SerialXpress® SDX100
Advanced Jitter Generation Tool for Tektronix AWG70000, AWG5000 & AWG7000 Series Signal Generators

Quick Start User Manual

077-0064-07

Tektronix

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www.tektronix.com
077-0064-07

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For product information, sales, service, and technical support:

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

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[W9b – 15AUG04]

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Compliance information

Environmental considerations

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

Product end-of-life handling

Observe the following guidelines when recycling an instrument or component:

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

This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2012/19/EU and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

Preface

This user guide describes the SerialXpress application. This application can emulate all forms of channel impairments and can pre-compensate for losses in the overall test setup and cabling. It eliminates the need for expensive and difficult-to-obtain cable emulators.

Key Features

The key features of the SerialXpress are:

- Jitter addition: Up to four different sinusoidal jitters with different amplitudes, frequencies and phases can be added to a base pattern. Two independent band-limited random jitters can also be added to the base pattern.
- SSC addition: Spread Spectrum Clocking (SSC) can be added with controlled profile, spread, deviation, modulation, and df/dt.
- Advanced Pre/De-emphasis and Noise: Many standards such as PCI-E require the output waveform to be pre/de-emphasized. SerialXpress allows easy addition of pre/de-emphasis with all other jitter parameters. Vertical noise can be added at both near and far ends of the channel.
- Inter-symbol interference (ISI) creation: SerialXpress allows you to create ISI by entering it directly or from an S-parameter file captured from a Tektronix sampling oscilloscope or a Vector Network Analyzer. The S-parameter can be directly convolved with the base pattern to recreate the channel characteristics. By applying inverse filtering, the effects of the channel can be de-embedded from the system. The ISI within the S-parameter can be scaled upward or downward, easily altering the characteristics of the channel.
- Base pattern: SerialXpress is bundled with several sample patterns for various standards like SATA, Display Port, SAS, PCI-E, Fiber Channel, MIPI, and USB. Patterns can also be directly entered in a Binary or Hex editor, or loaded from a file.
- Idle state: Standards like SATA call for OOB signaling, which requires an idle state followed by a burst. You can directly create this idle state without using additional power dividers. Noise can also be added to these idle state waveforms.
- Calibration: SerialXpress has a built-in calibration routine, which controls a Tektronix oscilloscope and calibrates the output of a Tektronix arbitrary waveform generator (AWG) for periodic jitter, random jitter, and ISI reducing the need for time-consuming manual calibration.
- Bandwidth expansion filter: The bandwidth of an arbitrary waveform generator can be expanded further by applying the bandwidth expansion filter which compensates for DAC roll-off. For example, when used with an AWG7122B with option 06, the bandwidth expansion filter compensates for the DAC roll-off at higher frequencies, thereby extending the bandwidth up to 9.6 GHz. This helps in improving the rise time.
- Batch processing: When more than one pattern needs to be synthesized, you can use batch processing to create multiple waveforms with a combination of random and sinusoidal jitter and a maximum of four different frequencies.
- Overview window: All jitter parameters can be switched on or switched off from the overview window.
- Cascading S-Parameters: SerialXpress allows you to cascade up to six Touchstone files of the same format to emulate a cascaded channel.
- Sequencing: SerialXpress supports sequencing of several base pattern types. You can specify several base pattern files, add different types of jitter to each base pattern, and compile them simultaneously. These waveforms are automatically transferred to the AWG sequencer at the end of compilation.
- Presets: SerialXpress provides pre-created setup files for standards such as SATA, USB 3.0, DisplayPort, and HDMI. Selecting a preset loads the appropriate setup into SerialXpress.

- Marker outputs: Marker outputs can be configured to be the same as the input base pattern or to generate clocks at a user-defined frequency. You can also set the marker output to all high, all low, or trigger.
- Pre/de-emphasis and Preshoot: Standards like PCIE, 10 GbE, SAS, and USB 3.0 need more than one tap for Pre/De-emphasis signal generation. The advanced Pre/de-emphasis feature of SerialXpress provides flexibility to program the Pre/De-emphasis and Preshoot sample by sample. The preview feature facilitates you to arrive at the most optimized Pre/de-emphasis for a particular channel quickly.
- Crest Factor Emulation: SerialXpress allows you to apply peak pseudo random jitter to a bit pattern and reduce your test time. The test cases can be repeated accurately so that the receiver can be debugged quickly. SerialXpress allows you to accurately control the crest factor of the random jitter to produce a worst case signal to stress the receiver.
- Delay: SerialXpress allows you to introduce a delay into the waveform which can be used to generate skew between channels or patterns.
- Scrambling and 8B10B encoding: The input data pattern can be scrambled by defining a polynomial. You can also encode using the 8B10B encoding option.
- NRZ, NRZI, 4-PAM, and PWM: SerialXpress allows you to define the pattern duty cycle using the Pulse Width Modulation (PWM), and alternatively encode the bit stream to 4-PAM, NRZ, or NRZI.

Documentation

SerialXpress Online Help, English	Tektronix part number 076-0112-xx
SerialXpress User Manual, English, (PDF)	Tektronix part number 077-0050-xx
SerialXpress Quick Start User Manual, English, (PDF)	Tektronix part number 077-0064-xx
SerialXpress Installation Manual, English, (PDF)	Tektronix part number 077-0049-xx
SerialXpress Programmer Online Help, English	Tektronix part number 076-0166-xx
SerialXpress Programmer Manual, English, (PDF)	Tektronix part number 077-0144-xx

Conventions Used in this Manual

When steps require a sequence of selections using the software interface, the ">" delimiter marks each transition between a menu and an option. For example, File > Save.

The terms “signal” and “waveform” are used interchangeably in this manual.

Installation

The SerialXpress installation wizard installs the following software:

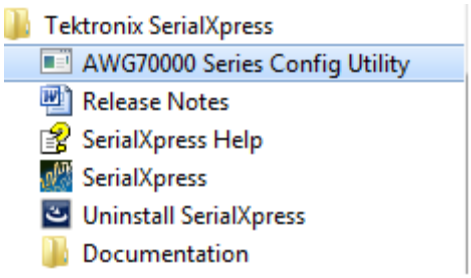
- SerialXpress SDX100 software (including MATLAB and .NET framework)
- TekVISA is installed on your instrument. You can download the latest TekVISA at www.tektronix.com/software. To define the search criteria, use TEKVISA in the Keyword field.

For information on how to install this software, refer to the *SerialXpress Installation Manual*, Tektronix part number 077-0049-xx.

AWG70000 Series configuration utility

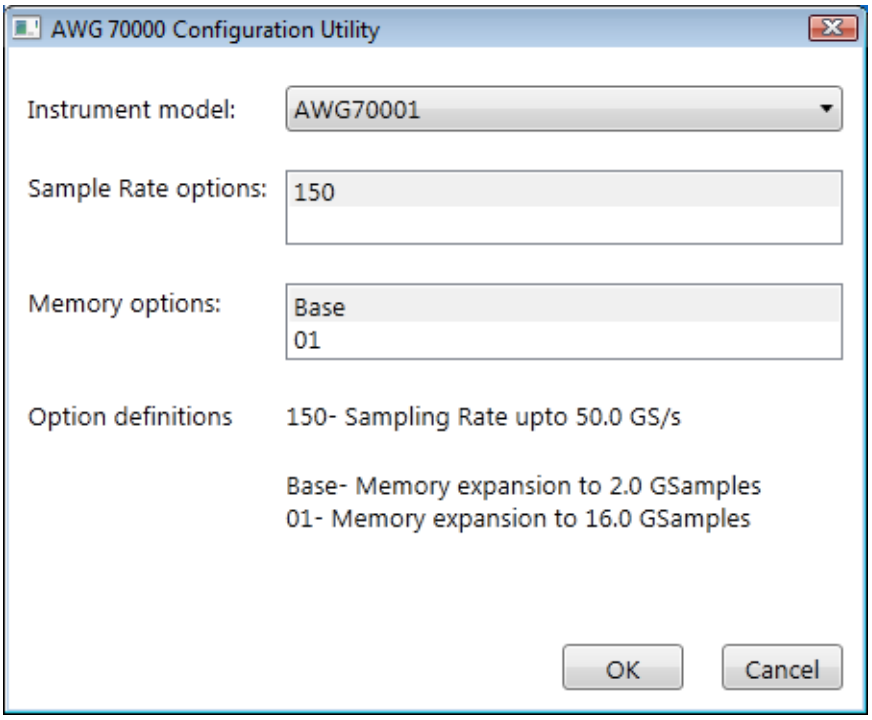
To use SerialXpress with an AWG70000 Series arbitrary waveform generator, you must run the AWG70000 Configuration Utility. This should be done before starting SerialXpress. The utility only needs to be run once to provide SerialXpress with the AWG70000 Series model and its options. SerialXpress stores these setting for all subsequent starts of SerialXpress.

The configuration utility is located in the Tektronix SerialXpress Program folder.



When the configuration utility starts, simply enter your AWG70000 Series model number and its options. This information provides SerialXpress with the information to properly adjust variables (such as sampling rate and waveform length) to accommodate the features of the AWG70000 Series generators.

NOTE. *All instrument information entered here must match your AWG70000 Series instrument exactly, including all options. Any mismatch of information will cause a an error when attempting to connect to the instrument.*



Starting the Software

Start the software in either of the following ways:

- From Start > All Programs > Tektronix SerialXpress, click SerialXpress.
- Double-click the SerialXpress icon on your desktop.

Closing the Software

Click File > Exit to close the software.

Software Upgrades

Periodic software upgrades may become available. The software is operational only if you have a valid dongle for the specific instrument model and serial number.

To check for upgrades:

1. Go to www.tektronix.com/software.
2. Enter the product name (SerialXpress).

Using the Software

This section covers the following information:

- Getting acquainted with the software
- Creating data streams with jitter
- Creating a PRBS waveform with inter symbol interference and pre-emphasis
- Compiling a signal
- Viewing graphs of a signal

Getting Acquainted with the Software

Using the Software Interface

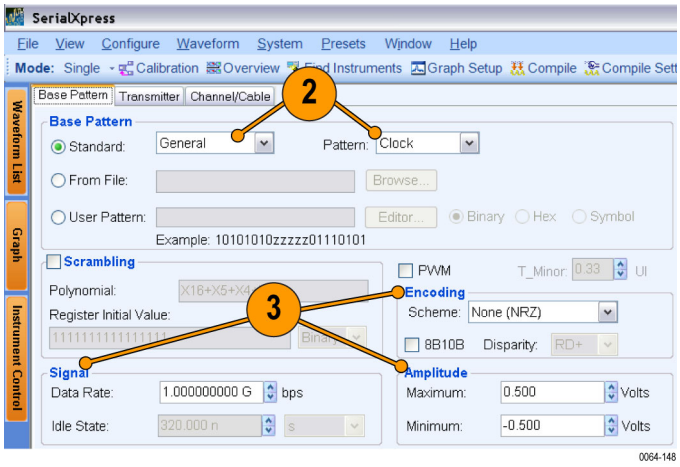
Use the keyboard or mouse to make selections in the software.

Use menus, toolbars, check boxes, and on-screen buttons to control the software functions. Use Microsoft Windows techniques to navigate menus and select or clear check boxes.

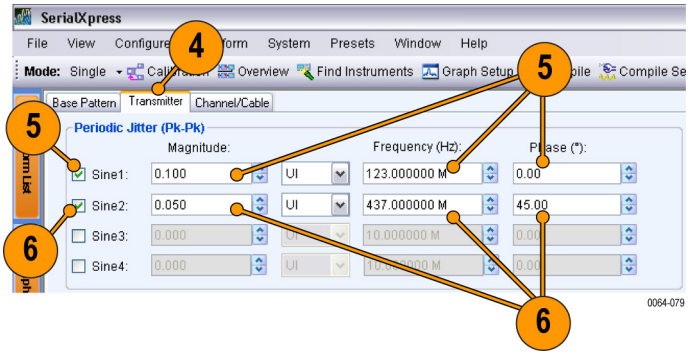
Creating Serial Data Streams with Periodic and Random Jitter

For compliance testing of the many different serial data streams, being able to add specific amounts of jitter is not only useful but also required for most receiver tests.

