RFXpress® RFX100
Advanced RF/IF/IQ Waveform Creation and Editing Software for the AWG5000/B & AWG7000/B Series Signal Generators

Quick Start User Manual

077-0159-05

Tektronix

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Advanced RF/IF/IQ Waveform Creation and Editing Software for the AWG5000/B & AWG7000/B Series Signal Generators

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www.tektronix.com
077-0159-05

Tektronix

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

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General Safety Summary

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

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

Only qualified personnel should perform service procedures.

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.*

Preface

This document is targeted to product users and explains operation and/or installation procedures. It also provides information about features and functions, and applications. This software runs as an integral part of AWG5000/AWG5000B and AWG7000/AWG7000B series arbitrary waveform generators and can also run from an external PC.

You can use RFXpress to:

- Design, debug, and develop wideband wireless communications receivers
- Generate UWB-WiMedia compliant and custom signals
- Generate general purpose digitally modulated IQ, IF, and RF signals

Key Features

The RFXpress RFX100 is a software product that allows you to create digitally modulated baseband, IF, and RF signals that can be generated through arbitrary waveform generators (AWG). This software allows you to:

- Define baseband I and Q signals using various modulation schemes
- Create single- and multi-carrier signals where each carrier is independently defined
- Apply impairments such as quadrature error and imbalance or non-linear impairments
- Add interferences during waveform creation
- Remotely connect to Tektronix oscilloscopes and to an Agilent Performance Signal Generator (PSG®)
- Remotely configure a Tektronix real-time spectrum analyzer and import I and Q trace data
- Characterize a DUT and provide S-parameter emulation of RF components
- Create multiple layers of modulation using subcarrier multiplexing

UWB-WiMedia

- Direct RF generation of WiMedia BG1 and BG2 waveforms
- Generate IQ and IF waveforms including band hopping for all band groups
- Define the IF frequency, including TFC pattern
- Generate WiMedia signals for MAC and PHY layers
- Create UWB-WiMedia correction files, which can be automatically applied as compensation to accurately generate signals
- Use Gated Noise to define noise profiles for each section of the UWB packet
- Create tone nulling with intermediate values (–40 dB to +20 dB) for OFDM carrier mapping

Radar

- Create single or multiple pulse groups forming a pulse train
- Define each pulse group independently or add different pulse groups to simulate simultaneous multiple target returns
- Create different predefined pulse shapes including user defined shapes for a pulse group
- Display a dynamic pulse plot showing the pulse shape, droop, and ripple parameters
- Have pulse-to-pulse hopping within a pulse group
- Apply impairments like Edge Jitter, Width Jitter, Overshoot, Ripple and Droop on a pulse group
- Apply different modulation schemes including user defined modulation
- Use the AWG sequence mode to optimize the memory and create large numbers of pulses
- Define antenna beam profile and simulate target returns
- Define a staggered PRI with ramp and user-defined profiles, and add up to ten multi-paths

OFDM

- Ability to configure all parameters of OFDM
- Custom build OFDM frames right from defining the base data, symbols, packets, and frames
- Support for Reed Solomon, Convolution coding and Scrambling
- Add Impairments, Phase Noise, Multi-path, and Quantization
- Define frequency hopping and gated noise
- Support for a variety of sub-carrier modulation (BPSK, QPSK, QAM (16,32,64,256), and 8-PSK
- Support for Tone Nulling and Clipping
- Presets for WiFi and WiMAX standards

Documentation

RFXpress RFX100 Online Help, English	Tektronix part number 076-0081-XX
RFXpress RFX100 User Manual, English, (PDF)	Tektronix part number 077-0045-XX
RFXpress RFX100 Quick Start User Manual, English (PDF)	Tektronix part number 077-0159-XX
RFXpress RFX100 Installation Manual, English (PDF)	Tektronix part number 077-0160-XX
RFXpress RFX100 Programmer Online Help, English	Tektronix part number 076-0216-XX
RFXpress RFX100 Programmer Manual (PDF), English	Tektronix part number 077-0435-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 document MultiBand OFDM Physical Layer Specification version 1.2 by WiMedia Alliance is referred to as the “WiMedia standard” or “WiMedia specification”.

The term “DUT” refers to a device under test.

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

Installation

For information on how to install this software, refer to the *RFXpress Installation Manual*, Tektronix part number 077-0160-XX.

Starting the Software

Start the software in either of the following ways:

- From **Start > Program Files > Tektronix RFXpress**, click RFXpress.
- Double-click the RFXpress 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 option key for the specific instrument model and serial number.

To check for upgrades:

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

Using the Software

The procedures in this section show you how to use the software to create, compile, and graph signals.

Getting Acquainted with the Software

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

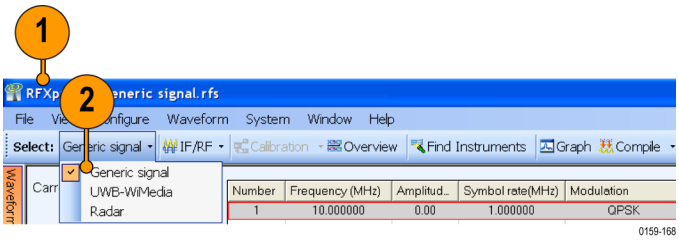
Use menus, toolbars, check boxes, and on-screen buttons to control the software functions. Use Microsoft Windows techniques to navigate menus and select or clear check boxes.

Generating a Single Carrier Signal

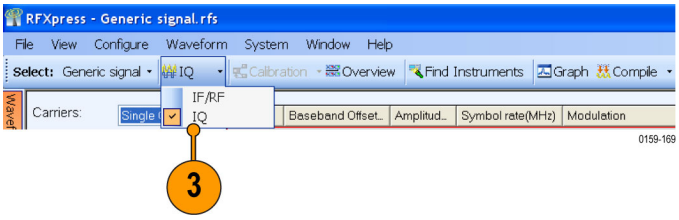
This section shows you a step-by-step procedure for creating a single carrier QPSK baseband signal.

1. Start RFXpress.

2. From the toolbar, click **Select > Generic signal**.



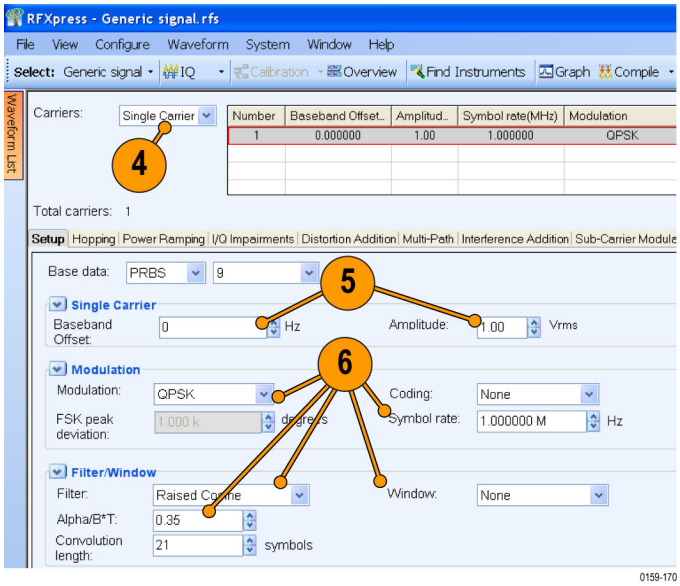
3. Set the signal type to **IQ**.



4. Click **Carriers > Single Carrier**.

5. Select the carrier and set the following:
   - **Baseband Offset** to 0 Hz.
   - **Amplitude** to 1 Vrms.

6. Ensure that the following parameters are set:
   - **Modulation** is QPSK.
   - **Filter** is Raised Cosine.
   - **Symbol rate** is 1 MHz.
   - **Alpha/B*T** is 0.35.
   - **Window** is None.

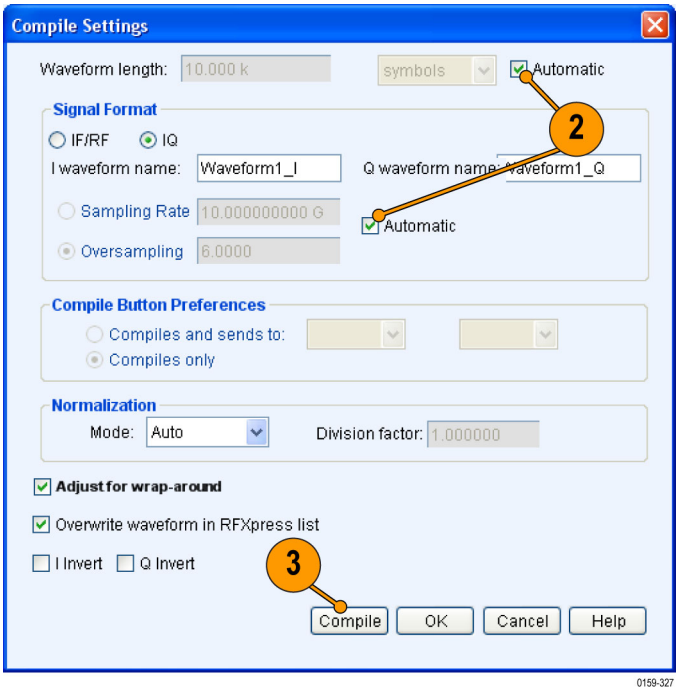


Compiling a Signal

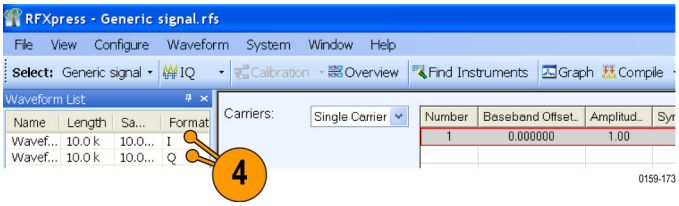
Follow these steps to compile and generate a signal using the parameters that you just defined.

1. From the toolbar, click **Compile > Compile Settings**.

2. Retain the default values as they are. Ensure that the **Automatic** options are selected.
3. Click **Compile**.



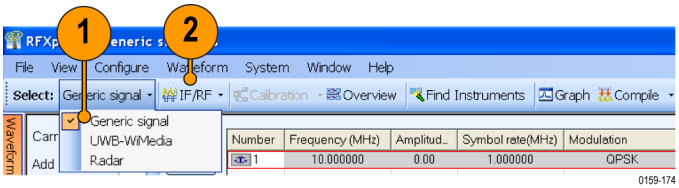
4. The compiled waveform is displayed in the waveform list.



