TELEDYNE LECROY
Everywhere**you**look™

ArbStudio 1104 1 GS/s Arbitrary Waveform Generator

DIGITAL POD A

DIGITAL POD B

EXT CLK
In

TRIGGER
In — Out

ANA
Ch.1

±5V$_{PK}$

+6V$_{PK}$
-2V$_{PK}$

⚠ 50Ω
3.3V$_{PK}$

ALL

Operator's Manual
ArbStudio
Arbitrary Waveform
Generator

ArbStudio
Arbitrary Waveform Generator
Operator's Manual
January 2013

TELEDYNE LECROY
Everywhere**you**look™

Warranty

922244-00 Rev A

January 2013

TABLE OF CONTENTS

Welcome

Thank you for purchasing a Teledyne LeCroy ArbStudio.

ArbStudio is a series of high performance Arbitrary Waveform Generators (AWG) consisting of 2 and 4 channel models, 2 Mpts/ch memory, 16 bit resolution and a maximum sample rate of 1 GS/s. Some models provide the ability to generate 18 or 36 channel digital patterns and all models can be operated in true arbitrary mode or Direct Digital Synthesis (DDS) mode.

We truly hope these materials provide increased comprehension when using Teledyne LeCroy's fine products.

Sincerely,

David C. Graef

Teledyne LeCroy Corporation
Vice President and Chief Technology Officer

Minimum System Requirements

- Operative system Microsoft™ Windows® 2000, Windows® XP, Windows® Vista 32 Bit Version, Windows® 7 32 Bit Version.
- Pentium® III processor.
- 512 MBytes RAM.
- 150 MBytes hard disk available space for software set-up.
- Video resolution 800 X 600.
- USB 2.0 or 1.1 connections.

Suggested System Requirements

- Operative system Microsoft™ Windows® XP, Windows® Vista 32 Bit Version, Windows® 7 32 Bit Version.

- Pentium® IV processor.

- 1.5 GBytes RAM.

- Video resolution 1024 X 768.

- USB 2.0 connection.

Package Contents

The standard ArbStudio 1102/1104 package includes the following:

- ArbStudio 1102/1104 Arbitrary Waveform Generator

- Standard USB 2.0 Cable

- Power Supply Adapter

- Power Cord

- Installation CD containing the **ArbStudio Software** setup files, **ArbStudio Function Generator** software, Drivers, and the **Getting Started Manual**.

- Performance/Calibration Certificate

- ArbStudio Introduction and Compliance document

- -D Models include a 'Digital Leadset'

Safety Instructions

This section contains instructions 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 precautions specified in this section. **The overall safety of any system incorporating this instrument is the responsibility of the assembler of the system.**

Symbols

These symbols appear on the instrument's front or rear panels and in its documentation to alert you to important safety considerations.

CAUTION of damage to instrument, or **WARNING** of hazard to health. Attend to the accompanying information to protect against personal injury or damage. Do not proceed until conditions are fully understood and met.

WARNING. Risk of electro-shock.

Measurement ground connection.

Safety (protective) ground connection.

Alternating Current.

Precautions

- **Use proper power cord**. Use only the power cord shipped with this instrument and certified for the country of use.

- **Maintain ground**. This product is grounded through the power cord grounding conductor. To avoid electric shock, connect the external AC adapter only to a grounded mating outlet.

- **Connect and disconnect properly**. Do not connect/disconnect probes or test leads while they are connected to a voltage source.

- **Observe all terminal ratings**. Do not apply a voltage to any input that exceeds the maximum rating of that input. Refer to the front of the instrument for maximum input ratings.

- **Use only within operational environment listed**. Do not use in wet or explosive atmospheres.

- **Use indoors only**.

- **Keep product surfaces clean and dry**.

- **Do not block the cooling vents**. Leave a minimum six-inch (15 cm) gap between the instrument and the nearest object. Keep the underside clear of papers and other objects.

- **Do not remove the covers or inside parts**. Refer all maintenance to qualified service personnel.

- **Do not operate with suspected failures**. Do not use the product if any part is damaged. Obviously incorrect measurement behaviors (such as failure to calibrate) might indicate impairment due to hazardous live electrical quantities. Cease operation immediately and sequester the instrument from inadvertent use.

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 ArbStudio 1104 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.

Cooling

The instrument relies on forced air cooling with internal fans and vents. Take care to avoid restricting the airflow to any part of the instrument. Around the sides and rear, leave a minimum of 15 cm (6 inches) between the instrument and the nearest object. At the bottom, the instrument feet (up or down) provide adequate clearance.

> ⚠ **CAUTION.** Do not block instrument vents. Always keep the area beneath the instrument clear of paper and other items.

The instrument also has internal fan control circuitry that regulates the fan speed based on the ambient temperature. This is performed automatically after start-up.

Cleaning

Clean only the exterior of the instrument using a damp, soft cloth. Do not use harsh chemicals or abrasive elements. Under no circumstances submerge the instrument or allow moisture to penetrate it. Avoid electric shock by unplugging the power cord from the AC outlet before cleaning.

> ⚠ **CAUTION.** Do not attempt to clean internal parts. Refer to qualified service personnel.

Calibration

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

> ⚠ **CAUTION.** It is required that all inputs be removed from the instrument prior to performing a manual calibration.

Schedule an annual factory calibration as part of your regular maintenance. Extended warranty, calibration, and upgrade plans are available for purchase. Contact your Teledyne LeCroy sales representative or customersupport@teledynelecroy.com to purchase a service plan.

Power

Power Consumption

35 VA (35 W) Max

AC Power Source

For External AC Adapter:

100 to 240 VAC (+/-10%) at 45-66 Hz

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

Standby Power

The ⏻ Power (Standby) button controls the operational state of the instrument. Press the button to switch the instrument On or into Standby mode (Off).

Always use the Power button to execute a proper shut down process and preserve settings before powering down.

Hardware Inputs and Outputs

Front Panel

Figure 3-1. ArbStudio 1104 model with a POD B connector and two additional Channel Outputs. Although digital pods appear on all models, they are only active on 1102D and 1104D models.

DIGITAL POD A / DIGITAL POD B

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

   NOTE: DIGITAL POD B is only available on ArbStudio 1104. POD A and POD B are only active on 1102D and 1104D models. ArbStudio 1102 and 1104 can be upgraded to include the digital pattern generator.

2. **EXT CLK** BNC input connector for external clock

3. **TRIGGER**
   - **Trigger Out** - BNC output connector for Trigger OUT.
   - **Trigger In** - BNC input connector for Trigger IN.

4. **ANALOG OUTPUTS** 12 V to 12 V BNC output connector

   NOTE: Ch3 and Ch4 are only available on ArbStudio 1104 and 1104D models.

5. **STATUS LED** Indicates instrument power status

6. **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**. ArbStudio 1102/1104 is uploading firmware for channels.

Back Panel

Numbered callouts on this image correspond with the following descriptions.

1. **POWER** - The power switch.
2. **DC IN** - 12 V – 2.5 A DC connector.
3. **USB** - USB 2.0 connector.
4. **EXPANSION BUS** - The Expansion bus connector is located on the rear panel of the ArbStudio 1104 and 1104D models only. Using the appropriate expansion cable, up to 8 total 4 Channel ArbStudio units may be connected.

   It is possible to have a system with up to 8 independent arbitrary waveform generators, each with the ability to have a synchronized trigger.

   PLEASE NOTE THE FOLLOWING:

   - ArbStudio 1104 and 1104D units sharing the Expansion bus must all be connected to the same controller (PC) via USB or hub.
   - If more than one ArbStudio 1104 or 1104D are connected to the same PC, they must also be linked through the Expansion bus.

Making Expansion Bus Connections

In order to connect several ArbStudio 1104 or 1104D units you must first:

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

When you launch the ArbStudio software, if all the correct connections are made, the instruments are shown as connected together. The interconnected instruments make up your complete ArbStudio 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 Teledyne LeCroy ArbStudio**, and then click the **Stop** button.

NOTE: If the instrument is switched off or disconnected without performing the proper safe removal process, the software may not operate correctly.

Getting Started with ArbStudio

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 ArbStudio Welcome screen contains links to step-by-step explanations of standard functions and setups using your new product.
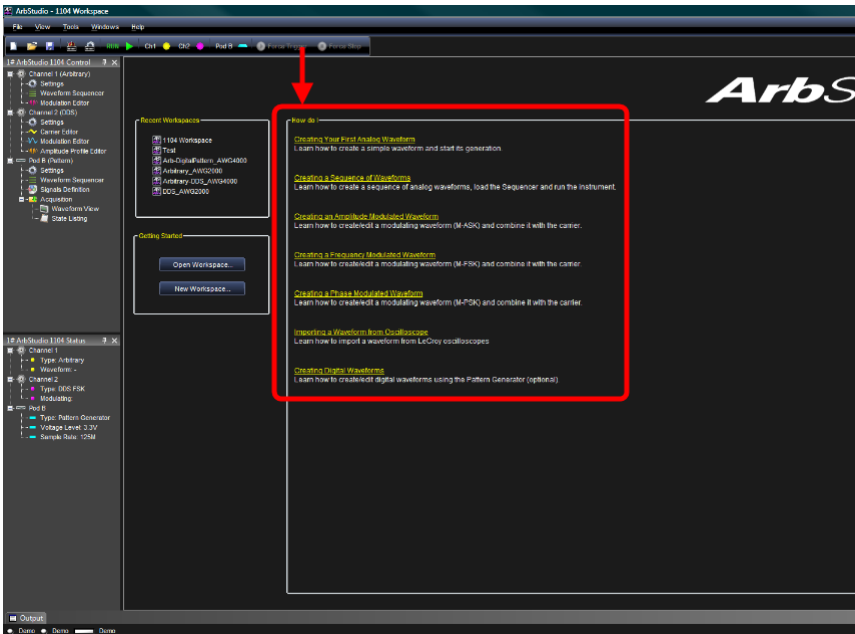
These titles along with others provided here and in other locations of this documentation provide accurate descriptions for regular tasks.

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 **cdstart.exe** file on the root directory of the installation files.

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

Software Installation

NOTE: The **Microsoft .NET Framework 2.0 Run-Time Engine** (or greater) is required to run the ArbStudio 1102/1104 software properly.

After inserting the installation CD into your CD/DVD reader, the **Welcome** screen is eventually shown, click **Install Teledyne LeCroy ArbStudio** to start setting up the software.

The ArbStudio 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**.
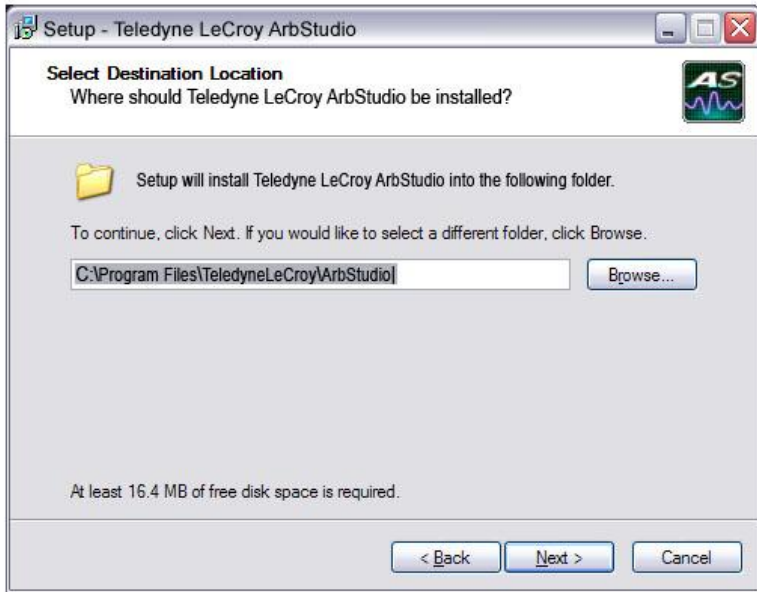
Now, either leave the default **Start Menu folder** path, or specify a new location and click **Next**.
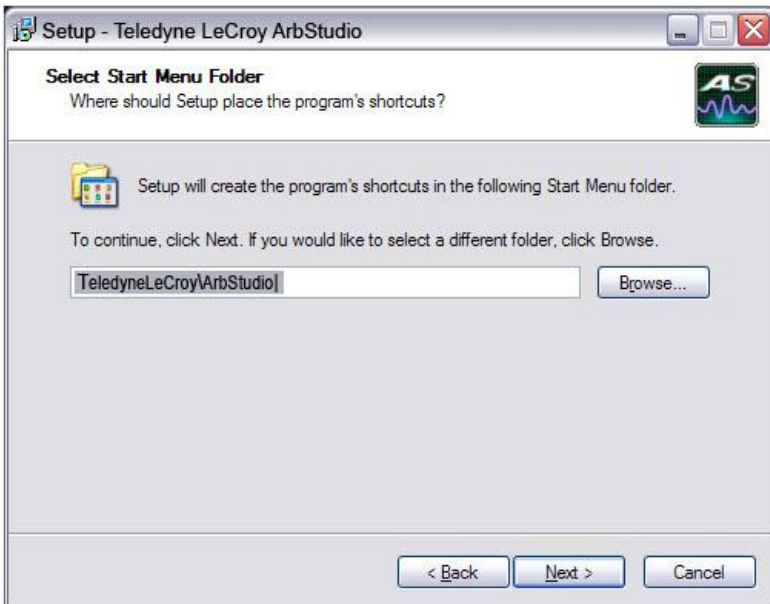
Use the next screen in the wizard to have the installation configure
Desktop shortcuts/icons for **ArbStudio**, **ArbStudio Function Generator**, and
ArbStudio PWM Generator. Mark the checkboxes for the desired tasks and
and click **Next**.
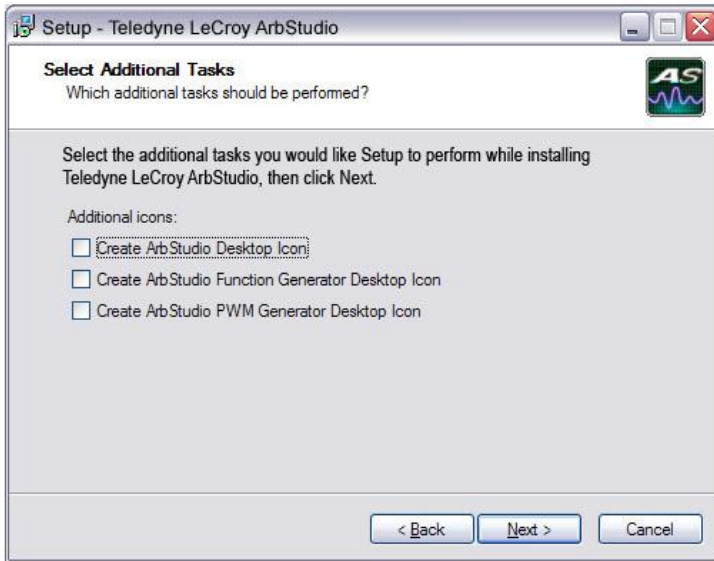
Review the installation summary shown on the **Ready to Install** screen and
click **Install** when ready.
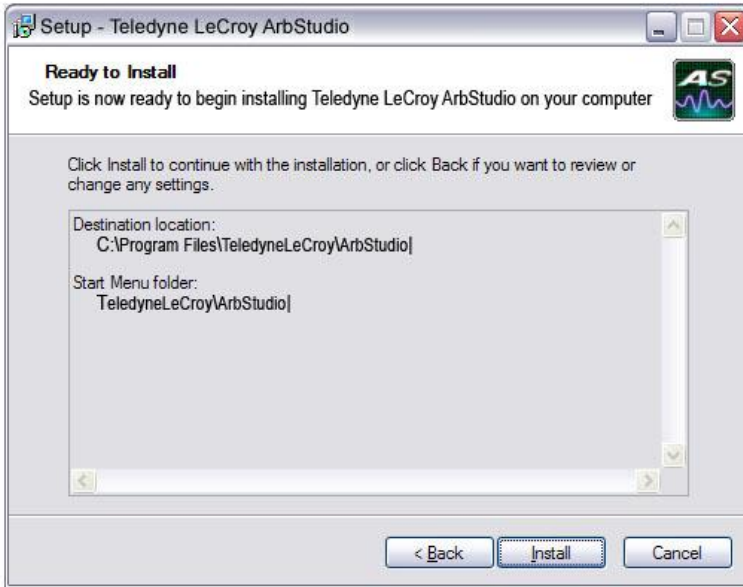
As the installation completes, the Completing the Teledyne LeCroy ArbStudio Setup Wizard screen is shown as follows. This same screen also provides a checkbox (marked by default) to continue the wizard and **Install Instrument Drivers**. Leave the checkbox marked and proceed by clicking the **Finish** button.

NOTE: While unmarking the checkbox and clicking the Finish button does complete the software installation, it does not install the necessary system drivers on your computer - making your ArbStudio system inoperable on your computer. This is why it is strongly recommended to leave the **Install Instrument Drivers** checkbox marked and proceed with the driver installation.

Driver Installation
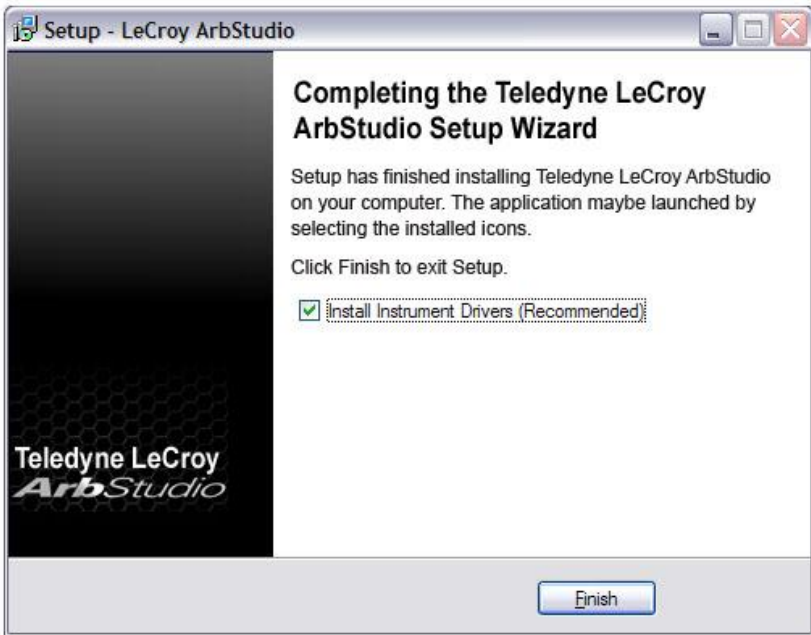
Click **Next** to proceed past the **Welcome to the Device Driver Installation Wizard** screen.

Select your device on the table shown in the **Completing the Device Driver Installation Wizard** screen and click the **Finish** button.

NOTE: If Windows shows the **Found New Hardware Wizard**, click **Cancel**. Only use the ArbStudio Software and Driver installation procedure to configure your system.
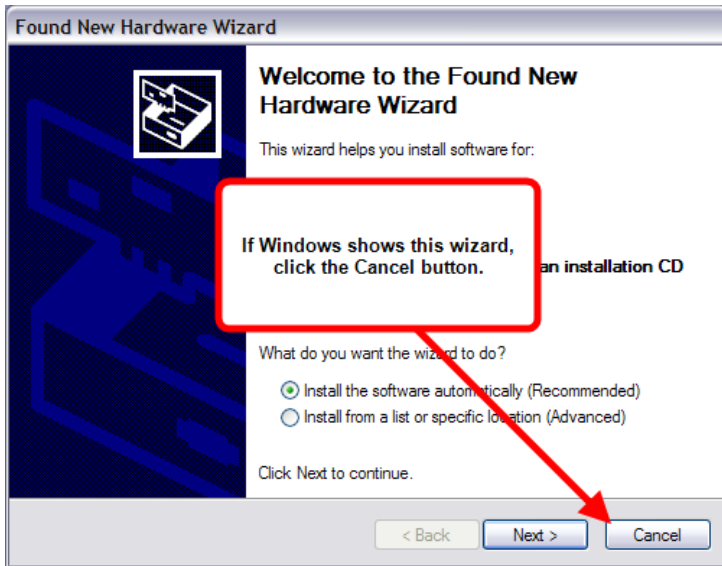
Now, with correct application software, drivers, and the latest .NET Framework installed, your ArbStudio is ready for use.

Initial ArbStudio Software Interfaces

The ArbStudio software environment provides access to all product functions. The interface allows you to control up to eight devices connected by the Expansion Bus Cable configuring them as Arbitrary Waveform Generators, Digital Pattern Generators, or Mixed Mode Generators.

ArbStudio Workspace

The ArbStudio software workspace consists of two main elements:

- The main document editing area, shown on the right side on the following screen-shot.

- The ArbStudio Control Navigation Tree, shown on the left side on the following screen-shot.

ArbStudio

As mentioned, when you open the ArbStudio 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** (on page 146)
- Recent Workspaces
- Open Workspace..
- New Workspace..
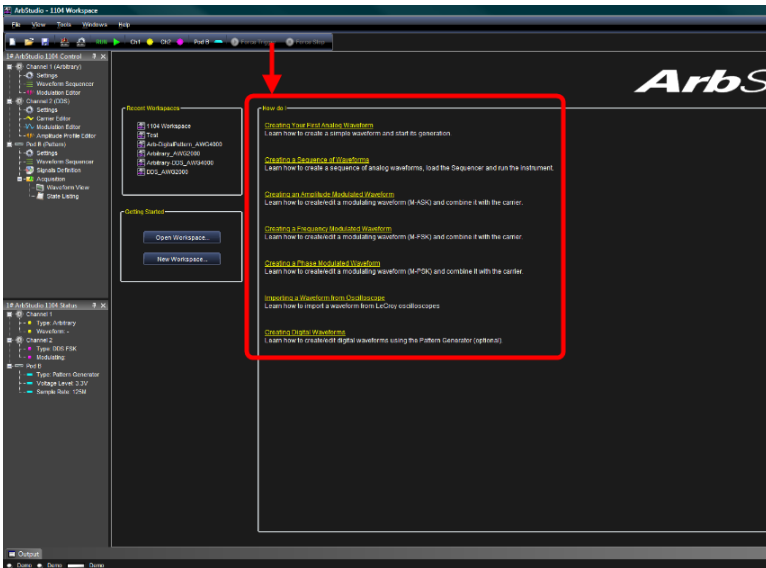
Interface and Display

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.
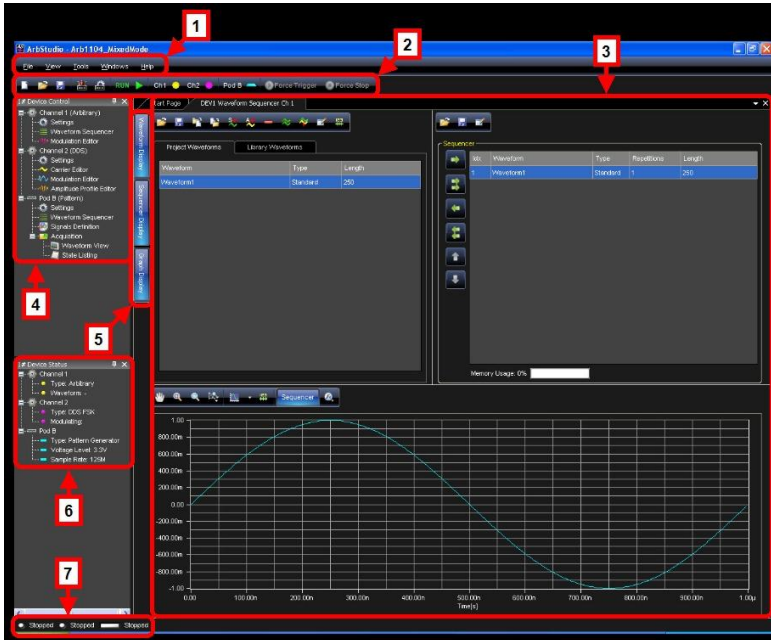
1. **Menu Bar** - Provides drop-down menu access to device functions, workspace, window management, and online help.

2. **Toolbar** - Various functions including channel/pod selection, device setup and instrument start/stop are made available as icons in this area.

     New Workspace - creates a new workspace.

     Open Workspace - opens an existing workspace.

Save Workspace - saves newly-created or edited workspaces.

System Setup - selects the Master/Slave channel when multiple devices are connected by the expansion bus or when you want channels managed by an event.

Device Setup - accesses more detailed ArbStudio option settings.

RUN/STOP - 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.

Ch(1, 2, 3, 4) **-** selects Channel
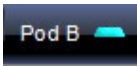
Pod *x* - activates or deactivates the RUN/STOP command for the specified Pod. This control is only available when the Digital Pattern option is enabled.
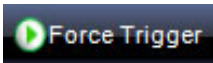
Force Trigger - makes the instrument generate an internal trigger signal and forces a start event on the selected channels/pods.
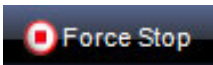
Force Stop - forces a stop event on the selected channels/pods.

3. **Editing Area** - This main display area shows the waveforms selected from the **Project Waveform List** or **Sequencer Window**. You can also create/edit waveforms and load the Sequencer from this location.

4. **Device Control Tree** - The Device Control (navigation) tree provides access to channel settings and tools to edit standard/modulating waveforms, set the amplitude profile of the modulated signal, and load the sequencer.
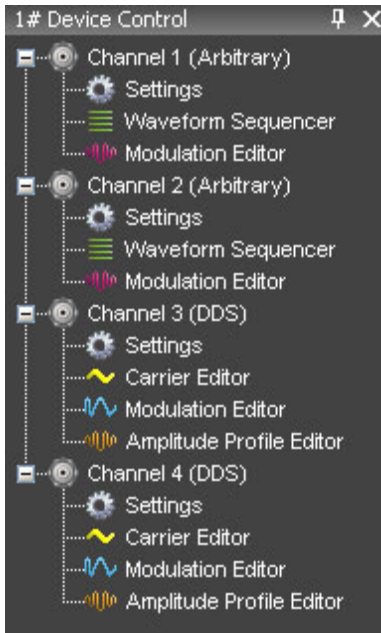
The icon associated to the channel string indicates if it is master or slave, respectively.

The following icons are used based on **Arbitrary** or **DDS** mode selection.

Arbritrary		DDS	
	Settings		Settings
	Waveform Sequencer		Carrier Editor
	Modulation Editor		Modulation Editor
			Amplitude Profile Editor

- **Settings** - This tool allows setting the sampling rate prescaler, the impedance output, the run mode (Single, Continuous, Burst), and the external control signals (trigger IN, trigger OUT).

- **Waveform Sequencer** - This tool, available only in the Arbitrary mode, allows you to edit the waveforms loaded in the channel and to select generation order and number of repetitions. The waveforms generated by this tool are considered as carrier signals if the modulation is needed.
- **Modulation Editor** - This tool allows editing a modulating waveform. The signal edited can modulate the waveform edited by the Waveform Editor tool, with a M-ASK, M-FSK or M-PSK modulation law.
- **Amplitude Profile Editor** - This tool, available only in DDS mode, allows setting the amplitude profile of the modulated signal as a function of the frequency.
- **Carrier Editor** - This tool, available only in DDS mode, allows editing the carrier waveform of the modulated signal.

5. **Editing Area Tag** - These tags conserve screen space by toggling the display of your open waveforms.

6. **Device Status Tree** - Lists various channel/pod instrument properties such as sampling rate, channel type, and voltage level.
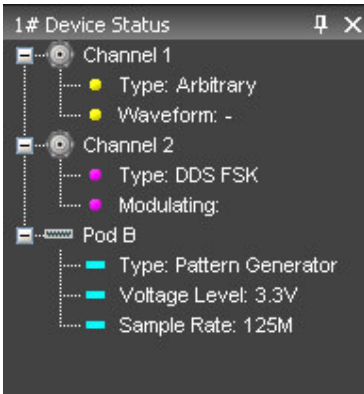
- **Type** - Shows the channel functionality (Arbitrary, DDS, Digital Pattern).
- **Waveform** - In Arbitrary mode, it shows the current waveform generated by the instrument.
- **Modulating** - In DDS mode, it shows the phase or the frequency of the modulating signal.
- **Voltage Level** - Displays the Pod voltage level.
- **Sample Rate** - The Sample rate of the Digital Pattern Generator.

7. **Status Bar** - This are of the screen provides channel/pod run mode status information as follows.

- **Initializing** - The software is loading the firmware into the instrument.

- **Ready** - The instrument is ready to start.

- **Running** - The ArbStudio hardware is running.

- **Stopped** - The instrument is stopped.

- **Demo** - The software is in demo mode.

PLEASE NOTE THE FOLLOWING:

- When you press the Run/Stop button, the output log displays the operation list the software is performing as it loads the waveforms and settings into the instrument. If any operations cause an error or a problem in the sequencer while loading, the log notifies you.

- 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

Overview

The following examples provide a quick way to learn standard ArbStudio signal setups and common tasks:

1. **Creating a New Workspace** (on page 24)
2. **Opening an Existing Workspace** (on page 26)
3. **Arbitrary Waveform Generator Setup Example** (on page 27)
4. **Digital Sampler Setup Example**

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 ARBStudio 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 ArbStudio software** as explained in the **Getting Started with ArbStudio** (on page 10) 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 147)
2. **Creating a Sequence of Waveforms** (on page 151)
3. **Creating an Amplitude Modulated Waveform** (on page 155)
4. **Creating a Frequency Modulated Waveform** (on page 161)
5. **Creating a Phase Modulated Waveform** (on page 166)
6. **Importing a Waveform from an Oscilloscope** (on page 171)
7. **Creating Digital Waveforms** (on page 175)

Creating a New Workspace

1. From the Start Page, click the ![icon] **New Workspace** button.

   The New Workspace form is shown and displays the connected ArbStudio hardware on the **Instrument selection** section.

2. Enter a **Name** and **Description** for your new **Workspace**.

3. Click the **Browse** button to locate your workspace file, select it and click the **OK** button.

The **Setup Devices** wizard is shown.

4. Select your Operating Mode from:

- **Arbitrary Waveform Generator** - Four arbitrary independent channels are available and generate a wide range of complex analog waveforms.

- **Pattern Generator** - Available on 1102D and 1104D models.

- **Mixed Mode** - Channel 1 and Channel 2 are available for arbitrary analog waveform generation and Pod B is available for 18 digital signals generation/acquisition.

Click **Next**.
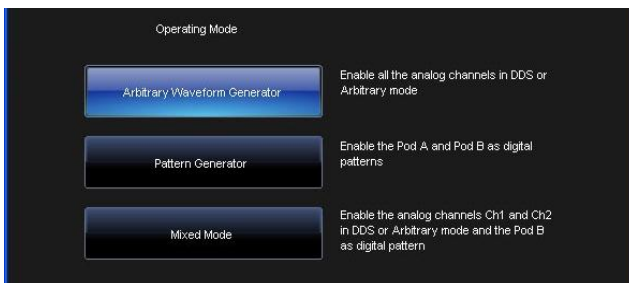
PLEASE NOTE THE FOLLOWING:

- The **ArbStudio 1104D** has **Arbitrary Waveform Generator**, **Pattern Generator**, and **Mixed Mode** operating modes.
- The **ArbStudio 1102D** has **Arbitrary Waveform Generator** and **Pattern Generator** operating modes.

5. On the channel functionality configuration screen, make settings as desired for each channel to run in either:

- **Arbitrary Mode** - If you need to generate a standard or amplitude modulated waveform.

- **DDS Mode** - If you need a frequency or phase modulated signal.

6. Click **Next**. The wizard Finish screen is shown.

7. Click **Finish**.

> **NOTE**: If your workspace contains additional ArbStudio devices, the wizard does not show this Finish screen. Instead, the wizard repeats itself to configure additional devices until all attached workspace devices are setup properly.

When a workspace has been created or edited, the ArbStudio environment becomes active and the workspace name is shown in the ArbStudio window header.

Opening an Existing Workspace

1. Click the **Open Workspace** toolbar button.

   The Open Workspace screen appears, displaying the AWGProjects folder.

2. Select the desired workspace and click **Open**.

> **NOTE**: Every workspace is associated with the serial number of a connected ArbStudio instrument.

3. If a Serial ID for a previously connected ArbStudio instrument in your workspace is different from ones currently connected, the **Relink Project Devices** screen is shown:
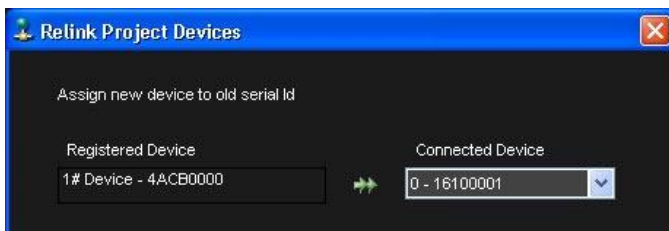
   Make new assignments using the **Connected Device** drop-down and click **OK**.

Arbitrary Waveform Generator Setup Example

1. Power on the instrument and connected it to the PC.

2. Launch the software and click the **Create Workspace** button.

3. On the Setup Devices wizard, select **Arbitrary Waveform Generator** as the operating mode and click **Next**.
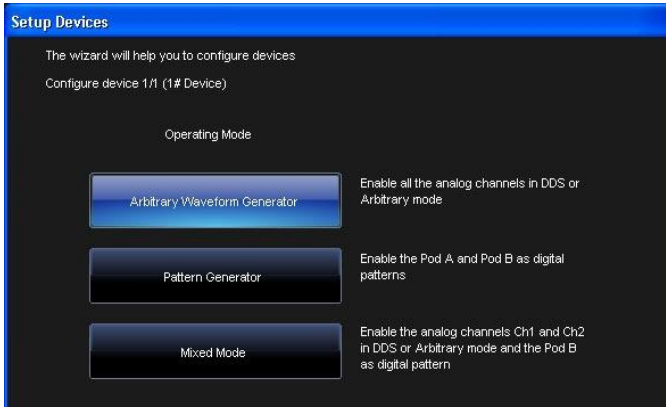
4. Configure channel functionality as **Arbitrary** and click **Next**.

The end of the wizard is shown.

5. Click **Finish**.

6. Now, on the Device Control Tree, double click the **Waveform Sequencer** item under **Channel 1**.
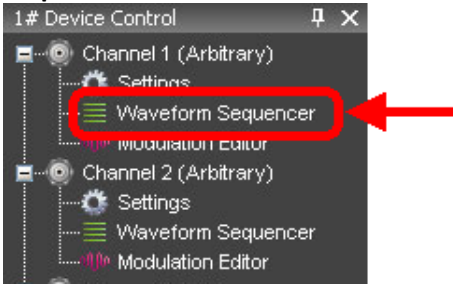
7. Click the **Add Standard Waveform** button.

   The **Waveform Standard Editor** form is shown.

8. Choose a sine waveform with the following specs:

   - 1 MHz frequency

   - 250 samples

   - 1 Volt amplitude
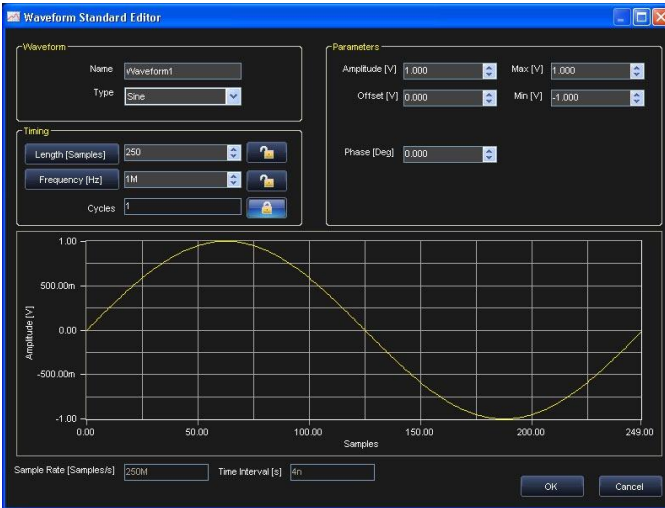
9. Select the **Waveform1** on the **Project Waveform** tab and click the

    Add button to include the waveform to the sequencer.

---

10. On the Device Control Tree, double click the **Settings** item under **Channel 1**.
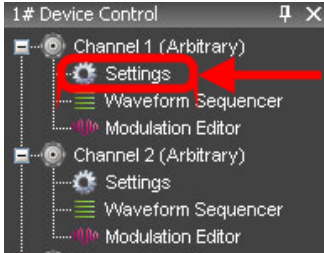
11. On the **General** tab of the **DEV1 Settings Ch 1** screen, select the appropriate **Output Impedance** value for your impedance load.
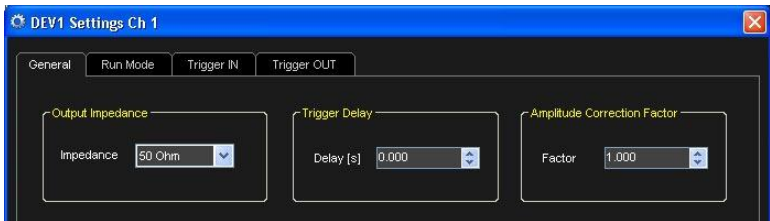
Example: When connecting ArbStudio to an oscilloscope, a 50 Ohm output impedance load is selected here and 50 Ohms is also selected as the input impedance on the oscilloscope channel.