1. Start SerialXpress.
2. In the **Base Pattern** tab, select the **Standard** as General and **Pattern** as Clock.
3. Leave the Signal, Encoding, and Amplitude parameters at their default values.

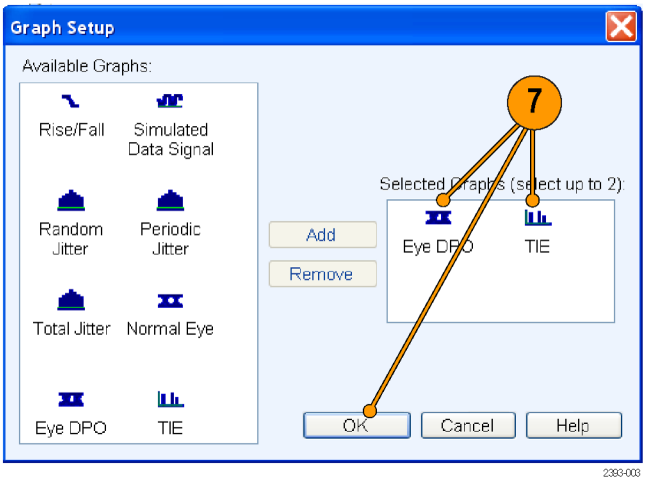


4. Click the Transmitter tab.
5. In the Periodic Jitter group, click Sine1 and set the following values:
   - **Magnitude** to 0.1 UI.
   - **Frequency** to 123 MHz.
   - **Phase** to 0°.
6. Click Sine2 and set the following values:
   - **Magnitude** to 0.05 UI.
   - **Frequency** to 437 MHz.
   - **Phase** to 45°.

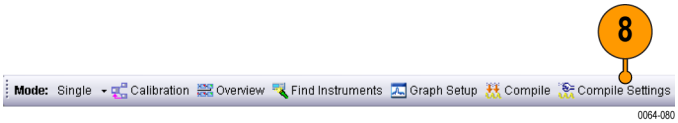


7. Click **Graph Setup** and select the following graphs:
   - Eye DPO
   - TIE

   Click **OK**.

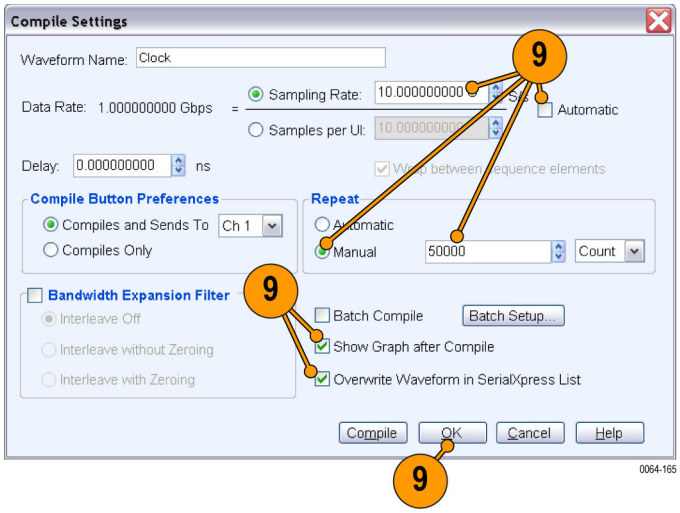


8. Click **Compile Settings**.

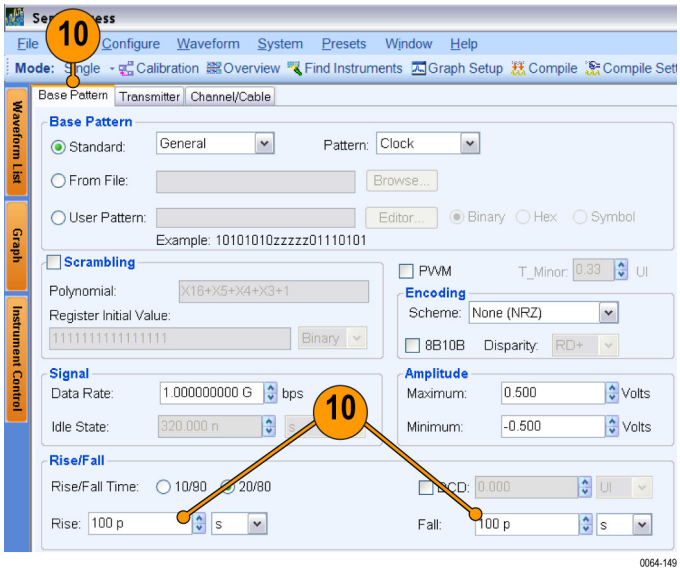


9. Do the following:

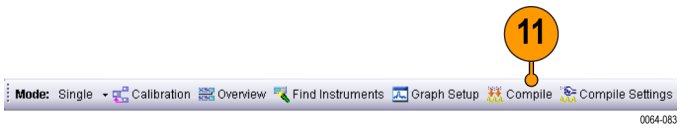
- Click **Automatic** to clear it.
- Set **Sampling Rate** to 10 G.
- Set the **Repeat** to Manual and set the **Count** to 50000.
- Ensure that **Show Graph after Compile** is selected.
- Ensure that **Overwrite Waveform in SerialXpress List** is selected.
- Click **OK**.



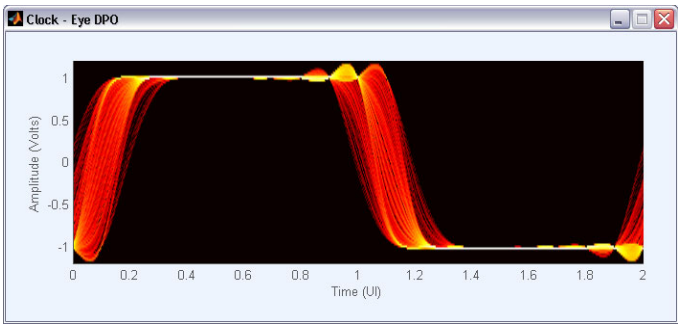
10. Go to the **Base Pattern** tab and set the **Rise** and **Fall** time to 100 ps (default).

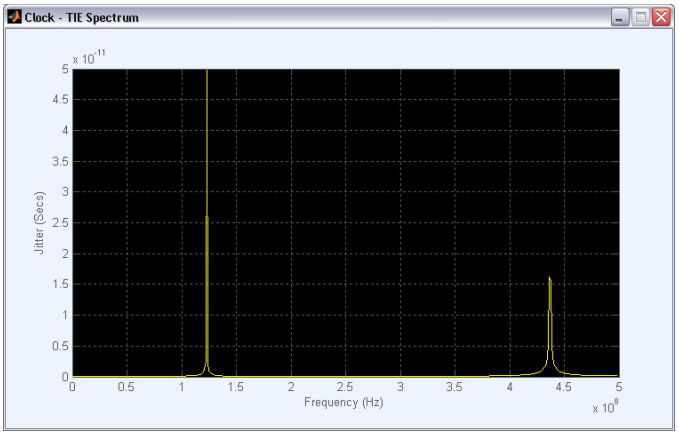


11. From the toolbar, click **Compile**.



12. The output waveforms are as shown.





13. Click the **Transmitter** tab.

14. In the Periodic Jitter group, clear Sine1 and Sine2.

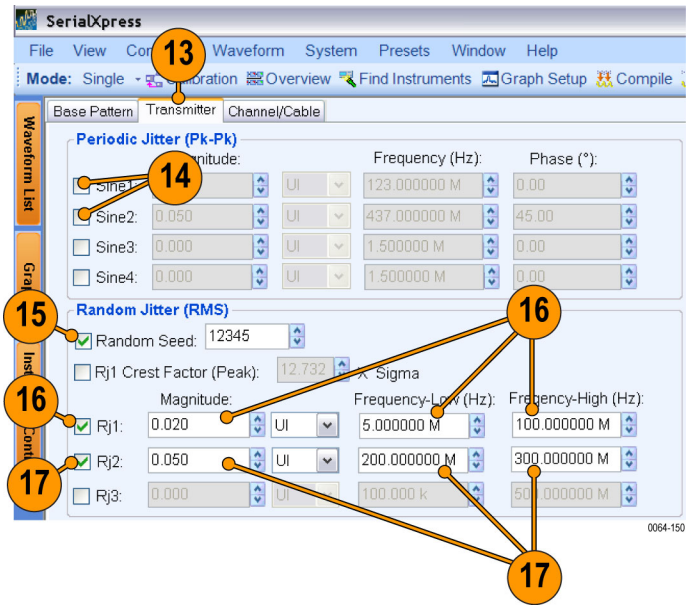
15. In the Random Jitter group, select **Random Seed**.

16. Select Rj1 and set the following:

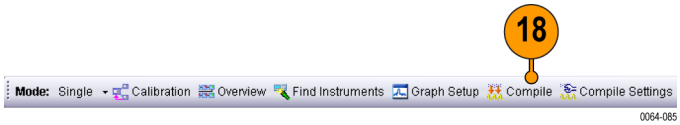
- **Magnitude** to 0.02 in UI.
- **Frequency-Low** to 5 MHz.
- **Frequency-High** to 100 MHz.

17. Select Rj2 and set the following:

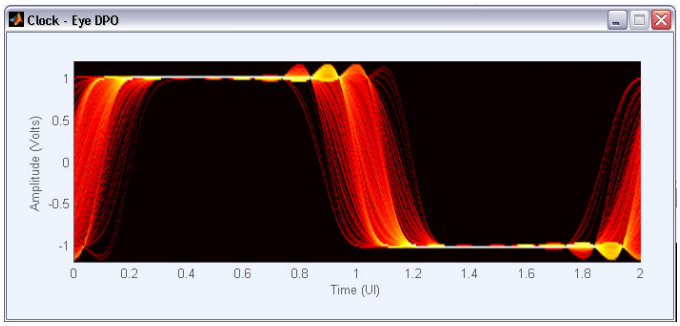
- **Magnitude** to 0.05 in UI.
- **Frequency-Low** to 200 MHz.
- **Frequency-High** to 300 MHz.

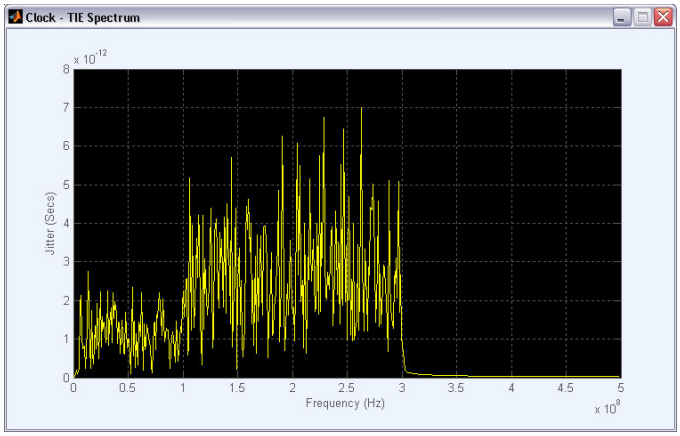


18. From the toolbar, click **Compile**.



19. The output waveforms are as shown.





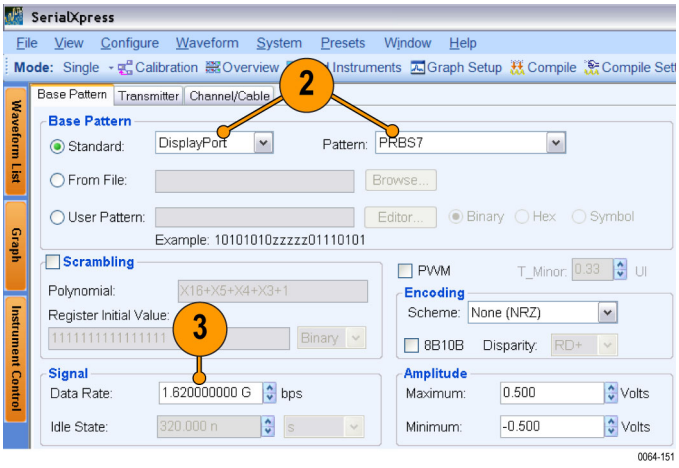
Creating a PRBS Waveform with Inter Symbol Interference and Pre-emphasis

The example shows how to create a signal with desired inter symbol interference (ISI) and nullify the effect of ISI using pre-emphasis.