NOTE. *If the waveform list is not visible, click* ***Window > Waveform List*** *to view it.*

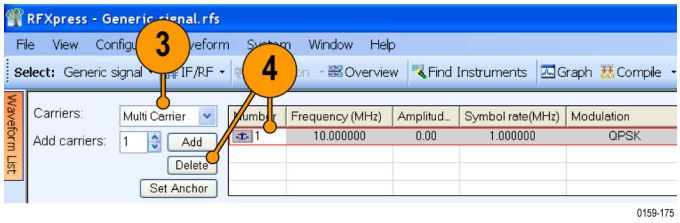
Generating a Multi-Carrier RF Signal

1. From the toolbar, click **Select > Generic signal**.
2. Select the signal type as **IF/RF**.



3. Select **Multi Carrier**.

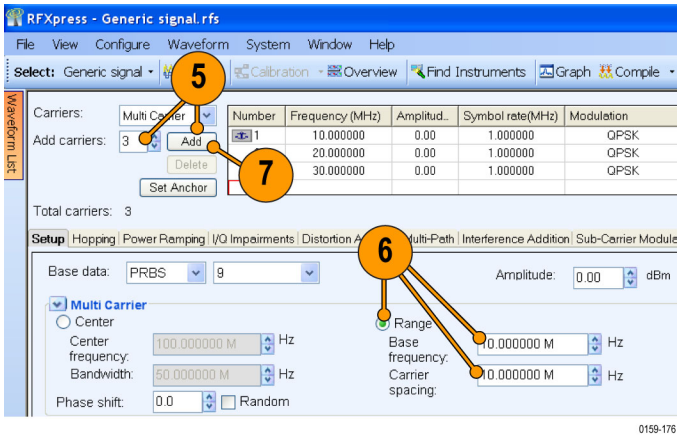
4. You can either add carriers directly or delete the existing carrier and add new ones. Select the carrier in the table and click **Delete**.



5. Click **Add carriers** and type 3.

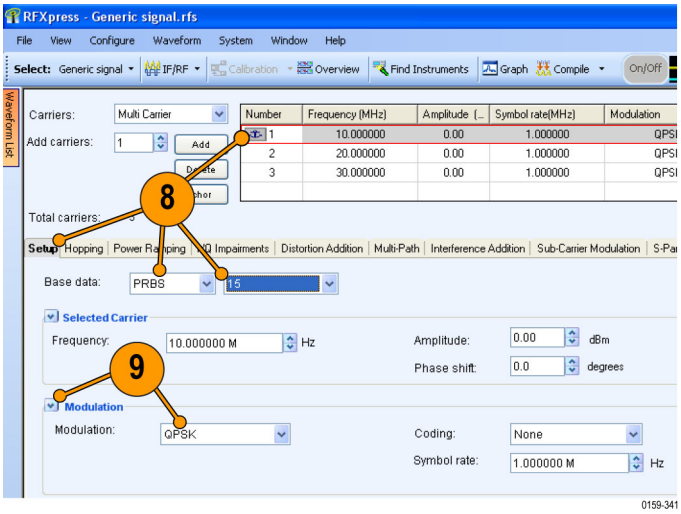
6. Click **Range**. Set the **Base frequency** to 10 M and the **Carrier spacing** to 10 M.

7. Click **Add**.



8. Select the first carrier from the table. In the **Setup** tab, set the **Base data** to PRBS and select 15 from the adjacent field.

9. Set the **Modulation** for the carrier to QPSK.



10. Repeat steps 8 and 9 for the remaining carriers, setting the **Base data** to PRBS 21 and PRBS 7, and **Modulation** to QPSK.

Adding Power Ramping, I/Q Impairments, and Interference

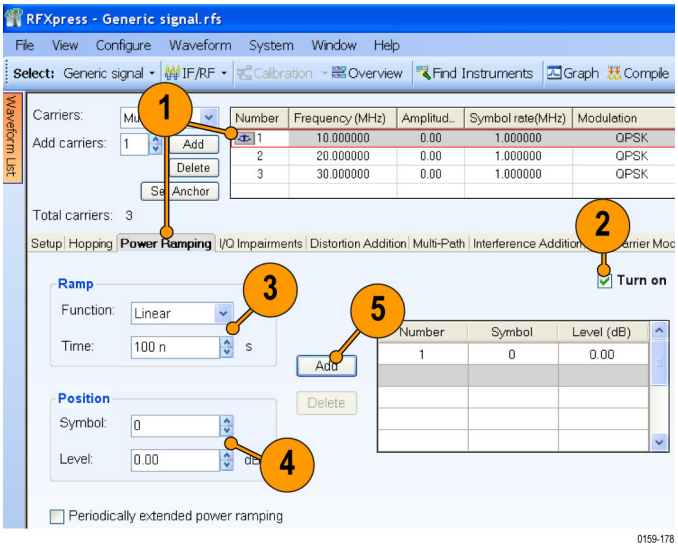
1. Select the first carrier from the table. Select the **Power Ramping** tab.

2. Select **Turn on**.

3. Set the Ramp parameters:
   - **Function** to Linear.
   - **Time** to 100 ns.

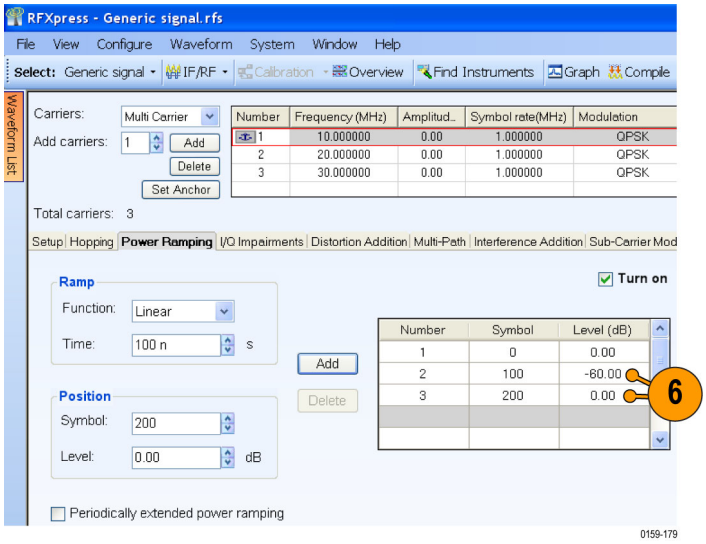
4. Set the Position parameters:
   - **Symbol** to 0.
   - **Level** to 0.00.

5. Click **Add**.



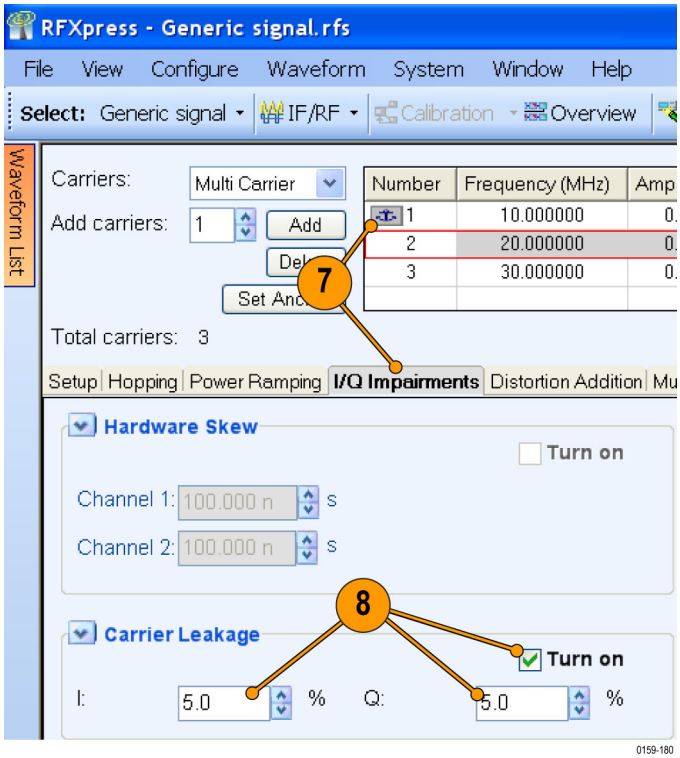
6. Repeat steps 4 and 5 two more times, adding these parameters:
   - Symbol = 100
   - Level = –60 dB

   and
   - Symbol = 200
   - Level = 0 dB



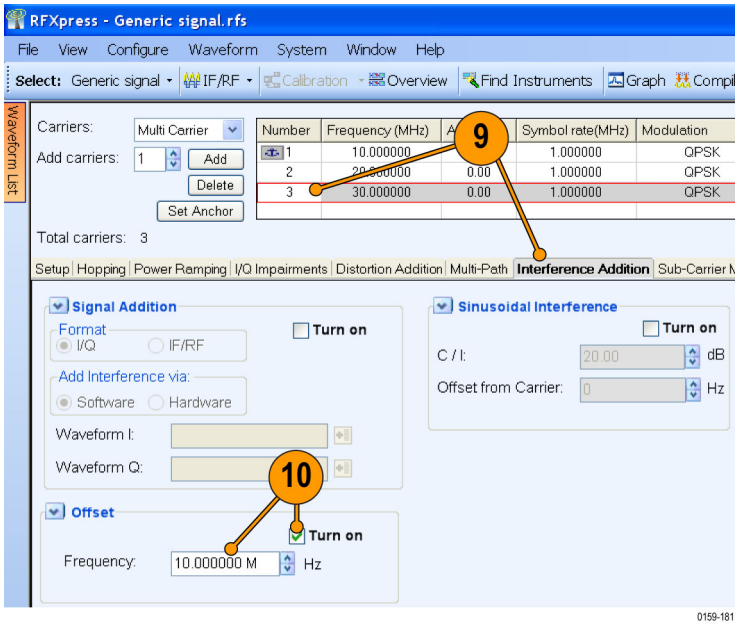
7. Select the second carrier from the table. Select the **I/Q Impairments** tab.

8. In the Carrier Leakage group, select **Turn on**. Set the following parameters:
   - **I** to 5.0.
   - **Q** to 5.0.



9. Select the third carrier from the table. Select the **Interference Addition** tab.

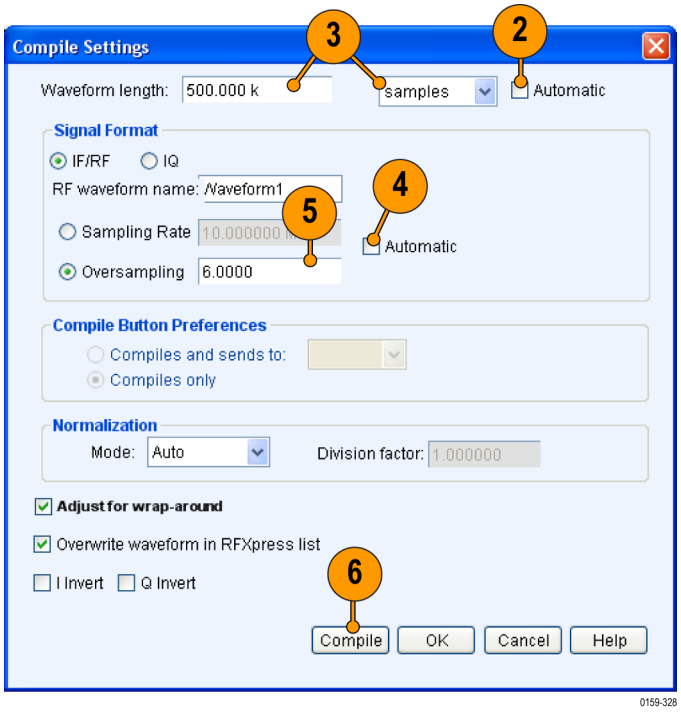
10. In the Offset group, select **Turn on**. Set the **Frequency** to 10 M.



