SerialXpress® SDX100
Advanced Jitter Generation Tool for Tektronix AWG5000/B & AWG7000/B Series Waveform Generators

Quick Start User Manual

077-0064-02

Tektronix

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www.tektronix.com
077-0064-02

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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]

Table of Contents

General Safety Summary

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

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

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Connect and Disconnect Properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

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

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

Power Disconnect. The power cord disconnects the product from the power source. Do not block the power cord; it must remain accessible to the user at all times.

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

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

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

Terms in this Manual

These terms may appear in this manual:

WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*

CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Environmental Considerations

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

Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

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

This symbol indicates that this product complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). 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, df/dt, and noise.
- 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, HDMI, and Fiber Channel. 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 and random jitter, 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.

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

Before you install the SerialXpress ensure that:

- MATLAB Runtime version 7.6 is installed on your instrument.
- VXI-11 server is installed and running on the Tektronix arbitrary waveform generator.
- .NET v2.0 is installed on your instrument.
- TekVISA is installed and running. 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.

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

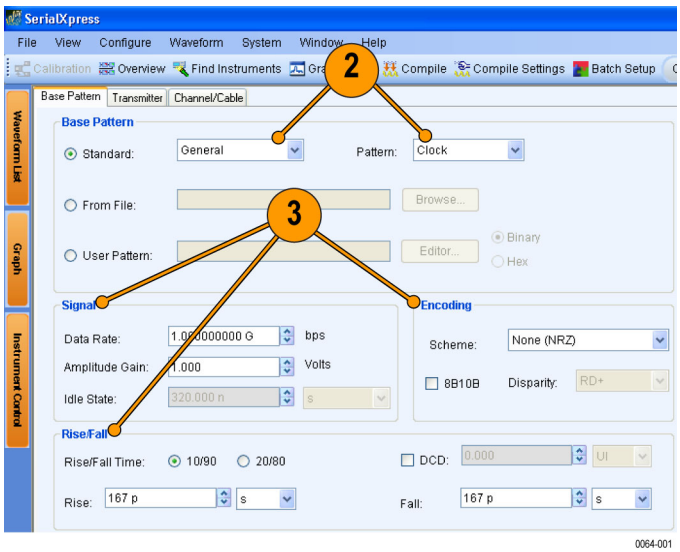
Use the keyboard or mouse to make selections in the software.

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.

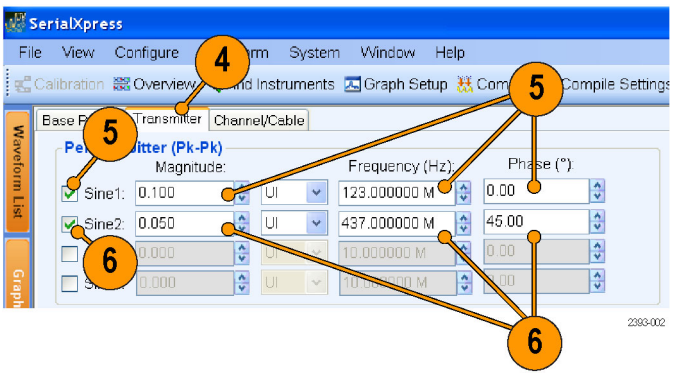
Creating Serial Data Streams with Periodic and Random Jitter

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 Rise/Fall parameters at their default values.

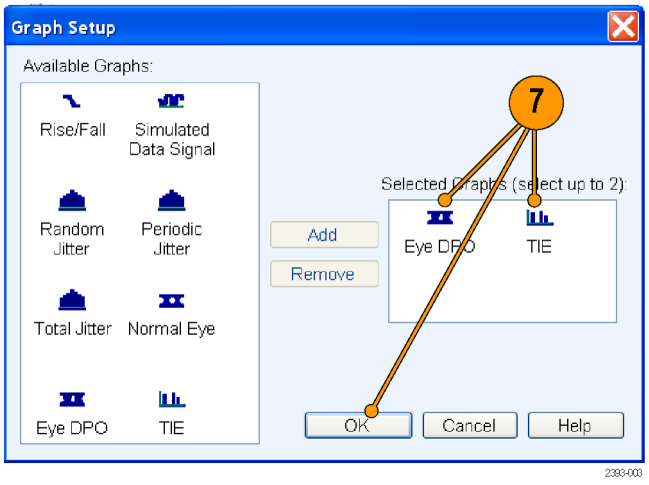


4. Click the Transmitter tab.
5. In the Periodic Jitter group, click Sine1 and set the following values:
   - **Magnitude** to 0.1 UI.
   - **Frequency** to 123 MHz.
   - **Phase** to 0 °.
6. Click Sine2 and set the following values:
   - **Magnitude** to 0.05 UI.
   - **Frequency** to 437 MHz.
   -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

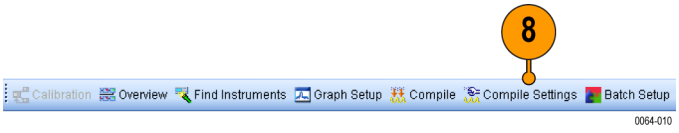


7. Click **Graph Setup** and select the following graphs:
   - Eye DPO
   - TIE

   Click **OK**.



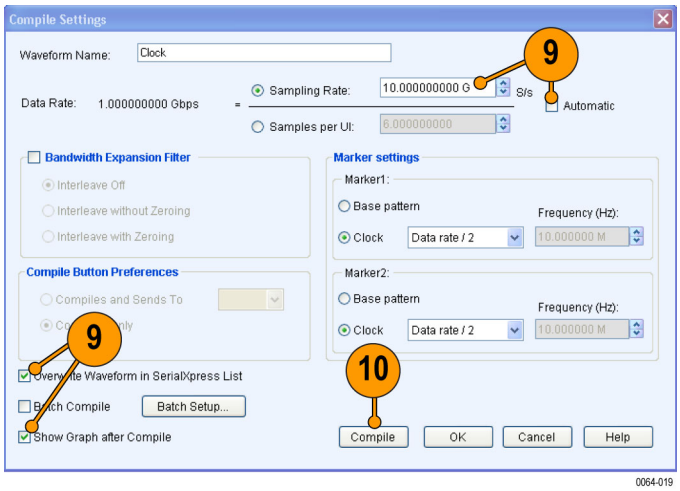
8. Click **Compile Settings**.



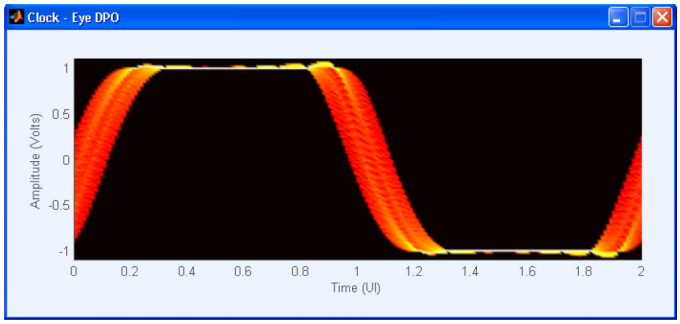
9. Do the following:

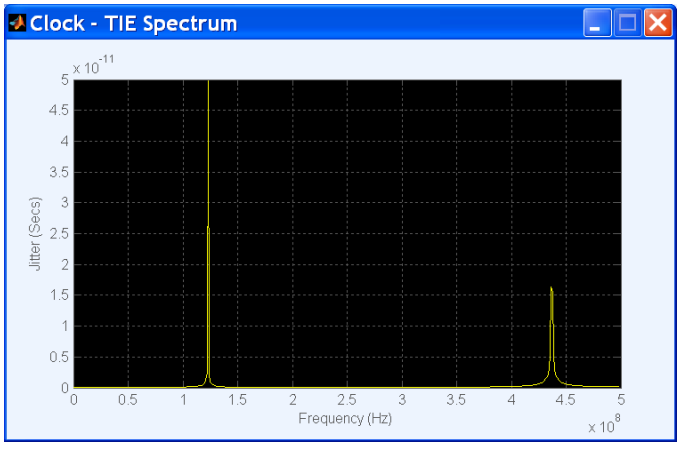
- Click **Automatic** to clear it.
- Set **Sampling Rate** to 10 G.
- Ensure that **Show Graph after Compile** is selected.
- Ensure that **Overwrite Waveform in SerialXpress List** is selected.