1. Start SerialXpress.

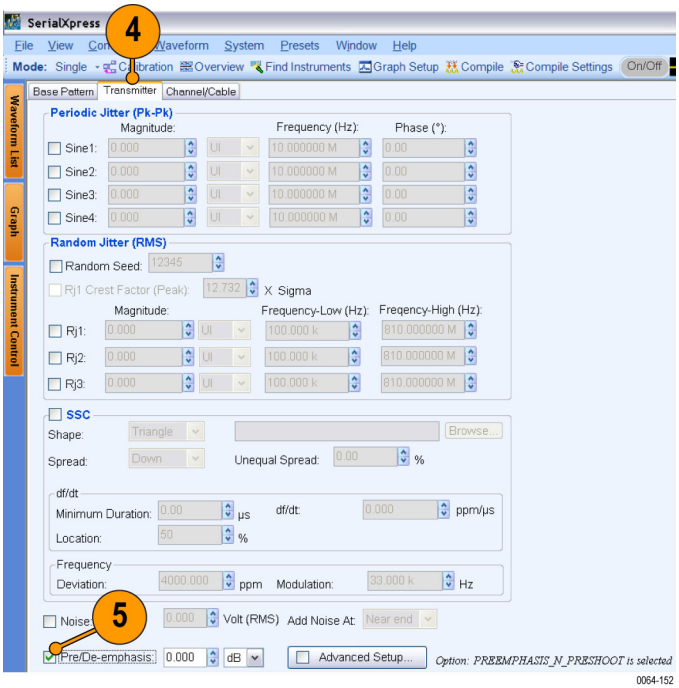
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:
   - **Standard** to DisplayPort.
   - **Pattern** to PRBS7.

3. In the Signal group, set the **Data Rate** to 1.62 G (corresponding to Reduced Bit Rate in the standards).

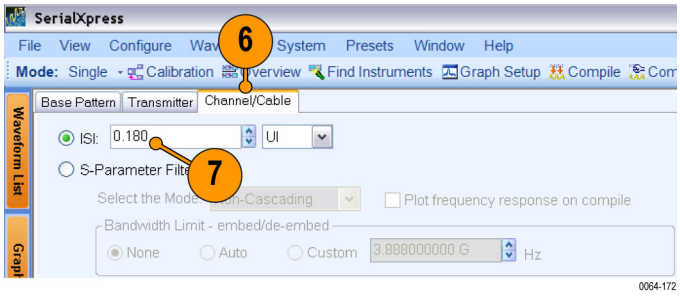


4. Click the **Transmitter** tab.

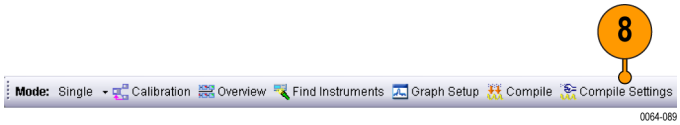
5. Select **Pre/De-emphasis** and set it to 0. This is the same as using the default value.



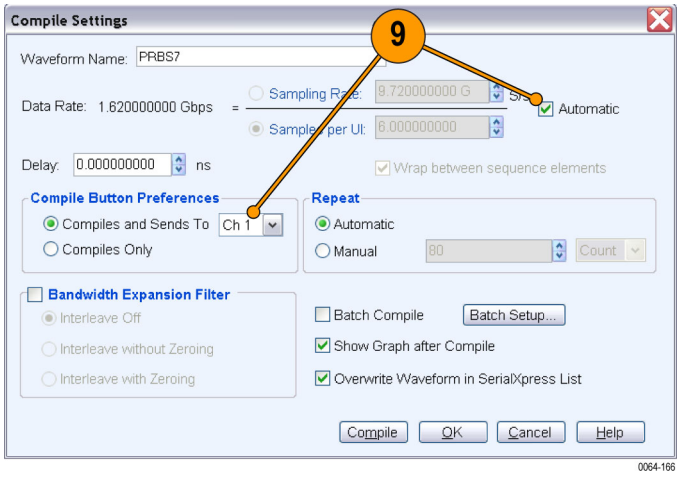
6. Click the **Channel/Cable** tab.
7. Select **ISI** and set it to 0.180.



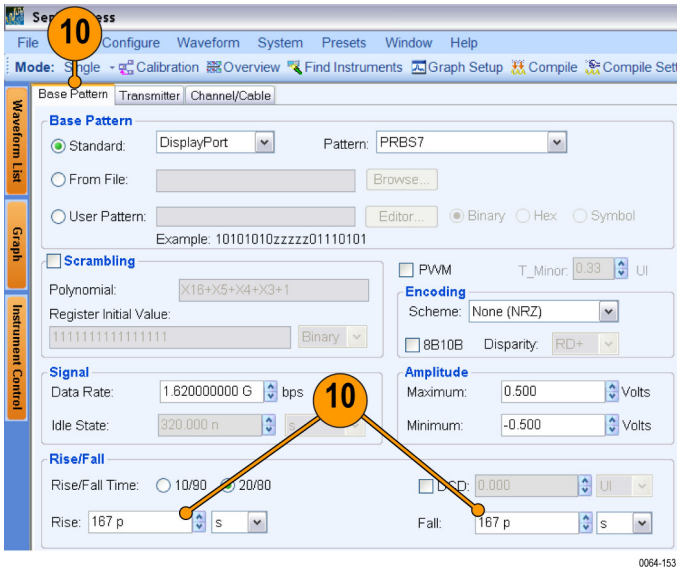
8. From the toolbar, click **Compile Settings**.



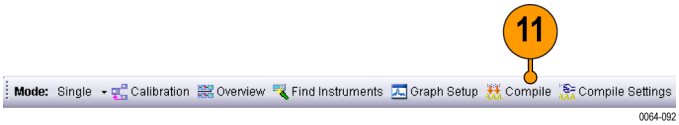
9. Do the following:
   - Ensure that **Automatic** is selected.
   - Select **Compiles and Sends To** and set the channel to Ch 1.



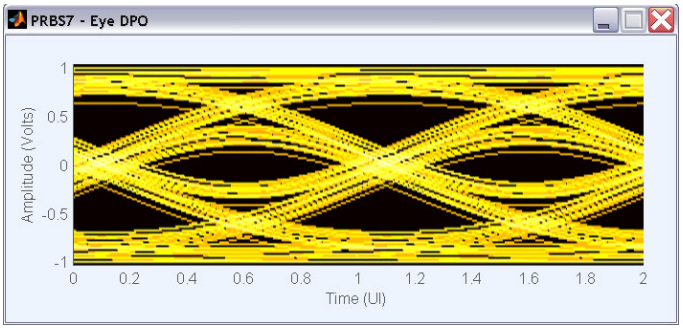
10. Go to the **Base Pattern** tab and set the **Rise** and **Fall** time to 167 ps.



11. From the toolbar, click **Compile**.

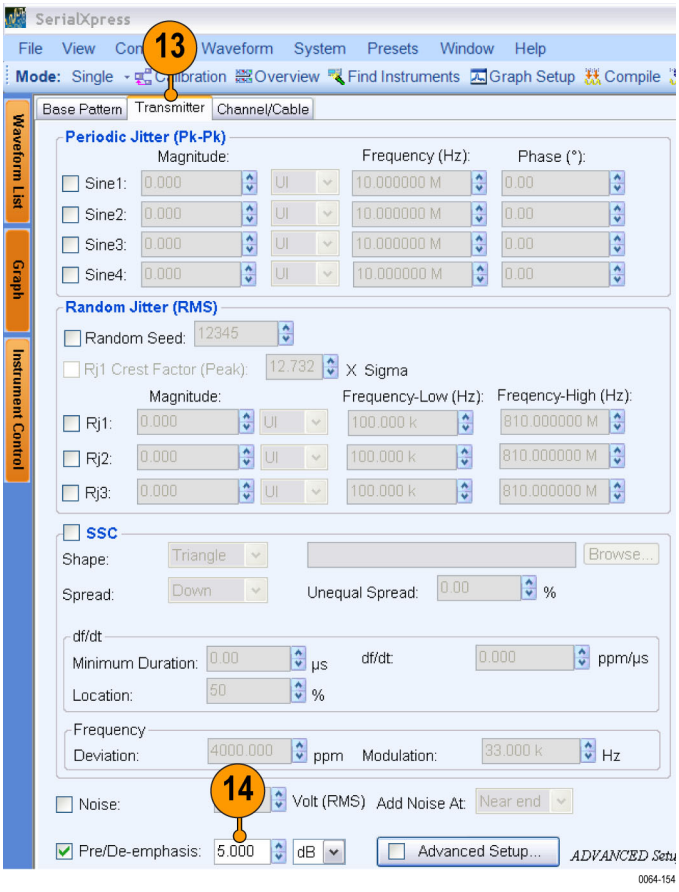


12. Observe the generated eye. The eye is distorted due to inter-symbol interference.

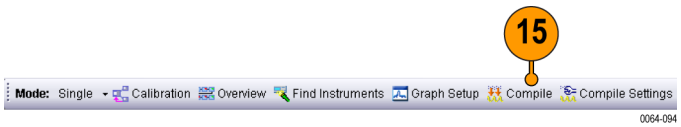


13. Click the **Transmitter** tab.

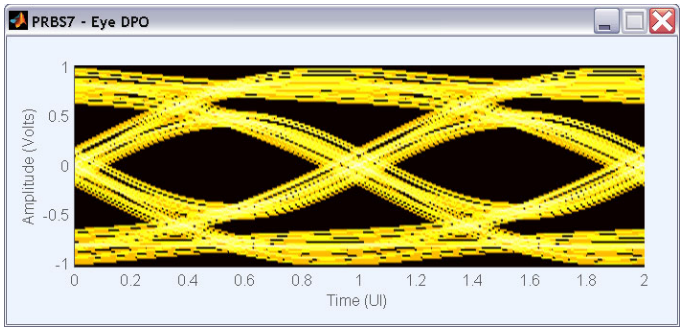
14. Select **Pre/De-emphasis** and set it to 5 dB.



15. From the toolbar, click **Compile**.



16. Observe the generated eye and compare it with the earlier eye. The eye is restored with pre-emphasis.



Application Examples

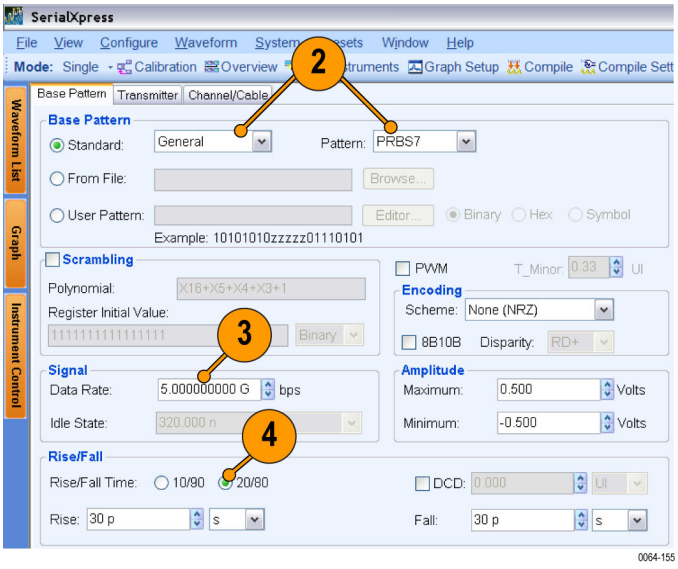
Enabling Predistortion Through Digital Filters for Bandwidth Enhancement

This example shows how the frequency response of the system can be enhanced by applying bandwidth enhancement digital filters. Using these filters, the frequency response can be whitened (flattened). You can apply these filters when a sharp rise time or fall time is required. The example shows how to use a bandwidth enhancement filter.