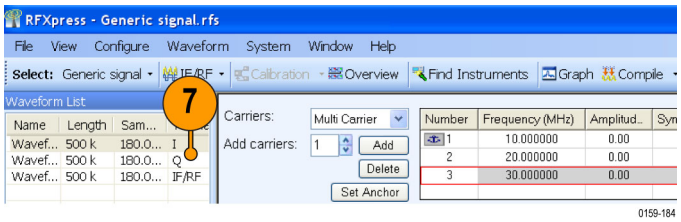
Compile Settings and Compile

1. From the toolbar, click **Compile > Compile Settings**.

2. Clear **Automatic**.
3. Set the **Waveform length** to 500 k and the units to samples.
4. Clear **Automatic**.
5. Set the **Oversampling** to 6.00.
6. Click **Compile**.



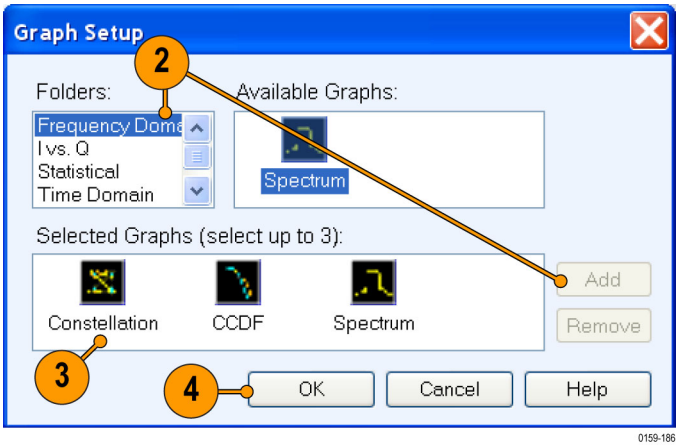
7. The compiled waveform is displayed in the waveform list.



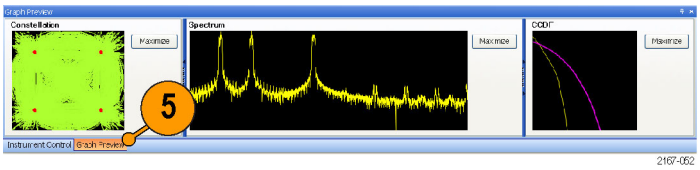
Previewing Graphs

1. From the toolbar, click **Graph**.

2. In Graph Setup, select the folder and click **Add** to add the following graphs:
   - Frequency Domain: Spectrum.
   - I Vs Q: Constellation.
   - Statistical: CCDF.
3. The graphs are added to the Selected Graphs.
4. Click **OK**.



5. Click **Graph Preview** at the lower left of the screen to view the graphs.

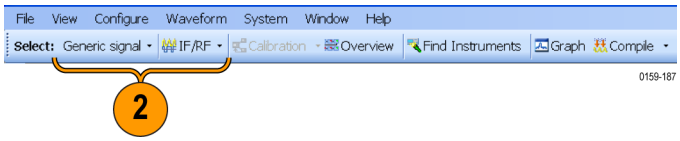


Replay a Captured Waveform to Test Receivers

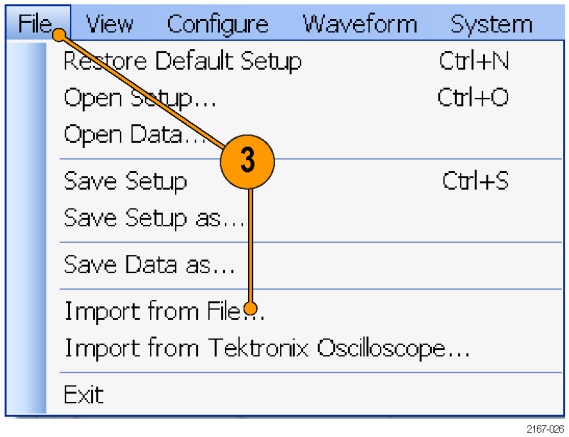
You can capture a real-world signal in a real-time spectrum analyzer and play it back in multiple locations to test your DUTs.

Import an RTSA File

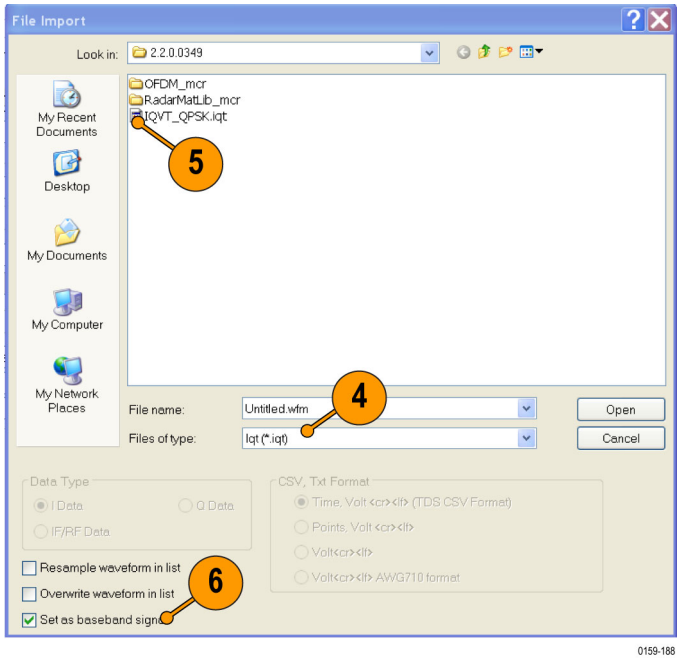
1. Start RFXpress.
2. Ensure that the selected application is set to **Generic signal** and the signal type is **IF/RF**.



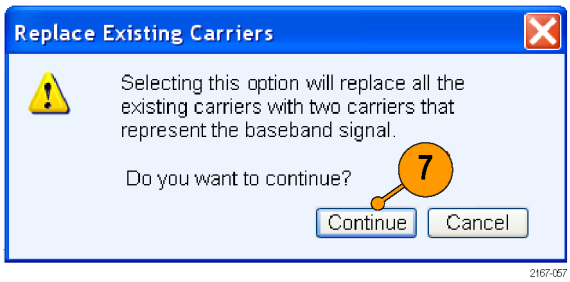
3. From the menu, click **File > Import from File**.



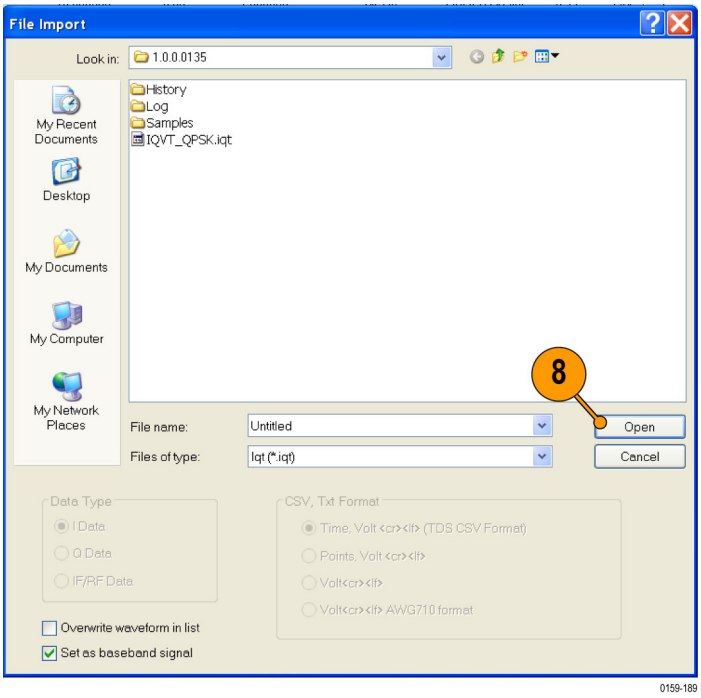
4. Select iqt in the **Files of type** field.
5. Select an iqt file.
6. Select **Set as baseband signal**.



7. A message appears. Click **Continue**.

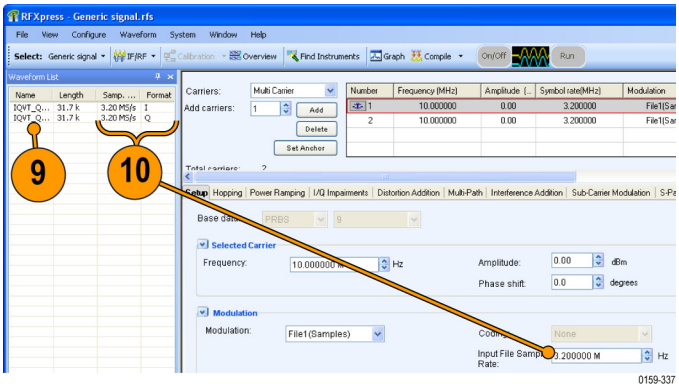


8. Click **Open**.



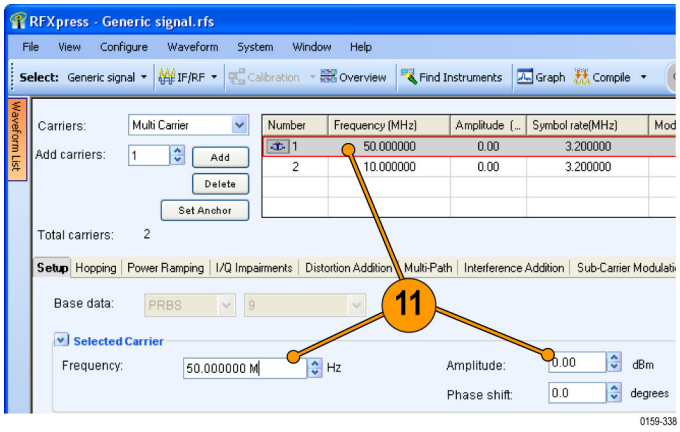
9. The waveform list displays the I and Q signals.

