Tektronix®

SourceXpress®
Waveform Creation Application

Printable Help Document

077-1145-05

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Waveform Creation Application

Printable Help Document

www.tek.com
077-1145-05

Supports SourceXpress Software Version 6.1 and above.

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Contacting Tektronix

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- In North America, call 1-800-833-9200.
- Worldwide, visit www.tek.com to find contacts in your area.

Table of Contents

Sequence list

Sequencer batch compiler

Waveform plug-ins

Welcome

SourceXpress is a waveform creation software application. With the various optional waveform modules, you're able to create a wide variety of digitally modulated signals and impairment waveforms.

SourceXpress is designed to interface seamlessly with the AWG70000 and AWG5200 Series arbitrary waveform generators, either connected to a virtual generator or connected to an instrument.

Connected to a Virtual Generator. The startup mode is for SourceXpress to connect to a Virtual generator. By default, a virtual generator is created when the software is installed. You can configure as many virtual generators as you want.

When connected to a virtual generator, SourceXpress provides a simulation of the instrument's interface, allowing you access to all controls and settings as if you were working with an actual instrument.

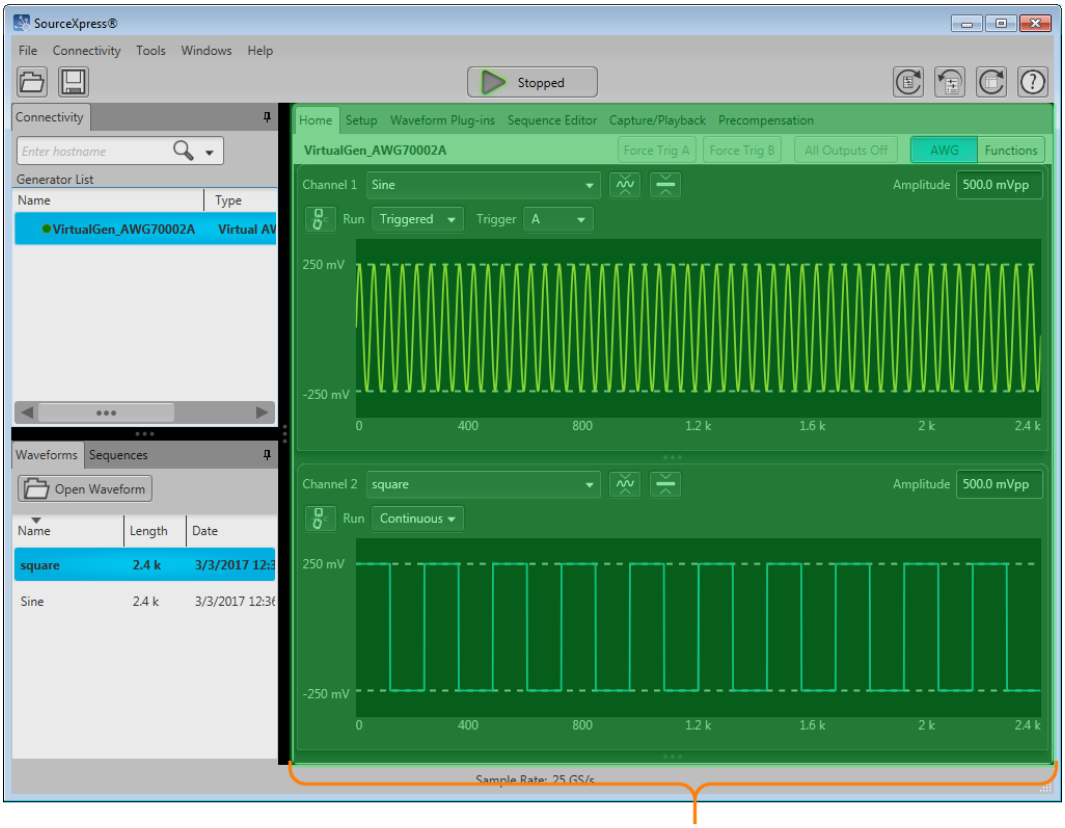
Because you can create as many virtual generators as you like, each with different configurations, you can create all your waveforms, sequences, and setups specific to instrument types, all in the absence of an instrument. Then, when an instrument is available, you can simply recall your saved files.

Connected to an instrument. With SourceXpress installed on a networked PC, the software can scan the network for compatible instruments and connect directly to the instrument. The interface of the instrument is displayed in the SourceXpress application window, providing you access to all instrument controls, directly from SourceXpress. (The instrument itself displays a message that it is being externally controlled.)

You can remotely connect to multiple instruments, and control them, one at a time, via SourceXpress.

In addition, you can control an active generator via the instrument's GPIB programming commands. You must send the GPIB commands to SourceXpress and then SourceXpress passes the command to the active generator. Refer to the connected instrument's programming manual for instrument specific commands.

NOTE. *Menus and controls of the active generator are not described in this help system. Refer to the documentation for the active generator.*



This shaded area of the display is dependant on the instrument type selected as the active generator.

For operation of the active generator, refer to the documentation for the instrument type.

Workspace interface

The workspace provided in SourceXpress is dependent on the chosen active generator, regardless of whether it is a virtual generator or connected to an instrument.

For operating information about the controls of the displayed generator, refer to the documentation available for the specific instrument.

All documentation is available on the Tektronix web site (www.tek.com/manual/downloads).

Software

SourceXpress

SourceXpress is designed to operate on these Windows platforms:

- Windows 7 (64-bit)
- Windows 8 (64-bit)
- Windows 10 (64-bit)

Compatible generators

SourceXpress can currently connect to and control the following generators:

- AWG70001A arbitrary waveform generator
- AWG70002A arbitrary waveform generator
- AWG5202 arbitrary waveform generator
- AWG5204 arbitrary waveform generator
- AWG5208 arbitrary waveform generator

Documentation

In addition to this application Help system, the following documentation is available for the software.

All documentation is available on the Tektronix web site (www.tek.com/manual/downloads).

To read about	Use these documents
SourceXpress operation and user interface help	Access the SourceXpress application help from the Help menu for information on all controls and elements on screen. The SourceXpress help system is also available in PDF format, available on the Tektronix web site. Tektronix part number 077-1145-xx.
SourceXpress programmer commands	Access the SourceXpress programmer manual for the syntax of remote commands. This document is available in PDF format located in the program's installation folder and also available on the Tektronix web site. Tektronix part number 077-1144-xx.
Connected instrument operation and user interface help	For operation and interface help of a connected instrument, refer to the instrument's documentation. This documentation is available with the instrument or on the Tektronix web site.
Connected instrument programmer commands	For programming information of a connected instrument, refer to the instrument's documentation. This documentation is available with the instrument or on the Tektronix web site.

Support information

Tektronix offers the following services in support of their products:

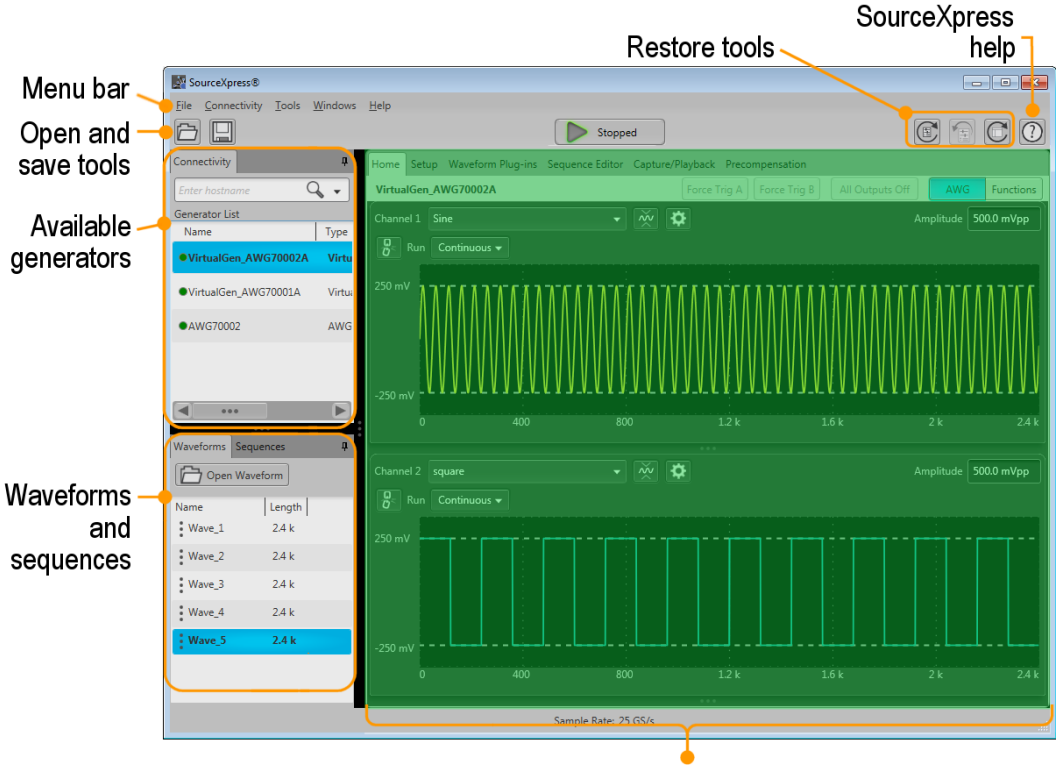
- **Technical Support**. For application-related questions about a Tektronix product, contact us by telephone or email).
- **Service Support**. For service-related questions about a Tektronix product, contact us by telephone or email).

Tektronix also offers extended warranty and calibration programs as options on many products. Contact your local Tektronix distributor or sales office.

Elements of the display

The main areas of the application window are shown in the following figure.

NOTE. *The workspace area is not discussed in this document since its content is based on the type of instrument selected as the active generator. For information about controls of the active generator, view the instrument's documentation available from the Tektronix web site (www.tek.com/manual/downloads).*



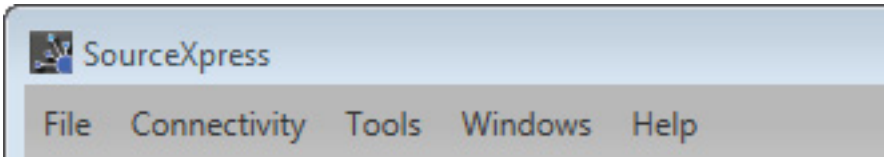
Play button

The play button starts and stops the waveform playout when SourceXpress is connected to an instrument and the connected instrument is set to Active in the Connected Generators tab.

If a virtual generator is active (selected in the Connectivity tab), the Play button is not enabled.

Menu bar

The Menu bar provides access to various actions.



File (see page 6) provides access to various open, save, and setup actions.

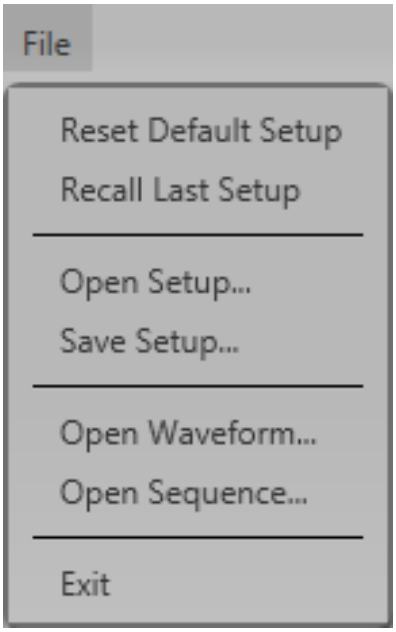
Connectivity (see page 8) provides access to add generators to the Connected Generators tab.

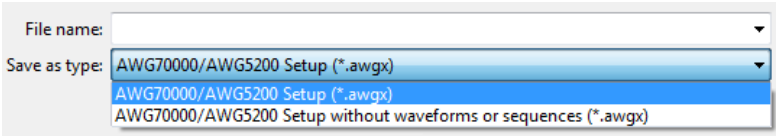
Tools (see page 8) allows you to hide pop-up error messages, forcing the errors to only show in the Status bar at the bottom of the screen.

Windows (see page 9) allows you to collapse or expand the tabbed panels.

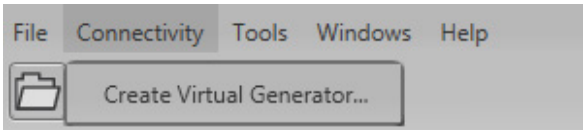
Help (see page 9) provides access to the SourceXpress User manual and information about SourceXpress.

File menu



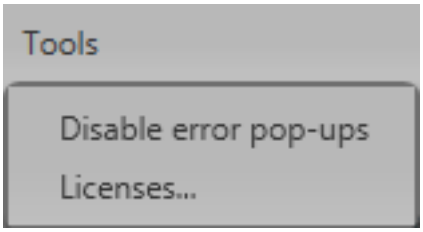
Item	Description
Reset Default Setup	Returns all settings of the active generator to the factory settings. ***NOTE.*** *The contents of the active generator's Waveforms tab, Sequences tab, and Captured Signal List are removed.* The contents of these lists of any connected instrument are not affected.
Recall Last Setup	Returns the active generator to the setup that was last accessed.
Open Setup...	Opens a window to allow you to navigate to saved setup files. Opening a setup file returns the active generator to the settings saved with the setup file. Waveforms and/or sequences saved with the setup file are also restored, removing all existing waveform and sequence files.
Save Setup...	Saves the current settings as a setup file, allowing you to easily return the application to a known setup. A windows Save As dialog box opens to the most recent location accessed. Use this window to navigate to where you want to save the setup. In the Save As window, you can choose to save the setup file (which includes all waveforms and sequences) or save the setup file without the assets (which excludes all waveforms and sequences).  The factory location is C:\Program Files\Tektronix\SourceXpress\Samples. ***NOTE.*** *Signals listed in the Capture/Playback tab are not saved as part of the setup file.*
Open Waveform...	Opens a window to allow you to navigate to saved waveform files. Performs the same actions as the Open Waveform button in the Waveforms tab, opening any of the supported file types. Refer to Open File for a description of the actions taken depending on the type of file being opened.
Open Sequence...	Opens a window to allow you to navigate to saved sequence files. To add a sequence to the Sequences tab, select the Open Sequence button. This opens a Windows dialog box that allows you to navigate to a saved sequence or setup file. If the sequence or setup file is a valid file type, the sequences are added to the Sequences tab and waveforms (used in the sequence) are added to the Waveforms tab.
Exit	Exits the application.

Connectivity menu



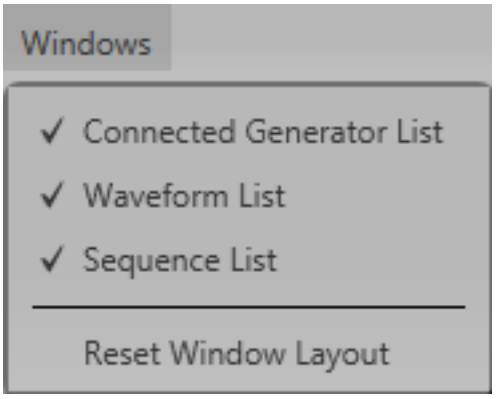
Create Virtual Generator...	Displays the Create Virtual Generator dialog screen. Enables you to create virtual generators which are added to the Generators List. Refer to Connectivity (see page 15) for information.

Tools menu



Item	Description
Disable error pop-ups	Enables or disables the pop-up error message windows. When disabled, error messages only show in the status bar at the bottom of the screen. The status bar shows the following icon to indicate that pop-up error messages are hidden. 
Licenses...	Displays the License Management window. The License Management window displays the installed plug-in licenses and access to install or return a license. See Licensing (see page 133) for information about how licensing works.

Windows menu



Item	Description
Connected Generator List	Displays or hides the Connectivity tab.
Waveform List	Displays or hides the Waveforms tab.
Sequence List	Displays or hides the Sequences tab.
Reset Window Layout	Returns all application windows to their original location and display. For example, all undocked tabs are returned to their original location and all closed tabs are reopened. This is performs the same function as the  icon in the Restore tools.

Help menu

Help & Support button: Help & Support provides links where you can obtain additional product help and documentation. About my SourceXpress button: About my SourceXpress provides you with detailed information about your instrument, such as installed options and software version. This information is helpful when contacting Tektronix about your instrument. You can use the Copy Instrument Info button to copy and paste the instrument information into another application such as an email program.

Item	Description
User manual	Opens the application help system, same as the  icon.
About SourceXpress...	Provides you with detailed information about your application, such as the software version. This information is helpful when contacting Tektronix about your instrument. Use the Copy System Information button to copy and paste the instrument information into another application such as an email program.

Open and save tools

The Open and Save tools provide access to various open, save, and setup actions.

Open File allows you to open any of the supported file types. The action taken depends on the file type opened.

- Setup files: Opening a saved setup file returns the instrument to the settings saved with the setup file. Waveforms and/or sequences saved with the setup file are also restored, removing all existing waveforms and sequences.

- Waveform files: Opening a waveform file from the toolbar allows you to select one waveform file at a time to load into the Waveforms tab. (Matlab files that contain more than one waveform will have all waveforms loaded into the Waveforms tab.

  See Adding a waveform (see page 31) for more information.

- Sequence files: Opening a sequence file from the toolbar allows you to select one sequence file at a time to load into the Sequence tab. If the sequence file contains subsequences, these are also placed in the Sequences tab. All waveforms used in the sequence are loaded into the Waveforms tab.

  See Adding a sequence (see page 58) for more information.

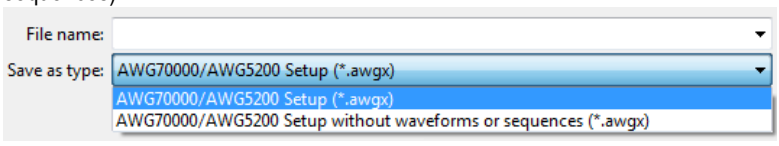
A windows Open dialog box opens to most recent location accessed. Use this window to navigate to your files.

The factory location is C:\Program Files\Tektronix\SourseXpress\Samples.

For more advanced options to add waveforms or sequences, use the Open icons located within the Waveforms tab and Sequences tab panels.

Save Setup saves the current settings as a setup file, allowing you to easily return the active generator to a known setup. A windows Save As dialog box opens to the most recent location accessed. Use this window to navigate to where you want to save the setup.

In the Save As window, you can choose to save the setup file (which includes all waveforms and sequences) or save the setup file without the assets (which excludes all waveforms and sequences).



The factory location is C:\Program Files\Tektronix\SourceXpress\Samples.

NOTE. *Signals listed in the Capture/Playback tab are not saved as part of the setup file.*

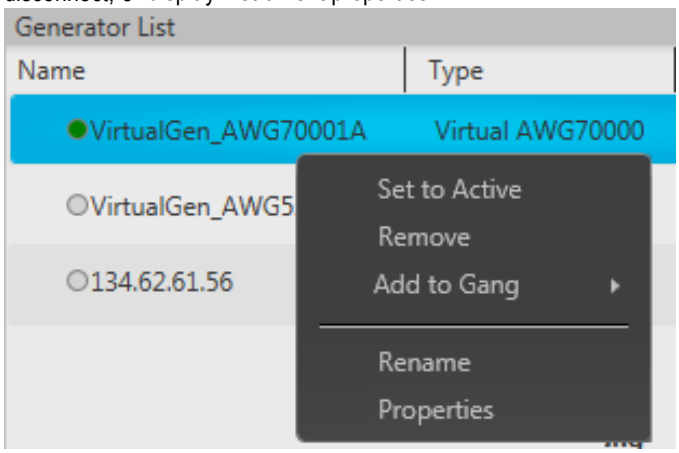
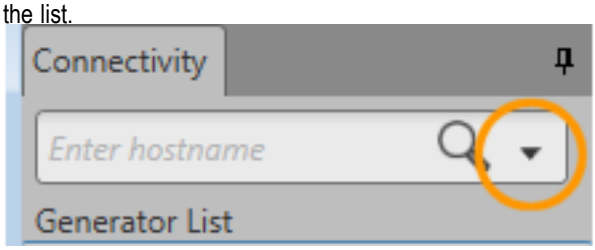
Restore tools

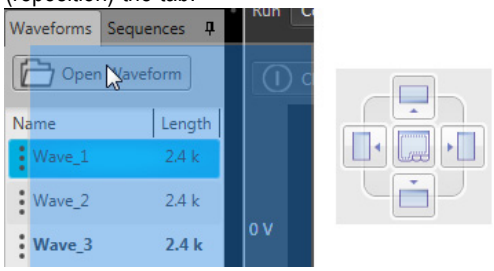
The Restore tools provide access to various actions to return the application to known setups and graphical layout.

	Reset to Default Setup returns all settings of the active generator to the factory settings. ***NOTE.*** *The contents of the Waveforms tab, Sequences tab, and Captured Signal List are removed.* *The contents of these lists of any connected instrument are not affected.*
	Restore Last Setup returns the application to the setup that was last accessed.
	Reset Window Layout returns all window panels (moved or undocked) to their original locations.
	The User Manual button displays the help system.

Screen interface features

The graphical user interface (GUI) is designed with some features that are only accessible via the right and left mouse clicks.

Left mouse click	Left mouse click on any control or setting to select or activate that control.
Right mouse click	Right mouse click on various areas, controls, and settings display a menu of available actions. In some instances, a right mouse click is the only method to access some menus. For instance, right click on one of the generators in the Connected Generators list to display the menu to activate, disconnect, or display instrument properties. 
Pull down lists	Selections with a triangle incorporate a pull-down list. Left mouse click on the triangle to display the list. 
Drag and drop	Use the left mouse click to drag a waveform from the Waveforms tab onto the waveform display area. If a waveform is already attached to the channel, the waveform is replaced. If the previous waveform was currently playing, the new waveform starts playing immediately.

Window resizing	The various window panels can be adjusted in size where-ever two panels are divided. Use the right mouse click to grab the 3 dot indicator and slide to increase or decrease its size. 
Undocking and docking tabs	Any tab can be undocked from the GUI. This allows you to reposition a tab to a new location or completely separate it from the main GUI. Use a left mouse click to grab a tab and slide it to a new area. The docking icon displays that you can use to choose how you want to dock (reposition) the tab.  Use the Reset Window Layout button  to return the display to the factory settings.

Connectivity

The Connectivity tab contains the list of generators that are currently connected (or available for connection) to SourceXpress, whether it's a virtual generator or a real instrument. You can connect as many generators as you wish, but only one can be one active.

At the initial startup of SourceXpress, an AWG70002A Virtual generator is created and connected. This is the default generator, named VirtualGen_AWG70002. As the default generator, it is automatically set to be the active generator and displays a simulated AWG70002A interface.

You can create additional virtual generators and choose which generator is the default active generator. There must always be a default generator.

Virtual Generator. The default mode of operation is for SourceXpress to connect to the default virtual generator. You can create other virtual generators, each with different configurations. Once you create additional virtual generators, you can choose a different default virtual generator. (Right mouse click in the Available Virtual Generators screen to select the default generator.)

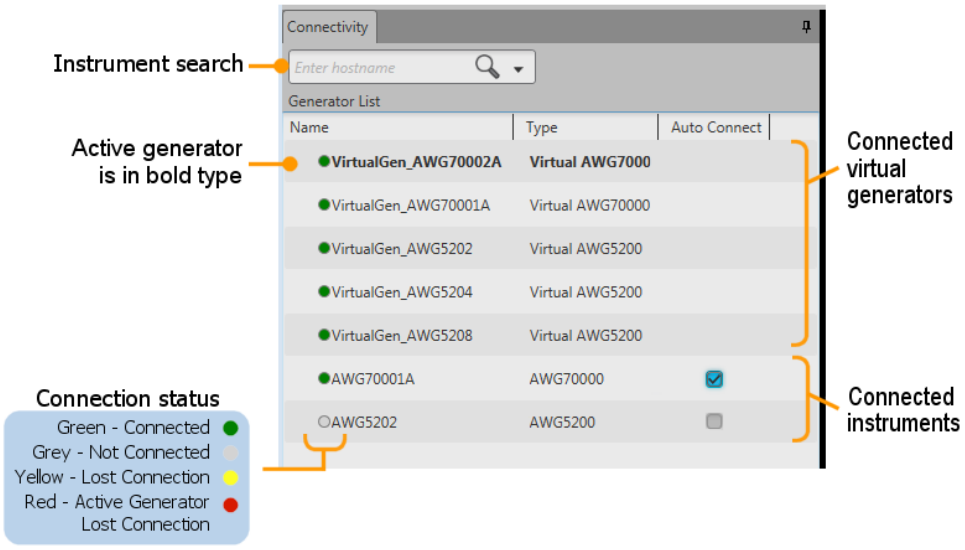
When connected to a virtual generator, you can create all your waveforms, sequences, and setups specific to instrument types, all in the absence of an instrument. Then when an instrument is available, you can simple recall your saved files.

Connected to an instrument. With SourceXpress installed on a networked PC, SourceXpress can remotely connect and control any compatible generator (see page 3) on the network. When the connected generator becomes the active generator, the interface of the generator is displayed in the SourceXpress application window, providing you access to all its controls, directly from SourceXpress.

Generator List

The Connectivity tab contains your list of available generators connected (or available for connection) to SourceXpress. You can connect to as many generators as you wish (virtual generators and instruments), but you can only have one active at a time.

NOTE. *When SourceXpress is connected to a generator, the generator's display will indicate that it is being externally controlled. Control of the generator can easily be regained directly from the generator's display, or by disconnecting the generator from SourceXpress via the Generator List.*



When SourceXpress is started for the first time, one Virtual generated is created and appears in the Generator List as the active generator along with the simulated display of the generator.

As you modify the Generator List (add/remove generators (virtual or real instruments), SourceXpress retains the latest list of generators and repopulates the list when SourceXpress is restarted.

When SourceXpress is restarted, SourceXpress populates the Generator List as follows:

- All previously existing virtual generators appear in the Generator List and are connected.
- All previously existing real generators appear in the Generator List but are not connected unless Auto Connect is checked for that generator. If Auto Connect is checked, SourceXpress attempts to reestablish a connection.
- If a virtual generator was the active generator at shut down, the same virtual generator is active.
- If a real generator was the active generator at shut down, the same generator will be connected and be the active generator if SourceXpress is able to reestablish a connection. If the connection can not be established with the generator, an error message is displayed.

Virtual Generators

You can create as many virtual generators you like, each with different configurations. Use the Connectivity > Create Virtual Generator... menu to display the dialog screen to create a new generator. When connected to a virtual generator, you can create all your waveforms or sequences, create setups specific to a generator type, all in the absence of a real instrument. Then when a generator is available, you can simple recall your saved files.

Connect to instruments

With SourceXpress installed on a networked PC, SourceXpress can remotely connect to and control any compatible generator on the network. The interface of the generator is displayed in the SourceXpress application window, providing you access to all generator controls, directly from SourceXpress.

Instrument search/connect

The connectivity tab provides a window for you to enter the computer name (hostname) or IP address of a networked generator you wish to connect to.

After entering the hostname or IP address, select the magnifying glass (or press Return) to initiate searching for the generator. When the connection is established, the generator is added to the Generator List. The name appearing in the Generator List is the same as entered in the Connectivity window. You can rename a generator by selecting it and use the right-click rename menu.

To obtain the hostname or IP address of an instrument, go to the target generator, select Computer > Properties and note the computer name or IP address.

Selecting the active generator

From the Connectivity tab, you select which generator you want to access, regardless if it's a virtual generator or a connected real generator. Making the generator active brings its display into view.

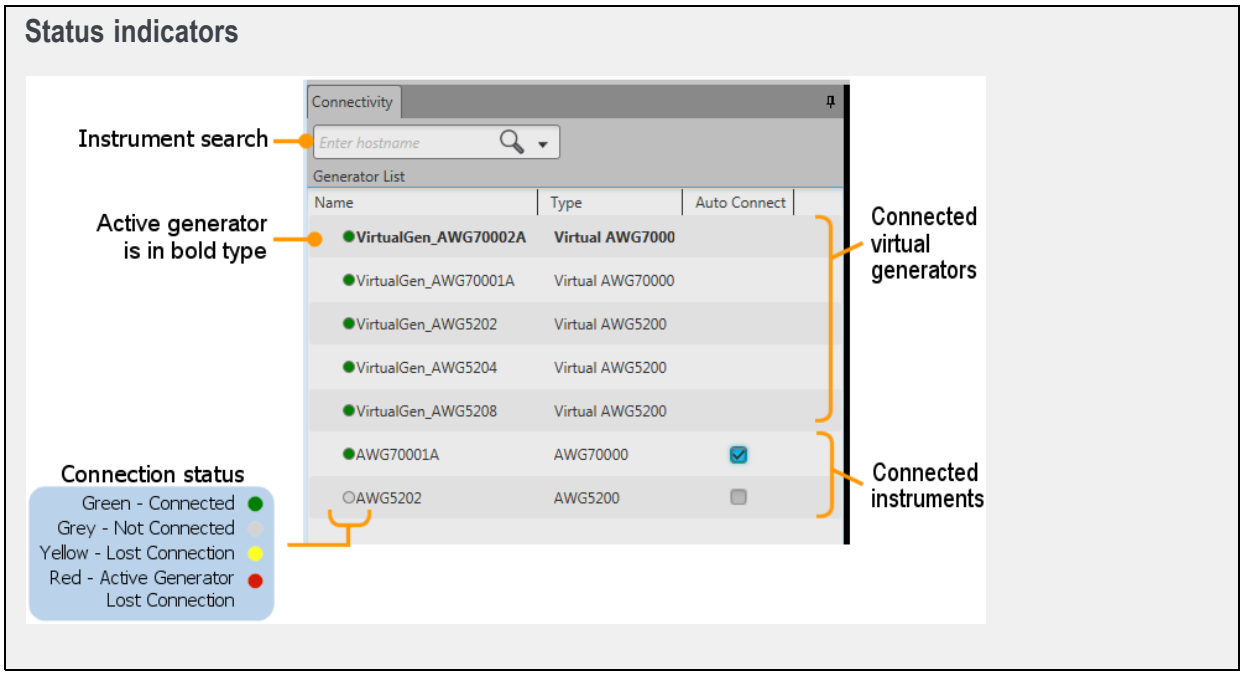
Right-click on the generator name and select Set to Active from the pop-up window.

Next to the name of each generator, the Type of generator is displayed to help identify real generators from virtual generators.

Connection status indicators

Next to each generator name in the Generator List (see page 18) is a colored icon to indicate the connection status of that generator.

- Green indicates SourceXpress is connected to the generator. Virtual generators are always connected.
- Grey indicates SourceXpress is not connected to the generator.
- Yellow indicates SourceXpress lost connection to the generator but it was not the active generator.
- Red indicates SourceXpress lost connection to the generator and it was the active generator.



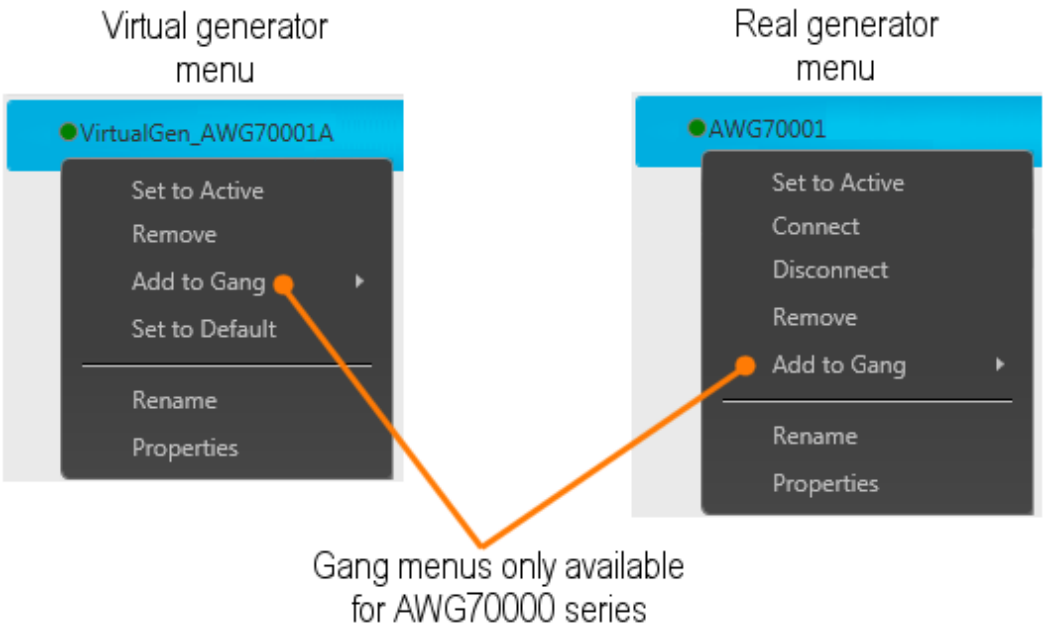
Auto Connect

Use the Auto Connect feature to automatically establish a connection to the selected instrument when SourceXpress is launched. You can choose to automatically reconnect to any or all instruments (currently in the Generator List) when SourceXpress is launched.