12. On the **Run Mode** tab, select **Single** for the Run Mode field value and click the **OK** button.
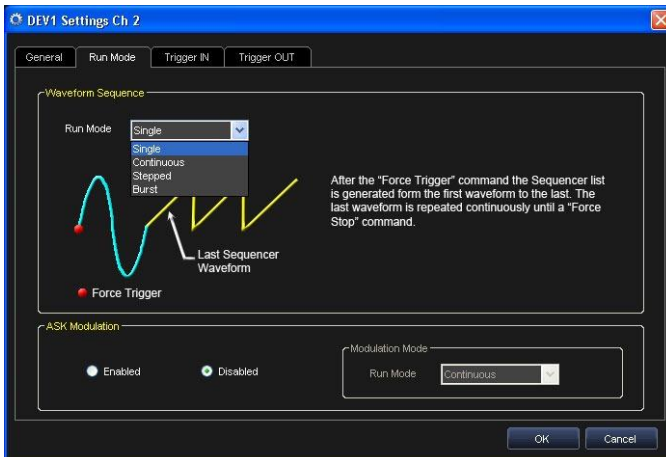
13. Press the **RUN ▶** **Run/Stop** toolbar button.

   > **NOTE**: Once the instrument has started (next step), Single Run Mode repeats Waveform1 until either the **Run/Stop** or **Force Stop** toolbar buttons are clicked.

   The software loads the settings and waveforms into the ArbStudio hardware and then generates waveforms.

   Waveform1 ports to the **CH1 BNC output**, which can be connected to an oscilloscope for signal analysis.

Digital Sampler Setup Example

1. Connect an ArbStudio with digital pattern generator capability to your PC and open the ArbStudio software.

2. Click the **Create Workspace** button and follow the steps to create a new workspace.

3. Connect the POD probe to **Digital POD A**.

4. On the Setup wizard, choose **Pattern Generator** mode.

5. Under POD A, select **Signals Definition**.

6. Enter **CLK** in the **Bus or Signal Name** field and press to add it to the list of signals.

7. Select **Ch0** from the list of channels on the right and press to associate Ch0 with the CLK signal.

8. Repeat steps 6 and 7 to add the **WR** and **RD signals**, associating them with Ch1 and Ch2, respectively.

9. Enter Data in the **Bus or Signal Name** field and associate it with as many digital channels as required by the digital data. More than one channel can be associated with the Data field by selecting all the required channels and pressing the button.

10. Double-touch on the **Waveform Sequencer** of POD A under the Control Navigation Tree.

11. Press to add a digital waveform to the Waveform List:

    - When the New Waveform window appears, press to add all buses/signals to the digital waveform.

    - Enter either the time length or the number of samples under **Waveform Length**.

    - Press **OK** to add the waveform to the Waveform List.

12. Press or double-click on **Waveform1** to open the Editing Waveform window.

13. Set **WR**, **RD**, and **WriteRAM** signals to **1** by selecting the "to 1" button.

14. Expand the **Data** field and change **CLK** signal to **HiZ**. This changes the pin direction from output to input. Press **OK**.

15. Select **Waveform1** from the Waveform List and press to add it to the sequencer.

16. Connect the digital leads from POD A to the digital signals, being sure to connect each channel to the same channel it was associated with in the ArbStudio software.

17. Press and allow ArbStudio to run long enough to capture the applied digital data. Press to stop the acquisition.

18. View the acquired data by selecting **Waveform View** under the Acquisition folder of POD A, then selecting to add the data to the signal selection.

Channel Settings

Overview

Use **Settings** to control the channel settings of the instrument. Access Settings by double clicking on the desired **Channel** in the **Device Control Tree**.
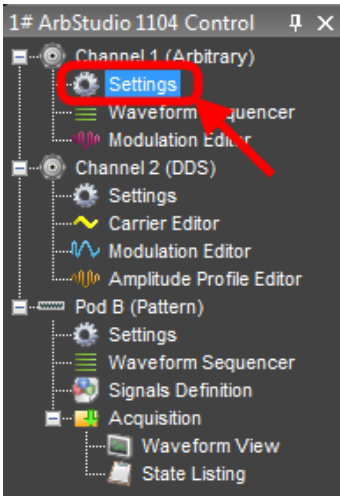
The **Settings** screen is divided into the following tabs:

Channel Settings - The General Tab

The **General** tab is shown by default when the **Channel Settings** screen is opened.
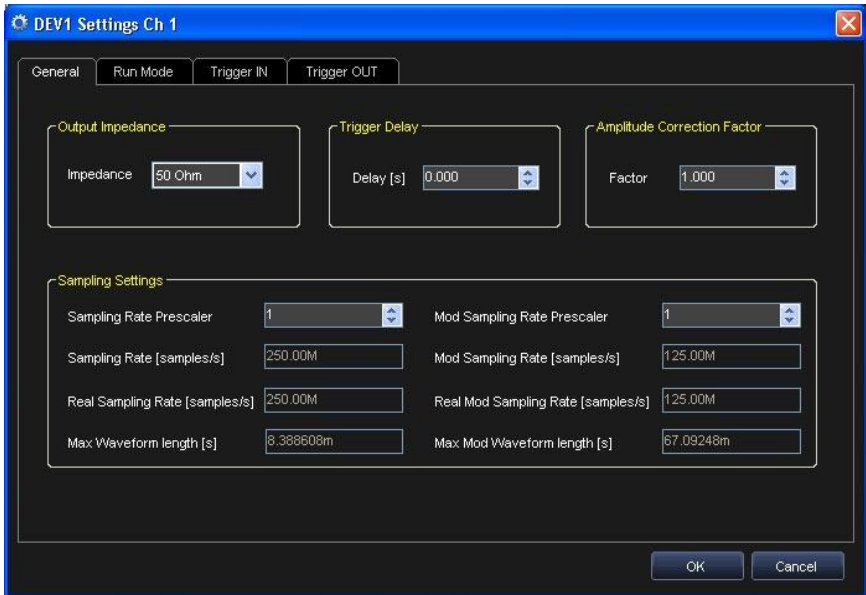
Sections of the Channel Settings General tab are explained as follows:

Output Impedance

It allows setting the channel output impedance and it can be set at: 50 Ohm, Low or High Impedance.

Trigger Delay

You can set a delay from the trigger event (start) for each analog output channel.

Amplitude Correction Factor

The Amplitude Correction Factor (CF) consider the deviation of the load and of the channel source resistance from the nominal 50 Ohm resistance.

Follow the next steps to evaluate the CF:

- Apply to the load a fixed 5 V nominal voltage using the strobe functionality of the selected channel

- Read the voltage load on the multimeter
- CF = Voltage Read at the load / Nominal voltage at the load. For example if the value read is 4.9 V, CF=4.9 V/5 V = 0.98

Sampling Settings

This section of the General Tab allows for dividing sampling Base Frequency (see Setup Sampling Rate Section) for both the signal carrier and for a possible M-ASK modulating signal, respectively.

CARRIER WAVEFORM

- Sampling Rate Prescaler (SRP) may assume values ranging from 1 (maximum frequency) up to 16777216 (minimum frequency), by multiples of 2.
- The optimal selection of SRP must take into account both the maximum frequency of the signal to be generated and its duration.
- The limit on the maximum frequency comes from the Nyquist sampling theory which imposes a frequency generation at least two times the maximum frequency of the signals generated.

  For example, if a sinusoid must be generated at 10 MHz, its sample frequency generation must be at least 20 Msps. In that case, however, the sinusoid period is represented by only 2 points.

ArbStudio has a set signal duration limit for the memory depth used while saving waveform samples. In fact, the memory space allocated to the sample storage makes the waveform duration inversely proportional to the generation frequency.

In particular, the maximum duration of a waveform is given by the number of possible samples divided by the generation frequency.

For example, a maximum frequency of 250 Msps and a memory depth of 2,097,152 samples, done by setting SRP = 1 (sampling rate = 250 Msps), can have saved waveforms with a total length of 8.388608 ms and a time resolution of 4 ns.

However, by setting SRP = 20 (sampling rate = 12.5 Msps), the total waveform length becomes 167.77216 ms with a time resolution of 80 ns.

MODULATING WAVEFORM

When M-ASK modulation is used you can set Mod Sampling Rate Prescaler (MSRP) for the modulating signal independent of the carrier signal.

- MSRP may assume values ranging from 1 (maximum frequency) up to 65532 (minimum frequency), by multiples of 4.
- The optimal selection of MSRP must take into account both the maximum frequency of the signal to be generated and its duration. For example, an ArbStudio 1102/1104 with a maximum frequency of 125 Msps (on the modulating signal) and a buffer depth of 2,096,896 samples in static mode, done by setting SRP = 1 (sampling rate = 125 Msps), you can save a modulating waveform with total length of 16.775168 ms and a time resolution of 8 ns.

Channel Settings - The Run Mode Tab (Waveform Sequence)

Use the Run Mode tab to define the generation mode for the edited sequence and set the trigger for the modulating signal.
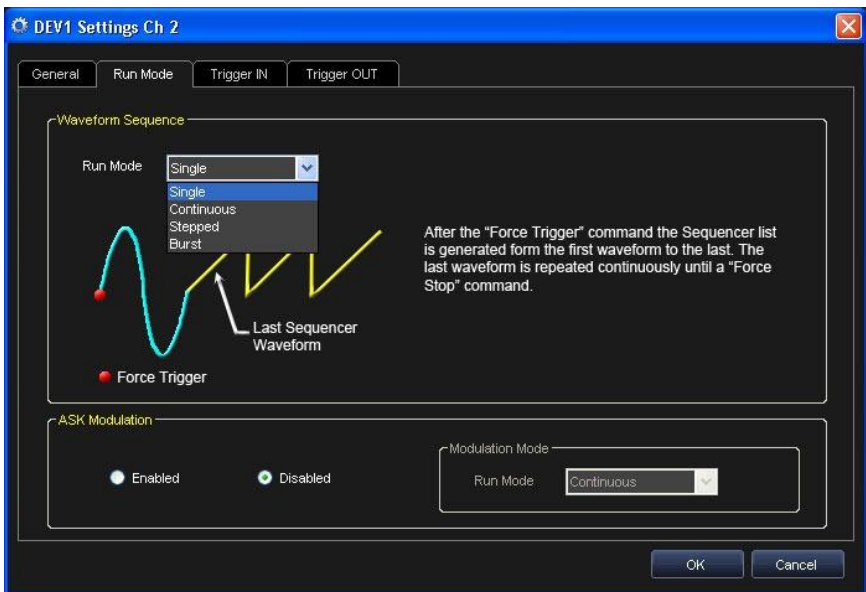
The Waveform Sequence Run Mode tab allows defining the generation mode for the edited sequence in Arbitrary mode. The available drop down Force Trigger options include **Single**, **Continuous**, **Stepped**, and **Burst** explained as follows:

Single

When a Force Trigger command is applied, waveforms inserted in the Generation Sequence are generated one after the other.
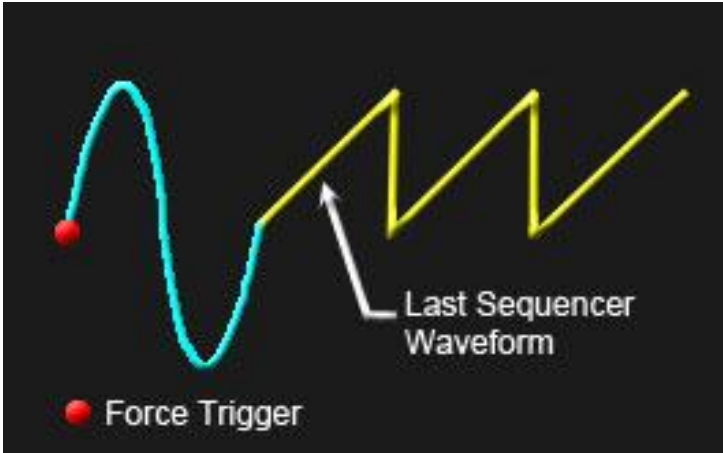
- The last waveform is repeated until a Force Stop command is received.
- The sequence can be interrupted at any time by a Force Stop command.

Continuous

When a Force Trigger command is applied, waveforms inserted in the Generation Sequence are generated one after the other in a continuous mode.
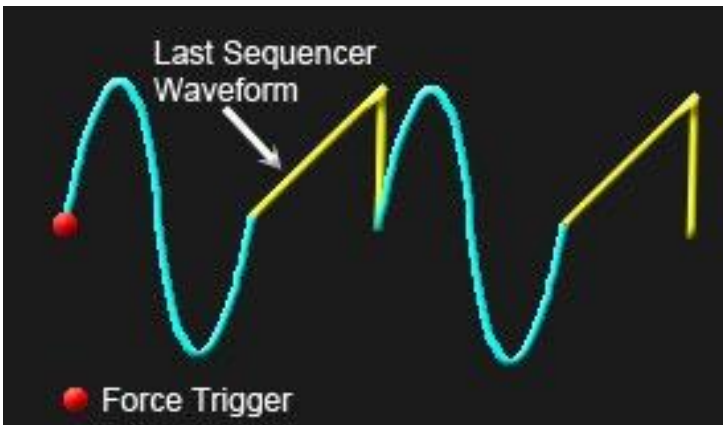
- After the generation of the last waveform, ArbStudio starts again with the first waveform, and then continues.

- The sequence can be interrupted at any time by a Force Stop command.

Stepped

A Force Trigger command activates the generation of the first waveform present in the generation sequence.

This waveform is repeated for a number of times indicated in the repetition number.
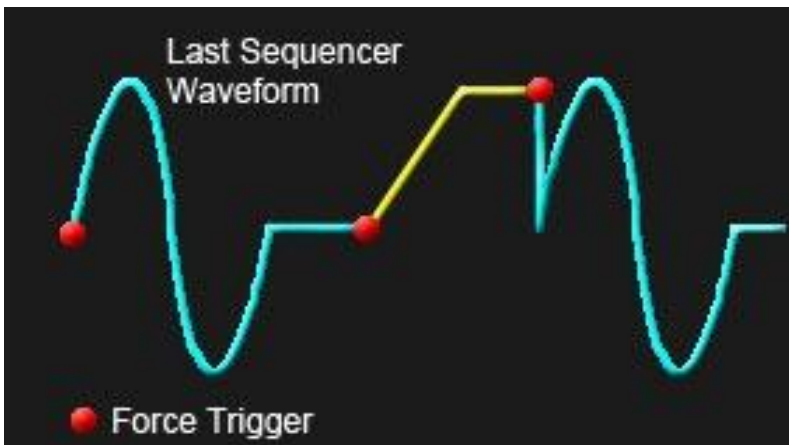
- The instrument output maintains the value imposed by the last sample of the generated waveform.

- A new Force Trigger command activates the generation of subsequent waveforms.

- After the generation of the last waveform, a new Force Trigger command activates again the generation of the first waveform.

- The generation can be interrupted at any time by a Force Stop command.

Burst

In this mode the first Force Trigger command activates the first waveform present in the Generation sequence.

This waveform is generated in a continuous mode until a new Force Trigger command is applied.

Force Trigger   ----- Repeat Current Waveform
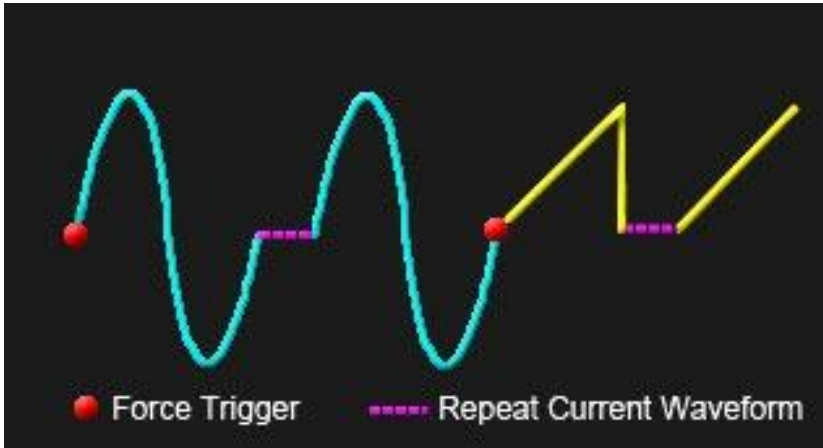
- This Force Trigger command activates the generation of subsequent waveforms (the generation of the latter waveform starts only when all points of the previous one are generated).

- A Force Trigger command applied during the generation of the last waveform activates the generation of the first waveform.

- The generation can be interrupted at any time by a Force Stop command.

- In this mode the repetition number associated to any waveform is ignored (the generation of one waveform starts only when all points of the previous one have been generated).

PLEASE NOTE THE FOLLOWING:

- If a unique waveform is inserted in the Generation Sequence, the Single, Continuous and Burst modes are equivalent.

- The Stop command resets the generation sequence and sets the output voltage at 0V. A Start command applied after a Stop command activates always the generation of the first waveform in the Generation Sequence.

- In Burst mode the graph and the duration column of the modulation table are disabled, having no meanings.

Channel Settings - Run Mode Tab (Modulation)

The Modulation Mode menu allows setting the trigger for the modulating signal. Available options include **Single**, **Continuous**, and **Burst**.

Single
ARBITRARY

- When the Force Trigger command is given, the carrier signal, see **Advanced Waveform Editing** (on page 61), is modulated with the edited, modulating signal samples.

- The last sample of the modulating signal is applied to the signal carrier until a Force Stop command is applied.

DDS

- When a Force Trigger command is applied, the frequencies (or phases) inserted in the Modulation Editor are generated one after the other for a time interval specified on the Durations field.

- The last frequency (or phase) is repeated until a Force Stop command is received.

- The sequence can be interrupted at any time by a Force Stop command.

Continuous
ARBITRARY

- When the Force Trigger command is given, the carrier signal, see **Advanced Waveform Editing** (on page 61), is modulated with the edited modulating signal samples.

- Once the last sample of the modulating signal is reached, ArbStudio returns to the first modulating signal sample until a Stop command is applied.

DDS

- When a Force Trigger command is applied, the frequencies (or phases) inserted in the Modulation Editor are generated one after the other in a continuous mode.

- After the generation of the last frequency (or phase), ArbStudio returns to the first frequency (or phase).

- The sequence can be interrupted at any time by a Force Stop command.

Burst (DDS Only)

- After a Force Trigger command is received, the frequency (or phase) defined in the Modulation Editor buffer is generated until another Force Trigger is received.

- At the next Force Trigger, the period of the waveform is completed with the previous frequency (or phase) entry before the second stage frequency (or phase) is generated.

- Once the last frequency (or phase) is exhausted, the waveform's frequency (or phase) resumes using the first value entry in the Modulation Editor list.

- The generation can be interrupted at any time by a Force Stop command.

- The Duration Time associated to any frequency (or phase) is ignored when using Burst/DDS mode.

Channel Settings - The Trigger IN Tab

This section allows setting the Trigger In parameters.
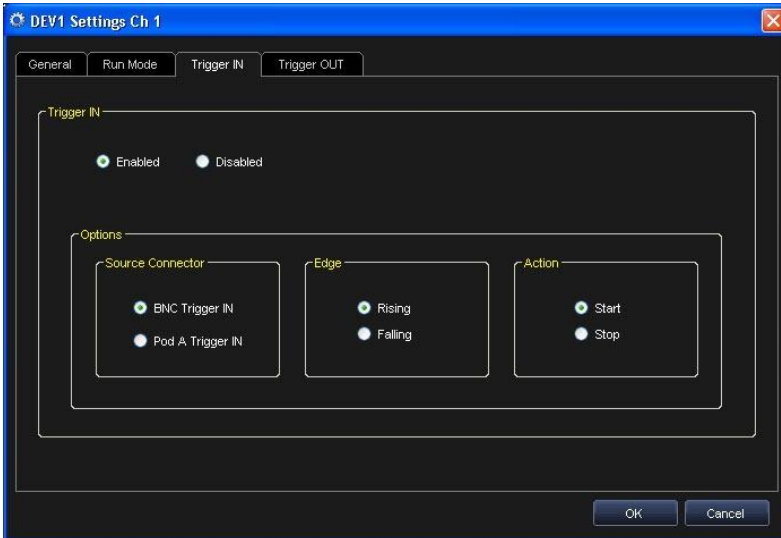
Source Connector

Use this field to select the physical source for a Trigger In event. Choose one of the following as explained.

- **BNC Trigger IN** - The trigger event is received by the dedicated BNC Connector on the instrument front panel.

- **Pod A Trigger IN** - The trigger event is received by a dedicated Digital input of the probe connected to the Pod A in the instrument front panel - see Probe Description.

NOTE: Trigger IN source setting is mutually exclusive.

Edge

You can set the sensitive edge for the input trigger as **Rising** or **Falling** Edges.

Action

You can set the action for ArbStudio to perform when there is an input Trigger event. The possible options include:

- A **Start** command being generated at any event.
- A **Stop** command being generated at any event.

Channel Settings - Trigger OUT Tab

This section allows setting the Trigger OUT parameters.
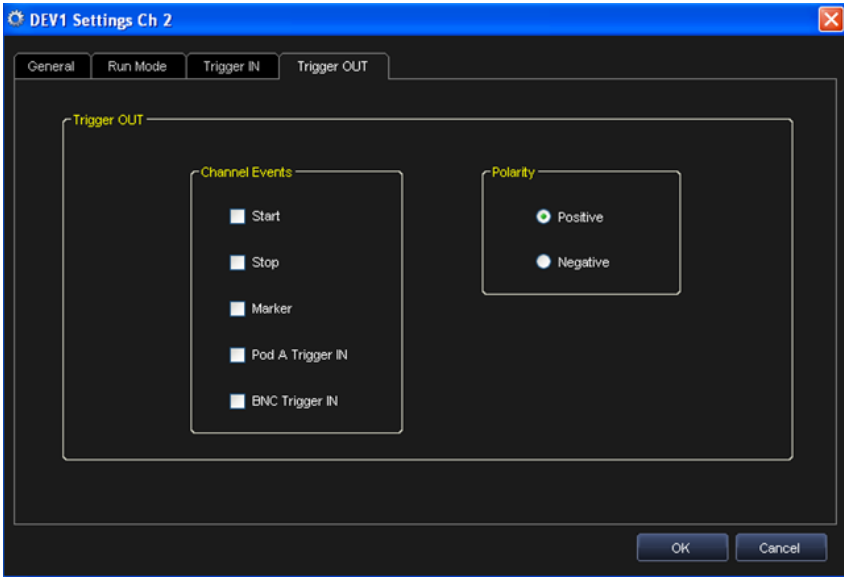
Trigger out source

Allows selecting the possible trigger source which generates a Trigger Out event.

One or more sources can be chosen at the same time.

The signals that can be sent to the Trigger OUT output include Start, Stop, and Event.

NOTE: Pod A Trigger IN and BNC Trigger IN are available on even channels only.

POLARITY

You can choose the Trigger OUT signal polarity as Positive or Negative.

DESTINATION

A logic combination of the Trigger Out event of the enabled channels is always available on the dedicated BNC Connector and on Pod A / Pod B Trigger Out signal on the instrument front panel see Setup Device Trigger Out Math section.

Setup System

Access the Setup System screen by clicking the **Setup System** toolbar button.

Setup System can be used when multiple devices are connected by the expansion bus or when channels have to be managed by an event.

The Setup System screen is shown.

- Now, from the Devices list on the left, select the Channel or Pod you want to set as the Master, and then click the **Set Channel as Master** button.

When the Master generates an event (Start, Stop, Marker) , now it can be evaluated by the slave devices.

- Slave devices can Start or Stop On the Master Event. Select the Master Channel Event from the right list and associate it with Start or Stop On of the selected slave. If you select None, the Master Channel events are ignored.
- Now the Start or Stop events on slave channels are synchronized with Start, Stop, or Marker event on the Master channel.

Other buttons on the **Setup System** screen include:

- **Reinitialize to Default** - Click this button and all devices are set as the slave.

- **Set Slave Start on Master Start** - Sets all slave devices to Start On the Master Channel Start Event.

- **Set Slave Stop on Master Start** - Sets all slave devices to Stop On the Master Channel Stop Event.

Setup Device

Setup Device Overview

Use the **Setup Device** tabs to quickly access the following ArbStudio parameters (the **Timing** tab is shown by default):

- **The Timing Tab** (below)
- **The Channel Out Math Tab** (on page 47)
- **The Trigger OUT Math Tab** (on page 48)
- **The Digital I/O Tab** (on page 49)
- **The Strobe Tab** (on page 50)

Timing Tab

The sample rate for the pair of adjacent channels can be set to the following ranges:

- The 4S/s – 250 MS/s range for Arbitrary channels or Pattern Generator Pods.
- The 125 MS/s – 250 MS/s for DDS channels.
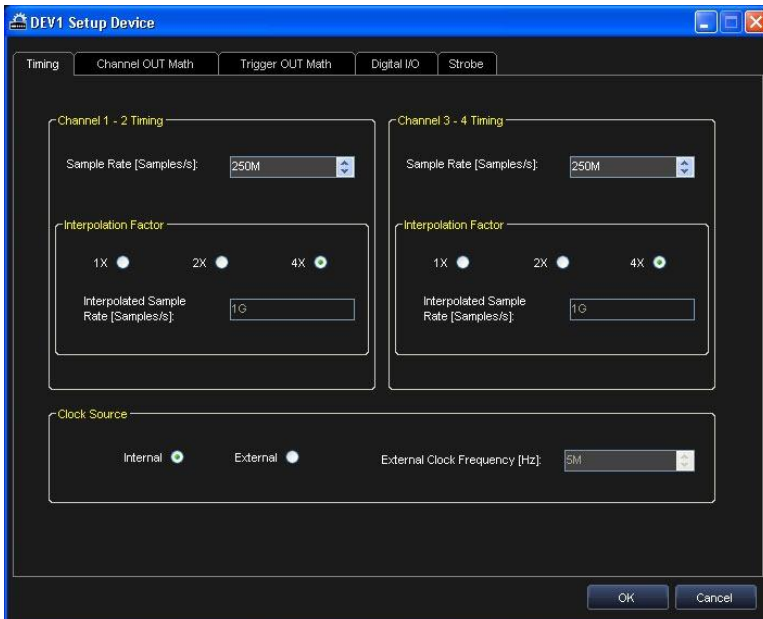
Interpolation Factor

One of 3 frequency interpolation types (1X, 2X or 4X) may be set for either channel pairing.

The interpolated sample rate of each channel pair can be calculated as a combination of the internal DAC's sample rate (250 MS/s for both Arbitrary and DDS projects) and the frequency interpolation's factor.

The maximum interpolated sample rate is 1 GS/s and can be achieved by selecting a 4X interpolation factor.

Clock Source

The clock source may be set to Internal or External.

- If **Internal** is selected, the clock signal is generated internally.
- If **External** is selected, the clock signal from the EXT CLOCK BNC connector is used. When the External Clock is selected, an External Clock Frequency must be set for your clock signal.

Multi Device Deskew Delay (1104 with Expansion Bus option only)

This parameter can set a fine delay between multiple devices in order to compensate the skew between the outputs belonging to different devices.

The skew delay is only active on Slave devices and can add a positive delay respect to the Master.

When deskewing the channel delay of a slave device with respect to the master, the Multi Device Deskew delay must be used in conjunction with the trigger delay. Multi Device Deskew delay sets a fine delay and can only be positive, while the trigger delay sets a normal delay and can also be slightly negative.

The deskew delay is only effective when all devices work with the same sampling frequency that must be in the following list: 250 MHz, 200 MHz, 150 MHz, 100 MHz, 75 MHz, 50 MHz, 37.5 MHz, 25 MHz.

Channel Out Math Tab

You can set a communication between adjacent channels allowing computations to be performed between generated waveforms or between a waveform and a constant.
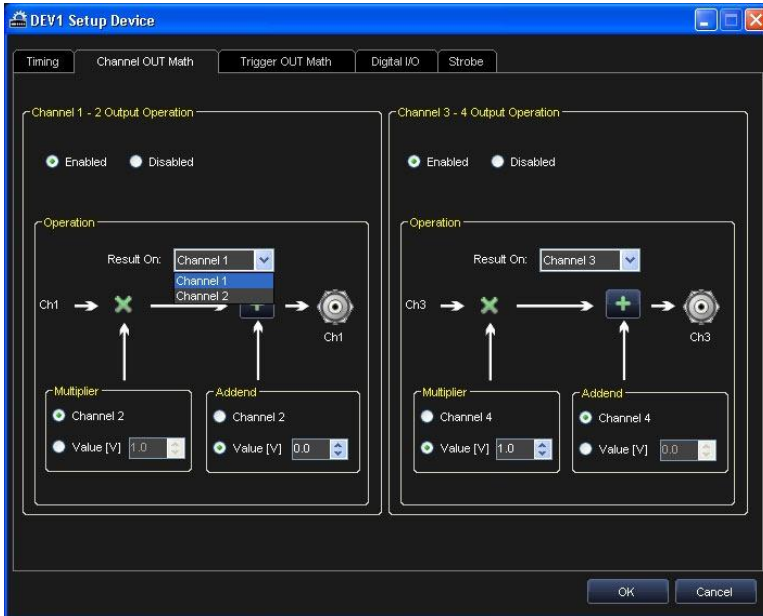
- Use the radio button to Enable operation on a channel pair.
- Select the channel where the operation result is to be performed. The selected channel is the Receiver (RX) and the other one is the Transmitter (TX).
- On the **Multiplier**, select the TX channel to multiply the TX waveform with the RX waveform or select a constant to multiply the RX waveform with a fixed voltage.
- On the **Addend** option select the TX channel or a constant value. Click the **Add** button to toggle the operator to subtraction instead.

Trigger OUT Math Tab

Enabled channels can have a logical combination set between all trigger out events.

The possible operations include **Force Low** (force to low logic level signal), **Force High** (force to high logic level signal), **AND**, **OR**, **XOR**, **NAND**, **NOR**, and **XNOR**.

Results are made visible on the BNC Trigger OUT Connector and on the Trigger Out signal of the digital connector (Pod A/B).

If the Pattern Generator option is available, click the **Toggle** button to switch the BNC Trigger Out selection from the left pair to the right (or vice versa).
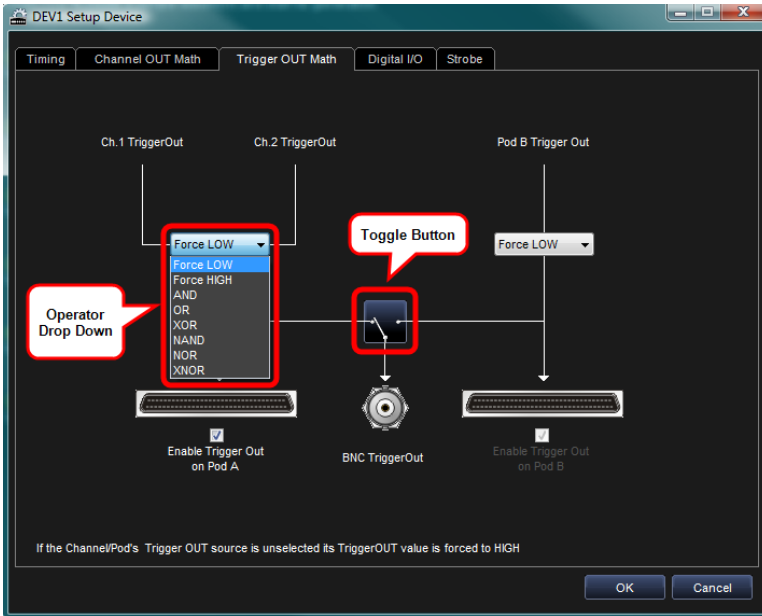
Digital I/O Tab
Arbitrary/DDS Channels

You can generate a digital pattern for the analog waveforms of channel 1 and 3 (ArbStudio 1104 only).

Digital pattern generation can be used to test digital devices such as serial and parallel DACs or to emulate protocols.

The 16-bit digital representation of the waveform samples is available on the digital output connectors Pod A for channel 1 and Pod B for channel 3 (ARBStudio 1102D/1104D) as a digital pattern. The data is available after some sample clock pipeline delay.

It is possible to set the output voltage level for digital pattern in the 1.6 V – 3.6 V range.

Pattern Generator

If the Pattern Generator option is enabled, you can set the output voltage level for Pod A/B in the 1.6 V – 3.6 V range. The default value is set to 3.3 V.

NOTE: When the software is first loaded, the digital pattern generation is disabled.

Strobe Tab

Channels Output Voltage (Arbitrary and DDS)

Use to set the DC Output voltage for the selected channel.

Pod A/B (Pattern Generator)

Use this panel to assign values to Digital Pattern Generator (optional) pins, read their status, or set in a high impedance state. Use the following explanations to guide your settings.

- **Strobe Vectors** - Allows the assignment of values to Vectors[15..0], to the Extended Trigger signal and to the Write RAM signal. By pressing the Strobe button, the output pins change their logic levels to the ones assigned.

- **Pods status** - The Digital Pattern Generator can also operate as a Sampler. Digital channels change their behavior from outputs to inputs. When the Read Pods Status button is pressed, the logic level of each input can be examined in real time.

- **HiZ Strobe** - By pressing the Set HiZ button all digital channels will go in a high impedance state.

The Waveform Sequencer - Analog
Creating Standard and Advanced Waveforms
Creating a Standard Waveform

Create a new waveform in the Waveform Sequencer using the following steps.

- Press the **Add Standard Waveform** button.

- The **Waveform Standard Editor** dialog box is shown.

- Provide a **Name** for your waveform.
- Use the **Type** drop-down and select **DC Level**, **Sine**, **Increase Ramp**, **Sawtooth**, **Rectangle**, or **Triangle**.
- Use fields on the Timing section to set **Length**, **Frequency**, and **Cycle** parameters.
- Fields on the Parameters section can be used to set **Amplitude**, **Offset**, **Phase**, **Maximum** and **Minimum Voltage** levels
- Click the **OK** button to create the waveform and add it to the project.

Creating an Advanced Waveform

Create a complex waveform in the Waveform Sequencer by clicking the
Add Advanced Waveform button.

Like Standard Waveform Creation, the **Waveform Editor** dialog box is again
shown.
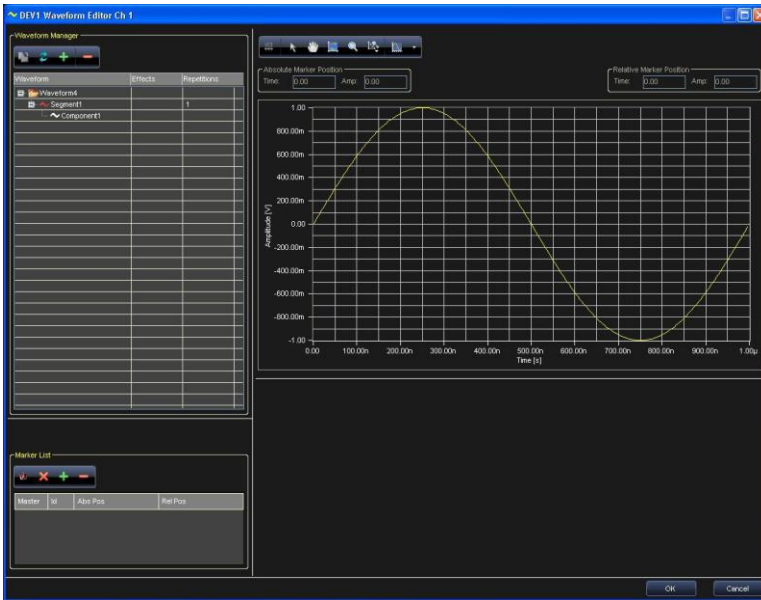
ArbStudio handles Waveforms, Segments, and Components in the
following manner.

WAVEFORMS

- **Standard Waveform** - A basic waveform like DC Level, Sine, Increase
  Ramp, Triangle, Sawtooth, or Rectangle.
- **Advanced Waveform** - A sequence of elementary waveforms, or
  segments. A Waveform contains the temporal order by which the
  segments are generated (and the number of repetitions for each
  segment). A segment is a combination of components.

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 ArbStudio frequency (sample rate) and of the length of the component itself (number of points).

THE WAVEFORM EDITOR / CARRIER EDITOR

Edit waveforms generated by ArbStudio using the Waveform Editor tool. Depending on Arbitrary or DDS project type mode, edited waveforms acquire different meanings.

- **Arbitrary** - Edited waveforms can be generated as they have been set. edited waveforms represent the signal carriers in case of amplitude modulation.
- **DDS** - Edited waveforms may only represent a period of the signal carrier.

Think of a waveform as a list of segments, where each segment can be positioned any way within the list and repeated as necessary. Consider the following when selecting detailed analysis.

- Each waveform may be constituted by an arbitrary number of segments and each segment can be repeated an arbitrary number of times.
- The maximum number of samples for all waveforms is fixed in Arbitrary Mode (2.097.152 samples 2M option). In DDS mode, the maximum number is 2048 samples.
- Each waveform must be constituted by an even number of samples ≥8. Each segment may have an even or an odd number of samples.
- In Arbitrary mode an arbitrary number of waveforms can exist. Unlike DDS mode, Arbitrary allows the number of edited waveforms

samples be lower than the maximum number set by the memory installed in the instrument.

The Waveform Manager

The Waveform Manager is part of the Waveform Sequencer and provides control of all possible waveform operations. Many common operations can be directly performed on waveforms or are easily accessed from the waveform tree (**Selection**, **Drag and Drop**, **Right Click**).

NOTE: Items selected on the waveform tree also updates some window fields (on the right of the following screen-shot).
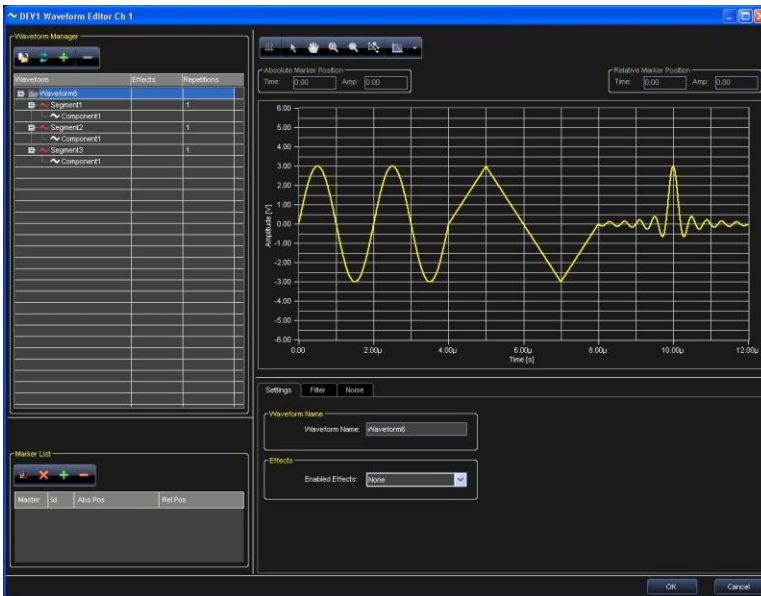
SELECTION

The window fields vary based on the selected item (Waveform or Segment).