You will need the following equipment:

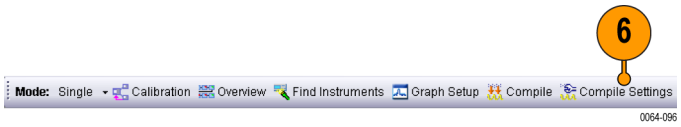
- A Tektronix DPO oscilloscope (for example, DPO71604) with a bandwidth greater than 16 GHz and capable of measuring rise and fall time of the order of 50 picoseconds.
- A Tektronix Arbitrary Waveform Generator AWG7102 with Option 06 with SerialXpress installed and running on it.
- An external hardware filter (from RLC Electronics, Inc., part number: F-30-10.0.R) with the following specifications:
  - Passband: DC-10000 MHz
  - 3 dB point (Typical): 10500 MHz
  - 30 dB point (Typical): 12000 MHz
  - 60 dB (Stop Band): 13500–40000 MHz
  - Insertion loss: 0.35 dB

1. Start SerialXpress.
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:
   - **Standard** to General.
   - **Pattern** to PRBS7.
3. In the Signal group, set the **Data Rate** to 5 G.
4. In the Rise/Fall group, ensure that **Rise/Fall Time** is set to 20/80.

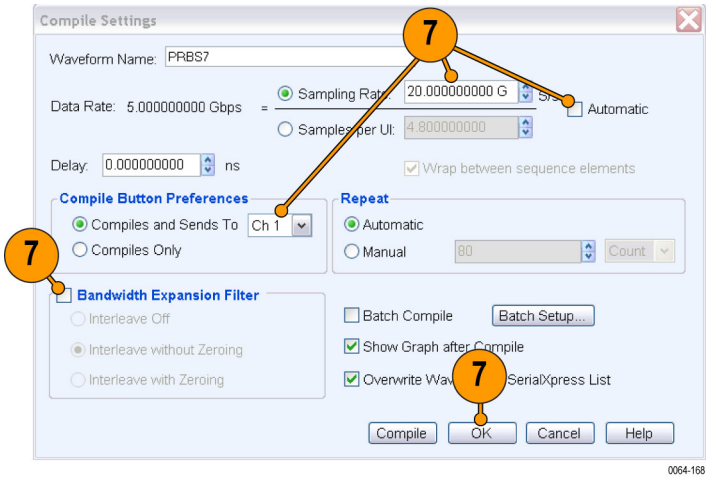


5. Leave the parameters in the **Transmitter** and **Channel/Cable** tabs in their default state.

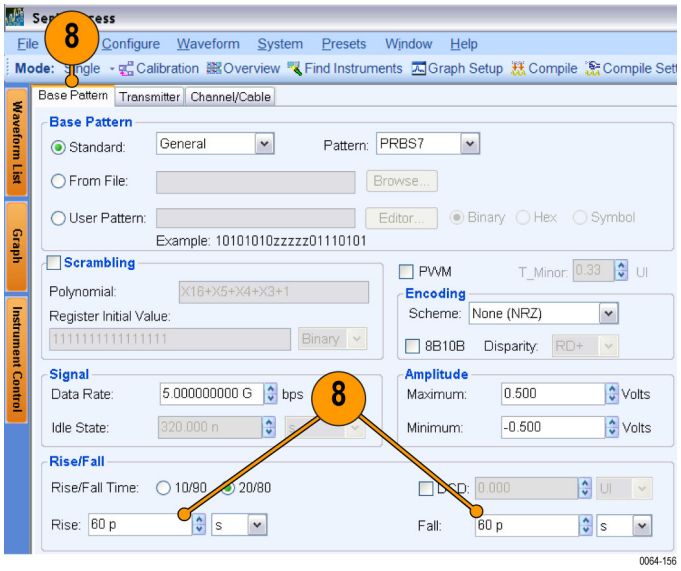
6. From the toolbar, click **Compile Settings**.



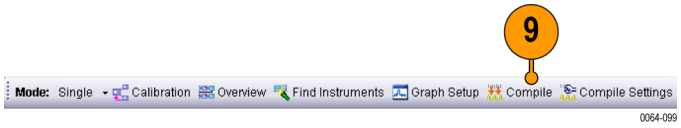
7. In the Compile Settings dialog box:
   - Select **Automatic** to clear it.
   - Set the **Sampling Rate** to 20 G.
   - Ensure that **Bandwidth Expansion Filter** is disabled.
   - Select **Compiles and Sends To** and set the channel to Ch 1.
   - Click **OK**.



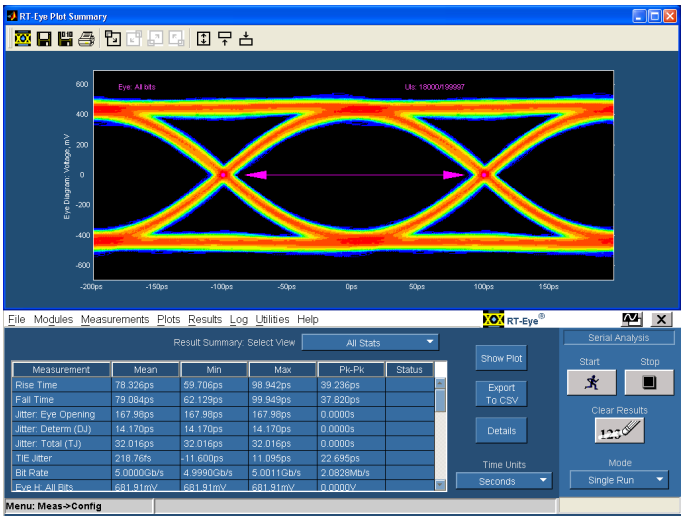
8. Go to the **Base Pattern** tab and set the **Rise** and **Fall** time to 60 ps.



9. From the toolbar, click **Compile**.



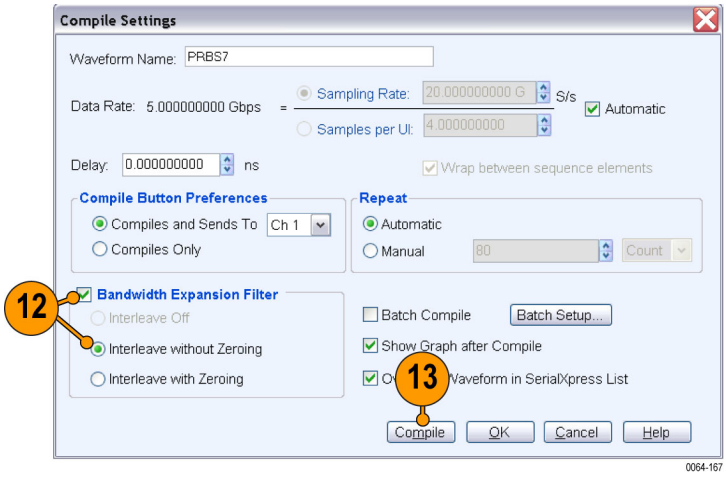
10. Measure the Rise/Fall time on an oscilloscope.



11. Connect the external hardware filter to the output channel of the AWG.

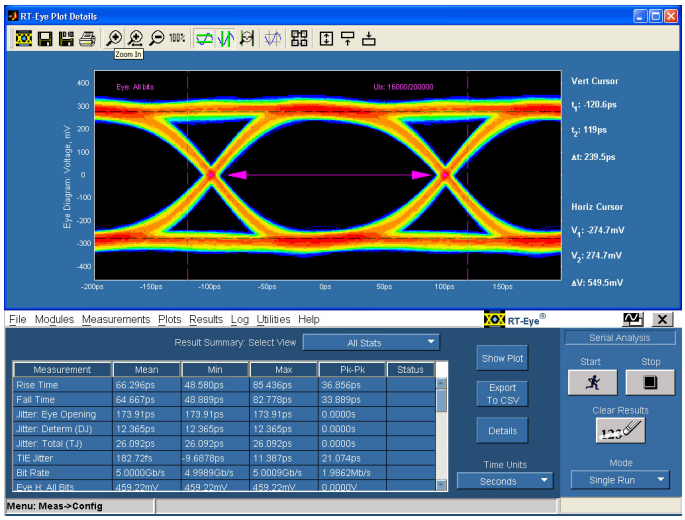
12. In the Compile Settings dialog box, select **Bandwidth Expansion Filter** and select **Interleave without Zeroing**.

13. Click **Compile**.



14. Again measure the rise and fall time on the oscilloscope.

Observe the improvement in the measurement accuracies when bandwidth expansion filter is used.



Characterizing the Receiver Using Spread Spectrum Clocking

The example shows how to characterize your receiver using spread spectrum clocking (SSC) modulation with and without setting the df/dt parameters.

When df/dt is set to 0, the period and frequency time trend waveform will be exactly the same as the shape selected (Sine or Triangle) in the SSC group.

When df/dt parameters are set, there will be a deviation in the period and frequency time trend waveforms at the specified location, df/dt, and duration.

1. Start SerialXpress.

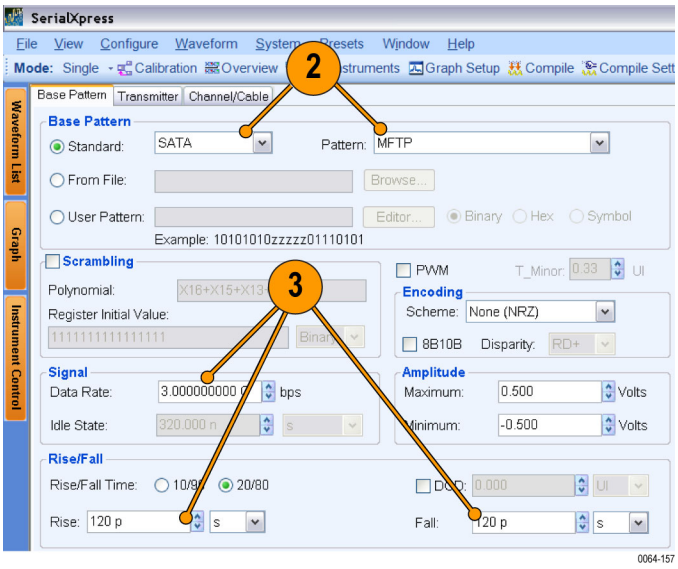
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:

   - **Standard** to SATA.
   - **Pattern** to MFTP (default).