10. Note that the **Input File Sample Rate** automatically takes the value with which the iqt file was created.



11. Select the first carrier and set the following:

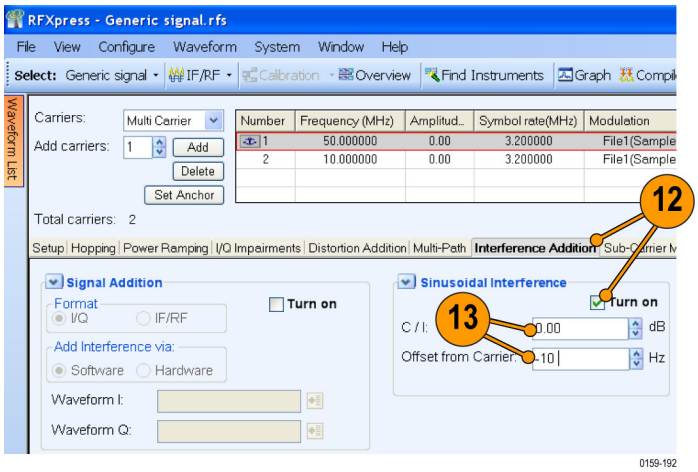
- **Frequency** to 50 M.
- **Amplitude** to 0 dBm.



12. Click **Interference Addition**. In the Sinusoidal Interference group, select **Turn on**.

13. Set the following:

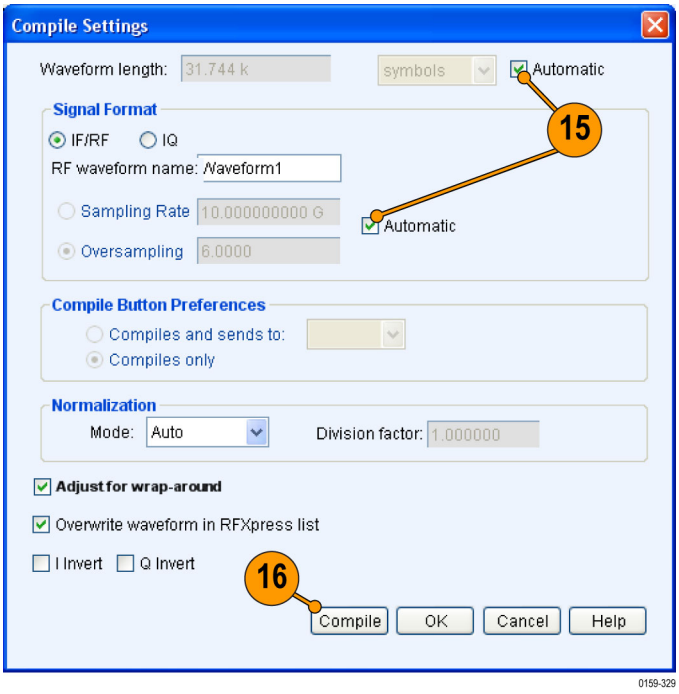
- **C/I** to 0 dB.
- **Offset from Carrier** to –10 M.



14. Select the second carrier and repeat steps 11 through 13.

15. Click **Compile > Compile Settings**. Ensure that **Automatic** is selected.

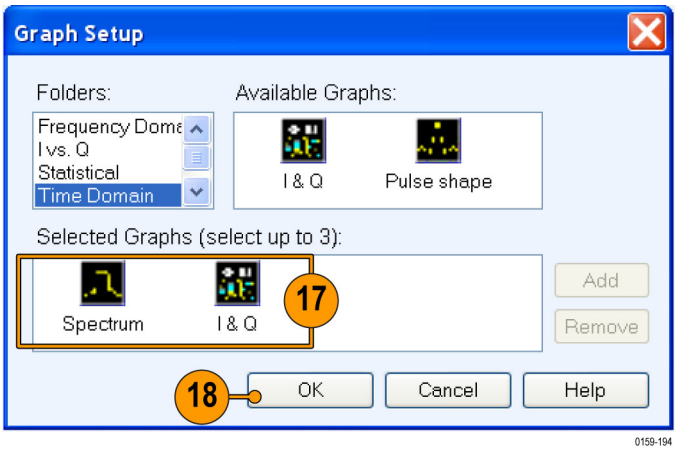
16. Click **Compile**. The software uses the default compile settings to generate the waveform.



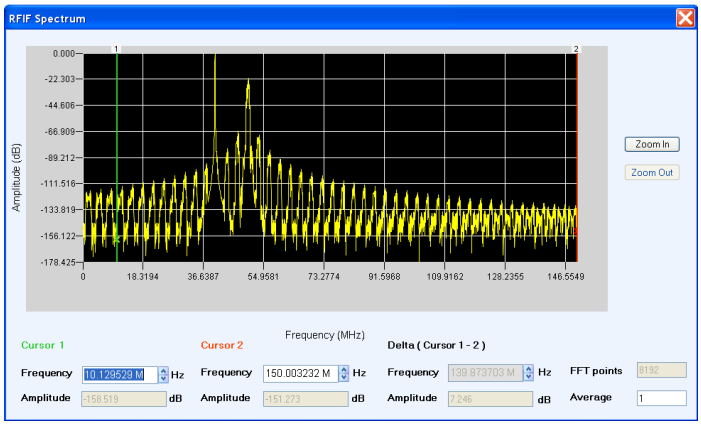
17. Add the following graphs in Graph Setup:

- Frequency Domain: Spectrum.
- Time Domain: I & Q.

18. Click **OK**.



19. The Spectrum graph is as shown.



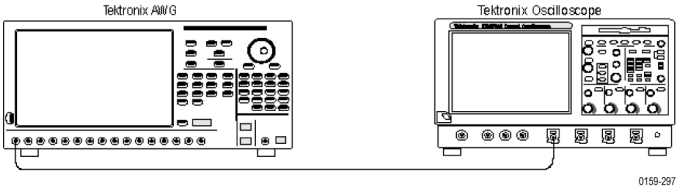
Calibrating a Generic Signal

When creating signals for testing wideband receivers, it is important that the test equipment generate signals with flat frequency and linear phase response. As the signal bandwidth is increased, because of the DAC roll-off and bandwidth limitation of the arbitrary waveform generator, the signal that is created does not have flat frequency and linear phase response. Calibration (predistortion) is applied to signals to correct amplitude and phase distortions.

1. Set up the instruments as shown. The instruments must be connected over a LAN.

   You will need:

   - A Tektronix AWG7122B with Option 06, running RFXpress software.
   - A Tektronix DPO oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
   - Connecting cable.

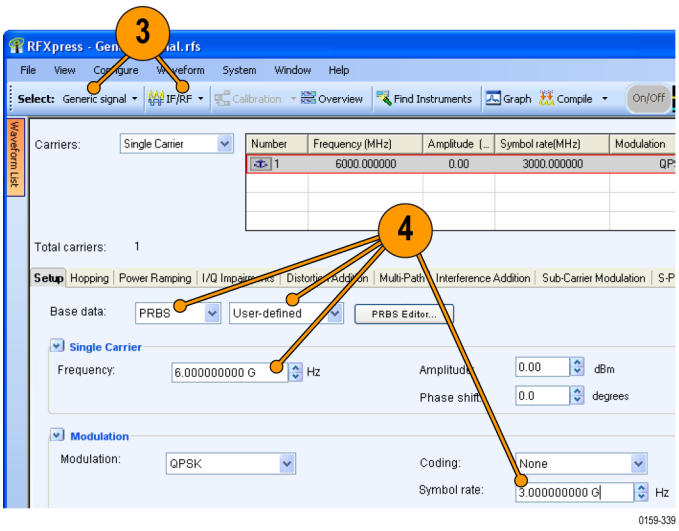


2. Start RFXpress.

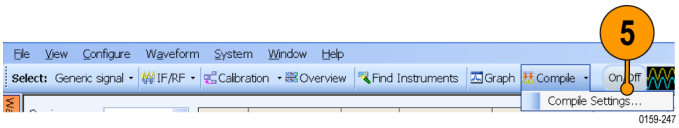
3. From the toolbar, click **Select > Generic signal** and signal type to IF/RF.

4. For the carrier, set the following:

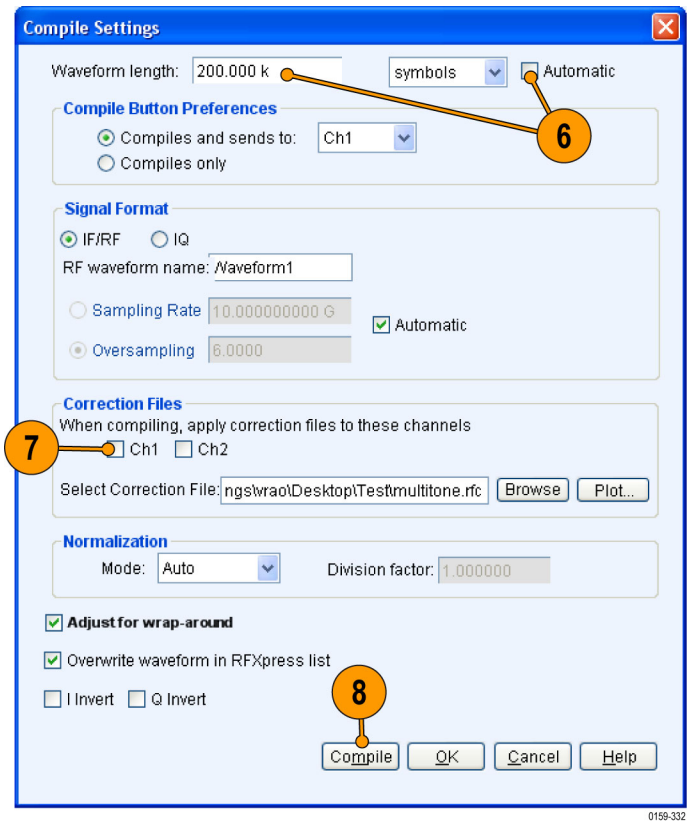
   - **Base data** to PRBS and User Defined.
   - **Frequency** to 6 GHz.
   - **Symbol rate** to 3 GHz.



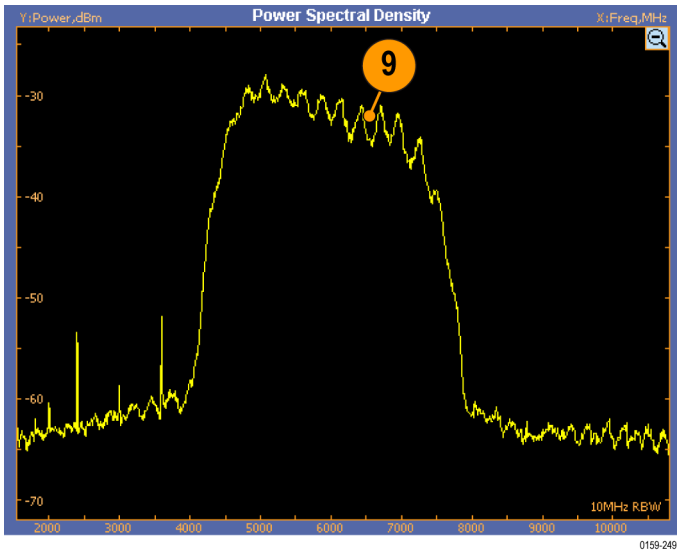
5. From the toolbar, click **Compile > Compile Settings**.