Waveform - When a waveform is selected, the graph is updated. The information related to the selected waveform is shown.

Segment - Wen a segment is selected, the result of its components are shown on the waveform graph.

The number of repetitions for each segment is shown in the **Repetitions** column of the waveform tree.

DRAG AND DROP

A Drag and Drop operation on an item (Segment or Component) produces its movement in another position within the tree. Some Drag and Drop operations are not allowed and are automatically ignored (waveforms within other waveforms).

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.

Move Up

Move Down

Add Segment

Export Waveform...
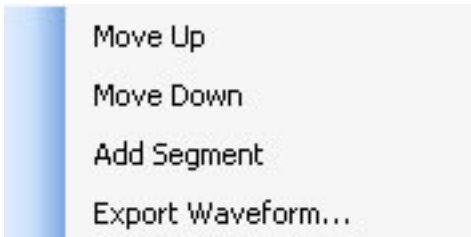
- **Move Up** and **Move Down** - Changes the position of the selected object (Waveform or Segment) up/down in the list.
- **Add Segment** or **Component**- If a waveform is selected, inserts a new segment with its first component (Component1) in the last position. If a component or segment is selected, inserts a new component in the last position. Either way, the Edit Component window is shown after segment/component creation.
- **Export Waveform...** - With a waveform selected, this option saves the waveform points to a flat text file.

WAVEFORM EDITOR/MANAGER BUTTONS

When you have a waveform open in the editor, many of the Right Click functions are also available directly from the Waveform Manager buttons shown on the upper-left of the screen.

- **Export Waveform**: Same as the right click option, exports the waveform points to a flat text file.

- **Reinitialize Waveform** - Reinitializes the waveform to the original condition, this command deletes all added segments and components.

- **Add Segment/Component** - Same as the right click option, if a waveform is selected, inserts a new segment with its first component (Component1) in the last position. If a component or segment is selected, inserts a new component in the last position. Either way, the Edit Component window is shown after segment/component creation.

- **Delete** - Removes a component or a segment from the Waveform Manager.

Available Waveforms from the Waveform Display

Project Waveforms - This tab contains a list of all standard/advanced waveforms previously created in your project. Right click on a selected waveform and a pop-up is shown with the following options (many of these functions are the same as the Waveform Editor/Manager buttons and the right click, discussed previously):

Library Waveforms - Contains all waveforms (.wlf) stored in the selected library folder.

NOTE: You can select a different library folder as your default in **Tools →Options**. Change the location of the **Waveforms Library Path**.

Waveform Sequencer Buttons

The Sequencer buttons cover many functions as the Waveform Editor/Manager buttons discussed previously. Many are also accessible via right clicking a selection if preferred.

- **Load Waveform** - Loads a waveform into the project waveform tab.

- **Save Waveform** - Saves the selected waveform in Waveform Library File (.wlf) format.

- **Import Waveform** - Imports data from a selected flat text file (Tab or Comma Separated, or .trc format) and converts it into a waveform display.

- **Export Waveform** - Exports the selected waveform to a flat text file.

- **Add Standard Waveform** - Opens the Standard Waveform Editor dialog box.

- **Add Advanced Waveform** - Opens the Waveform Editor dialog box for complex waveform editing.

- **Remove** - Removes a component or a segment from the Project Waveform tab.

- **Duplicate Waveform** - Creates a new waveform just like the one selected in the list.

- **Convert Waveform** - Changes Standard waveform to Advanced.

- **Edit Waveform** - Opens the selected waveform in the **Waveform Standard Editor** dialog box.

- **Length Samples/Time**

Waveform Graph Toolset

When viewing a waveform in the Waveform Editor, ArbStudio's main toolset is provided and your waveform is plotted in a graph.
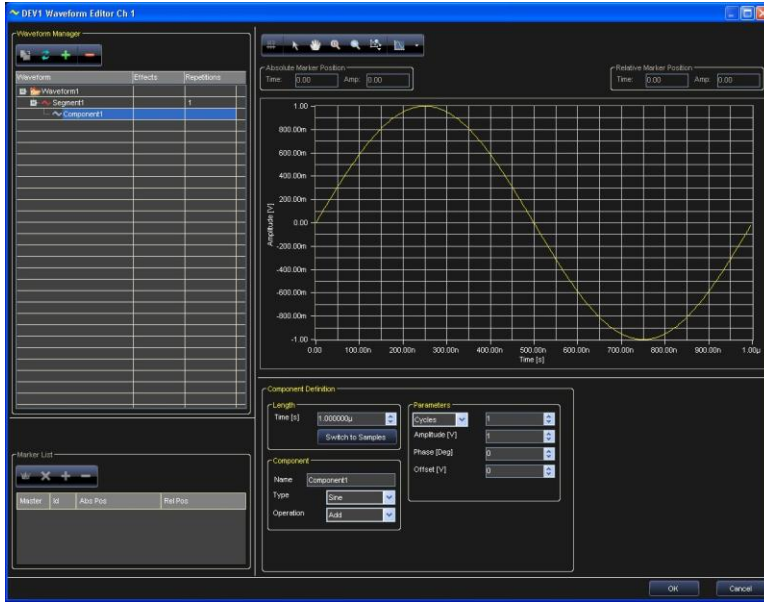
The toolset includes the following:

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

- 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 resets all activated zooms.

- 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 zooms in on an area of the graph along the X(Y)-axis. Click and drag inside the graph area to create your zoom rectangle. The scale on the Y(X)-axis does not change.

- The right-side drop-down on this button provides the following plot type options:

    - **Point Style** - Provides cross, plus, circle, etc. point styles for the data points on the graph area.

    - **Point Color** - You can assign colors to data points as desired.

    - **Line Style** - You can set solid or dashed line styles for the graph area.

    - **Line Color** - You can set colors for waveform lines as desired.

    - **Line Width** - You can set your waveform line width/thickness as desired.

    - **Anti-Aliased** - Mark this checkbox and line plots appear smoother. However, anti-aliased line drawings can be computation intensive and slow performance.

    - **Fill/Line to Base** - Provides filling options (styles, colors, width) for the waveform representation.

NOTE: First, click on a tool to select its function, and then click again to show the On Screen Keyboard to provide specific value data (where applicable).

Advanced Waveform Editing

This example edits a sine signal waveform (amplitude 5 V, frequency 10 kHz, duration 300 μs), concatenated to a triangular signal (amplitude 6 V, frequency 20 kHz, duration 800 μs). The following steps demonstrate the procedure.

1. Click the **Add Advanced Waveform** button to open the **Waveform Editor** dialog box.

2. Select **Component1** of **Segment1**, choose **sine wave** in the component **type**, set its **length** to **300 μs**, and **3 cycles** in the **Parameters** window. Now, set the **amplitude** to **5 V**.
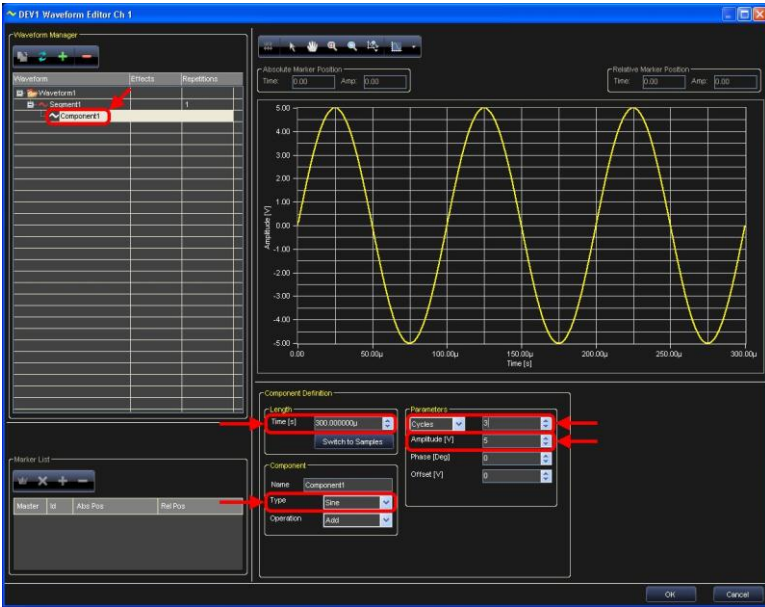
3. Now, in the **Waveform Manager** area, right click on **Waveform1** and select **Add Segment**.

4. Repeat the settings in step 2, only for **Type** select **Triangle**, **Frequency 20 kHz**, **Time 800 µs**, and an **Amplitude** of **6 V**.

5. Click **Waveform1**. The desired waveform is shown in the **Waveform Editor** window.

Segment Editing

Segments, the building blocks of waveforms, are composed by a specific combination of components with the same length. Editing a segment requires the following **Component Definition** settings:

- Setting the segment **length** as either **time duration** or **number of samples**.
- **Adding a component** by right clicking on the corresponding segment.
- Setting the component **function** (Add, Multiply,…) with respect to the segment.
- Set the component **type** (Sine, Cosine, Triangle,…).
- Set the component **characteristics** (Amplitude, Frequency, Phase,…).

Component Operation Field

The component operation field provides mathematical operators for applying to the current component and others present in a segment. Operators include **Add**, **Sub**, **Multiply**, and **Divide**. The operation is performed on each data point in a component and on each component in a segment. This example edits a rectangular waveform (amplitude 5V,

frequency 200 kHz, duration 100 µs) amplitude-modulated with a period of sine signal. The following steps demonstrate the procedure.

1. Click the **Add Advanced Waveform** button to open the **Waveform Editor** dialog box.

2. Select **Component1** of **Segment1**, choose **sine wave** in the component **type**, set its **length** to **100 µs**, and **1 cycle** in the **Parameters** window. Now, set the **amplitude** to **5 V**.

3. Now, in the **Waveform Manager** area, right click on Waveform1 and select **Add Segment**.

4. Select **Add** on the Component **Operation** drop-down field.

5. Select Segment1 and then click the Add Segment/Component button in the Waveform Manager to add a new component.

6. In the **Type** field, select **Rectangle**, **Frequency 200 kHz** (or select **20 cycles** from the first two parameters drop-down fields), **Time 100 µs**, **amplitude** to **1 V**, and **duty cycle** to **50%**.

7. Set the segment amplitude (1 V) and duty cycle (50%).

8. Now select **Multiply** on the Component **Operation** drop-down and click the **OK** button.

9. Click **Waveform1** and the desired waveform is shown in the **Waveform Editor** window.
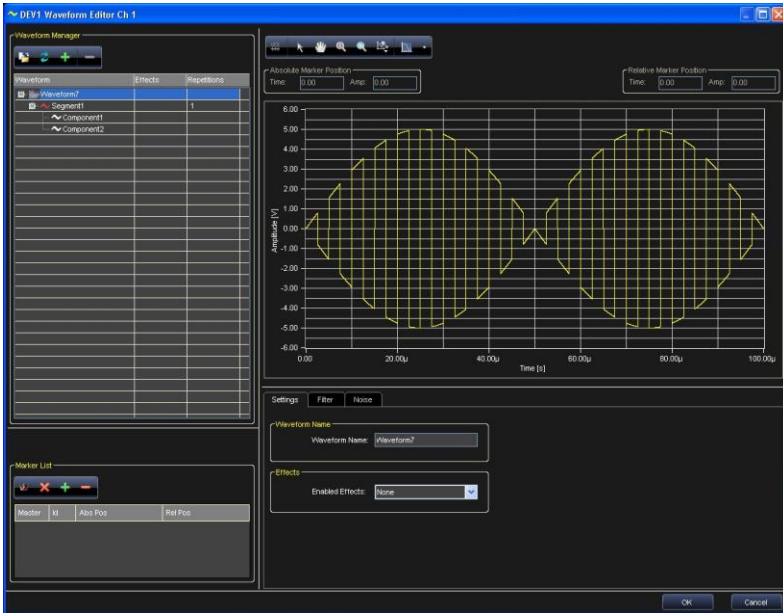
NOTE: The order of components shown on the list is of basic importance for the calculation of points composing the segment. By selecting a component within the list, both the graph and the waveform editing section are updated with the information of the selected component.

Component Type

The **Type** menu allows selecting the component 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

The Formula type allows defining the component by means of a mathematical expression.

The component 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.

The From File type allows importing the components points from a text file (*.txt) where the component voltages are reported in sequence.

Segment Parameters

Select a segment in the Waveform Manager and its graphical representation is shown on the waveform graph to the right. For each segment of the Waveform you can change the:

- **Segment Name**
- **Repetitions** - The number of times the segment is repeated inside the waveform.

Waveform Parameters

Select the Waveform in the Waveform Manager. The tabs under the waveform graph provide access to the **Waveform Settings**, **Filter**, and **Noise**.

Settings

- **Waveform Name**
- **Effects** - 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

This operation allows applying a digital filter to the selected waveform. The presence of a digital filter is evidenced by the Filter label in the Effects column of the waveform tree.

The Filter setting window is divided into **Application Zone**, **Specification**, and **Parameters** sections.
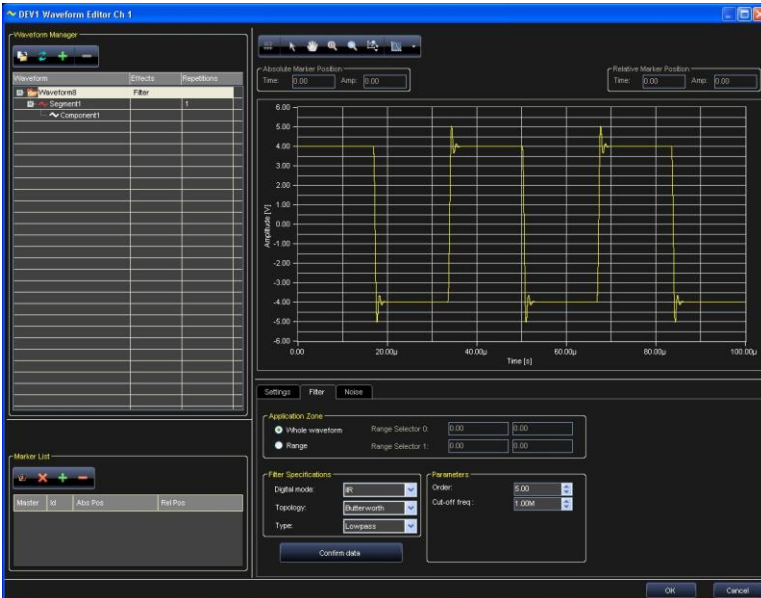
FILTER APPLICATION ZONE

This section allows selecting whether the digital filtering is to be applied to the entire waveform or to a limited part. This option can be selected by means of the **Whole Waveform** or **Range** option in the Application Zone section, respectively.

In the **Range** case, two vertical lines appear in the graph area to delimit the waveform section to be filtered. The two vertical lines can be moved by the user. Their position is shown in the same Application Zone section.

Filter

This section allows setting all the characteristics of the filter.

FILTER SPECIFICATIONS

- **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.

Type, Topology and filter Order options depend on the specific filter characteristics.

Click the **Confirm Data** button and the set filtering options are applied to the waveform.

A preview of the 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

This operation allows applying a digital noise to the selected waveform. The presence of a digital noise is evidenced by the Noise label in the Effects column of the waveform tree.

The Noise setting window 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. This option can be selected

by means of the **Whole Waveform** or **Range** option in the Application Zone section, respectively.

In the **Range** case, two vertical lines appear in the graph area to delimit the waveform section where the noise is to be applied. The two vertical lines can be moved by the user. 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 **Confirm Data** 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.

Markers

The Markers List section of the Waveform Editor window allows setting one or more markers for Arbitrary modes and only one marker in DDS mode.

ARBITRARY

In Arbitrary mode a marker identifies univocally a waveform sample.

A maximum of **n** markers can be inserted arbitrarily where **n** = number of waveform's samples / 2.

During the waveform generation the marked samples generates a signal pulse that may provoke a level change on the instrument Trigger Out, or that may send a synchronous signal on a line of the Expansion Bus (if the selected instrument is configured as Master - see Expansion Bus Section).

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.

- The **Add** button puts a new cursor in the visualization area.

- The **Remove** button eliminates the cursor selected in the Marker screen.

- **Set Master Marker** - The first marker added to the Marker screen is set as the Master with a zero relative position value on the graph. Subsequent markers are created with positions relative to the Master.

  Change the master marker by selecting the new marker from the Marker List and then clicking the **Set Master Marker** button.

- Remove all cursors by clicking the **Clear all markers** button.

The same marker operations are available by right clicking on one of the markers in the list and selecting the desired function.
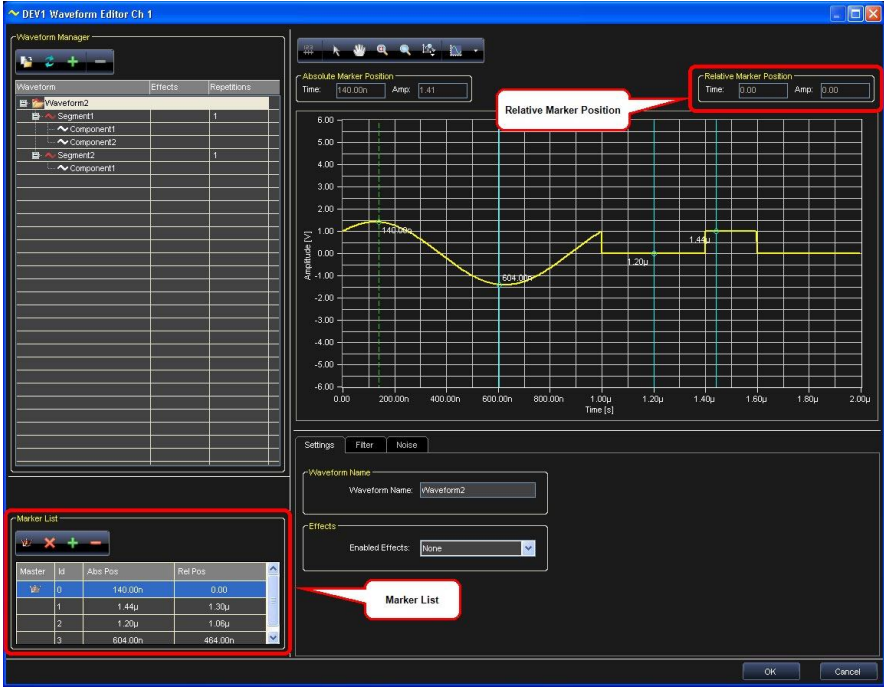
DDS (CARRIER EDITOR)

In DDS mode the only available marker identifies a single amplitude value on the carrier waveform. During the waveform generation, when the instrument output becomes higher than the marker value, a leading/trailing edge on the Trigger Out signal is generated.

The Trigger Out signal remains high/low while the output signal remains higher than the marker amplitude, at which point it switches.

The leading/trailing edge for the Trigger Out signal can be selected on the Channel Settings Trigger Out tab.

If the selected instrument is configured as the Master, a marker can also send a synchronous signal on an Expansion Bus line.

Sequencing Analog Waveforms

This section is for sequencing Analog waveforms. ArbStudio 1102D/1104D include digital pattern generation capabilities. See, **The Waveform Sequencer - Digital Pattern** (on page 110) for more information.

When using Arbitrary mode the Waveform Sequencer can be used to **Create** Standard/Advanced waveforms, **Add them in the project**, or in the **Library** and **Load the sequencer**. The Sequencer allows you to select which edited waveforms are generated, their sequence, and number of repetitions.
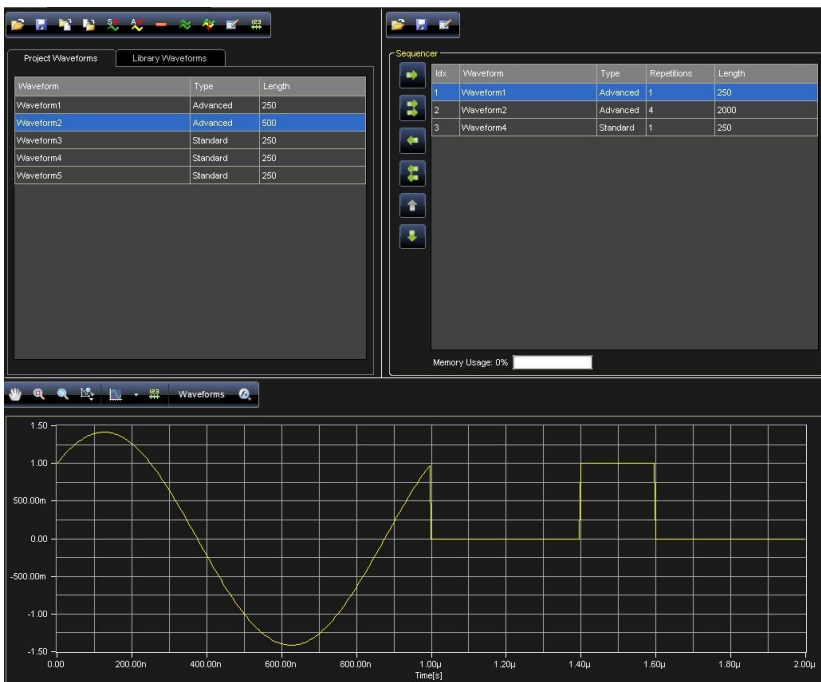
Editing a Sequence

The Sequencer allows you to select waveforms from the Project/Library list for generation by the ArbStudio instrument. In the sequencer, you can also choose the repetition and duration of waveforms.

Add/Remove waveforms to the Sequencer using the Sequencer Buttons. **Drag and Drop** added waveforms to change their positions inside the generation list.

PLEASE NOTE THE FOLLOWING:

- All trigger modes (except the Burst trigger mode), any waveform inserted in the generation sequence may be repeated an arbitrary number of times (with an upper limit imposed by the hardware capabilities of 8,589,934,592 number of repetitions).

- Each waveform present in the Available Waveform section can be inserted in the Generation Sequence an arbitrary number of times and in any order.

- Waveforms present in the Available Waveform list may not be inserted in the Generation Sequence. These waveforms are loaded in ArbStudio memory, but they are not generated.

The following commands are provide for sequence edit:

- **Load Sequencer** - Loads a selected sequencer generation list.

- **Save** - Saves the current sequencer generation list.

- **Edit** - Edits the duration and repetitions of the selected waveform in the sequencer generation list.

- **Add** - Adds the selected Project waveforms to the Sequencer.

- **Add All** - Adds all Project waveforms to the Sequencer.

- **Remove All** - Removes all waveforms from the Sequencer generation list.

- **Remove** - Removes the selected waveform from the Sequencer generation list.

- **Move Up** - Moves the selected sequencer entry up in the list order.

- **Move Down** - Moves selected sequencer entry down in the list order.

Additional Waveform Sequencer Settings/Tools
Zoom

To move along the waveforms and to zoom, the Digital Editor window provides many instruments (shown on the upper side toolbar) as follows:

- **The Selection Tool**

- **The Hand Tool** - Use the hand tool to pan the waveforms. Click and drag to move it.

- **Zoom In Auto** - Click to zoom in.

- **Zoom Out Auto** - Click to zoom out.

- **Zoom Manual** - Select this tool to manually select the area to zoom. Click in the start point of the Waveform View and drag the cursor to the end point keeping the left mouse button pressed.

- **Zoom All** - Click to fit the visualization to view all the acquisition time.

Waveform View Settings

You can change the properties of the graph display area. Click the **Waveform View Settings** button and the **Graph Property** screen is shown.
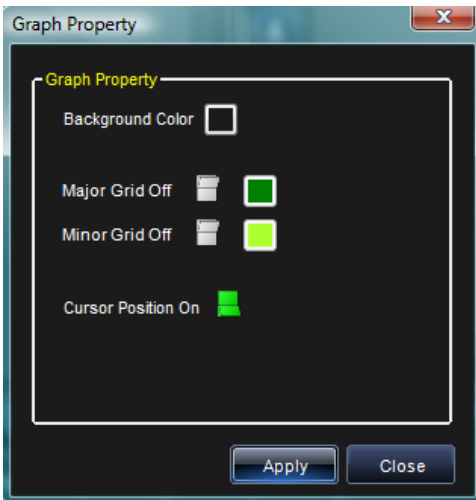
Changes can be made as follows:

- 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.

Signals Property Settings

Change signal properties by clicking the Signals Property button. The Signal Property screen is shown.
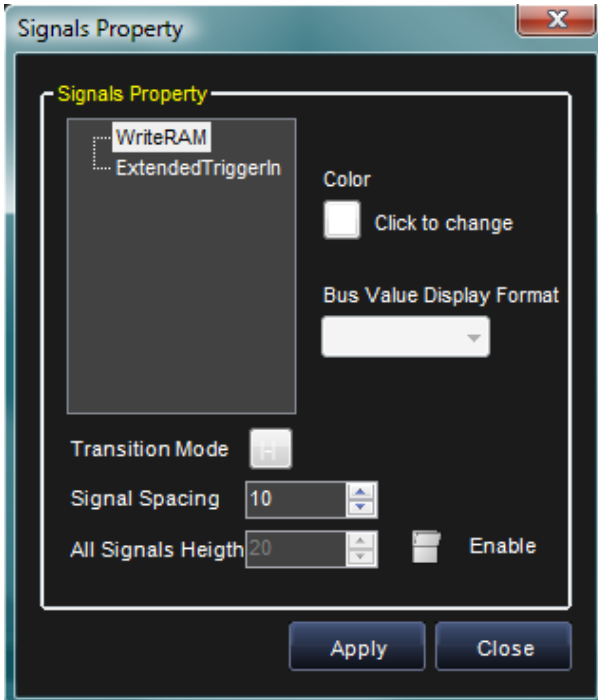
Here you can change single **signal colorings**, the **bus value display format**, **transition modes**, the **space between**, and the **height** of all signals.

NOTE: The minimum All Signals Height value is 20.

Cursors

Cursors (also called markers) are useful to identify and enlighten data for improved organization and viewing. You can also use cursors to measure and analyze acquired data.

Clicking the **Markers** button on the Digital Waveform Editor toolbar shows or hides the marker window.

Show or Hide Markers

Cursor ID, Active, and Relative Positions

Markers ➕ ➖ 🏆 🛡 ⊞ Active 0 Abs: 4.000000µ Rel: 0.000000
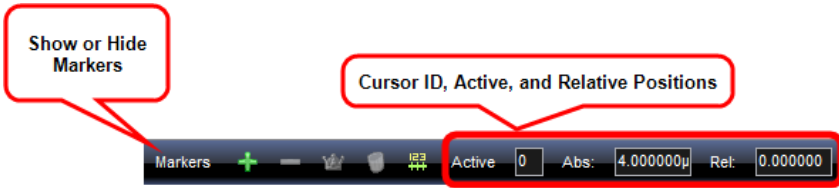
Other field values on the toolbar show the **Active** (or ID) of the currently selected cursor, and its **Absolute** and **Relative** positions.

When Markers are turned on, all of the cursors present in the Digital Editor are listed inside the **Marker** screen.

Master	Id	Abs Pos	Rel Pos	Sync
	0	0.000000	-588.46...	
🏆	1	588.469...	0	
	2	6.14711...	5.5586...	
	3	5.04970...	4.4612...	
	4	2.13121...	1.5427...	

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 marker window and clicking the Master Cursor icon in the Digital Editor toolbar.

🏆

NOTE: In the Digital Waveform Editor window, the master cursor is shown in blue while the other cursors are shown in yellow.

Marker 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 cursors is moved, all the values are automatically updated and shown.

The following functions are used on Cursors

- The **Add** button puts a new cursor in the visualization area.

- The **Remove** button eliminates the cursor selected in the Marker screen.

- Move a cursor by clicking and dragging a selected cursor.
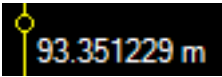
- Remove all cursors by clicking the **Clear all markers** button.

PLEASE NOTE THE FOLLOWING:

- You can also perform many of the aforementioned functions by right clicking inside the Marker 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 Digital Editor toolbar contains multiple functions on its right side drop-down. The functions allow you to select the position where the master cursor 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.

- **Marker n** - Centers the visualization area on the cursor/marker **n** (position specified in the text field to the left of the control).

You can also 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 Sequencer. It also is available in the aforementioned search section regarding the **State Listing** and **Waveform View** screens.

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 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:

- **=** - Find the equivalent value.
- **!=** - Find the unequal value.
- **>** - Find values greater than the one specified (only available if a bus is selected).
- **<** - Find values less than the one specified (only available if a bus is selected).
- **HiZ** - Find high impedance values.

Use the **Value** field to provide the specific value or edge on which to search. If one Signal Type is selected, the **Value** field has the following options:

- **0** - Searches for a logic **0**.
- **1** - Searches for a logic **1**.
- **HiZ** - Search for a High Impedance (only for Pattern Generator Mode).

- **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 acquisition. Possible options include:

- **From Start** - Starts the search from the beginning of the acquisition.
- **From End** - Starts the search from the end of the acquisition.
- **From Trigger** - Starts the search from the trigger position.
- **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 Sequencer**.

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.

Modulation Editor - Arbitrary/DDS

Overview

Use the Modulation Editor tool to create or edit a modulating waveform in Arbitrary mode (M-ASK) and DDS mode (M-FSK and M-PSK).

The window contains the **edit modulation section** and the **graph area**.
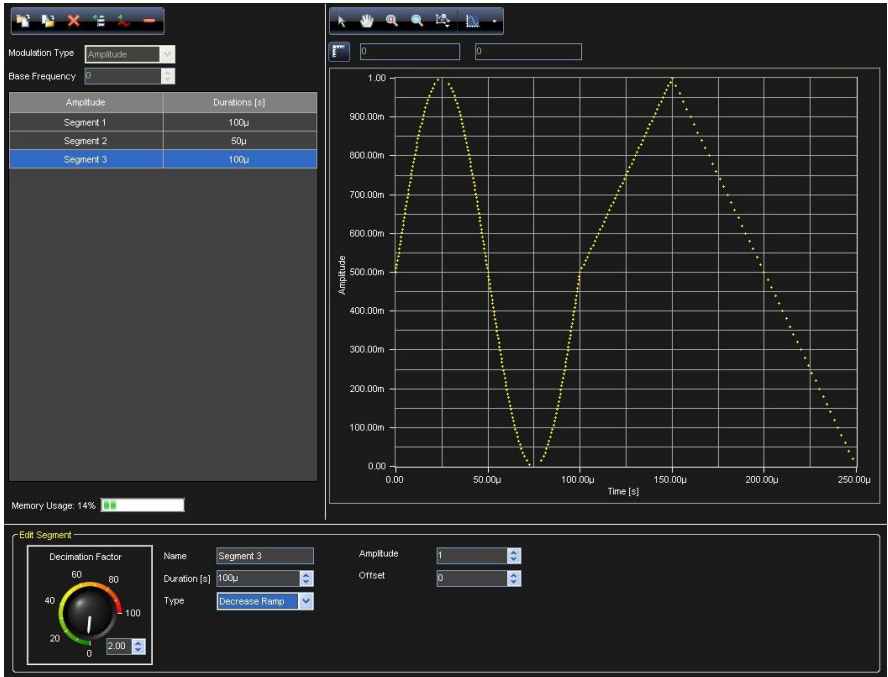
Hardware Resources

ArbStudio allows you to save a limited number of modulating waveform samples depending on hardware resources and the modulation type.

- M-FSK / M-PSK modulations: maximum number of samples/Channel = 511
- M-ASK: maximum number of samples/Channel = 2047

ArbStudio allows a minimum and a maximum time resolution for the modulating signal.

- Maximum Resolution = 1/max sampling frequency (max sampling frequency = 8 ns)
- Minimum Resolution = Max Resolution * X   (X = 4096 for M-ASK and X = 1048576 for M-FSK and M-PSK)
- Each sample of the modulating waveform may be separated respect to the adjacent samples by a minimum of 8ns to a maximum of 32.768us for M-ASK and by a minimum of 8ns to a maximum of 8.38 ms for M-PSK and M-FSK.

A smart control of these intervals allows editing very long modulating signals by generating the carrier at its maximum frequency.

Summarizing the previous statements, the maximum duration for the modulating signal is 67.076ms for M-ASK modulation (MSRP = 1, Sampling Rate in Setup Sampling Rate= 250 MHz) and 4.29s for M-PSK and M-FSK modulations (Sampling Rate in Setup Sampling Rate= 250 MHz).

Edit Modulation Rule

This section provides information for setting the **modulation type** using the Modulation type control (DDS mode only) and the **modulating signal** using the **Modulating Table** and the **Command Bar**.

Modulation Type

This control allows setting the modulation type (Frequency or Phase) in DDS mode, while in Arbitrary mode this option is not active since the only available modulation type is the Amplitude one.

- **Amplitude (M-ASK)** - In an Arbitrary mode channel the Modulation Editor tool is automatically set to M-ASK. The window allows setting the time behavior of the amplitude modulation factor. The samples constituting the modulating signal may assume values between 0 and 1. These samples are the multiplying factors of the signal carrier amplitude.
- **Frequency (M-FSK)** - By selecting the frequency modulation, the Modulation Editor tool is set to M-FSK. The window allows setting the time behavior to be assumed by the carrier signal. The samples of the modulating signal can assume values between 0 and 110 MHz.
- **Phase (M-PSK)** - By selecting the phase modulation, the Modulation Editor tool is set to M-PSK. 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 Base Frequency control (maximum 110 MHz for a ArbStudio 1102/1104 instrument), while samples of the modulating signal may assume values between 0 and 360 degrees.

Modulating Table

Each row of the Modulating Table represents a time interval in which the modulating signal may assume Constant values or Variable values

- **Constant Values** - The modulating signal is kept at a constant value for the entire interval duration. The corresponding row in the Modulation Table is called an **Entry**.

- **Variable Values** - The modulating signal varies within the time interval, following a predefined behavior. The corresponding row in the Modulation Table is called a **Segment**.

The first column contains the modulation coefficients or the Segment names, while the second column contains the corresponding duration. The time sequence of each table item can be modified by dragging an entry in the desired position.

PLEASE NOTE THE FOLLOWING:

- The Duration and Amplitude values inserted in the table are automatically rounded depending on the sampling rate and on the instrument resolution.

- The Memory Usage indicator visualizes in real time the occupation of the hardware resources.

Command Bar

The Command contains the following 6 buttons for editing the Modulation Table.

- Clear the Modulation Law

- Delete the selected Entry or Segment on the Modulation Table

- Add an Entry to the Modulation Table

- Add a Segment to the Modulation Table

- Export the modulation law to a flat, 2 column text file.

- Import the modulation law from a flat, 2 column text file.

NOTE: In Single and Continuous Trigger mode, the graph representation of the modulating signal is updated when any change is made to the Modulation Table.

Modulation Entry Editor

The Modulation Entry Editor Tab is opened by clicking Add Entry button on the Command Bar. This window allows setting the constant value for the modulation coefficient (amplitude, frequency, phase) and its time duration.
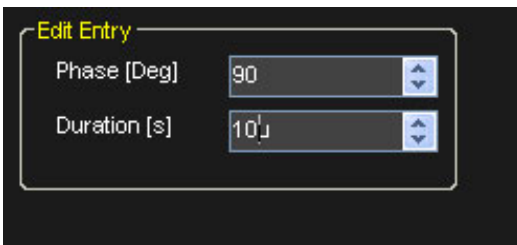
Depending on its time duration, the Entry is represented by a number of points optimizing the memory buffer occupancy (samples are separated at the minimum resolution).

NOTE: A duration field values are ignored when using Burst mode.

Modulation Segment Editor

Click the **Add Segment** button to open the **Edit Modulation Segment** screen.
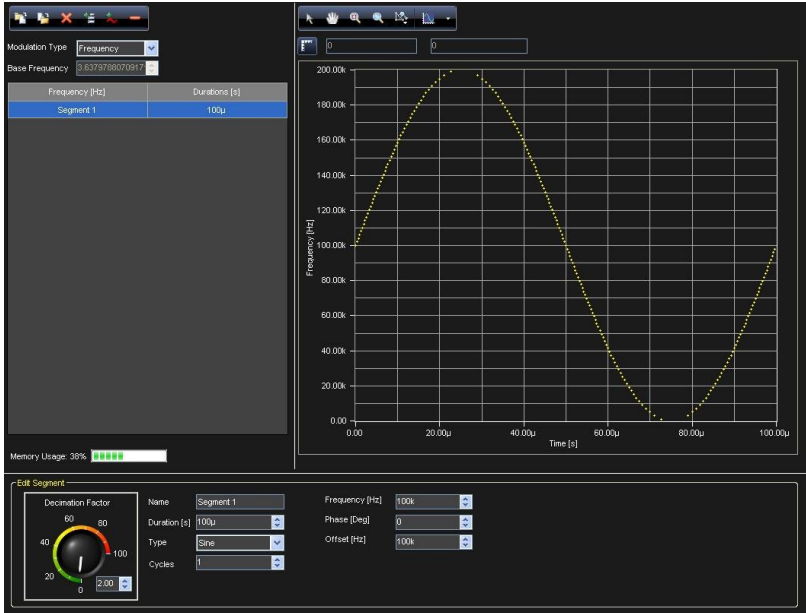
This screen allows you to edit a Segment - a time interval (Duration) in which the samples of the modulation signal follow a predefined function (Type).