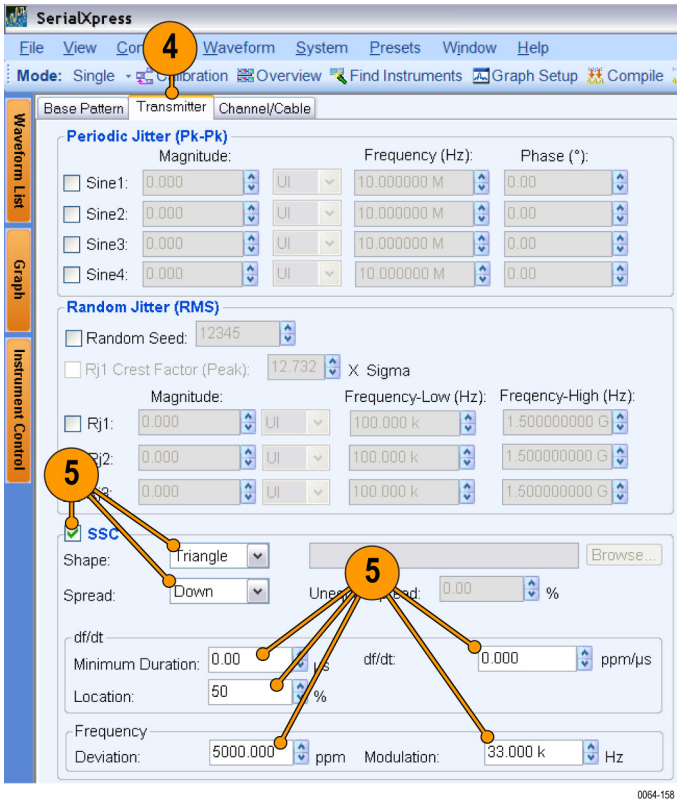
3. In the Signal group, the **Data Rate** is automatically set to 3 G.

   Leave the rest of the parameters at their default values.

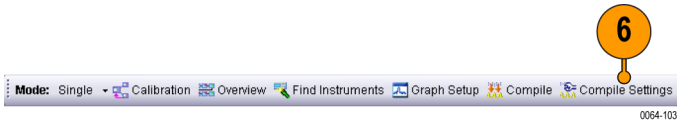
   In the Rise/Fall group, set the **Rise** and **Fall** time to 120 ps.



4. Click the **Transmitter** tab.
5. Enable **SSC** and set the following:
   - **Shape** to Triangle.
   - **Spread** to Down.
   - **Minimum Duration** to 0.
   - **df/dt** to 0.
   - **Location** to 50% (default setting).
   - **Deviation** to 5000 ppm.
   - **Modulation** to 33 K.

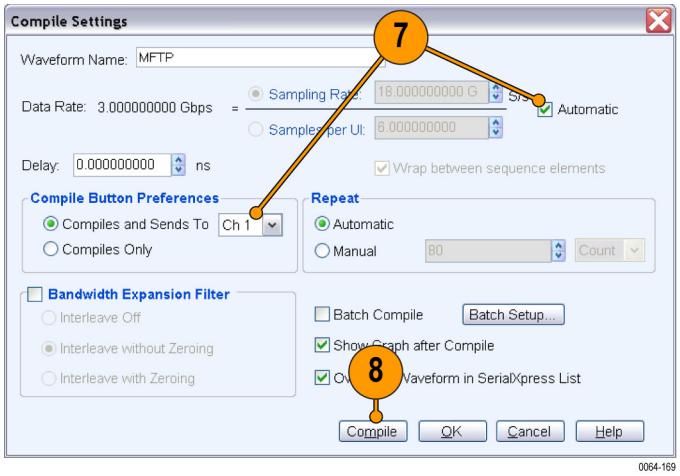


6. From the toolbar, click **Compile Settings**.

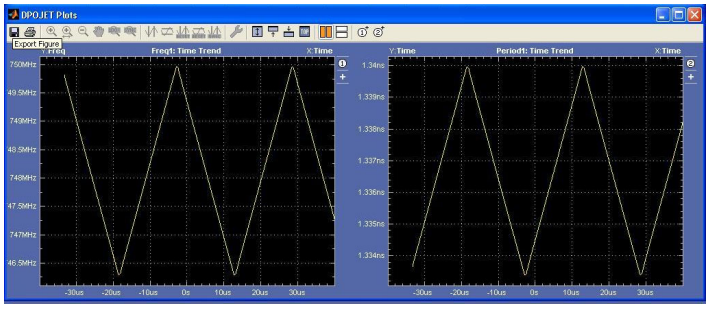


7. Do the following:
   - Ensure that **Automatic** is selected.
   - Select **Compiles and Sends To** and set the channel to Ch 1.
8. Click **Compile**.

   The compiled waveform is sent to Ch 1 of the Tektronix AWG.



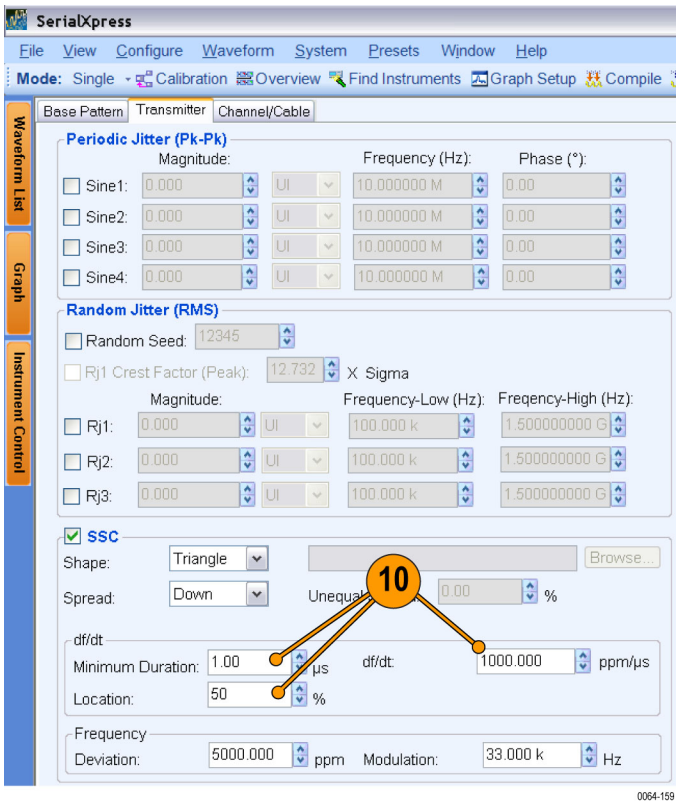
9. You can transfer the generated SSC pattern to an oscilloscope and use Tektronix DPOJET Eye Diagram and Analysis Tools application to analyze the period and frequency trend waveform.



10. Go to step 5.

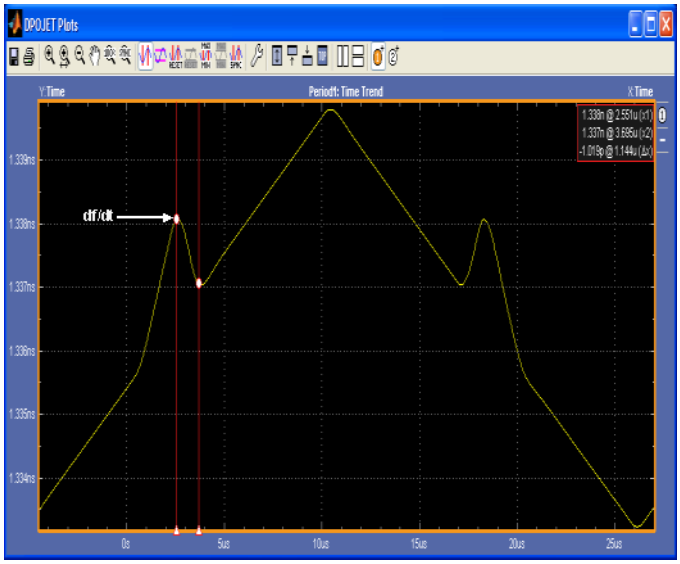
Keep the settings of the SSC but change the df/dt group values as follows:

- **Minimum Duration** to 1 µs.
- **df/dt** to 1000 ppm.
- **Location** to 50%.



11. Perform step 6 to step 8.

12. You can transfer the generated SSC pattern to an oscilloscope and use Tektronix DPOJET Eye Diagram and Analysis Tools application to analyze the period and time trend waveform.



Characterizing the Receiver Using Spread Spectrum Clocking with Custom Profile

The example shows how to characterize your receiver using spread spectrum clocking (SSC) modulation with custom profile.

1. Start SerialXpress.

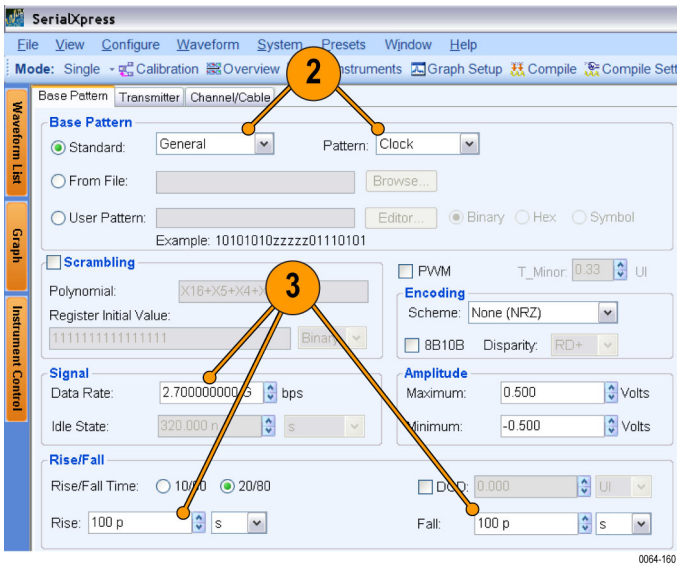
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:

   - **Standard** to General.
   - **Pattern** to Clock (default).

3. In the Signal group, set the **Data Rate** to 2.7 G.

   Leave the rest of the parameters at their default values.

   - In the Rise/Fall group, set the **Rise** and **Fall** time to 100 ps (default).

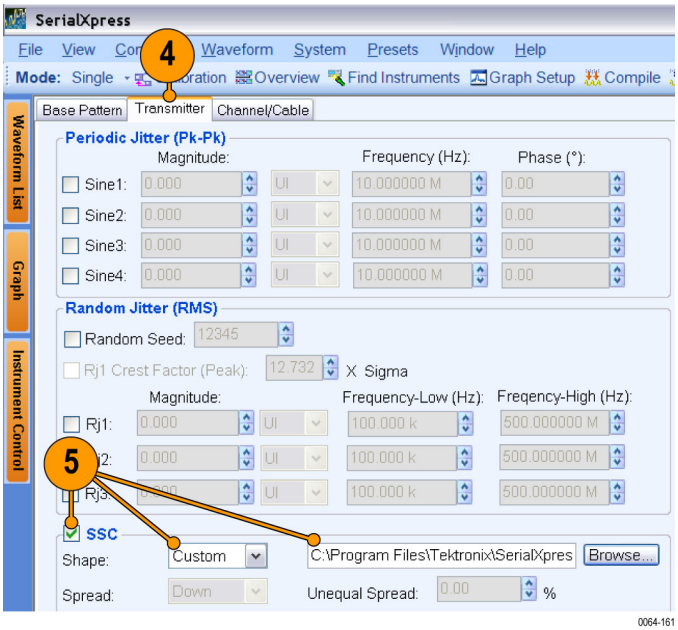


.

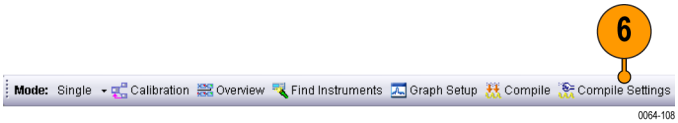
4. Click the **Transmitter** tab.