10. Click **Compile**.



11. The output waveforms are as shown.





12. Click the **Transmitter** tab.

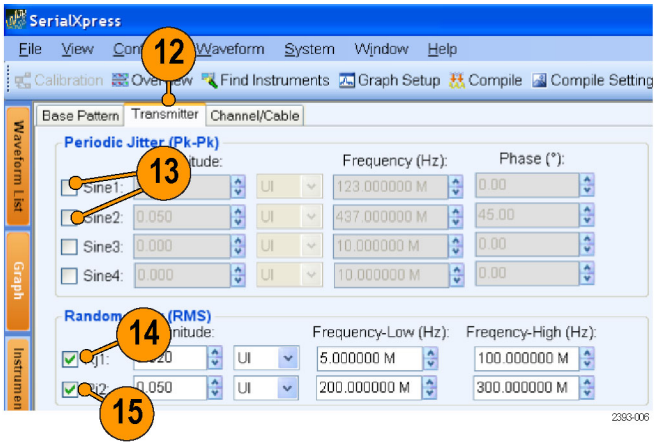
13. In the Periodic Jitter group, clear Sine1 and Sine2.

14. In the Random Jitter group, select Rj1 and set the following:

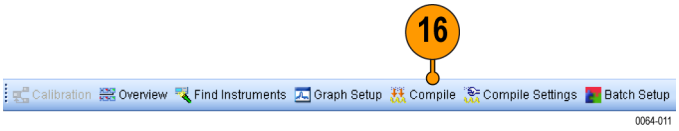
- **Magnitude** to 0.02 in UI.
- **Frequency-Low** to 5 MHz.
- **Frequency-High** to 100 MHz.

15. Select Rj2 and set the following:

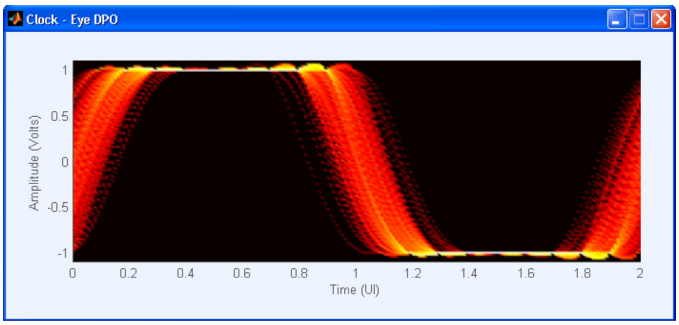
- **Magnitude** to 0.05 in UI.
- **Frequency-Low** to 200 MHz.
- **Frequency-High** to 300 MHz.

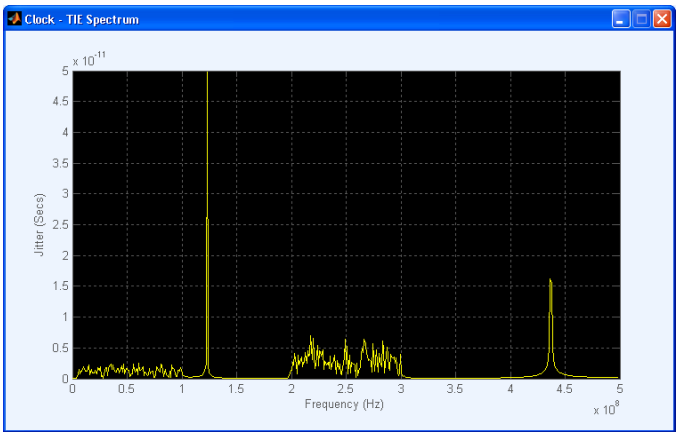


16. From the toolbar, click **Compile**.



17. The output waveforms are as shown.





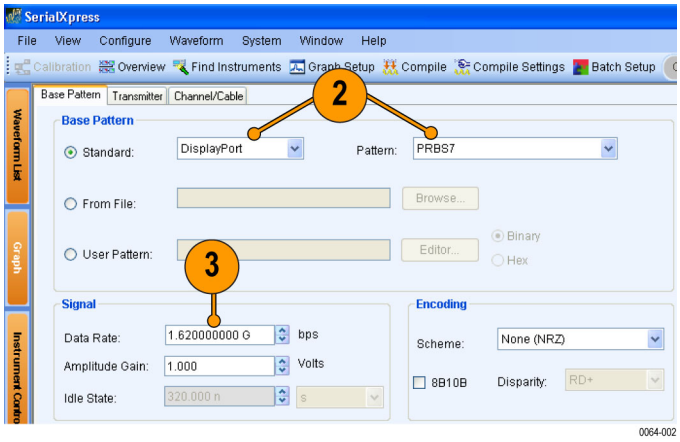
Creating a PRBS Waveform with Inter Symbol Interference and Pre-emphasis

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.

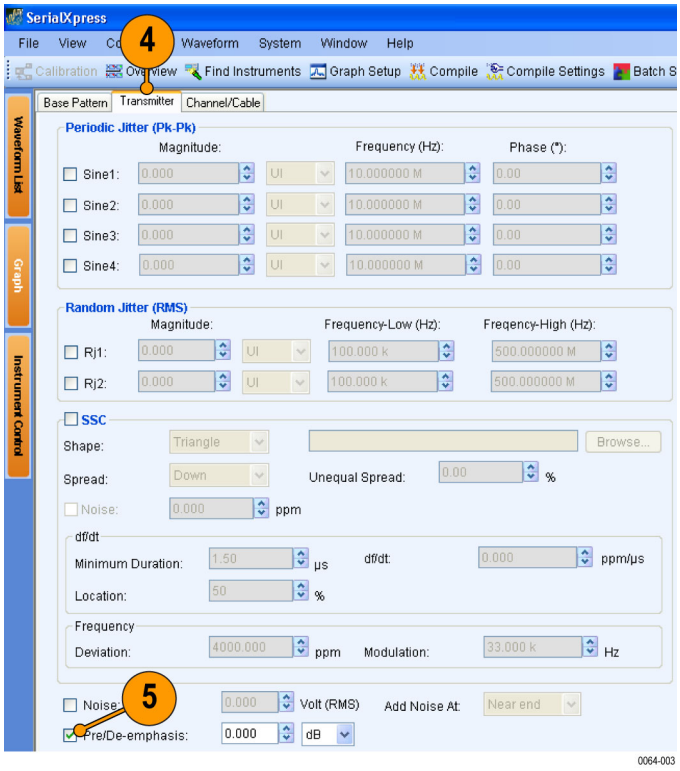
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:
   - **Standard** to DisplayPort.
   - **Pattern** to PRBS7.

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

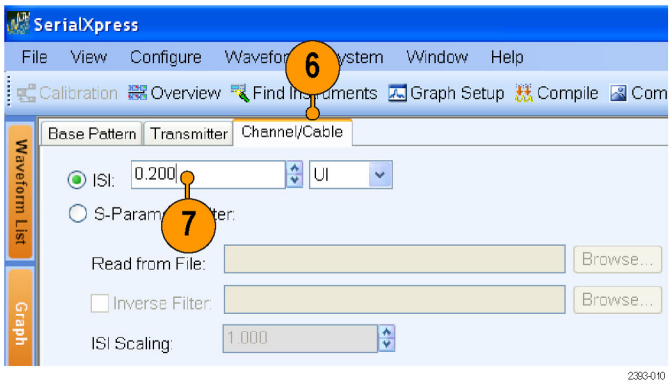


4. Click the **Transmitter** tab.

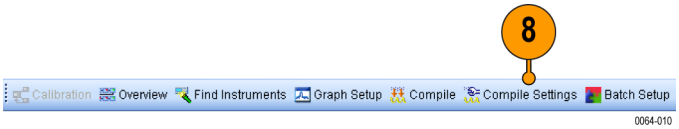
5. Set the following:
   - Select **Pre/De-emphasis** and set it to 0. This is the same as using the default value.