Auto Connect is not available for virtual generators since they are connected at all times.

Right-click menu operations

Right-click on a generator name displays a menu of actions. The menus are different between a virtual generator and a real generator as noted below.



NOTE. *Right-click menus differ for AWG70000 series generators contained in a Gang. Refer to* *Generator gangs (see page 22)*.

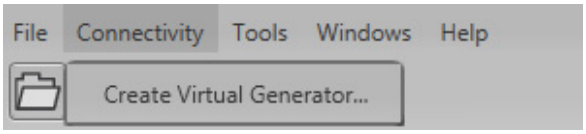
Item	Description
Set to Active	Sets the selected generator to the active generator, bringing its controls into view. Only one active generator is allowed at a time.
Connect	Establishes a connection from SourceXpress to the selected generator. This item is gray if the generator is already connected. This is not available if a virtual generator is selected. Virtual generators are always connected.
Disconnect	Disconnects the selected generator from SourceXpress. The generator name remains in the Generator List and can be reconnected with the Connect menu. This item is gray if the generator is already connected. This is not available if a virtual generator is selected. Virtual generators are always connected.
Remove	Removes the selected generator from the Generator List. If the generator is connected, it is first disconnected. ***NOTE.*** *You cannot remove the default virtual generator.*
Add to Gang	Allows you to add the selected AWG70000 series generator to a generator gang. This menu item is gray if no gangs exists. See the topic Generator gangs (see page 22) for information about created generator gangs and a their use. ***NOTE.*** *Add to Gang is only available when an AWG70000 series generator is selected.*

Item	Description
Set to Default	Sets the selected virtual generator as the default generator to display. This is not available for real generators.
Rename	Displays the Rename dialog screen for the selected generator. If a generator has been renamed, you can locate its original name by displaying the Properties of the generator.
Properties	Displays the system information about the selected generator.

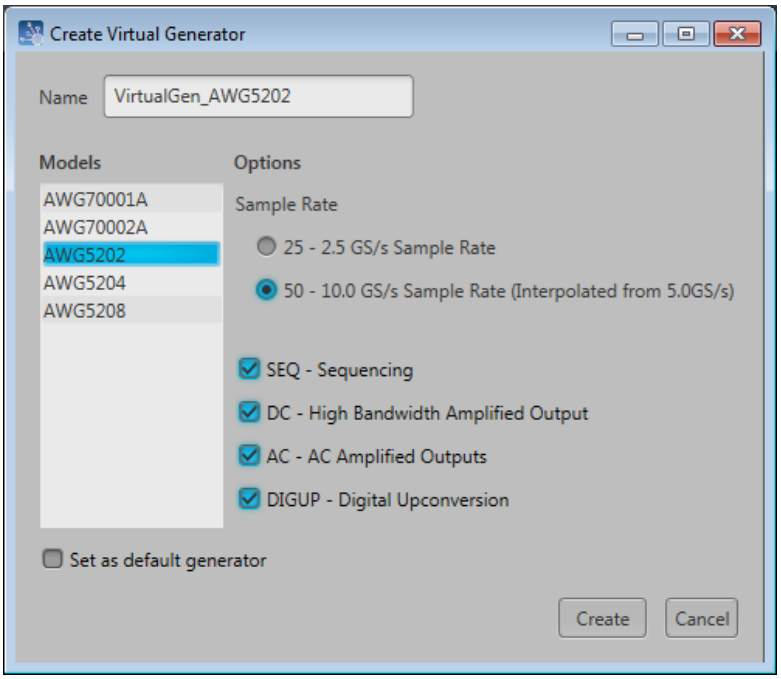
Create a virtual generator

The Connectivity menu allows you to create virtual generators, each with its own set of properties, such as a two-channel or single-channel instrument to simulate the actual instrument you may connect to in the future. As virtual generators are created, they are added to the Generator List in the Connectivity tab (see page 15).

To create a virtual generator, select the menu Connectivity > Create Virtual Generator...



This displays the Create Virtual Generator window.



You can create additional virtual generators, each with its own set of properties, such as a two-channel or single-channel instrument to simulate the actual instrument you may connect to in the future.

Item	Description
Name	Define a name for the generator you are creating. By default, the name is given a base name of VirtualGen with the model type appended to the name. If needed, the name is appended further with a numerical value. You can overwrite the Name field entirely by typing in a generator name. ***NOTE.*** *You cannot duplicate or overwrite an existing Virtual Generator name.*
Models	Choose the model you want to simulate
Options	Choose the options you want to be included with your simulated model. The options selections change depending on the model selected. This allows you to choose only options appropriate for the selected model.
Set as default generator	When checked, the generator being created becomes the default generator in the Generator List in the Connectivity tab. The default generator can be changed in the Generator List window.
Create	Creates the generator as defined, and adds the named generator to the Generator List (see page 15) in the Connectivity tab.
Cancel	Exits out of the Create Virtual Generator window without creating any new generators.

Connect to a generator

To connect to a generator, use the search field in the Connectivity tab.

NOTE. *If the Connectivity tab is not displayed, enable the setting "Connected Generator List" located in the Windows menu or press the Reset Windows Layout button.*

Enter the computer name (Hostname) or the IP address of a networked generator you wish to connect to. Select the magnifying glass to initiate searching for the named generator.

If the generator is found, it is added to the Generator List and connected to SourceXpress.

NOTE. *TCP/IP port 59557 is required to be open for the WCF (Windows Communication Foundation) connection. For example, when communicating through a router.*

Once a generator is connected to SourceXpress, the generator's display is disabled. A message is displayed indicating it is being remotely controlled. The connection can be disabled directly from the instrument's screen by ending the remote session.

Generator gangs

Generator gangs is a way to group up to four AWG70000 series generators together as a single gang of generators, displaying all channels together in the Home screen. This gives the appearance of a multi-channel generator, displaying up to 8 channels (four AWG70002A generators ganged together).

The gang appears in the Generator List and is treated like other generators. The connection status (see page 26) is shown by the colored icons next to the name. If the gang is the active generator(s), the name appears bold in the list.

NOTE. *Generator gangs can only be created with AWG70000 series generators. AWG5200 series cannot be ganged together or included within a gang of AWG70000 series generators.*

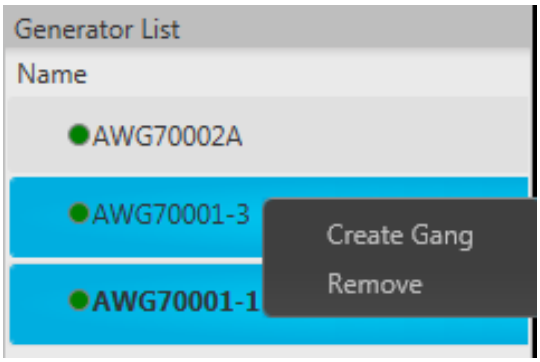
- Gangs can consist of 2 to 4 generators.
- A generator gang can only be created of like generators. For instance, you cannot mix single-channel and two-channel generators within the same gang.
- Generators within a gang can be set to the active generator. This causes only that generator to display.
- A generator within a gang can be removed (unless synchronization is enabled) but a gang must have at least two generators.
- The active generator can be a gang or a member of a gang.
- You cannot remove a generator from a gang once sychronization has been enabled.
- A gang of generators can be created with virtual generators or real generators. (A gang cannot mix the two types.) Virtual generator and Real generator gangs act similarly except for:
  - Real generators must be connected to an AWGSYNC01 Synchronization Hub, with the master and slave generators defined.
  - A gang of real generators (connected to an AWGSYNC01 Synchronization Hub) automatically have their master/slave status set, and the Sync Enable activated.

Create a gang of real generators

NOTE. *When creating a gang of real generators, all generators must be connected to an AWGSYNC01 Synchronization Hub.*

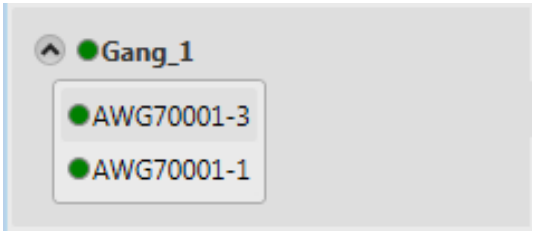
1. Select the generators you want to gang together, then right click to display the Create Gang menu. You can gang up to four generators.

   The selected generators must all be of the same model and connected to a sync hub.

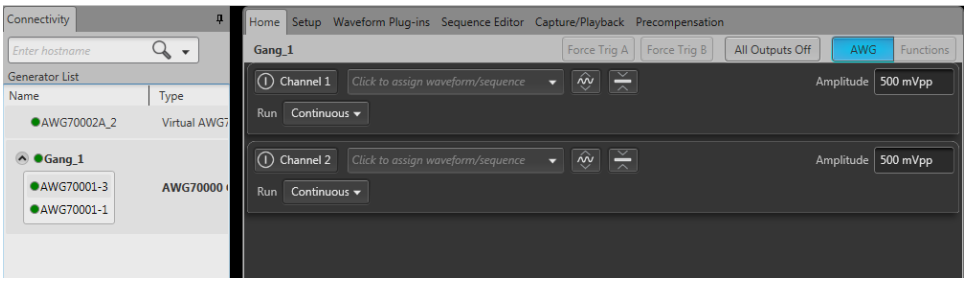


2. The gang is created, containing the selected generators.

   You can see the generators by clicking the arrow icon next to the gang name to expand and collapse the list of generators contained in the gang.

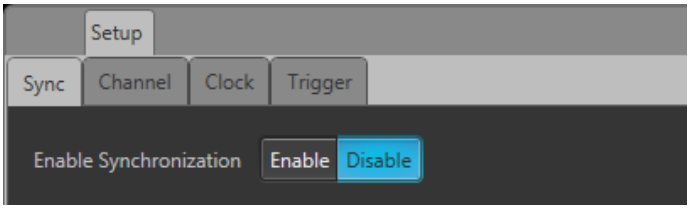


3. In this example, we've ganged two 1-channel generators together. With the gang selected as the active generator, it displays as two channels.

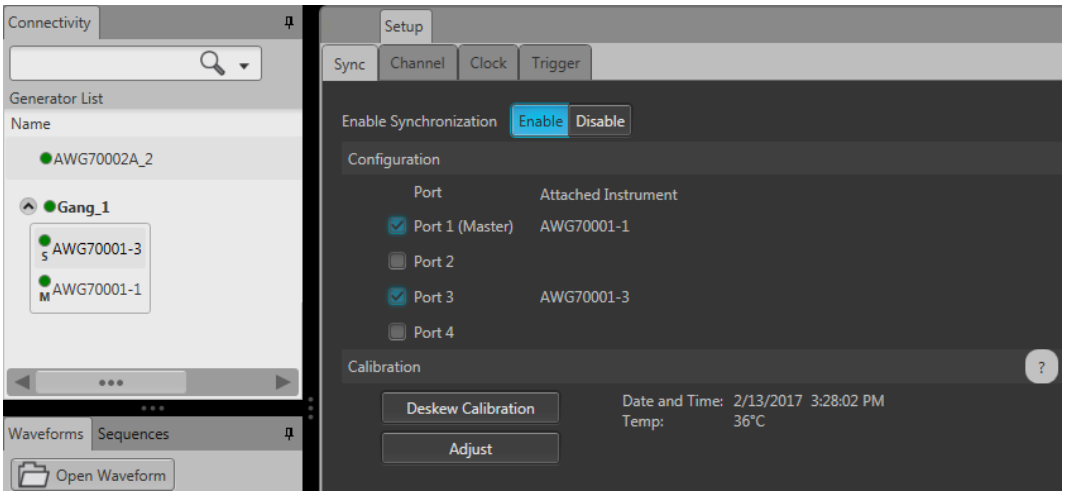


4. Select the Setup tab to display the settings for the generator gang.

   First, notice that the Sync tab is displayed.



5. Click Enable to automatically set the generators to synchronize with the AWGSYNC01 Synchronization Hub.

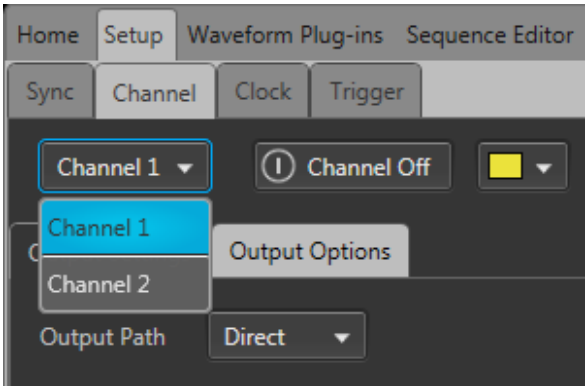


As you can see, the generator that was connected to Port 1 of the Sync Hub is the master, and the generator connected to Port 2 is a slave.

Also notice in the Generators list that the generators are identified as master and slaves.

6. Select Channel under the Setup tab.

With the gang as the active generator, the Channel pull-down menu now shows two channels.



If you were to create a gang of four 2-channel instruments, the pull-down list would contain eight channels.

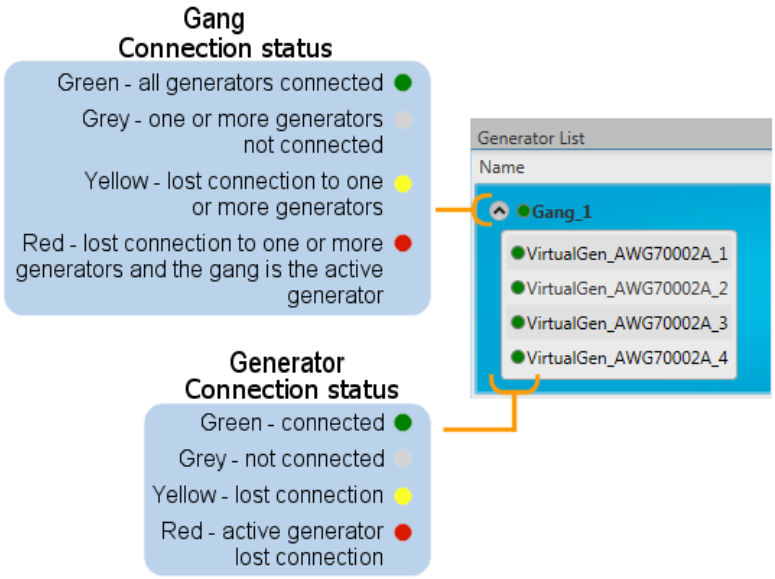
Creating a gang of virtual generators

The creation of a gang of virtual generators is almost identical to the process of real generators. The differences are:

- Virtual generators are not connected to a synchronization hub,
- When Sync is enabled for the gang (in the Sync menu in the Setup tab), the generators will be assigned ports as if they were connected to a hub.
- The first listed generator in the gang becomes the master generator.

Connection status

Next to each generator gang name in the Generator List is a colored icon to indicate the connection status of that gang of generators. There are slight differences of the connection status indicators for a gang to the status of a generator.



Gang connection status

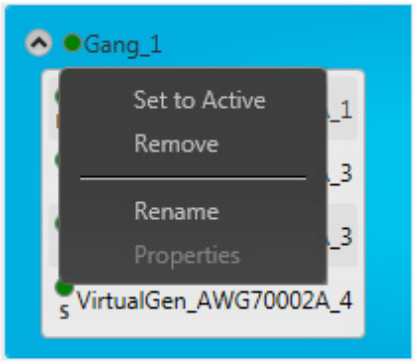
- Green indicates that SourceXpress is connected to all generators in the gang.
- Grey indicates that SourceXpress is not connected to one or more generators in the gang.
- Yellow indicates SourceXpress has lost connection to one or more generators in the gang, but the gang was not the active generator.
- Red indicates SourceXpress lost connection to one or more generators in the gang and the gang was the active generator.

Generator connection status

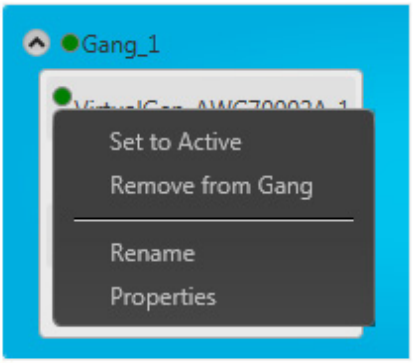
- Green indicates SourceXpress is connected to the generator. Virtual generators are always connected.
- Grey indicates SourceXpress is not connected to the generator.
- Yellow indicates SourceXpress lost connection to the generator but it was not the active generator.
- Red indicates SourceXpress lost connection to the generator and it was the active generator.

Right-click gang menu operations

A right click on the generator name displays a menu of actions. The menus and actions are different between a gang and a gang member.



Gang menu



Gang member menu

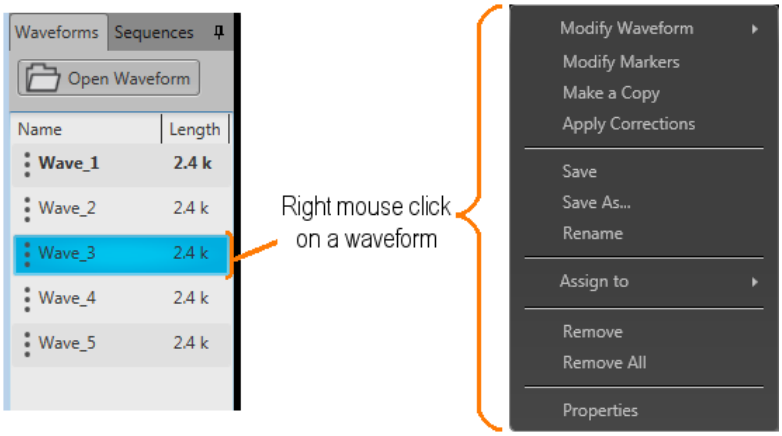
Item	Description
Set to Active	Sets the selected gang or gang member as the active generator. An active gang brings all channels of the gang together. An active gang member only displays that generator.
Remove	For gangs only. Removes the selected gang and all of its members from the Generator List. If it is a gang of real generators, the generators are first disconnected.
Remove from Gang	For gang members only. Removes the selected gang member from the gang. If the gang member is a connected real generator, it is first disconnected. ***NOTE.*** *A gang must have at least two members.*
Rename	Displays the Rename dialog screen. If a generator has been renamed, you can locate its original name by displaying the Properties of the generator.
Properties	Displays the system information about the selected generator.

Waveform list

The Waveform List contains the waveforms available to assign to a channel.

You can drag and drop a waveform from the Waveform list onto the channel's graph area, assigning that waveform to play on the channel. See below when working with IQ waveforms.

Right-mouse click on a waveform to display a pop-up menu of tools to modify waveforms, assign a waveform to a channel, save, remove waveforms, and view a waveform's properties.



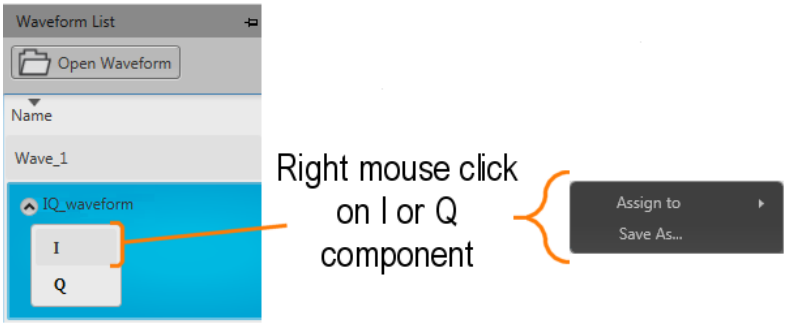
IQ waveforms (display)

AWG70000 series. IQ waveforms cannot directly be assigned to play on a channel, only the I or Q components can be played out.

AWG5200 series. IQ waveforms can directly be assigned to play on a channel if the Digital Up Converter (DIGUP) is licensed. Otherwise, only the individual I or Q components can be assigned.

When adding an IQ waveform to the Waveforms List, the I and Q components are separated and a sublist is created under the IQ waveform. Use the arrow next to the IQ waveform name to expand or collapse the sublist.

Use the sublist to assign the I or Q components to a channel for playout.



IQ waveform (create)

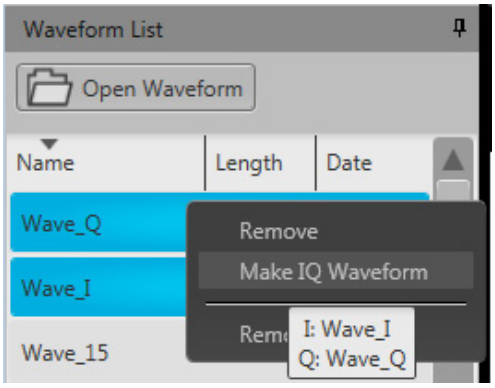
If you have I and Q waveform files, you can use the Waveform list to combine them into an IQ waveform.

From within the Waveform List, select both the I and Q waveforms.

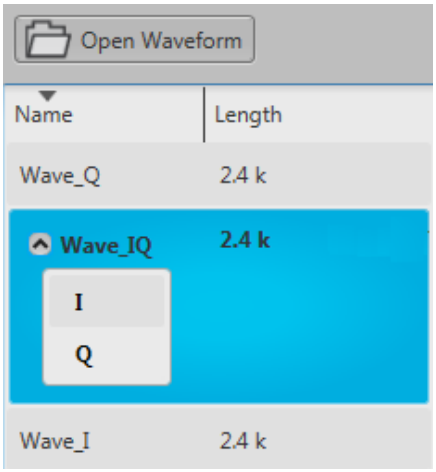
NOTE. *The waveform selected first becomes the I waveform. The waveform selected second becomes the Q waveform.*

With the selections made, display the right-click menu and select Make IQ Waveform. The I and Q waveforms must be of equal length.

A new IQ waveform is generated using the first selected waveform as the I component and the second selected waveform as the Q component. Hovering over the menu displays a tool tip showing which waveform is I and which waveform is Q.



The name of the IQ waveform generated uses the name of the I waveform (without suffix "_I" or "_Q") and is appended with "_IQ".



Adding a waveform

To add a waveform to the Waveform List, select the Open Waveform button. This opens a Windows dialog box that allows you to navigate to a stored waveform, setup file, or sequence file. (You can load waveforms contained in Setup files and sequence files.)

If the waveform is a valid waveform type, the waveform is added to the Waveform List. Once a waveform is in the Waveform List, it can be assigned to a channel for playout. Click here to see the list of valid waveform file types.

Valid file types	Description
.AWGX file format	Setup file created by Tektronix AWG5200/AWG70000 Series instruments or SourceXpress. Setup files can contain multiple waveforms and multiple sequences. ***NOTE.*** *Opening a setup file from the Waveform List does not restore the instrument settings, only the waveforms contained in the setup file are restored.*
.WFMX file format	Created by Tektronix AWG5200/AWG70000 Series instruments or SourceXpress.
.AWG file format	Setup file created by Tektronix AWG5000 or AWG7000 Series instruments. ***NOTE.*** *The Tektronix AWG5000 or AWG7000 Series instruments had predefined waveforms available for use.* *Saved setup files that used predefined waveforms did not save the actual waveform data with the setup, only the waveform name. Hence, importing setup files that used predefined waveforms will not import the waveforms. To import these types of waveforms, first copy and rename the predefined waveform, then save the setup file before importing.*
.WFM file format	Created by Tektronix AWG5000/7000 Series instruments. Created by Tektronix AWG400/500/600/700 Series instruments. Created by Tektronix TDS/DPO/MSO/DSA Series instruments.

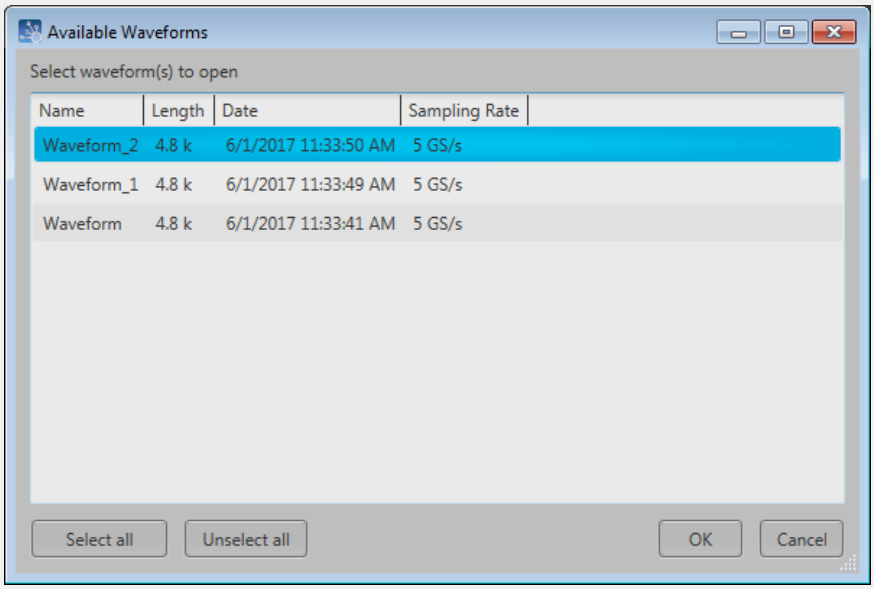
Valid file types	Description
.ISF file formats	Created by Tektronix TDS/DPO/MSO/DSA Series instruments.
.PAT file formats	Created by Tektronix AWG400/500/600/700 Series instruments.
.IQT file format	Created by Tektronix RSA3000 Series instruments.
.TIQ file format	Created by Tektronix RSA6000/5000 Series, SPECMON Series ,MDO4000 Series instruments. or SignalVu-PC.
.TFW file format	Created by Tektronix AFG3000 Series instruments.
.TXT file format	Created by Tektronix AWG5000 or AWG7000 Series instruments.
.RFD file format	Created by Tektronix RFX100 RFXpress Advanced RF/IF/IQ waveform software.
.SXD file format	Created by Tektronix SDX100 SerialXpress high-speed serial data signals software.
.MAT file format	Matlab file type (Level 5 or Level 7.3) for AWG5200/AWG70000 Series. Matlab file type for RSA6000/5000 Series and SPECMON Series.
.TMP file format	Midas BLUE file type.
.PRM file format	Midas BLUE file type.
With the Sequencing option (Option 03), the following files types are also valid waveform sources.	
.SEQX file format	Sequence file created by Tektronix AWG5200/AWG70000 Series instruments or SourceXpress. (Also can be a subsequence.)
.SEQ file format	Sequence file created by Tektronix AWG400, AWG500, or AWG600 Series instruments. (Also can be a subsequence.)

If selecting a file type containing multiple waveforms (.AWGX, .MAT, .AWG, .SEQX), you are presented with the Available Waveforms dialog box (see page 33) that lists all waveforms contained in the setup file. You can load all the waveforms or select a subset of the waveforms.

NOTE. *When opening a setup file (.AWGX) from the Waveform List, only the waveforms are extracted; instrument settings contained in the setup file are not restored. Use the File > Open Setup... menu in the Menu bar (see page 10) to restore both the settings and waveforms from a .AWGX setup file.*

If you want any of the waveforms (extracted from a setup file) to be available outside of the setup file, select and save each individual waveform.

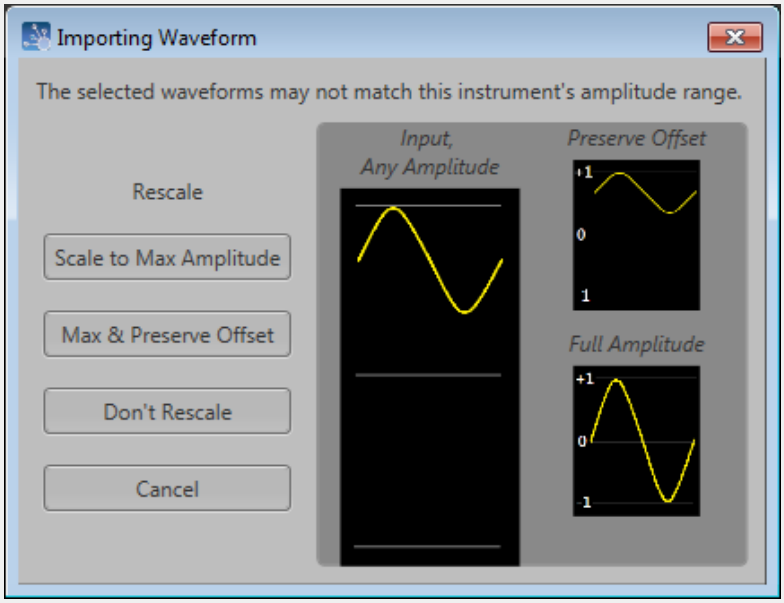
Available waveforms



Non-navtive analog files

When adding analog waveform file types that are not native to the AWG, you are presented with the Importing waveform dialog screen (see page 33) to normalize (rescale) the waveform while adding to the Waveform List.

Import waveform



Digital text waveform file

When adding a digital text (.TXT) waveform file, an Import Digital Waveform Text File dialog box displays to specify the digital bit resolution of the file before the waveform is added to the Waveform List.

Choose from the following:

AWG70000 Series (see page 34)

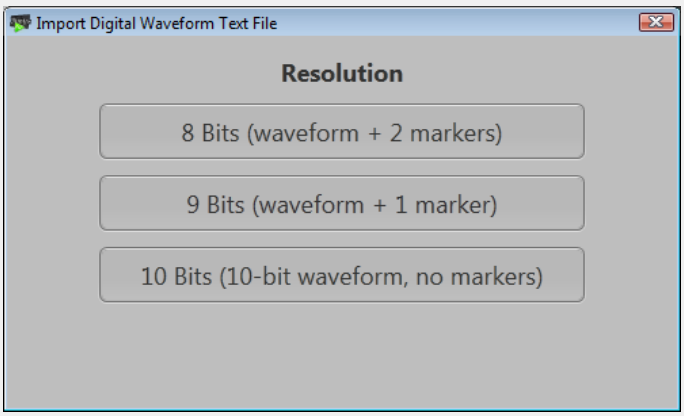
- **8 Bits (waveform + 2 markers)**: For 10 bit files that use 8 bits for data, and two bits for markers.
- **9 Bits (waveform + 1 marker)**: For 10 bit files that use 9 bits for data, and one bit for a marker.
- **10 bits**: For 10 bit files without markers.

AWG5200 Series (see page 35)

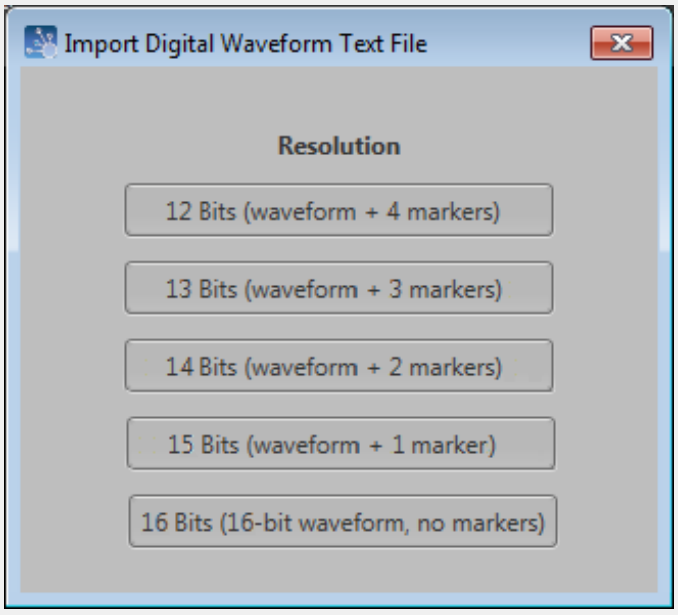
- **12 Bits (waveform + 4 markers)**: For 16 bit files that use 12 bits for data, and four bits for markers.
- **13 Bits (waveform + 3 markers)**: For 16 bit files that use 13 bits for data, and three bits for markers.
- **14 Bits (waveform + 2 markers)**: For 16 bit files that use 14 bits for data, and two bits for markers.
- **15 Bits (waveform + 1 marker)**: For 16 bit files that use 15 bits for data, and one bit for a marker.
- **16 bits**: For 16 bit files without markers.

It's important to know the details of your waveform before you import so you do not affect the integrity of the waveform. For instance, selecting 10 bits for a waveform that is intended to use 8 bits for data and two bits for markers will add the marker bits to the waveform data and markers will not be available.

AWG70000 import digital waveform text file



AWG5200 import digital waveform text file



NOTE. *If sequencing is available, waveforms are also added to the Waveform List when loading a sequence file or setup file that contains a sequence.*

IQ files

When adding an IQ waveform file (.TIQ), the waveform is added to the Waveform list but with a sublist of its I and Q components. You cannot assign the IQ file directly to a channel on the home screen, only the I or Q components can be assigned.