5. Enable **SSC**, set the **Shape** to Custom and browse to select the custom file (**CustomFile.csv**).

NOTE. *When you select* ***Custom****, all the other options in the* ***Transmitter*** *tab are disabled.*

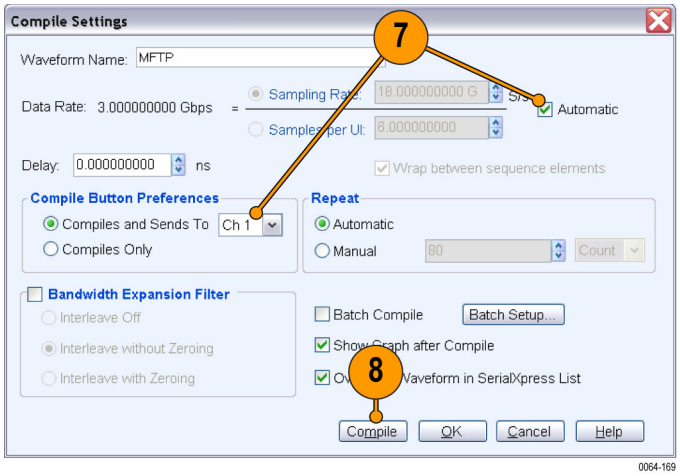


6. From the toolbar, click **Compile Settings**.



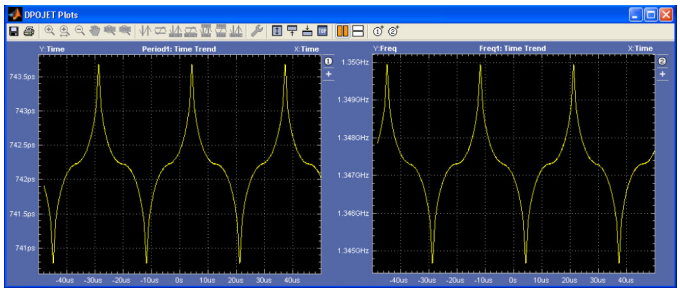
7. Do the following:
   - Ensure that **Automatic** is selected.
   - Select **Compiles and Sends To** and set the channel to Ch 1.
8. Click **Compile**.

   The compiled waveform is sent to Ch 1 of the Tektronix AWG.



.

9. You can transfer the generated SSC pattern to an oscilloscope and use Tektronix DPOJET Eye Diagram and Analysis Tools application to analyze the period and frequency time trend waveform.

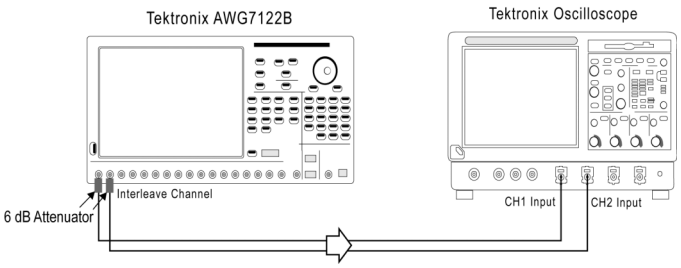


Creating a USB Compliant Signal with Cascading Channel and Cross-talk Emulation

The example shows how to create a signal with cascading channel and cross-talk emulation (that is compliant with the USB standards).

1. Set up the instruments as shown. The instruments must be connected over a LAN. You will need:

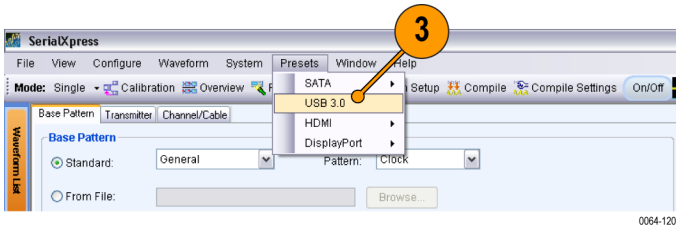
   - A Tektronix AWG7122B with Option 08 running SerialXpress software
   - A Tektronix oscilloscope with DPOJET installed to capture the signal
   - Two 6 dB attenuators
   - Connecting cable



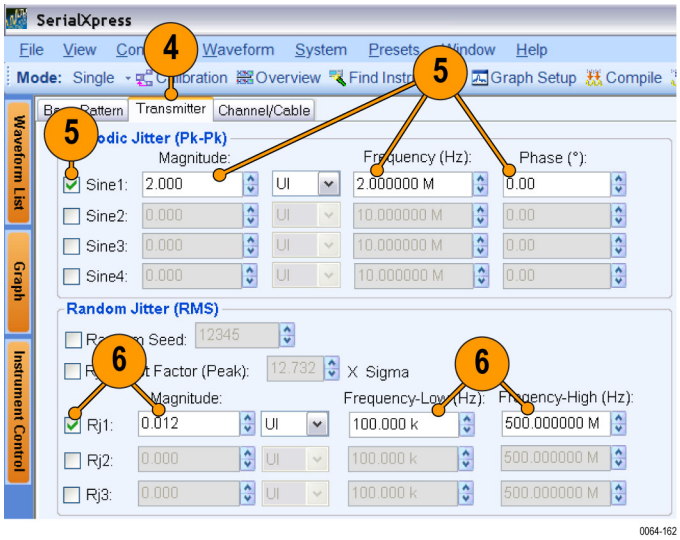
NOTE. Ensure that the output of the AWG Interleave channel is connected to Channel 1 of the oscilloscope.

2. Start SerialXpress.

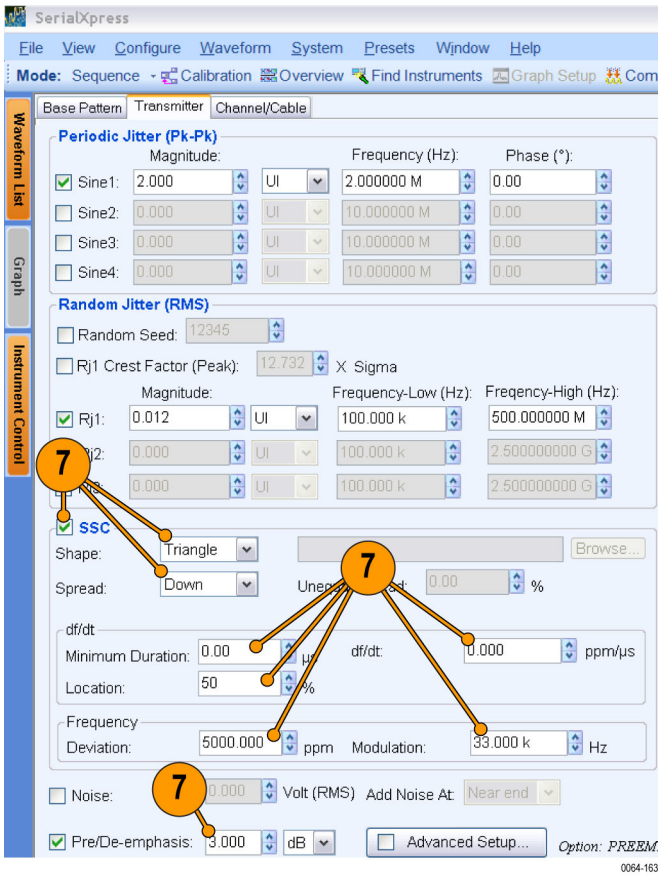
3. From the toolbar, click **Presets > USB 3.0**.



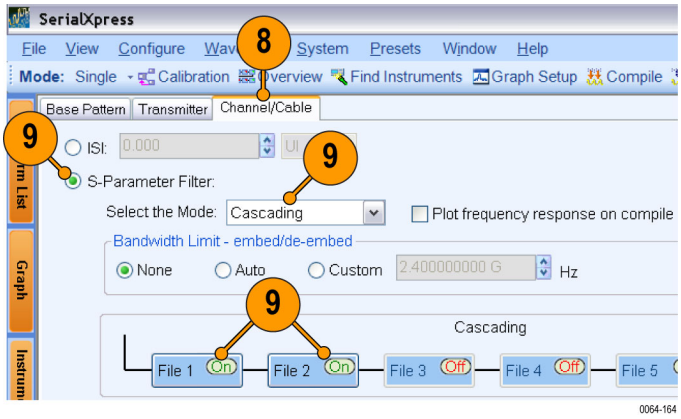
4. Click the **Transmitter** tab.
5. In the Periodic Jitter group, select **Sine1** and do the following:
   - Set the **Magnitude** to 2 UI.
   - Set the **Frequency** to 2 MHz.
   - Set the **Phase** to 0°.
6. In the Random Jitter group, select Rj1 and do the following:
   - Set the **Magnitude** to 0.012 UI.
   - Keep the default values for **Frequency-Low** and **Frequency-High**.



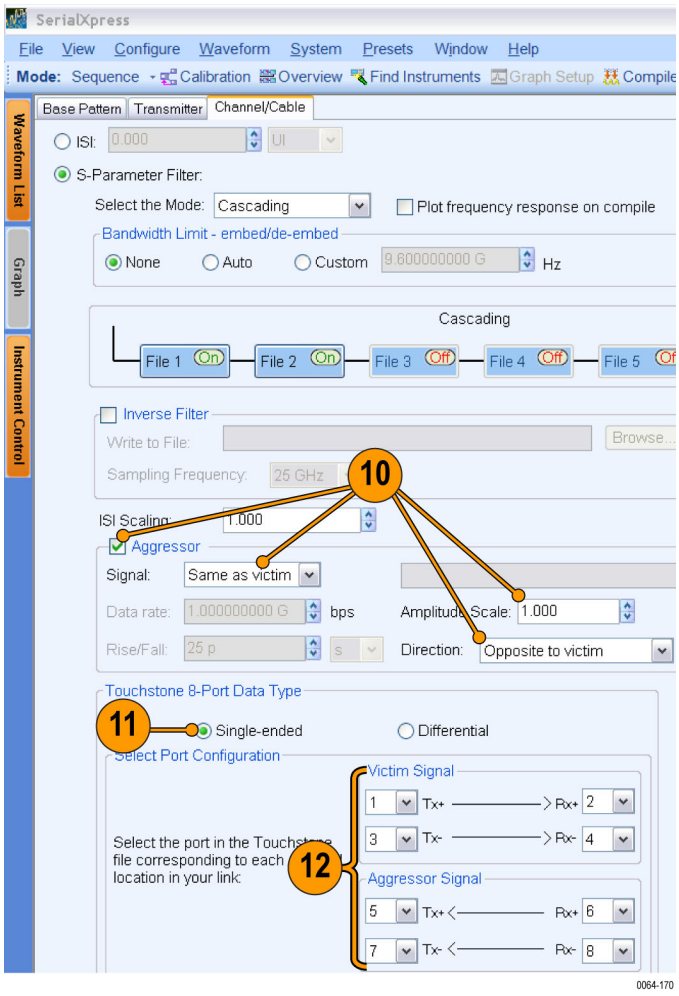
7. Enable **SSC** and do the following:
   - Set the **Shape** to Triangle.
   - Set the **Spread** to Down.
   - Keep the default values for **Minimum Duration**, **df/dt**, and **Location**.
   - Set the **Deviation** to 5000 ppm.
   - Set the **Modulation** to 33 K.
   - Select **Pre/De-emphasis** and set it to 3 dB.



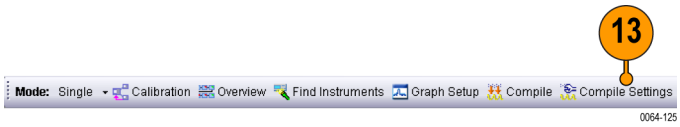
8. Click the **Channel/Cable** tab.
9. Select **S-Parameter Filter** and do the following:
   - Set the mode to **Cascading**.
   - Turn on file 1 and select `usb3_spec_compliance_r095_20081106_cable.s8p`
   - Turn on file 2 and select `usb3_spec_compliance_r095_20081106_device.s8p`



10. Select Aggressor and set the following:
    - **Signal** to Same as victim.
    - **Amplitude Scale** to 1.
    - **Direction** to Opposite to victim.
11. Select the **Single-ended** data type.
12. Keep the default settings of the port configuration.