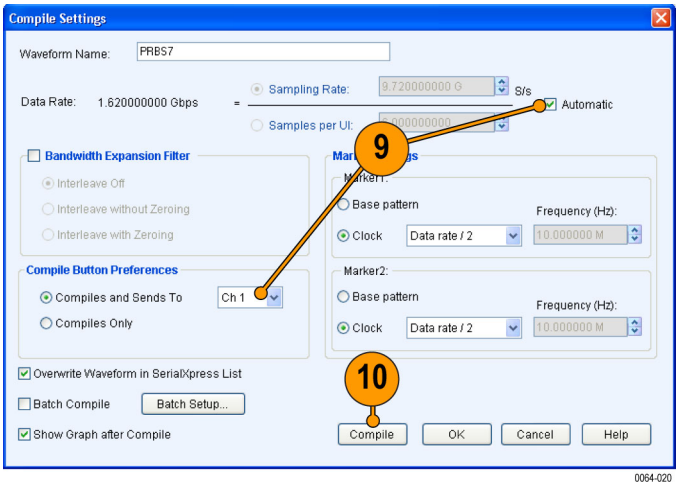
6. Click the **Channel/Cable** tab.
7. Select **ISI** and set it to 0.2.



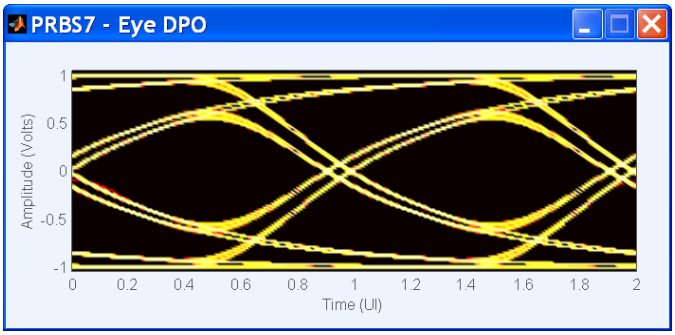
8. From the toolbar, click **Compile Settings**.



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

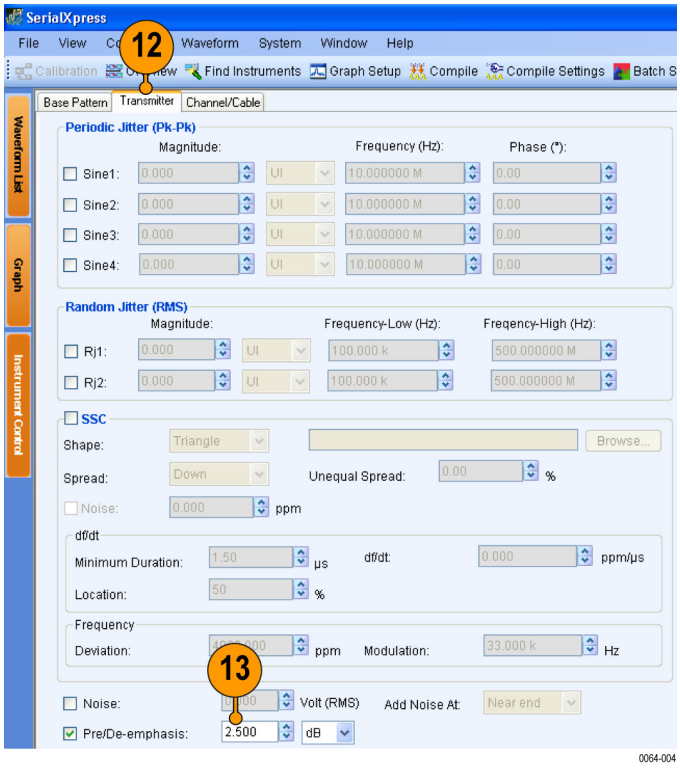


11. Observe the generated eye. The eye is distorted due to inter- symbol interference.

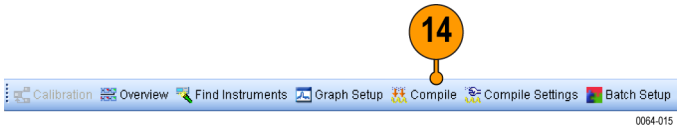


12. Click the **Transmitter** tab.

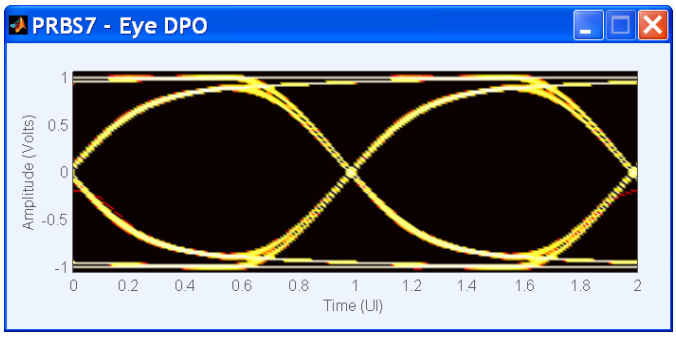
13. Select **Pre/De-emphasis** and set it to 2.5 dB.



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



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

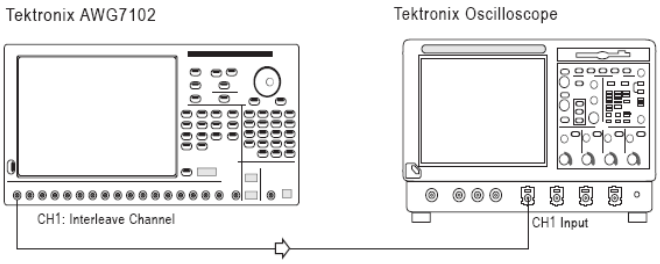


Application Examples

Creating a Display Port Compliant Signal

The example shows how to calibrate and create a signal that is compliant with Display Port standards.

1. Set up the instruments as shown. The instruments must be connected over a LAN. You will need:
   - A Tektronix AWG7102 with Option 06 running SerialXpress software
   - A Tektronix oscilloscope with DPOJET installed to capture the signal
   - Connecting cable

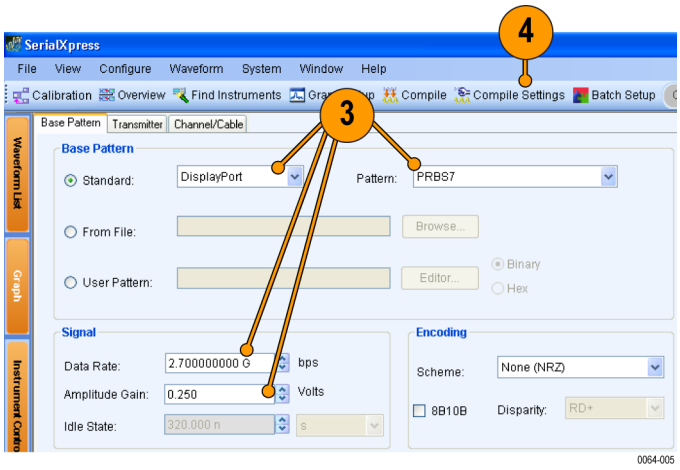


NOTE. *Ensure that the output of the AWG Interleave channel is connected to Channel 1 of the oscilloscope.*

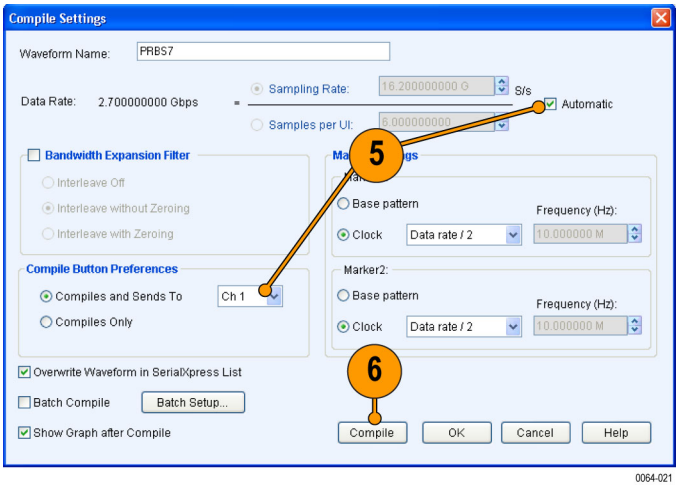
2. Start SerialXpress.

3. In the **Base Pattern** tab, set the following:
   - **Standard** to DisplayPort.
   - **Pattern** to PRBS7.
   - **Data Rate** to 2.7 Gb/s (corresponding to High Bit Rate in the standards).
   - **Amplitude Gain** to 0.250 V

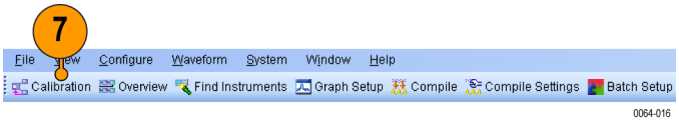
4. Click **Compile Settings** from the toolbar.