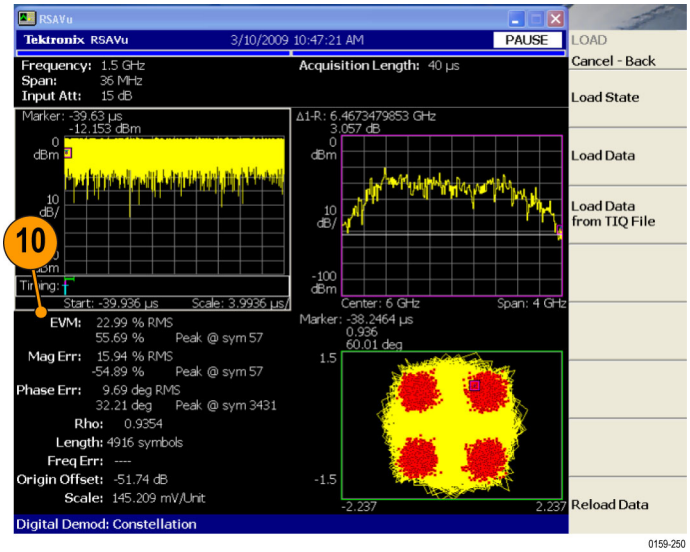
6. Disable **Automatic** and set the **Waveform length** to 200 k symbols.
7. Ensure that **When compiling, apply correction files to these channels** is disabled.
8. Click **Compile**.



9. Capture the waveform in the oscilloscope. The signal spectrum is observed using Tektronix Ultra Wideband Spectral Analysis software.

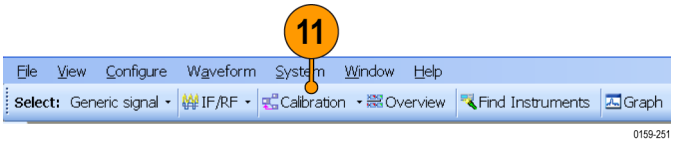


10. Note that the EVM value before calibration is 22.99%.



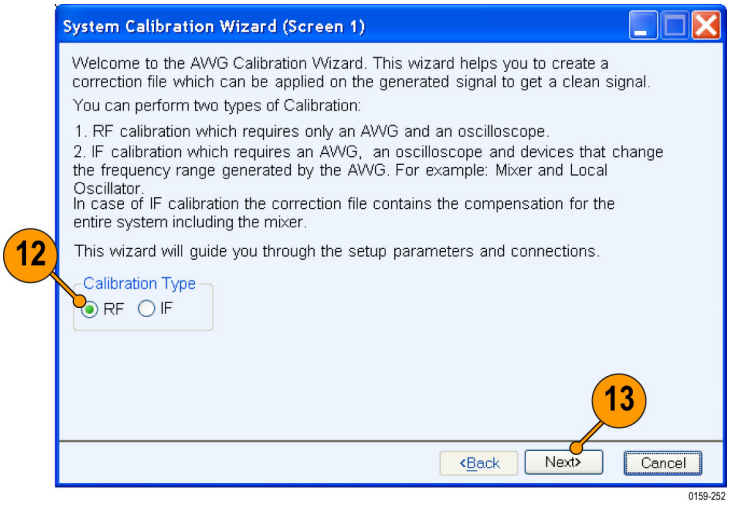
11. From the toolbar, click **Calibration**.

NOTE. *You will be prompted with a message to compile your setup, if you have not already done so. Click Continue to proceed with calibration.*



12. The Calibration wizard opens. Ensure that the signal type is RF.

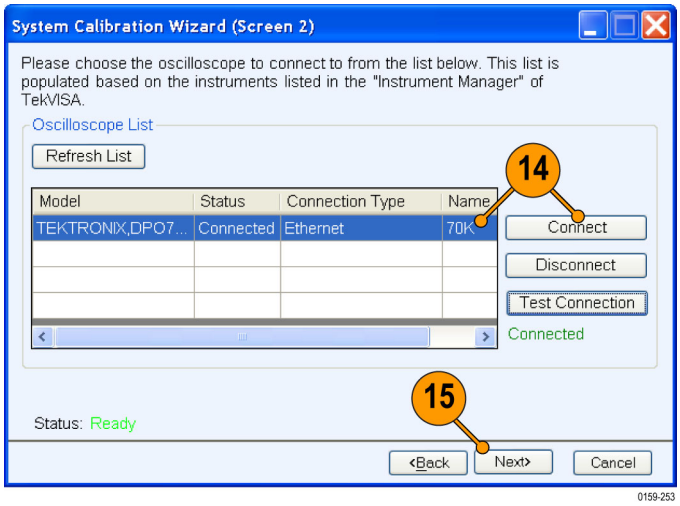
13. Click **Next**.



14. The wizard displays a table of instruments connected on the network. Select the DPO oscilloscope and click **Connect**. Note that the status changes to Connected.

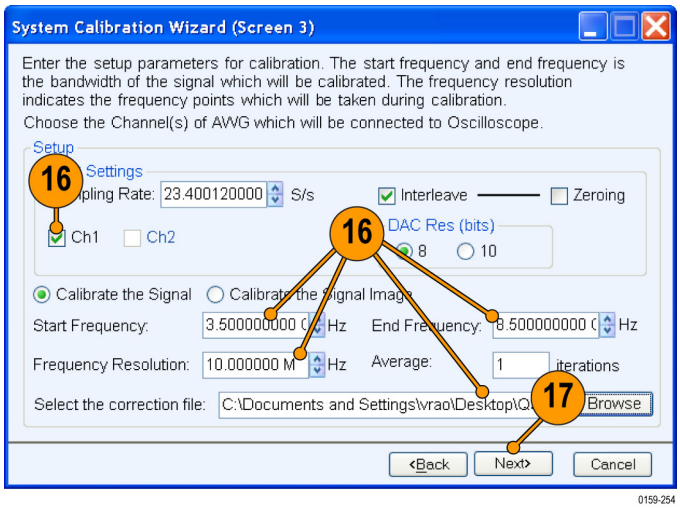
NOTE. *You can click Test Connection to test the status of the instrument.*

15. Click **Next**.



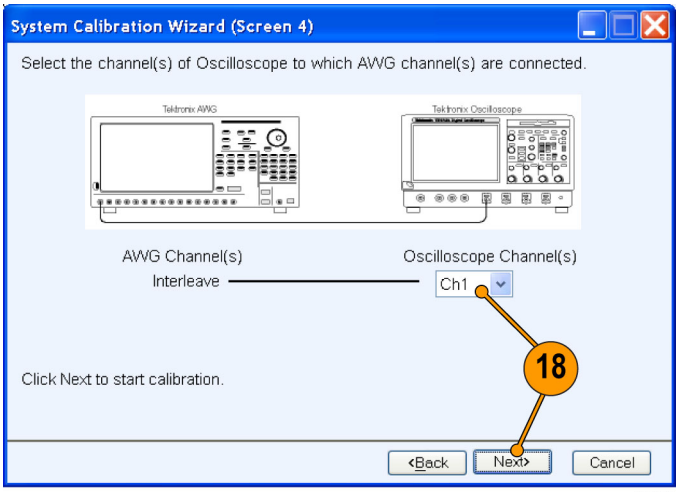
16. Set the following:

- **Start Frequency** to 3.5 GHz.
- **End Frequency** to 8.5 GHz.
- **Frequency Resolution** to 10 M.
- **Select the correction file** name to generate the correction file.
- Select **Ch1**.

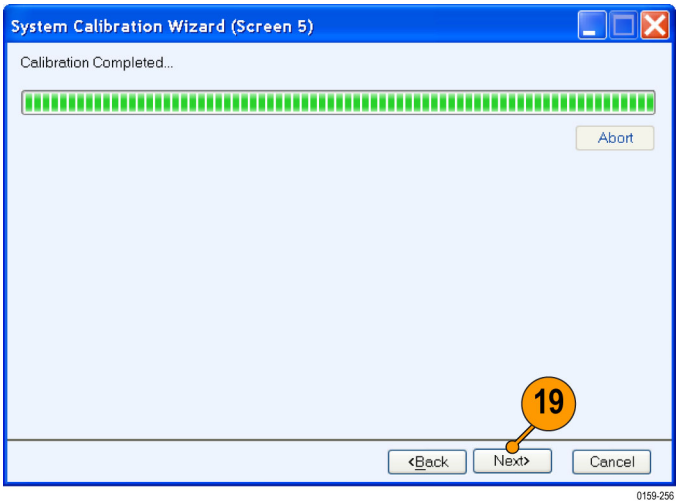


17. Click **Next**.

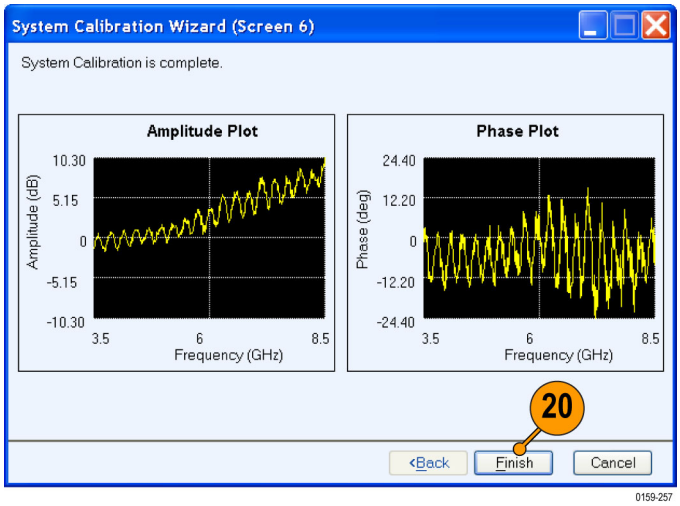
18. Set the oscilloscope channel to Ch1. Click **Next** to start calibration.