You can assign the I and Q components to channels for playout. If the connected instrument contains an IQ modulator, you can assign the IQ waveform to a channel.

NOTE. *You can select to modify an IQ waveform. The modify dialog screen does support displaying an IQ waveform. See the section* *Modify waveform dialog screen (see page 41)**.*

Multi-waveform select

Through the Open Waveform menu in the Waveform List, you can select multiple waveform files to load into the waveform list at once.

To select a contiguous block of files, click the first file in the block. Then hold down the Shift key as you click the last file in the block. This will select not only those two files, but everything in between.

To select multiple files that are not a contiguous block, click one file. Then hold down the Ctrl key while you click each additional desired file.

If your selection includes sequence files or setup files, all waveforms saved with those file types are loaded into the waveform list.

CAUTION. *Loading groups of waveforms will overwrite any existing waveform of the same name in the Waveform List without warning.*

NOTE. *Multiple file selection is available via the Open Waveform menu. Loading waveforms from the Open File menu (in the tool bar) or from the pull-down list in the graphical waveform area does not support multiple file selection.*

Saving a waveform

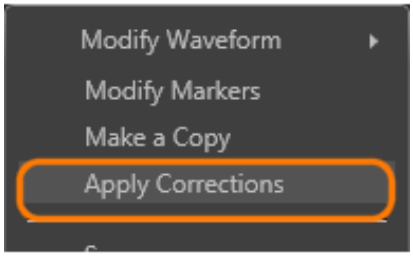
To save a waveform, right mouse click on a waveform and select Save or Save As. This opens a Windows dialog box that allows you to navigate to a location to save the waveform.

Click here to see the list of valid waveform file types.

Valid file types	Description
.WFMX file format	Native waveform file.
.WFM file format	Tektronix AWG400/500/600/700 series waveform file. Maximum waveform size is limited to <200 M.
.TXT file format	Waveform file.
.TIQ	Valid for IQ waveforms. For Tektronix SignalVu-PC.

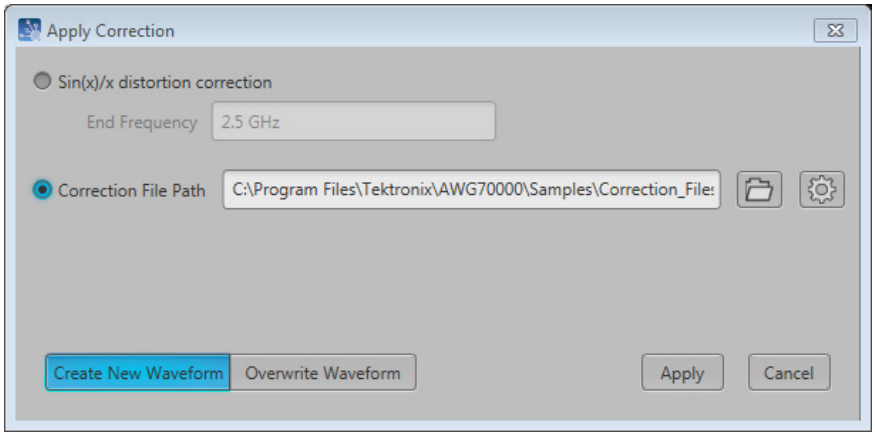
Apply corrections (AWG70000 series)

Right click on any waveform (or two waveforms for I/Q correction) and select the Apply Corrections menu.



With the Apply Corrections dialog screen, you can choose to apply one of two types of correction:

- Sin(x)/x distortion correction
- Apply a correction file (coefficient file)

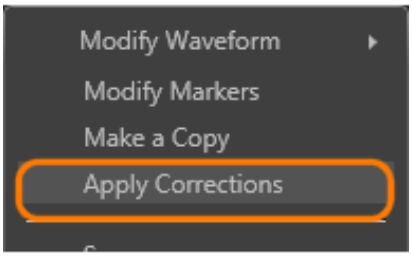


For information about the two types of correction, refer to these sections:

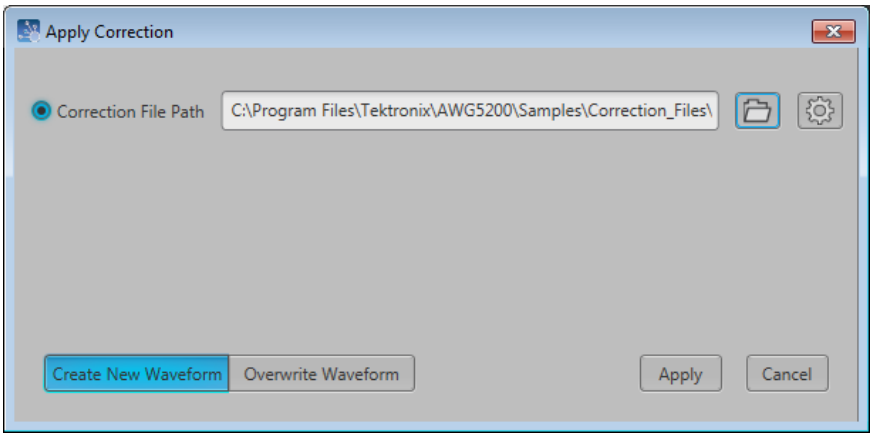
- Apply Sin(x)/x correction (see page 48)
- Apply correction file (see page 48)

Apply corrections (AWG5200 series)

Right click on any waveform (or two waveforms for I/Q correction) and select the Apply Corrections menu.



With the Apply Corrections dialog screen, you can choose to apply a correction file (coefficient file) to the waveform



For information about the correction file, refer to:

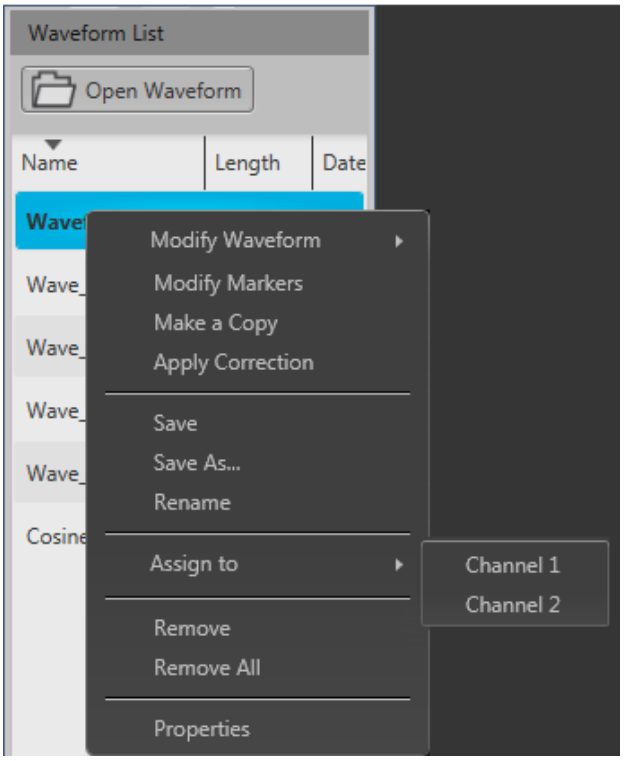
- Apply correction file (see page 48)

Assign a waveform to a channel

To play a waveform, you need to assign it to a channel. This is true even for a single channel instrument.

There are several methods to assign a waveform to a channel.

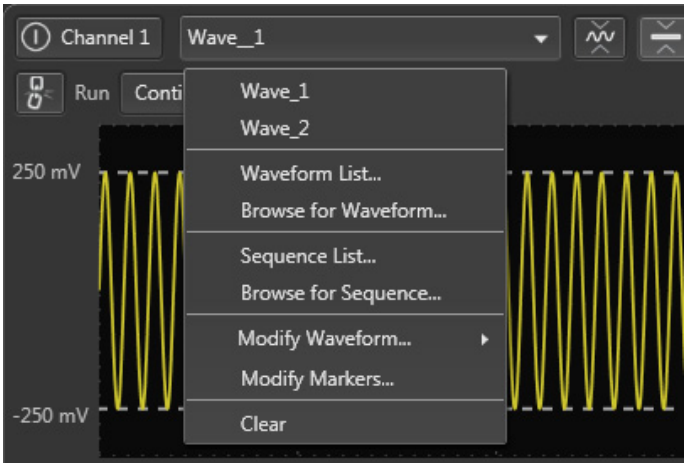
- Drag a waveform from the Waveform List onto a channel's plot area.
- Right mouse click on a waveform name in the Waveform List and use the pop-up window to assign it to a channel.



- Use the drop-down list in the channel's plot area to assign the channel to play a waveform.

  You can choose waveforms already loaded into the Waveform List or you can browse for waveform files. Selecting a waveform by browsing, the waveform is added to the Waveform List and assigned to the channel for playout.

  If Sequencing is available, you can also open a sequence type file and load any of the waveforms that were saved with the sequence.

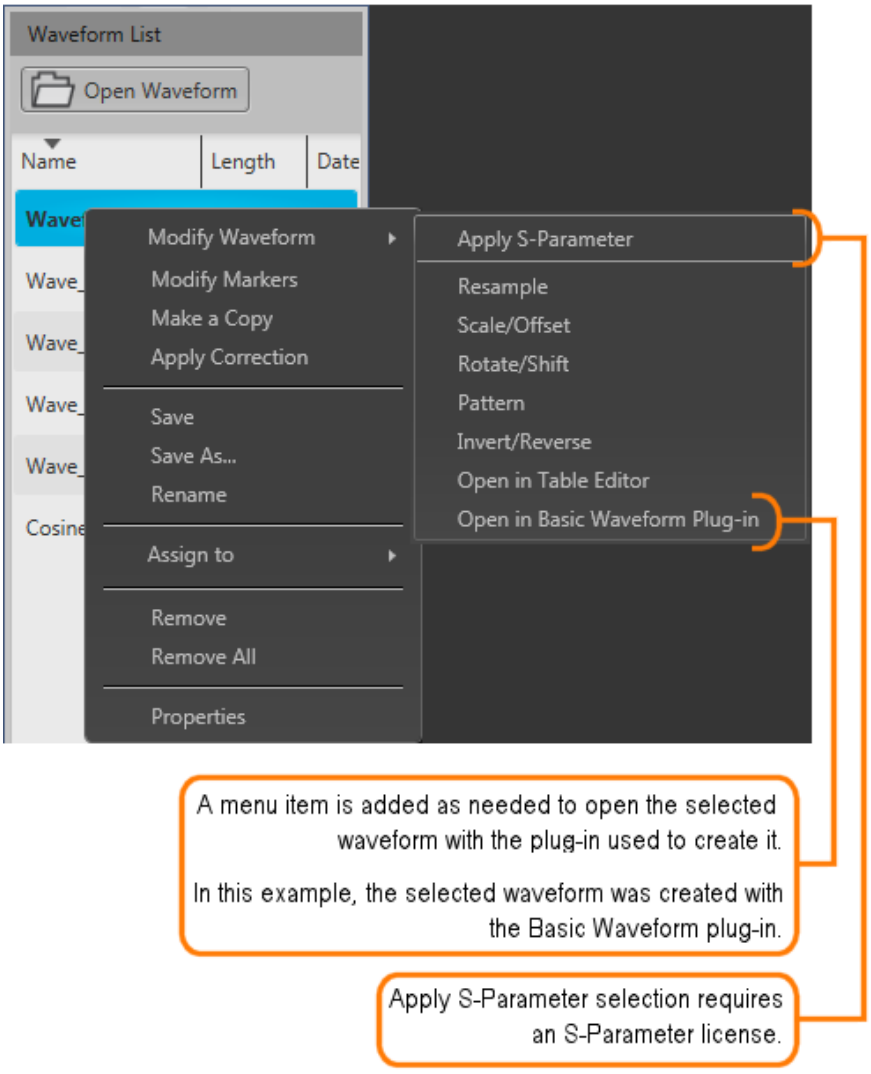


Modify waveform

You can select any waveform contained in the Waveform List to modify it or create a new waveform based on the existing waveform. But note the following conditions:

- Any waveform can be modified by selecting Modify Waveform > {Resample / Scale/Offset / Rotate/Shift / Pattern}. Select one of these waveform modifiers displays the Modify Waveform (see page 41) dialog screen.
- If selecting a waveform that was created with a Waveform Plug-in, a menu choice is added to take you directly to the specific Waveform Plug-in editor screen.
- With an S-Parameter license, you also have the option to apply S-Parameters to the waveform. Refer to the section about Applying S-Parameters (see page 50).

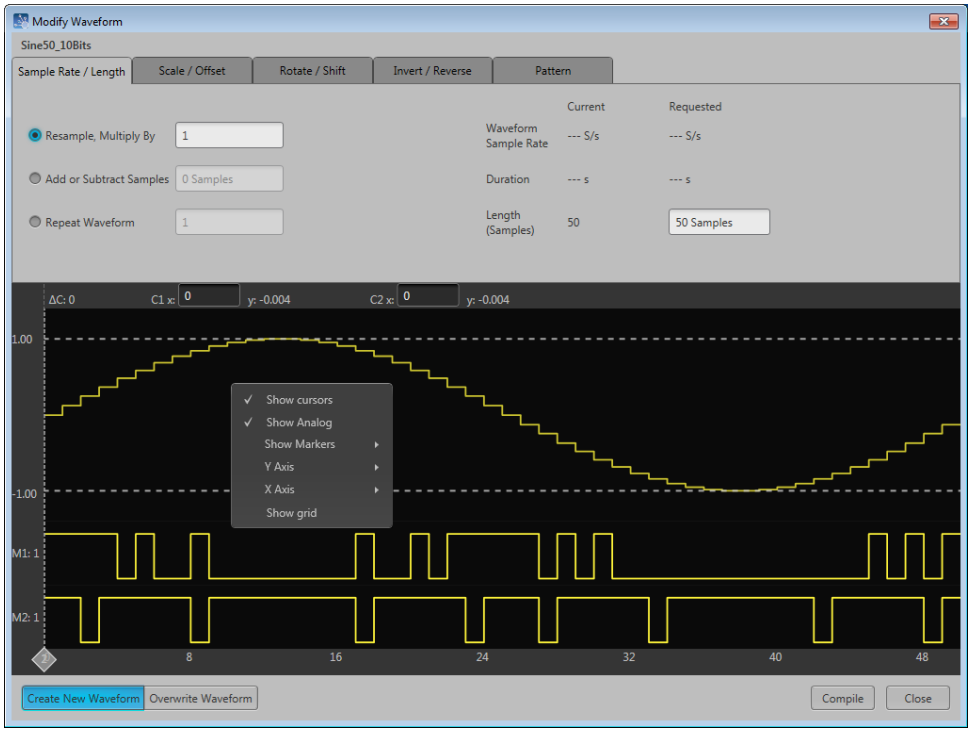
Select a waveform in the Waveform List and right mouse click to display the waveform operations.



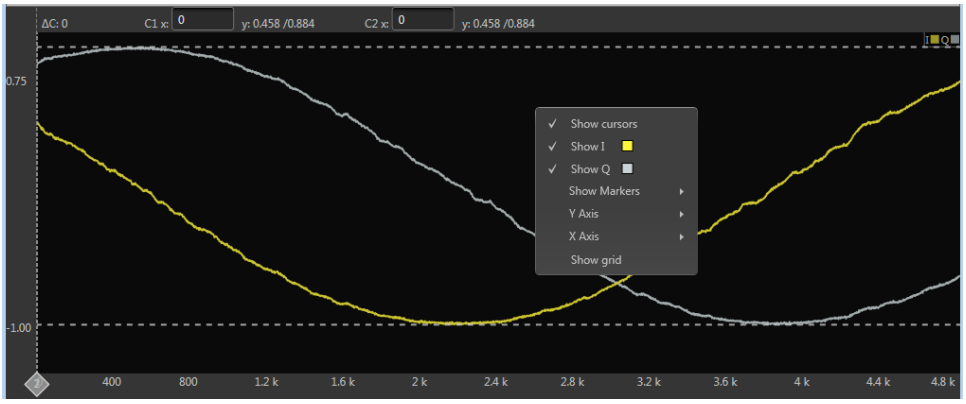
Select one of the waveform modifiers to display the Modify waveform dialog screen (see page 41).

Modify waveform dialog screen

The Modify waveform dialog screen provides you with the controls and settings to modify a waveform and save it as a new waveform or overwrite the original waveform.



If modifying an IQ waveform, the I and Q waveforms are displayed. The I waveform color uses the color assigned to the channel; the Q waveform is show in gray.

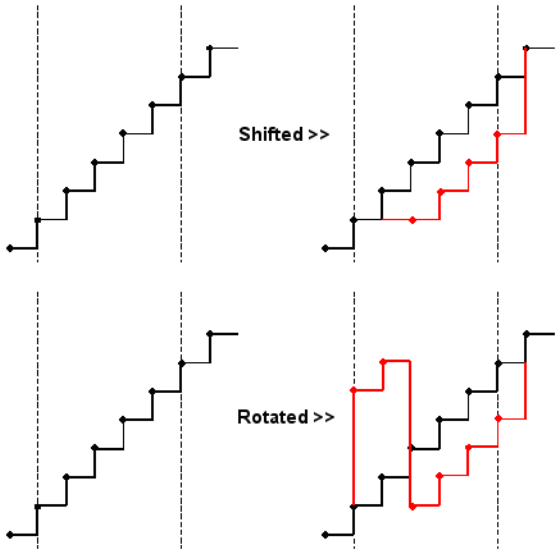


Here are tips and notes about using the Modify Waveform feature:

- The waveform must be in the Waveform List.
- New or modified waveforms are placed in the Waveform List, but are not automatically saved to the hard drive (or other location). They do become part of the setup file if the setup is saved. To make a modified waveform available for use in other setups, select the modified waveform and use Save or Save As to save the waveform.
- Only one modification is allowed at a time, requiring you to compile the new waveform for each modification. This avoids any uncertainty of modifications since some modifications can affect other characteristics.
- Some modifications may cause a reduction in fidelity to the new waveform.
- The waveform displayed in the dialog screen represents the modified waveform before compiling.

Sample Rate / Length tab	
Resample, Multiply By	Increases the number of samples of the waveform.
Add or Subtract Samples	Adds samples to the end of the waveform by repeating the last sample of the waveform.
Repeat Waveform	Duplicates the waveform the defined number of times.
Scale / Offset tab	
Multiply by	The scale and offset tab allows you to modify the output amplitude and offsets using the Multiply by value. Fractional values are allowed. You can use the Show more options check box to display and adjust individual settings. Only the analog data is modified. Markers are not affected.
Normalization Presets	The Scale to Max Amplitude adjusts all values to obtain the full scale amplitude of 500 mVpp. The Max & preserve Offset adjusts the values to their maximum value while preserving the offset value.
Rotate / Shift tab	
Rotate waveform, wrap samples	Enter a value in degrees or number of samples to rotate the waveform horizontally. Rotating the waveform takes the end of the waveform (defined by the degrees or samples) and moves it to the front of the waveform.
Shift waveform, repeat sample to fill	Enter a value in degrees or number of samples to shift (or move) the waveform horizontally. Shifting moves the waveform and repeats the first waveform sample value to fill in the waveform.

Rotate / Shift tab	
Apply Rotation/Shift To	Rotation and Shift is available for the analog data and the markers.

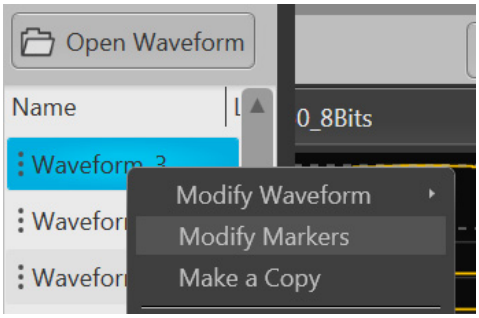


Invert/Reverse	
Invert	Select which components of the waveform you wish to invert.
Reverse	Select which components of the waveform you wish to reverse.
Range	Select the range of samples you want to invert or reverse. All samples affects the entire analog and marker signals. Between Cursors
All Samples	All samples affects the entire analog and marker signals.
Between Cursors	You can define a particular segment of the waveform to invert or reverse. If cursors are not displayed, they are automatically enabled. Move the cursors to define the affected area. The waveform display has the same control functions as those for the waveform in the Home tab, such as zooming.
Pattern tab	
See the Modify markers (see page 43) section on using the Pattern features.	

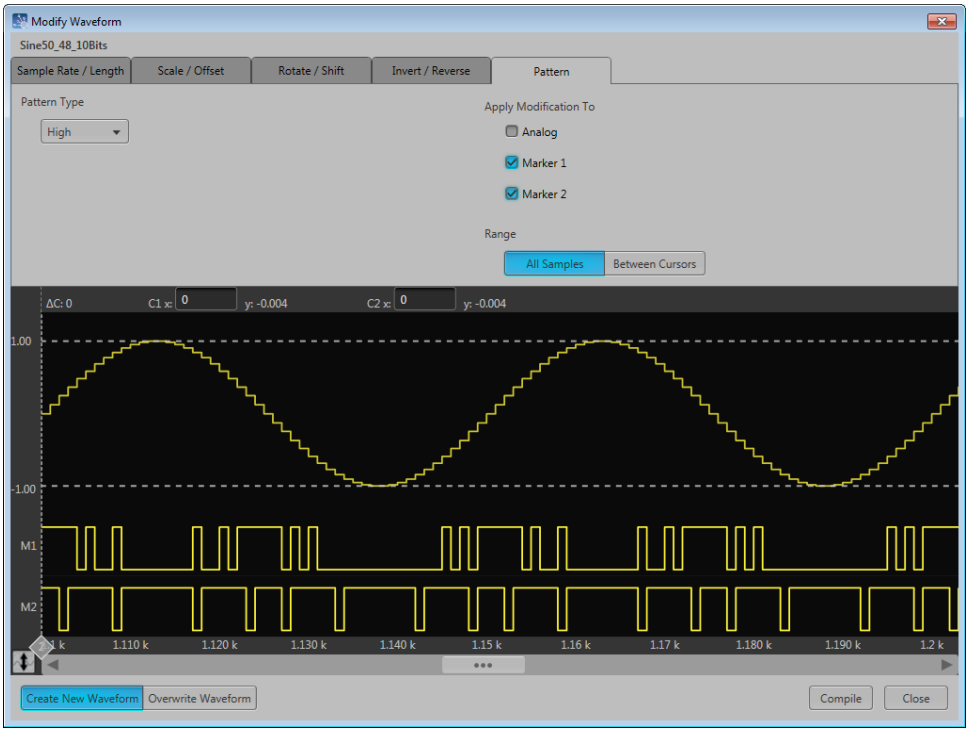
Modify markers

You can select any waveform contained in the Waveform List to modify the waveform markers.

Select a waveform and right mouse click to display the waveform operations.



Select Modify Markers to display the Pattern editor tab in the Modify Waveform dialog screen.



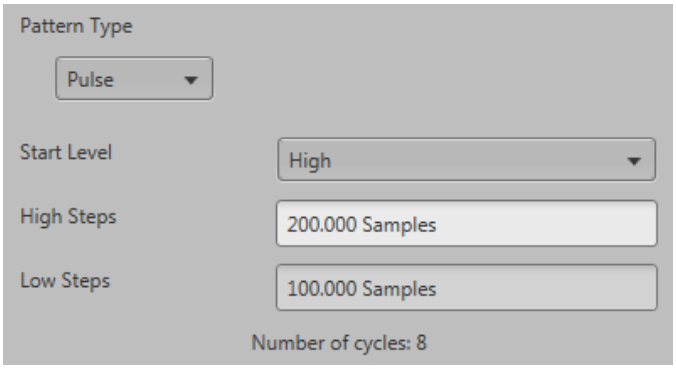
The pattern editor allows you to modify the Analog waveform and/or the Markers. Once you've defined your changes, you need to compile the new waveform. By default, a new waveform is created (based on the existing name) and is placed in the Waveform List.

The controls are described below.

Pattern Type. Three patterns are available:

- **High**: The sample points (all samples or between cursors) are set to their high values. Marker samples are set to 1. The analog waveform samples are set to the waveform maximum value.
- **Low**: The sample points (all samples or between cursors) are set to their low values. Marker samples are set to 0. The analog waveform samples are set to the waveform minimum value.
- **Pulse**: The sample points (all samples or between cursors) alternate between their high and low values for the defined number of samples.

  When choosing Pulse, additional settings are displayed:



  Start Level defines whether the cycle of pulses start from their high or low value.

  High Steps defines how many sample points are set to high.

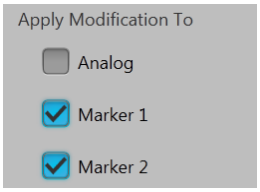
  Low Steps defines how many sample points are set to low.

  The combined number of samples for the High and Low steps are limited to the number of samples available in the waveform

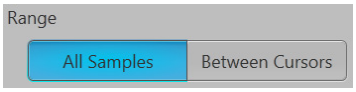
  The number of pulse cycles is calculated and displayed. The number of cycles based on the number of samples used for the high and low steps and if it's being applied to the entire waveform or between cursors.

NOTE. *An invalid pulse definition (such as 0 samples for the high or low steps) will not let the waveform compile.*

Apply Modifications To. The modifications can be applied to the analog waveform and the markers. By default, only the markers are selected.



Range. You can apply the pattern modifications to the entire waveform (All Samples) or between the cursors.



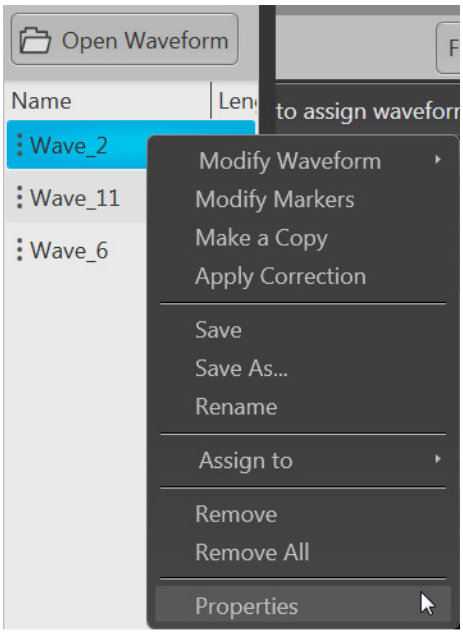
If you select Between Cursors then the cursors are automatically turned on. This also turns on the cursors in the Home tab. Position the two cursors on the displayed waveform in order to define where the pattern is applied.

The waveform display has the same control functions as those for the waveform in the Home tab, such as zooming.

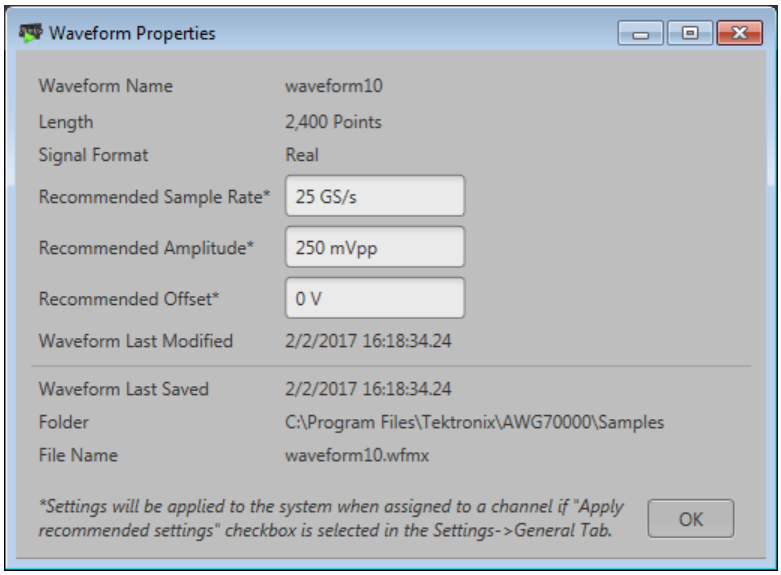
Properties

You can select any waveform contained in the Waveform List to view its properties.

Select a waveform and right mouse click to display the waveform operations.



Select Properties to display the Waveform Properties dialog screen.



The Waveform Properties dialog screen provides many details about the waveform that are static (not able to modify), such as the name, length, and signal format.

The Signal Format displays the type of waveform, which will show one of the following:

Real: Waveform containing data other than I, Q, or IQ.

I: Waveform contains I data.

Q: Waveform contains Q data.

IQ: Waveform contains IQ data.

The items you are able to modify include:

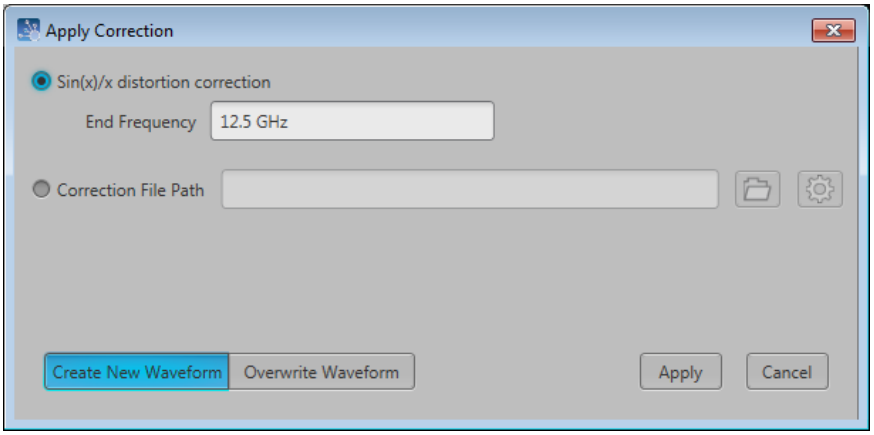
- **Recommended Sample Rate**: Typically defined by the waveform when it was created, you can change the recommend sample rate as needed.
- **Recommended Amplitude**: Typically defined by the waveform when it was created, you can change the recommend amplitude as needed.
- **Recommended Offset**: Typically defined by the waveform when it was created, you can change the recommend offset as needed.
- **Recommended Frequency**: IQ waveforms only. Typically defined by the waveform when it was created, you can change the recommend frequency as needed.

NOTE. *Recommended settings are used when the system is defined to use the waveform settings instead of the system settings during playout.*

Applying Sin(x)/x correction (AWG70000 series)

Select the Sin(x)/x distortion correction to apply to the waveform. The End Frequency of the Sin(x)/x distortion correction is initially set to ½ the recommended sample rate of the waveform.

Distortion correction coefficients are defined up to the End Frequency. FIR filter is applied to the impulse response (smooth roll-off).



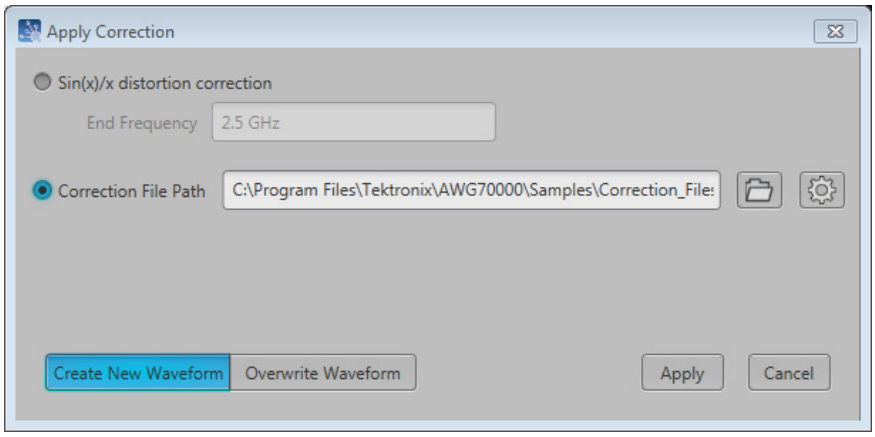
Choose to either create a new waveform or overwrite the existing waveform and select Apply.

Applying correction file

Correction files for waveforms can contain two types of coefficients, RF coefficients or IQ coefficients.

- RF coefficients can be applied to Real, I, or Q files. Select a single waveform and apply the correction file.
- IQ coefficients must be applied to two waveforms, I and Q. Select the two waveforms (high lighting both at the same time) and apply the correction file.

A window opens to allow you to navigate to the saved coefficient file (correction file).