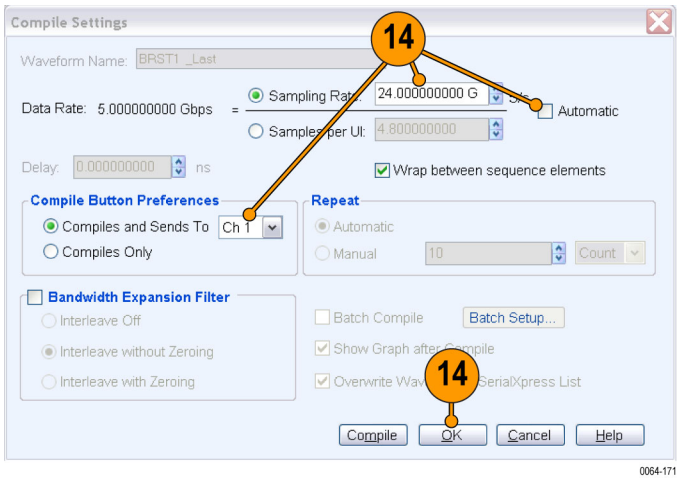


13. From the toolbar, click **Compile Settings**.

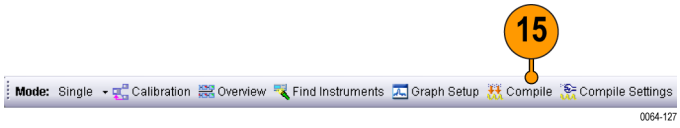


14. In the Compile Settings dialog box, do the following:

- Select **Automatic** to clear it.
- Set the **Sampling Rate** to 24 G.
- Select **Compiles and Sends To** and set the channel to Ch 1.
- Click **OK**.



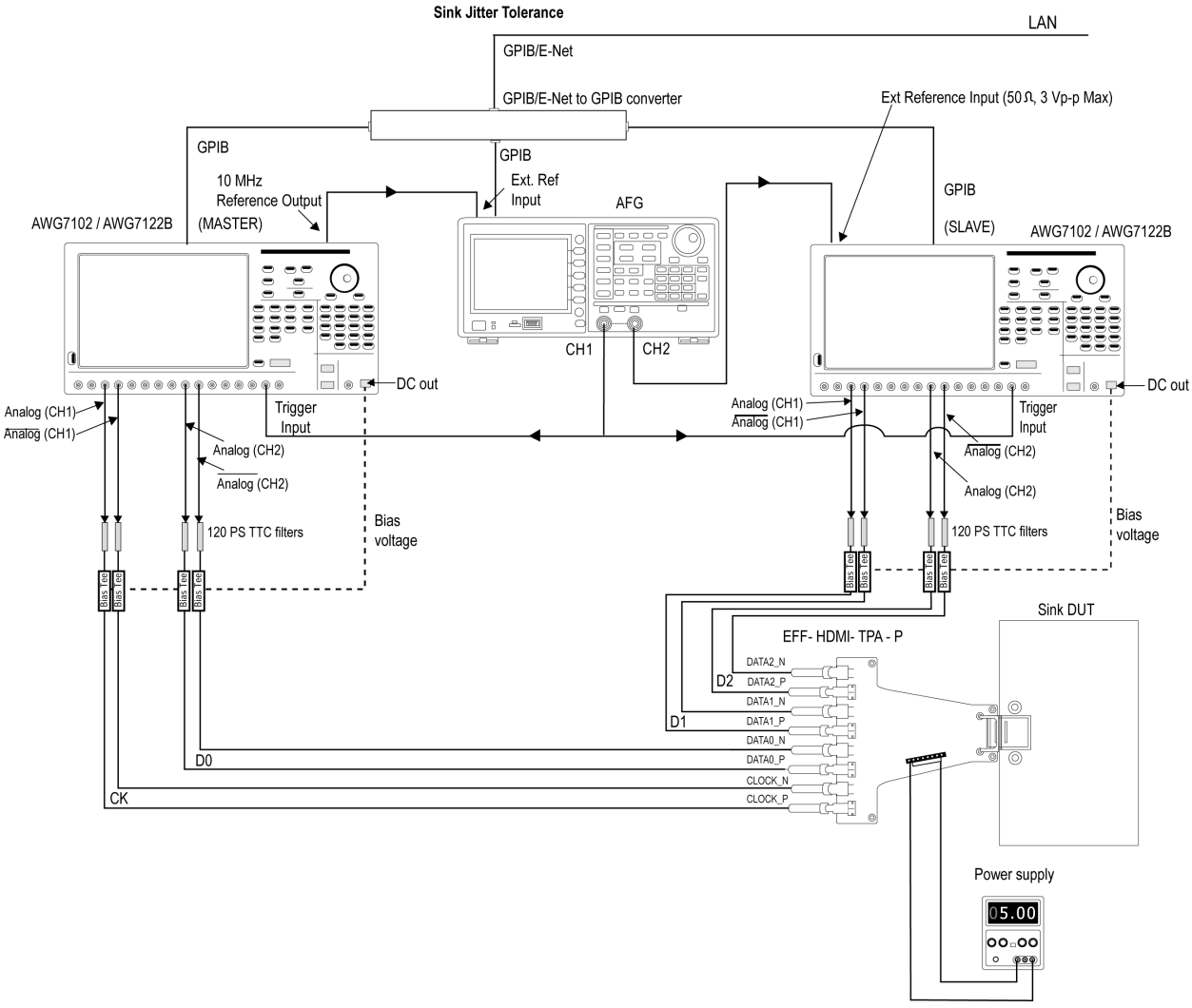
15. Click **Compile** to generate the waveform.



Creating an HDMI No-Jitter Compliant Signal

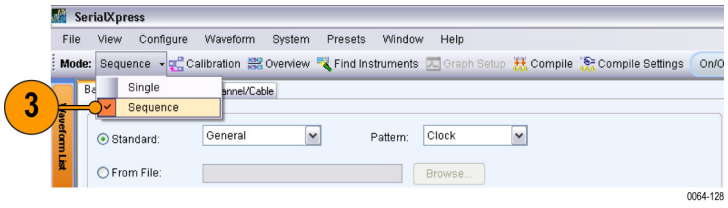
The example shows how to create an HDMI 27 MHz, 60 Hz, no-jitter compliant signal.

1. Set up the instruments as shown.

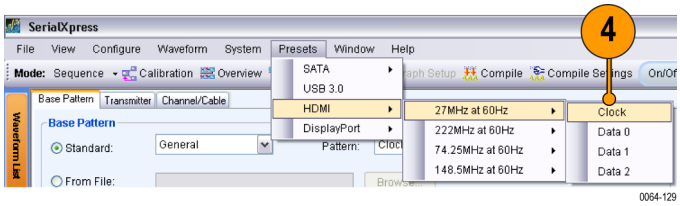


2. Start SerialXpress on AWG1 (Master).

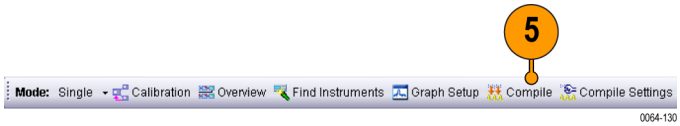
3. From the toolbar, click **Mode > Sequence**.



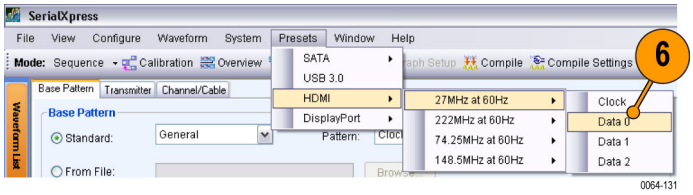
4. From the toolbar, click **Presets > HDMI > 27 MHz > Clock**.



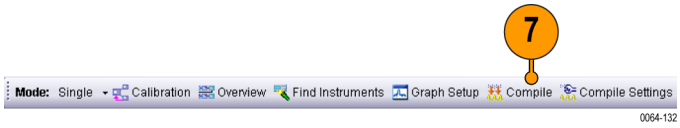
5. Click **Compile**.



6. From the toolbar, click **Presets > HDMI > 27 MHz > Data 0**.



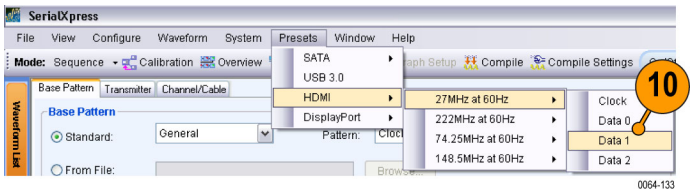
7. Click **Compile**.



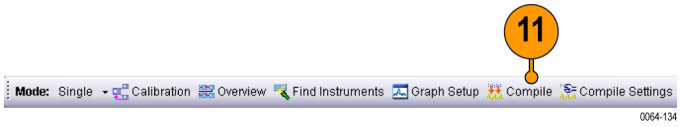
8. On AWG1, switch the Run state to **ON** and both channel outputs to **ON**.
   The AWG1 will be in the wait mode.

9. Start SerialXpress on AWG2 (Slave).

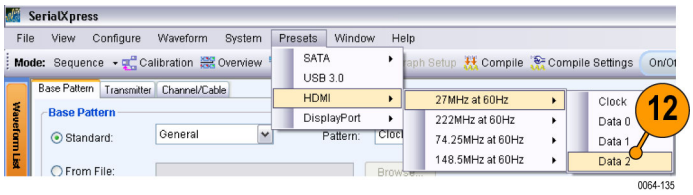
10. From the toolbar, click **Presets > HDMI > 27 MHz > Data 1**.



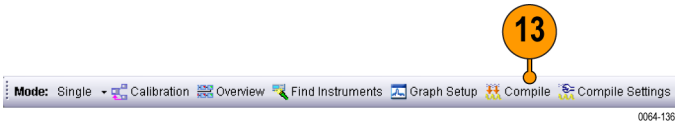
11. Click **Compile**.



12. From the toolbar, click **Presets > HDMI > 27 MHz > Data 2**.



13. Click **Compile**.



14. On AWG2, switch the Run state to ON and both channel outputs to **ON**.
    The AWG2 will be in the wait mode.

15. On the AFG, toggle the state of CH1.

16. Connect TPA-P to DUT as shown in the setup diagram (step 1).

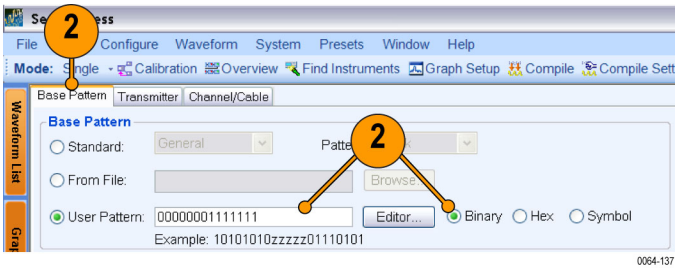
17. Confirm the gray bars.

Creating a Pre-emphasis Signal

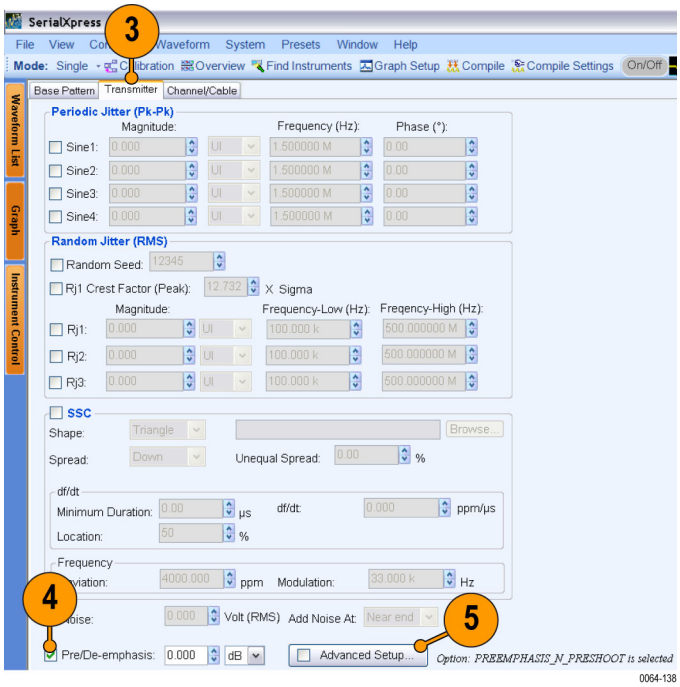
1. Start SerialXpress.