5. Do the following:
   - Ensure that **Automatic** is selected.
   - Enable **Compiles and Sends To** and select Ch 1.
6. Click **Compile**. The compiled waveform is sent to Ch 1 of the Tektronix AWG.



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



8. The Calibration window displays a table of instruments connected on the network. Select the oscilloscope and click **Connect**. Note that the status changes to Connected.

NOTE. *You can click Test Connection to test the status of the instrument.*

9. Select **Manual** DPOJET Settings.

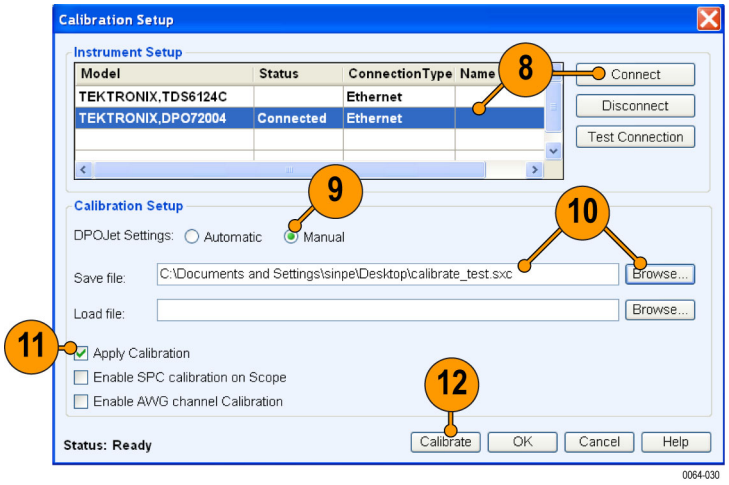
10. Set the path and file name to create the correction file.

11. Select **Apply Calibration**.

12. Click **Calibrate** to create the correction file (.sxc).

NOTE. *You will be prompted with a message to start the DPOJET application on the oscilloscope. Do the required oscilloscope and DPOJET settings. Click **OK** in the message dialog box to proceed with calibration.*

*You will again be prompted with a message to configure DPOJET manually, if you want to measure SSC. Configure all the DPOJET parameters manually. Click **OK** in the message dialog box to proceed with calibration.*



The calibration status is continually updated.

13. Click the **Transmitter** tab.

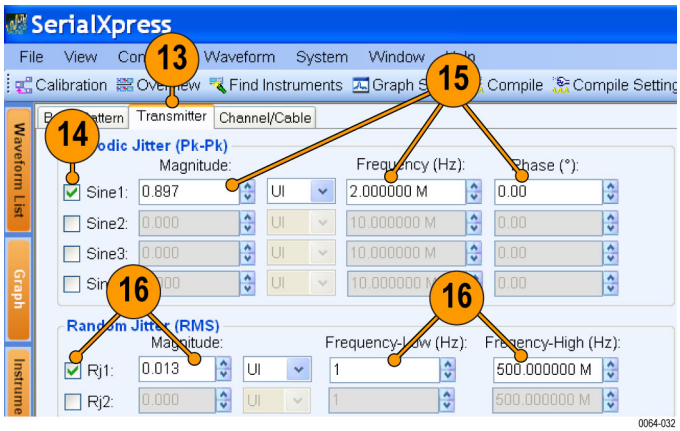
14. In the Periodic Jitter group, enable **Sine1**.

15. Set the following:

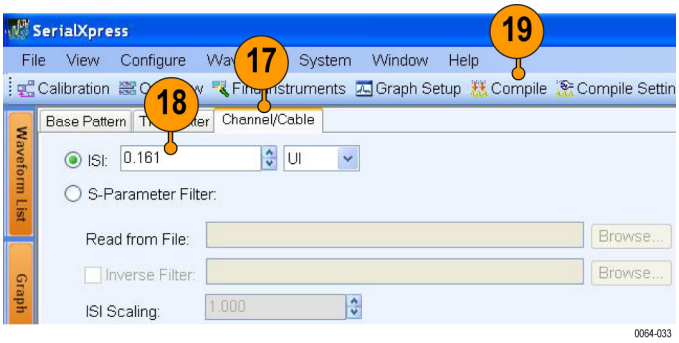
    - **Magnitude** to 0.897 UI.
    - **Frequency** to 2 MHz.
    - **Phase** to 0 °.

16. In the Random Jitter group, select Rj1 and do the following:

    - **Magnitude** to 0.013 UI.
    - Keep the default values for **Frequency-Low** and **Frequency-High**.



17. Click the **Channel/Cable** tab.
18. Set the **ISI** to 0.161 UI.
19. From the toolbar, click **Compile**.



20. You can transfer the waveform to an oscilloscope and use Tektronix DPOJET Eye Diagram and Analysis Tools application to measure the added jitter.

NOTE. *You can get an accurate ISI value only after calibration.*

Enabling Predistortion Through Digital Filters for Bandwidth Enhancement

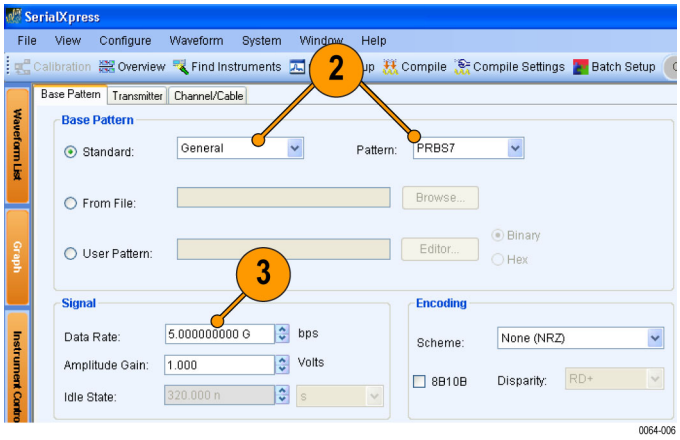
This example shows how the frequency response of the system can be enhanced by applying bandwidth enhancement digital filters. Using these filters, the frequency response can be whitened (flattened). You can apply these filters when a sharp rise time or fall time is required. The example shows how to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

You will need the following equipment:

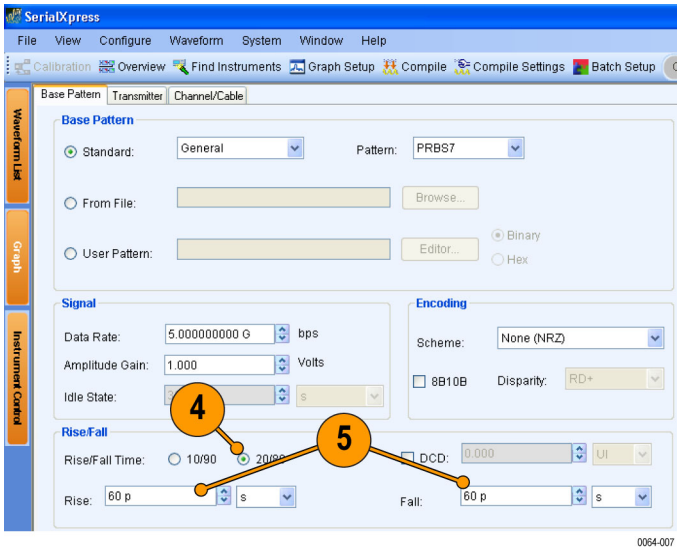
- A Tektronix DPO oscilloscope (for example, DPO71604) with a bandwidth greater than 16 GHz and capable of measuring rise and fall time of the order of 50 picoseconds.
- A Tektronix Arbitrary Waveform Generator AWG7102 with Option 06 with SerialXpress installed and running on it.
- An external hardware 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.

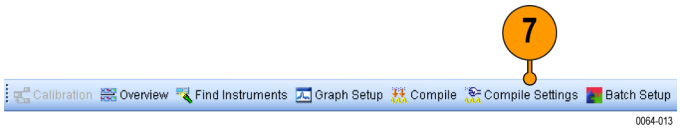
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:
   - **Standard** to General.
   - **Pattern** to PRBS7.
3. In the Signal group, set the **Data Rate** to 5 G.