19. Once the calibration is complete, click **Next** to display the phase and amplitude plots.

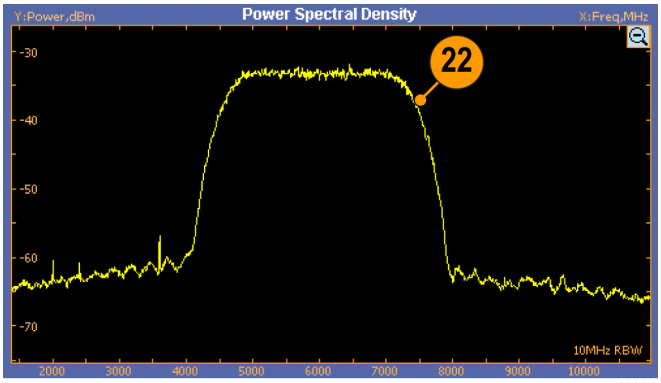


20. Click **Finish** to exit the wizard.

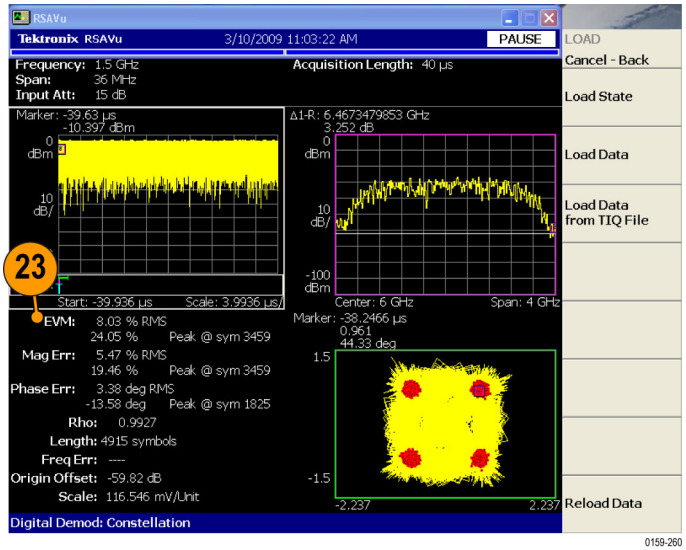


21. From the toolbar, click **Compile**.

22. Capture the calibrated waveform in the oscilloscope. The signal spectrum is observed using Tektronix Ultra Wideband Spectral Analysis software.



23. Note that the EVM value after calibration is 8.03%.



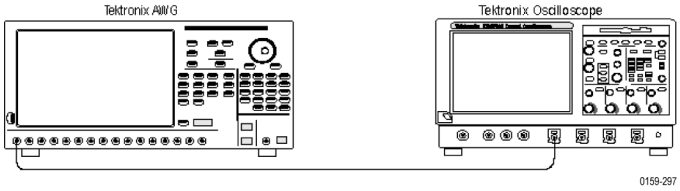
Applying Calibration to an Imported Custom Signal

In this example, you import an OFDM signal (not created using RFXpress) and calibrate it.

1. Set up the instruments as shown. The instruments must be connected over a LAN.

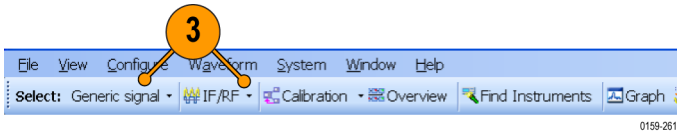
   You will need:

   - A Tektronix arbitrary waveform generator, such as AWG7122B with Option 06, running RFXpress software.
   - A Tektronix DPO oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
   - Connecting cable.

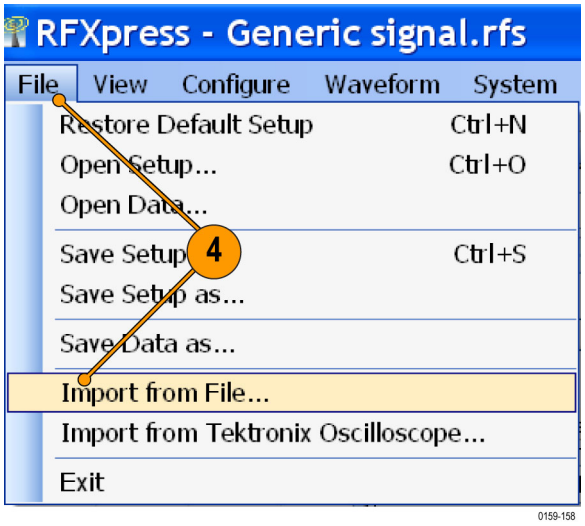


2. Start RFXpress.

3. From the toolbar, click **Select > Generic signal** and set the signal type to IF/RF.

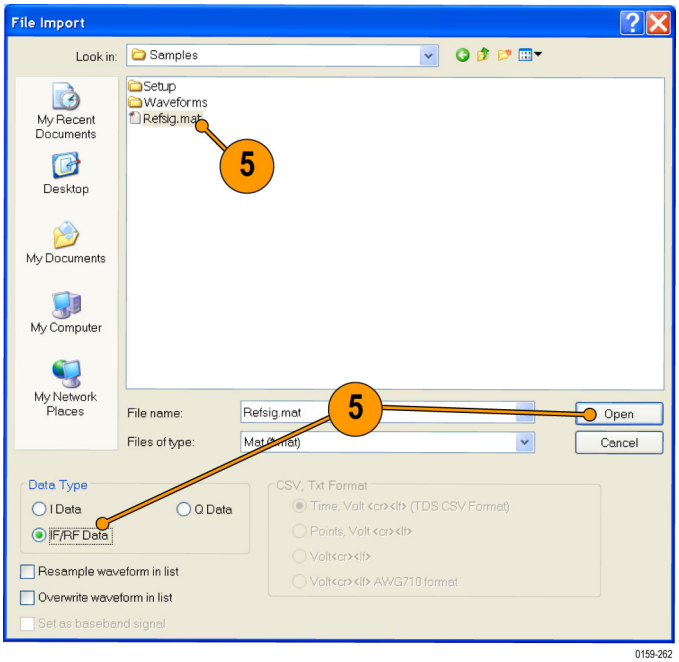


4. Select **File > Import from File**.



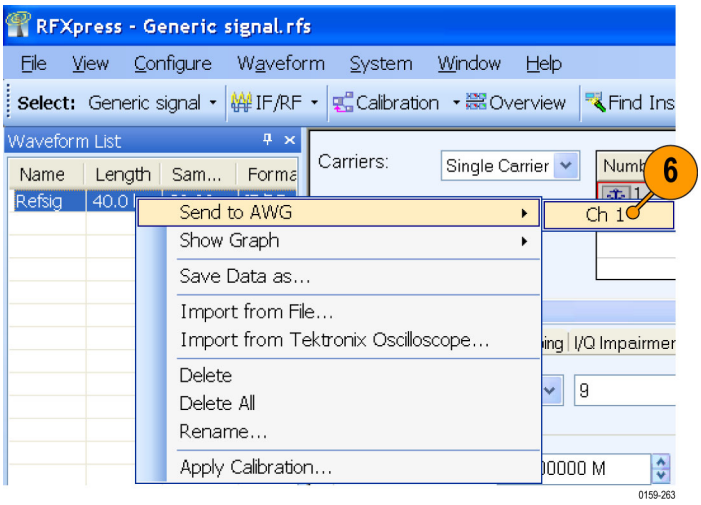
5. Select a file, for example RefSig.mat. Set the **Data Type** to IF/RF Data and click **Open**. RefSig.mat represents an OFDM signal that cannot be directly generated using RFXpress.

NOTE. *If you import a .txt file, you are prompted to enter the sampling rate.*

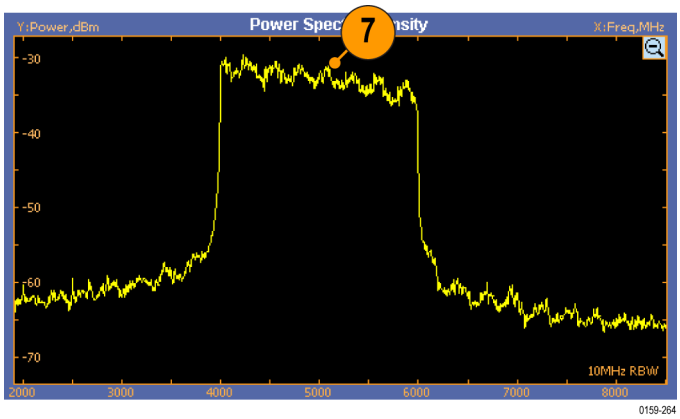


6. Select the signal and right-click. Select **Send to AWG > Ch 1**.

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



7. Capture the waveform on the oscilloscope and observe the signal spectrum using Tektronix Ultra Wideband Spectral Analysis software. Note that the frequency response is not flat.



8. From the toolbar in RFXpress, click **Calibration**. The calibration wizard opens.

9. Ensure that the signal type is RF and click **Next**.

10. From the table of instruments connected on the network, select a Tektronix oscilloscope and click **Connect**. Note that the status changes to Connected. Click **Next**.

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

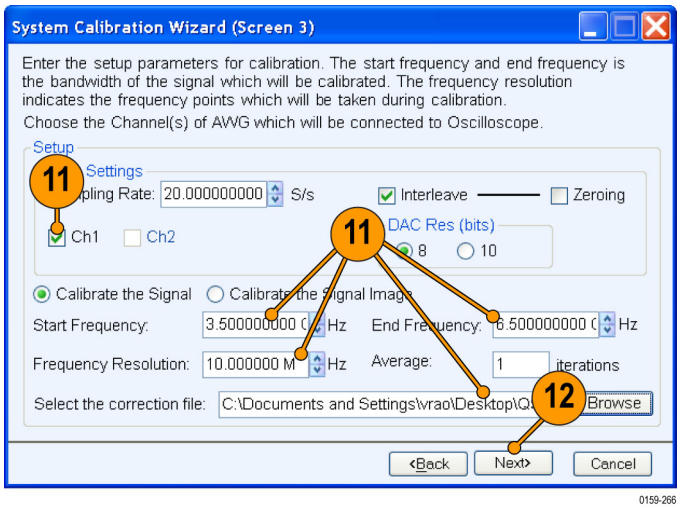
11. Set the following:

- **Start Frequency** to 3.5 GHz.
- **End Frequency** to 6.5 GHz.

NOTE. *The start and end frequencies correspond to the bandwidth of the imported OFDM signal.*

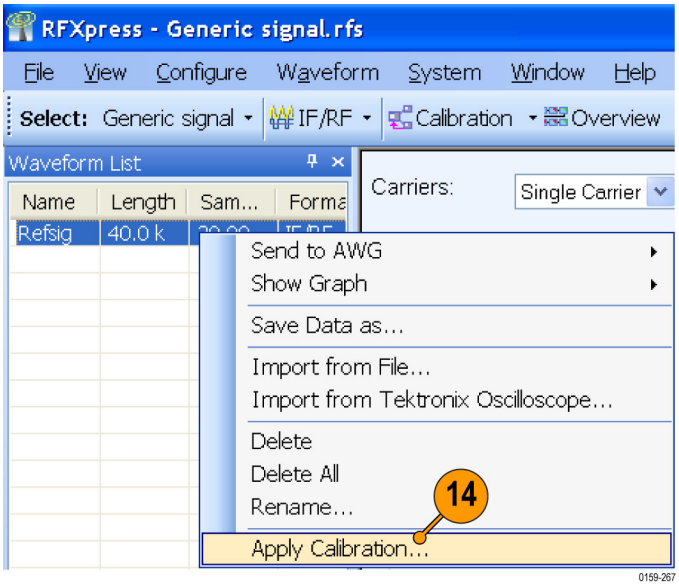
- **Select the correction file** name to generate the correction file.
- Select **Ch1**.