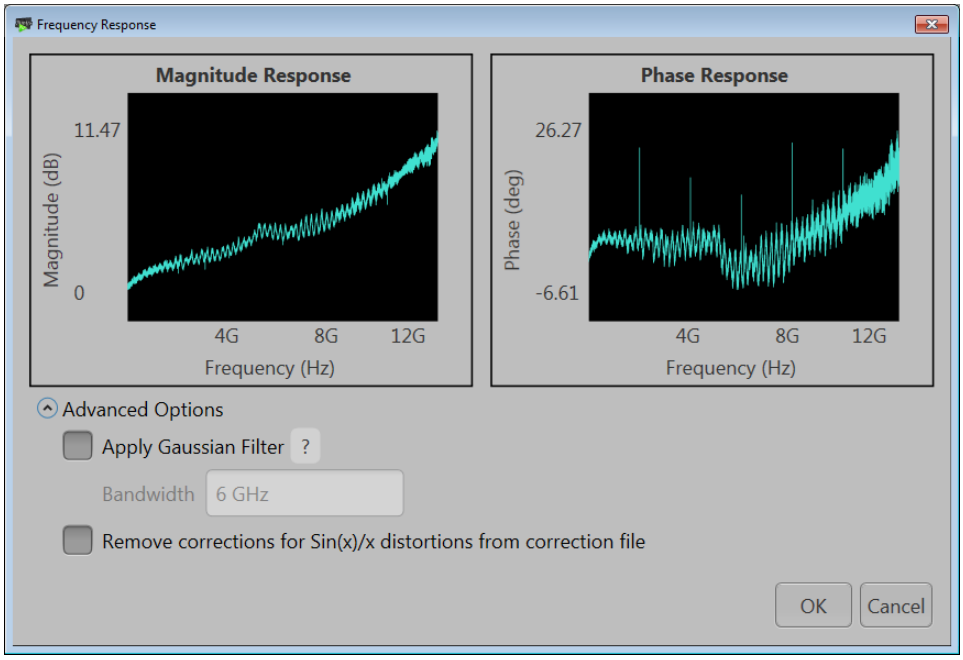


Use the browse folder icon to navigate to a saved correction file.

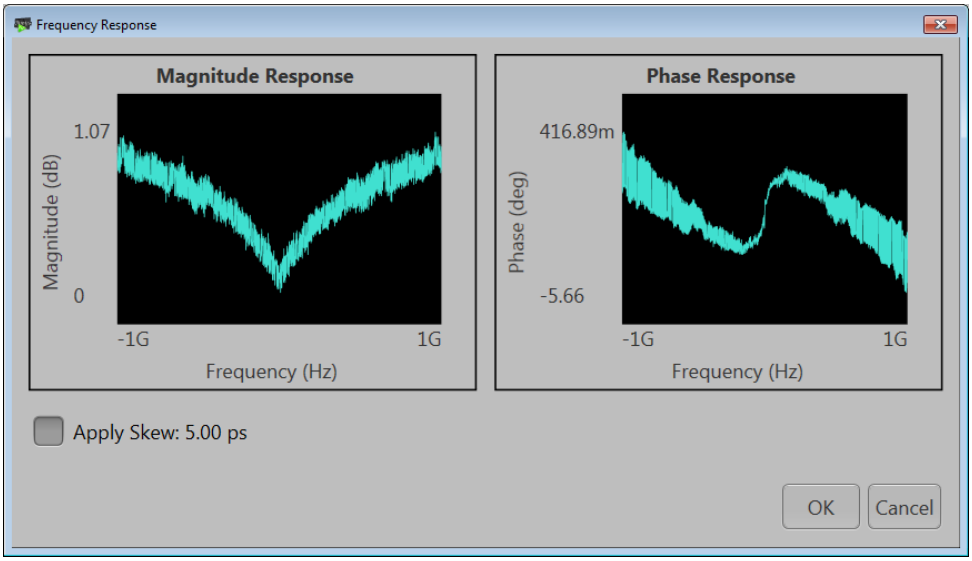
Choose to either create a new waveform or overwrite the existing waveform.

Once a valid file path is entered, the Correction Settings icon  is enabled. Select the Setting icon to display the Frequency Response screen.

If applying an RF correction file, the Frequency Response screen shows plot information and provides Advanced options to apply a Gaussian filter or remove Sin(x)/x distortions.



If applying an I/Q correction file (to a pair of I and Q waveforms), the Frequency Response screen shows plot information and provides Advanced options to apply a skew.



Apply S-Parameters

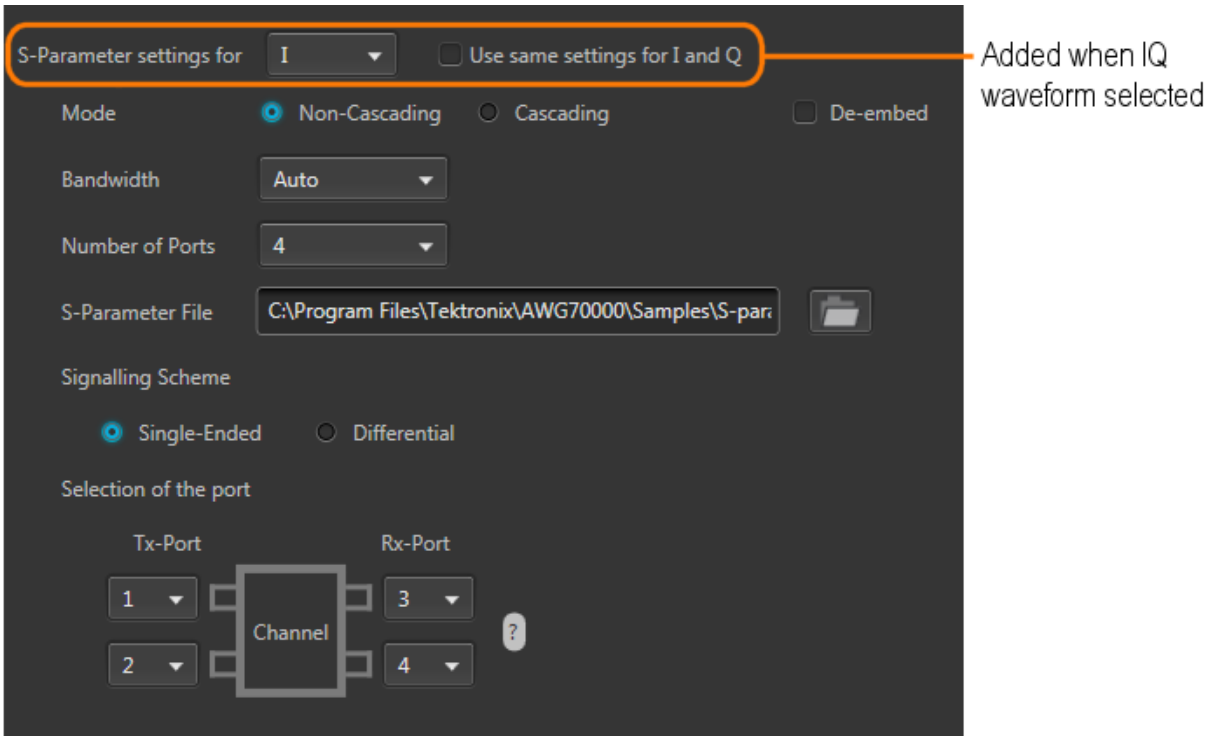
S-Parameters (scattering parameters) can be applied to RF waveforms or IQ waveforms in the Waveform List.

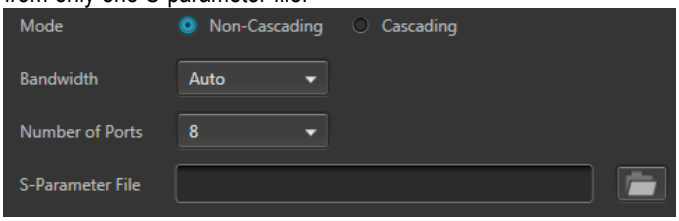
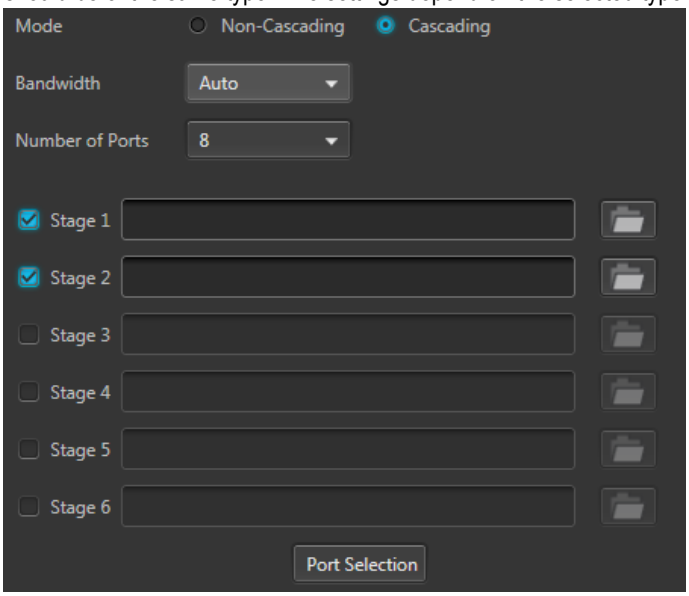
NOTE. *The S-Parameter selection becomes available only if an S-Parameter license is currently installed.*

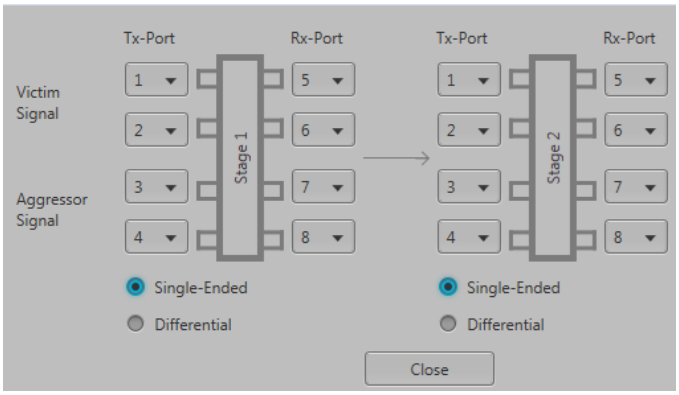
Selecting to apply S-Parameters displays the Apply S-Parameter dialog screen to select the S-Parameter file and define its characteristics.

Below is a sample S-Parameter dialog screen with the Number of Ports set to 4. If an IQ waveform is being modified, the S-Parameters dialog screen provides additional selections to apply the parameters to the I component, Q component, or both I and Q.

The information provided for S-Parameters apply to both the Non-Cascading and Cascading modes.


S-Parameter settings for
I
Use same settings for I and Q
Added when IQ waveform selected
Mode
Non-Cascading
Cascading
De-embed
Bandwidth
Auto
Number of Ports
4
S-Parameter File
C:\Program Files\Tektronix\AWG70000\Samples\S-para
Signalling Scheme
Single-Ended
Differential
Selection of the port
Tx-Port
Rx-Port
1
2
Channel
3
4
?

Item	Description
Mode	Select Non-Cascading or Cascading S-parameter mode. In the Non-Cascading mode, you apply S-parameter characteristics on the signal from only one S-parameter file.  In the Cascading mode, you can cascade up to six S-parameter files in Stages and apply the characteristics on the signal. You can select the files to apply by turning on or turning off the corresponding Stages shown in the display. All the selected files should be of the same type. The settings depend on the selected type of file.  The files supported are s1p, s2p, s4p, s6p, s8p, and s12p.
De-embed (Non-Cascading mode) Cascading De-embed (Cascading mode)	Check the box to invert the S-Parameters from the signal. This removes the effects of the component (for which the S-Parameters were created) from the signal path.
Bandwidth	Auto – The bandwidth is defined at the point where the signal rolls off to -60 dB. If this results in a bandwidth greater than the instrument supports, the bandwidth is set to ½ of the waveform's sample rate (i.e. Nyquist Frequency). Full Bandwidth – The bandwidth is set to ½ of the waveform's sample rate (i.e. Nyquist Frequency). Manual – The bandwidth can set by the user from 1 Hz to ½ of the maximum sample rate of the instrument. If the set Bandwidth is greater than the Nyquist (Sample rate of the waveform/2), then the software limits the bandwidth to ½ of the waveform's sample rate. A warning message is provided.

Item	Description
Number of Ports	Choose the number of ports. The port matrixes supported are 1, 2, 4, 6, 8, and 12. The number of ports selected determines: • The type of S-Parameter file to apply • The Signalling Scheme choice • The port matrixes available
S-Parameter File	Navigate to the Touchstone file to apply to the signal. The type of Touchstone files that you are able to open is dependent on the number of ports selected. For instance, only .s4p files can be opened if the Number of Ports is set to 4. The files supported are s1p, s2p, s4p, s6p, s8p, and s12p.
Signalling Scheme (Only for 4, 8, and 12 ports)	Signle-Ended: If the data is single-ended, you must map the port numbers as used in the file to physical locations in your link. Differential: If the data is differential, you must select the data layout in the file.
Selection of the port (No port selection for 1 Port environments)	Use the diagrams to map the ports for the transmitter ports (Tx-Port) and the receiver ports (Rx-Port). When choosing the number of Ports, you are presented with an active diagram of the ports. The diagram presented reflects the Number of Ports selected and the Signalling Scheme (if appropriate for the ports selected).
Victim Aggressor and Both (Only for 8 and 12 ports)	Victim: The default setting with no cross-talk effects. Aggressor: Select this to activate aggressor signal parameters, adding the effect of cross-talk.
Port Selection	The Port Selection button is available only when in Cascading mode. Press the Port Selection button to display an active dialog screen to map the ports for the transmitter ports (Tx-Port) and the receiver ports (Rx-Port) for each stage. 

S-Parameter file descriptions

1-port

Files with one port of data contain only one S-parameter file (s1p) so they do not require any further input.

2-port

Files with data for two ports contain four S-parameters as a 2x2 matrix. These are Touchstone 2-port files (s2p). A dialog box is created to define the 2-port mapping.

4-Port

Files with data for four ports contain 16 S-parameters as a 4x4 matrix. These are Touchstone 4-port files (s4p). They may contain single-ended or differential data. A dialog box is created to define the 4-port mapping for either single-ended or differential data.

- If the data is single-ended, you must map the port numbers as used in the file to physical locations in your link.

  You can select the port for both transmitter and receiver from the drop-down list. Each drop-down list has ports from 1 to 2.

- If the data is differential, you must select the data layout in the file.

6-port

Files with data for six ports contain 36 S-parameters as a 6x6 matrix. These are Touchstone 6-port files (s6p). A dialog box is created to define the 6-port mapping.

8-Port

Files with data for eight ports contain 64 S-parameters as an 8x8 matrix. These are Touchstone 8-port files (s8p). They may contain single-ended or differential data. A dialog box is created to define the 8-port mapping for either single-ended or differential data.

- If the data is single-ended, you must map the port numbers as used in the file to physical locations in your link.

  You can select the port for both transmitter and receiver from the drop-down list. Each drop-down list has ports from 1 to 4.

- If the data is differential, you must select the data layout in the file.

12-Port

Files with data for 12 ports contain 144 S-parameters as an 12x12 matrix. These are Touchstone 12-port files (s12p). They may contain single-ended or differential data. A dialog box is created to define the 12-port mapping for either single-ended or differential data.

- If the data is single-ended, you must map the port numbers as used in the file to physical locations in your link.

  You can select the port for both transmitter and receiver from the drop-down list. Each drop-down list has ports from 1 to 6.

- If the data is differential, you must select the data layout in the file.

Aggressor signals

8 and 12 port S-parameters allows you to activate aggressor signal parameters and to add the effect of cross-talk. 12 port S-parameters allows 2 Aggressor signal parameters.

Aggressors can be added in either Non-Cascading Mode or Cascading Mode.

The Aggressor signal parameters include:

Item	Description
Signal	Choose the type of aggressor signal with the dropdown list: • Clock: Indicates that the aggressor signal is a clock pattern. • PBRS: Also choose the number of bits • File: Indicates that the aggressor signal is another pattern file. Navigate to the Pattern file • Same as victim: The signal flow of the aggressor is same as the victim.
Data Rate	Specify the data rate (in bps) of the signal. This is not available when the Aggressor signal is set to be the same as the victim.
Aggressor Amplitude	Enter the signal amplitude. This is not available when the Aggressor signal is set to be the same as the victim.
Crosstalk Type	Choose the type of crosstalk of the aggressor signal. • Near-End Crosstalk • Far-End Crosstalk • Both

Sequence list

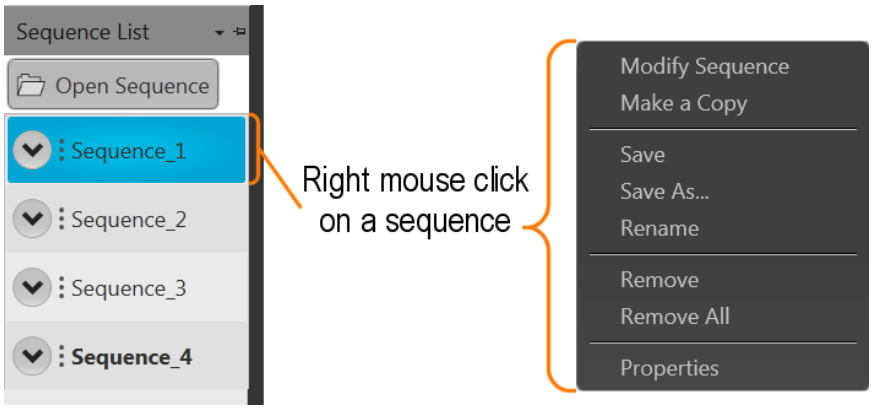
NOTE. *When connected remotely to an instrument, the connected instrument must have Sequencing enabled.*

The Sequences list contains the available sequences. Right-mouse click on a sequence to display a pop-up menu of tools to modify, rename, save, copy, and remove sequences.

To add a sequence to the list, see Adding a sequence (see page 58).

To play a sequence track, it needs to be assigned to a channel. Refer to Assigning tracks to channels (see page 60).

Right-mouse click on a sequence to display a pop-up menu of tools to modify, rename, save, copy, and remove sequences.



Item	Description
Modify Sequence	Opens the Sequence tab and loads the selected sequence into the sequence editor.
Make a Copy	Creates a copy of the selected sequence and places the copy in the Sequence List. The copy is renamed by adding a numerical suffix to the end of the original name.
Save	Saves the sequence to the specified location.
Save As ...	Opens a window to save the sequence with a new file name. This only changes the file name, it does not change the sequence name that appears in the Sequence List.
Rename	Changes the sequence name currently displayed in the Sequence List. Use Save or Save As .... to save the sequence with the new name.

Item	Description
Remove	Use remove to remove the selected sequence(s).
Remove All	Remove All removes all sequences from the Sequence List.
Properties	Displays information about the sequence. Refer to the section Sequence properties (see page 62).

Adding a sequence

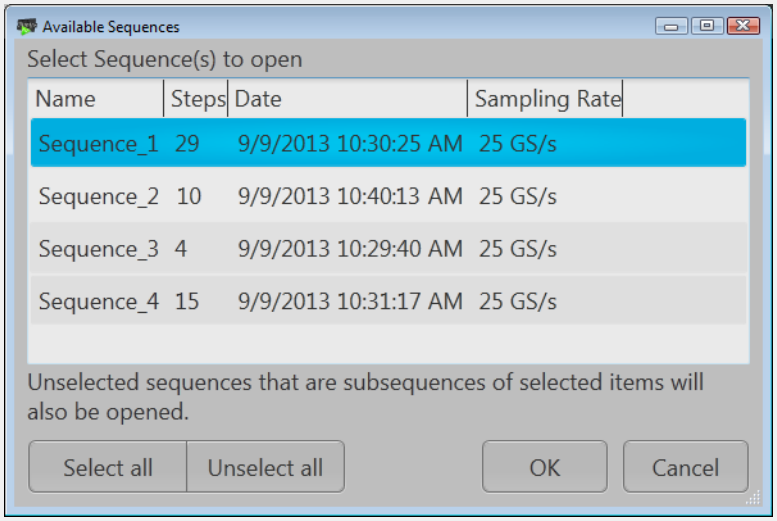
To add a sequence to the Sequences List, select the Open Sequence button. This opens a Windows dialog box that allows you to navigate to a saved sequence or setup file. If the sequence or setup file is a valid file type, the sequences are added to the Sequence List and waveforms (used in the sequence) are added to the Waveform List. Once a sequence is in the Sequences List, a sequence track can be assigned to a channel for playout. (See Assign a track to a channel.) (see page 60)

Click here to see a list of valid sequence file types.

Valid sequence file types	Description
.SEQX file format	Sequence file created by Tektronix AWG70000/AWG5200 Series instruments or SourceXpress.
.AWGX file format	Setup file created by Tektronix AWG70000/AWG5200 Series instruments or SourceXpress. Setup files can contain multiple sequences and multiple waveforms. ***NOTE.*** *Opening a setup file from the Sequence List does not restore the instrument settings, only the sequences contained in the setup file are restored along with any waveforms used in the sequences.*
.AWG file format	Setup file created by Tektronix AWG5000 or AWG7000 Series instruments. ***NOTE.*** *The Tektronix AWG5000 or AWG7000 Series instruments had predefined waveforms available for use.* *Saved setup files that used predefined waveforms did not save the actual waveform data with the setup, only the waveform name. Hence, importing setup files that used predefined waveforms will not import the waveforms. To import these types of waveforms, first copy and rename the predefined waveform, then save the setup file before importing.* ***NOTE.*** *The Tektronix AWG5000 or AWG7000 Series instruments supported subsequencing (using another sequence as a step in a sequence). Subsequences are imported as another sequence and added to the Sequences list.*
.SEQ file format	Sequence file created by Tektronix AWG400, AWG500, or AWG600 Series instruments.

If selecting a setup type file containing multiple sequences, you are presented with the Available Sequences (see page 59) dialog box that lists all sequences contained in the setup file. You can load all sequences or select a subset of the sequences. Waveforms that are part of any sequence are added to the Waveform List.

Available sequences



NOTE. *When opening a setup file (.AWGX) from the Waveforms or Sequences tabs, only waveforms and sequences are extracted; instrument settings contained in the setup file are not restored. Use the Open Setup in the File menu to restore the settings, waveforms, and sequences from a .AWGX setup file.*

If you want any of the waveforms or sequences (extracted from a setup file) to be available outside of the setup file, select and save each individual waveform.

Multi-sequence select

Though the Open Sequence menu in the Sequences List, you can select multiple sequence files to load into the sequence list at once.

To select a contiguous block of files, click the first file in the block. Then hold down the Shift key as you click the last file in the block. This will select not only those two files, but everything in between.

To select multiple files that are not a contiguous block, click one file. Then hold down the Ctrl key while you click each additional desired file.

⚠ ***CAUTION.*** *Loading a group of sequences will overwrite any existing sequence of the same name in the Sequences List without warning.*

NOTE. *Multiple sequence selection is not available from the Open File menu in the tool bar or from the pull-down list in the graphical waveform area.*

Saving a sequence

To save a sequence, right mouse click and select Save or Save As. This opens a Windows dialog box that allows you to navigate to a location to save the sequence.

Click here to see the list of valid sequence file types.

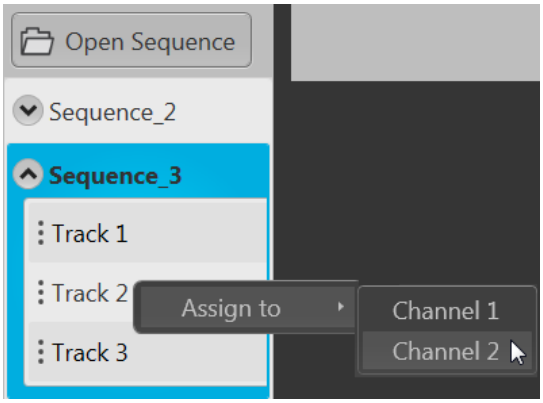
Valid file types	Description
.SEQX file format	Native sequence file.
.SEQ file format	Sequence file for AWG5000 and AWG7000 series instruments.

Assigning tracks to channels

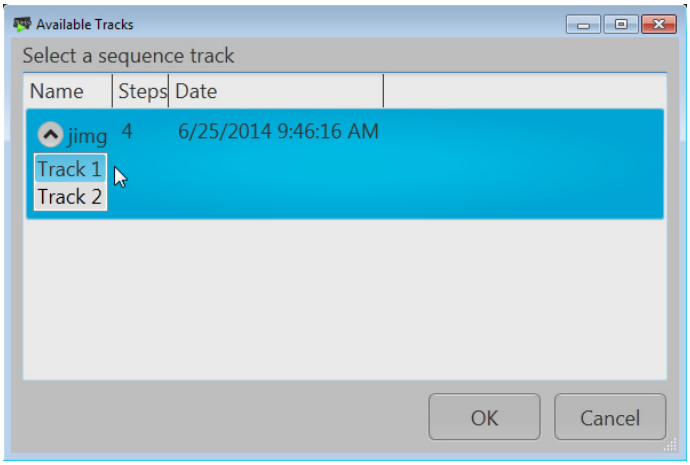
A sequence can consist of up to eight different tracks. (A minimum of one track is required). To play a sequence track, you need to assign it to a channel. This is true even for a single channel instrument.

There are several methods to assign a sequence track to a channel. (See below for further information regarding one channel and two channel instruments.)

- Drag an entire sequence onto a channel's plot area.
- Drag a track from a sequence onto a channel's plot area.
- Right mouse click on a sequence track in the Sequences tab and use the pop-up window to assign it to a channel.



- Use the drop-down list in the channel's plot area to assign the channel to play a sequence track. You can choose sequence tracks from sequences already loaded into the Sequences tab or you can browse for sequence files. When browsing, you select the sequence file, and then select the track to assign to the channel.



Assigning tracks on a one channel instrument

With a one channel instrument, the following actions occur when assigning a track to play on the channel:

- If you drag and drop a sequence onto the channel's graph area, Track 1 is assigned to the channel. This is true regardless of how many tracks the sequence may contain.
- You can drag and drop (or assign) any track from any sequence onto the channel's graph area.

Assigning tracks on a two channel instrument

With a two channel instrument, you have the option to play multiple tracks, either from the same sequence or different sequences. You also have the option to play a sequence track on one of the channels while playing a single waveform on the other.

The following describes the interactions between the two channels:

- You can drag and drop the entire sequence onto one of the channel's graph area. This automatically assigns Track 1 of the sequence to the channel.
  - If the sequence has only one track, you can drag and drop the sequence to one or both channel's graph area and the single track will play on both channels.
  - If the sequence has multiple tracks, you can drag and drop the sequence to either channel's graph area. In this case, Track 1 is assigned to Channel 1 and Track 2 is assigned to Channel 2. This is the track assignment regardless of which channel you drag the sequence to.
  - If playing tracks from the same sequence on both channels, the channels are coupled together. This requires that the waveforms be of equal length for each step of the two tracks. In this case, the **Force jump to...** buttons are coupled together. (Coupled Sequence is displayed on the Home tab when tracks from the same sequence are assigned to both channels.)
- You can drag and drop (assign) a specific track from different sequences onto the channel's graph area.

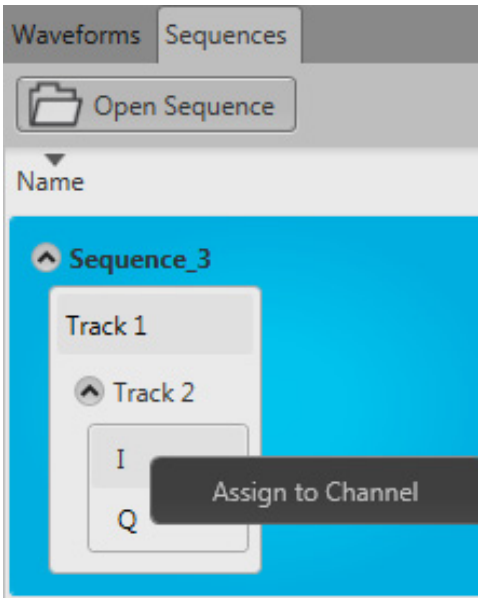
This gives you the freedom to play any track from any sequence. Since the tracks are from different sequences, the channels are not coupled together.

- You can play a sequence track on one channel while playing a waveform on the other channel.

Assigning tracks containing IQ waveforms

IQ waveforms cannot be assigned to a channel for playout, only their I or Q components can be assigned to a channel.

Sequence tracks that contain an IQ waveform provide a drop down menu for you to choose which component of the IQ waveform you want the channel to play. If a track contains multiple IQ waveforms, the I or Q selection applies to all IQ waveforms in the track.

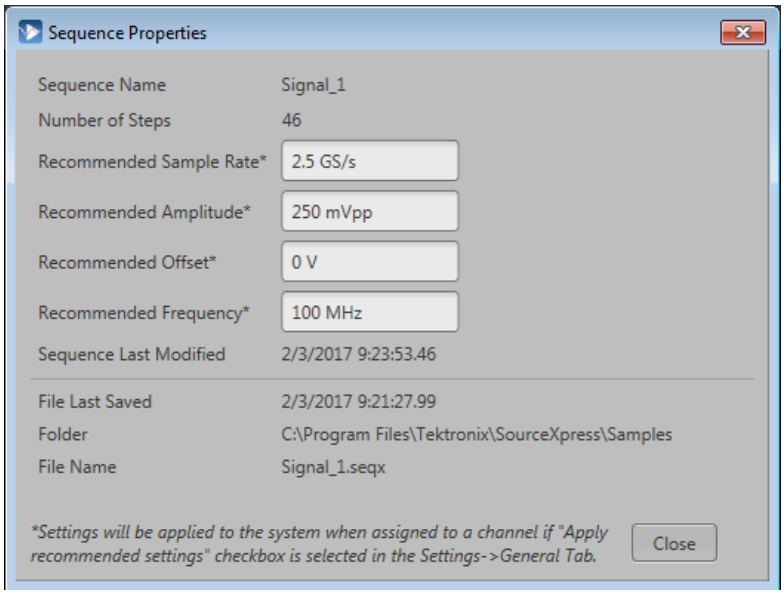


Edit a sequence

You can select any sequence contained in the Sequences tab to modify it or create a new sequence based on the existing sequence. Select any sequence in the list, right mouse click to display the sequence operations. Selecting Modify sequence opens the sequence in the Sequences tab window for editing.

Sequence properties

You can select any sequence contained in the Sequence List to view its properties.



The Sequence Properties dialog screen provides many details about the Sequence that are static (not able to modify). The items you are able to modify include:

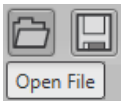
- **Recommended Sample Rate**: This is typically defined by the sequence when it was created. You can change the recommend sample rate as needed.
- **Recommended Amplitude**: This is typically defined by the sequence when it was created. You can change the recommend amplitude as needed.
- **Recommended Offset**: This is typically defined by the sequence when it was created. You can change the recommend offset as needed.
- **Recommended Frequency**: This is typically defined by the sequence when it was created and is only displayed if the sequence contains an IQ waveform. You can change the recommended frequency as needed.

Recommended settings are used when the system is defined to use the sequence settings instead of the system settings during playout.

Sequencer batch compiler

The batch compiler provides a method to create sequences and waveforms using an Excel spreadsheet (.CVS file type) and then importing the file into the AWG. The comma delimited file type (.CSV) must be used.

To import the batch compiler file, you must use the Open File folder from the toolbar.



Opening the file compiles all defined waveforms and loads the sequence into the Sequences tab and loads all waveforms into the Waveforms tab.

The waveforms created by the batch compiler are limited to:

- Basic waveforms via the use of the Basic Waveform plug-in
  - Create sine waves, square waves, triangle waves, ramps, noise, and DC
- RF waveforms via the use of the RF Generic Signal plug-in. A license for the RF Generic Signal plug-in is required.
  - Create AM, FM, and PM Analog Modulation signals

Creating a batch compile file (.CSV)

The .csv file must be created with very specific information in the proper cells. Deviating from this design will likely create an invalid file. The following information defines the rows, columns, and cell content required to create the batch file.

NOTE. *The Samples directory (C:/Program Files/Tektronix/SourceXpress/Samples) contains a sample batch file (Batch Compile Example.csv) that you can use as a basis to create your own batch file. The sample batch file contains the proper header information and basic track definitions.*

Header information. The first four lines in column A must use the content as shown.

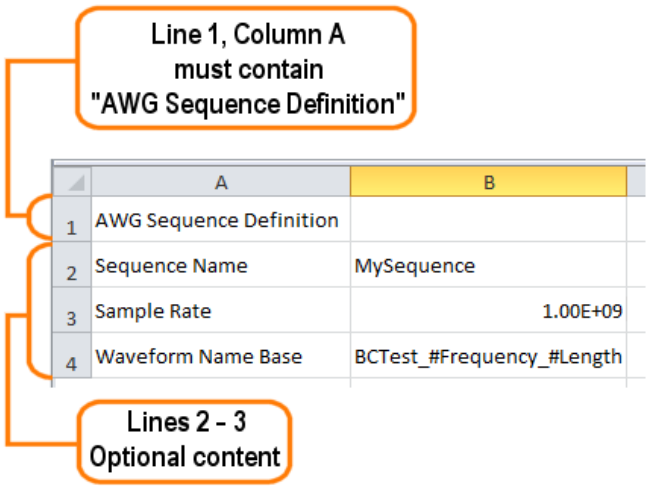


Table 1: Batch compiler header information

Line	Column A	Column B (Optional)
Line 1 Mandatory	AWG Sequence Definition	blank
Line 2 (Optional)	Sequence Name	Enter a name for your sequence. If omitted, the system will generate a unique name.
Line 3 (Optional)	Sample Rate	Enter the sampling rate to use. If omitted, the system calculates the sample rate based on the waveform frequency specified.
Line 4 (Optional)	Waveform Name Base	Enter the base name for the waveform files. Use the following syntax: <base name> [#Frequency_#Length_#Marker1_#Marker2....] The base name is used for all waveforms. You can also include any of the waveform parameters by including the parameter column heading, preceded by a # sign. If omitted, the system will generate unique names.