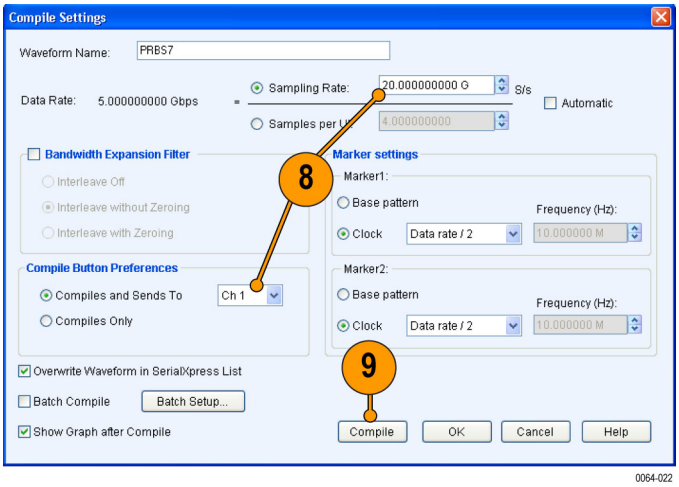
4. In the Rise/Fall group, ensure that **Rise/Fall Time** is set to 20/80.
5. Set **Rise** and **Fall** time to 60 ps.



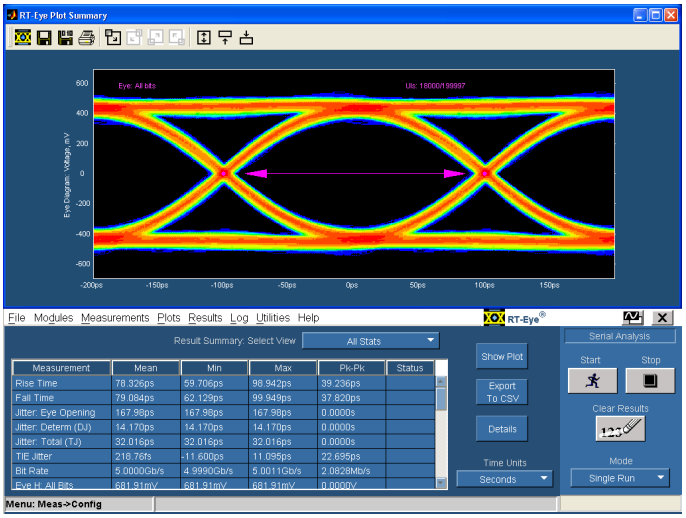
6. Leave the parameters in the **Transmitter** and **Channel/Cable** tabs in their default state.
7. From the toolbar, click **Compile Settings**.



8. In the Compile Settings dialog box, do the following:
   - 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.
9. Click **Compile**.



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

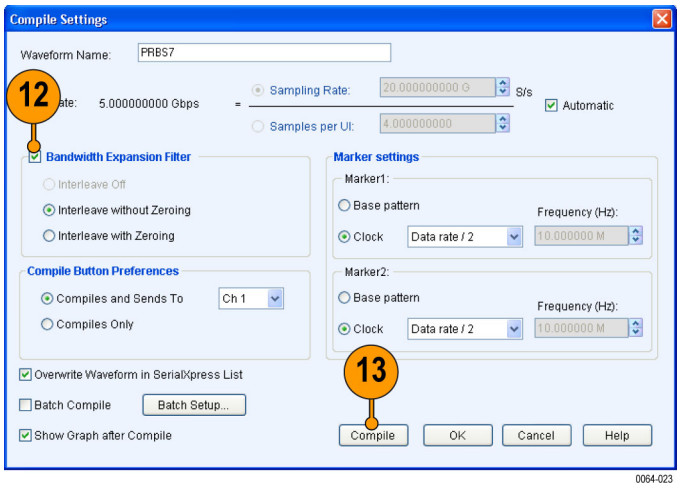


11. Connect the external hardware filter to the output channel of the AWG.

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

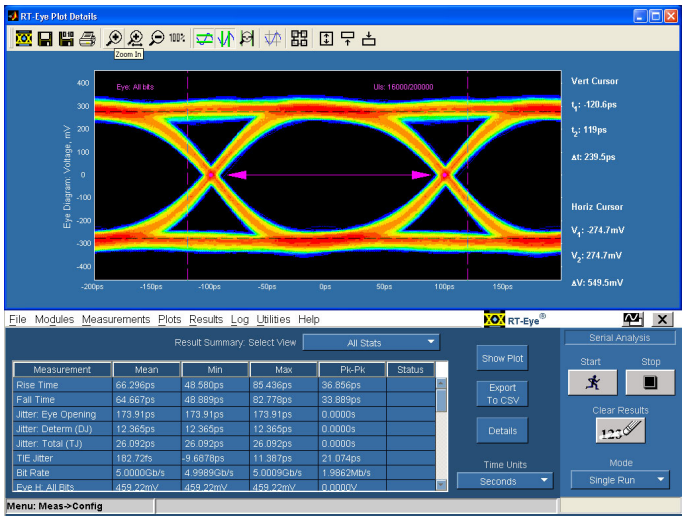
- Select **Bandwidth Expansion Filter** and select **Interleave without Zeroing**.

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.

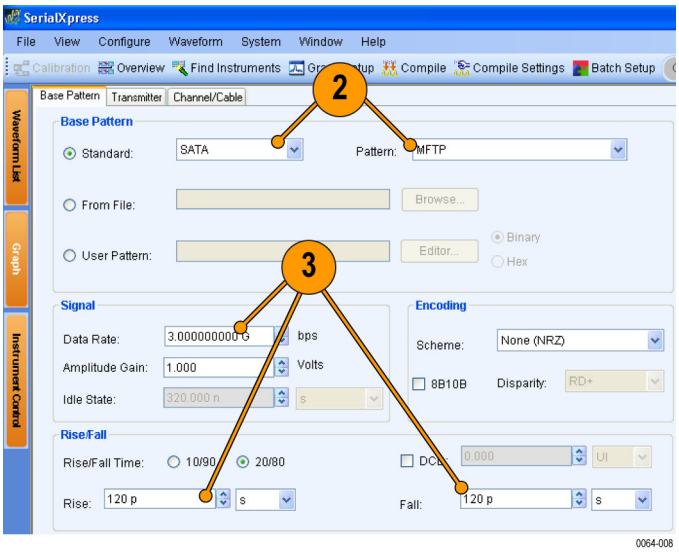
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:

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

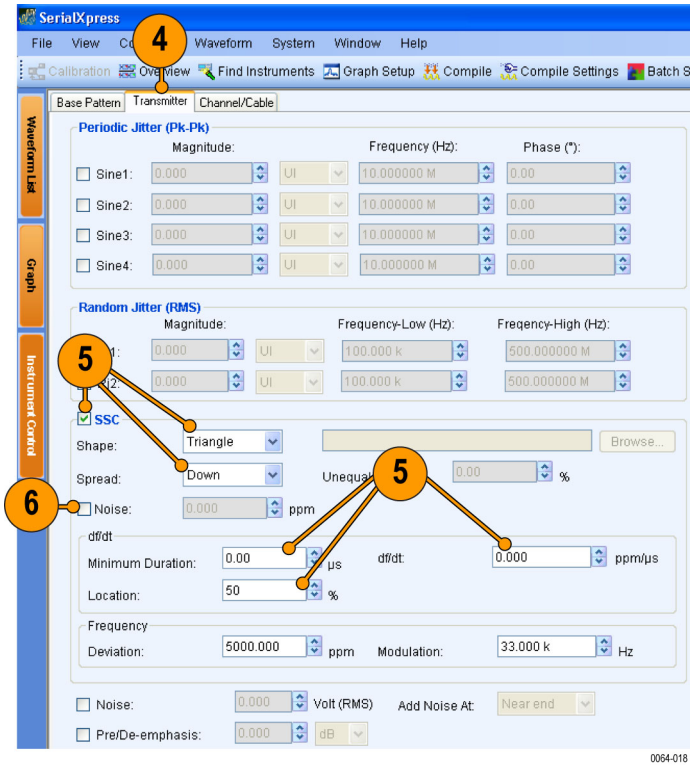
3. In the Signal group, the **Data Rate** is automatically set to 3 G.

   Leave the rest of the parameters at their default values.