The selectable functions and their available parameters include:

Type	Parameters
Sine	Cycles, Amplitude*, Phase (°), Offset*
Cosine	Cycles, Amplitude*, Phase (°), Offset*
Triangle	Cycles, Amplitude*, Phase (°), Offset*
Rectangle	Cycles, Amplitude*, Phase (°), Offset*, Duty Cycle (%)
Sawtooth	Cycles, Amplitude*, Phase (°), Offset*
Increase Ramp	Amplitude*, Offset*
Decrease Ramp	Amplitude*, Offset*

Table 3-1.Asterisk * indicates the parameter varies based on the modulation type selected.

ArbStudio

 Two compression algorithms are used for a Segment memory usage optimization. The algorithm used depends on the linear or non-linear behavior of the selected function (Type).

The maximum compression factor corresponds to equally separated samples in both cases, with a separation time equal to the minimum time resolution allowed. Intermediate compression factors can be set by controlling the amplitude factor (Decimation Factor).

- **Decimation Factor** - Physically represents a percent value of the signal maximum amplitude and is used by the compression algorithm differently depending on the linear or nonlinear behavior of the function selected (Type).

- **Linear Compression** - The compression algorithm is linear for a signal characterized by a linear time variation of the signal amplitude (Increase Ramp, Decrease Ramp).

  The compressed signal samples are equally spaced and the separation between two successive samples is given by one of the following conditions (the strictest one applies):

    - The maximum time separation between two successive samples must be equal to the minimum resolution.

    - The minimum amplitude gap between two successive samples is given by the percent of the maximum signal amplitude, set by Decimation Factor. For example, a signal with a maximum voltage of 10V and a Decimation Factor of 10%, the minimum voltage gap is 1 V.

- **Non-Linear Compression** - The compression algorithm for non-linear functions (Triangle, Rectangle, Sawtooth, Sine and Cosine) is similar to the previous one, but the compressed signal samples are equally separated only if the Decimation Factor is such that the former condition is satisfied.

By using a suitable Decimation Factor the algorithm allows compressing the modulating signal using a cluster of samples directly proportional to the amplitude variation in the time unit.

Therefore, the compression algorithm for non-linear signals takes into account the relative time variation of the signal amplitude.

If the Decimation Factor is very small with respect to the waveform duration, the compression algorithm may not be able to perform the signal compression by using the maximum number of available samples.

In such cases a message asks the user to increase the Decimation Factor.

Amplitude Profile Editor (DDS)
Overview

Use the Amplitude Profile tool to set the amplitude profile of the generated signal as a function of its frequency.

- For a given frequency of the modulated signal, its amplitude is multiplied by the corresponding value of the amplitude profile (whose samples vary between -1 and 1).
- The amplitude 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.
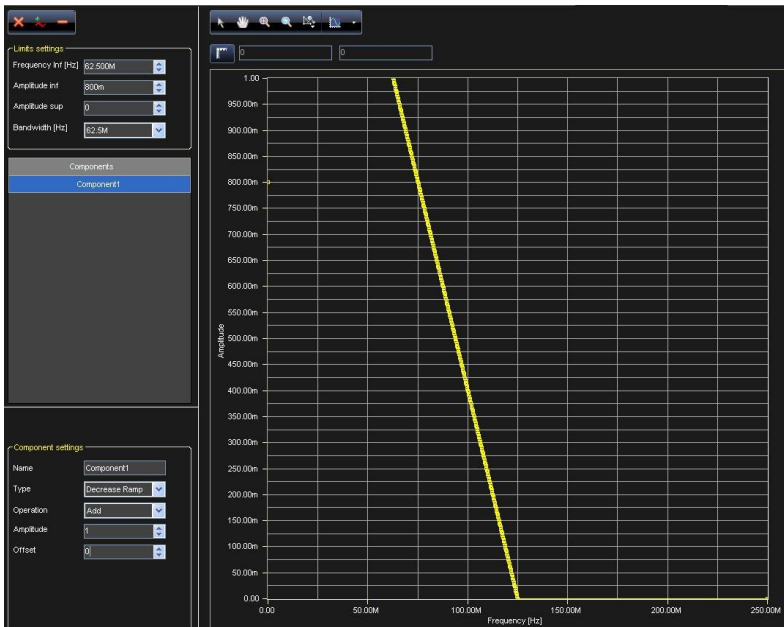
Limits Settings

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 256 samples constituting the segment can be edited as a standard segment, by editing its components.

The Profile Settings section is similar to the Segment Manager section described in **Advanced Waveform Editing** (on page 61). With respect to the Segment Manager case the component frequency can be provided only in terms of Cycles, while the component amplitude must vary between -1 and 1.

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.

Profile Command

The following buttons are used for editing the Component List.

- **Add Component** Adds a component to the list. This component can be set for addition (or subtraction, multiplication, or division) with others components in the list. An error message is shown when the Component List exceeds the amplitude range.

- **Remove Component** Removes a component from the Component List.

- **Remove All Components** Removes all components from the Component List.

Digital Pattern Generator - Sampler (Optional)

Overview

ArbStudio can be configured to work as a powerful Digital Pattern Generator-Sampler.

In this working mode ArbStudio 1102/1104 provides the capability to emulate standard serial or parallel bus transitions or custom digital interfaces for system debugging and characterization.
The architecture is based on a vector/command memory and a powerful sequencer defining the vector/command execution flow.

The Sequencer unit is a programmable finite state machine with a microcode memory that, combined with the vector/command memory, can generate very long digital patters and control signals at a very high speed.

PLEASE NOTE THE FOLLOWING:

- ArbStudio 1104D has 36 digital channels available, 18 CHs on Pod A and 18 CHs on Pod B.
- ArbStudio 1102D has only 18 digital channels on Pod A.

As a Digital Pattern Generator-Sampler ArbStudio provides:

- 36/18 Channels @ 125 MHz with Per Bit Direction (up to 288 Digital I/O with Expansion Bus)
- 2 Million Vectors in Generation
- 2 Million samples in Acquisition
- Digital Waveform Sequencer
- 31 Levels Programmable Event Detector
- 2 Bank Programmable I/O Levels
- Multi-device synchronization with Expansion Bus

Digital waveforms (vectors and commands) can be edited in a tabular format or by means of a powerful and intuitive digital waveform editor that provides tools for advanced pattern definitions: clock, count and random patterns over a selection or the entire signal or bus.
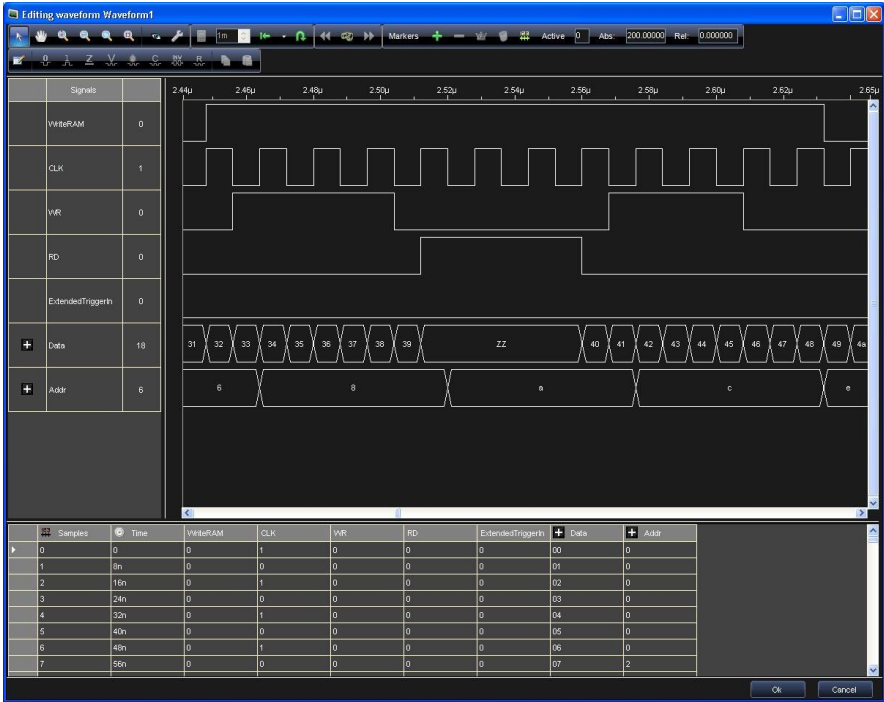
Pattern (Sampling and Acquisition) Settings
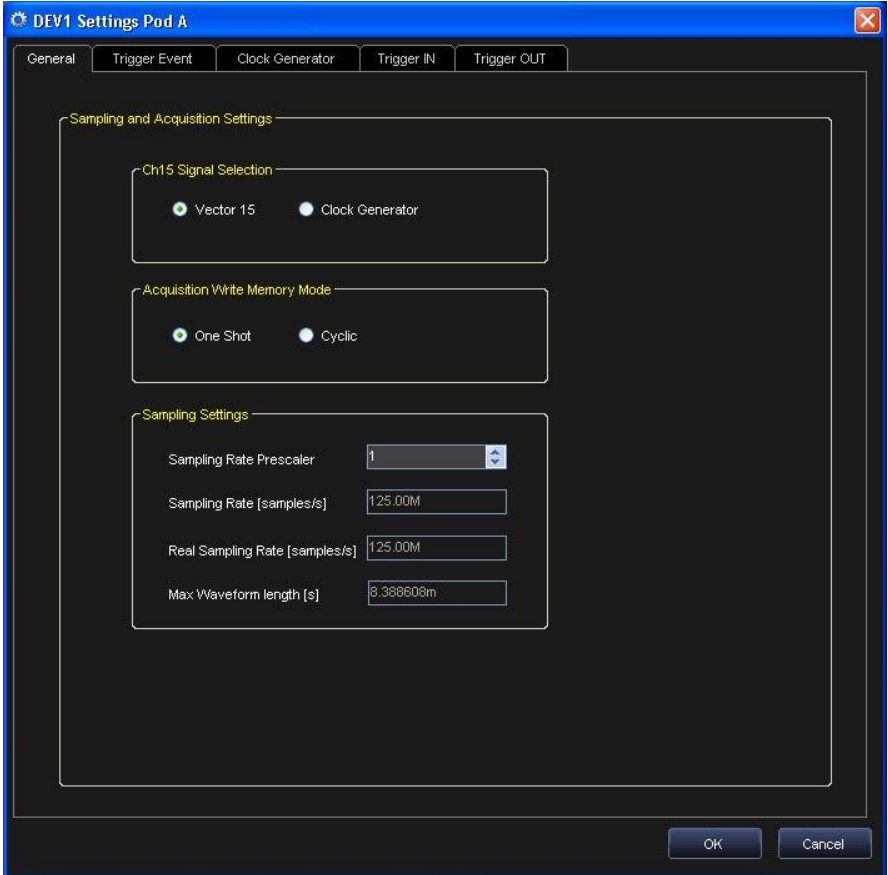
Pattern Settings

OVERVIEW

Use the Settings screen to configure correct pattern generation/acquisition on your ArbStudio. The screen contains the following tabs.

Pattern Settings - The General Tab

The **General** tab is shown by default when the **Pattern (Sampling and Acquisition) Settings** screen is opened.

Sections of the Pattern Settings General tab are explained as follows:

CH15 SIGNAL SELECTION

The digital **Channel 15** can be used as output for the clock generated by the Clock Generator Module or as output for Vector(15).

- Vector 15 sets Ch15 as output for Vector(15).
- Clock Generator sets Ch15 as Clock output.

ACQUISITION WRITE MEMORY MODE

When the Digital Pattern Generator works as a sampler, it stores the data it reads from the input pins to internal memory. This memory can be written in **One Shot** or **Cyclic** modes.

- **One Shot** - The data is written until the end of the memory is reached.
- **Cyclic** - The memory is written in a cyclic mode and data can be overwritten when the end of memory is reached.

SAMPLING SETTINGS

The Sampling Rate Prescaler (SRP) may assume values ranging from 1 (maximum frequency) up to 16777216 (minimum frequency), by multiples of 2.

The Real Sampling Rate = Sampling Rate / SRP.

For example setting SRP = 20 with a sampling rate of 125 MS/s, the real sampling rate becomes 6.25MS/s and it is possible to generate digital waveforms with total length of 167.77216 ms with a time resolution of 160 ns.

Pattern Settings - The Trigger Event Tab

The Trigger Event tab allows setting a trigger condition on Ch (17..0) and on Vector(16) (Ext Trig) to generate a trigger event similar to a logic analyzer.

MASTER TRIGGER EVENT (SLAVE MODE ONLY)

On a slave device, Ch17 can be used as an input to evaluate the trigger condition (Master Trigger Event disabled) or as a Master Trigger Event.

The device set as the master transmits the Trigger Event by the Expansion Bus to all slave devices.

If you enable the Master Trigger Event on a slave device, it can also trigger on a master trigger event condition.

THE TRIGGER EVENT TAB MENU BUTTONS

The menu buttons on the Trigger Even tab are explained as follows:

The Add Button

Adds a new trigger level at the end of the list.

The Remove Button

Removes the last trigger level from the list.

The Clear All Button

Clear all trigger settings and resumes the default trigger conditions.

TRIGGER LEVELS

The ArbStudio Digital Pattern Generator allows editing up to 31 trigger levels, which are represented by the **Edge** symbol in the tree positioned on the left side of the tab.

Each trigger level has an **A** and **B** trigger condition.

Each condition can be set by clicking its name and by using the **Action** drop-down field (on lower-right side of the tab). Action field options include:

None - The occurring condition is ignored (Never Trigger).

Trigger - The occurring condition leads to a Trigger event.

Jump to Level(n) - The occurring condition leads to a jump at the specified trigger level (n), where **n** is the number of a present trigger level.

EDGES AND LEVELS

In order to set condition **A** or **B**, the state of the Digital Pattern Generator channels must be set properly. Each channel state can assume one of the following attributes:

Don't care

The signal is ignored.

High logic level

Low logic level

Rising edge

Falling edge

Any edge

Va (Bus HEX)

Sets a bus at the hexadecimal value entered in the field adjacent (to the right).

Set the state on a channel by first selecting condition **A** or **B** of the desired level, and then clicking on the corresponding channel row to be set on the right side listing.

NOTE: The column Signal Names contains the user-defined names for the signals to acquire.

Set a condition by clicking the desired button on the top. If more than one signal is selected, the same level or edge setting is applied to the group of signals.

You can also set a level on all selected signals by writing its value in hexadecimal format in the HEX field, and then clicking the **Va** button.

CONDITIONS ON EDGES

You can indicate whether the trigger condition must be detected on a rising, falling, or either edge for each signal.

When trigger conditions are set on edges of several signals, the trigger event is determined by the occurrence of at least one condition.

If no trigger conditions on edges are set for any signals, trigger events on edges never occur.

CONDITIONS ON LOGIC LEVELS

You can indicate whether the trigger condition must be detected on a high or low logic level for each signal. When trigger conditions are set on logic levels of several signals, the trigger event is determined by the occurrence of all conditions simultaneously.

If no trigger conditions on logic levels are set for any signal, the trigger conditions on logic levels are always considered verified.

The trigger condition set on logic levels is useful when the trigger event must be detected for a specific pattern.

Use the **Level Condition** drop-down field to select among the following conditions for trigger events on logic levels:

- **Trigger when EQUAL** - The trigger event occurs when the state of the evaluated signals is equal to the specified pattern.
- **Trigger when NOT EQUAL** - The trigger event occurs when the state of the evaluated signals is different from the specified pattern.
- **Trigger when CHANGED** - The signals selected for a trigger event on logic levels are examined when data acquisition starts. These sampled values constitute the reference pattern. The trigger event occurs when the state of the selected signals is different from the reference pattern.

    The conditions chosen by the user on logic levels are ignored. ArbStudio uses the information related to channels for trigger detection.

RELATIONSHIP BETWEEN TRIGGER CONDITIONS

Relationships between trigger conditions on edges and trigger conditions on logic levels can be set using the Trigger condition drop-down field. The following options are available:

- **Edge OR Level** - A trigger condition occurs when one between an edge condition or a logic level condition is detected.
- **Edge AND Level** - A trigger condition occurs when an edge condition and a logic level condition are simultaneously satisfied.
- **Edge BEFORE Level** - A trigger condition occurs when an edge condition is detected at least once before one is detected on logic levels.

- **Edge AFTER Level** - A trigger condition occurs when an edge condition is detected at least once after one is detected on logic levels.

- **ALWAYS** - A trigger condition occurs automatically when data acquisition starts. Any setting on edges or on logic levels is ignored.

- **NEVER** - Trigger is inhibited. Any setting on edges or on logic levels is ignored. A trigger event, however, can be activated manually during data acquisition.

Pattern Settings - The Clock Generator Tab

Use the Clock Generator to generate a clock signal with a frequency up to 125 MHz.

- The clock is created on Ch15.
- It is possible to combine the clock with the Extended Trigger In vector using the strobe function. The following options are available: **NOP**, **OR**, **AND**, **XOR**, **NOT**, **NOR**, **NAND**, and **XNOR**.
- The Clock generator provides a synchronized signal to the Sequencer Module to generate vectors synchronized with the output clock.
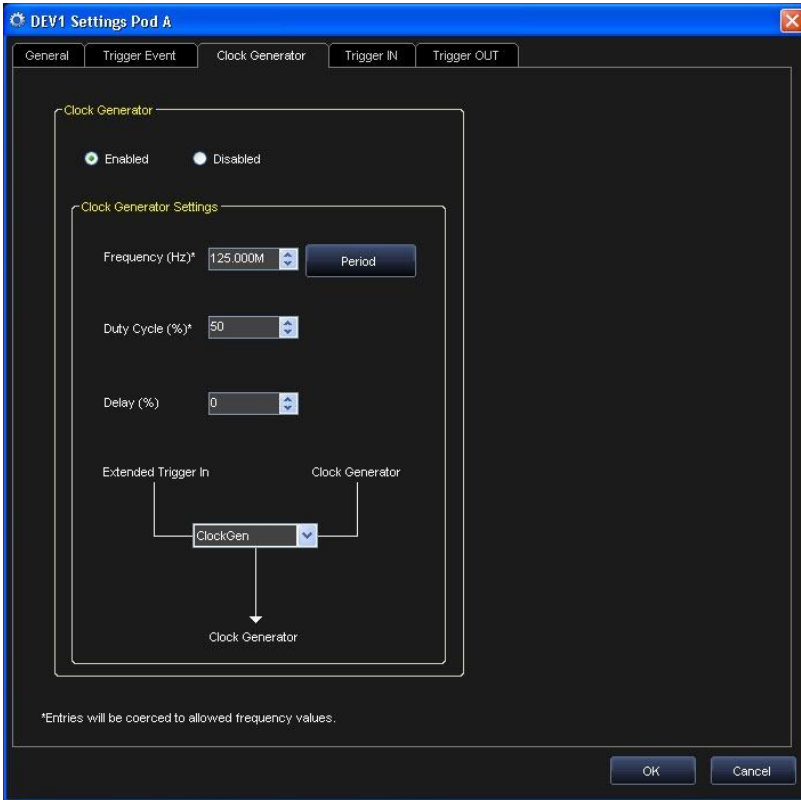
The following fields are available on the Clock Generator tab:

- **Enable** - Turns the Clock Generator Module on or off.
- **Frequency** - Sets the frequency (MHz) of the Clock Generator. The output frequency depends on the Sample Rate set by the user on the Setup Device Timing tab.

  > **NOTE**: User entries can be recalculated to allow frequency values.

- **Duty Cycle** - Sets the generated clock duty cycle of the clock signal.

  > **NOTE**: User entries can be recalculated to allow duty cycle values.

- **Delay** - It sets the delay to the synchronized signal.

  > **NOTE**: User entries can be recalculated to allow delay values.

- **Strobe Operation** - Lets you logically combine the Output clock with the Extended Trigger In vector. Possible options are: **NOP**, **OR**, **AND**, **XOR**, **NOT**, **NOR**, **NAND**, **XNOR**, **FORCE LOW**, and **FORCE HIGH**.

Pattern Settings - The Trigger In Tab
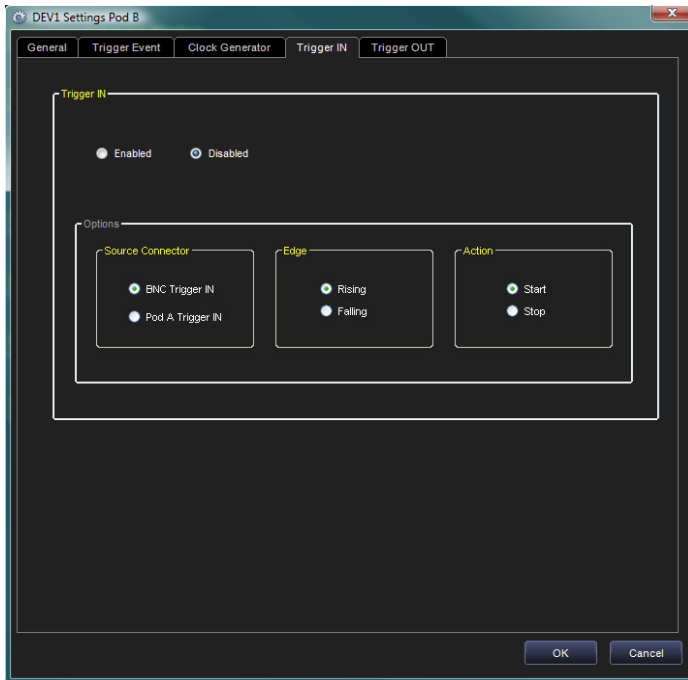
SOURCE CONNECTOR

Select the physical source for a Trigger In event. The possible options include:

- **BNC Trigger IN** - The trigger event is received by the dedicated BNC Connector on the instrument front panel.
- **Pod A Trigger IN** - The trigger event is received by a dedicated Digital input of the probe connected to the Pod A in the instrument front panel - see Probe Description.

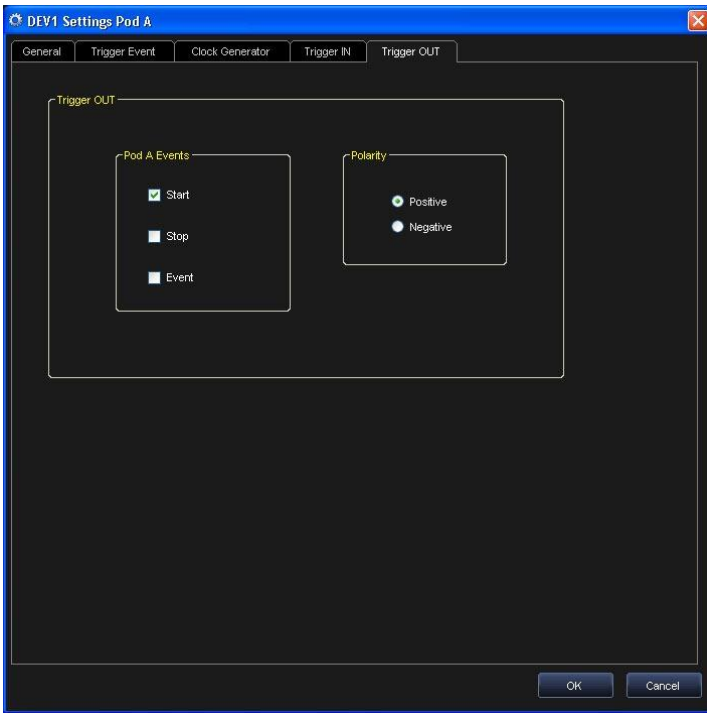**NOTE**: Trigger IN source setting is mutually exclusive.

EDGE

Allows you to set the sensitive edge for the input trigger as either a **Rising** or **Falling Edge**.

ACTION

You can set the **Start** or **Stop** action to be performed by a possible input Trigger event.

Pattern Settings - The Trigger Out Tab

The following parameters are available on the tab:

TRIGGER OUT SOURCE

You can select the trigger source that generates a Trigger Out event.

Multiple sources may be selected.

Signals that can be sent to the Trigger OUT output include **Start**, **Stop**, **Marker**, **Pod A Trigger IN**, and **BNC Trigger IN**.

POLARITY

Choose **Positive** or **Negative** for the Trigger OUT signal polarity as desired.

DESTINATION

A logic combination of the Trigger Out event of the enabled channels is always available on the dedicated BNC Connector and on Pod A/B Trigger Out signals on the instrument front panel. For more information, see **The Trigger OUT Math Tab** (on page 48).

Example - Digital Pattern Generator Setup

This example demonstrates a digital pattern generator setup on an ArbStudio.
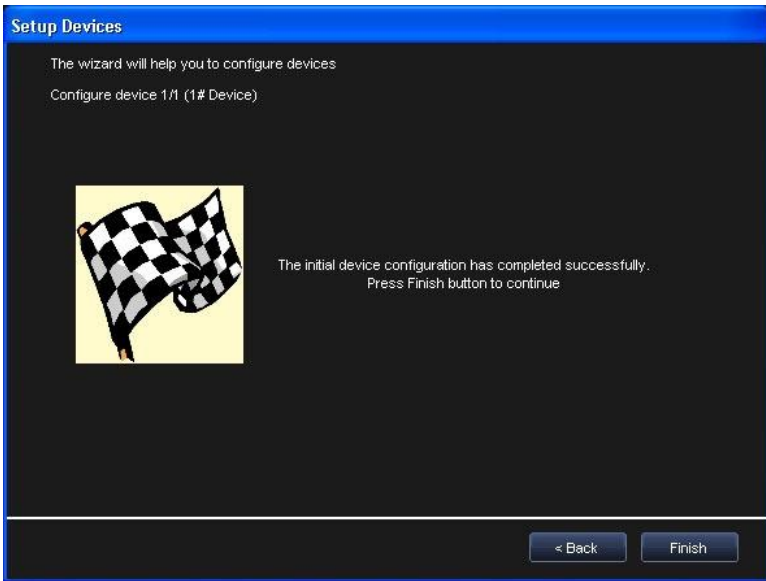
After powering on the instrument and connecting it to your PC, launch the software and use the system menu bar or the toolbar to create a New Workspace. Connect the probes to the instrument.

1. Setup the devices following the steps of the wizard, select Pattern Generator as operating mode.
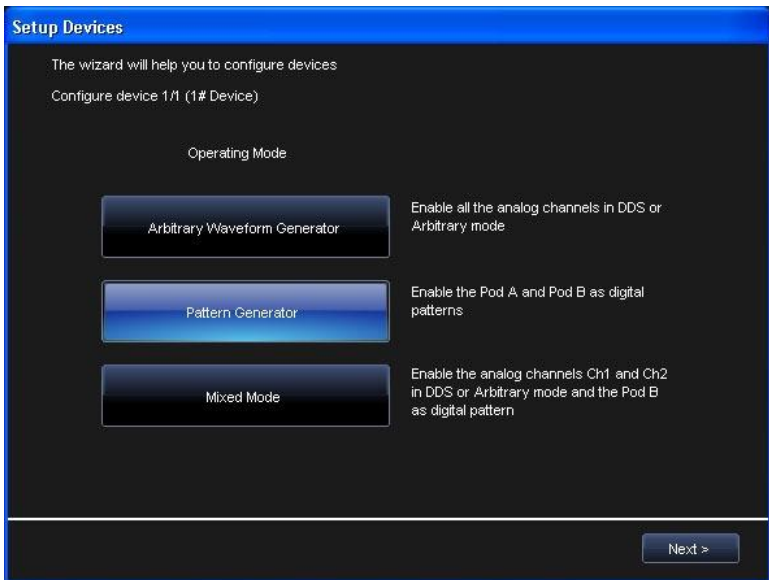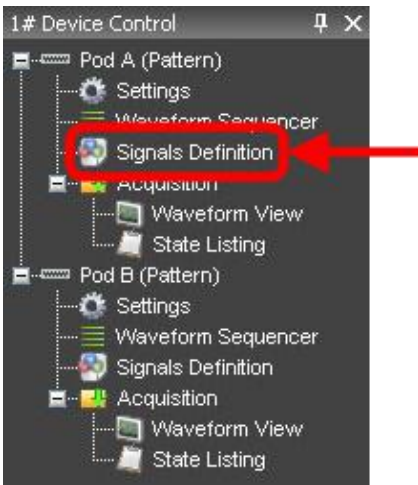

Click **Next**.

2. Now, click the **Finish** button.

3. Double click **Signal Definition** on the Pod A Control navigation tree.

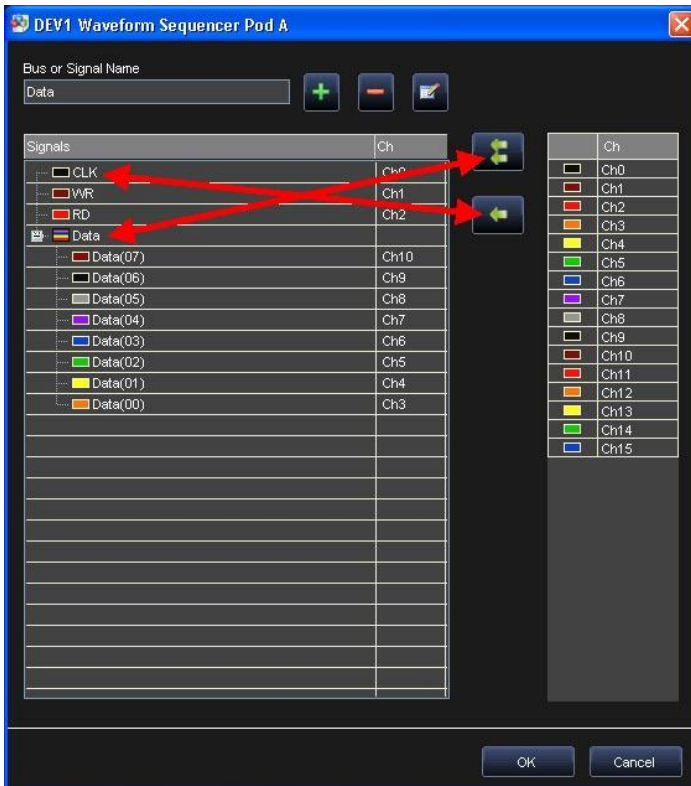The **Waveform Sequencer** screen is shown.

4. Select the CLK signal on the Signals name list. It should be shown in the **Bus or Signal Name** field.

5. Now, select **Ch0** from the Channel list on the right.

6. Press the **Change Selected Pod** button to associate the **Ch0** with the **CLK** signal.

7. Now, repeat steps 1-6 for **WR** and **RD** signals.
8. Select the Data bus.
9. Select **Ch3** to **Ch10** on the right.
10. Press the **Add signals to bus** button to associate the **Data bus** with the **selected channels**.

11. Double click the **Waveform Sequencer** on the Pod A Control
     navigation tree.
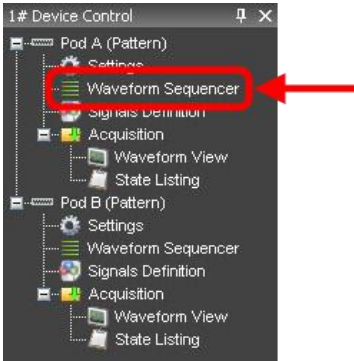
12. Click the Add Waveform button to add a digital waveform in the
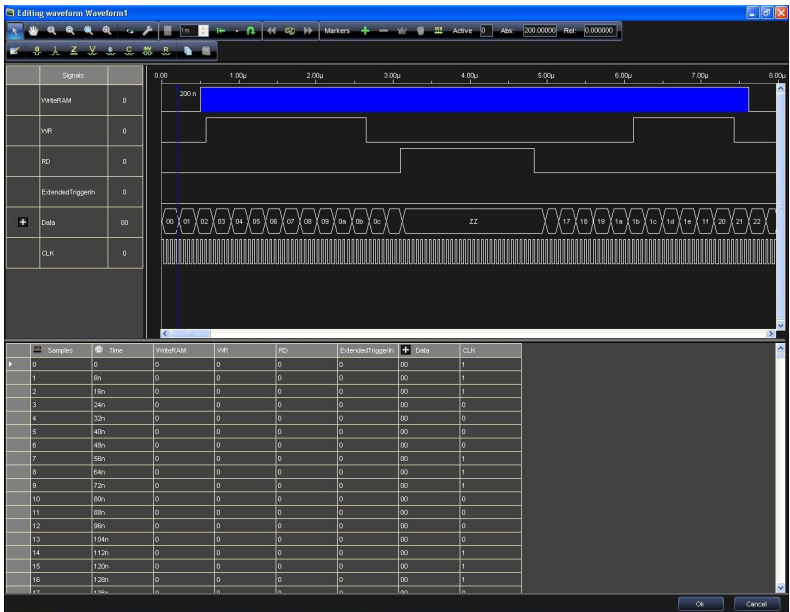   Waveform List.

13. The New Waveform screen is shown. Click the **Add All** button to add
     all the buses/signals to the digital waveform.

14. Now, click the **OK** button to add Waveform1 to the Waveform List.

15. Press the **Edit Waveform** button or double click on Waveform1 to
   open the **Editing waveform** screen.

Use the clock editor and the counter editor to define the CLK and DATA
waveforms. Define the WR/RD/WriteRAM signals making graph selections
and clicking the **To 1** button. Set to 1 the WriteRAM signal if you want to
acquire data with the Pattern Generator. Set to HiZ to change the pin
directions from output to input. Click **OK** to confirm.

16. Select the Waveform1 from the Waveform List and click the **Add** button to add it to the Sequencer list.

17. Select the Jump To operation from the Operation List tab and click the Add button to add it to the Sequencer list (Jump To Address 0).
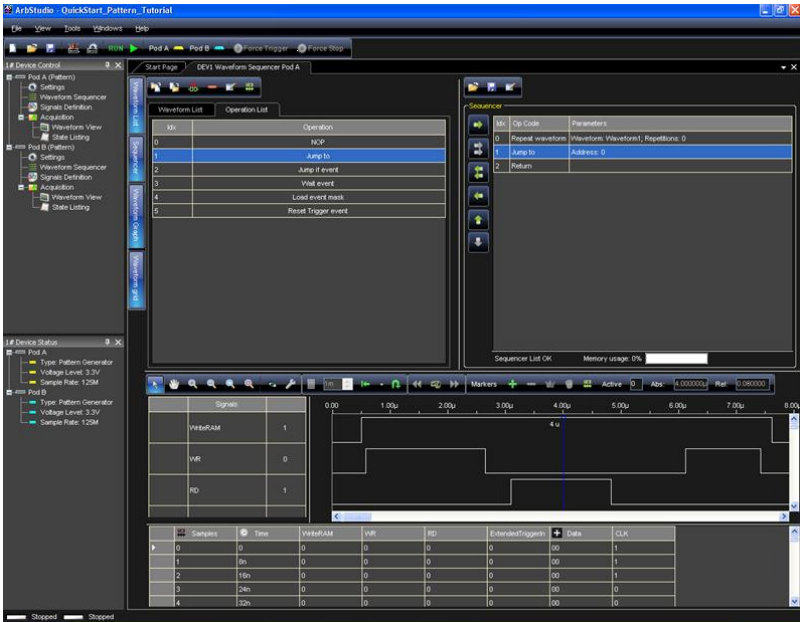
18. Press the **Run/Stop** button on the ArbStudio toolbar.

    The software loads the settings and the digital waveforms into the ArbStudio instrument and starts generating waveforms.

19. Waveform1 is then generated on the Pod A probe. You can connect a logic analyzer to the probes to analyze the generated signals.

20. Stop the digital waveform generation by clicking the **Run/Stop** button again.

21. Double click **Waveform View** or **State Listing** on the Device Control tree to analyze the acquired data.
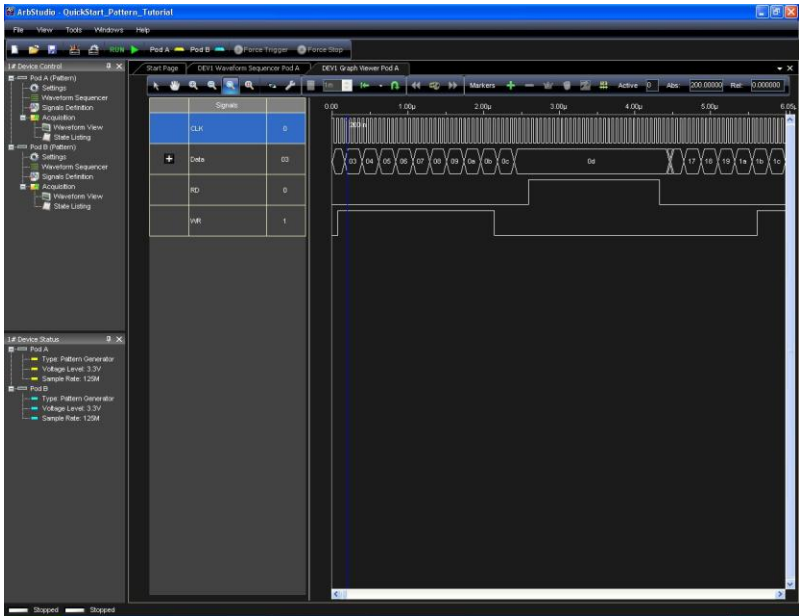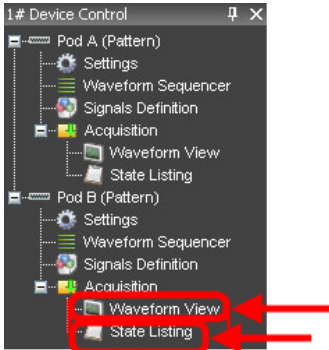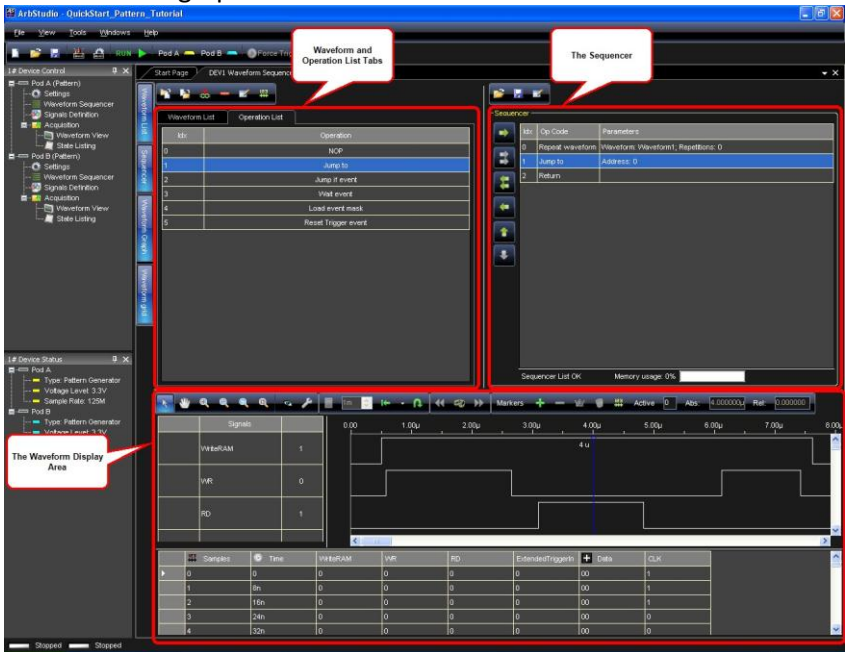
Waveform Sequencer - Digital Pattern

OVERVIEW

Vector/control memory (1048576 samples) can be segmented into blocks called Waveforms. The sequencer then recalls the Waveforms during operations.