Track information. Following the header information is the start of the track definitions. You can create up to eight tracks containing multiple waveforms.

Each new track definition must start by creating a row with the name “Track” in cell A. This row signifies where the definition of each track begins.

The following row contains the headings for the waveform parameters. Note that some headings are global definitions while some headings define elements for each waveform. And the required and optional elements change based on the waveform editor you invoke (Basic or RF). See the tables below that describe the column contents depending on the waveform editor chosen.

A track can have many waveforms, with each waveform creating a new step in the sequence. The waveform definitions continue for the Track until another "Track" row is encountered. When defining multiple tracks, each track must contain the same number of waveform definitions.

The following illustrates the spreadsheet representing the columns for creating a basic waveform (using the Basic Waveform plug-in).

A	B	C	D	E	F	G
Track						
Wait	Repeat	Event Input	Event Jump To	GoTo	Flags	Waveform Name

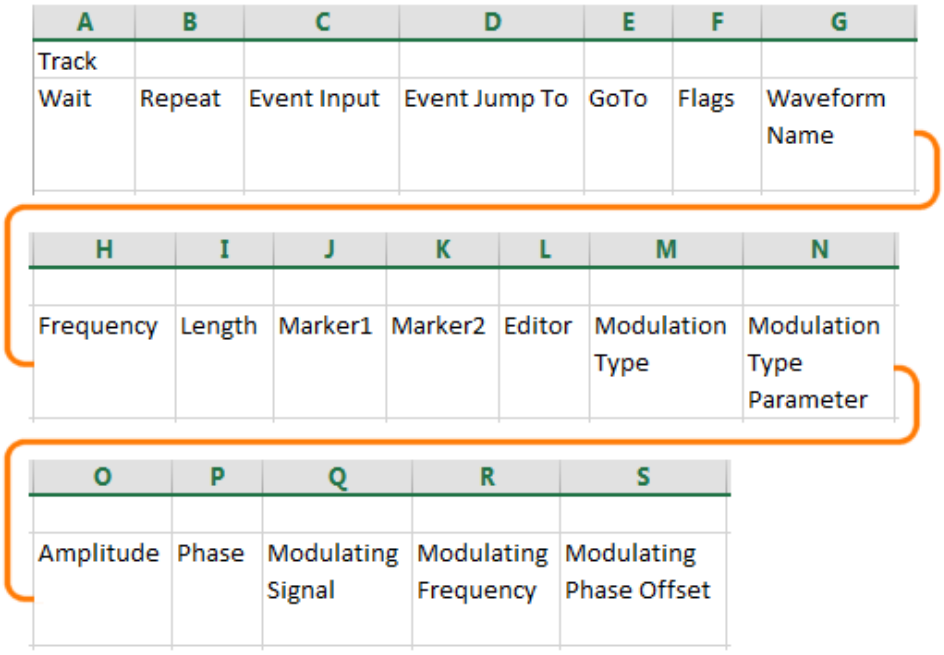
H	I	J	K	L	M	N	O
Frequency	Length	Marker1	Marker2	Editor	Waveform Type	Amplitude	Offset

The following illustrates the spreadsheet representing the columns for creating an RF waveform (using the RF Generic Signal plug-in).

A	B	C	D	E	F	G
Track						
Wait	Repeat	Event Input	Event Jump To	GoTo	Flags	Waveform Name

H	I	J	K	L	M	N
Frequency	Length	Marker1	Marker2	Editor	Modulation Type	Modulation Type Parameter

O	P	Q	R	S
Amplitude	Phase	Modulating Signal	Modulating Frequency	Modulating Phase Offset



A	B	C	D	E	F	G
Track						
Wait	Repeat	Event Input	Event Jump To	GoTo	Flags	Waveform Name

H	I	J	K	L	M	N
Frequency	Length	Marker1	Marker2	Editor	Modulation Type	Modulation Type Parameter

O	P	Q	R	S
Amplitude	Phase	Modulating Signal	Modulating Frequency	Modulating Phase Offset

NOTE. *Creating an RF waveform uses the RF Generic Signal plug-in. The RF Generic Signal must be licensed for use.*

Table 2: Batch compiler header: editor = Basic Waveform plug-in

Column		
A	Wait	Optional: Wait condition. This is a global setting for all tracks and must be defined in the first track. Syntax: <Off | TrigA | TrigB | Internal> If omitted, set to Off.
B	Repeat	Optional: Repeat element. This is a global setting for all tracks and must be defined in the first track. Syntax: <<Integer> | ∞> If omitted, set to 1.
C	Event Input	Optional: Event input. This is a global setting for all tracks and must be defined in the first track. Syntax: <Off | TrigA | TrigB | Internal> If omitted, set to Off.

Table 2: Batch compiler header: editor = Basic Waveform plug-in (cont.)

Column		
D	Event Jump To	Optional: Event jump. This is a global setting for all tracks and must be defined in the first track. Syntax: <<step number> | Next | First | Last | End> If omitted, set to Next.
E	Go To	Optional: Go To element. This is a global setting for all tracks and must be defined in the first track. If omitted, set to Next.
F	Flags	Optional: Flag element. If defining flags, you must define all four flags. Use semicolons (;) to separate the flag definitions. Syntax: <FlagA;FlagB;FlagC;FlagD> Values include: Toggle | High | Low | Pulse | NoChange If omitted, set to NoChange.
G	Waveform Name	Optional: Waveform name. This supersedes the Waveform Name Base in the header information. If omitted, the Waveform Name Base is used.
H	Frequency	Specifies the frequency of the waveform to be compiled.
I	Length	Specifies the length in sample points of the waveform to be compiled. If omitted, the system calculates the length.
J	Marker1	Optional: Marker1 value. Syntax: <0 | 1> If omitted, set to 0.
K	Marker2	Optional: Marker2 value. Syntax: <0 | 1> If omitted, set to 0.
Add column	Marker3	(AWG5200 series only) Optional: Marker1 value. Syntax: <0 | 1> If omitted, set to 0.
Add column	Marker4	(AWG5200 series only) Optional: Marker1 value. Syntax: <0 | 1> If omitted, set to 0.
		NOTE. *The sample batch file provided includes columns for two Markers. AWG5200 series can support up to four marker columns. This changes the column assignments of the remaining parameters.*

Table 2: Batch compiler header: editor = Basic Waveform plug-in (cont.)

Column		
L	Editor	Optional: Editor to use to compile waveform. Syntax: <Basic Waveform> If omitted, set to Basic Waveform. Use Parameter columns to set the Basic Waveform function. The Basic Waveform editor supports all functions of the Basic Waveform plug-in.
M	Waveform Type	Defines the type of waveform to create when Editor = Basic Waveform. Syntax: <Function=[Sine | Square | Triangle | Ramp | Noise | DC> If omitted, set to Sine.
N	Amplitude	Sets the peak-to-peak amplitude. Syntax: <Amplitude=[variable]> If omitted, set to 500 mV_{pp}.
O	Offset	Defines the offset. Syntax: <Offset=[variable]> If omitted, set to 0.

Table 3: Batch compiler header information: editor = RF Generic Signal plug-in

Column		
A	Wait	Optional: Wait condition. This is a global setting for all tracks and must be defined in the first track. Syntax: <Off | TrigA | TrigB | Internal> If omitted, set to Off.
B	Repeat	Optional: Repeat element. This is a global setting for all tracks and must be defined in the first track. Syntax: <<Integer> | ∞> If omitted, set to 1.
C	Event Input	Optional: Event input. This is a global setting for all tracks and must be defined in the first track. Syntax: <Off | TrigA | TrigB | Internal> If omitted, set to Off.
D	Event Jump To	Optional: Event jump. This is a global setting for all tracks and must be defined in the first track. Syntax: <<step number> | Next | First | Last | End> If omitted, set to Next.

Table 3: Batch compiler header information: editor = RF Generic Signal plug-in (cont.)

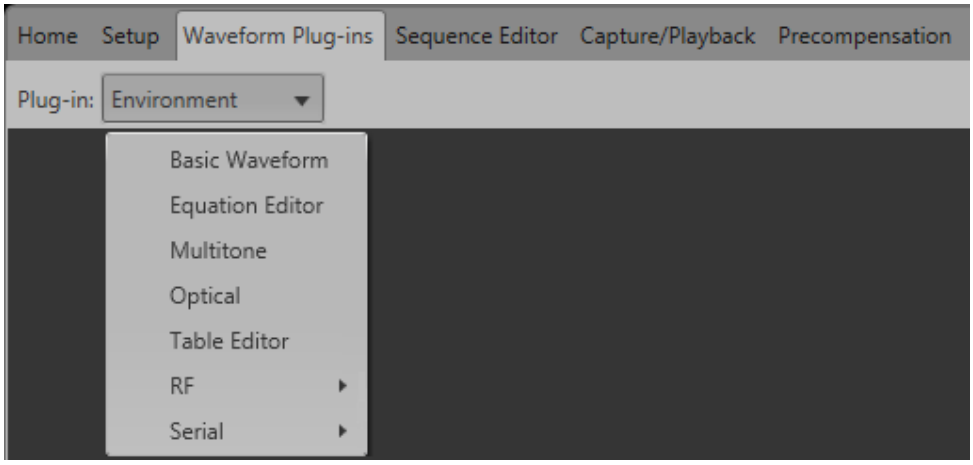
Column		
E	Go To	Optional: Go To element. This is a global setting for all tracks and must be defined in the first track. If omitted, set to Next.
F	Flags	Optional: Flag element. If defining flags, you must define all four flags. Use semicolons (;) to separate the flag definitions. Syntax: <FlagA;FlagB;FlagC;FlagD> Values include: Toggle | High | Low | Pulse | NoChange If omitted, set to NoChange.
G	Waveform Name	Optional: Waveform name. This supersedes the Waveform Name Base in the header information. If omitted, the Waveform Name Base is used.
H	Frequency	Specifies the frequency of the waveform to be compiled.
I	Length	Specifies the length in sample points of the waveform to be compiled. If omitted, the system calculates the length.
J	Marker1	Optional: Marker1 value. Syntax: <0 | 1> If omitted, set to 0.
K	Marker2	Optional: Marker2 value. Syntax: <0 | 1> If omitted, set to 0.
Add column	Marker3	(AWG5200 series only) Optional: Marker1 value. Syntax: <0 | 1> If omitted, set to 0.
Add column	Marker4	(AWG5200 series only) Optional: Marker1 value. Syntax: <0 | 1> If omitted, set to 0.
L	Editor	Optional: Editor to use to compile waveform. Syntax: <RF Generic Signal> Use the Parameters columns to define the RF Generic Signal. The RF Generic Signal editor supports analog modulation only. If omitted, set to the Basic Waveform plug-in and uses the Basic Waveform plug-in default settings.
M	Modulation Type	Defines the type of waveform to create when Editor = RF Generic Signal. Syntax: <Modulation Type=[AM | FM | PM> If omitted, set to AM.

Table 3: Batch compiler header information: editor = RF Generic Signal plug-in (cont.)

Column		
N	Modulation Type Parameter	Defines the base modulation type parameter. Modulation Type = AM Syntax: <AM Index=[variable] If omitted, set to 50. Modulation Type = FM Syntax: <Frequency Deviation=[variable] If omitted, set to 100000. Modulation Type = PM Syntax: <Phase Deviation=[variable] If omitted, set to 10.
O	Amplitude	Defines the carrier amplitude. Syntax: <Amplitude=[variable] If omitted, set to -6.24 dBm.
P	Phase	Defines the carrier phase. Syntax: <Phase=[variable] If omitted, set to 0.
Q	Modulating Signal	Defines the modulating signal type. Syntax: <Modulating Signal=[Sinusoidal | Triangular | Square> If omitted, set to Sinusoidal.
R	Modulation Frequency	Defines the frequency of the modulating signal. Syntax: <Modulation frequency=[variable] If omitted, set to 1000000.
S	Phase Offset	Defines the Phase offset of the modulating signal. Syntax: <Phase Offset=[variable] If omitted, set to 0.

Waveform plug-ins introduction

The Waveform Plug-ins tab provides access to the available plug-in applications. Three plug-ins are provided as standard plug-ins and are free to use. As other optional waveform creation plug-ins are installed, they are added to the Plug-ins pull-down list.



The standard plug-ins available include:

- Basic Waveform (see page 74)
- Equation editor (see page 77)
- Table editor (see page 109)

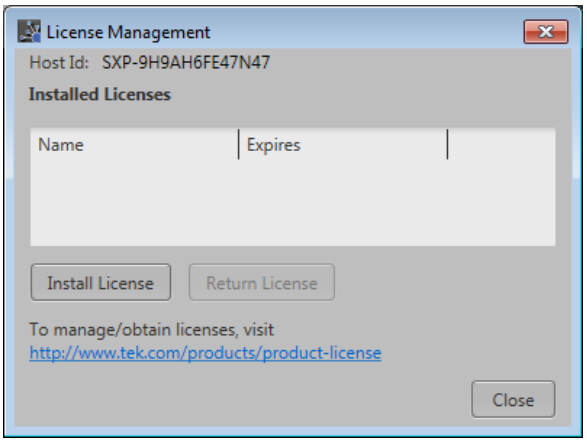
All optional plug-ins require a license and have their own help systems. To use a plug-in application that requires, a plug-in must be installed and licensed in SourceXpress in order to compile waveforms. This is true whether you are using a virtual generator or connected to a real instrument.

A plug-in that has a floating license can be moved between any installation of the plug-in. Refer to Licensing (see page 133) for information about how to use license files to enable or move a plug-in application.

NOTE. *SourceXpresss must have the license file (for a plug-in requiring a license) installed in the SourceXpress application in order to use the plug-in.*

A plug-in installed and licensed in a connected instrument is not available for use through SourceXpress unless SourceXpress also has a license for the plug-in.

To view and install licenses, select Licenses... from the Tools menu to display the License Management screen.



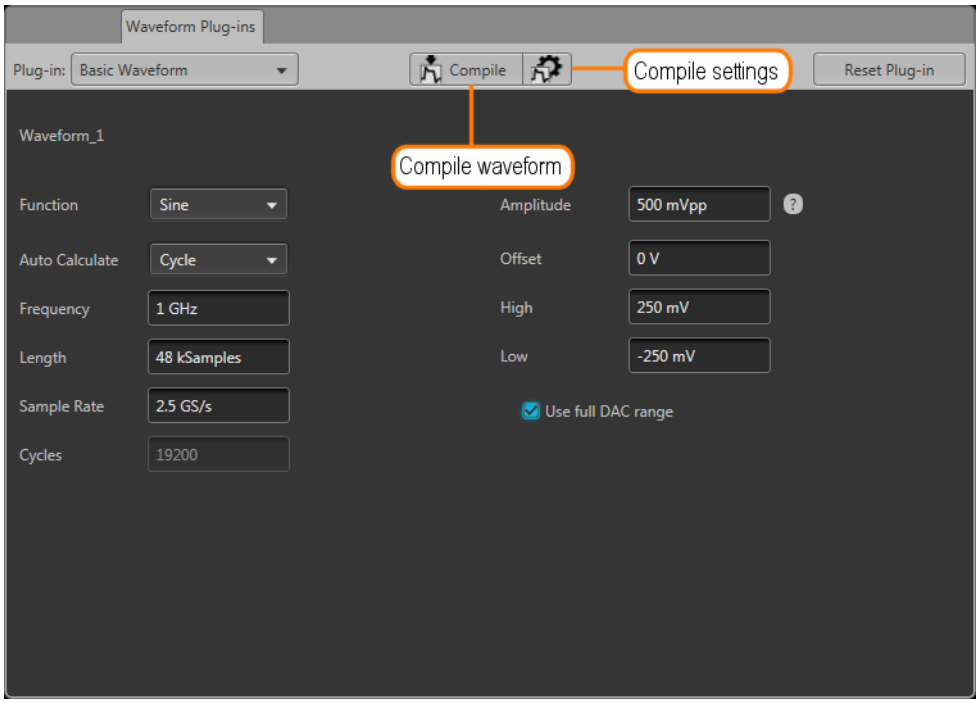
Plug-in applications have their own installation programs available for download from the Tektronix Web site. Plug-in applications have their own documentation and help systems and are not described in this document.

Waveforms created (compiled) using a plug-in are placed in the Waveform List. Use the Waveform List to save or edit waveforms created by a plug-in. Editing a waveform created by a plug-in requires that the plug-in is available.

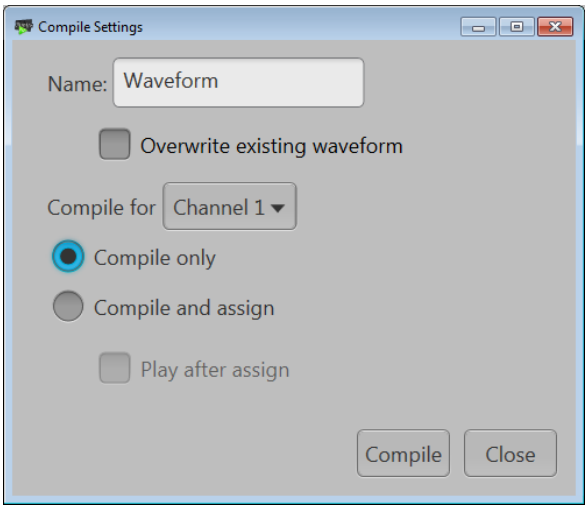
Basic waveform

The Basic Waveform application is provided as a standard plug-in.

This plug-in provides a method to quickly and easily create simple waveforms such as sine waves, square waves, and others. The compiled waveforms are placed in the Waveforms tab.



Item	Description
Plug-in:	Select Basic Waveform. Other plug-ins installed appear in the pull-down list but are not described here.
Compile	Use the compile button to create the new or modified waveform. How the waveform is named and the actions taken are controlled in the Compile Settings dialog screen. If the Waveforms list is closed or not in focus, the Waveforms tab flashes, indicating waveforms are being added.

Item	Description
Compile Settings	Use the Compile Settings parameters to set the actions taken each time you press the Compile button.  **Name**: Enter a name for the compiled waveform. If the name already exists in the Waveform List, the name is appended with an underscore suffix such as “Waveform_1”. **Overwrite existing waveform**: If checked, waveforms in the Waveform List are overwritten without warning. This selection is particularly useful to modify existing waveforms without creating new waveforms. **Compile for**: Select the playout channel intended for the compiled waveform. The channel selection is also used to set the amplitude and offset range. Multi-channel instruments may have differing channel output capabilities. This is the channel used when **Compile and assign** is selected. **Compile only**: Creates the waveform and places it in the Waveform List. **Compile and assign**: Creates the waveform, places it in the Waveform List, and assigns it to the channel selected with the **Compile for** selection. **Play after assign**: When checked, automatically loads the waveform and starts the waveform playout. When waveforms are compiled, they are placed in the Waveform List, but are not saved to the hard drive. To save to the hard drive, save the waveform from the Waveform List.
Reset Plug-in	Returns Basic Waveform plug-in settings to their default values. This control affects only the Basic Waveform plug-in application. This instrument application settings are not affected.
Function	Choose the type of waveform to create. Selections include: Sine wave, Square wave, Triangle, Ramp, Noise, DC.
Auto Calculate	Choose one of the waveform properties that you want the instrument to calculate (based on the other waveform properties). Only one property can be automatically calculated. The chosen property to calculate is grayed out and cannot be edited.
Frequency	Set the waveform frequency. The available range is dependent on the instrument model and installed options. The available frequency range is also affected by the Length and Sampling Rate settings.

Item	Description
Length (Advanced)	Determines the length (size) of the waveform. The minimum and maximum waveform length is dependent on the instrument model and installed options. The Length is affected by the Frequency and Sample Rate and settings.
Sample Rate	Sets the suggested sampling rate of the waveform. The minimum and maximum sampling rate is dependent on the instrument model and installed options. The sampling rate is affected by the Frequency and Length and settings.
Cycles	Sets the number of times the waveform will repeat.
Amplitude	Defines the peak-to-peak amplitude of the waveform. Changing the amplitude causes the instrument to recalculate the High and Low values. With a 0 V Offset, the High and Low values are one half the amplitude.
Offset	Defines the offset value (center) of the waveform. Changing the offset value causes the High and Low values to change to accommodate the difference, but the total amplitude is not affected. This limits the amount of offset that can be applied.
High and Low	Defines High and Low values of the waveform amplitude. The High and Low values are initially one half the amplitude of the waveform (with an offset of 0 V). Changing these values causes the Amplitude value to adjust. Changing the High and Low to uneven values cause a change to the Offset value.
Use full DAC range	Using the full DAC range when compiling waveforms results in waveforms with the best resolution. This feature is enabled by default. When enabled: If the selected offset and amplitude are within the range of the instrument's hardware, then the compiled waveform is compiled using the full DAC range and the compiled waveform's recommended amplitude and offset properties are set to the requested amplitude and offset values. If the selected offset and amplitude will result in a compiled waveform that does not take advantage of the full DAC range, the instrument adjusts the compiled waveform's recommended amplitude and offset values to use the full DAC range. If the system cannot achieve the full DAC range, a warning message is displayed. When disabled: The waveform is compiled using the specified amplitude and offset values and the compiled waveform's recommended amplitude is set to the maximum value and the recommended offset is set to 0. The control is not available for a DC waveform.

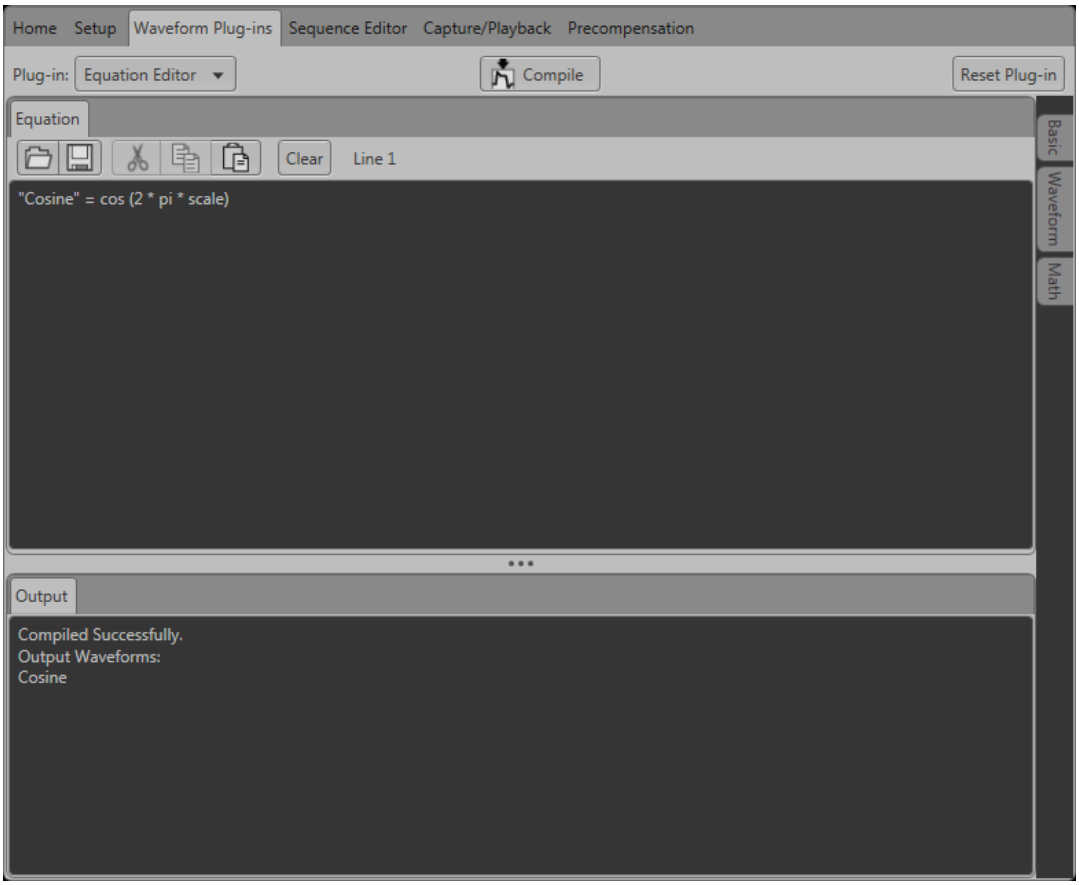
Equation editor overview

The Equation editor is provided as a standard plug-in.

The Equation editor is an ASCII text editor that allows you to create, edit, load, and compile equation waveform definitions into a waveform using the Waveform Programming Language (WPL). Use WPL to

generate a waveform from a mathematical function, perform calculations between two or more waveform files, and use loop and conditional branch commands to generate waveform values.

Compile the equation file to generate the described waveforms and sequences and place them into the Waveforms List and Sequence List.



Item	Description
Toolbar	Provides edit operations, such as open, save, cut, copy, paste, and clear. The Line position shows the cursor position in the equation.
Equation editor window	Use this area to enter text and/or equation information.
Output window	Displays the compile results. If the compilation fails, an error message is displayed. It also displays the list of waveform and sequence files created after successful compilation.
Compile	Compiles the currently loaded equation file. The status of the compilation is displayed in the output window. Generated waveforms and sequences are placed into the Waveforms List and Sequence List.
Basic tab	Opens a window that provides basic keywords to use while constructing an equation.

Item	Description
Waveform tab	Opens a window that provides waveform functions to use while constructing an equation.
Math tab	Opens a window that provides math functions to use while constructing an equation.

See also:

- Basic keywords (see page 81)
- Waveform functions (see page 82)
- Math functions (see page 98)
- Math operators (see page 99)
- Equation examples (see page 100)

Limitations

The limitations of the Waveform Programming Language are as follows:

- The Equation editor allows you to open and compile equation files (.equ) that are compatible with the AWG400/500/600/700/5000/7000 series instruments.
- The compiler can support equation files with a maximum of 10,000 lines or 800,000 characters.
- References to a waveform file in an equation file should be created by the equation file or exist before the equation file is compiled. (The equation file cannot refer to anything other than waveforms created by the equation file or existing waveform files.)
- The .wfmx or .wfm extension is optional on the left side of an assignment operator. If omitted, the file will still be created without an extension and automatically imported into the waveform list.
- Compilation is dependent on the available memory and other resources of the instrument, such as model and instrument options.

Tips on using the equation editor

- Waveform names
  - Waveform names use double quotes.
  - Waveform names are not required to begin with an alphabetical character (unlike variables).
  - Waveform names are case sensitive.
  - Waveform names may contain underscores(_) and dashes(-).
  - Waveform names can be a concatenation of strings using a colon (:).
  - The maximum number of characters is 256 which includes any extension that will be ignored.

NOTE. *When creating a file, it's best practice to ensure the filename does not already exist by placing a Delete "filename" in the equation prior to the creation of the file. This ensures the equation creates a new file rather than appending to an existing file.*

- Equations
  - An equation script (ES) has one or more statements and/or waveform operations.
  - The compiler is an interpretive implementation and does each statement sequentially.
  - Each statement is evaluated from left to right.
  - Any error terminates the compile. No statements after the error are executed.
- Statements
  - A statement has a identifier, assignment and an expression.
  - All spaces, line feeds and tabs are ignored unless inside a string.
  - All text from a single quote (') to the end of a line is regarded as a comment.
- Variables
  - The first character must be an alphabetical character.
  - Alphabetical characters are case-insensitive.
  - User-defined variables do not need to be declared before using them.
  - User-defined variables are 64-bit floating-point decimal numbers.
  - User-defined variables initial values are undefined.
  - A maximum of 100 variables may be included in a program
- Paths
  - Files can have the full path or they can reference the working path which is "C:\ProgramData\Tektronix\AWG\AWG70k\EquationEditor".
  - Relative paths in the equation editor syntax must include a "." or "..".

- Markers
  - Markers do not have names but are an extension of a waveform in the form of a ".markerN" where "N" is the marker name such as ".marker1".
  - The marker extension is not case sensitive like waveform names are.
  - Markers can be assigned in a statement in which every point for a marker will be evaluated for every point in the analog set of points.
- Assignment
  - The assignment is a single equal sign "=". In a statement that has more than one "=", going from left to right, the first "=" is an assignment, all others to the right are treated as a "Boolean relational operation".

Basic keywords

The Equation editor has built-in keywords and functions to easily create equations. These commands insert correctly-formatted keywords or functions into the text file at the current cursor position. Inserted keywords are treated as ordinary text if you need to edit them.

The basic keywords are grouped into two types, predefined variables and control statements.

The following table lists the predefined variables that you can use as part of a waveform equation expression.

Item	Description
clock	Sets the current instrument sample clock rate.
size	Sets the current waveform record length.
time	Current data time value, starting at 0. Read only. Only useable within an equation expression.
point	Current data point number value, starting at 0. Read only. Only useable within an equation expression.
scale	Returns the current scale value that increase 0 to 1. Read only. Only useable within an equation expression.
pi	The number pi (π). Use the pi character from the symbol list.

The following table lists the control statements that you can use as part of a waveform equation expression.

Item	Description
if	Provides control statements to execute expressions when a condition resolves to true or false.
then	Provides control statements to execute expressions when a condition resolves to true or false.
else	Provides control statements to execute expressions when a condition resolves to true or false.
endif	Defines the end of the if statement.
for	Provides a structure for executing one or more equation expressions a defined number of times.
next	Provides control statements to execute expressions when a condition resolves to false.

Item	Description
step	Defines the size of the loop count increments.
to	Defines the upper limit of the loop count increment.

Waveform functions

The waveform functions are listed as follows:

bpf	
The bpf statement creates a new waveform file by passing the specified waveform file through a band-pass filter.	
Syntax	"output_filename" = bpf("filename1", cutoff_freq_lo, cutoff_freq_hi, taps, atten)
Arguments	"output_filename" is the complete file name (file name and extension) to contain the filtered waveform data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" is the complete (file name and extension) name of the source file for the band-pass filter operation. The file must be on the active drive. The argument can include a relative or an absolute path name. Enclose the file name within double quotation marks. cutoff_freq_lo is the band-pass filter low-frequency cutoff value. Enter the value as a real or scientific notation number or as an expression that resolves to a valid number. cutoff_freq_hi is the band-pass filter high-frequency cutoff value. Enter the value as a real or scientific notation number or as an expression that resolves to a valid number. taps is the number of delay elements that composes the digital filter. The range of taps is 3 to 101. Enter the integer value as an odd number. atten is the inhibit zone attenuation factor (in dB). The range of attenuation is 21 dB to 100 dB. Enter the integer value.
Example	"filtered.wfm" = bpf("sine.wfm", 3.0e6, 5.0e6, 101, 35)
brf	
The brf statement creates a new waveform file by passing the specified waveform file through a band-rejection filter.	
Arguments	"output_filename" is the complete file name (file name and extension) to contain the filtered waveform data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" is the complete (file name and extension) name of the source file for the band-pass filter operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. cutoff_freq_lo is the band-reject filter low-frequency cutoff value. Enter the value as a real or scientific notation number or as an expression that resolves to a valid number. cutoff_freq_hi is the band-reject filter high-frequency cutoff value. Enter the value as a real or scientific notation number or as an expression that resolves to a valid number. taps is the number of delay elements that composes the digital filter. The range of taps is 3 to 101. Enter the integer value as an odd number. atten is the inhibit zone attenuation factor (in dB). The range of attenuation is 21 dB to 100 dB. Enter the integer value.
Example	"filtered.wfm" = brf("sine.wfm", 3.0e6, 5.0e6, 101, 45)

code

The code statement executes code conversion from a source waveform containing digital or analog information to another digital waveform. For example, it converts a file to one of several digital formats, such as, NRZ, RZ, or Manchester codes. All marker values in the output file are set to 0. Refer to Code conversion (see page 90).

Syntax	"output_filename" = code("filename1", "code-conversion-table")
Arguments	"output_filename" is the complete file name (file name and extension) to contain the code-converted waveform data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" is the complete (file name and extension) name of the source file for the code conversion operation. The file is 0 1 pattern data. If the file is an analog waveform file, this function reads as 1 if the data value is equal to or larger than 0.5, and 0 if the value is less than 0.5. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "code-conversion-table" is the text file containing a code conversion table in text form. Use the files that are saved with the Code Conversion table in the waveform or pattern editor. You can also create those text files, each line of which is composed of the following five fields delimited by comma (,): Past source, Current source, Next source, Past output, Output code Refer to Code Conversion (see page 90).
Example	"C1.wfm" = code("C0.wfm", "nrz.txt")

conv

The conv statement executes convolution between the waveform data of two specified files. All marker values in the output file are set to 0.