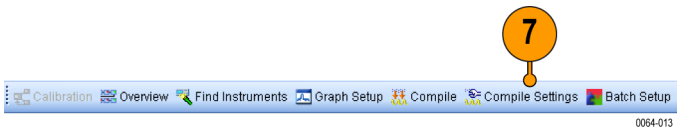
   In the Rise/Fall group, set the **Rise** and **Fall** time to 120 ps.



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

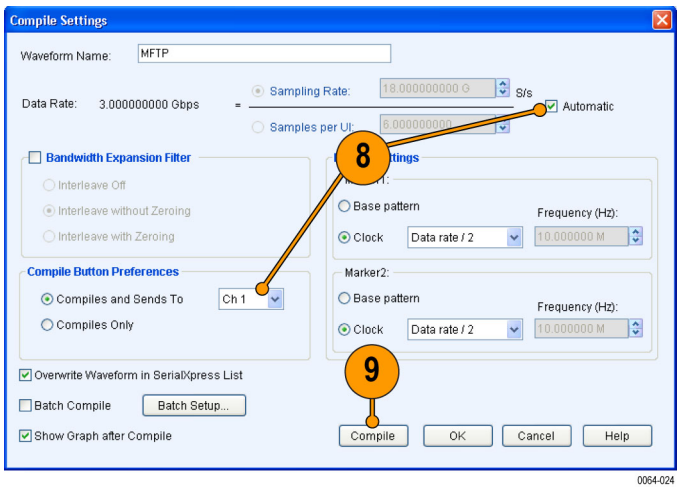


7. From the toolbar, click **Compile Settings**.

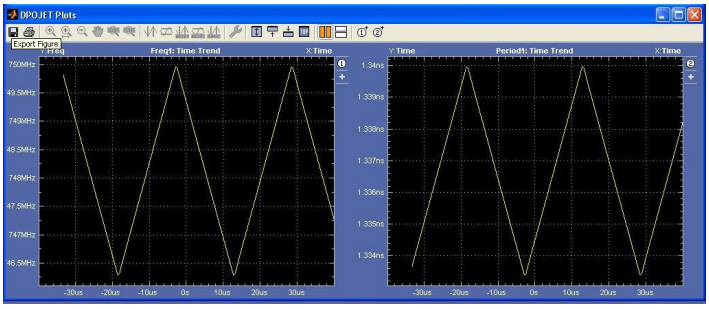


8. Do the following:
   - Ensure that **Automatic** is selected.
   - Select **Compiles and Sends To** and set the channel to Ch 1.
9. Click **Compile**.

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



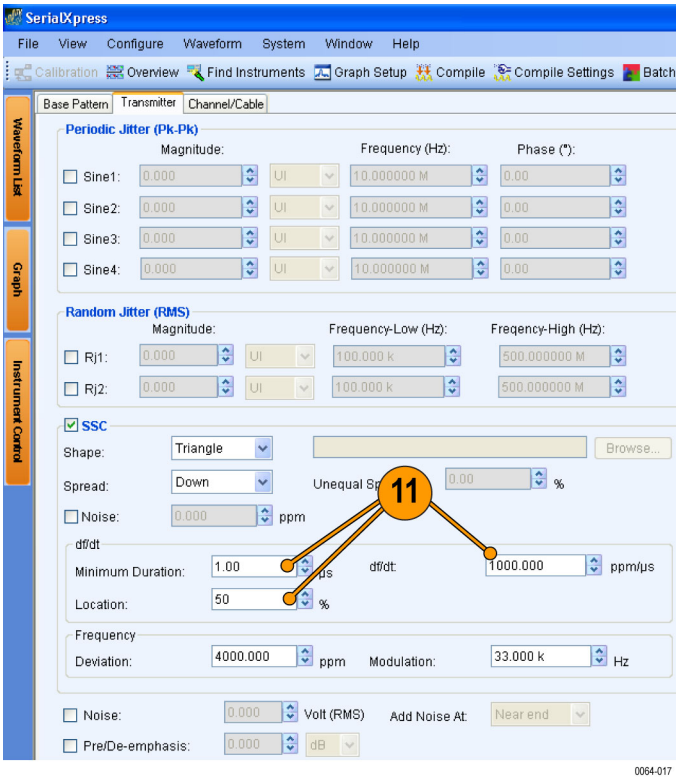
10. You can transfer the generated SSC pattern to an oscilloscope and use Tektronix DPOJET Eye Diagram and Analysis Tools application to analyze the period and frequency trend waveform.



11. Go to step 5.

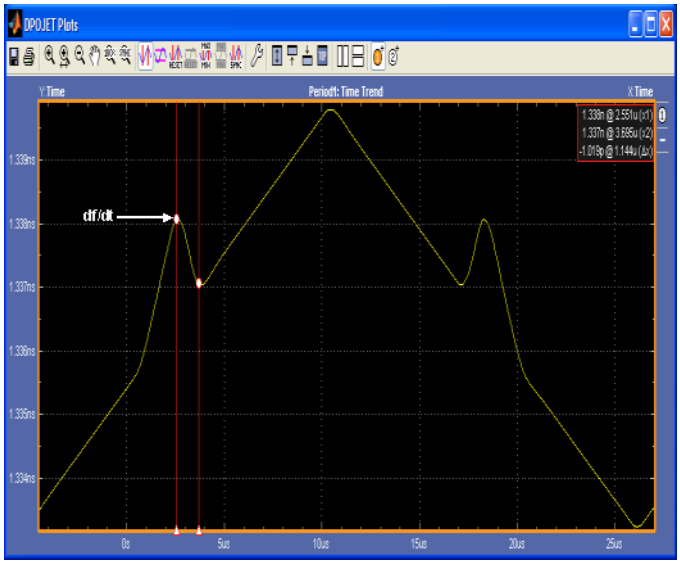
Keep the settings of the SSC but change the df/dt group values as follows:

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



12. Perform step 6 to step 9.

13. 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.

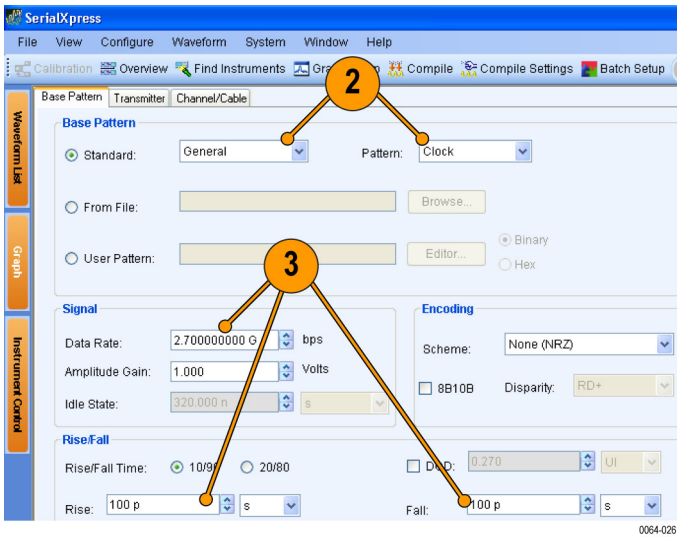
2. In the **Base Pattern** tab, in the Base Pattern group, set the following:

   - **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.

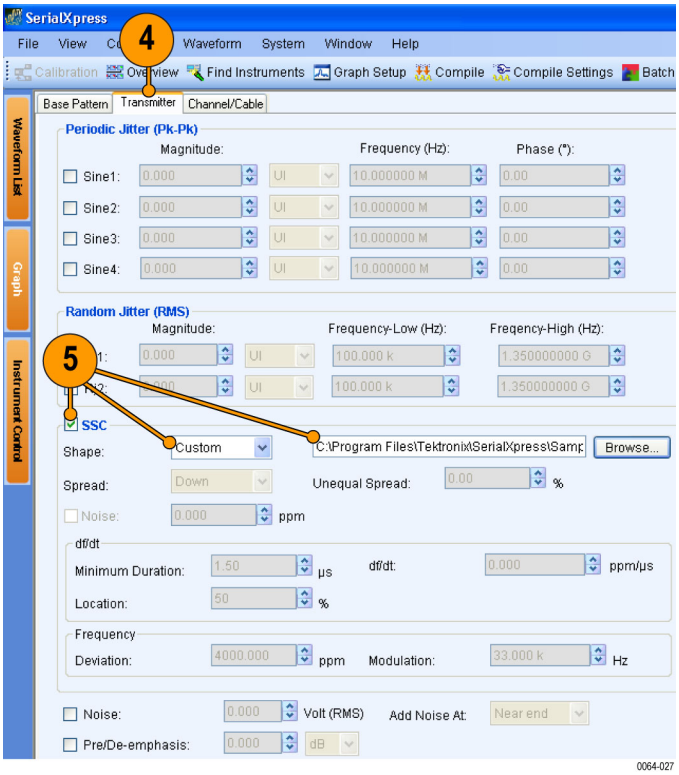
   - In the Rise/Fall group, set the **Rise** and **Fall** time to 100 ps.