Three main areas comprise the Sequencer:

- **The Waveform and Operation List Tabs** - Projects digital waveforms and operations for editing and adding to the Sequencer generation list.
- **The Sequencer**
- **The Waveform Display** - This area allows you to display selected Waveforms in graph and tabular format.

Use the Waveform Sequencer to **create** your digital Waveforms, add them in the **Waveform List**, and then load the **Sequencer** with the **Operations** and the **Edited Waveforms**.

DIGITAL WAVEFORM COMMANDS

Buttons atop the Waveform and Operation List Tabs provide the following digital waveform functions, respectively:

- **Import Waveforms** - The import file must be encoded using the CSV (Comma Separated Values) format. Each line in the CSV file corresponds to a row in the table and within a line. Fields are separated by commas and each field belongs to one table column. The first row contains the pod index with the prefix character #, for example #1 stands for Pod 1.

  PLEASE NOTE THE FOLLOWING:

  - #17 is the Write Ram signal, #16 is the Extended Trigger IN signal.
  - The next imported rows contain the pod values. Only values 0,1,2 are allowed. 0 is the low logical level, 1 is the high logical level and 2 is the high impedance state (HiZ).
  - The imported data is shown on the Waveform Graph and on the Waveform grid. However, only data corresponding to bus/signals added on the waveform selected from the Waveform List is imported.
  - Instrument settings cannot be imported. So imported data is shown with the current user settings.

- **Export Waveforms** - The file is encoded using the CSV (Comma Separated Values) format, each line in the CSV file corresponds to a row in the table and within a line, fields are separated by commas, each field belonging to one table column. The first exported row contains the pod index with the prefix character #, for example #1 stands for Pod 1.

  PLEASE NOTE THE FOLLOWING:

  - #17 is the Write Ram signal, #16 is the Extended Trigger IN signal.
  - The next exported rows contain the pod values. Only values 0,1,2 are allowed. 0 is the low logical level, 1 is the high logical level and 2 is the high impedance state (HiZ).

- Only bus and signal corresponding data added using the Digital Editor is included in the export.
- Instrument settings cannot be imported.

- **Add Waveform** - Opens the New Waveform screen.

- **Remove Waveform** - Removes the selected Waveform from the Waveform List.

- **Open** - Opens the Editing Waveform screen to modify the selected Waveform.

- **Change** - Changes the length representation to Time or Samples.

NOTE: For more information on various functions Waveform Sequencer, please refer to **Additional Waveform Sequencer Settings and Tools** (on page 75).

The New Waveform Screen

When the Add Waveform button (above the Waveform and Operation List Tabs) is clicked, the **New Waveform** screen is shown. You can define the waveform length in samples or time and decide which signals are inserted in the Digital Editor Window.

Add a Bus or a Signal to the list for the Digital Editor by selecting it on the left and clicking the **Add** button.

Remove, **Add All**, and **Delete** buttons are available and work for items on either list.

WriteRAM and **Extended Trigger IN** signals are always present in the new waveform. Their functions are as follows:

- **WriteRAM** - If this value ends up being very high, the Digital Pattern Generator stores data on its memory (up to 1048576 samples).

- **Extended Trigger IN** - Works like an internal trigger to generate a trigger event for the Trigger Module.

  Since the Extended Trigger IN is a vector, it can be used as a trigger condition indicator and provide notice when high or low levels are exceeded.

CREATING A DIGITAL WAVEFORM

You can create a digital waveform using the Editing waveform dialog box

- Press the button to add a waveform in the waveform list
- Press the button or double click on the selected waveform to open the Editing waveform dialog box

EDITING A DIGITAL WAVEFORM

The **Editing Waveform** screen is used to create or edit digital waveforms in a graphic or tabular format.

Single signals are visualized as digital signals, while grouped signals are represented as buses.
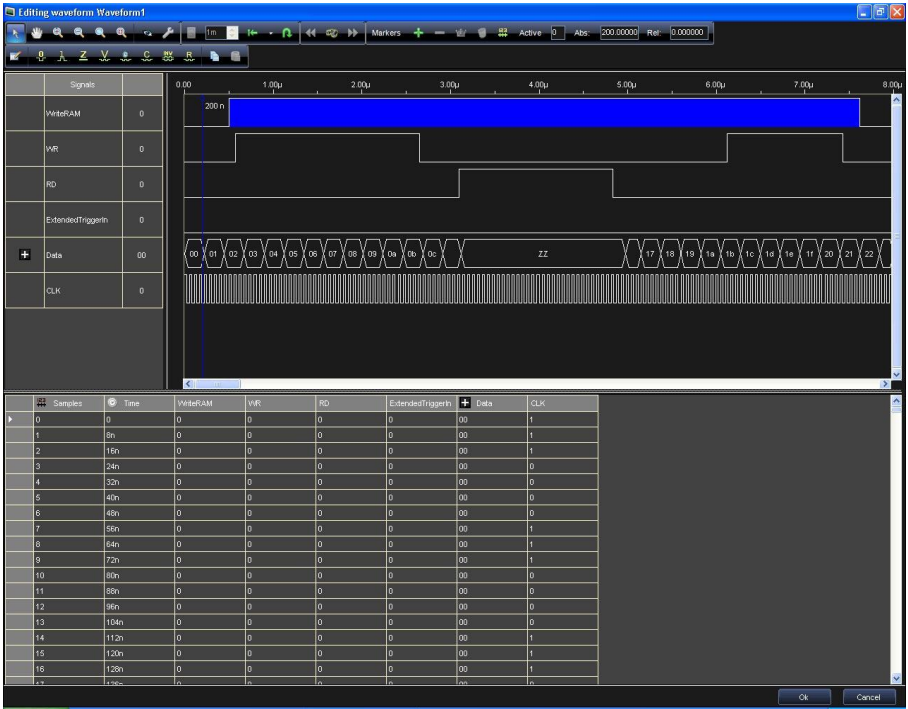
- In the Digital Graph Editor, a bus node is indicated by the **Expandable Bus** icon shown to the left of the bus name.

  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.

Changing Waveform Order

You can drag and drop the waveforms inside the listing on the left of the screen to change their order. This often helps users focus on the time relationship between edges. Just click a signal name on the list and drag it to the desired position in the list. You can also insert a signal or bus on the list or remove one from the list.

Resizing Signal Amplitude

Resize the signal amplitude by dragging the line between a signal name cell.

To the right of every signal or bus name, a number indicates the value the signal or bus assumes at the time position of the master cursor.

Right Click Menu

Right clicking on the signal name column shows the right click menu with the following options:

- **Add samples scale** - Select this option to add a signal (indicated by the Add samples scale icon) 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.

- **Waveform View Settings...** - This option opens the Signal Property screen.

- **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.

Digital Waveform Editor Toolbar

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

- Signal/bus to 0.

- Signal/bus to 1.
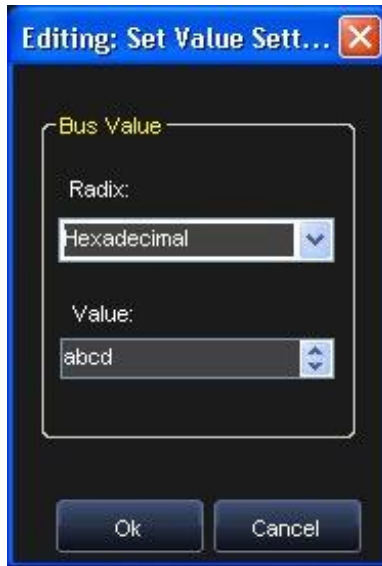

- Signal/bus to High Impedance.

- 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.
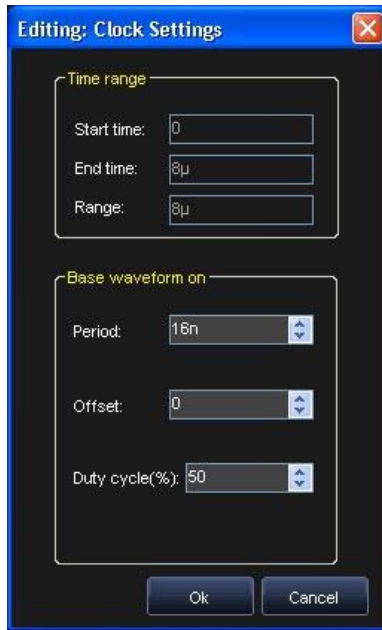

2. In the Radix list, select the radix type.

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.
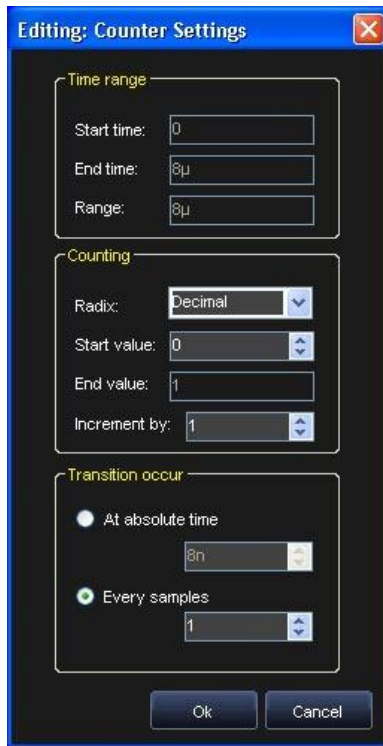
- Invert signal/bus value.

- 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.

Editing: Random Settings ☒

┌─ Generate ... ──────────────────┐
│   │
│   ⦿ every samples   │
│   │
│   ● every specfied time: [8n] ▲▼│
│   │
│   ● every specified samples[1]▲▼ │
│   │
│   │
│   [Ok] [Cancel] │
└──────────────────────────────────┘

- 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.

Data Editor

The Data Editor can also be used to edit signal/bus values. Data is visualized numerically in columns when using the Data Editor. Selections made in the Data Editor are also shown on the Digital Waveform Editor directly above it.

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).

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.

RESIZING COLUMN AMPLITUDE

Resize column amplitude by dragging the line between the signal name.

TABLE VALUES AND EXPORTING DATA

You can change table values by pressing 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. The table data is then exported into a .txt file.

Sequencer Operations

Use the Operation List tab to select which operations load into the
Sequencer microcode memory.

Idx	Operation
0	NOP
1	Jump to
2	Jump if event
3	Wait event
4	Load event mask
5	Reset Trigger event

Sequencer operations allow you to:

- Repeat vectors stored inside the vector memory at each of several
  addresses
- Make conditional and unconditional jumps
- Monitor input signals combining them with a mask
- Modify the mask on input signals
- Insert wait states
- Wait for trigger events
- Reset the Trigger events

Instruction	Explanation	Parameters
NOP	No Operation	Repetitions. Minimum=0 Maximum = 65535 (It means that NOP instruction can be repeated from 1 to 65536 times). Loop Mode: NO LOOP, LOOP BEGIN (it marks the first instruction of a loop), LOOP END (it marks the last instruction of a loop).
Repeat Waveform	Repeat a waveform	Waveform: waveform name Repetitions. Minimum=0 Maximum = 65535 (It means that the waveform will be repeated from 1 to 65536 times) . Loop Mode: NO LOOP, LOOP BEGIN (it marks the first instruction of a loop), LOOP END (it marks the last instruction of a loop).
Sync Repeat Waveform	Repeat a waveform synchronized with the clock signal generated by the Clock Generator	Waveform: waveform name Repetitions. Minimum=0 Maximum = 65535 (It means that the waveform will be repeated with allowed values from 1 to 65536 times) . Loop Mode: NO LOOP, LOOP BEGIN (it marks the first instruction of a loop), LOOP END (it marks the last instruction of a loop).
Jump To	Jump to the instruction address N	Address: instruction jump address. Jump addresses inside a Loop must be avoided
Jump If Event	Jump if an event occurs Address: instruction jump address.	Jump addresses inside a Loop must be avoided Input Event (HEX):16 bits input event. Input Event [14..0] are DPIO[14..0], Input Event[15] is the trigger event (see Settings -> Trigger Event tab for description). The Input Event bits are masked in AND with Mask value. The event occurs if: Input Event AND Input MASK = Input Group Value

| Instruction	Explanation	Parameters
Load Event Mask	Load the mask value	Event Mask (HEX): the value of the mask. Loop Mode: NO LOOP, LOOP BEGIN (it marks the first instruction of a loop), LOOP END (it marks the last instruction of a loop).
Wait Event	Wait until the event occurs	Input Event (HEX):16 bits input event. Input Event[14..0] are DPIO[14..0], Input Event[15] is the trigger event (please see Trigger Module for description).The Input Event bits are masked logically in AND with Mask value. The event occurs if:Input Event AND Input MASK = Input Group Value Loop Mode: NO LOOP, LOOP BEGIN (it marks the first instruction of a loop), LOOP END (it marks the last instruction of a loop).
Reset Trigger Event	Reset the trigger event value	Loop Mode: NO LOOP, LOOP BEGIN (it marks the first instruction of a loop), LOOP END (it marks the last instruction of a loop).

PLEASE NOTE THE FOLLOWING:

- The last sequencer instruction must be RETURN.
- REPEAT WAVEFORM: the generated vectors are asynchronous respect to the clock generator signal.
- SYNC REPEAT WAVEFORM: the generated vectors are synchronous respect to the clock generator signal. Sync signal can be delayed with Sync Delay.
- Sequencer Memory depth is 1024 instructions.
- Waveforms Memory depth is 1048576.
- A block of instructions can be repeated with Loop Begin / Loop End parameters. Loop Begin marks the first instruction of the loop, Loop End marks the last instruction.
  LOOP REPETITIONS parameter is the number of times that the loop will be repeated. Allowed values are from 1 to 8191.

Add an operation to the sequencer by selecting the operation in the Operation List tab, and then pressing the **Add** button.

The Wait event parameters window is shown where you can manage or change the parameters for the selected instruction.
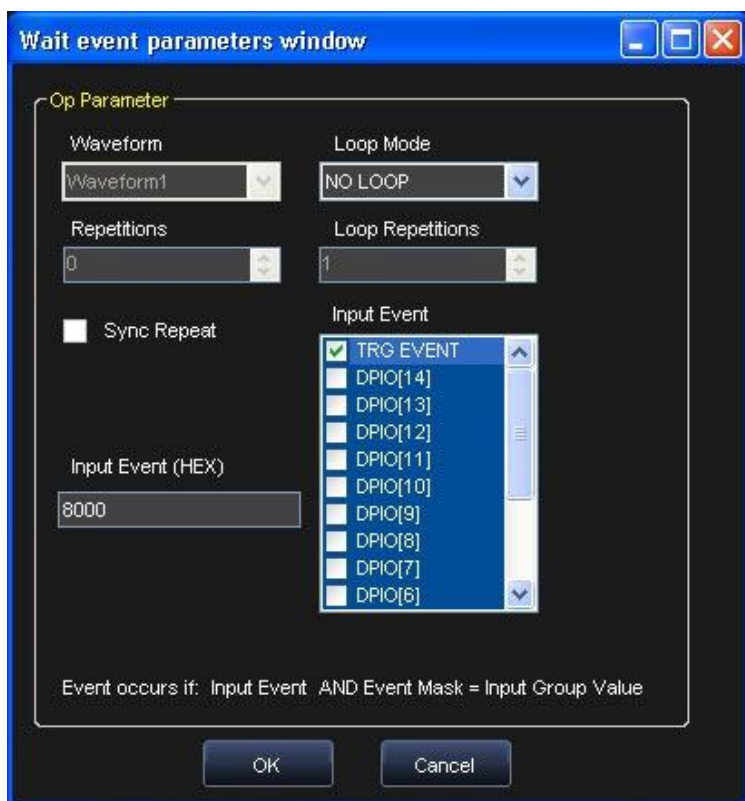
Sequencing Digital Waveforms

The sequencer unit is a programmable finite state machine with a microcode memory that, combined with the vector/command memory, can generate very long digital patters and control signals at a very high speed (up to 125 MHz).

You can select which digital waveforms from the Waveform list are to be generated by the Pattern Generator. You can also select their repetitions and duration and operations for execution by the sequencer microcode memory.

You can add/remove waveforms/operations to the Sequencer with the commands previously mentioned in **Sequencing Analog Waveforms** (on page 73)

NOTE: the Memory Usage indicator visualizes in real time the occupation of the hardware resources.

Signal Definitions

Use the following steps to create a new signal definition.

1. Double click Signal Definition on the Device Control Tree.
2. The Signal Definition screen is shown.

Use the Signal Definition panel to define a list of signals or buses and choose their correspondence to the channels of the ArbStudio 1102D/1104D Digital Pattern Generator.

Only the signals defined in this panel can be viewed in the Editing waveform window or Waveform View window.

The listing on the right of the Signal Definition screen shows all the ArbStudio 1102D/1104D channels and corresponding wire colors.
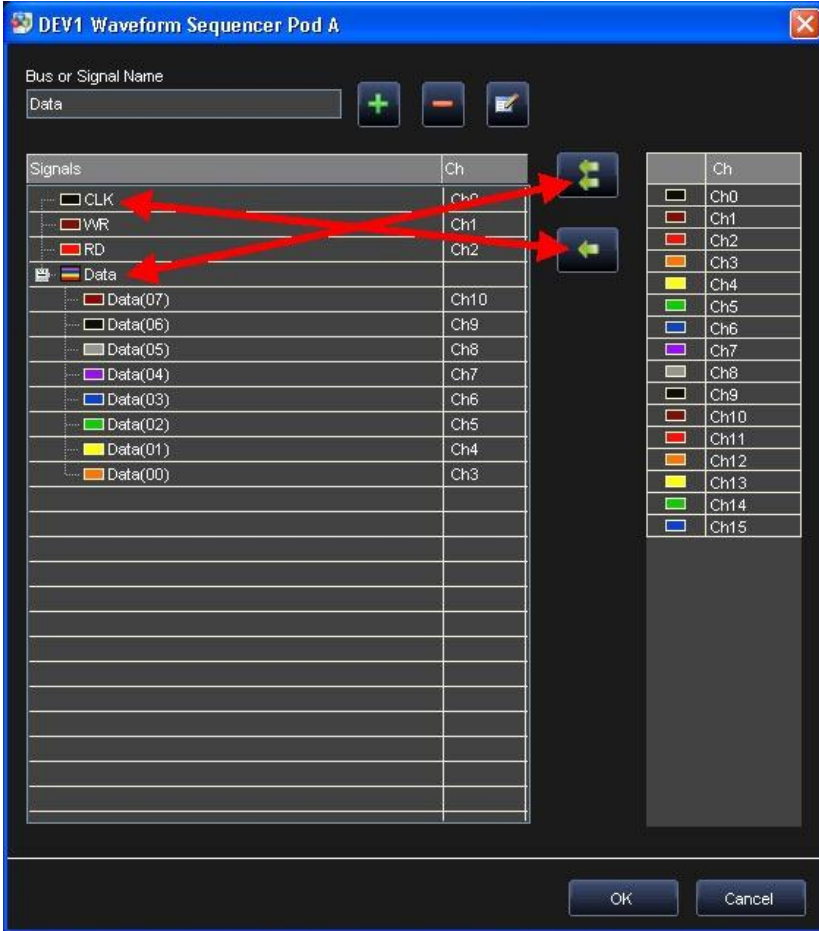
Adding a signal

Add a signal to the list by entering the desired name in the **Bus or Signal Name** field and then clicking the **Add bus or signal** button. Now, select the newly added Bus or Signal showing in the list on the left of the screen, select the Ch you wish to associate the new Bus or Signal with, and then click the **Change selected pod**button.

Adding a bus

Add a signal to the list by entering the desired name in the **Bus or Signal Name** field and then clicking the **Add bus or signal** button. Now, select the newly added Bus or Signal showing in the list on the left of the screen, select the Ch you wish to associate the new Bus or Signal with, and then click the **Add signals to bus** button.

Removing a signal or a bus

Remove a signal or a bus by selecting the row or rows on the left for removal and clicking the **Remove bus or signal** button.

Editing a signal or bus name

Edit a signal or a bus by selecting the row on the left for edit, making your name changes in the **Bus or Signal Name** field, and then clicking the **Edit current bus or signal** button

Acquisition - Using The Pattern Generator as a Sampler

The Digital Pattern Generator can also be used as a Sampler. All acquired data is stored into a file. This information can be exported, or accessed from the **Waveform View** and **State Listing** screens.

The acquisition command is the WriteRAM vector. When acquisitions run high, the Digital Pattern Generator stores data on its memory (up to 1,048,576 samples).

The Waveform View Screen

Access the Waveform View, by double clicking **Waveform View** from the Device Control tree.

With a new acquisition complete, the Waveform View screen is not yet shown. Instead, a **Signal Selection** screen is shown where you can select which signal(s) should be displayed.

- To add a signal or bus to the list on the right, select it on the left and click the **Add** button.
- Add all signals with one click using the **Add All** button.
- Remove a single signal from the visualization list (on the right) by selecting it and clicking the **Remove** button.
- Remove all signals from the visualization list with one click using the **Remove All** button.

Once you've made your selections and clicked the **OK** button, the **Waveform View** screen is then shown.

The Waveform Window allows analyzing acquired data in a graph containing digital waveforms. Single signals are visualized as digital signals, while grouped signals are represented as buses.
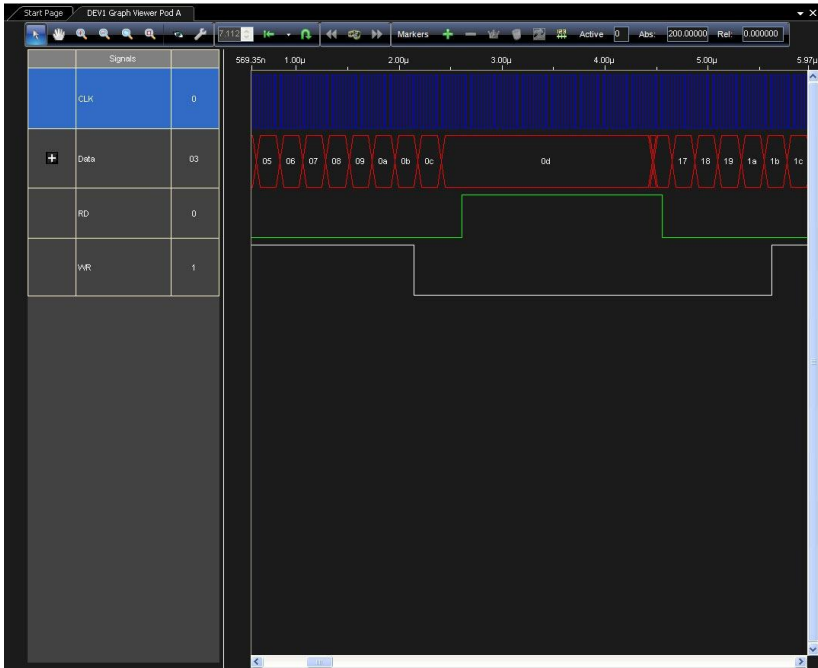
> **NOTE**: If the **Waveform View** screen is opened before a data acquisition has taken place, signals (and their names) are not visualized and the screen is not shown. Only when an acquisition takes place are signals then visualized on the **Waveform View** screen.

- In the Waveform View, a bus node is indicated by the **Expandable Bus** icon shown to the left of the bus name.

  Double click the bus name to display its data on the right of the Waveform View screen.

- 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.

CHANGING WAVEFORM ORDER

You can drag and drop the waveforms inside the listing on the left of the screen to change their order. This often helps users focus on the time relationship between edges. Just click a signal name on the list and drag it

to the desired position in the list. You can also insert a signal or bus on the list or remove one from the list.

RESIZING SIGNAL AMPLITUDE

Resize the signal amplitude by dragging the line between a signal name cell inside an expanded bus on the left of the Waveform View screen.

To the right of every signal or bus name, a number indicates the value the signal or bus assumes at the time position of the master cursor.

RIGHT CLICK MENU

Right clicking on the signal name column shows the right click menu with the following options:

- **Add samples scale** - Select this option to add a signal (indicated by the Add samples scale icon) 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.

- **Add-Remove signals** - This option allows adding or removing signals to the Waveform View.

ADDITIONAL TOOLS

Using **Zoom**, **Cursors**, **Graph Property**, and **Search** tools on the toolbar are done the same way as previously described in the Digital Waveform Editor section.
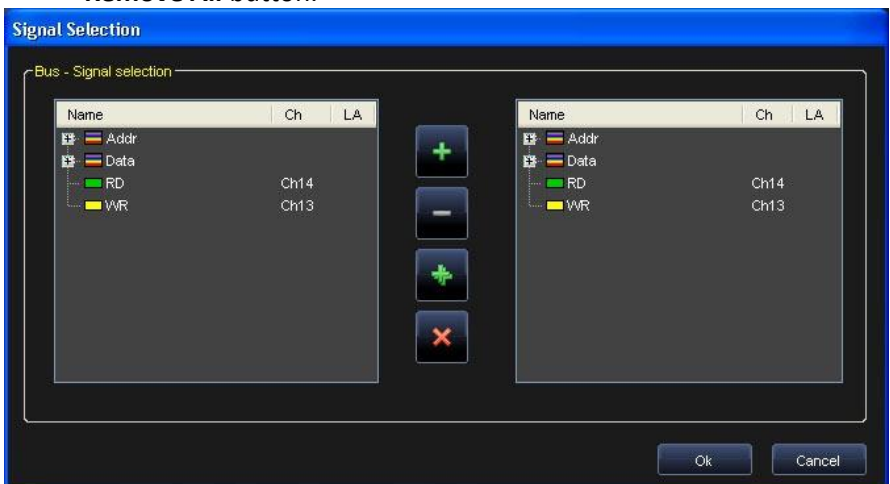
The State Listing Screen

The State Listing screen shows acquired data numerically in columns, each one representing a signal or a group of signals. Additional columns indicate the sample number (Samples column), the absolute time (Time column) and the interpretation of the serial protocol bus operations (if the trigger option has been selected).

Access the State Listing screen, by double clicking **State Listing** from the Device Control tree.

With a new acquisition complete, the **State Listing** screen is not yet shown. Instead, a Signal Selection screen is shown where you can select which signal(s) should be displayed.

- To add a signal or bus to the list on the right, select it on the left and click the **Add** button.
- Add all signals with one click using the **Add All** button.
- Remove a single signal from the visualization list (on the right) by selecting it and clicking the **Remove** button.
- Remove all signals from the visualization list with one click using the **Remove All** button.

Once you've made your selections and clicked the **OK** button, the **State Listing** screen is then shown.

THE BUS COLUMN

- In the State Listing, 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).

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.

THE SAMPLES COLUMN

The Samples column contains the progressive number of the acquired samples. It is indicated by the **Samples scale** icon.

THE TIME COLUMN

The Time column contains the progressive absolute time of every sample. It is indicated by the **Time** icon.

RESIZING COLUMN AMPLITUDE

Resize column amplitude by dragging the line between the signal name.

CURSORS

Cursors (also called markers) are useful to identify and enlighten data that, therefore, may be recognized or found easier. In addition cursors can be used to measure and to analyze acquired data.

The left side of the **State Listing** screen contains all the available cursors. The master cursor is identified by the Master Cursor icon.

All relative positions are calculated with respect to the position of the master cursor. Also, the master cursor is automatically moved during a data search operation to show result data from the search perspective.

You can also access cursors by right clicking the cursor list selecting from one of the following cursor right click menu options.

- **Add marker** - Adds a cursor to the State Listing screen.
- **Delete marker** - Removes the selected cursor from the State Listing screen.
- **Set master** - Sets the selected cursor as the master.
- **Clear marker list** - Deletes all cursors from the State Listing screen except for one.
- **Go to this marker** - Moves the State Listing results to reflect the position of the selected cursor.
- **Representation...** - Allows the setting of Absolute and Relative cursor positions. You can choose between Time and Samples.

NOTE: You can create as many cursors as needed.

BROWSING THE STATE LISTING SCREEN AND EXPORTING DATA

Navigating the State Listing samples can be done using the right click menu. The following options available for use and also includes the **Save to txt file…** (Export function).

NOTE: Many are the same as the cursor list right click menu (previous right click function list).

- **Add marker** - Adds a cursor to the selected point of the State Listing screen.
- **Move selected marker here** - Places the selected cursor to the specified position of the State Listing screen.
- **Show this sample Graph View** - Centers the Waveform View on the selected sample (only if the Waveform View is already open).
- **Go to selected marker** - Moves the State Listing results to show the position of the selected cursor.
- **Go to samples…** - After selecting a sample number on the pop-up, moves the State Listing results to corresponding samples.
- **Go to time…** - After selecting an absolute time on the pop-up, moves the State Listing results to show corresponding samples.
- **Save to txt file…** - After selecting rows and columns on the pop-up, exports the data to a Comma Separated Value file.

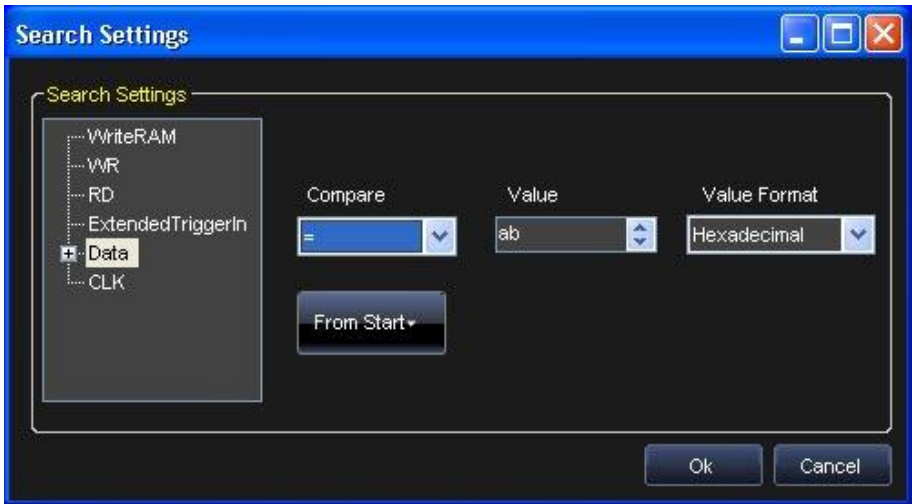**NOTE**: Exporting an entire acquisition may take a long time.

SEARCH

The Search function is available from both the **State Listing** and **Waveform View** screens. 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 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:

- **=** - Find the equivalent value.
- **!=** - Find the unequal value.
- **>** - Find values greater than the one specified (only available if a bus is selected).
- **<** - Find values less than the one specified (only available if a bus is selected).
- **HiZ** - Find high impedance values.

Use the **Value** field to provide the specific value or edge on which to search. If one Signal Type is selected, the **Value** field has the following options:

- **0** - Searches for a logic **0**.
- **1** - Searches for a logic **1**.

- **HiZ** - Search for a High Impedance (only for Pattern Generator Mode).

- **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 acquisition. Possible options include:

- **From Start** - Starts the search from the beginning of the acquisition.
- **From End** - Starts the search from the end of the acquisition.
- **From Trigger** - Starts the search from the trigger position.
- **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 **State Listing** or **Waveform View** screen (depending on where you started your search).

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.
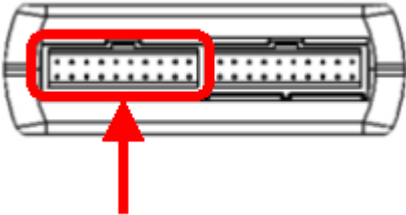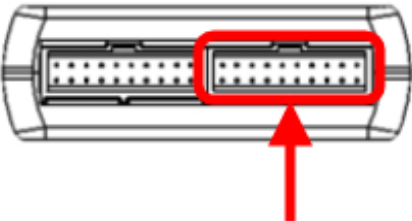
Probes

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

DP[0]	DP[1]	DP[2]	DP[3]	DP[4]	DP[5]	DP[6]	DP[7]	DP[8]	DC_TI
DGND	DGND	DGND	DGND	DGND	DGND	DGND	DGND	DGND	DGND

BANK 1

DP[9]	DP[10]	DP[11]	DP[12]	DP[13]	DP[14]	DP[15]	DP[16]	DP[17]	DC_TO
DGND	DGND	DGND	DGND	DGND	DGND	DGND	DGND	DGND	DGND

Signal Description (Arbitrary/DDS Mode)

The signals available on ArbStudio 1102D/1104D probes connected to digital output connectors are as follows:

Signal Name	Type	Description
DGND		Digital ground
DP[0..17] DP [9...16]	Output	Digital pattern output. When channel 1 and 2 are configured as Arbitrary Waveform Generators, the 16-bit digital representation of the analog waveform of channel 1 is available on DP[0..7] and DP[9..16] of Pod A if Channel 1 Digital Pattern on Pod A is enabled. See **Setup Device** (on page 49).
		When channel 3 and 4 are configured as Arbitrary Waveform Generators (ArbStudio 1102/1104 only), the 16-bit digital representation of the analog waveform of channel 3 is available on DP [0..7] and DP[9..16] of Pod B if Channel 3 Digital Pattern on Pod B is enabled.
		The bit assignment to Pod Channel is:
		DP[0..7] ≤ SampleBit[0..7]
		DP[9..16] ≤ SampleBit[8..15]
		DP[8] and DP[16] are not significant.
DC_TO	Output	Digital Connector Trigger out.
		When DC Trigger Out Destination is enabled (see Trigger out menu): trigger out signal combination of CH1 and CH2 is sent to DC_TO on Pod A, trigger out signal combination of CH3 and CH4 is sent to DC_TO on Pod B (1104 ArbStudio only).
DC_TI	Input	Digital Connector Trigger IN.
		When DC Trigger IN Source is enabled (see Settings →Trigger IN menu), trigger in signal of CH1/CH2 is acquired from DC_TI pin on Pod A, trigger in signal of CH3/CH4 is acquired from DC_TI pin on Pod B (1104 ArbStudio only).

Signals Description (Pattern Generator, Optional)

The signals available on ArbStudio 1102D/1104D Pattern Generator/Sampler connectors are reported as follows:

Signal Name	Type	Description
DGND		Digital ground
DP[0..17]	Input Output	Digital pattern generator bidirectional pins
DP[15] / CLK	Input / Output	Clock generator module output pin or additional input pin
DP[16] / EXT TRG	Input / Output	Extended Trigger output pin or additional input pin
DP[17] / WR RAM	Input / Output	Write Ram signal used as output pin or additional input pin
DC_TO	Output	Digital Connector Trigger out. Pattern Generator Trigger Out signals are sent to DC_TO pins on Pod A/Pod B probes.
DC_TI	Input	Digital Connector Trigger IN. When DC Trigger IN Source is enabled (see Settings →Trigger IN menu), trigger in signal of Pod A Pattern is acquired from DC_TI pin on Pod A, trigger in signal of Pod B Pattern is acquired from DC_TI pin on Pod B.

The Pulse Width Modulation (PWM) Generator Workspace

Overirew

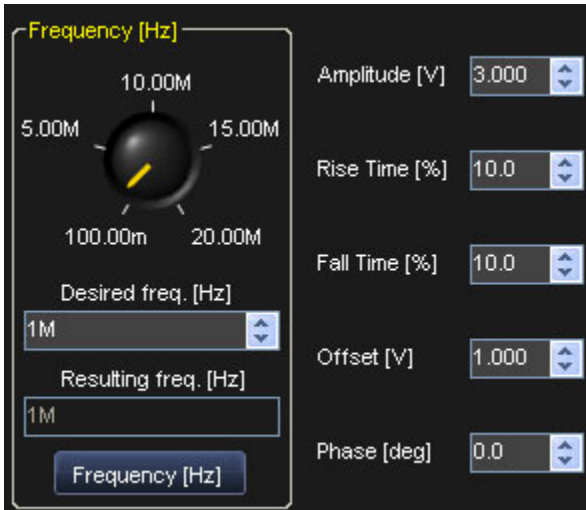The PWM Generator consists of three main elements:

- **The Pulse Definition Area** - Provides access to pulse waveform parameters.

- **The Duty Cycle Modulation Area** - Where you can define the modulation law changing the modulating shape of the duty cycle and its parameters.

- **The Control Area** - Provides access to channel selection, device setup, and where you can start/stop the instrument channels.

Pulse Definition Area

This section allows defining the pulse for the selected channel.