12. Click **Next**.



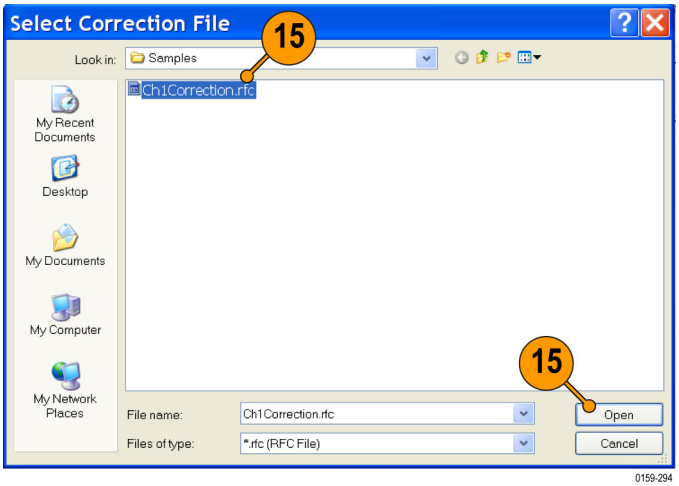
13. Once the calibration is complete, click **Next** to display the amplitude and phase plots. Click **Finish** to exit the wizard.

14. In the waveform list, select the signal and right-click. Select **Apply Calibration**.

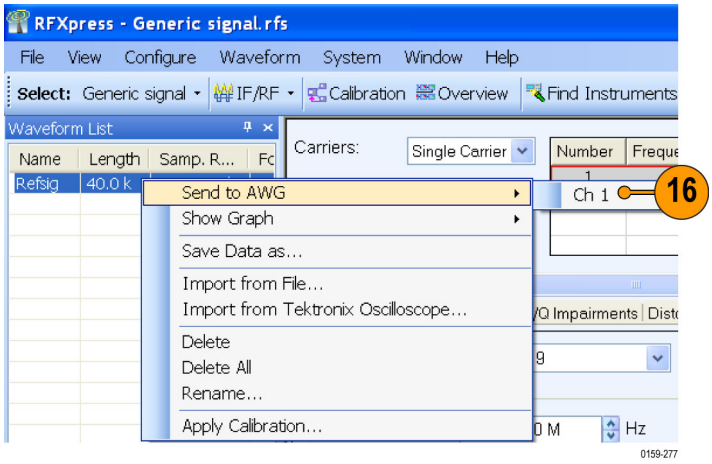


15. Select the correction file that was created during calibration and click **Open**.

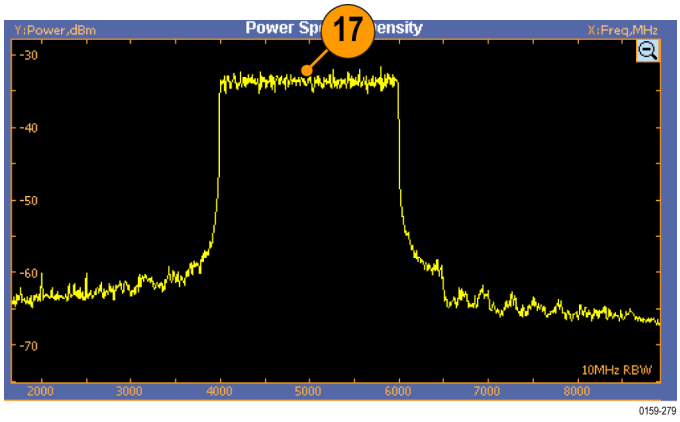
    The correction file is applied to the existing imported signal.



16. To see the calibrated signal in the AWG, select the file, right-click, and choose **Send to AWG > Ch 1**.



17. Capture the waveform on the oscilloscope and observe the signal spectrum using Tektronix Ultra Wideband Spectral Analysis software. Note that the frequency response is flat.



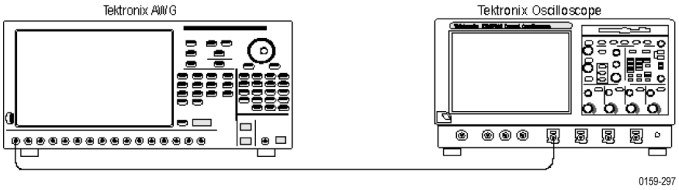
Characterizing a Low-pass Wideband Filter (DUT)

You can determine the characteristics of a device under test, a low-pass wideband filter in this case, and store these characteristics in a file. Use this file later as an input to the S-parameter feature.

1. Set up the instruments as shown. The instruments must be connected over a LAN.

   You will need:

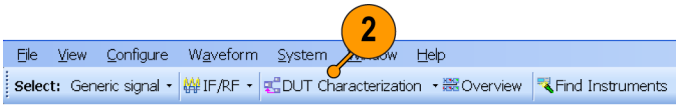
   - A Tektronix AWG7122B with Option 06, running RFXpress software.
   - A Tektronix DPO72004 oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
   - Connecting cable.
   - A low-pass wideband filter (the device under test)



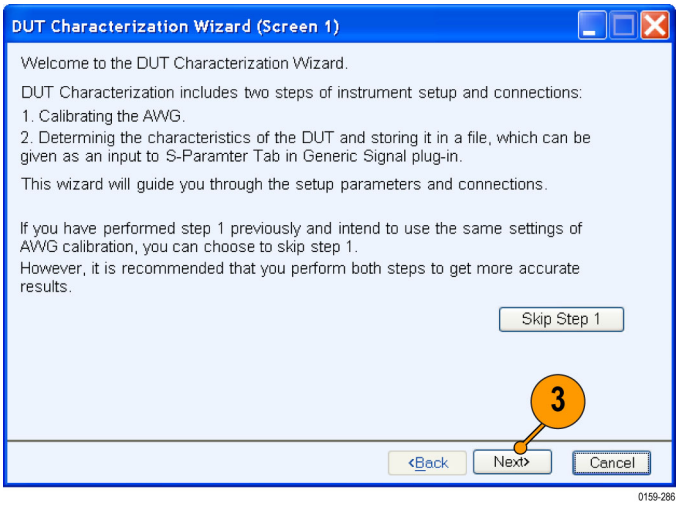
NOTE. *Ensure that the output of the AWG Interleave channel is connected to Channel 1 of the oscilloscope.*

2. Start RFXpress on the AWG7122B with Option 06.

   Select **DUT characterization** from the toolbar.



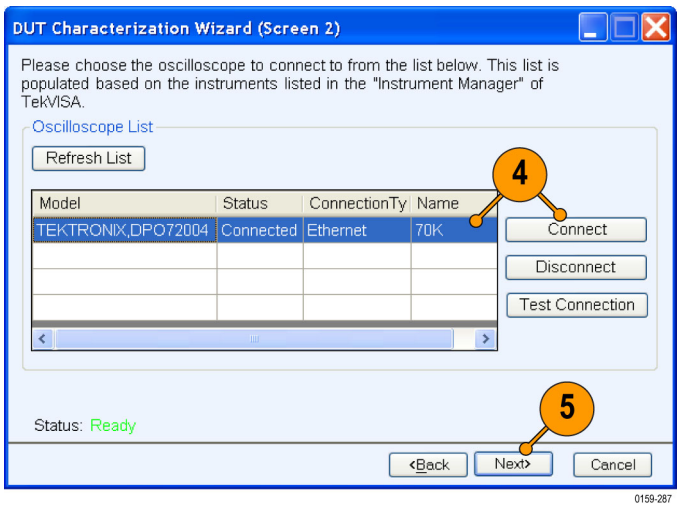
3. The DUT Characterization wizard opens. Click **Next**.



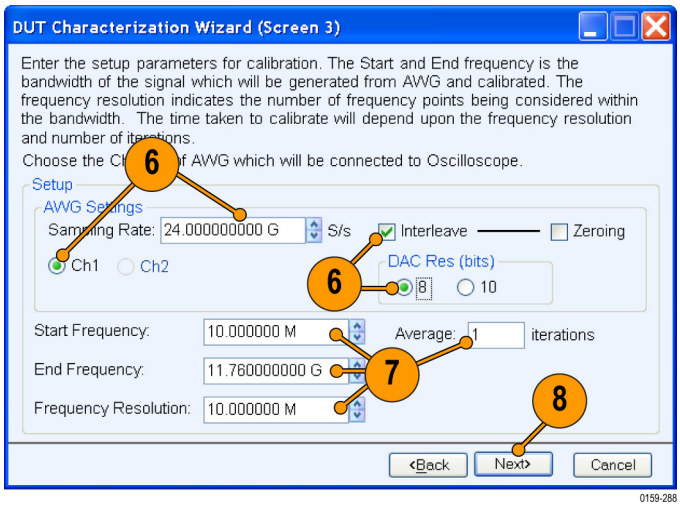
4. Select an oscilloscope from the list and click **Connect**.

NOTE. If you are unable to view a list of connected instruments, click Refresh List.

5. Click **Next**.



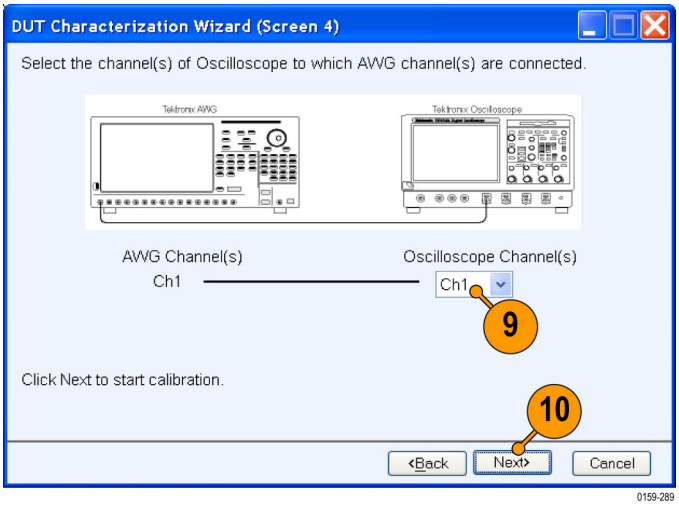
6. Set the following Setup parameters:
   - **Sampling Rate** to 24 GS/s.
   - Enable **Interleave**.
   - Select **Ch1**.
   - **DAC Res** to 8 bits.



7. Set the other parameters as follows:
   - **Start Frequency** to 10 MHz.
   - **End Frequency** to 11.76 MHz.
   - **Frequency Resolution** to 10 MHz.
   - **Average** to 1 iteration.