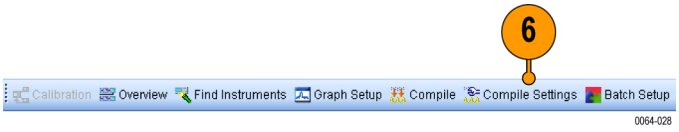
4. Click the **Transmitter** tab.

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**.

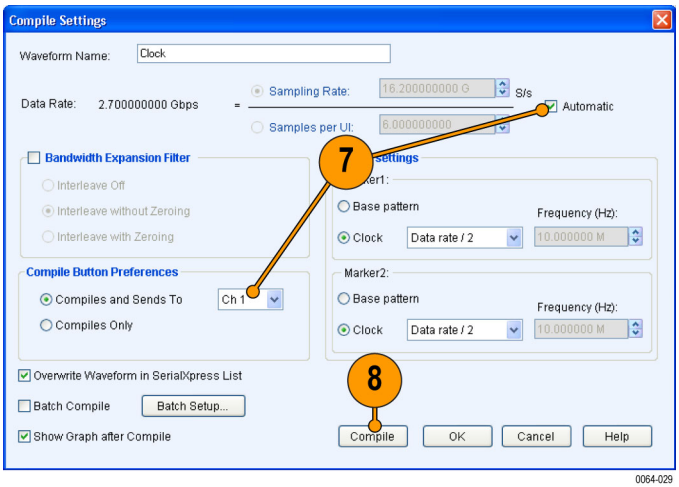


7. Do the following:

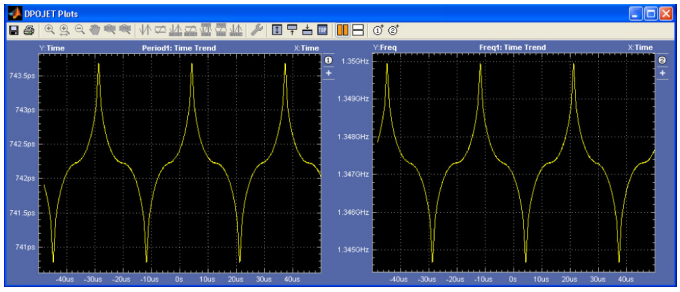
   - Ensure that **Automatic** is selected.
   - Select **Compiles and Sends To** and set the channel to Ch 1.

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.

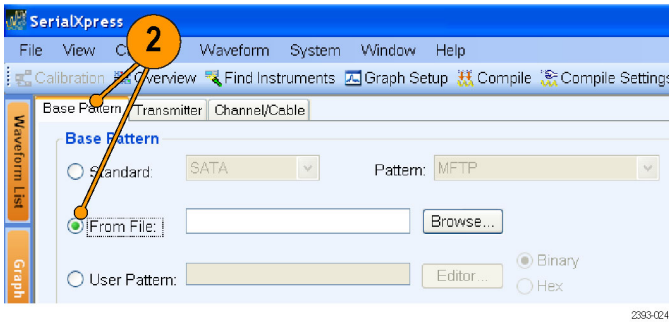


Simulating Cable Effects Using Touchstone Files

The example shows how to create the effect of cable on serial data signal using the relevant Touchstone files.

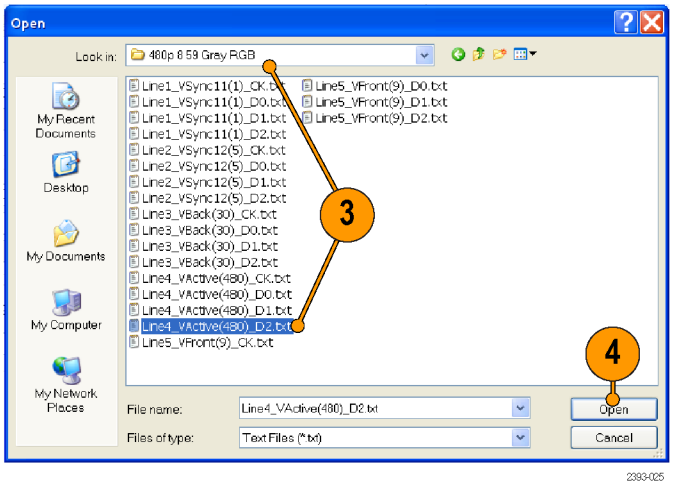
1. Start SerialXpress.

2. In the **Base Pattern** tab, click **From File**.

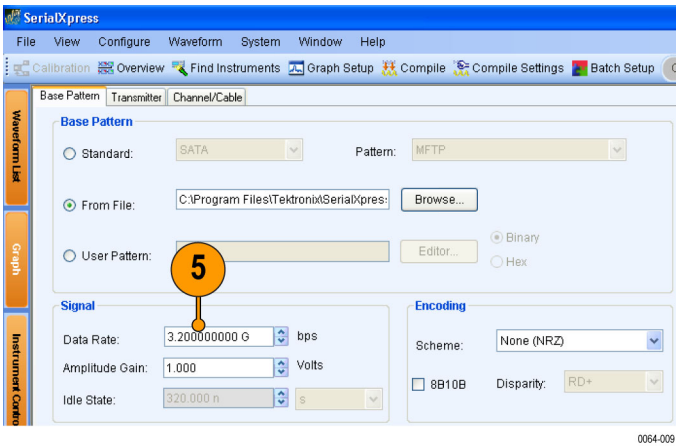


3. Browse to the folder **Samples\HDMI\480p 8 59 Gray RGB** and select the file **Line4_VActive(480)_D2.txt**.

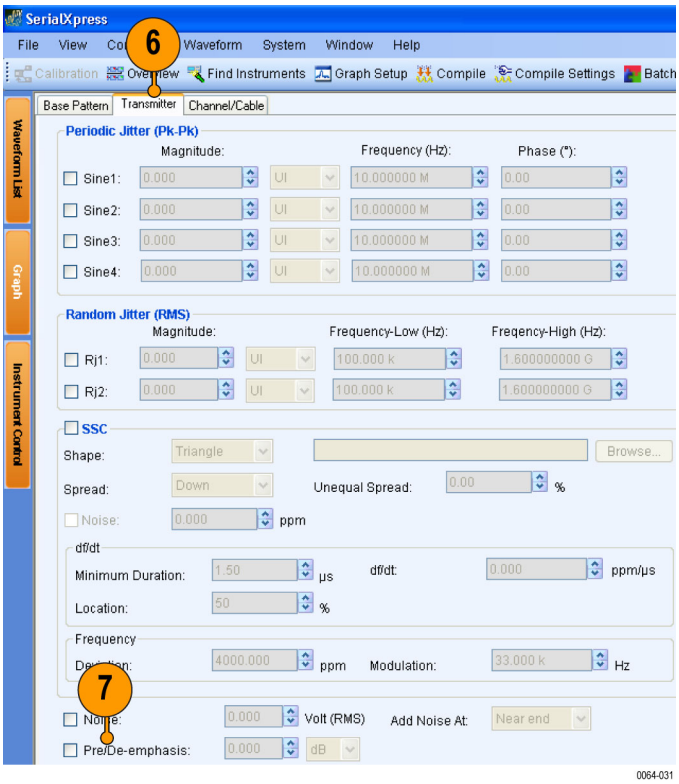
4. Click **Open**.