2. In the **Base Pattern** tab, do the following:

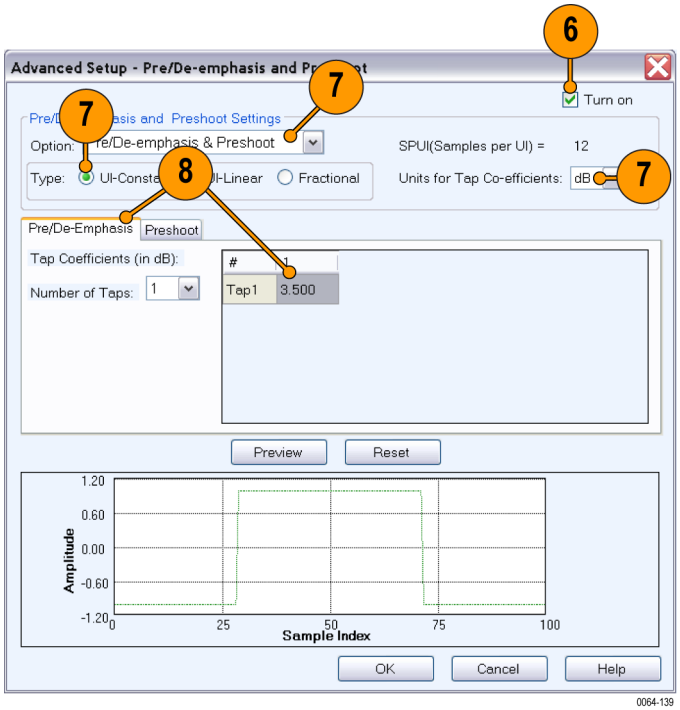
   - Select **User Pattern** and set the pattern to 00000001111111.
   - Ensure that **Binary** is selected.



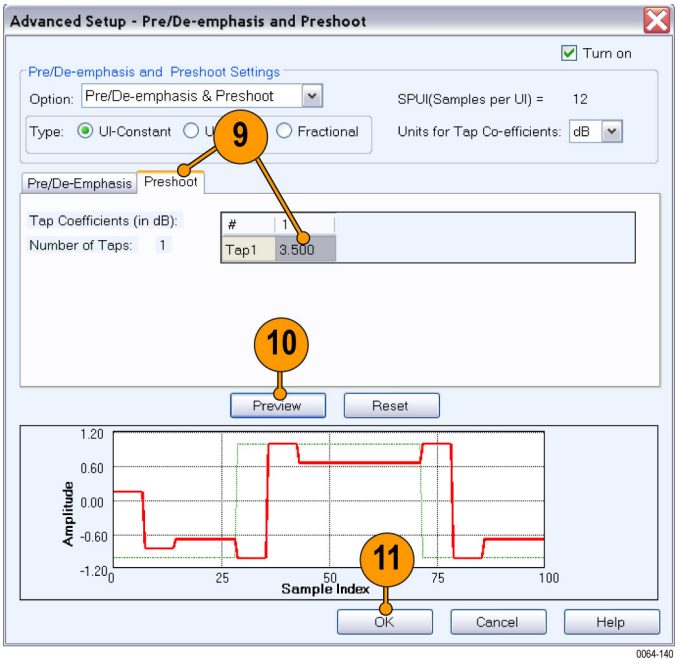
3. Click the **Transmitter** tab.
4. Select **Pre/De-emphasis**.
5. Click **Advanced Setup**.



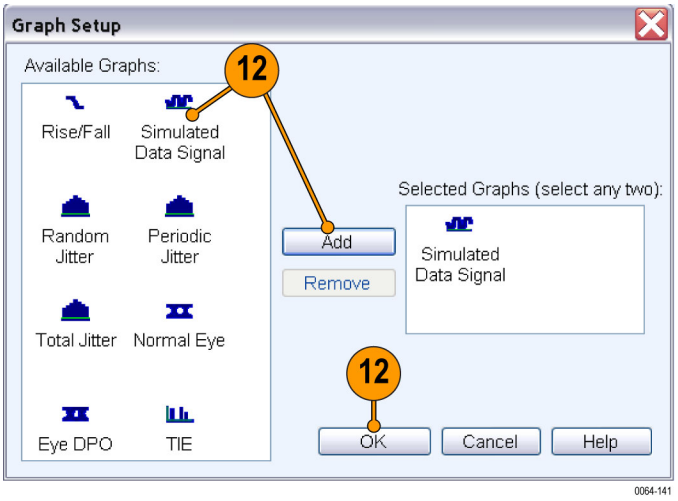
6. Select **Turn on**.
7. In the Pre-De/emphasis and Preshoot Settings group, set the following:
   - **Option** to Pre/De-emphasis and Preshoot.
   - **Type** to UI-Constant.
   - **Units for Tap Co-efficients** to dB.
8. Click **Pre/De-Emphasis** and set the Tap1 coefficient to 3.500.



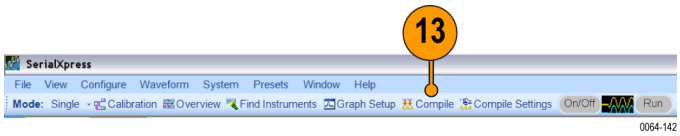
9. Click **Preshoot** and set the Tap1 coefficient to 3.500.
10. Click **Preview** to view the plots.
11. Click **OK**.



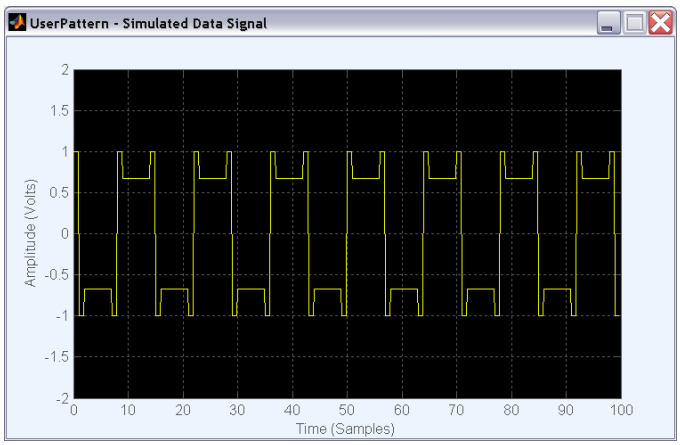
12. Click **Graph Setup** and select Simulated Data Signal.



13. From the toolbar, click **Compile**.

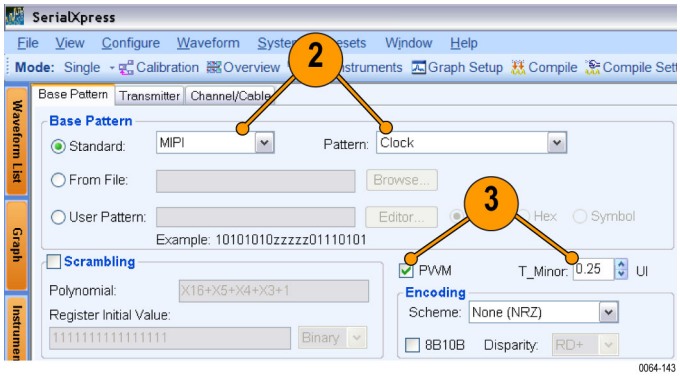


14. The outputs are as shown.

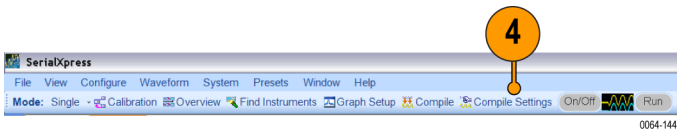


Creating a PWM Signal

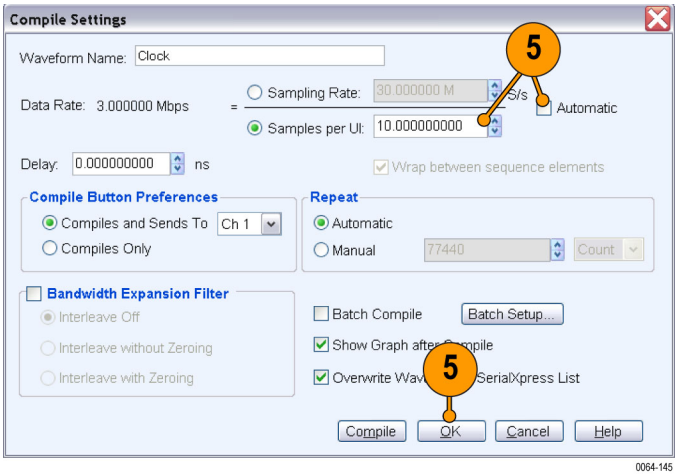
1. Start SerialXpress.
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:
   - **Standard** to MIPI.
   - **Pattern** to Clock.
3. Select **PWM** and set the **T_Minor** to 0.25 UI.



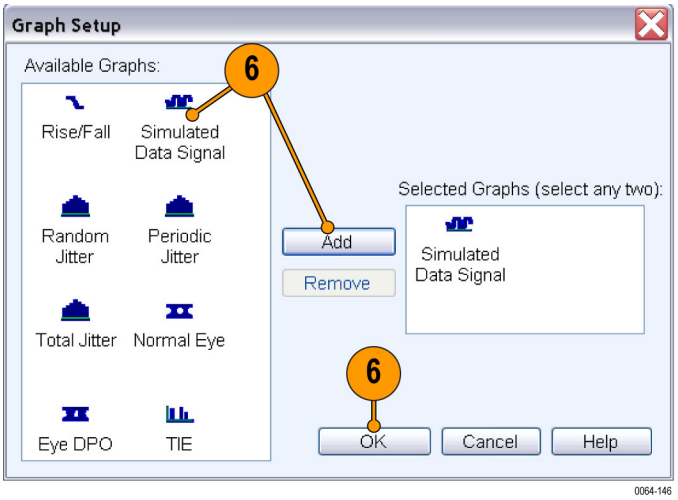
4. From the toolbar, click **Compile Settings**.



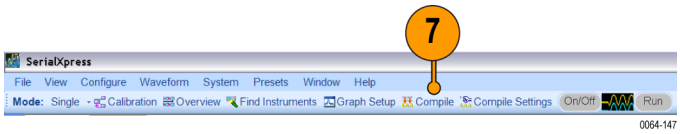
5. Do the following:
   - Click **Automatic** to clear it.
   - Set **Samples per UI** to 10.
   - Click **OK**.



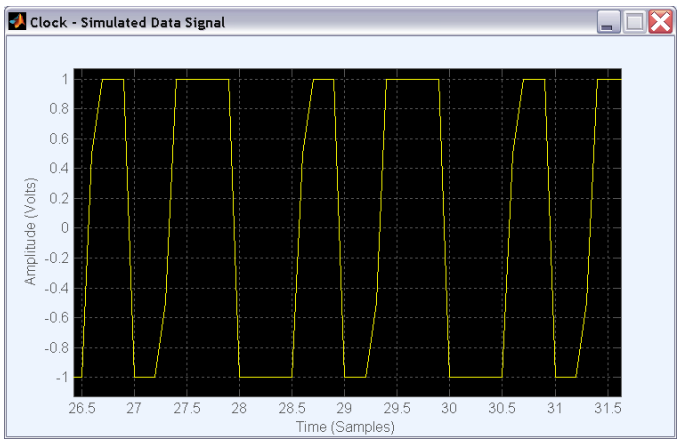
6. Click **Graph Setup** and select Simulated Data Signal.
   Click **OK**.



7. From the toolbar, click **Compile**.



8. The outputs are as shown.



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