The following fields are available:

- **Frequency [Hz]** - Set the frequency of the pulse waveform from 100mHZ to 20MHz. Cannel frequencies are independent pairs (1-2 / 3-4 for 1104 ArbStudio instruments). Within the sample pair, the channel frequency is perfectly matched if one is an even multiple of the other, otherwise the channel frequency might be rounded to minimize the frequency % error. The rounded off frequency value is shown on the **Resulting freq. [Hz]** field.
- **Period[s]/Frequency[Hz]** - Click the Period(s) button if you want to define the pulse waveform by its period.
- **Amplitude[V]** - Amplitude of the pulse waveform. It refers to the impedance load, so if the load is 50 Ω the maximum amplitude is ±6V; if the load is low impedance, the maximum amplitude is ±12V.
- **Rise Time[%]** - Rise time percentage relative to the period of the pulse waveform.
- **Fall Time[%]** - Fall time percentage relative to the period of the pulse waveform.
- **Offset[V]** - Voltage offset of the pulse waveform.
- **Phase[deg]** - Phase of the pulse waveform.

Duty Cycle Modulation Area

This section allows defining the modulation law of the duty cycle of the pulse waveform by setting the modulating parameters.
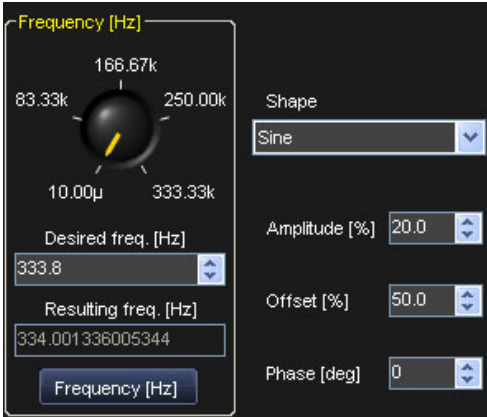

The following fields are available:

- **Frequency [Hz]** - Set the frequency of the duty cycle modulating waveform from 10uHZ to 6.67MHz depending on the pulse waveform frequency.

  If you change the Frequency of the pulse waveform, it automatically updates the duty cycle modulating waveform frequency to have the minimum % error and also updates the min-max range. The rounded off frequency value is shown on the **Resulting freq. [Hz]** field.

- **Period[s]/Frequency[Hz]** - Click the Period(s) button if you want to define the duty cycle modulating waveform by its period.
- **Shape** - The shape of the modulation waveform. Available options include **sine**, **triangle**, **ramp**, **white noise** and **manual**. In manual mode you can run-time change the Duty Cycle percentage rotating the knob control.
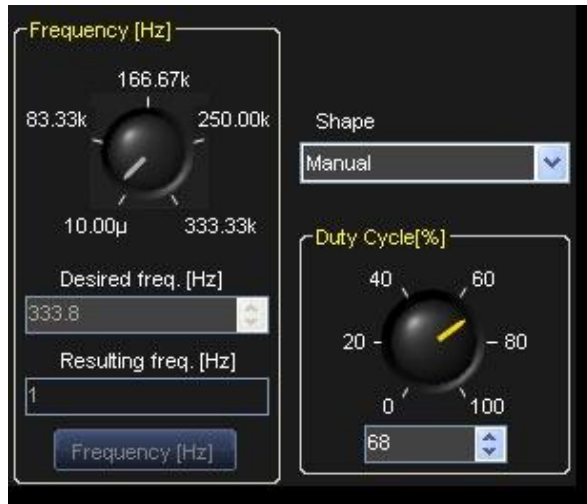
Figure 3-2. Manual Mode Example

- **Amplitude[%]** - Amplitude percentage of the duty cycle modulating waveform.

- **Offset[%]** - Offset percentage of the duty cycle modulation waveform.

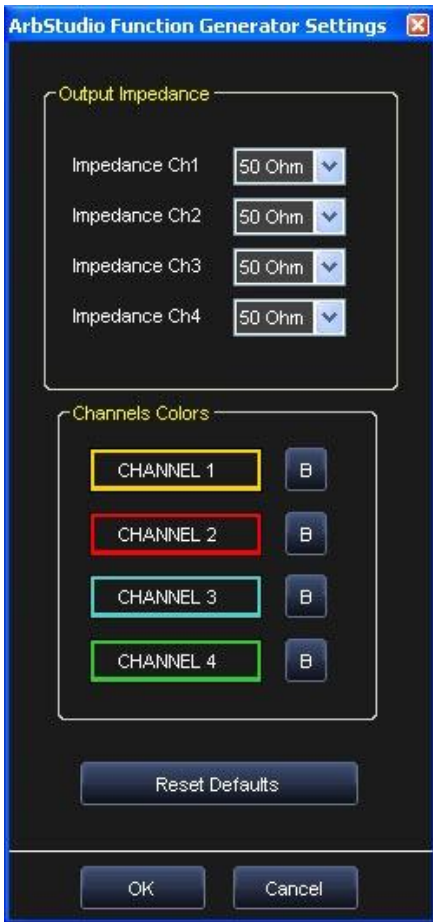- **Phase[deg]** - Phase of the duty cycle modulating waveform.

Control Area

Settings Screen

Click the **Settings** button.

The PWM Generator **Settings** screen is shown.

- **Output Impedance** - Allows setting the channel output impedance. Drop-down values include **50 Ω**, **Low**, or **High** Impedance settings.
- **Channels Colors** - Change the color of the selected channels as desired.

Start/Stop

Press the **Start/Stop** button to load the PWM waveforms into the ArbStudio hardware and start/stop the selected channels.

The Status box (under the button) provides instrument status messages.

Example - PWM Setup

After you have powered on the instrument and connected it to the PC, launch the PWM Generator.

On the PWM Generator screen, make the following settings:

1. Set the Pulse Frequency to **100 KHz**.
2. Set the Amplitude to **3 V**, Rise and Fall Times to **30%**, Offset to **0 V**, and Phase[deg] to **0**.
3. Select **Sine** for the Duty Cycle Modulation Shape.
4. Set the Amplitude[%] to **30**, Offset[%] to **50%**, and Phase[deg] to **0**.
5. Set the Duty Cycle Modulation Frequency to **1 Hz**.
6. Press the Settings button to show the Settings screen.

    Set the channel output impedance to **50 Ω**.

7. Back on the Control area, select the **CH1**.
8. Connect the **CH1 output** to the oscilloscope.
9. Click the **Start** button.
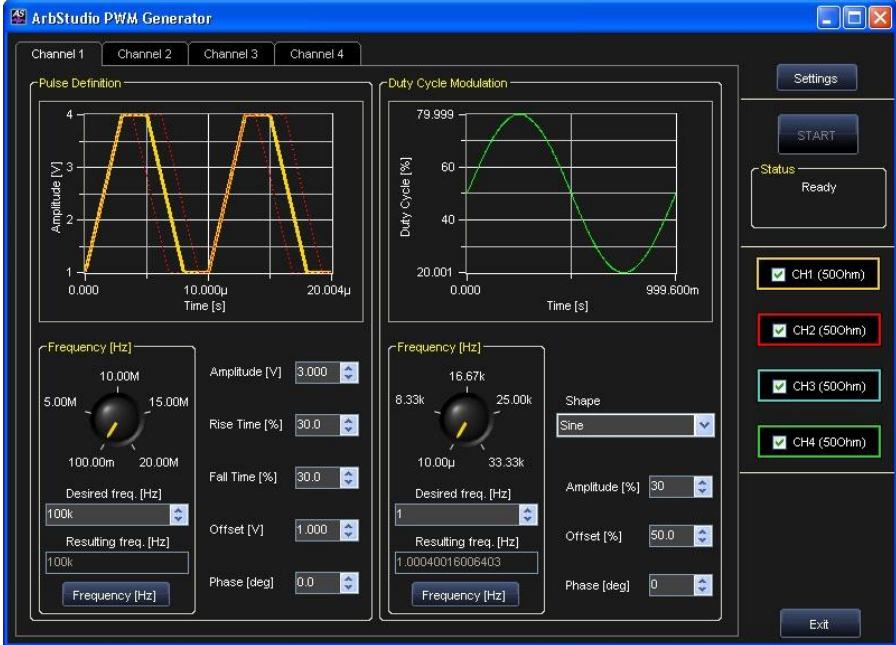
"How do I" Scenario Details

Scenarios with detailed steps for performing typical tasks and setups using ARBStudio are 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 ArbStudio software** as explained in the **Getting Started with ArbStudio** (on page 10) section.

- Some more specific steps are required around Creating a New Workspace for each scenario. Details are provided for those scenarios when necessary.

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:
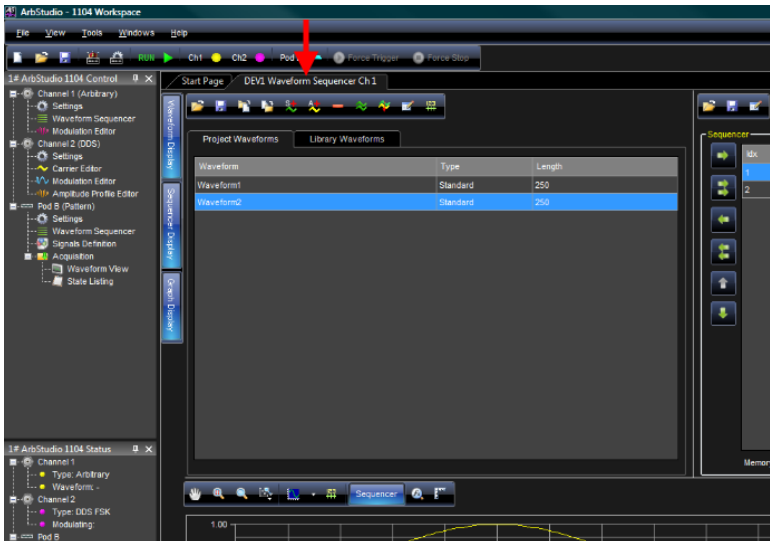
1. **Arbitrary Waveform Generator Setup Example** (on page 27)
2. **Creating a New Workspace** (on page 24)
3. **Opening an Existing Workspace** (on page 26)

Creating Your First Analog Waveform

To create your first Analog Waveform, you must first create a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one Analog Channel. See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

1. Double-click the Waveform Sequencer under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

   The **Waveform Sequencer** is then shown.

2. Press the **Add Standard Waveform** button.

3. The **Waveform Standard Editor** dialog box is shown.

In the fields on the Editor, select a **Sine waveform Type**, **1 MHz Frequency**, **250 Samples**, and **1 Volt Amplitude**.
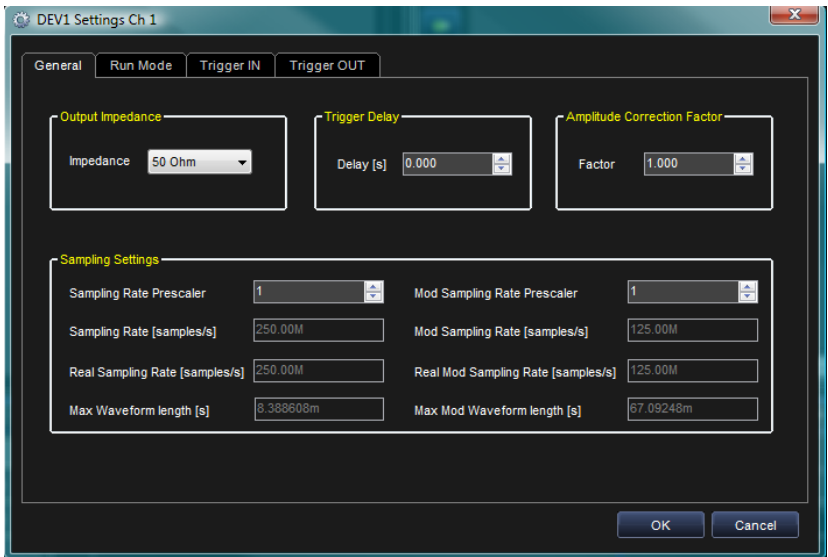
Click **OK**.

4. On the Project Waveforms tab under the Waveform Sequencer, select the waveform you just created and click the **Add Waveform** button (adding your new waveform to the Sequencer).
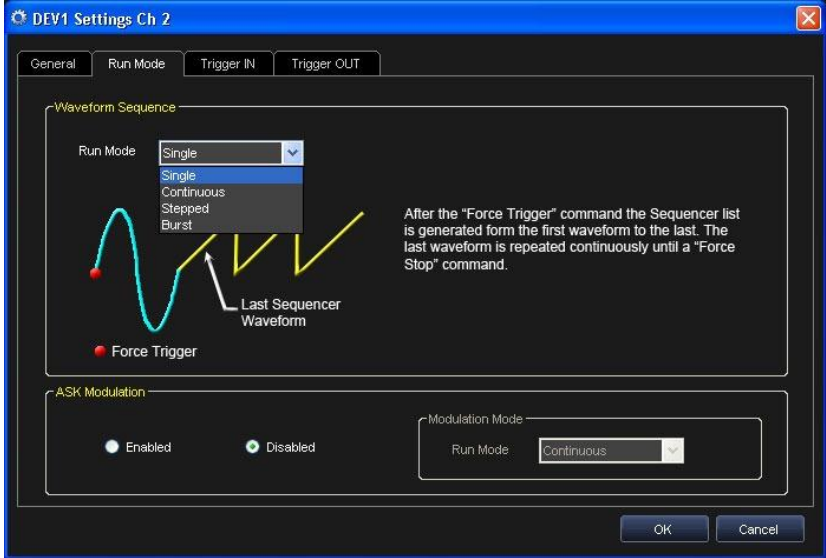

5. Double-click **Settings** under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

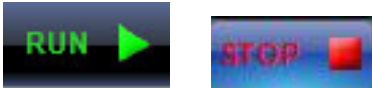The **DEV1 Settings Ch 1** pop-up screen is shown.

The General Tab is shown by default when the pop-up displays. On the General Tab be sure to select an **Output Impedance** value suitable for your impedance load. For example, if you need to connect the instrument to an oscilloscope, select 50 Ω as the output impedance load and 50 Ω as the input impedance on the oscilloscope channel.

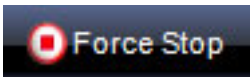6. On the The **DEV1 Settings Ch 1** pop-up screen's **Run Mode** tab, select **Single** and press **OK**.

When the instrument starts, the **Single Run Mode** repeats Waveform1 until you press the **Force Stop** button.

7. Now, press the **Run/Stop** button on the ARBStudio toolbar.

The software loads the settings and the waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

8. Waveform1 is generated on the CH1 BNC output. You can connect an oscilloscope to this output and analyze the signal.

9. Stop generating waveforms by pressing the **Run/Stop** button again or the **Force Stop** button (also on the ARBStudio toolbar).

Creating a Sequence of Waveforms

To create your first Sequence of Waveforms, you must first create a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one Analog Channel. See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

1. Double-click the Waveform Sequencer under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

    The **Waveform Sequencer** is then shown.
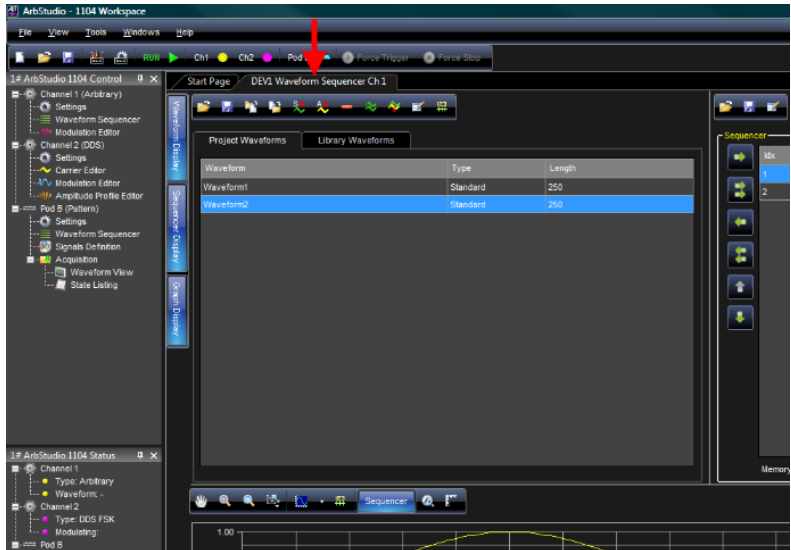
2. Now, we'll add three waveforms to our Project Waveforms. Do this by pressing the **Add Standard Waveform** button and providing the following specifications for waveforms 1, 2, and 3 on the **Waveform Standard Editor** dialog box each time.

    The Add Standard Waveform Button

The Waveform Standard Editor Dialog Box

- **Waveform 1** - **Sine waveform Type**, **1 MHz Frequency**, **250 Samples**, and **1 Volt Amplitude**. Click **OK** when finished, and then repeat by clicking the **Add Standard Waveform** button on the **Waveform Sequencer**.

- **Waveform 2** - **Triangle waveform Type**, **2 MHz Frequency**, **250 Samples**, and **1 Volt Amplitude**. Click **OK** when finished, and then repeat by clicking the **Add Standard Waveform** button on the **Waveform Sequencer**.

- **Waveform 3** - **Rectangle waveform Type**, **4 MHz Frequency**, **250 Samples**, and **1 Volt Amplitude**. Click **OK** when finished.

3. On the Project Waveforms tab under the Waveform Sequencer, select the waveform you just created and click the **Add All Waveforms** button (adding all of your new waveforms to the Sequencer).
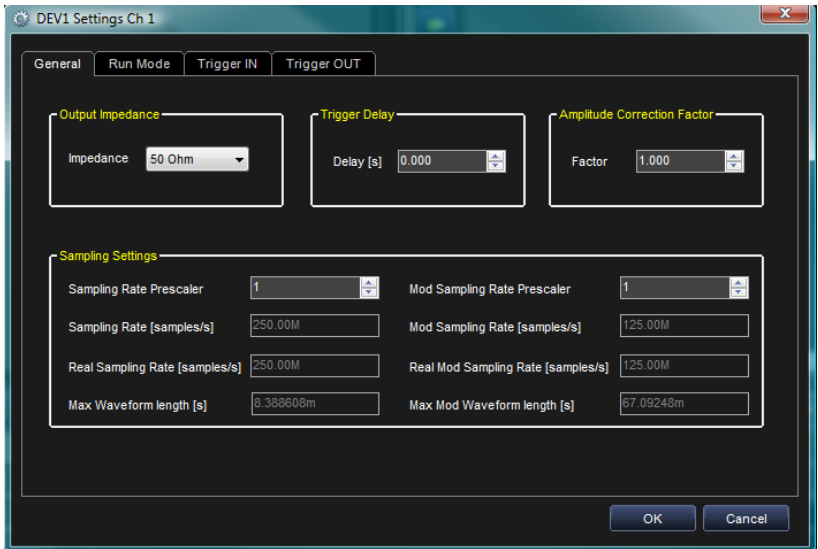

4. Double-click **Settings** under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have

configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Settings Ch 1** pop-up screen is shown.

The General Tab is shown by default when the pop-up displays. On the General Tab be sure to select an **Output Impedance** value suitable for your impedance load. For example, if you need to connect the instrument to an oscilloscope, select 50 Ω as the output impedance load and 50 Ω as the input impedance on the oscilloscope channel.

5. On the The **DEV1 Settings Ch 1** pop-up screen's **Run Mode** tab, select **Continuous** and press **OK**.
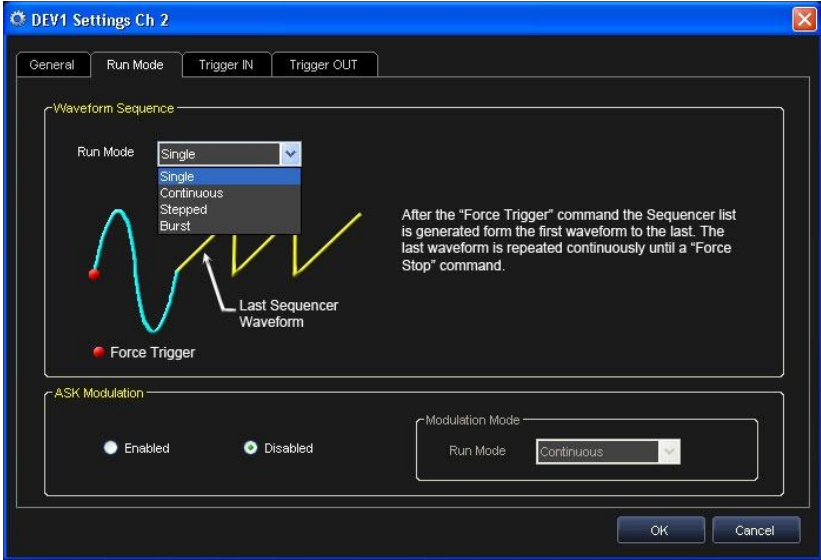

When the instrument starts, the **Continuous Mode** repeats all of your waveforms entered into the sequencer (previously during step 3) until you press the **Force Stop** button.

6. Now, press the **Run/Stop** button on the ARBStudio toolbar.
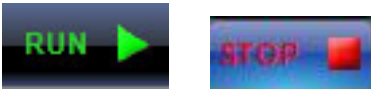
The software loads the settings and the waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

7. Your sequence of waveforms is generated on the CH1 BNC output. You can connect an oscilloscope to this output and analyze the signal.

8. Stop generating waveforms by pressing the **Run/Stop** button again or the **Force Stop** button (also on the ARBStudio toolbar).
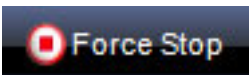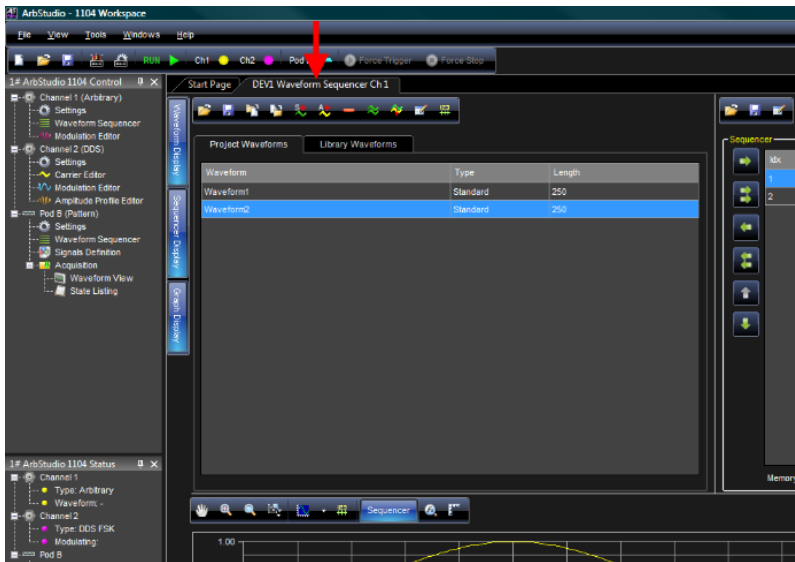
Creating an Amplitude Modulated Waveform

To create your first Amplitude Modulated Waveform, you must first create a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one Analog Channel. See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

1. Double-click the Waveform Sequencer under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)
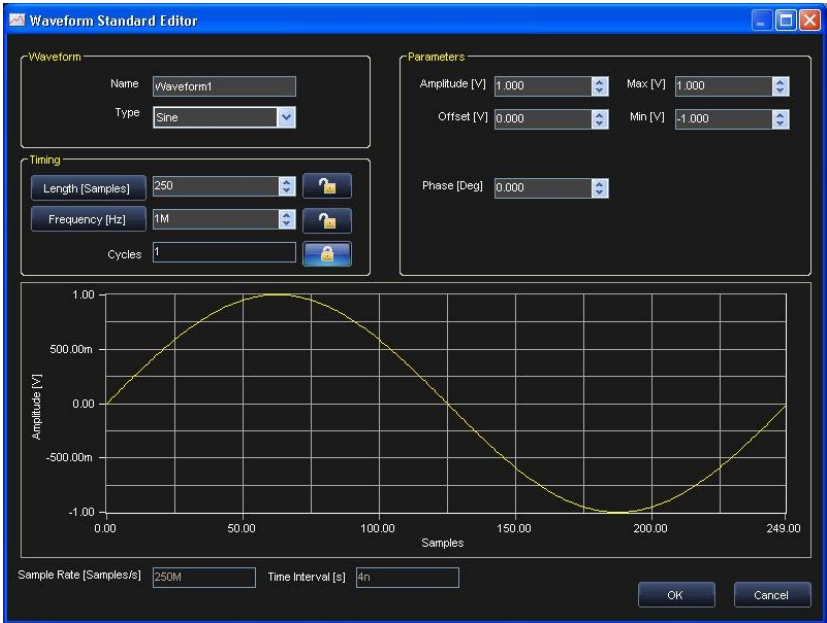
    The **Waveform Sequencer** is then shown.

2. Press the **Add Standard Waveform** button.

3. The **Waveform Standard Editor** dialog box is shown.

In the fields on the Editor, select a **Sine waveform Type**, **1 MHz Frequency**, **250 Samples**, and **1 Volt Amplitude**.

Click **OK**.

> **NOTE**: The aforementioned steps create our Carrier Waveform.

4. On the Project Waveforms tab under the Waveform Sequencer, select the Carrier Waveform we just created and click the **Add Waveform** button (adding it to the Sequencer).
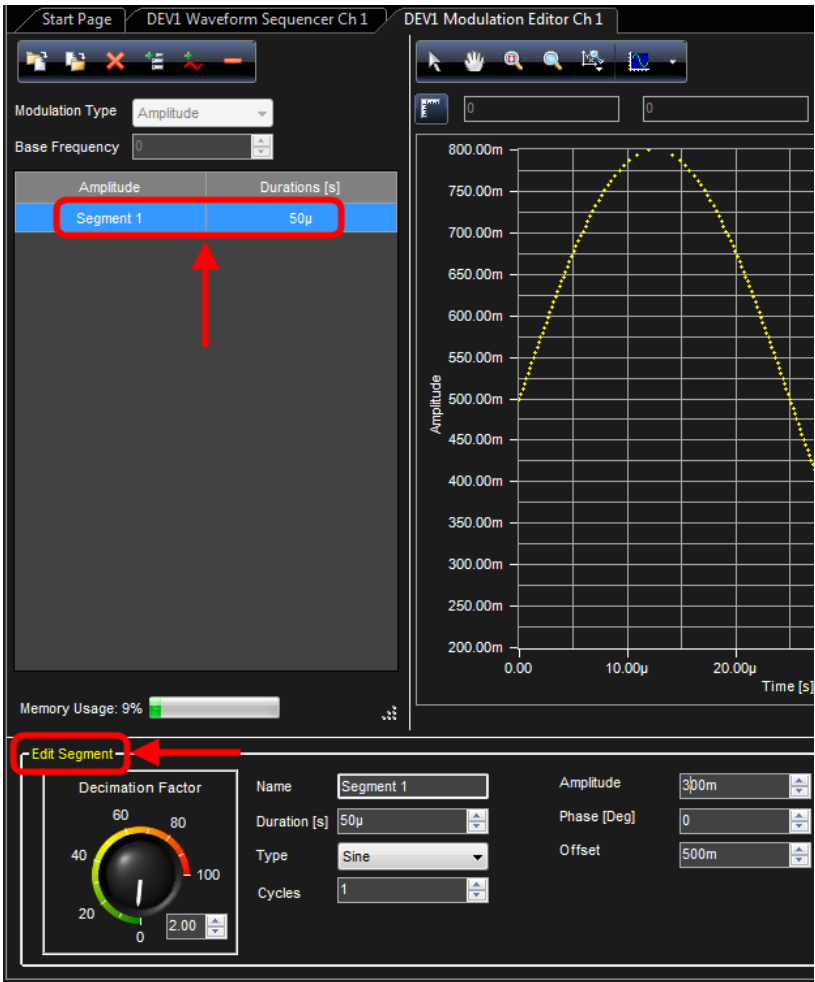

5. Double-click **Modulation Editor** under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Modulation Editor Ch 1** screen is shown.
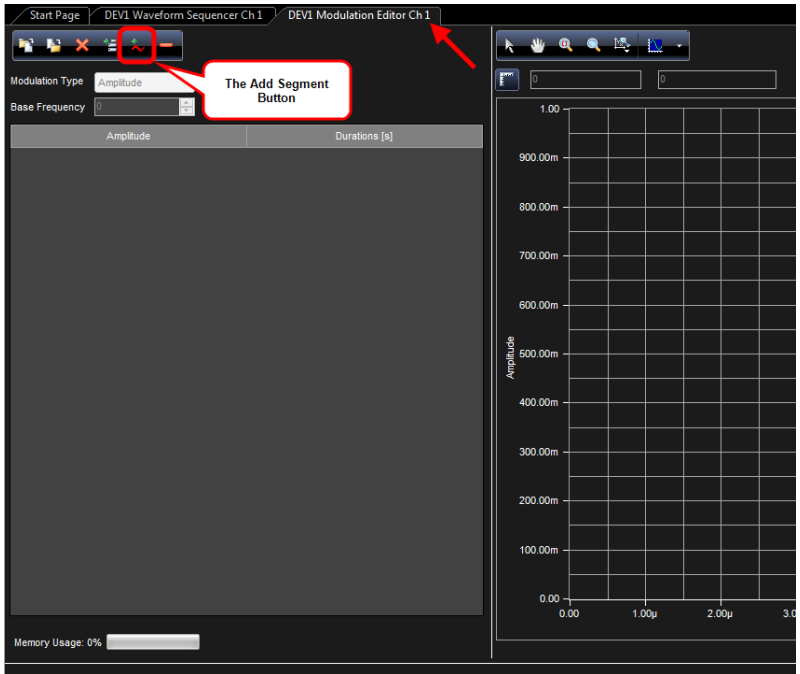
Click the **Add Segment** button.

Your new segment (Segment 1) should be shown on the **Amplitude Modulation List** and the **Edit Segment** dialog is shown on the lower part of the screen.

On the **Edit Segment** dialog, set the Type to **Sine**, Duration to **50 µs**, Cycles **1**, Amplitude **300m**, Phase **0**, and Offset **500m**.

6. Now, double-click **Settings** under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Settings Ch 1** pop-up screen is shown.
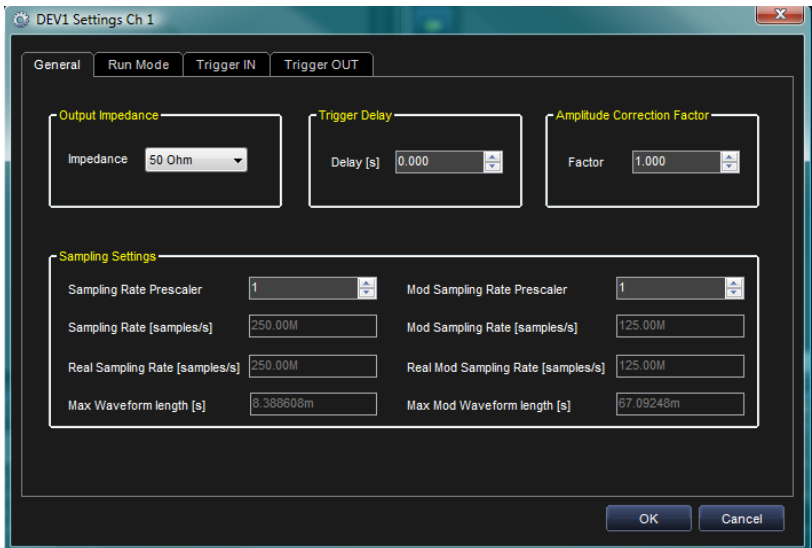
The General Tab is shown by default when the pop-up displays. On the General Tab be sure to select an **Output Impedance** value suitable for your impedance load. For example, if you need to connect the instrument to an oscilloscope, select 50 Ω as the output impedance load and 50 Ω as the input impedance on the oscilloscope channel.

7. On the The **DEV1 Settings Ch 1** pop-up screen's **Run Mode** tab, select **Continuous**.
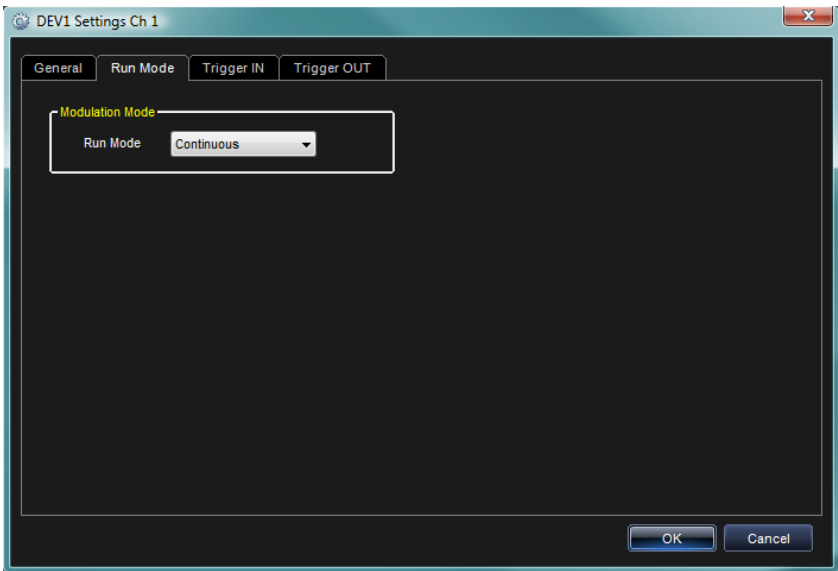
    Click **OK**.

8. Now, press the **Run/Stop** button on the ARBStudio toolbar.

The software loads the settings and the waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

9. The Frequency Modulated Waveform1 is generated on the CH1 BNC output. You can connect an oscilloscope to this output and analyze the signal.

10. Stop generating waveforms by pressing the **Run/Stop** button again or the **Force Stop** button (also on the ARBStudio toolbar).
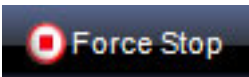
Creating a Frequency Modulated Waveform

Create a Frequency Modulated Waveform by first creating a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one DDS Channel. See steps 2, 5, and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details (and be sure to select DDS instead of Arbitrary during step 2). If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:
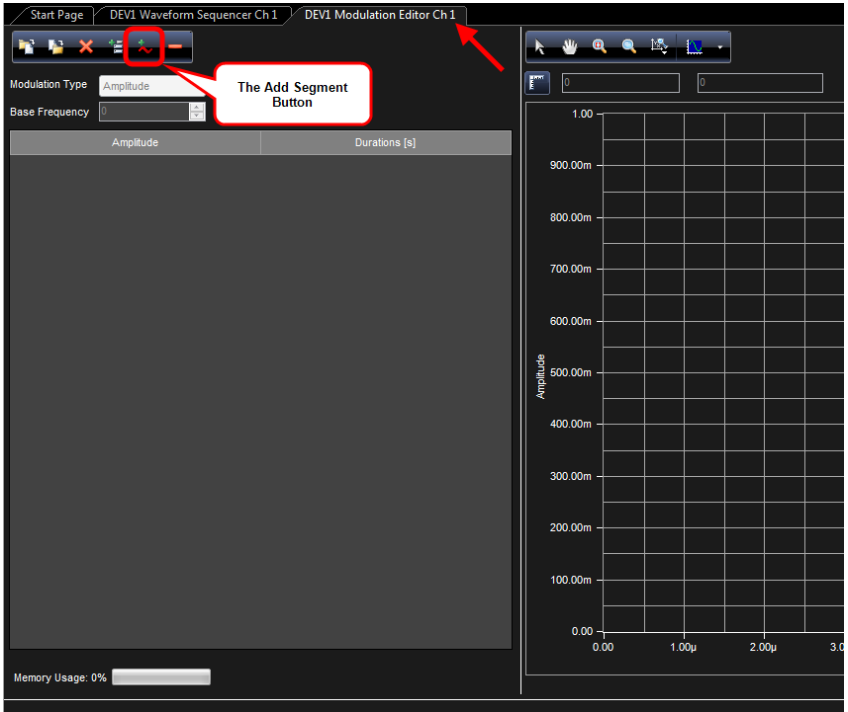
1. Double-click the Carrier Editor under Channel 1 (DDS) on the Device Control Tree. (Channel 1 can be any DDS channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

2. The default Component 1 Carrier settings are shown on the Component Definition dialog. These default settings include a **Sine** wave Type with a Length of **2048** samples, Amplitude of **1** V, and **1** Cycle. You can modify **Component 1** of the **Carrier** as desired.

3. Double-click **Modulation Editor** under Channel 1 (DDS) on the Device Control Tree. (Channel 1 can be any DDS channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Modulation Editor Ch 1** screen is shown.

Click the **Add Segment** button.

Your new segment (Segment 1) should be shown on the **Amplitude Modulation List** and the **Edit Segment** dialog is shown on the lower part of the screen.

On the **Edit Segment** dialog, set the Type to **Triangle**, Duration to **2 µs**, Cycles **1**, Frequency **100k**, Phase **0**, and Offset **500k**.

4. Now, double-click **Settings** under Channel 1 (DDS) on the Device Control Tree. (Channel 1 can be any DDS channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Settings Ch 1** pop-up screen is shown.

The General Tab is shown by default when the pop-up displays. On the General Tab be sure to select an **Output Impedance** value suitable for your impedance load. For example, if you need to connect the instrument to an oscilloscope, select 50 Ω as the output impedance load and 50 Ω as the input impedance on the oscilloscope channel.