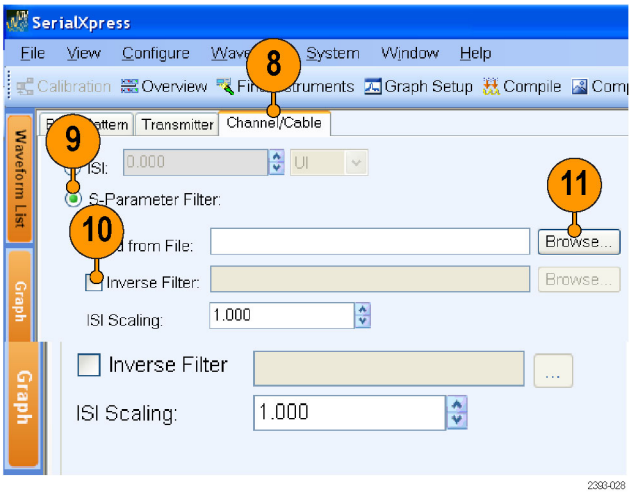
5. In the Signal group, set **Data Rate** to 3.2 G.



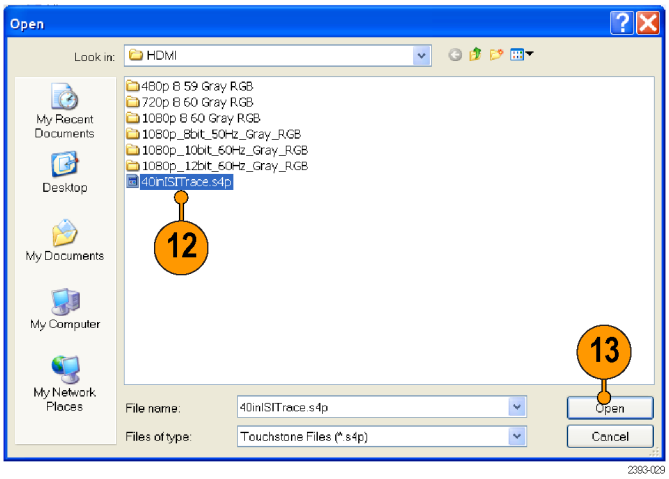
6. Click the **Transmitter** tab.
7. Ensure that **Pre/De-emphasis** is set to 0.



8. Click the **Channel/Cable** tab.
9. Select **S-Parameter Filter**.
10. Clear (disable) **Inverse Filter**.
11. Click **Read from File**.



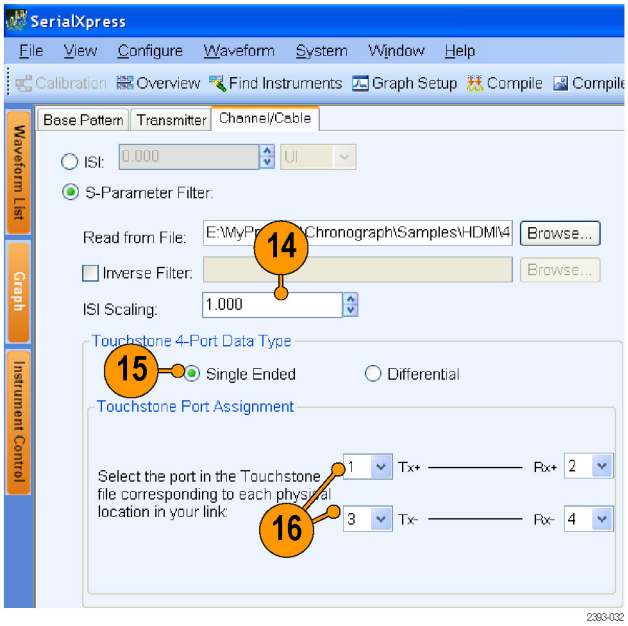
12. Select the file **40inISITrace.s4p**.
13. Click **Open**.



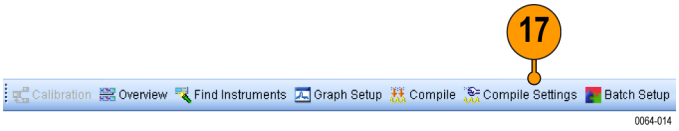
14. Set **ISI Scaling** to 1.

15. Set Touchstone 4–Port Data Type to **Single-Ended**.

16. Keep the Touchstone Port Assignment.



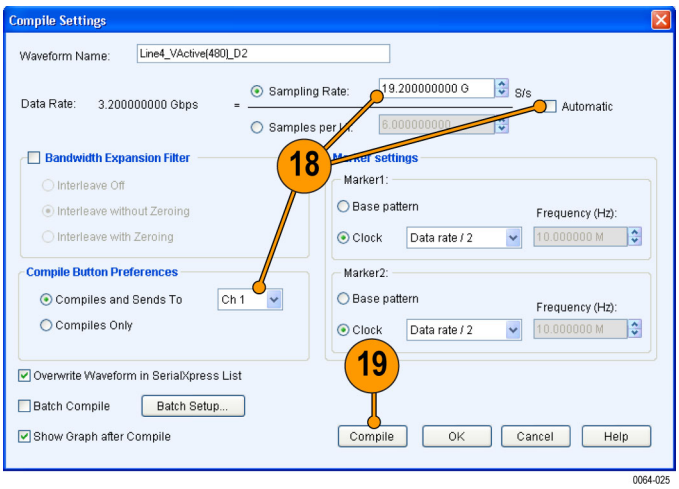
17. From the toolbar, click **Compile Settings**.



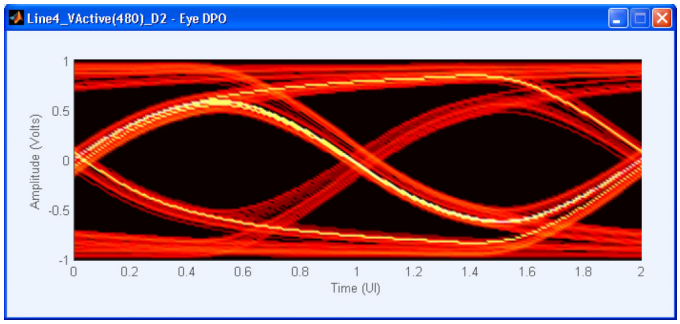
18. Set the following:

- Clear **Automatic**.
- **Sampling Rate** to 19.2 G.
- Select **Compiles and Sends To** and set the channel to Ch 1.

19. Click **Compile**.



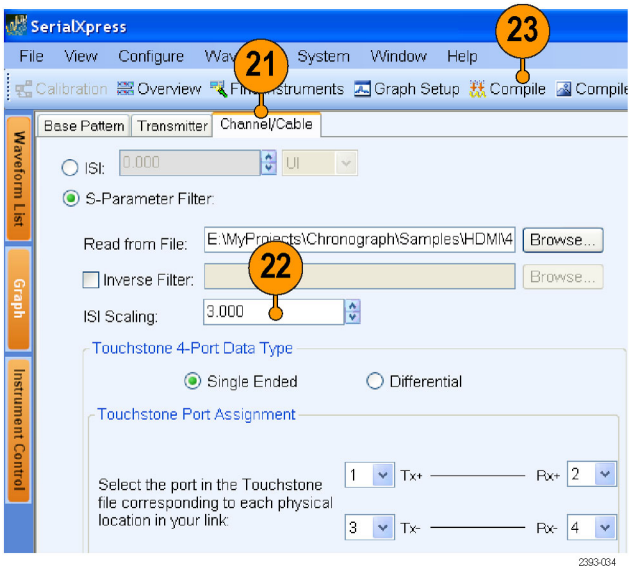
20. You will observe a distorted eye caused by the cable effect and the data dependent jitter (DDJ) can be measured. You can transfer the generated waveform to an oscilloscope and use Tektronix DPOJET Eye Diagram and Analysis Tools application to analyze the waveform.



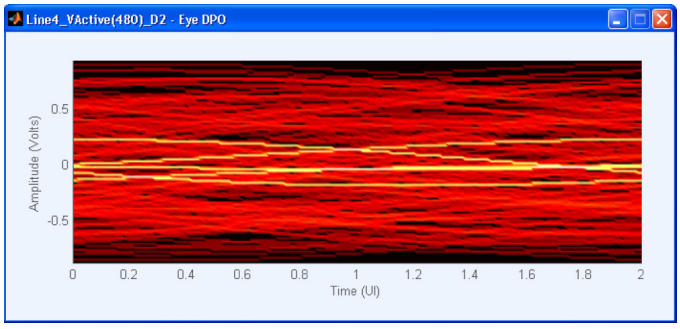
21. Click the **Channel/Cable** tab.

22. Set **ISI Scaling** to 3.

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



24. You will observe a further deterioration of the eye caused by the cable effect.



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