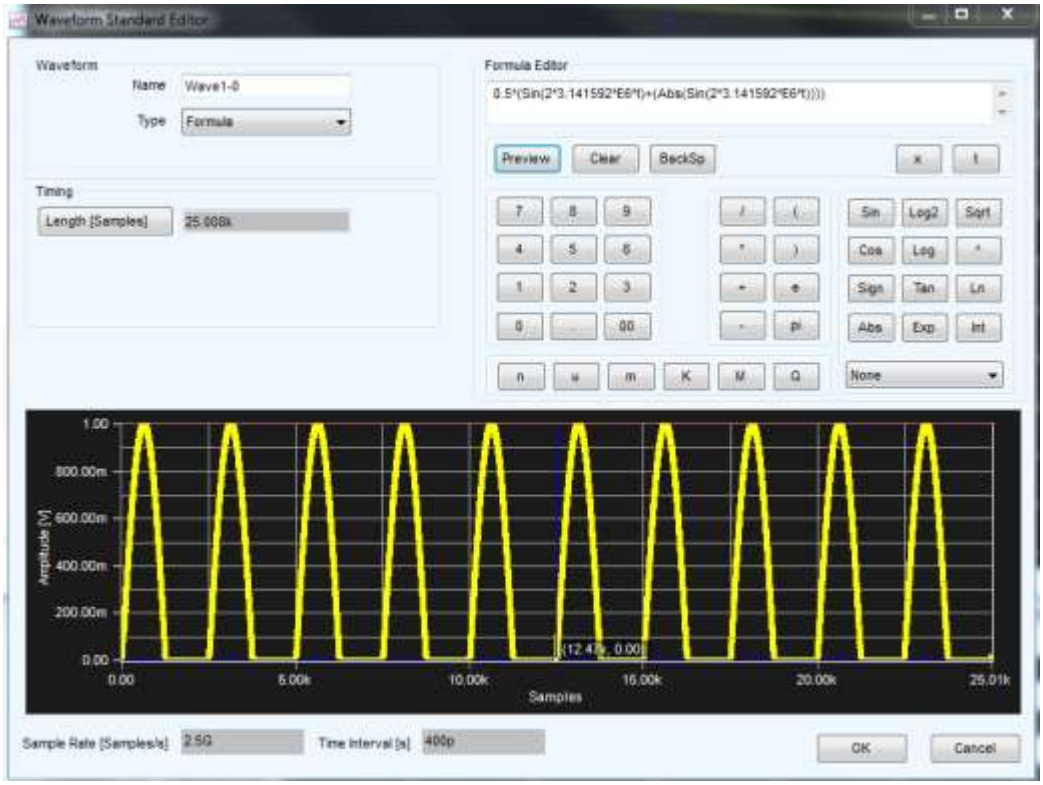
A full-wave rectified sine waveform. The actual formula used here is Abs(Sin(2*3.141592*E6*t)).

Formula's General Format

$$Abs(Sin(2*3.141592*F_s*t))$$

Where F_s – Sine wave frequency in Hertz.

Half-Wave Rectified Sine



A half-wave rectified sine waveform. The actual formula used here is 0.5*(Sin(2*3.141592*E6*t)+(Abs(Sin(2*3.141592*E6*t)))).

Formula's General Format

$$0.5*(Sin(2*3.141592*F_s*t)+(Abs(Sin(2*3.141592*F_s*t))))$$

Where F_s – Sine wave frequency in Hertz.