Refer to Convolution (see page 97) for additional information.

Syntax	"output_filename" = conv("filename1", "filename2")
Arguments	"output_filename" is the complete file name (file name and extension) to contain the resultant convolution waveform. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" and "filename2" are the complete (file name and extension) names of the source files for the convolution operation. Both files must be on the active drive. The argument can include a relative or absolute path name. Enclose each file name within double quotation marks.
Example	"newsine.wfm" = conv("sine.wfm", "sine2x.wfm")

copy

The copy statement copies the specified file name to a new file name and/or location on the current drive.

Syntax	copy("source_file", "target_file")
Arguments	"source_file" is the complete file name (path, file name and extension) to the file that you want to copy. The file must be located on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "target_file" is the complete file name (path, file name and extension) to the location to which you are copying the source file. The target file must be located on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks.
Example	copy("sine.wfm", "/test_dir/sine2.wfm")

corr

The corr statement executes correlation between the waveform data of two specified files. All marker values in the output file are set to 0. There are no restrictions on the data lengths of the two waveforms.

Refer to Correlation (see page 88) for more information.

Syntax	"output_filename" = corr("filename1", "filename2")
Arguments	"output_filename" is the complete file name (file name and extension) to contain the resultant correlation waveform. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" and "filename2" are the complete (file name and extension) names of the files on which you are performing the correlation. Both files must be on the active drive. The argument can include a relative or absolute path name. Enclose each file name within double quotation marks.
Example	"newsine.wfm" = conv("sine.wfm", "sine2x.wfm")

data

The data statement writes the defined data points to the specified file. The number of <expression>s specified must equal the number of points. All marker values will be 0. At least one <expression> must be included.

Syntax	"output_filename" = data(data_defn, data_defn, ...)
Arguments	"output_filename" is the complete file name (file name and extension) to contain the expanded waveform and marker data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. data_defn is a value that defines the data point value. The first data point value starts at point 0 in the resulting waveform. You must include at least one data definition expression. Separate each definition with a comma. ***NOTE.*** *Use this command to create a waveform file that does not meet the instrument waveform minimum data requirement. If you create such a file, open it in a waveform editor, and then attempt to save it, the instrument displays a dialog box asking you to correct the problem. If you attempt to load the waveform in the Setup screen, the instrument displays an error message stating that the file does not have enough data points.*
Example	"foo.wfm" = data(1, 0, .2, .4, .5)

delete

The delete statement deletes the specified file name from the current drive.

Syntax	delete("filename")
Arguments	"filename" is the complete file name (path, file name and extension) to the file that you want to delete. The file must be located on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks.
Example	delete("/test_dir/wvfrms/sine2x.wfm")

diff

The diff statement performs a differentiation operation on a specified file. The output file retains all marker values of the input file. Refer to Differentiation (see page 94) for information about the differentiation algorithm.

Syntax	"output_filename" = diff("filename")

diff

Arguments	"output_filename" is the complete file name (file name and extension) to contain the resultant waveform. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename" is the complete (file name and extension) name of the file on which you are performing the differentiation operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks.
Example	"diffwave.wfm" = diff("log_swp.wfm")

expand

The expand statement horizontally expands (scales) the waveform and marker data of the specified waveform file and writes it to a new file.

Syntax	"output_filename" = expand("filename", expand_multiplier)
Arguments	"output_filename" is the complete file name (file name and extension) to contain the expanded waveform and marker data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename" is the complete (file name and extension) name of the file on which you are performing the expand operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. expand_multiplier is an integer value specifying how much to expand the waveform data. The value must be greater than one. Values less than or equal to one result in the output waveform being the same as the input waveform.
Example	"longswp.wfm" = expand("lin_swp.wfm", 2)

extract

The extract statement extracts the specified portion of a waveform file and writes it to a new file. The marker data is also extracted. Specify the start and end points to extract the data. Waveform data starts at point 0.

Syntax	"output_filename" = extract("filename", start_point, end_point)
Arguments	"output_filename" is the complete file name (file name and extension) to contain the extracted waveform and marker data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename" is the complete (file name and extension) name of the source file for the extract operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. start_point is the location of the first data point to extract from the input file. This is an integer value. The starting point value must be less than or equal to the ending point value or an error occurs during compilation. end_point is the location of the last data point to extract from the input file. This is an integer value. The ending point value must be greater than or equal to the starting point value or an error occurs during compilation. ***NOTE.*** *Use this command to create a waveform file that does not meet the instrument waveform minimum data requirement. If you create such a file, open it in a waveform editor, and then attempt to save it, the instrument displays a dialog box asking you to correct the problem. If you attempt to load the waveform in the Setup screen, the instrument displays an error message stating that the file does not have enough data points.*
Example	"shortsin.wfm" = extract("sine.wfm", 0, 511)

hpf

The hpf statement creates a new file by passing the specified waveform file through a high-pass filter.

Syntax	"output_filename" = hpf("filename1", cutoff_freq, taps, atten)
Arguments	"output_filename" is the complete file name (file name and extension) to contain the filtered waveform data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" is the complete (file name and extension) name of the source file for the high-pass filter operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. cutoff_freq is the high-pass filter cutoff frequency. Enter the value as a real or scientific notation number or as an expression that resolves to a valid number. taps is the number of delay elements that composes the digital filter. The range of taps is 3 to 101. Enter the integer value as an odd number. atten is the inhibit zone attenuation factor, in dB. The range of attenuation is 21 dB to 100 dB. Enter the integer value.
Example	"filtered.wfm" = hpf("sine.wfm", 3.25e5, 2, 25)

integ

The integ statement performs an integration operation on a specified file. The output file retains all marker values of the input file. Refer to Integration (see page 96) for information about the integration algorithm.

Syntax	"output_filename" = integ("filename")
Arguments	"output_filename" is the complete file name (file name and extension) to contain the resultant waveform and marker data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename" is the complete name (path, file name and extension) of the source file for the integration operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks.
Example	"intwave.wfm" = integ("sineswp.wfm")

join

The join statement joins (concatenates) two waveform files (waveform and marker data) into a single file. The clock sample rate in the first file sets the clock sample rate for the output file waveform. You can only concatenate waveform (.wfm) files. The output file retains all marker values of the input file. Marker data is embedded in the waveform data as the ninth and tenth bits in an 8-bit waveform.

Syntax	"output_filename" = join("filename1", "filename2")
Arguments	"output_filename" is the complete file name (file name and extension) to contain the concatenated files. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" and "filename2" are the complete names (path, file name, and extension) of the files you are concatenating. Both files must be on the active drive. The argument can include a relative or absolute path name. Enclose each file name within double quotation marks.
Example	"newsine.wfm" = join("sine.wfm", sine2.wfm")

lpf

The lpf statement creates a new file by passing the specified waveform file through a low pass filter.

Syntax	"output_filename" = lpf("filename1", cutoff_freq, taps, atten)

lpf	
Arguments	"output_filename" is the complete file name (file name and extension) to contain the filtered waveform data. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" is the complete (file name and extension) name of the source file for the low pass filter operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. cutoff_freq is the low pass filter cutoff frequency. Enter the integer value. taps is the number of delay elements that composes the digital filter. The range of taps is 3 to 101. You must enter the integer value as an odd number. atten is the inhibit zone attenuation factor, in dB. The range of attenuation is 21 dB to 100 dB. Enter the integer value.
Example	"filtered.wfm" = lpf("sine.wfm", 10.454e2, 2, 30)

norm	
The norm statement performs a normalization operation on a specified file waveform data. Normalization scales the waveform within a ±1.0 range, and retaining the offset. The output file retains all marker values of the input file.	
Syntax	"output_filename" = norm("filename1")
Arguments	"output_filename" is the complete file name (file name and extension) to contain the resultant waveform. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "filename1" is the complete (file name and extension) name of the file on which you are performing the normalization operation. The file must be on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks.
Example	"intwave.wfm" = norm("sineswp.wfm")

pn	
The pn statement creates a pseudo-random waveform using a shift register. You can specify the register size (1 to 32) and XOR feedback tap position. The initial values of the registers are set to one. If you omit the tap position specifier, a default maximum data length tap setting is used.	
Syntax	"output_filename" = pn(reg_size [, tap_position ...])
Arguments	"output_filename" is the complete file name (file name and extension) to contain the pseudo-random waveform. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. reg_size specifies the number of registers in the pseudo-random generator. This is an integer value from 1 to 32. tap_position specifies the register positions to 'tap' for XOR feedback to the register input. A tap does an XOR operation on the output signal and the specified register and passes the result to the next-lower tap position or the register input (register 1), whichever it encounters first.
Example	"random.wfm" = pn(12, 3, 6, 8)

rename	
The rename statement renames the specified file name to a new file name and/or location on the current	
Syntax	rename("source_file", "target_file")

rename

Arguments	"source_file" is the complete file name (path, file name and extension) to the file that you want to rename. The file must be located on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks. "target_file" is the complete file name (path, file name and extension) to the location to which you are renaming the source file. The target file must be located on the active drive. The argument can include a relative or absolute path name. Enclose the file name within double quotation marks.
Example	rename("/test_dir/sine.wfm", "/test_dir/old_sine.wfm")

write

The write statement writes the specified text to a new file name and/or location on the current drive. If an output file already exists, the source file contents are appended to the end of the existing file.

Syntax	write("output_filename", "text" ["text" ...])
Arguments	"output_filename" is the complete file name (path, file name, and extension) to the file that you want to write. The file must be located on the active drive. The argument can include a relative or absolute path name. Enclose the file name in double quotation marks. "text" is the text string enclosed in double quotation marks. If you need to use a double quotation mark as part of the text, precede each double quotation character with a slash character (\). For example: This function writes a text to a \"ABC.TXT\" in text form." In a similar way, the following codes can be used in text strings: \n – LF \r – CR \t – Tab \\ – Backslash \" – Double-quote
Example	write("sine.wfm", "This is a comment line.")

Correlation

The operation expressed by the following equation is called correlation. With respect to a discrete system, correlation y(n) of a certain waveform x(n) and a second one h(i) is expressed by the following equation. N is the number of items of data.

$$y(n) = \sum_{t=0}^{N-1} x(i)\, h(n+1)$$

Periodic

Periodic enables you to specify whether the two-waveforms must be regarded as periodic during calculation. Below is an example showing differences between non-periodic and periodic waveforms.

Waveform A = a0, a1, a2, a3, a4 (5 points)

Waveform B = b0, b1, b2 (3 points)

For non-periodic case:

<A,B> =	a0b2, a0b1+a1b2, a0b0+a1b1+a2b2, a1b0+a2b1+a3b2, a2b0+a3b1+a4b2, a3b0+a4b1, a4b0, 0, (8 points)

The data length of the waveform created is the total of the number of points of the two-waveform files.

For periodic case:

AxB =	a0b0+a1b1+a2b2, a1b0+a2b1+a3b2, a2b0+a3b1+a4b2, a3b0+a4b1+a0b2, a4b0+a0b1+a1b2, (5 points)

Waveforms A and B are regarded as periodic during calculation. The count of the operation of the sum of the products is equivalent to the length of the shorter waveform. The resulting cycle of the waveform equals the same as the longer waveform. The actual output segment of the waveform corresponds to one cycle. The starting point value of the waveform equals the sum of products that is obtained with the starting point values of waveforms A and B added.

Unlike convolution, the result of A×B and B×A are different in correlation. B×A is calculated as follows:

For non-periodic case:

BxA =	b0a4, b0a3+b1a4, b0a2+b1a3+b2a4, b0a1+b1a2+b2a3, b0a0+b1a1+b2a2, b1a0+b2a1, b2a0, 0, (8 points)

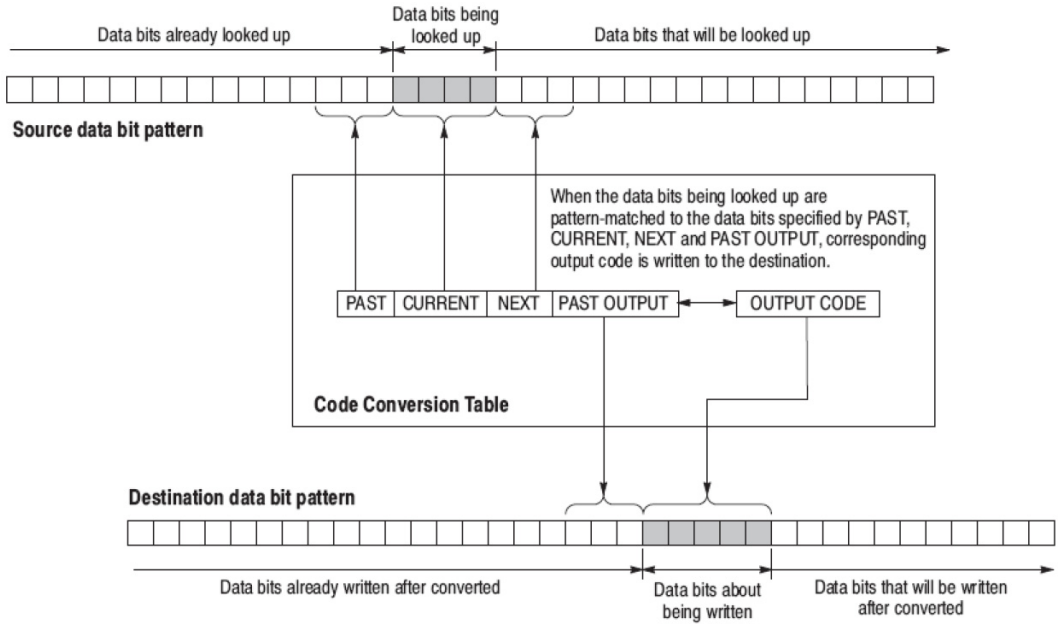
For periodic case:

BxA =	b0a0+b1a1+b2a2, b0a4+b1a0+b2a1, b0a3+b1a4+b2a0, b0a2+b1a3+b2a4, b0a1+b1a2+b2a3, (5 points)

Code conversion

You can select the coding system to use when outputting pattern strings. If the code is affected by the immediately preceding data, the data item just before the first item of data will be calculated as 0. The following tables show the coding systems.

Using the code conversion table, the bit pattern can be converted to another code. The following figure shows an image of how the code conversion table is used.



This part inputs the binary bit pattern and converts the transition from 1 to 0 or 0 to 1 to a series of positive and negative pulses. The following table lists the available code conversion types:

Code conversion	Description
NRZ	Converts a transition from 0 to 1 to a positive pulse, and from 1 to 0 to a negative pulse. This conversion considers the input data as representing a direction of magnetization.
NRZI	Generates a pulse when the input data is 1. The first pulse is always positive, and after this, the pulse polarity toggles for every input data value of 1. This conversion considers the input data as representing the disk writing data.

Examples

In following examples, data bits to be written in the tables are introduced. And input and output data bit pattern example is following each table.

- Inverting bit of the NRZ data.

Past	Current	Next	P.OUT	Output code
	0			1
	1			0

Example

Input	0	1	0	0	1	1	0	0	0
Output	1	0	1	1	0	0	1	1	1

- Converting NRZ data to NRZI.

Past	Current	Next	P.OUT	Output code
	1		0	1
	1		1	0
	0		0	0
	0		1	1

Example

Input	0	1	0	0	1	1	0	0	0
Output	0	1	1	1	0	1	1	1	1

- Converting NRZ data to NRZI-2. Two bit are generated for each input bit.

Past	Current	Next	P.OUT	Output code
	1		0	01
	1		1	10
	0		0	00
	0		1	11

Example

Input	0	1	0	0	1	1	0	0	0
Output	00	01	11	11	10	01	11	11	11

- Converting NRZ data to FM. Two bit are generated for each input bit.

Past	Current	Next	P.OUT	Output code
	0		0	11
	0		1	00
	1		0	10
	10		1	01

Example

Input	0	1	0	0	1	1	0	0	0
Output	11	01	00	11	01	01	00	11	00

- Converting NRZ data to BI-PHASE. Two bit are generated for each input bit.

Past	Current	Next	P.OUT	Output code
	0			00
	1			10

Example

Input	0	1	0	0	1	1	0	0	0
Output	01	10	01	01	10	10	01	01	01

- Converting NRZ data to RZ. Two bit are generated for each input bit.

Past	Current	Next	P.OUT	Output code
	0		0	01
	1		0	10

Example

Input	0	1	0	0	1	1	0	0	0
Output	00	10	00	00	10	10	00	00	00

- Output bit is always set to 1 when input bit changes from 1 to 0 or 0 to 1.

Past	Current	Next	P.OUT	Output code
0	1			1
1	0			1
	1			0
	0			0

Example

Input	0	1	0	0	1	1	0	0	0
Output	0	1	1	0	1	0	1	0	0

- Converting NRZ data to 1-7 RLL (Run-length Limited Codes).

Past	Current	Next	P.OUT	Output code
	0000		1	100000
	0000		0	011111
	0001		00	111111
	0001		01	111111
	0001		10	000000
	0001		11	000000
	0010		01	111110
	0010		10	000000
	0010		00	111110
	0010		11	000001
	0011		1	100001
	0011		0	011110
	01		0	100
	01		0	011
	10		01	111
	10		10	000
	10		00	111
	10		11	000
	11		01	110
	11		10	001
	11		00	110
	11		11	001
	0			0
	1			1

Example

Input	01	10	11	0010	10	0011	11	0001	0011	10	0000
Output	011	000	110	0000 1	111	1000 01	110	0000 00	0111 10	000	0111 111

Code conversion table

The code conversion table is only a text file. You can create the code conversion tables using a text editor on your PC or other computer.

The format is in the form of <past>,<current>,<next>,<past.out>,<output>.

nrz.txt	nrzi.txt	nrzi-2.txt
,0,,,1	,1,,0,1	,1,,0,01
,1,,,0	,1,,1,0	,1,,1,10
	,0,,0,0 ,	,0,,0,00
	0,,1,1	,0,,1,11
fm.txt	**bi–phase.txt**	**rz.txt**
,0,,0,11	,0,,,01 ,	,0,,,00 ,
,0,,1,00	1,,,10	1,,,10
,1,,0,10		
,1,,1,01		
custom.txt	**1–7rill.txt**	
0,1,,,1	,0000,,1,100000	
1,0,,,1	,0000,,0,011111	
,1,,,0	,0001,,00,111111	
,0,,,0	,0001,,01,111111	
	,0001,,10,000000	
	,0001,,11,000000	
	,0010,,01,111110	
	,0010,,10,000001	
	,0010,,00,111110	
	,0010,,11,000001	
	,0011,,1,100001	
	,0011,,0,011110	
	,01,,1,100 ,01,,0,011	
	,10,,01,111 ,10,,10,000	
	,10,,00,111	
	,10,,11,000	
	,11,,01,110 ,11,,10,001	
	,11,,00,110	
	,11,,11,001	
	,0,,,0	
	,1,,,1	

Differentiation

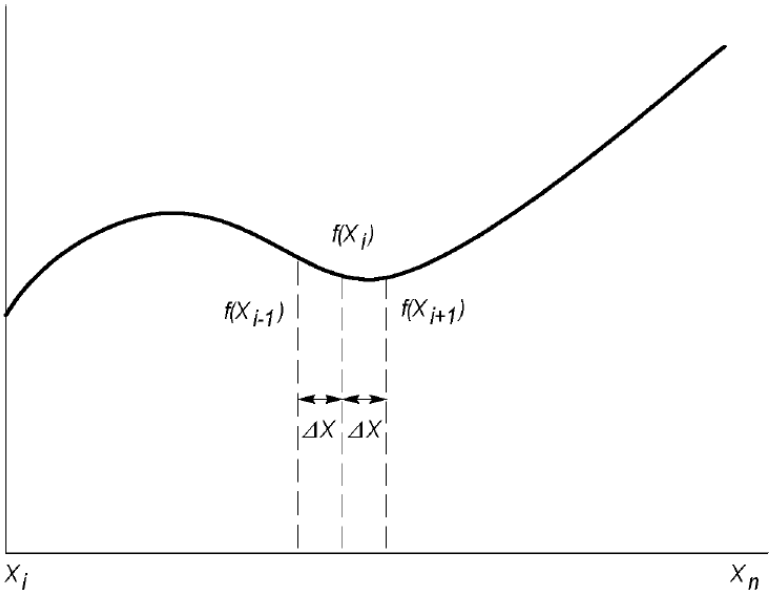
The diff(function calculates the central deviation as the differential value. The equation below expresses the central deviation when the function f(x) is given at even intervals of Δx.

$$f'(x) = \frac{f(x+\Delta x) - f(x-\Delta x)}{(2\Delta x)}$$

In actual practice, when function f(x)is expressed by n values, the differential value f'(x i) at point x i is given by the following equation:

$$f'(x_i) = n\frac{|f(x_{i+1}) - f(x_{i-1})|}{2}$$

Here, "n" is the number of waveform points and "i" is an integer in the range, i=1, 2, ..., n. The



The values at the first and last points are obtained from the following equations rather than from the center deviation:

First point

$$f'(x_1) = \frac{n|-3f(x_1) + 4f(x_2) - f(x_3)|}{2}$$

Last point

$$f'(x_n) = \frac{n|f(x_{n-2}) - 4f(x_{n-1}) - 3f(x_n)|}{2}$$

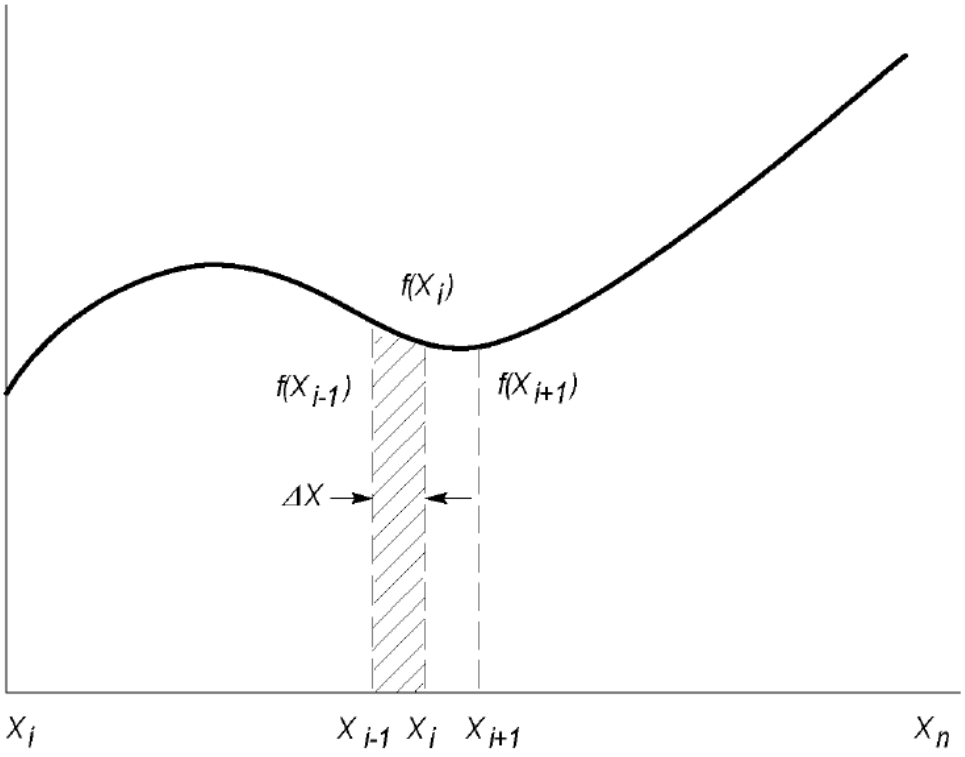
Integration

The integ function integrates numerically based on a trapezoidal formula. The trapezoidal formula is expressed with the following equation:

$$\int f(x)\,dx = \sum_{i-1}^{n} \frac{f(x_{i-1}) + f(x_i)}{2}.\Delta x$$

$$= \Delta\frac{X}{2}\{\Delta f(X_1) + 2f(X_2) + 2f(X_3) + \ \ldots + 2f(X_{n-1}) + f(X_n)\}$$

Here, n is the number of waveform points and i is an integer in the range i = 1, 2, ..., n.



The integration is actually calculated with the following formula:

$$\int f(x)\,\Delta x = 1/2\{f(x_1) + 2f(x_2) + 2f(x_3) + \ \ldots + 2f(x_{n-1}) + f(x_n)\}$$

However, the imaginary initial value f(x0) always takes a value of 0.

Convolution

The operation expressed by the following equation is called convolution. With respect to a discrete system, convolution y(n) of a certain waveform x(n) and a second one h(i) is expressed by the following equation. N is the number of items of data.

$$y(n) = \sum_{t=0}^{N-1} x(i)\, h(n-i)$$

Periodic

Periodic enables you to specify whether the two-waveforms must be regarded as periodic during calculation. Below is an example showing differences between non-periodic and periodic waveforms.

Waveform A = a0, a1, a2, a3, a4 (5 points)

Waveform B = b0, b1, b2 (3 points)

For non-periodic case:

<A,B> =	a0b0, a0b1+a1b0, a0b2+a1b1+a2b0, a1b2+a2b1+a3b0, a2b2+a3b1+a4b0, a3b2+a4b1, a4b2, 0, (8 points)

The data length of the waveform created is the total of the number of points of the two-waveform files.

For periodic case:

AxB =	a0b2+a1b1+a2b0, a1b2+a2b1+a3b0, a2b2+a3b1+a4b0, a3b2+a4b1+a0b0, a4b2+a0b1+a1b0, (5 points)

Waveforms A and B are regarded as periodic during calculation. The count of the operation of the sum of the products is equivalent to the length of the shorter waveform. The resulting cycle of the waveform equals the same as the longer waveform. The actual output segment of the waveform corresponds to one

cycle. The starting point value of the waveform equals the sum of products that is obtained with the starting point values of waveforms A and B added.

Math functions

The following table lists the programming language math functions that you can use as part of a waveform equation expression.

Item	Description
abs(	Absolute value of a
acos(	Arc cosine of a
and	Logical AND
asin(	Arc sine of a
atan(	Arc tangent of a
ceil(	Minimum integer greater than or equal to a
cos(	Cosine of a
cosh(	Hyperbolic cosine of a
exp(	Exponential function of base of natural logarithm for a
floor(	Maximum integer less than or equal to a
int(	Truncation (Same as floor(a) if a >= 0; same as ceil(a) if a < 0)
log(	Natural logarithm of a
log10(	Base 10 logarithm of a
max(	Returns larger (maximum) value of a and b
min(	Returns smaller (minimum) value of a and b
noise(	Generates pseudo Gaussian distribution white noise signal with a standard deviation (= RMS) of 1
or	Logical OR
pow(	Exponentiation (bth power of a, or a^b) A negative value may be specified for a only if b is an integer. Otherwise, NaN will result. The pow function returns one of the following values: If b = 0: Always 1 If b ≠ 0 and a = 0: Always 0 If b ≠ 0 and a < 0 and b is a positive integer: axb If b ≠ 0 and a < 0 and b is a negative integer: Reciprocal of ax(-b) If b ≠ 0 and a < 0, NaN (Not a Number)
rnd(	Returns a random number in the 0 to 1 range. Generated base seed = (253 x seed + 1)% 16777216, return seed/16777216. Seed is a 32-bit unsigned integer.
round(	Rounds off the value of a to an integer

Item	Description
saw(	Saw tooth wave with a cycle of 2π and an amplitude ±1. If a = –2π, 0, 2π, 4π, or 6π, etc., the value is –1. The value approaches 1 at points immediately before these. (This function will not take the value 1.0.)
sinc(	Same as sin(a)/a, except that 1 results if a=0
sign(	Sign of a (1 if a > 0; –1 if a < 0; 0 if a = 0)
sin(	Sine value of a
sinh(	Hyperbolic sine value of a
sqr(	Rectangular wave with a cycle of 2π and an amplitude ±1. If k is even: For a = kπ to (k+1)π, sqr returns -1, except +1.0 when a equals (k+1)π. If k is odd: For a = kπ to (k+1)π, sqr returns +1, except -1.0 when a = (k+1)π.
sqrt(	Square root value of a
srnd(	Sets the random number generator seed value. Seed is 0 to 231-1. Default value is 0.
tan(	Tangent value of a
tanh(	Hyperbolic tangent value of a
tri(	Triangular wave with a cycle of 2π and an amplitude ±1. If a = 0, the value is 0. If a = 0.5π, it is 1.0. If a = π, it is 0.0. If a = 1.5π, it is –1.

Math operators

The following tables lists the programming language math operators that you can use as part of waveform equation expressions.

Item	Description
Unary operations	
–	Inverts the sign.
+	No effect
Binary operations	
+	Addition
–	Subtraction
*	Multiplication
/	Division
^	Exponentiation

Binary relational operations	
=	If both side values are equal, 1 results. Otherwise 0 results.
<>	If both side values are not equal, 1 results. Otherwise 0 results.
>	If the left side value is larger than the right side value, 1 results. Otherwise 0 results.
>=	If the left side value is larger than or equal to the right side value, 1 results. Otherwise 0 results.
<	If the left side value is smaller than the right side value, 1 results. Otherwise 0 results.
<=	If the left side value is smaller than or equal to the right side value, 1 results. Otherwise 0 results.
Binary conditional operators	
and	If both side values are not 0, 1 results. Otherwise 0 results.
or	If both side values are 0, 0 results. Otherwise 1results.

The operator priorities are as follows, starting with higher priority at the top of the list. Operators on the same line have equal priority.

^
– (unary), + (unary)
*, /
=, <>, >, >=, <, <=
and, or

Equation examples

This section provides example equations to help illustrate using the equation editor. The equations can be copied and pasted into the equation editor to generate the described waveforms.

Example 1 (see page 100)	Describes how to create a square wave with two markers.
Example 2 (see page 101)	Describes how to create a waveform file.
Example 3 (see page 103)	Describes how to use 'for' loop and 'if' conditional branch statements.
Example 4 (see page 104)	Describes how to put comments, and how to create sequence file.
Example 5 (see page 106)	Describes how to use marker data and how to use the binary relational operations in the assignment statement.
Example 6 (see page 108)	Describes how to handle specific point data in the waveform file using the extract(), join() and integ() function, and also the for and if statements.

Example 1

This example creates a square wave with two markers.

```
clock = 10e9 'Recommended sample rate
```

```
size = 2400
"Square2pt5"=sqr(2.5 * 2 * pi * scale) * -1
"Square2pt5".Marker1 = (point= 480)
"Square2pt5".Marker1 = "Square2pt5".Marker1 + (point= 960)
"Square2pt5".Marker2 = (point <= 5)
```

This example shows 3 basic statement components: Left Hand Side (LHS) assignment, Right Hand Side(RHS), and clockas a variable.

The first line sets the recommended sample rate to 10 GS along with a comment. The sample rate is added to the properties of the waveform.

The second line assigns the reserved keyword size to be 2400.

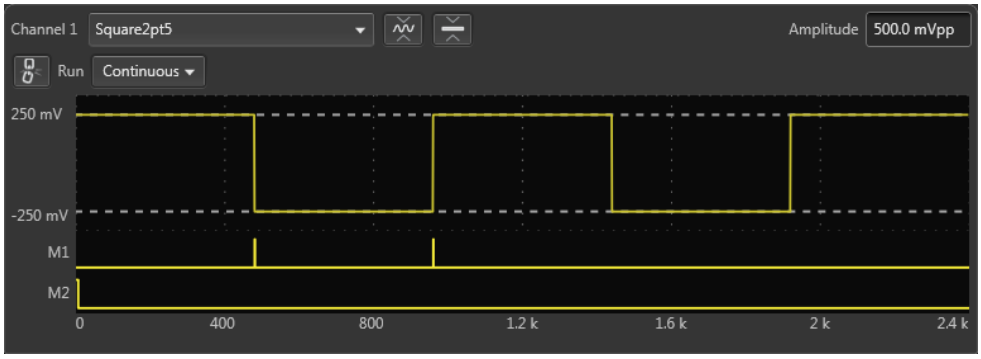
The third line generates the waveform.

The fourth line modifies marker1. The keyword point refers to the current data point being evaluated, one of the 2400 points of the waveform, being processed. The first "=" is the assignment. The next "=" is treated as "==" or "isEqual". When marker1 is being processed, the "point=480" is evaluated. For data point 0 to 479 the test will return a 0. For data point 480, the test will return a 1. For the rest of the data points, the test will be 0.

The fifth line modifies (adds to) marker1 with another pulse at 960.

The 6th line creates a pulse of 6 points starting at 0 (the beginning of marker2). Every data point from 0 to 5 is true (1) and is assigned to marker2.