5. On the The **DEV1 Settings Ch 1** pop-up screen's **Run Mode** tab, select **Single**, on the ASK Modulation section of the Run Mode tab, select **Enabled**, and from the Modulation Mode drop-down, select **Continuous**.
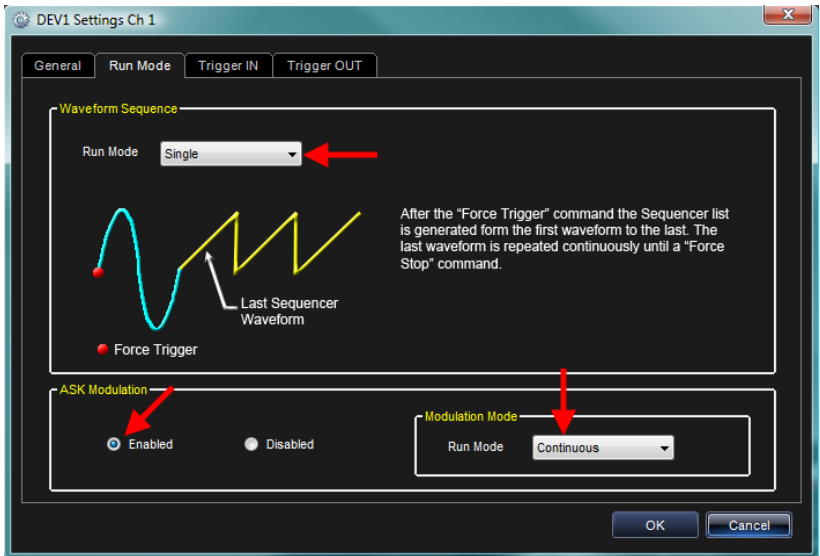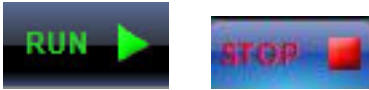
Click **OK**.

6. Now, press the **Run/Stop** button on the ARBStudio toolbar.

The software loads the settings and the waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

7. The Amplitude Modulated Waveform1 is generated on the CH1 BNC output. You can connect an oscilloscope to this output and analyze the signal.

8. Stop generating waveforms by pressing the **Run/Stop** button again or the **Force Stop** button (also on the ARBStudio toolbar).
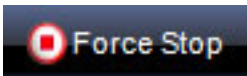
Creating a Phase Modulated Waveform

Create a Phase Modulated Waveform by first creating a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one DDS Channel. See steps 2, 5, and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details (and be sure to select DDS instead of Arbitrary during step 2). If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:

1. Double-click the Carrier Editor under Channel 1 (DDS) on the Device Control Tree. (Channel 1 can be any DDS channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

2. The default Component 1 Carrier settings are shown on the Component Definition dialog. These default settings include a **Sine** wave Type with a Length of **2048** samples, Amplitude of **1** V, and **1** Cycle. You can modify **Component 1** of the **Carrier** as desired.

3. Double-click **Modulation Editor** under Channel 1 (DDS) on the Device Control Tree. (Channel 1 can be any DDS channel you have

configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Modulation Editor Ch 1** screen is shown.

Click the **Add Entry** button.

Your new entry should be shown on the **Phase Modulation List** and the **Edit Entry** dialog is shown on the lower part of the screen.
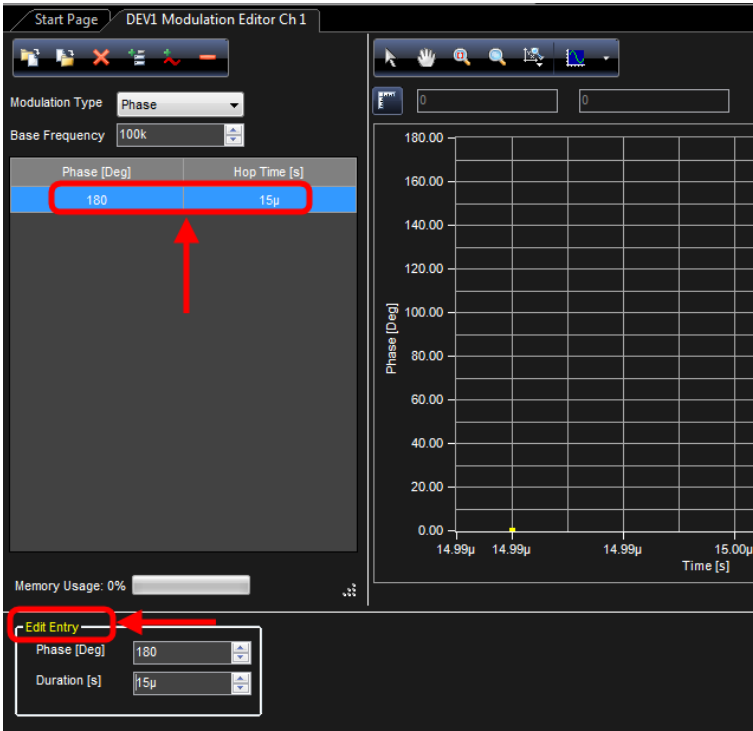
On the **Edit Segment** dialog, set the Phase to **180**, and Duration to **15µs**.

Now, repeat this step and create a second entry in the Phase Modulation List. Set its Phase to **90**, and Duration to **30µs**.

4. Now, double-click **Settings** under Channel 1 (DDS) on the Device Control Tree. (Channel 1 can be any DDS channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

The **DEV1 Settings Ch 1** pop-up screen is shown.

The General Tab is shown by default when the pop-up displays. On the General Tab be sure to select an **Output Impedance** value suitable for your impedance load. For example, if you need to connect the instrument to an oscilloscope, select 50 Ω as the output impedance load and 50 Ω as the input impedance on the oscilloscope channel.

5. On the The **DEV1 Settings Ch 1** pop-up screen's **Run Mode** tab, select **Continuous**.

    Click **OK**.

6. Now, press the **Run/Stop** button on the ARBStudio toolbar.

The software loads the settings and the waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

7. The Phase Modulated Waveform1 is generated on the CH1 BNC output. You can connect an oscilloscope to this output and analyze the signal.

8. Stop generating waveforms by pressing the **Run/Stop** button again or the **Force Stop** button (also on the ARBStudio toolbar).

Importing a Waveform from an Oscilloscope

Import a Waveform from an Oscilloscope by first creating a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one Arbitrary Channel. See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details. If you already have a workspace open, be sure it meets the aforementioned requirements before proceeding with the following steps:
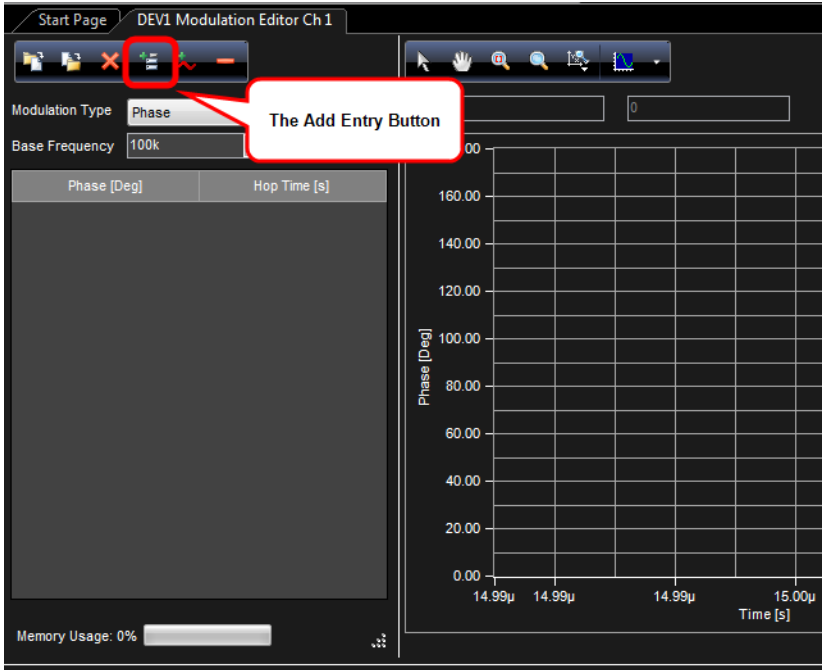
1. Double-click the Waveform Sequencer under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

   The **Waveform Sequencer** is then shown.
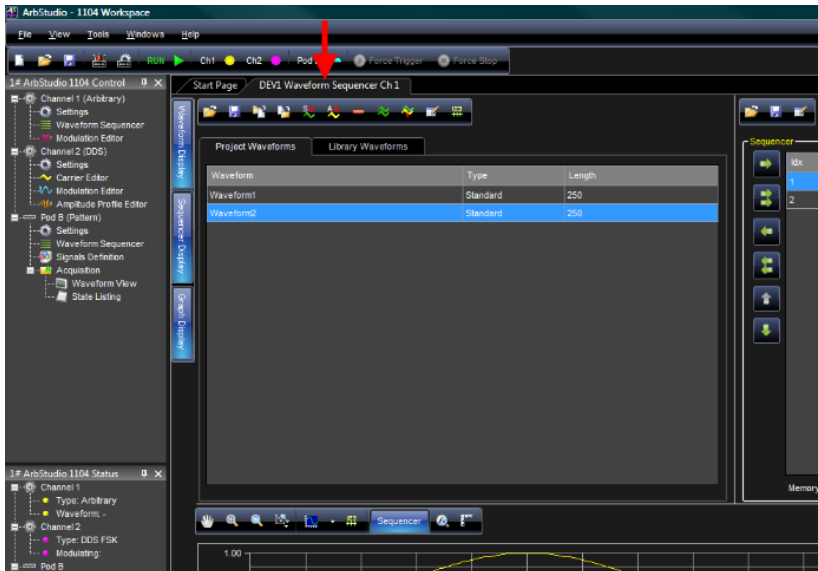
2. Click the **Import Waveform** button.

3. The Import waveform pop-up screen is shown.

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

A. Click the **Browse** button and locate your desired .trc (Teledyne LeCroy oscilloscope file format) file for import. ArbStudio 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 then the 1102/1104 ARBStudio target sampling rate (250 MS/s), the waveform points are re-sampled and shown on the **Sampling information** fields.

Click **OK** to confirm the import of your waveform.

4. On the Project Waveforms tab under the Waveform Sequencer, select the waveform you just imported and click the **Add Waveform** button (adding your newly imported waveform to the Sequencer).

5. Double-click **Settings** under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

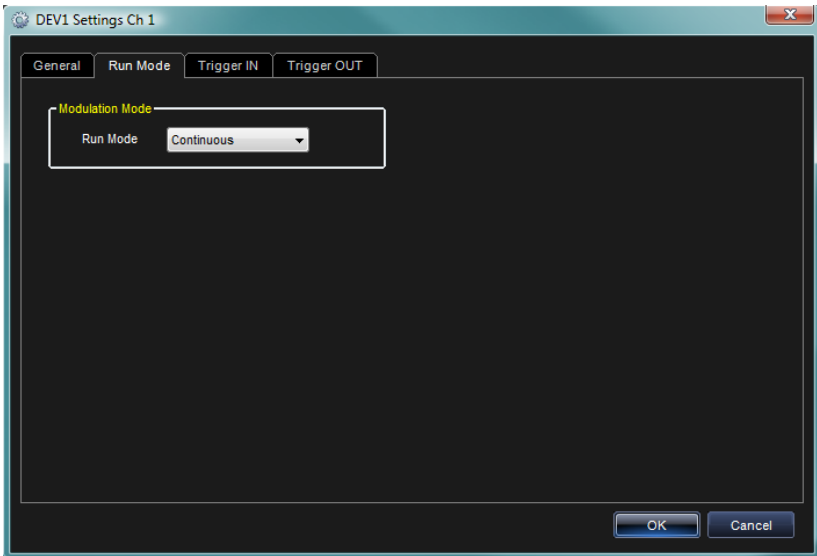The **DEV1 Settings Ch 1** pop-up screen is shown.

The General Tab is shown by default when the pop-up displays. On the General Tab be sure to select an **Output Impedance** value suitable for your impedance load. For example, if you need to connect the instrument to an oscilloscope, select 50 Ω as the output impedance load and 50 Ω as the input impedance on the oscilloscope channel.

6. On the The **DEV1 Settings Ch 1** pop-up screen's **Run Mode** tab, select **Single** and press **OK**.

When the instrument starts, the **Single Run Mode** repeats Waveform1 until you press the **Force Stop** button.
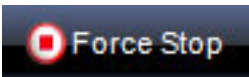
7. Now, press the **Run/Stop** button on the ARBStudio toolbar.

The software loads the settings and the waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

8. Waveform1 is generated on the CH1 BNC output. You can connect an oscilloscope to this output and analyze the signal.

9. Stop generating waveforms by pressing the **Run/Stop** button again or the **Force Stop** button (also on the ARBStudio toolbar).

Creating Digital Waveforms

The ArbStudio 1102/1104 may optionally be configured to work as a powerful Digital Pattern Generator-Sampler.

When the ArbStudio 1102/1104 runs in this mode it can emulate standard serial or parallel bus transitions or custom digital interfaces for system debugging and characterization. Based on a vector/command memory, its architecture also includes a powerful sequencer defining the vector/command execution flow.

NOTE: The following steps are done on an ArbStudio 1104 with the Pattern Generator option enabled.

A workspace with Pattern Generator as the operating mode must first be created in order to create Digital Waveforms.

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

1. Double click the **Signals Definition** under Pod A on the Device Control Tree.
2. The **DEV1 Waveform Sequencer Pod A** pop-up screen is shown.

3. Provide a Name in the **Bus or Signal Name** field. Let's use the name CLK. With the name provided, click the **Add bus or signal** button.

4. Your new Bus/Signal name is then shown in the **Signals** list on the left.
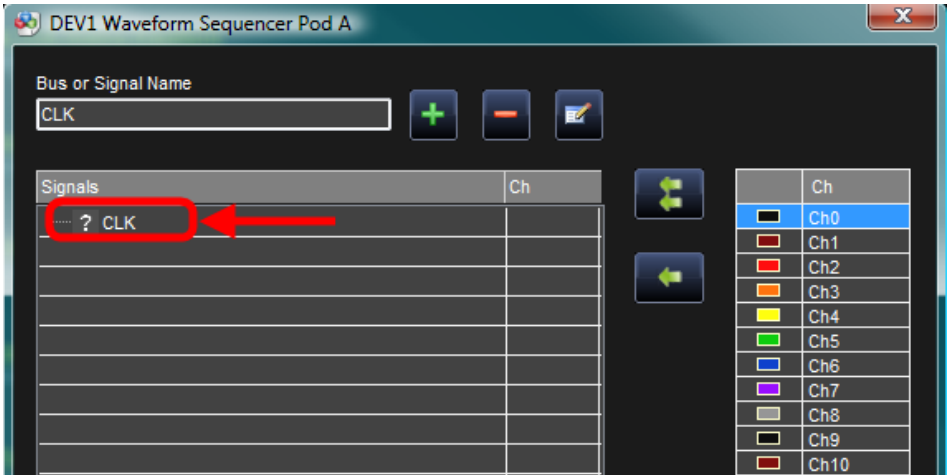
5. Now, let's associate our added Bus/Signal (CLK) with a pod Channel (Ch0) by selecting Ch0 on the channel list on the right, and then clicking the **Change Selected Pod** button.

Our added Bus/Signal (CLK) is now shown as mapped to Ch0.
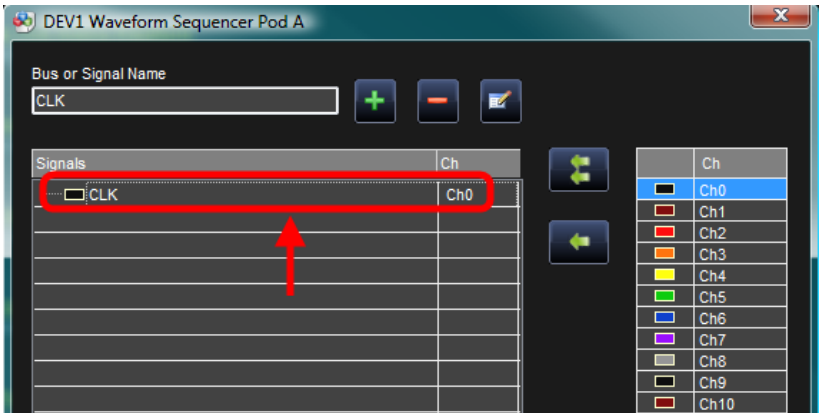
Repeat steps 3 - 5 and create Bus/Signals for **WR** and **RD**, associating them with Ch1 and Ch2, respectively.

6. Now, provide a name for the Data Bus. in the Bus or Signal Name field, click the **Add bus or signal** button, select Ch3 - Ch10, and then click the **Add signals to bus** button.
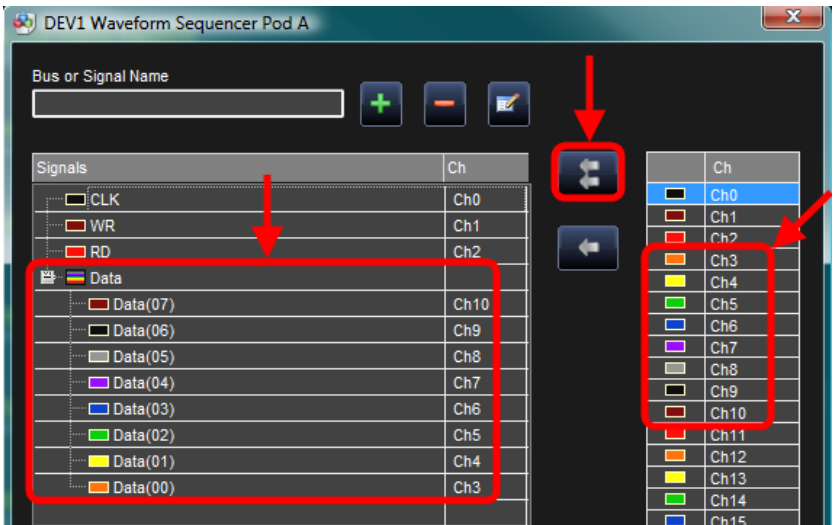
7. Double-click the Pod A (Pattern) **Waveform Sequencer**
8. The **Waveform Sequencer** is then shown.
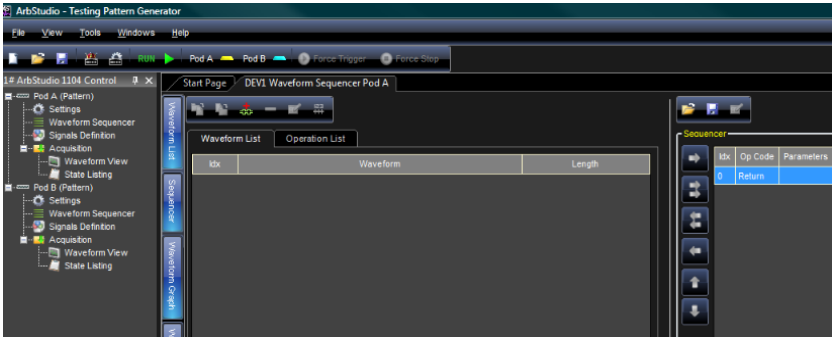
9. Click the **Add Waveform** button to add a digital waveform to the **Waveform List**.
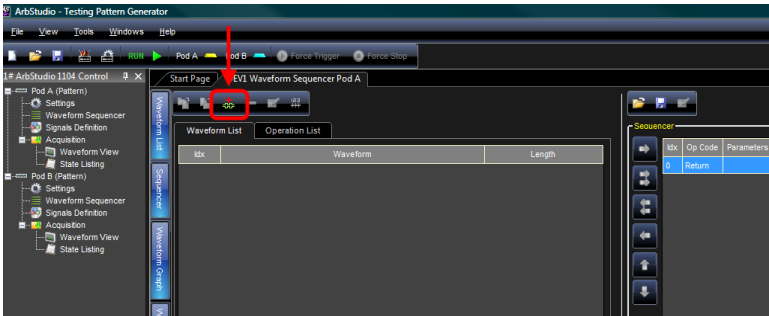
10. The **New Waveform** screen is then shown.
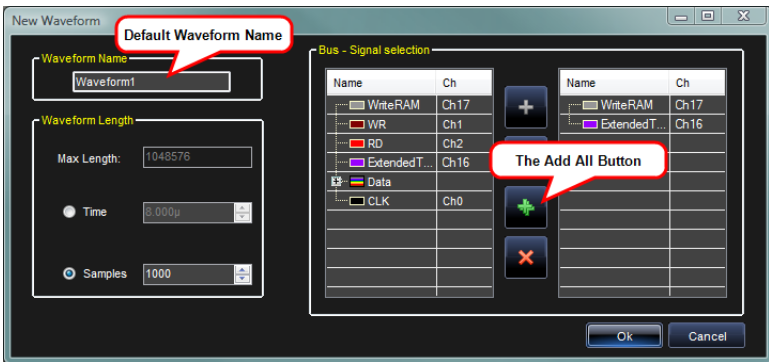
11. Provide a name (the system default is Waveform1), and click the **Add All** button to add all the Bus/Signals to your **New Waveform**.

12. Your newly created waveform is shown on the **Waveform List**.
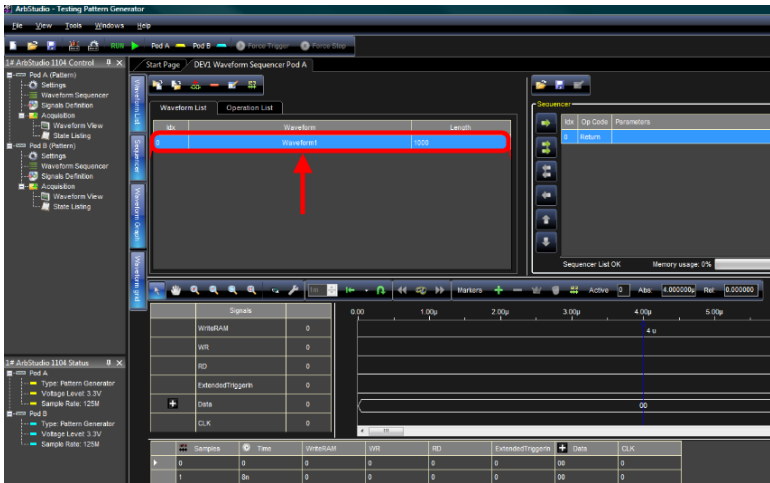
13. Double-click your newly created waveform on the list, or select it and click the **Edit Waveform** button.

14. The **Editing waveform Waveform1** screen is shown.
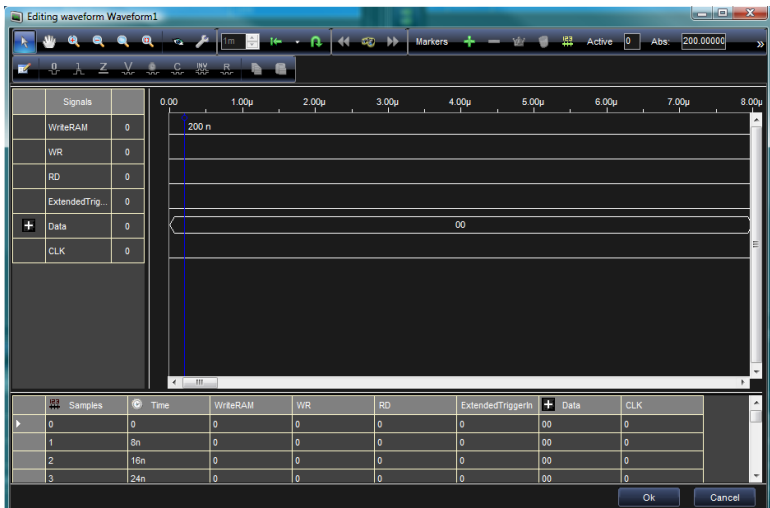
15. Select the **CLK** and **Data** bus rows and use the **Clock** and **Counter** buttons (respectively) to modify settings on the corresponding pop-ups.
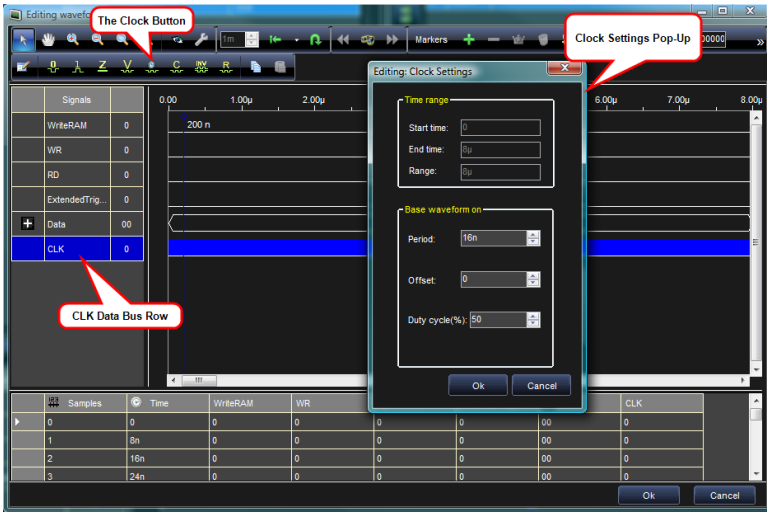
16. Now, define WR, RD and Write RAM signals similarly, by selecting the respective row, and clicking the desired button from the following choices:
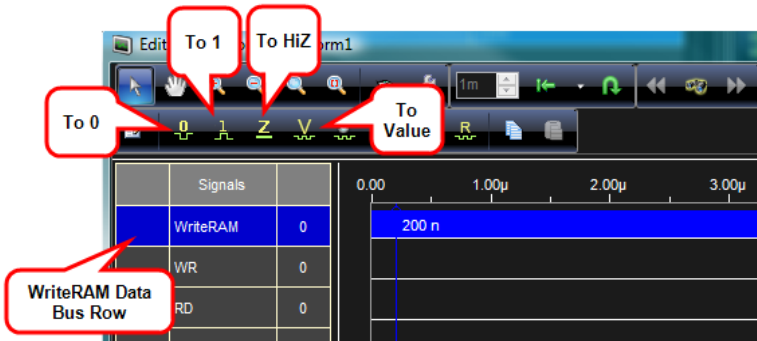
PLEASE NOTE THE FOLLOWING:

- Set the WriterRAM **To 1** to acquire data with the Pattern Generator.
- Setting the WriterRAM **To HiZ** changes the pin directions from output to input.

Click **OK** on the The **Editing waveform Waveform1** screen to confirm your changes.

On the **Waveform Sequencer**, select **Waveform1**, and then add it to the Sequencer by clicking the **Add Waveform** button.

17. Click the Operations List tab on the Waveform Sequencer to select the **Jump to** operation from the Operation List tab. With the Jump To operation selected, add it to the sequencer by clicking the **Add Waveform** button.

> **NOTE**: Don't use a **jump to Address** when prompted by the **Jump to parameters window**.

18. Now, press the **Run/Stop** button on the ARBStudio toolbar.

The software loads the settings and the digital waveforms into the ArbStudio 1102/1104 instrument and starts generating the waveforms.

19. Waveform1 is generated on the Pod A probe. You can connect a logic analyzer to the probes and analyze the generated signals.

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

Creating Waveforms Using Formulas
Overview

When creating standard analog and digital waveforms, **sine** and **squarewave (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 ArbStudio.

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 ArbStudio, you must first create a workspace with Arbitrary Waveform Generator as the Operating Mode and at least one Analog Channel.

PLEASE NOTE THE FOLLOWING:

- At least one **Direct Digital Synthesis (DDS) Channel** must be in your workspace for the **Frequency Modulation**, **Phase Modulation**, and **Linear Frequency Sweep** examples.

- See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details.

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

1. Double-click the Waveform Sequencer under Channel 1 (Arbitrary) on the Device Control Tree. (Channel 1 can be any Analog channel you have configured under Arbitrary Waveform Generator operating mode in your workspace.)

   The **Waveform Sequencer** is then shown.
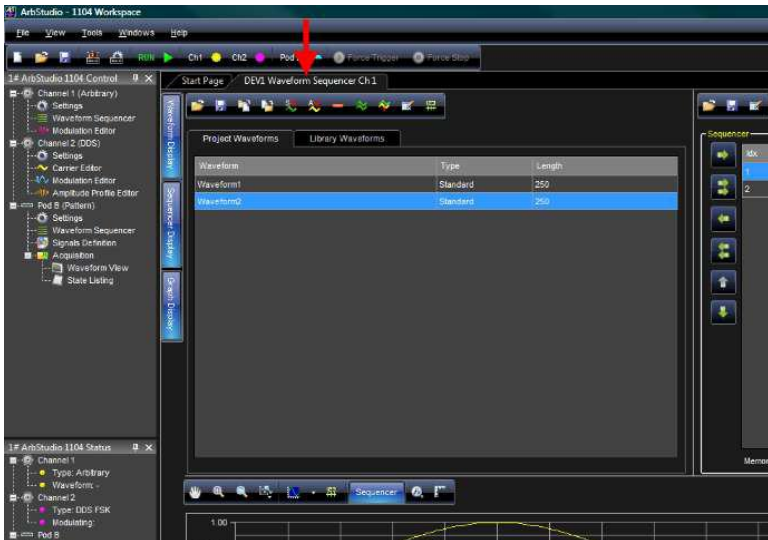
2. Press the **Add Advanced Waveform** button.

3. The **DEV1 Waveform Editor Ch 1** dialog box is shown. Double-click **Component 1**.
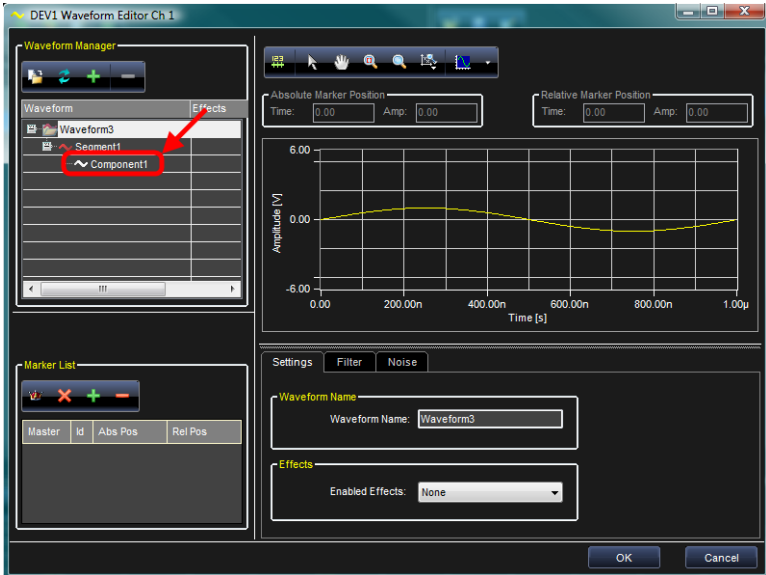
4. The **Component Definition** dialog is then shown in the lower-right area of the **DEV1 Waveform Editor Ch 1** dialog box.

5. In the **Component** area of the **Component Definition** dialog, select **Formula** on the **Type** drop-down control.
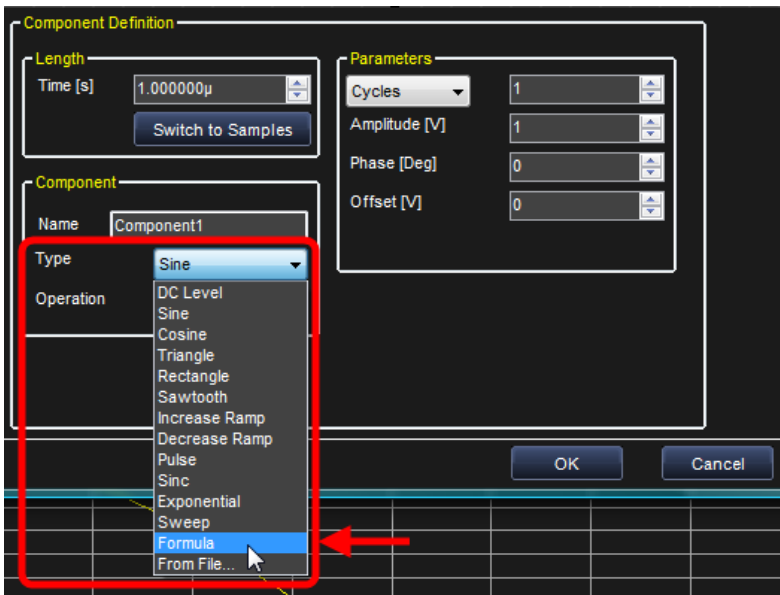
Tip: If desired, use the Name control (directly above the Type control) to rename your Component.

6. A **Formula** area is then shown on the **Component Definition** dialog. Click the **Edit** button under the Formula box.
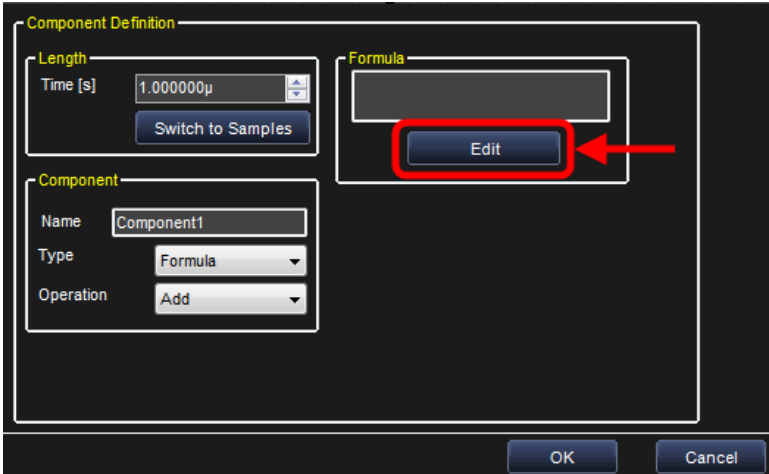
7. The **Formula Editor** is then shown. The editor helps build your waveform analytically using equations. Your equation can be based on time (**t**) or samples (**x**).

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**, **^** (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 **Confirm** button saves your formula and exits the **Formula Editor** showing the **Component Definition** dialog. Your saved formula is shown on the **Formula** area text display box.
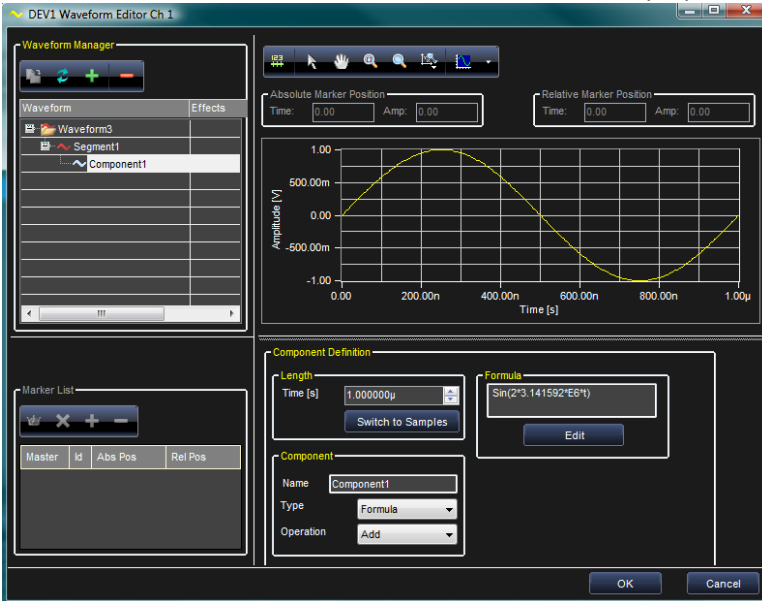
At this point, your newly-created waveform (made using formulas) is now saved as a component.

From here you can create additional components and/or add your newly-created component to the sequencer and output your waveform from ArbStudio.

The next set of topics show example formulas producing various waveform types.

Exponentially Decaying Sine Wave
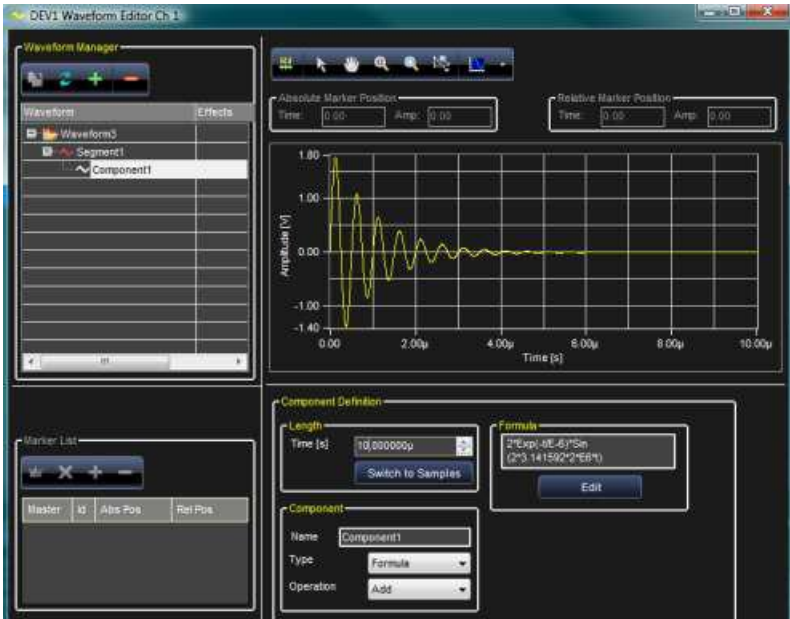
An exponentially decaying 2 MHz sine wave. The actual formula used here is 2*Exp(-t/E-6)*Sin(2*.3.14592*2*E6*t). Set the time to 10.000000µ to view the graph as previously shown.

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. Set the time to 10.000000µ to view the graph as previously shown.

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/(2*E-6)). Set the time to 10.000000μ to view the graph as previously shown.

Formula's General Format

$1-Exp(-t/T_c)$

Where T_c – Time Constant in seconds.

Decaying Exponential

*A decaying exponential waveform. The actual formula used here is Exp(-t/(2*E-6)). Set the time to 10.000000μ to view the graph as previously shown.*

Formula's General Format

$Exp(-t/T_c)$

Where T_c – Time Constant in seconds.