The following figure shows the waveform generated by the above example.



Example 2

This example creates three waveform files: a.wfm, b.wfm, and c.wfm.

```
size = 2000
"a.wfm" = cos (2 * pi * scale)
size = 1512
```

```
"b.wfm" = cos (2 * pi * scale)

"c.wfm" = "a.wfm" * "b.wfm"
```

The first and third lines define the waveform record length (in points). You can change the record length any time within an equation; all created files use the last-set size value. When you do not define the waveform record length, the instrument uses the default length of 1000.

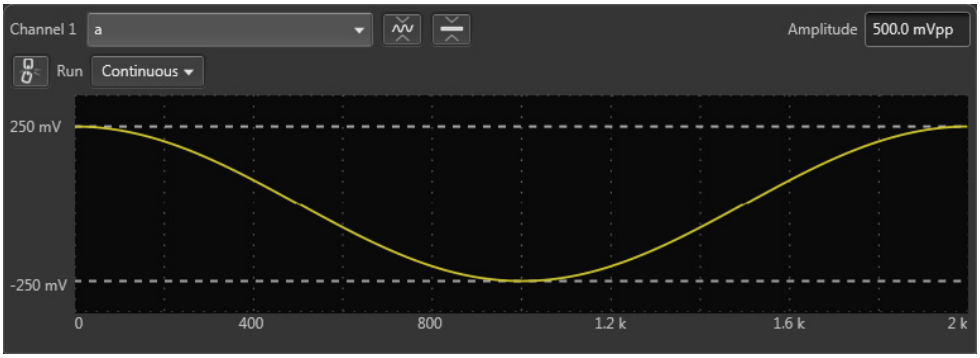
The second line generates the waveform a.wfm with 2000 data points. The scale is the system-used variable to fit the generated waveform within the ±1.0 vertical scale range.

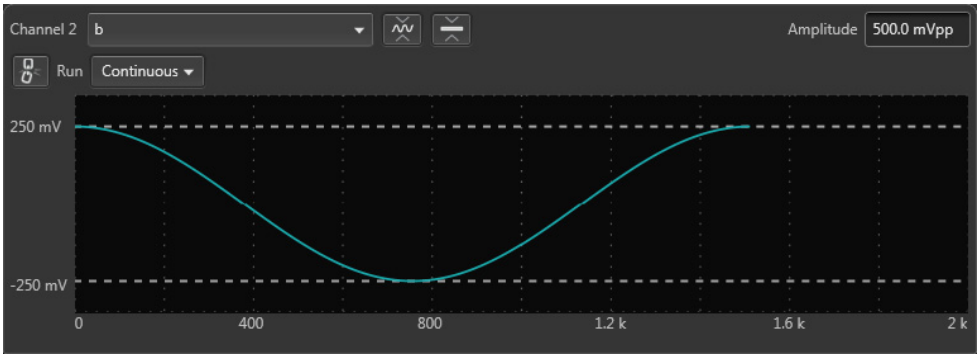
The waveforms b.wfm and c.wfm have point sizes of 1512.

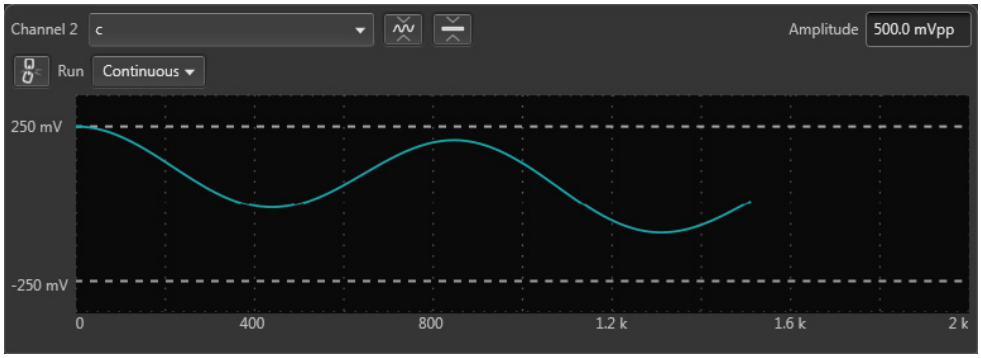
Waveform c.wfm is generated by multiplying the a.wfm and b.wfm waveforms.

When you perform the operation between the waveforms which have different point sizes, the lowest point size among them is used. Therefore the c.wfm will have the point size of 1500.

The following figures shows the waveforms generated by the above example.







Example 3

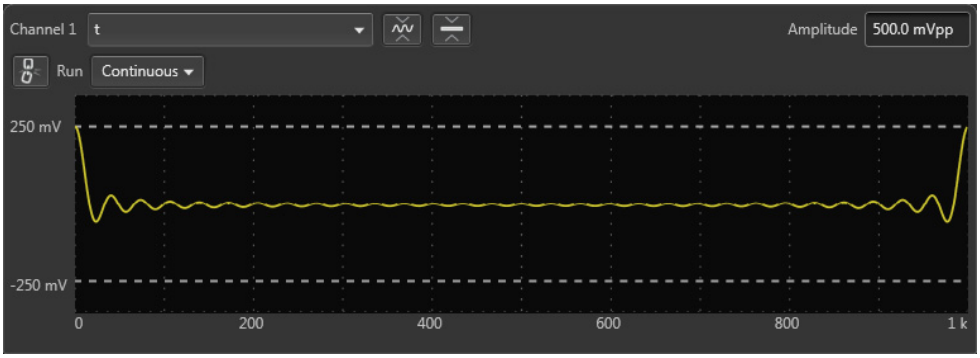
This example demonstrates using the for and if statements.

```
num = 30
for i = 1 to num
if i = 1 then
"t.wfm"=cos(2*pi*scale)
else
"t.wfm"="t.wfm"+cos(2*pi*i*scale)
endif
next
"t.wfm"="t.wfm"/num
```

Num and i are user-defined variables. I is used as part of the for loop parameter. The statements placed between the for and next keywords repeat 30 times while the i increments by 1 for each loop.

The conditional branch statement must start with the if keyword and end with the endif keyword. In this example, if i = 1, the equation creates the waveform t.wfm. When i ≠ 1, the newly created waveform and the one created in the previous loop are added, and the result is stored in the waveform t.wfm. The resultant waveform is then normalized.

The following figure shows the waveform generated by the previous example:



Example 4

The following example creates one sequence file and four waveforms.

```
delete("test.seq")

size=1000

clock=1e9

num=4

'write sequence file header

write("test.seq","MAGIC 3002\n")

write("test.seq","LINES ":num:"\n")

for i = 1 to num

   'create a waveform file

   "test":i:".wfm" = sin(2 * pi * i * scale)

   'add line to sequence file

   rep = num * I

   write("test.seq","\"test":i:".wfm\",\"\",":rep:"\n")

next
```

The first line deletes the sequence file named “test.seq”. This is the name of the sequence file that will be created by the example. We want to ensure the file does not already exist. If the file does not exist, the command is ignored.

The size and clock keywords are the system valuables representing the waveform record length, in points, and the sampling clock frequency. They are set to 1000 points and 1.0 GS/s in this example.

The comment text on line 5 starts with a single quotation (') character. Comment text is effective until the end of the line containing the single quote character.

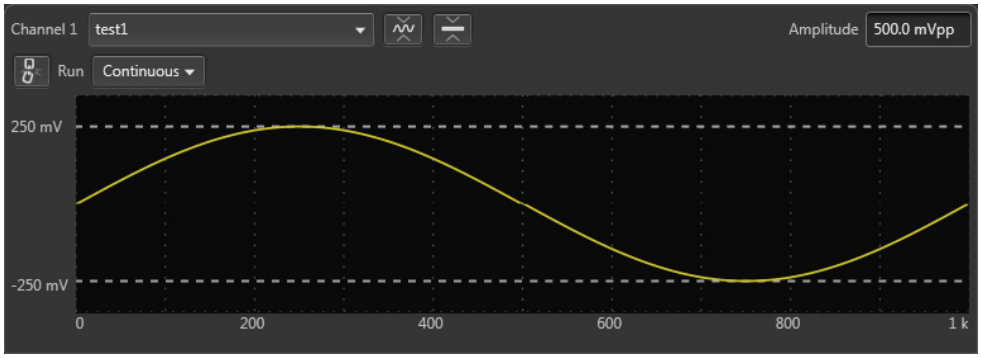
The write command writes the specified text to the specified file. If the file being written to exists, the write command appends the specified string to the end of the file. The first argument is the file name. The second argument and subsequent arguments are strings which are written to the file. The string must be enclosed in double quotation marks. To use a variable as a string, you must place the colon (:) before and after the variable.

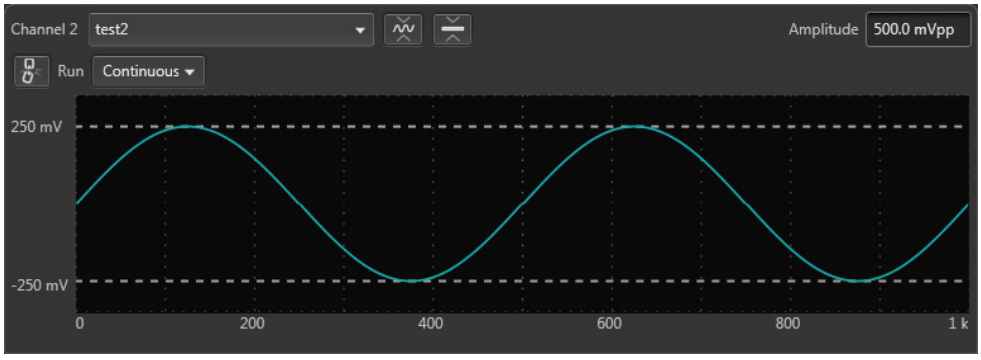
For example: "test":i:".wfm"

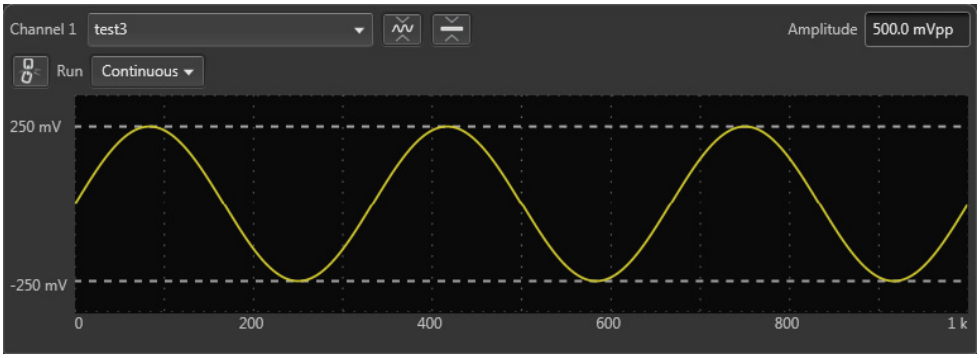
In the above example, if the variable i is currently 4, the value of the string will be text4.wfm. The slash is used as an escape character, and precedes the double quotation marks in a string. The '\n' inserts an end of line (EOL) character in the file.

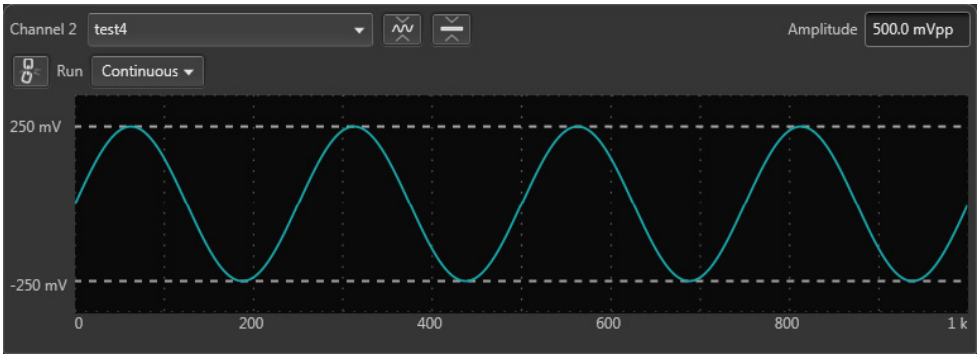
The sequence file is a text file which has the number 3002 on the first line of the text and the number of lines (for example LINES 4) on the second line.

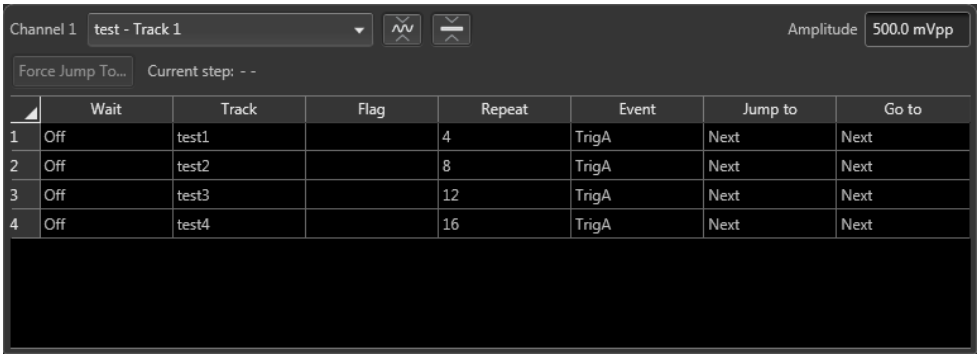
The following figures show the four waveforms generated by this example and the sequence file.











Example 5

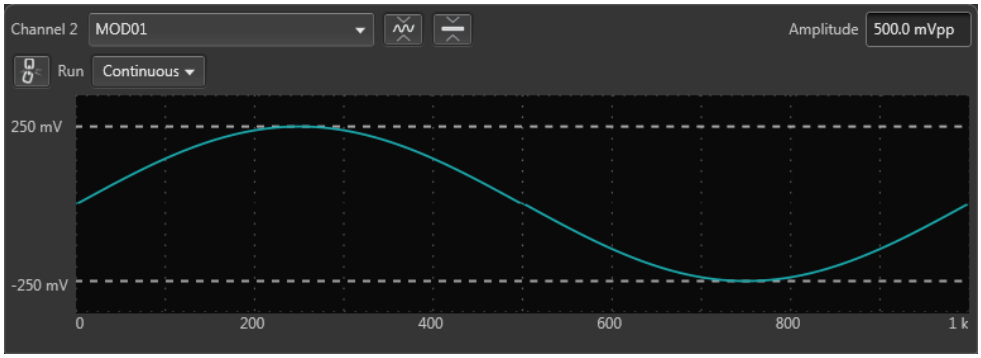
This example shows how to use Boolean relational operations between a waveform and its marker data.

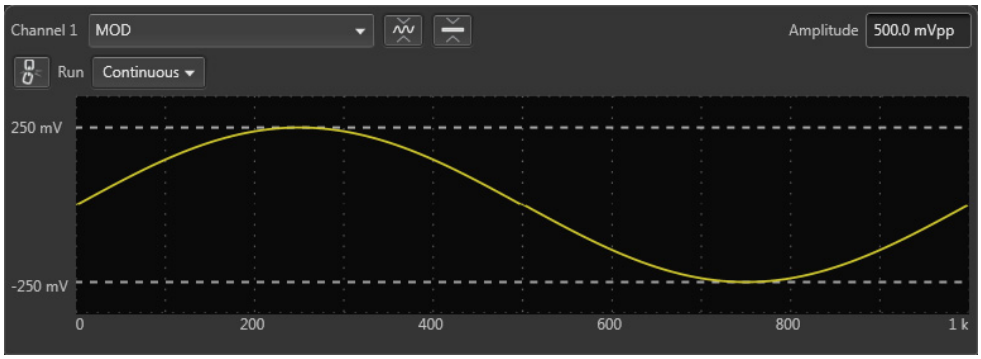
```
"MOD.wfm" = sin (2 * pi * scale)

"MOD01.wfm" = "MOD.wfm"

"MOD01.wfm".marker1 = "MOD01.wfm" >= 0.5

"MOD01.wfm".marker2 = "MOD01.wfm" <= -0.5

"MOD02.wfm" = ("MOD01.wfm".marker1 = "MOD01.wfm".marker2) / 2
```

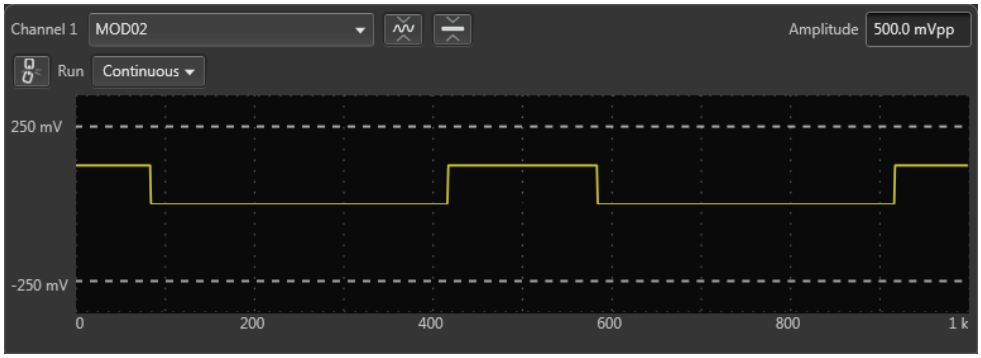
The Boolean relational operation results in 1 if the condition is true, and 0 if the condition is false. Therefore the MOD01.wfm marker1 signal is 1 if the waveform data is greater than or equal to 0.5, and 0 for all other values. Likewise, the marker2 signal is 1 if the waveform data is less than or equal to –0.5, and 0 for all other values.

The Boolean relational operation results in 1 if the condition is true, and 0 if the condition is false. Therefore the MOD01.wfm marker1 signal is 1 if the waveform data is greater than or equal to 0.5, and 0 for all other values. Likewise, the marker2 signal is 1 if the waveform data is less than or equal to –0.5, and 0 for all other values.

The results are shown in the following figures:







Example 6

This example applies a 7-point smoothing operation to a noise waveform.

The equation uses the extract(), integ() and join() functions, and also for and if control statements. Although you do not have any other method to perform smoothing with the instrument, this is not a preferable way to apply a smoothing operation. Refer to this example for learning how to use these functions and control statements.

You can change the number of smoothing points by changing the value of the variable nump. The greater the value of nump, the faster the instrument can finish the compile.

```
' Simple smoothing (7 points)
nump = 7
extp = nump - 1
nsht = extp / 2
size = 960
"NOISE.wfm" = noise()
"NOISE.wfm" = norm("NOISE.WFM")
cc = 1
for i = nsht to (size - nsht -1) step 1
   sp = i - nsht
   ep = i + nsht
   "TEMP1.wfm" = extract("NOISE.wfm", sp, ep)
   "TEMP1.wfm" = integ("TEMP1.wfm")
   "TEMP2.wfm" = extract("TEMP1.wfm", extp, extp)
   "TEMP2.wfm" = "TEMP2.wfm" / nump
   if cc = 1
   then
   "SMOOTH.wfm" = "TEMP2.wfm"
   else
   "SMOOTH.wfm" = join("SMOOTH.wfm", "TEMP2.wfm")
   endif
   cc = cc + 1
next
delete("TEMP1.wfm")
delete("TEMP2.wfm")
```

In this example, the following occures:

- The *noise()* function generates a noise waveform into the file NOISE.wfm, in which the waveform data are normalized using the norm() function.
- The *extract()* function extracts the data sp through ep and stores them into the file TEPM1.wfm.
- The *integ()* function integrates the 7-point data. The data of last point is the amount of 7-point data. This last data is divided by 7 and concatenated to the file SMOOTH.wfm.
- The *for* statement shifts the points to be read by one point for each loop and repeats these procedures.
- The temporary files are deleted.

The following figure shows the noise waveforms before (upper) and after (lower) 7-point smoothing.

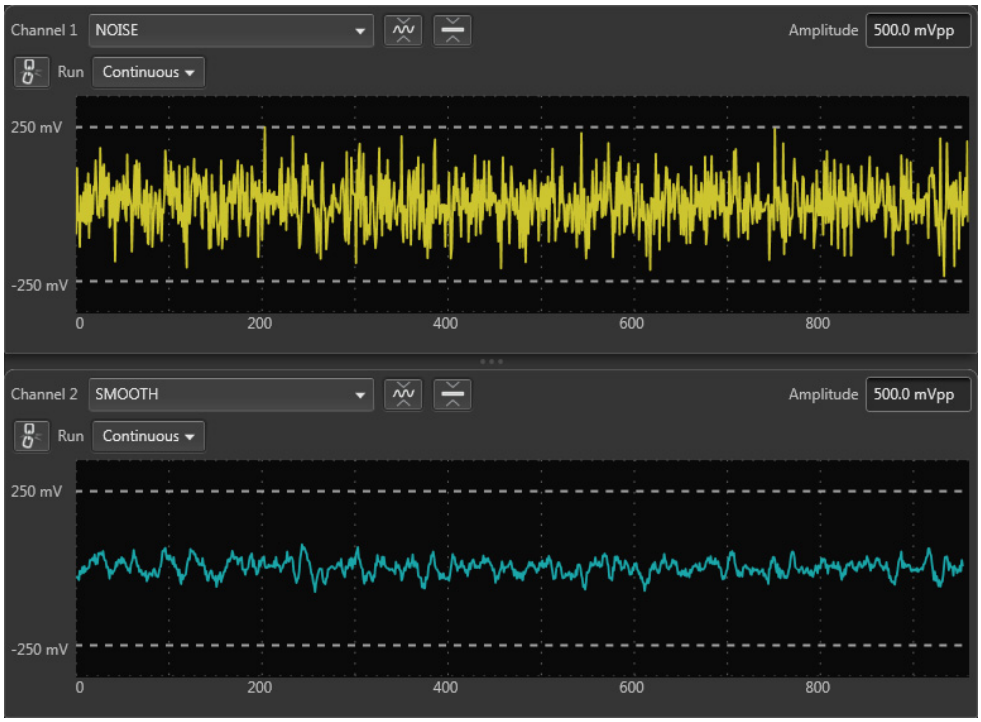
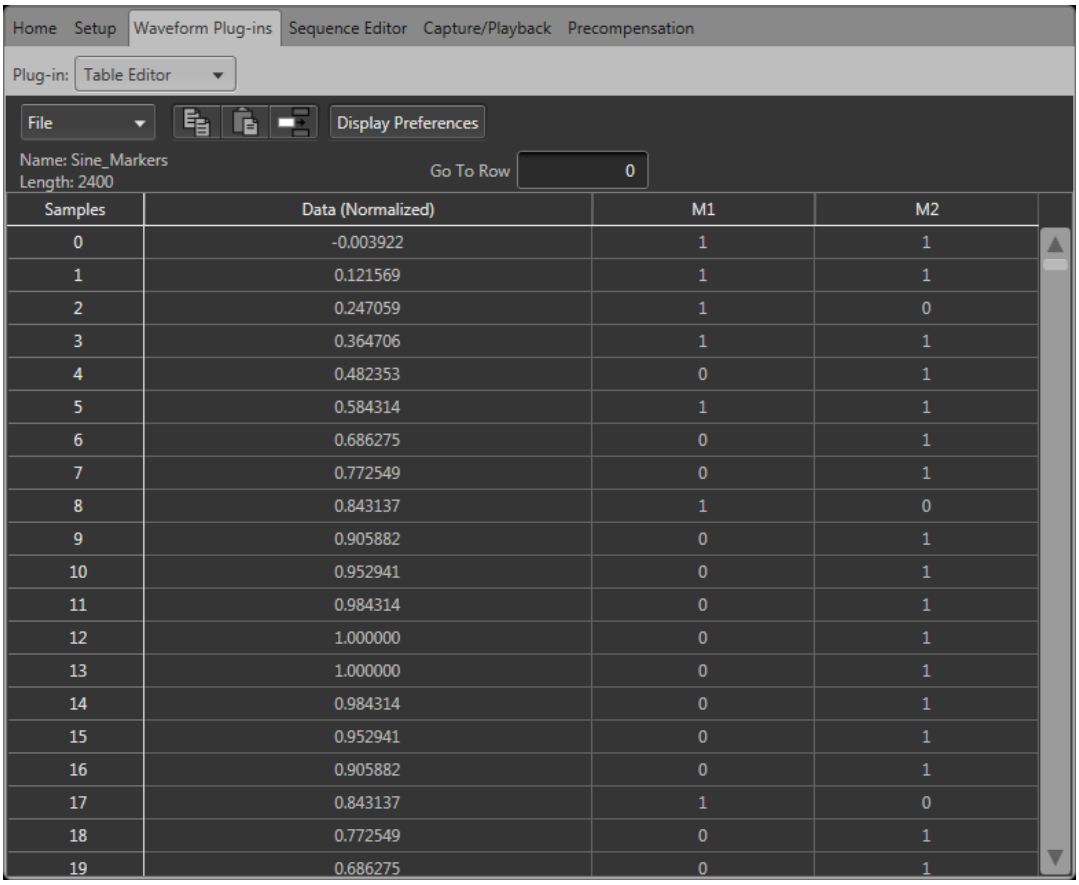
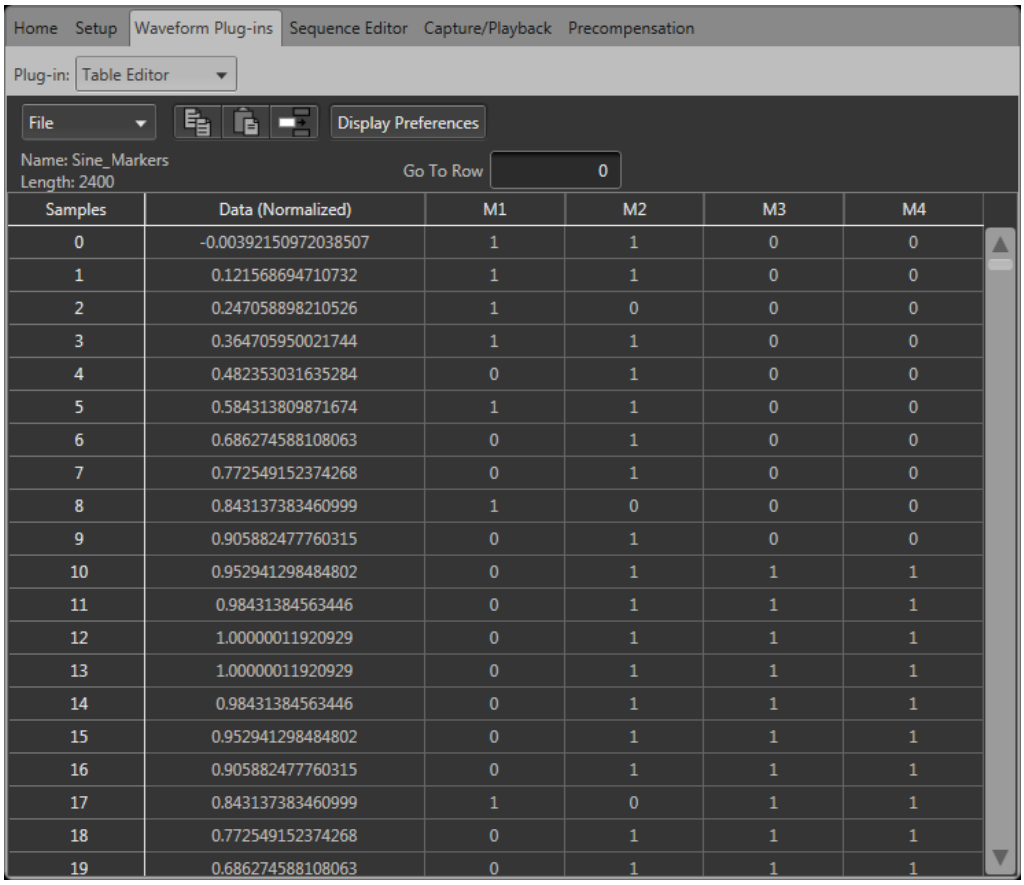


Table editor

The Table Editor plug-in allows you to display any waveform's sample points in table format. Using the table, you can then directly modify any sample point of the waveform, including marker data.



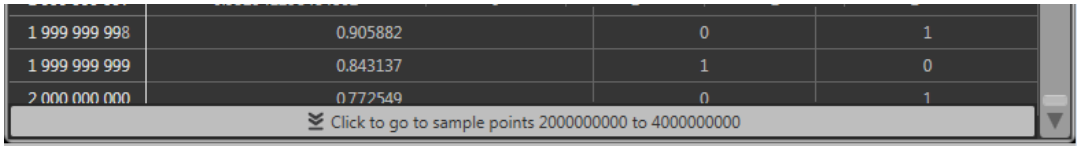
Samples	Data (Normalized)	M1	M2
0	-0.003922	1	1
1	0.121569	1	1
2	0.247059	1	0
3	0.364706	1	1
4	0.482353	0	1
5	0.584314	1	1
6	0.686275	0	1
7	0.772549	0	1
8	0.843137	1	0
9	0.905882	0	1
10	0.952941	0	1
11	0.984314	0	1
12	1.000000	0	1
13	1.000000	0	1
14	0.984314	0	1
15	0.952941	0	1
16	0.905882	0	1
17	0.843137	1	0
18	0.772549	0	1
19	0.686275	0	1

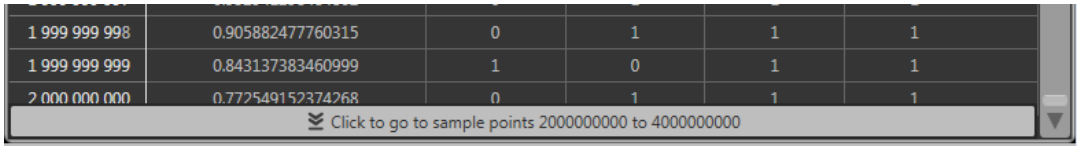


Samples	Data (Normalized)	M1	M2	M3	M4
0	-0.00392150972038507	1	1	0	0
1	0.121568694710732	1	1	0	0
2	0.247058898210526	1	0	0	0
3	0.364705950021744	1	1	0	0
4	0.482353031635284	0	1	0	0
5	0.584313809871674	1	1	0	0
6	0.686274588108063	0	1	0	0
7	0.772549152374268	0	1	0	0
8	0.843137383460999	1	0	0	0
9	0.905882477760315	0	1	0	0
10	0.952941298484802	0	1	1	1
11	0.98431384563446	0	1	1	1
12	1.00000011920929	0	1	1	1
13	1.00000011920929	0	1	1	1
14	0.98431384563446	0	1	1	1
15	0.952941298484802	0	1	1	1
16	0.905882477760315	0	1	1	1
17	0.843137383460999	1	0	1	1
18	0.772549152374268	0	1	1	1
19	0.686274588108063	0	1	1	1

The table is able to display up to 2 G samples at a time. If viewing waveforms larger than this, once you reach the end of the table, a navigation bar is displayed to load the next 2 G of sample points. This continues until you reach the final sample point of the waveform.

In the partial view below, we've reached the end of the table, and we need to click on the navigation bar to load the next set of samples.

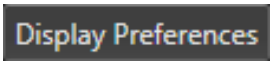




A similar navigation bar appears at the top of the table bar to go back to previous samples.

Toolbar operations

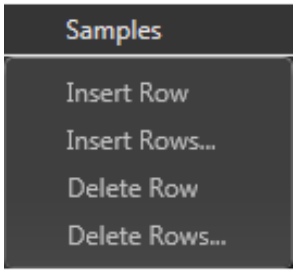
The tool bars in the table editor provides several functions.

	The File drop-down list contains the following menu selections. ■ **New...**: Displays the New Waveform dialog screen to create a new waveform. See New Waveform (see page 113) for details about the waveform creation parameters. ■ **Open...**: Displays a windows directory. Use the Windows directory to navigate to a saved waveform files or sequence files. You can select multiple files and all waveforms are added to the Waveforms list. Opening a sequence file displays a window of all waveforms included within the sequence. Choose any or all waveforms. The selected waveforms are added to the Waveforms list. (The sequence is not added to the Sequences list.) ■ **Recent**: Displays the list of waveforms that have been opened in the Table Editor during the current session. The waveform must be available in the Waveforms list. ■ **Save**: Opens a Windows navigation screen to allow you to name (or rename) and save the waveform currently in the Table Editor to the hard drive or any available devices. ■ **Save As**: Saves the opened sequence as a new waveform with a new name. ■ **Properties**: Displays the properties of the opened waveform.
	Copy icon: Copies the selected cells in the Table Editor to the clipboard.
	Paste-replace icon: Pastes the data from the copy clipboard to the table. Paste from this menu always rights over the existing data in the cell. The data being pasted must match the data type for the cells. For example, you can not paste marker data into a waveform data cell. You can also paste data from an Excel spreadsheet, replacing data in any number of cells (rows).
	Insert row icon: Use this to insert a new row into the Table Editor. The row is inserted above the currently selected row and the values are set to zero.
	The Display Preferences button displays a dialog screen to set the following: ■ **Data**: View the waveform data as either Normalized or in Volts. When volts is selected, you must select which channel to use as the amplitude reference. ■ **Points**: Select to view the waveform sample points as sample number or seconds. ■ **Show Analog**: Enable or disable viewing the Data column. ■ **Show Marker (1 — 2)**: Enable or disable viewing the available Markers columns. ■ **Show Marker (1 — 4)**: Enable or disable viewing the available Markers columns.
	The Go To Row lets you jump directly to a row within the waveform to view and edit the row.