Sine
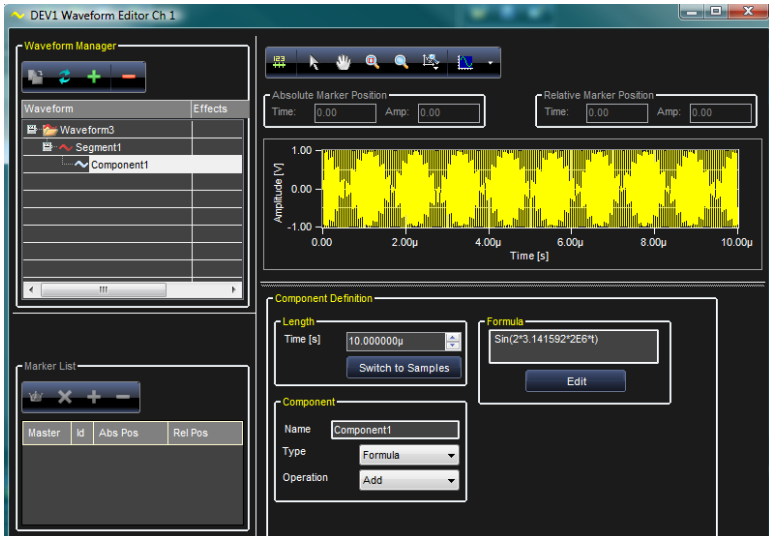
A Sine waveform. The actual formula used here is Sin(2*3.141592*2E6*t). Set the time to 10.000000μ to view the graph as previously shown.

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
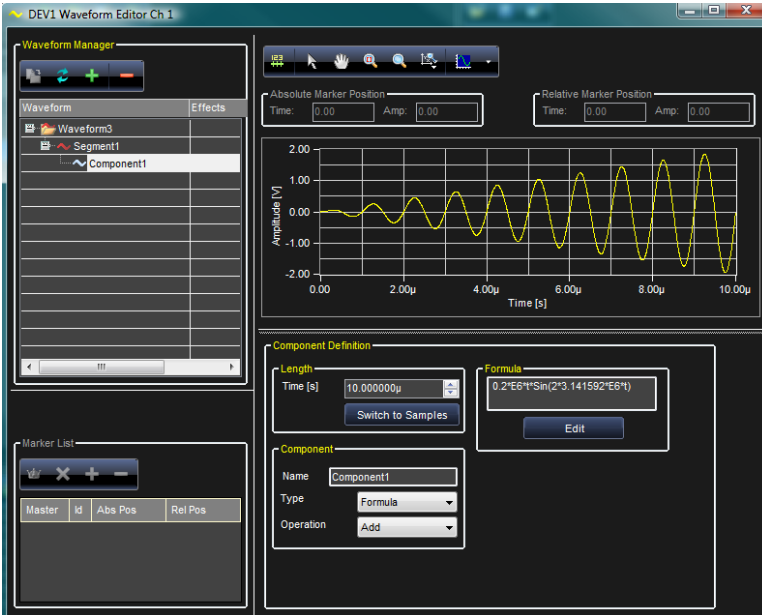
A linear amplitude sweep of a 1 MHz sine waveform. The actual formula used here is 0.2*E6*t*Sin(2*3.141592*E6*t). Set the time to 10.000000µ to view the graph as previously shown.

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

PLEASE NOTE THE FOLLOWING:

- At least one **Direct Digital Synthesis (DDS) Channel** must be in your workspace for this example.

- See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details.

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)). Set the time to 10.000000μ to view the graph as previously shown.

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

PLEASE NOTE THE FOLLOWING:

- At least one **Direct Digital Synthesis (DDS) Channel** must be in your workspace for this example.
- See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details.

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))). Set the time to 10.000000μ to view the graph as previously shown.

Formula's General Format

$Sin((2*pi*t*F_c+ K*Sin(2*pi*t*F_M))$

Where

- F_c – Carrier frequency in Hertz.
- K – Peak phase excursion in radians.
- F_M – Modulation frequency in Hertz.

Linear Frequency Sweep

PLEASE NOTE THE FOLLOWING:

- At least one **Direct Digital Synthesis (DDS) Channel** must be in your workspace for this example.

- See steps 5 and 6 in **Arbitrary Waveform Generator Setup Example** (on page 27) for details.

A linear frequency sweep waveform. The actual formula used here is Sin(3.141592*(2*t*E6+((4*E6-1*E6)/(10*E-6))*t^2)). Set the time to 10.000000µ to view the graph as previously shown.

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
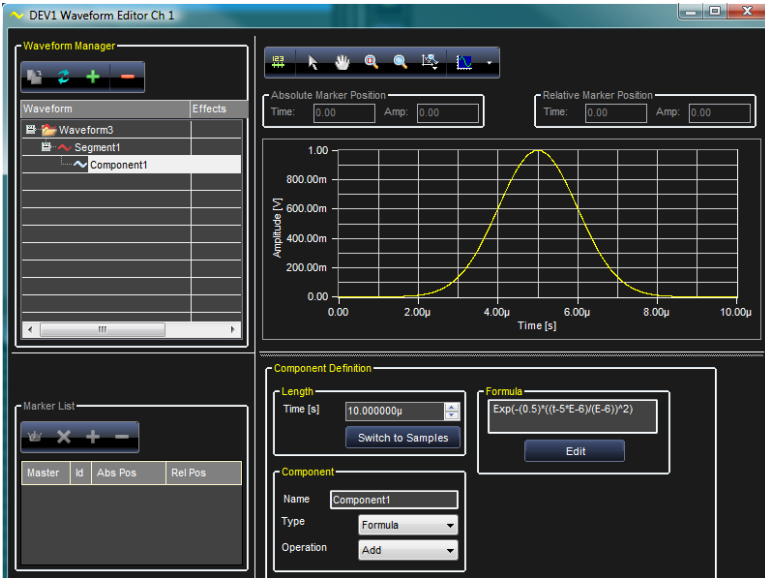
A Gaussian pulse waveform. The actual formula used here is Exp(-(0.5)*((t-5*E-6)/(E-6))^2). Set the time to 10.000000μ to view the graph as previously shown.

Formula's General Format

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

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**.
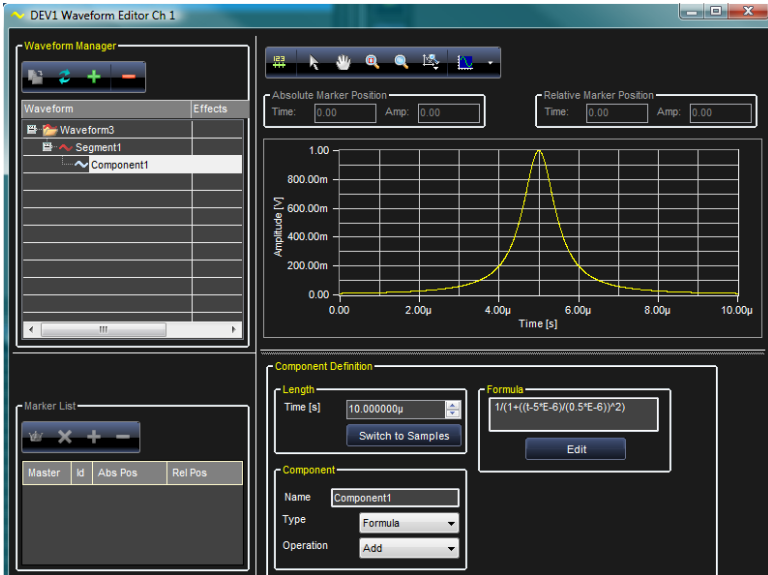
Lorentzian Pulse

A Lorentzian pulse waveform. The actual formula used here is 1/(1+((t-5*E-6)/(0.5*E-6))^2). Set the time to 10.000000µ to view the graph as previously shown.

Formula's General Format

$1/(1+((t-5*T_D)/(T_W))^2)$

Where

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

Amplitude Modulated Sine
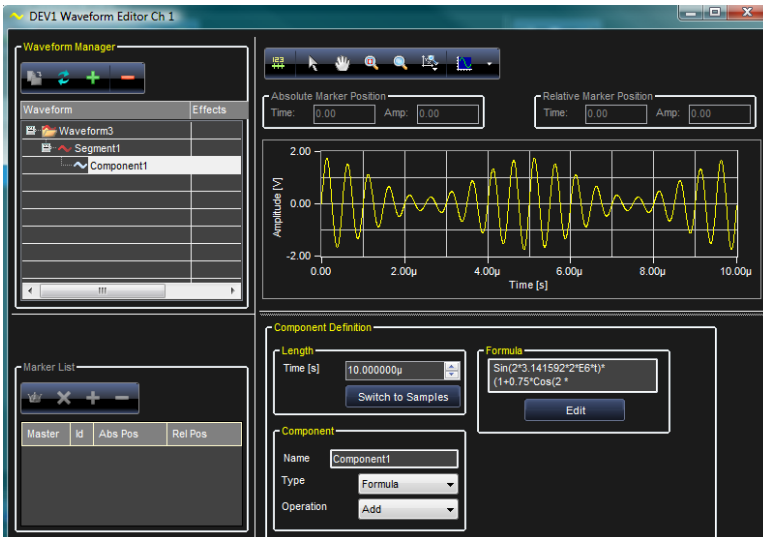
An amplitude modulated sine waveform. The actual formula used here is Sin(2*3.141592*2*E6*t)*(1+0.75*Cos(2 * 3.141592*0.2*E6*t)). Set the time to 10.000000µ to view the graph as previously shown.

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)). Set the time to 10.000000μ to view the graph as previously shown.

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)))). Set the time to 10.000000μ to view the graph as previously shown.

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.

Reference

Certifications

This section contains the instrument's Electromagnetic Compatibility (EMC), Safety and Environmental certifications.

EMC Compliance

EC DECLARATION OF CONFORMITY - EMC

The instrument meets intent of EC Directive 2004/108/EC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 61326-1:2006, EN 61326-2-1:2006 EMC requirements for electrical equipment for measurement, control, and laboratory use. [1]

Electromagnetic Emissions:
CISPR 11:2003, Radiated and Conducted Emissions Group 1, Class A [2][3]

EN 61000-3-2:2006 Harmonic Current Emissions, Class A

EN 61000-3-3/A2:2005 Voltage Fluctuations and Flickers, Pst = 1

Electromagnetic Immunity:
EN 61000-4-2:2001 Electrostatic Discharge, 4 kV contact, 8 kV air, 4 kV vertical/horizontal coupling planes [4]

EN 61000-4-3:2006 RF Radiated Electromagnetic Field, 3 V/m, 80-1000 MHz; 3 V/m, 1400 MHz - 2 GHz; 1 V/m, 2 GHz - 2.7 GHz [4]

EN 61000-4-4:2004 Electrical Fast Transient/Burst, 1 kV on power supply lines, 0.5 kV on I/O signal data and control lines [4]

EN 61000-4-5:2006 Power line Surge, 1 kV AC Mains, L-N, L-PE, N-PE [4]

EN 61000-4-6:2007 RF Conducted Electromagnetic Field, 3 Vrms, 0.15 MHz - 80 MHz [4]

EN 61000-4-11:2004 Mains Dips and Interruptions, 0%/1 cycle, 70%/25 cycles, 0%/250 cycles [4][5]

1 To ensure compliance with all applicable EMC standards, high quality shielded interface cables should be used.

2 Emissions which exceed the levels required by this standard may occur when the instrument is connected to a test object.

3 This product is intended for use in nonresidential areas only. Use in residential areas may cause electromagnetic interference.

4 Meets Performance Criteria "B" limits of the respective standard: during the disturbance, product undergoes a temporary degradation or loss of function or performance which is self-recoverable.

5 Performance Criteria "C" applied for 70%/25 cycle voltage dips and for 0%/250 cycle voltage interruption test levels per EN61000-4-11.

European Contact:
Teledyne LeCroy Europe GmbH
Waldhofer Str 104
D-69123 Heidelberg
Germany
Tel: (49) 6221 82700

AUSTRALIA & NEW ZEALAND DECLARATION OF CONFORMITY – EMC
The instrument complies with the EMC provision of the Radio Communications Act per the following standards, in accordance with requirements imposed by Australian Communication and Media Authority (ACMA):

CISPR 11:2003 Radiated and Conducted Emissions, Group 1, Class A, in accordance with EN61326-1:2006 and EN61326-2-1:2006.

Australia / New Zealand Contacts:

Vicom Australia Ltd.	Vicom New Zealand Ltd.
1064 Centre Road	60 Grafton Road
Oakleigh, South Victoria 3167	Auckland
Australia	New Zealand

Safety Compliance

EC DECLARATION OF CONFORMITY – LOW VOLTAGE
The instrument meets intent of EC Directive 2006/95/EC for Product Safety. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 61010-1:2010 Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements

EN 61010-2:030:2010 Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits

Environmental Compliance

END-OF-LIFE HANDLING
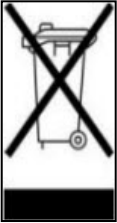
The instrument is marked with this symbol to indicate that it complies with the applicable European Union requirements to Directives 2002/96/EC and 2006/66/EC on Waste Electrical and Electronic Equipment (WEEE) and Batteries. The instrument is subject to disposal and recycling regulations that vary by country and region. Many countries prohibit the disposal of waste electronic equipment in standard waste receptacles. For more information about proper disposal and recycling of your Teledyne LeCroy product, please visit teledynelecroy.com/recycle.

RESTRICTION OF HAZARDOUS SUBSTANCES (RoHS) EC

This instrument has been classified as Industrial Monitoring and Control Equipment, and is outside the scope of the 2011/65/EU RoHS Directive (Exempt until July 2017, per Article 4).

RESTRICTION OF HAZARDOUS SUBSTANCES (RoHS) CHINA

EFUP (Environmental Friendly Use Period) Use Conditions: refer to environmental conditions stated in the Safety section of this manual. Also, consult the RoHS Compliance for China insert included with your product.

Windows® License Agreement

Teledyne LeCroy's agreement with Microsoft prohibits users from running software on Teledyne LeCroy X-Stream oscilloscopes that is not relevant to measuring, analyzing, or documenting waveforms.

X-Stream Software End-User License Agreement

IMPORTANT-READ CAREFULLY: THIS END-USER LICENSE AGREEMENT ("EULA") IS A LEGAL AGREEMENT BETWEEN THE INDIVIDUAL OR ENTITY LICENSING THE SOFTWARE PRODUCT ("YOU" OR "YOUR") AND TELEDYNE LECROY CORPORATION ("TELEDYNE LECROY") FOR THE SOFTWARE PRODUCT(S) ACCOMPANYING THIS EULA, WHICH INCLUDE(S): COMPUTER PROGRAMS; ANY "ONLINE" OR ELECTRONIC DOCUMENTATION AND PRINTED MATERIALS PROVIDED BY TELEDYNE LECROY HEREWITH

("DOCUMENTATION"); ASSOCIATED MEDIA; AND ANY UPDATES (AS DEFINED BELOW) (COLLECTIVELY, THE "SOFTWARE PRODUCT"). BY USING AN INSTRUMENT TOGETHER WITH OR CONTAINING THE SOFTWARE PRODUCT, OR BY INSTALLING, COPYING, OR OTHERWISE USING THE SOFTWARE PRODUCT, IN WHOLE OR IN PART, YOU AGREE TO BE BOUND BY THE TERMS OF THIS EULA. IF YOU DO NOT AGREE TO THE TERMS OF THIS EULA, DO NOT INSTALL, COPY, OR OTHERWISE USE THE SOFTWARE PRODUCT; YOU MAY RETURN THE SOFTWARE PRODUCT TO YOUR PLACE OF PURCHASE FOR A FULL REFUND. IN ADDITION, BY INSTALLING, COPYING, OR OTHERWISE USING ANY MODIFICATIONS, ENHANCEMENTS, NEW VERSIONS, BUG FIXES, OR OTHER COMPONENTS OF THE SOFTWARE PRODUCT THAT TELEDYNE LECROY PROVIDES TO YOU SEPARATELY AS PART OF THE SOFTWARE PRODUCT ("UPDATES"), YOU AGREE TO BE BOUND BY ANY ADDITIONAL LICENSE TERMS THAT ACCOMPANY SUCH UPDATES. IF YOU DO NOT AGREE TO SUCH ADDITIONAL LICENSE TERMS, YOU MAY NOT INSTALL, COPY, OR OTHERWISE USE SUCH UPDATES.

THE PARTIES CONFIRM THAT THIS AGREEMENT AND ALL RELATED DOCUMENTATION ARE AND WILL BE DRAFTED IN ENGLISH. LES PARTIES AUX PRÉSENTÉS CONFIRMENT LEUR VOLONTÉ QUE CETTE CONVENTION DE MÊME QUE TOUS LES DOCUMENTS Y COMPRIS TOUT AVIS QUI S'Y RATTACHÉ, SOIENT REDIGÉS EN LANGUE ANGLAISE.

1. **GRANT OF LICENSE**.

    1.1. **License Grant**. Subject to the terms and conditions of this EULA and payment of all applicable fees, Teledyne LeCroy grants to you a nonexclusive, nontransferable license (the "License") to: (a) operate the Software Product as provided or installed, in object code form, for your own internal business purposes, (i) for use in or with an instrument provided or manufactured by Teledyne LeCroy (an "Instrument"), (ii) for testing your software product(s) (to be used solely by you) that are designed to operate in conjunction with an Instrument ("Your Software"), and (iii) make one copy for archival and back-up purposes; (b) make and use copies of the Documentation; provided that such copies will be used only in connection with your licensed use of the Software Product, and such copies may not be republished or distributed (either in hard copy or electronic form) to any third party; and (c) copy, modify, enhance and prepare derivative works ("Derivatives") of the source code

version of those portions of the Software Product set forth in and identified in the Documentation as "Samples" ("Sample Code") for the sole purposes of designing, developing, and testing Your Software. If you are an entity, only one designated individual within your organization, as designated by you, may exercise the License; provided that additional individuals within your organization may assist with respect to reproducing and distributing Sample Code as permitted under Section 1.1(c)(ii). Teledyne LeCroy reserves all rights not expressly granted to you. No license is granted hereunder for any use other than that specified herein, and no license is granted for any use in combination or in connection with other products or services (other than Instruments and Your Software) without the express prior written consent of Teledyne LeCroy. The Software Product is licensed as a single product. Its component parts may not be separated for use by more than one user. This EULA does not grant you any rights in connection with any trademarks or service marks of Teledyne LeCroy. The Software Product is protected by copyright laws and international copyright treaties, as well as other intellectual property laws and treaties. The Software Product is licensed, not sold. The terms of this printed, paper EULA supersede the terms of any on-screen license agreement found within the Software Product.

1.2. **Upgrades**. If the Software Product is labeled as an "upgrade," (or other similar designation) the License will not take effect, and you will have no right to use or access the Software Product unless you are properly licensed to use a product identified by Teledyne LeCroy as being eligible for the upgrade ("Underlying Product"). A Software Product labeled as an "upgrade" replaces and/or supplements the Underlying Product. You may use the resulting upgraded product only in accordance with the terms of this EULA. If the Software Product is an upgrade of a component of a package of software programs that you licensed as a single product, the Software Product may be used and transferred only as part of that single product package and may not be separated for use on more than one computer.

1.3. **Limitations**. Except as specifically permitted in this EULA, you will not directly or indirectly (a) use any Confidential Information to create any software or documentation that is similar to any of the

Software Product or Documentation; (b) encumber, transfer, rent, lease, time-share or use the Software Product in any service bureau arrangement; (c) copy (except for archival purposes), distribute, manufacture, adapt, create derivative works of, translate, localize, port or otherwise modify the Software Product or the Documentation; (d) permit access to the Software Product by any party developing, marketing or planning to develop or market any product having functionality similar to or competitive with the Software Product; (e) publish benchmark results relating to the Software Product, nor disclose Software Product features, errors or bugs to third parties; or (f) permit any third party to engage in any of the acts proscribed in clauses (a) through (e). In jurisdictions in which transfer is permitted, notwithstanding the foregoing prohibition, transfers will only be effective if you transfer a copy of this EULA, as well as all copies of the Software Product, whereupon your right to use the Software product will terminate. Except as described in this Section 1.3, You are not permitted (i) to decompile, disassemble, reverse compile, reverse assemble, reverse translate or otherwise reverse engineer the Software Product, (ii) to use any similar means to discover the source code of the Software Product or to discover the trade secrets in the Software Product, or (iii) to otherwise circumvent any technological measure that controls access to the Software Product. You may reverse engineer or otherwise circumvent the technological measures protecting the Software Product for the sole purpose of identifying and analyzing those elements that are necessary to achieve Interoperability (the "Permitted Objective") only if: (A) doing so is necessary to achieve the Permitted Objective and it does not constitute infringement under Title 17 of the United States Code; (B) such circumvention is confined to those parts of the Software Product and to such acts as are necessary to achieve the Permitted Objective; (C) the information to be gained thereby has not already been made readily available to you or has not been provided by Teledyne LeCroy within a reasonable time after a written request by you to Teledyne LeCroy to provide such information; (D) the information gained is not used for any purpose other than the Permitted Objective and is not disclosed to any other person except as may be necessary to achieve the Permitted Objective; and (E) the information obtained is not used (1) to create a computer program substantially similar in its

expression to the Software Product including, but not limited to, expressions of the Software Product in other computer languages, or (2) for any other act restricted by Teledyne LeCroy's intellectual property rights in the Software Product. "Interoperability" will have the same meaning in this EULA as defined in the Digital Millennium Copyright Act, 17 U.S.C. §1201(f), the ability of computer programs to exchange information and of such programs mutually to use the information which has been exchanged.

1.4. **PRERELEASE CODE**. Portions of the Software Product may be identified as prerelease code ("Prerelease Code"). Prerelease Code is not at the level of performance and compatibility of the final, generally available product offering. The Prerelease Code may not operate correctly and may be substantially modified prior to first commercial shipment. Teledyne LeCroy is not obligated to make this or any later version of the Prerelease Code commercially available. The License with respect to the Prerelease Code terminates upon availability of a commercial release of the Prerelease Code from Teledyne LeCroy.

2. **SUPPORT SERVICES**.

At Teledyne LeCroy's sole discretion, from time to time, Teledyne LeCroy may provide Updates to the Software Product. Teledyne LeCroy shall have no obligation to revise or update the Software Product or to support any version of the Software Product. At Teledyne LeCroy's sole discretion, upon your request, Teledyne LeCroy may provide you with support services related to the Software Product ("Support Services") pursuant to the Teledyne LeCroy policies and programs described in the Documentation or otherwise then in effect, and such Support Services will be subject to Teledyne LeCroy's then-current fees therefor, if any. Any Update or other supplemental software code provided to you pursuant to the Support Services will be considered part of the Software Product and will be subject to the terms and conditions of this EULA. Teledyne LeCroy may use any technical information you provide to Teledyne LeCroy during Teledyne LeCroy's provision of Support Services, for Teledyne LeCroy's business purposes, including for product support and development. Teledyne LeCroy will not utilize such technical information in a form that personally identifies you.

3. **PROPRIETARY RIGHTS**.

3.1. **Right and Title**. All right, title and interest in and to the Software Product and Documentation (including but not limited to any intellectual property or other proprietary rights, images, icons, photographs, text, and "applets" embodied in or incorporated into the Software Product, collectively, "Content"), and all Derivatives, and any copies thereof are owned by Teledyne LeCroy and/or its licensors or third-party suppliers, and is protected by applicable copyright or other intellectual property laws and treaties. You will not take any action inconsistent with such title and ownership. This EULA grants you no rights to use such Content outside of the proper exercise of the license granted hereunder, and Teledyne LeCroy will not be responsible or liable therefor.

3.2. **Intellectual Property Protection**. You may not alter or remove any printed or on-screen copyright, trade secret, proprietary or other legal notices contained on or in copies of the Software Product or Documentation.

3.3. **Confidentiality**. Except for the specific rights granted by this EULA, neither party shall use or disclose any Confidential Information (as defined below) of the other party without the written consent of the disclosing party. A party receiving Confidential Information from the other shall use the highest commercially reasonable degree of care to protect the Confidential Information, including ensuring that its employees and consultants with access to such Confidential Information have agreed in writing not to disclose the Confidential Information. You shall bear the responsibility for any breaches of confidentiality by your employees and consultants. Within ten (10) days after request of the disclosing party, and in the disclosing party's sole discretion, the receiving party shall either return to the disclosing party originals and copies of any Confidential Information and all information, records and materials developed therefrom by the receiving party, or destroy the same, other than such Confidential Information as to which this EULA expressly provides a continuing right to the receiving party to retain at the time of the request. Either party may only disclose the general nature, but not the specific financial terms, of this EULA without the prior consent of the other party; provided either party may provide a copy of this EULA to any finance provider in

conjunction with a financing transaction, if such provider agrees to keep this EULA confidential.   Nothing herein shall prevent a receiving party from disclosing all or part of the Confidential Information as necessary pursuant to the lawful requirement of a governmental agency or when disclosure is required by operation of law; provided that prior to any such disclosure, the receiving party shall use reasonable efforts to (a) promptly notify the disclosing party in writing of such requirement to disclose, and (b) cooperate fully with the disclosing party in protecting against any such disclosure or obtaining a protective order. Money damages will not be an adequate remedy if this Section 4.3 is breached and, therefore, either party shall, in addition to any other legal or equitable remedies, be entitled to seek an injunction or similar equitable relief against such breach or threatened breach without the necessity of posting any bond. As used herein, "Confidential Information" means Teledyne LeCroy pricing or information concerning new Teledyne LeCroy products, trade secrets (including without limitation all internal header information contained in or created by the Software Product, all benchmark and performance test results and all Documentation) and other proprietary information of Teledyne LeCroy; and any business, marketing or technical information disclosed by Teledyne LeCroy, or its representatives, or you in relation to this EULA, and either (i) disclosed in writing and marked as confidential at the time of disclosure or (ii) disclosed in any other manner such that a reasonable person would understand the nature and confidentiality of the information. Confidential Information does not include information (A) already in the possession of the receiving party without an obligation of confidentiality to the disclosing party, (B) hereafter rightfully furnished to the receiving party by a third party without a breach of any separate nondisclosure obligation to the disclosing party, (C) publicly known without breach of this EULA, (d) furnished by the disclosing party to a third party without restriction on subsequent disclosure, or (e) independently developed by the receiving party without reference to or reliance on the Confidential Information.

4. **TERMINATION**.

This EULA will remain in force until termination pursuant to the terms hereof. You may terminate this EULA at any time. This EULA will also terminate if you breach any of the terms or conditions of this EULA. You agree that if this EULA terminates for any reason, the License will immediately terminate and you will destroy all copies of the Software Product (and all Derivatives), installed or otherwise, the Documentation, and the Confidential Information (and all derivatives of any of the foregoing) that are in your possession or under your control. The provisions of Sections 1.3, 4, 6, 7, 8, and 9 will survive any termination or expiration hereof.

5. **U.S. GOVERNMENT RESTRICTED RIGHTS**.

   If any Software Product or Documentation is acquired by or on behalf of a unit or agency of the United States Government (any such unit or agency, the "Government"), the Government agrees that the Software Product or Documentation is "commercial computer software" or "commercial computer software documentation" and that, absent a written agreement to the contrary, the Government's rights with respect to the Software Product or Documentation are, in the case of civilian agency use, Restricted Rights, as defined in FAR §52.227.19, and if for Department of Defense use, limited by the terms of this EULA, pursuant to DFARS §227.7202. The use of the Software Product or Documentation by the Government constitutes acknowledgment of Teledyne LeCroy's proprietary rights in the Software Product and Documentation. Manufacturer is Teledyne LeCroy Corporation, 700 Chestnut Ridge Road, Chestnut Ridge, NY 10977 USA.

6. **EXPORT RESTRICTIONS**.

   You agree that you will not export or re-export the Software Product, any part thereof, or any process or service that is the direct product of the Software Product (the foregoing collectively referred to as the "Restricted Components"), to any country, person, entity or end user subject to U.S. export restrictions. You specifically agree not to export or re-export any of the Restricted Components (a) to any country to which the U.S. has embargoed or restricted the export of goods or services, which currently include, but are not necessarily limited to Cuba, Iran, Iraq, Libya, North Korea, Sudan and Syria, or to any national of any such country, wherever located, who intends to transmit or transport the Restricted Components back to

such country; (b) to any end user who you know or have reason to know will utilize the Restricted Components in the design, development or production of nuclear, chemical or biological weapons; or (c) to any end-user who has been prohibited from participating in U.S. export transactions by any federal agency of the U.S. government. You warrant and represent that neither the BXA nor any other U.S. federal agency has suspended, revoked or denied your export privileges. It is your responsibility to comply with the latest United States export regulations, and you will defend and indemnify Teledyne LeCroy from and against any damages, fines, penalties, assessments, liabilities, costs and expenses (including reasonable attorneys' fees and court costs) arising out of any claim that the Software Product, Documentation, or other information or materials provided by Teledyne LeCroy hereunder were exported or otherwise accessed, shipped or transported in violation of applicable laws and regulations.

7. **RISK ALLOCATION**.

7.1. **No Warranty**. THE SOFTWARE PRODUCT IS NOT ERROR-FREE AND THE SOFTWARE PRODUCT AND SUPPORT SERVICES IS/ARE BEING PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND. TELEDYNE LECROY, FOR ITSELF AND ITS SUPPLIERS, HEREBY DISCLAIMS ALL WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE SOFTWARE PRODUCT OR ANY SUPPORT SERVICES INCLUDING, WITHOUT LIMITATION, ALL IMPLIED WARRANTIES OF TITLE OR NON-INFRINGEMENT, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY, INTEGRATION, VALIDITY, EXCLUSIVITY, MERCHANTABILITY, NON-INTERFERENCE WITH ENJOYMENT, FITNESS FOR ANY PARTICULAR PURPOSE, AND ALL WARRANTIES IMPLIED FROM ANY COURSE OF DEALING OR USAGE OF TRADE. YOU ACKNOWLEDGE THAT NO WARRANTIES HAVE BEEN MADE TO YOU BY OR ON BEHALF OF TELEDYNE LECROY OR OTHERWISE FORM THE BASIS FOR THE BARGAIN BETWEEN THE PARTIES.

7.2. **Limitation of Liability**. TELEDYNE LECROY'S LIABILITY FOR DAMAGES FOR ANY CAUSE WHATSOEVER, REGARDLESS OF THE FORM OF ANY CLAIM OR ACTION, SHALL NOT EXCEED THE GREATER OF THE AMOUNT ACTUALLY PAID BY YOU FOR THE SOFTWARE PRODUCT OR U.S.$5.00; PROVIDED THAT IF YOU HAVE ENTERED

INTO A SUPPORT SERVICES AGREEMENT WITH TELEDYNE LECROY, TELEDYNE LECROY'S ENTIRE LIABILITY REGARDING SUPPORT SERVICES WILL BE GOVERNED BY THE TERMS OF THAT AGREEMENT. TELEDYNE LECROY SHALL NOT BE LIABLE FOR ANY LOSS OF PROFITS, LOSS OF USE, LOSS OF DATA, INTERRUPTION OF BUSINESS, NOR FOR INDIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES OF ANY KIND, WHETHER UNDER THIS EULA OR OTHERWISE ARISING IN ANY WAY IN CONNECTION WITH THE SOFTWARE PRODUCT, THE DOCUMENTATION OR THIS EULA. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE EXCLUSION OR LIMITATION MAY NOT APPLY TO YOU. THESE LIMITATIONS ARE INDEPENDENT FROM ALL OTHER PROVISIONS OF THIS EULA AND SHALL APPLY NOTWITHSTANDING THE FAILURE OF ANY REMEDY PROVIDED HEREIN.

7.3. **Indemnification**. You will defend, indemnify and hold harmless Teledyne LeCroy and its officers, directors, affiliates, contractors, agents, and employees from, against and in respect of any and all assessments, damages, deficiencies, judgments, losses, obligations and liabilities (including costs of collection and reasonable attorneys' fees, expert witness fees and expenses) imposed upon or suffered or incurred by them arising from or related to your use of the Software Product.

8. **GENERAL PROVISIONS**.

8.1. **Compliance with Laws**. You will comply with all laws, legislation, rules, regulations, and governmental requirements with respect to the Software Product, and the performance by you of your obligations hereunder, of any jurisdiction in or from which you directly or indirectly cause the Software Product to be used or accessed.

8.2. **No Agency**. Nothing contained in this EULA will be deemed to constitute either party as the agent or representative of the other party, or both parties as joint venturers or partners for any purpose.

8.3. **Entire Agreement; Waiver; Severability**. This EULA constitutes the entire agreement between the parties with regard to the subject matter hereof. No provision of, right, power or privilege under this EULA will be deemed to have been waived by any act, delay,

omission or acquiescence by Teledyne LeCroy, its agents, or employees, but only by an instrument in writing signed by an authorized officer of Teledyne LeCroy. No waiver by Teledyne LeCroy of any breach or default of any provision of this EULA by you will be effective as to any other breach or default, whether of the same or any other provision and whether occurring prior to, concurrent with, or subsequent to the date of such waiver. If any provision of this EULA is declared by a court of competent jurisdiction to be invalid, illegal or unenforceable, such provision will be severed from this EULA and all the other provisions will remain in full force and effect.

8.4. **Governing Law; Jurisdiction; Venue**. This EULA will be governed by and construed in accordance with the laws of the State of New York, USA, without regard to its choice of law provisions. The United Nations Convention on Contracts for the International Sale of Goods will not apply to this EULA. Exclusive jurisdiction and venue for any litigation arising under this EULA is in the federal and state courts located in New York, New York, USA and both parties hereby consent to such jurisdiction and venue for this purpose.

8.5. **Assignment**. This EULA and the rights and obligations hereunder, may not be assigned, in whole or in part by you, except to a successor to the whole of your business, without the prior written consent of Teledyne LeCroy. In the case of any permitted assignment or transfer of or under this EULA, this EULA or the relevant provisions will be binding upon, and inure to the benefit of, the successors, executors, heirs, representatives, administrators and assigns of the parties hereto.

8.6. **Notices**. All notices or other communications between Teledyne LeCroy and you under this EULA will be in writing and delivered personally, sent by confirmed fax, by confirmed e-mail, by certified mail, postage prepaid and return receipt requested, or by a nationally recognized express delivery service. All notices will be in English and will be effective upon receipt.

8.7. **Headings**. The headings used in this EULA are intended for convenience only and will not be deemed to supersede or modify any provisions.

8.8. **Acknowledgment**. Licensee acknowledges that (a) it has read and understands this EULA, (b) it has had an opportunity to have its legal counsel review this EULA, (c) this EULA has the same force and effect as a signed agreement, and (d) issuance of this EULA does not constitute general publication of the Software Product or other Confidential Information.

Contact Teledyne LeCroy

Teledyne LeCroy Service Centers	
United States and Canada - ***World Wide Corporate Office*** Teledyne LeCroy Corporation 700 Chestnut Ridge Road Chestnut Ridge, NY, 10977-6499, USA Ph: 800-553-2769 / 845-425-2000 FAX: 845-578-5985 teledynelecroy.com **Support**: contact.corp@teledynelecroy.com **Sales**: customersupport@teledynelecroy.com	***United States - Protocol Solutions Group*** Teledyne LeCroy Corporation 3385 Scott Boulevard Santa Clara, CA, 95054, USA FAX: 408-727-0800 teledynelecroy.com **Sales and Service**: Ph: 800-909-7211 / 408-727-6600 contact.corp@teledynelecroy.com **Support**: Ph: 800-909-7112 / 408-653-1260 psgsupport@teledynelecroy.com
European Headquarters Teledyne LeCroy SA 4, Rue Moïse Marcinhes Case postale 341 1217 Meyrin 1 Geneva, Switzerland Ph: + 41 22 719 2228 / 2323 /2277 FAX:+41 22 719 2233 contact.sa@teledynelecroy.com applications.indirect@teledynelecroy.com teledynelecroy.com/europe **Protocol Analyzers:** Ph: +44 12 765 03971	***Singapore, Oscillosocpes*** Teledyne LeCroy Singapore Pte Ltd. Blk 750C Chai Chee Road #02-08 Technopark @ Chai Chee Singapore 469003 Ph: ++ 65 64424880 FAX: ++ 65 64427811 ***Singapore, Protocol Analyzers*** Genetron Singapore Pte Ltd. 37 Kallang Pudding Road, #08-08 Tong Lee Building Block B Singapore 349315 Ph: ++ 65 9760-4682
China Teledyne LeCroy Corporation Beijing Rm. 2001 - Office; Rm. 2002 - Service Center Unit A, Horizon Plaza No. 6, Zhichun Road, Haidian District Beijing 100088, China Ph: ++86 10 8280 0318 / 0319 / 0320 FAX:++86 10 8280 0316 **Service:** Rm. 2002 Ph: ++86 10 8280 0245	***Korea*** Teledyne LeCroy Korea 10th fl.Ildong Bldg. 968-5 Daechi-dong, Gangnam-gu Seoul 135-280, Korea Ph: ++ 82 2 3452 0400 FAX: ++ 82 2 3452 0490
Taiwan LeColn Technology Co Ltd. Far East Century Park, C3, 9F No. 2, Chien-8th Road, Chung-Ho Dist., New Taipei City, Taiwan Ph: ++ 886 2 8226 1366 FAX: ++ 886 2 8226 1368	***Japan*** Teledyne LeCroy Japan Hobunsya Funchu Bldg, 3F 3-11-5, Midori-cho, Fuchu-Shi Tokyo 183-0006, Japan Ph: ++ 81 4 2402 9400 FAX: ++ 81 4 2402 9586 teledynelecroy.com/japan

Index

ArbStudio

TELEDYNE LECROY
Everywhere**you**look™

700 Chestnut Ridge Road
Chestnut Ridge, NY 10977
USA
www.teledynelecroy.com