Right-click menu operations

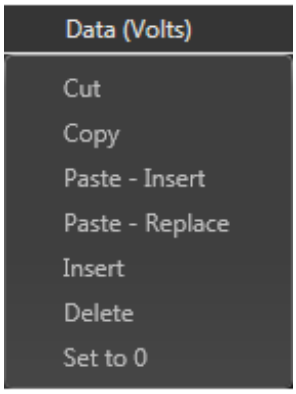
The table editor window provides many additional editing operations with the right-click menus available within the various columns of the table editor.

Samples column



- **Insert Row**: Inserts one new row above the currently selected sample row. The data and marker values are set to 0.
- **Insert Rows...**: Displays a pop-up window to enter multiple rows. The rows are inserted above the currently selected row. The data and marker values are set to 0.
- **Delete Row**: Deletes the currently selected row.
- **Delete Rows...**: Displays a pop-up window to enter a range of rows to delete.

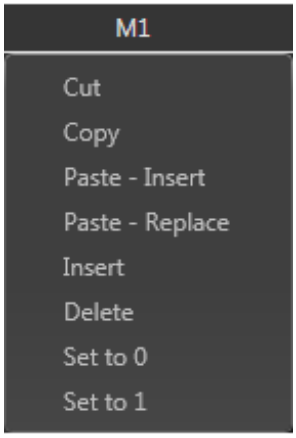
Data column



- **Cut**: Cuts the selection and places it in the clipboard. You can cut and paste from one waveform to another.
- **Copy**: Copies the selection and places it in the clipboard. You can copy and paste from one waveform to another.
- **Paste - Insert**: Inserts the clipboard contents into the table, creating a new sample point above the current selected cell/row. Other columns will have data cells added to the end, keeping all column length even.
- **Paste - Replace**: Inserts the clipboard contents into the selected cell.
- **Insert**: Inserts a new cell to the column, above the currently selected cell. Other columns will have data cells added (0 value) to the end, keeping all column length even.
- **Delete**: Deletes the currently selected cell. The column will have a data cell added (0 value) to the end.
- **Set to 0**: Sets the value to 0.

The Data column splits into two data columns (I Data and Q Data) when viewing an IQ waveform.

Markers column



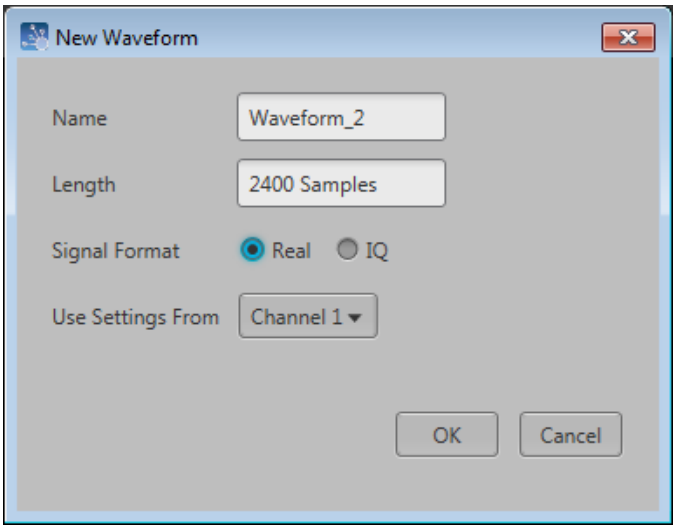
Same functions as the Data column except for the Set to 1 selection.

Markers can only be set to 0 or 1.

New Waveform

Selecting New... from the Table Editor File menu displays the New Waveform dialog screen.

The new waveforms created have the waveform data and marker values set to zero.



Name	Enter a name for the waveform. If the name already exists in the Waveforms list, the name is appended with an underscore suffix such as “Waveform_1”.
Length	Enter the number of sample points. The minimum and maximum number of points is dependent on the instrument model.
Signal Format	Select Real to describe the waveform as an RF type waveform. Select IQ to describe the waveform as IQ data. When selecting IQ, both an I and Q waveform is created.
Use Settings From	Specify the channel to use as the settings source.

When waveform is created, it is placed in the Waveform List, but is not saved to the hard drive. To save to the hard drive, save the waveform from the Waveform List.

Sequence file format (.seq)

Tektronix AWG70000 series instruments can read sequence files created with other Tektronix AWGs (such as the AWG400, 700 series). These instruments produced files using the .seq file extension and were ASCII files.

Tektronix AWG5200 series instruments can read sequence files created with other Tektronix AWGs (such as the AWG400, 700 series). These instruments produced files using the .seq file extension and were ASCII files.

Being a simple ASCII file, you can create these types of sequence files on a PC or other computer with an ASCII text editor.

The sequence file must conform to the format described below.

NOTE. *Waveform files referenced in the sequence file must reside in the same directory location as the sequence file.*

The ASCII file must follow this format:

MAGIC 3002

LINES <number>

<line description>

<line description>

…

<line description>

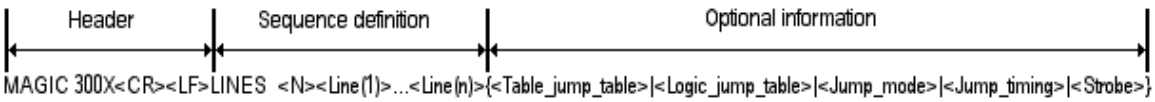
TABLE_JUMP 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

LOGIC_JUMP -1,-1,-1,-1

JUMP_MODE LOGIC

JUMP_TIMING ASYNC

STROBE 0



where	contains
Header	MAGIC<space>300x<CR><LF> X = 1 – 8 represents the number of tracks for which sequences are defined in the file.
Sequence definition	LINES<space><N><Line(1)><Line(2)>…<Line(N)> <N> is the number of lines (or steps) that follow.
<Line Description>	<Ch1_file_name>,<Ch2_file_name>,…<ChX_file_name>,<Repeat_Count>[,<F1>[,<F2>[,<F3>…[,<F13>]
<ChX_file_name>	<string> is the waveform or pattern file name for the specified channel. All channels must be present.
<Repeat_Count>	<NR1> is the repeat count for the line. 0 = Infinity 1 to 65536 for repeat count
<F1>	<Wait_Trigger> = <NR1> specifies whether or not to wait for a trigger. 0 = Off 1 = Trigger A 2 = Trigger B 3 = Internal Trigger
<F2>	<Goto-1> = <NR1> specifies whether or not to go to the next line. 0 = Off 1 = On
<F3>	<Logic_jump_target> = <NR1> is the line number for the Logic-Jump 0 = Off -1 = Next -2 = Table Jump 1 to 65535 = Line number
<F4>	<Goto N> = <NR1> is the jump to line N value
<F5>	<Event_Input> = <NR1> specifies the event input 0 = Off (will overrule the Logic_jump_target if selected) 1 = Trigger A 2 = Trigger B 3 = Internal Trigger

where	contains
<F6> | <F13>	Channel Flags <Ch1_Flags> = <string> specifies, in 4 character blocks, channel flag values. Four flag values are specified per flag group – Flag A, Flag B, Flag C, and Flag D. Each flag can have one of five values: N = No Change H = High L = Low T = Toggle P = Pulse Example Flag usage: <F6/Ch1_Flags> = TLHP <F7/Ch2_Flags> = LNPN This will set Channel 1 flags to Toggle, Low, High, and Pulse respectively. The next field will set Channel 2 flags to Low, No Change, Pulse, and No Change respectively.
Optional Information	{<Table_jump_table>|<Logic_jump_table>|<Jump_mode>|<Jump_timing>|<Strobe>}
<Table_jump_table>	TABLE_JUMP<space><Jump_target(1)>,<Jump_target(2)>,...<Jump_target(n)><CR><LF> <Jump_target(n)> = <NR1> is the line number to the Table-Jump or 0 (Off). The default is Off.
<Logic_jump_table>	LOGIC_JUMP<space><Jump_on/off(1)>,<Jump_on/off(2)>,<Jump_on/off(3)>,<Jump_on/off-(4)><LF> <Jump_on/off(n)> = <NR1> sets the Logic-Jump on oroff. <NR1> = 0 is Off, 0> is On, and <0 is Ignore. The default is Ignore.
<Jump_mode>	JUMP_MODE<space>{LOGIC|TABLE|SOFTWARE}<CR><LF> sets the jump mode. The default is TABLE.
<Jump_timing>	JUMP_TIMING<space>{SYNC|ASYNC}<CR><LF> sets the jump mode. The default is ASYNC.
<Strobe>	STROBE<space><NR1><CR><LF> determines whether or not to use the STROBE signal from the EVENT IN connector on the rear panel. <NR1>=0 is Off, ≠0 is On. The default is Off.

Waveform file format (.wfmx)

The waveform file format (.wfmx) contains all the primary and auxiliary data associated with the waveform data required (for both the hardware and software). The file is a binary XML file containing the metadata information and the waveform sample data. The XML file type is particularly useful with its expandable nature and quick parsing.

Some instruments/applications tag their waveforms with Amplitude and Offset values used to acquire the waveform.

The AWGs allow you to specify the amplitude and offset values to use when playing that waveform.

Primary requirements

The waveform file contains the following information:

- Marker data
- Waveform data
- Recommended playback parameters including recommended sample rate
- Amplitude and offset
- Samples are interpreted as Little Endian.

Waveform sample data

The waveform data can consist of the following types of data:

- Samples consisting of single precision float data + 1 byte of marker data.
- Samples consisting of complex (I and Q) data + 1 byte of marker data.

Waveform metadata elements

Element	Description	Req.	Opt.
DataFile			
Version	The version that waveform was created under. Currently, the proper format for .wfmx files is version 0.2. This parameter is contained within the DataFile element with a tag of "version". Proper usage example: <DataFile version="0.2">	X	
DataDescription			

Element	Description	Req.	Opt.
NumberSamples	The number of samples contained in the waveform (length). It is a "long" integer value, no decimals. Proper usage example: <NumberSamples>4800</NumberSamples>	X	
MarkersIncluded	Helps determine if markers are included in the data file or not. It is a boolean value. Only "true" and "false" are valid values. Proper usage example: <MarkersIncluded>true</MarkersIncluded>	X	
NumberFormat	This value is "Single". Element must be: <NumberFormat>Single</NumberFormat>	X	
Endian	This value is "Little". Element must be: <Endian>Little</Endian>		X
Timestamp	A guide for when the waveform was last saved. The element uses Microsoft's standard date and time formatting. Proper usage example: <Timestamp>2016-09-12T13:36:47.2147485-07:00</Timestamp>		X
ProductSpecific			
RecSamplingRate	Indicates the ideal sample rate in Hertz during playback of the stored waveform. If the system setting is enabled to apply recommended settings upon channel assignment, then the recommended sample rate will be applied to the system clock. Proper usage example: <RecSamplingRate>5000000000</RecSamplingRate>		X
RecAmplitude	Indicates the ideal amplitude in pk-pk Volts during playback of the stored waveform. If the system setting is enabled to apply recommended settings upon channel assignment, and if the instrument is capable of setting the amplitude, then the recommended amplitude will be applied to the assigned channel. Proper usage example: <RecAmplitude>1</RecAmplitude>		X
RecOffset	Indicates the ideal offset in Volts during playback of the stored waveform. If the system setting is enabled to apply recommended settings upon channel assignment, and if the instrument is capable of setting an offset, then the recommended offset will be applied to the assigned channel. Proper usage example: <RecOffset>1</RecOffset>		X
RecFrequency	Indicates the ideal frequency in Hertz during playback of the stored IQ waveform. This field is only relevant for waveforms with a Signal Format of IQ. Proper usage example: <RecFrequency>2000000000</RecFrequency>		X

Element	Description	Req.	Opt.
SerialNumber	Indicates the serial number of the instrument that this waveform was saved from. It is only for archival purposes and does not affect software behavior. Proper usage example: <SerialNumber>B0000001</SerialNumber>		X
SoftwareVersion	Indicates the software version that this waveform was saved from. It is only for archival purposes and does not affect software behavior. Proper usage example: <SoftwareVersion>6.0.058.0</SoftwareVersion>		X
UserNotes	This parameter is not being used or populated. There is no location within the software that displays user modifiable notes. However, if the user would like to store information in this parameter, it will be imported. Proper usage example: <UserNotes>My notes go here</UserNotes>		X
SignalFormat	Indicates whether the samples in the file are Real (standard) or Complex (IQ). Valid values are: "Real", "I", "Q", and "IQ". Proper usage example: <SignalFormat>Real</SignalFormat> Defaults to "Real".		X
CreatorProperties			
name	This field is primarily meant to populate fields in the Plug-in editors. This field it typically empty. Proper usage example: <CreatorProperties name="" />	X	

Waveform and marker data

The waveform and marker data immediately follows the Waveform metadata elements. In the file, all data samples are written, then all marker data is written.

For example, if you have 1k samples, then the file would contain 4k bytes (4 bytes per data sample) followed by 1k marker bytes.

Regular data files. For regular data files, the data is normalized (–1 to +1) and stored as a float, and the markers as a byte:

D=Data, M=Marker

D1, D2, D3, ...Dn, M1, M2, M3, ...Mn.

Complex data files. For complex data files, I and Q data is normalized (–1 to +1) and is stored as floats, and the markers as a byte:

I=I-Data, Q=Q-Data, M=Marker

I1, I2, I3, ...In, Q1, Q2, Q3, ...Qn, M1, M2, M3... Mn

Marker bits. Marker bits are stored in LSB fashion: XXXX XXMM (with Marker 1 being the LSB). If there are 2 markers, Marker 2 would be the MSB.

Waveform examples

Example 1. The following is an example of the minimum requirements for the waveform metadata section in a .wfmx file.

```
<DataFile version="0.2">
  <DataSetsCollection>
    <DataSets version="1">
      <DataDescription>
        <NumberSamples>4800</NumberSamples>
        <MarkersIncluded>true</MarkersIncluded>
        <NumberFormat>Single</NumberFormat>
      </DataDescription>
      <ProductSpecific name="">
        <CreatorProperties name="" />
      </ProductSpecific>
    </DataSets>
  </DataSetsCollection>
  <Setup />
</DataFile>
```

Waveform data and marker data to immediately follow.

Example 2. The following is an example of a typical metadata section, including optional parameters, for a waveform metadata section in a .wfmx file.

```
<DataFile offset="000001274" version="0.2">
  <DataSetsCollection>
    <DataSets version="1">
      <DataDescription>
        <NumberSamples>4800</NumberSamples>
        <MarkersIncluded>true</MarkersIncluded>
        <Timestamp>2016-09-12T13:36:47.2147485-07:00</Timestamp>
      </DataDescription>
      <ProductSpecific name="">
        <RecSamplingRate>5000000000</RecSamplingRate>
        <RecAmplitude>1</RecAmplitude>
        <RecOffset>1</RecOffset>
        <RecFrequency>2000000000</RecFrequency>
        <SerialNumber />
        <SoftwareVersion>6.0.058.0</SoftwareVersion>
        <UserNotes />
        <Thumbnail />
        <SignalFormat>Real</SignalFormat>
        <CreatorProperties name="" />
      </ProductSpecific>
    </DataSets>
  </DataSetsCollection>
  <Setup />
</DataFile>
```

Waveform data and marker data to immediately follow.

MATLAB waveform file format

Tektronix AWG70000/AWG5200 series generators can read waveform files created with MATLAB (.MAT), a third party software application. MATLAB files can contain multiple waveform data sets (including marker data). Waveforms created with MATLAB must meet the waveform requirements.

This section defines the proper elements and conditions that the MATLAB file must meet to create an AWG waveform file.

MATLAB versions supported

The following versions of MATLAB files are supported.

- MATLAB version 7.3 (supports files larger than 2 GB)
- MATLAB version 5 (supports files less than 2 GB)

NOTE. *Verify that MATLAB is configured to save as one of the supported versions. (The default selection may not be appropriate.)*

Waveform files saved as other versions will not import.

AWG MATLAB waveform elements

Waveform elements for an AWG MATLAB file format waveform must be contained in the same .mat file.

Each waveform will be grouped together by a trailing numerical value.

- For example - given the following elements: Waveform_Name_1, Waveform_Data_1, Waveform_Name_2, Waveform_Data_2, Waveform_M1_2, Waveform_M2_2, two complete waveforms can be formed:
  - The first waveform will have the name identifier from Waveform_Name_1 and the data held in Waveform_Data_1.
  - The second waveform will have the name identifier from Waveform_Name_2 and the data held in Waveform_Data_2. Additionally, the second waveform will have Marker 1 and Marker 2 data.

Table 4: MATLAB required elements

Element	Condition
Waveform_Name_#	The MATLAB file must have the "Waveform_Name_#" specified. The "Waveform_Name_#" must contain a string value denoting the waveform name.
Waveform_Data_#	The AWG MATLAB file must have the "Waveform_Data_#" specified. The "Waveform_Data_#" must contain an array of data values (representing waveform samples) in one of the types: double, single, or UInt16. Ideally, double and single should have values scaling from –1 to 1, and UInt16 should have values ranging from 0 to 65535.

Table 5: MATLAB optional elements

Element	Condition
Waveform_M1_#	The AWG MATLAB file can contain marker 1 data, having the "Waveform_M1_#" specified. The "Waveform_M1_#" must contain a UInt8 array of marker values for the waveform's Marker 1. Only 1 and 0 are considered valid values. The length of the marker array must match that of the AWG MATLAB file format waveform data array length.
Waveform_M2_#	The AWG MATLAB file can contain marker 2 data, having the "Waveform_M2_#" specified. The "Waveform_M2_#" must contain a UInt8 array of marker values for the waveform's Marker 2. Only 1 and 0 are considered valid values. The length of the marker array must match that of the AWG MATLAB file format waveform data array length.
Waveform_Sampling_Rate_#	The AWG MATLAB file can contain the sampling rate, having the "Waveform_Sampling_Rate_#" specified. The "Waveform_Sampling_Rate_#" must contain a "Double" value, indicating the waveform's suggested sampling rate. The specified sampling rate is the waveform's recommended sampling rate, but it will not directly change any sampling rate settings of the instrument.
Waveform_Amplitude_#	The AWG MATLAB file can contain the waveform amplitude, having the "Waveform_Amplitude_#" specified. The "Waveform_Amplitude_#" must contain a "Double" value, indicating the unique waveform's suggested amplitude. The specified amplitude is the waveform's recommended amplitude, but will not directly change any amplitude settings of the instrument.
Waveform_Signal_Format_#	The AWG MATLAB file can contain the waveform signal format having the "Waveform_Signal_Format_#" specified. The "Waveform_Signal_Format_#" must contain a 'String' value indicating the unique waveform's signal format. Signal format indicates whether a Waveform is of the format type: Real, I, or Q.

MATLAB waveform file example

The following MATLAB coding example demonstrates how to create a MATLAB file that:

- creates a small, simple sinusoidal waveform with markers
- saves the waveforms into separate files
- saves the waveforms into a single file

MATLAB waveform coding example

```
%% Create Sinusoid

x = 2399;
t = 0:1:x;
baseWfm = sin(2*pi*1/x*t); % Generate Sine Wave
baseMarkers = uint8(square(2*pi*1/x*t,50));

%% Create Waveform 1 (Double)
Waveform_Name_1 = 'MyDoubleWfm';
Waveform_Data_1 = baseWfm; %already a double array
Waveform_M1_1 = baseMarkers; %already uint8 array
Waveform_M2_1 = baseMarkers;
save('AWG_Double', '*_1', '-v7.3'); % MAT 7.3 Can save > 2GB

%% Create Waveform 2 (Single)
Waveform_Name_2 = 'MySingleWfm';
Waveform_Data_2 = single(baseWfm);
save('AWG_Float', '*_2', '-v7.3');

%% Save All Waveforms
save('All_Wfms.mat', 'Waveform_*', '-v7.3');
```

MATLAB IQ file example

The following MATLAB coding example demonstrates how to create a MATLAB file that:

- creates a complex signal
- creates and saves an I waveform
- creates and saves a Q waveform

MATLAB IQ file coding example

```
clear;clc;

%% Create Complex Signal
nConstellationPoints=4; % Number of Constellation Points
numSymbols=1000; % Number of Symbols
samplesPerSymbol=10; % Samples per symbol
% For the Symbol Rate of 1M the Sampling Rate would be 10M
% Symbol Rate = Sampling Rate / Samples per Symbol

alpha=0.35; % RC Filter Rolloff (Alpha)
convLength=21; % Convolution Length
baseDataPattern=mod(randi(nConstellationPoints,1,numSymbols),nConstellationPoints); % Creates the base data
y=pskmod(baseDataPattern,nConstellationPoints, pi/4); % Creates the PSK modulation
rrcfilter = rcosdesign(alpha,convLength, samplesPerSymbol); % Create the filter coefficients
IQData = upfirdn(y, rrcfilter, samplesPerSymbol); % Filter and Interpolation

clear nConstellationPoints numSymbols samplesPerSymbol alpha convLength
clear baseDataPattern y rrcfilter

%% Retrieve IQ Data
iData = real(IQData);
```

```
qData = imag(IQData);

%% Normalize to +1/-1
maxI = max(abs(iData));
maxQ = max(abs(qData));
maxMax = max(maxI, maxQ);
iData = iData / maxMax;
qData = qData / maxMax;

IQData = iData + 1i*qData; % Re-set I and Q data
plot(IQData)

clear maxI maxQ maxMax

%% Create I Waveform
Waveform_Name_1 = 'MyI_Waveform';
Waveform_Data_1 = iData;
Waveform_Sampling_Rate_1 = 10e9;
Waveform_Signal_Format_1 = 'I';

save('MAT - MAT5 - AWG - I Waveform', '*_1', '-v6');
save('MAT - HDF5 - AWG - I Waveform', '*_1', '-v7.3');

%% Create Q Waveform
Waveform_Name_2 = 'MyQ_Waveform';
Waveform_Data_2 = qData;
Waveform_Sampling_Rate_2 = 10e9;
Waveform_Signal_Format_2 = 'Q';

save('MAT - MAT5 - AWG - Q Waveform', '*_2', '-v6');
save('MAT - HDF5 - AWG - Q Waveform', '*_2', '-v7.3');
```

```
%% Save Files
save('MAT - MAT5 - AWG - Complex Waveforms.mat', '*_1', '*_2', '-v6');
save('MAT - HDF5 - AWG - Complex Waveforms.mat', '*_1', '*_2', '-v7.3');

%% Create Invalid Waveforms
%Too many waveforms
Waveform_Name_3 = 'TooManyWfms';
Waveform_Data_3 = Waveform_Data_2;

save('MAT - MAT5 - AWG - Invalid Too Many Complex Waveforms', '*_1', '*_2', '*_3', '-v6');
save('MAT - HDF5 - AWG - Invalid Too Many Complex Waveforms', '*_1', '*_2', '*_3', '-v7.3');

%Mismatching Sample Rates
Waveform_Sampling_Rate_2 = 1e9; %1G & 10G

save('MAT - MAT5 - AWG - Invalid Complex SR Mismatch Waveforms', '*_1', '*_2', '-v6');
save('MAT - HDF5 - AWG - Invalid Complex SR Mismatch Waveforms', '*_1', '*_2', '-v7.3');
```

Licensing overview

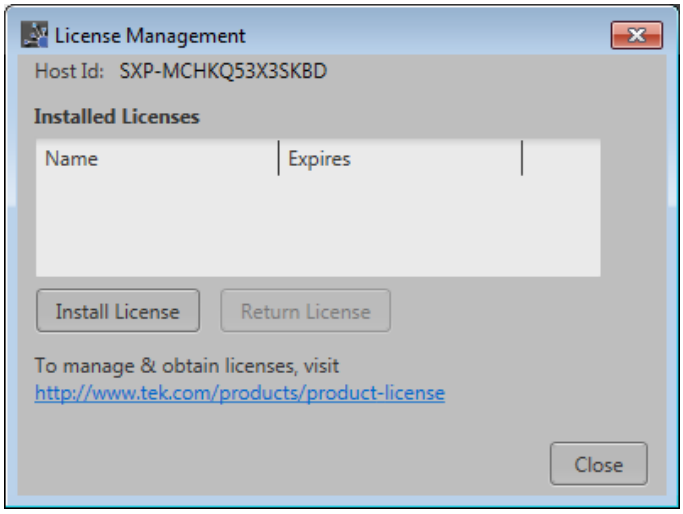
License files are used in SourceXpress to enable optional plug-ins and features.

A Licensing scheme is used to host your license files. The product license administration is through Tektronix Asset Management System (TekAMS). TekAMS has an easy to use web based interface that provides:

- Inventory of all the licenses in the company account
- Ability to check out a license
- Ability to check in a license

The Tektronix Asset Management System is available at http://www.tek.com/products/product-license .

To view and install licenses in SourceXpress, select Licenses... from the Tools menu to display the License Management screen.



Generally, to properly install and activate a plug-in application, follow these steps.

1. Purchase a license from Tektronix. See How to purchase a license (see page 134).
2. Store the license file in a location available to the application. This can be on the instrument's drive, a USB flash drive, or any networked drive.
3. Obtain the plug-in installation file. Plug-in installation files are available for download from the Tektronix web site.

4. Install the plug-in application.
5. Install the license file. See How to install a plug-in license (see page 134).

How to purchase a license

Contact your local Tektronix Account Manager to purchase a plug-in license. After purchasing, you will receive an email listing the licenses purchased. The email also contains the URL to the Tektronix Asset Management System (TekAMS) that enables you to manage your licenses.

Floating Licenses provide the ability to move the license from an instrument or a personal computer to another by checking in a license from an instrument or PC and checking it out to another.

The Tektronix Asset Management System (http://www.tek.com/products/product-license) provides an inventory of the license(s) in your account. If a license is a Floating license, it also enables you to check out or check in the license.

There are two different types of licenses available for plug-ins:

License type	Description
Node-Locked License [1]	This license is permanently assigned to a specific Hostid or product model/serial number. Node Locked Licenses provide your own copy of the application on your instrument or personal computer.
Floating License	This license can be moved between different Hostids or product models. Use the Tektronix Asset Management system to check in and check out floating licenses.

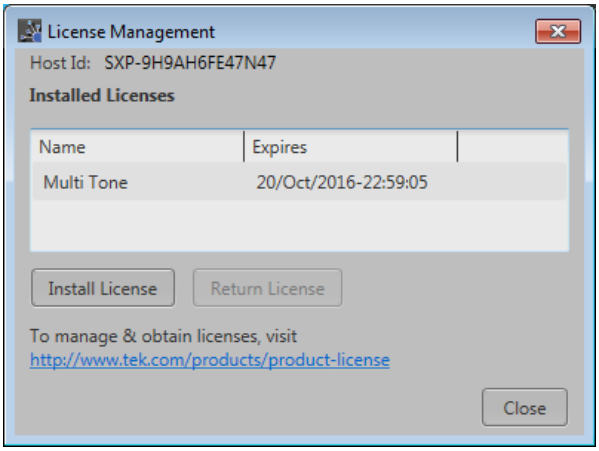
[1] A Node-Locked license can be move up to two times after the initial installation to allow for operating system upgrades or other PC failures.

How to install a license

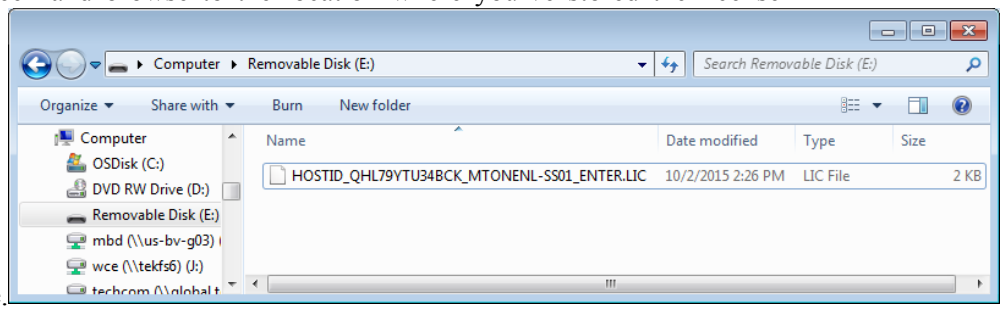
License files are used to enable optional applications.

NOTE. *Applications may have been previously installed, but without a license, you cannot create waveforms.*

1. Select Licenses... from the Tools menu to display the License Management screen.

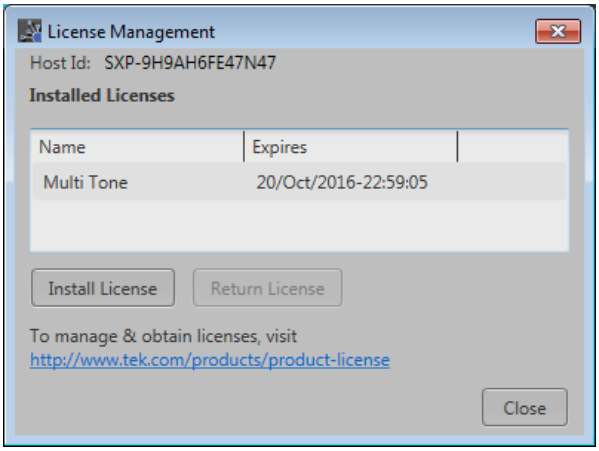


2. Select the Install License button to display the license file selection screen and browse to the location where you've stored the license file.



3. Select the license file and select Open.

4. After the successful installation is finished, the name of the plug-in is listed along with the expiration date and time.



Floating licenses display the expiration date for that application. The expiration date for a floating license is defined when the license is checked out from the Tektronix Asset Management system. After the license expires, the application is automatically disabled and the license on the TekAMS is free to be assigned to a different host.

Node locked license have no expiration date.

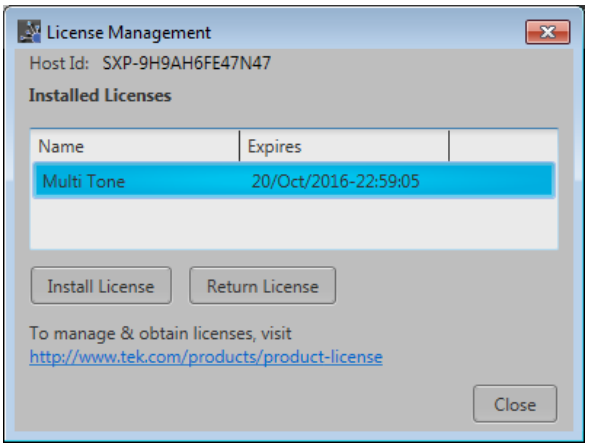
How to return a license

You can return a floating license to the Tektronix Asset Management System (TekAMS). After a floating license is returned to the TekAMS, it becomes available to be assigned to a different host.

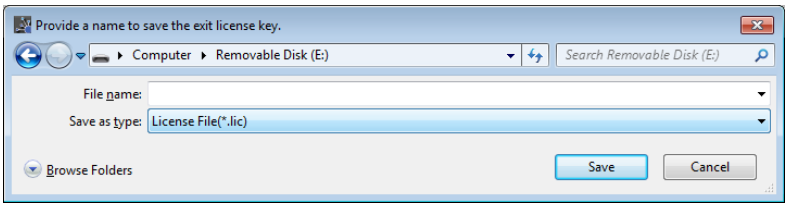
NOTE. *Only floating licenses can be returned and reassigned to different hosts.*

When assigning a license, you need to specify the host id or instrument and include the duration the feature is to be enabled on the host. This is all done on the Tektronix Asset Management System (TekAMS) web site. After the license expires, the feature is automatically disabled on the host and the license on the TekAMS is free to be assigned to a different host.

1. Select Licenses... from the Tools menu. Under Installed Licenses, select the license to return and select Return License. (A confirmation box is displayed in order to continue.)



After confirming to continue, a license exit file will be created. You need to provide a name for the exit file and browse to a location to save the license exit file.



NOTE. *The next step creates and saves the exit file. Once the exit file is created, the application will immediately become nonfunctional (unable to compile).*

2. Browse to the location where you would like to place the exit file (for example, a network drive or a USB memory stick), and select Save to generate the exit file.
3. Login to your account on TekAMS (Tektronix Asset Management system) and upload the exit file. Once the license is returned successfully, it can be re-assigned to a different host or instrument.

Index

L

M

N

O

P

R

S

T

U

V

W