8. Click **Next**.

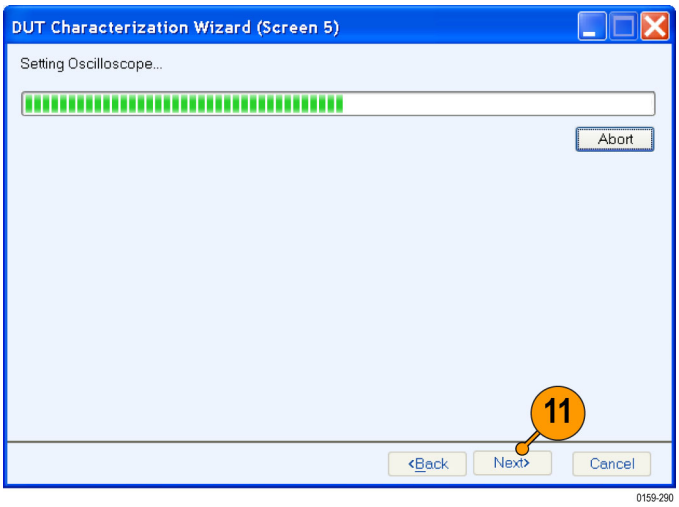
9. Select the oscilloscope channel **Ch1** to connect the AWG Interleave channel to.



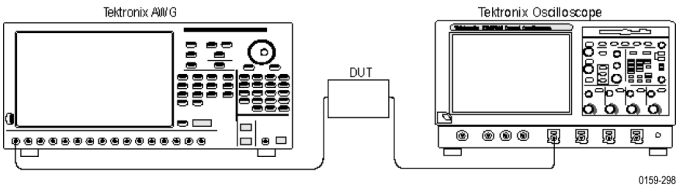
10. Click **Next** to start AWG calibration.

NOTE. *AWG calibration may take up to 10-15 minutes.*

11. Once calibration is over, click **Next**.

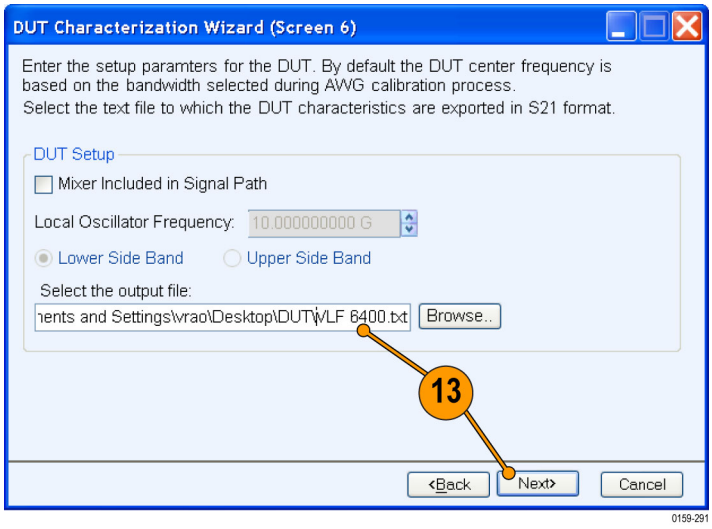


12. Add the low-pass wideband filter at channel 1 of the oscilloscope.

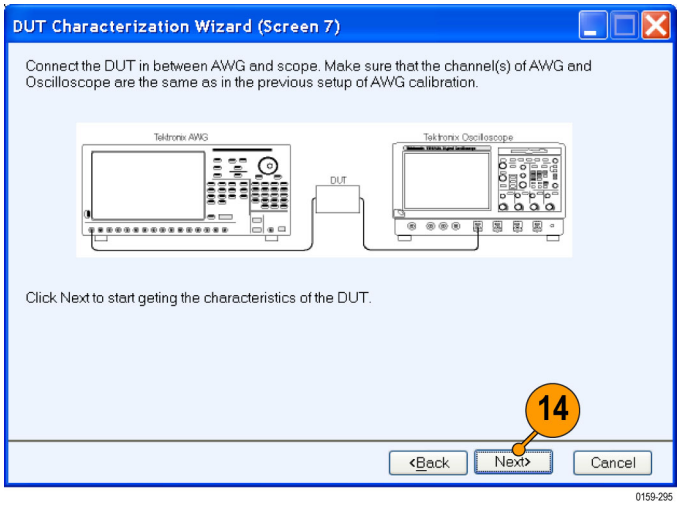


13. Specify the output file name. Click **Next**.

NOTE. *Characterizing the DUT may take up to 10-15 minutes.*



14. Click **Next**.

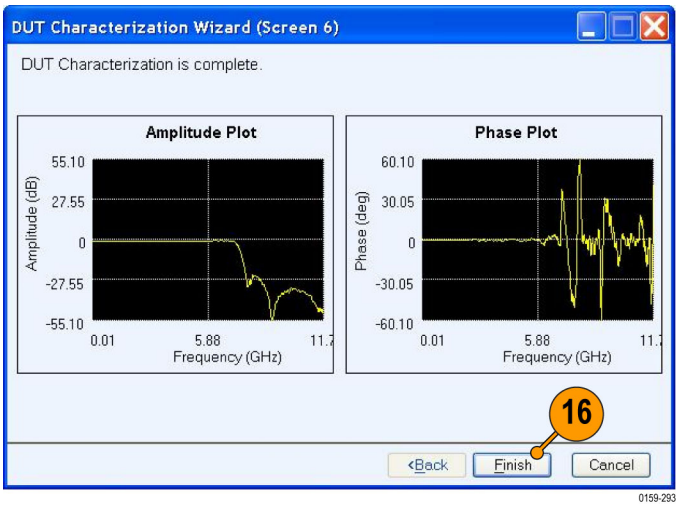


15. Click **Next**.

The wizard displays phase and amplitude plots.

16. Click **Finish** to exit the wizard.

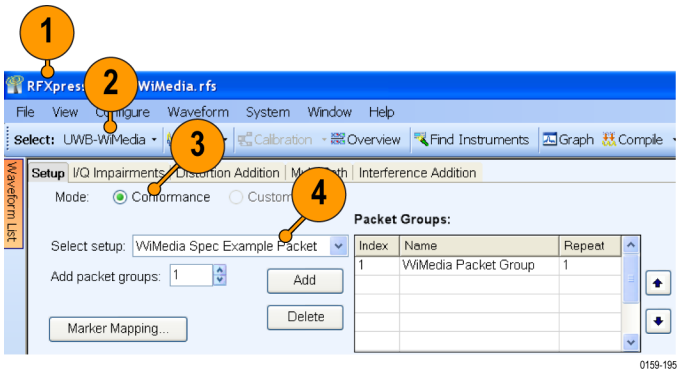
Use the file with the DUT characteristics as an input to S-parameter function.



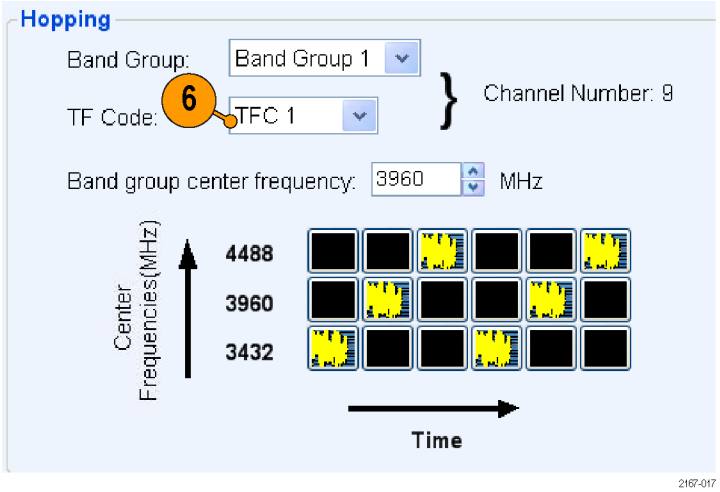
Creating a UWB Waveform to Test Your Receivers

You can create an ideal waveform and use it to test whether your receivers are operating within the WiMedia specifications.

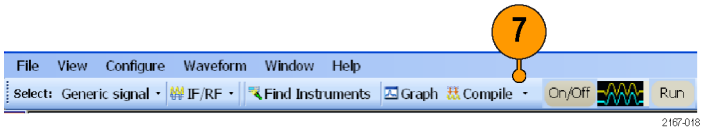
1. Start RFXpress.
2. From the toolbar, click **Select > UWB-WiMedia**.
3. By default, **Conformance** is selected.
4. From the Select Setup, select **WiMedia Spec Example Packet**.



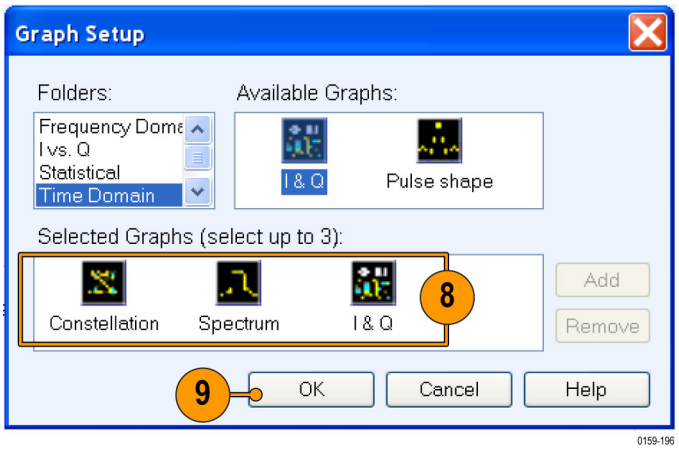
5. The **WiMedia Spec Example Packet** settings (according to Annex A of the WiMedia specification document) are displayed in the fields in each tab.
6. Confirm the **Hopping Pattern** for TF Code 1.



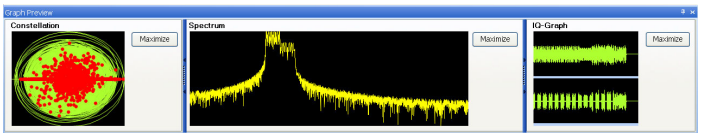
7. Click **Compile**.



8. Add the following graphs in Graph Setup:
   - Frequency Domain: Spectrum.
   - I Vs Q: Constellation.
   - Time Domain: I & Q.
9. Click **OK**.



10. The graphs are as shown.

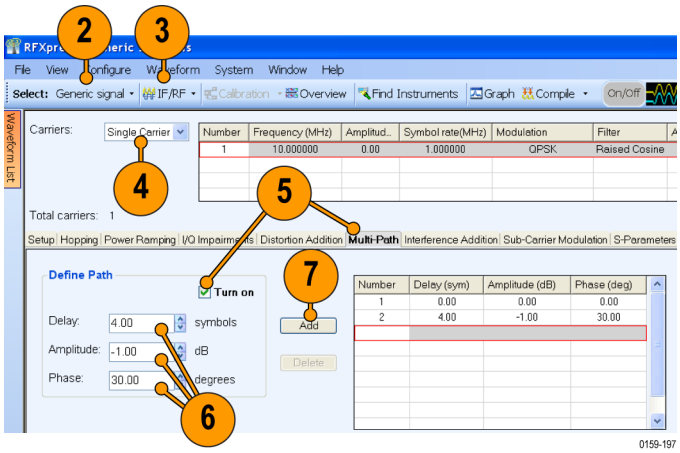


Application Examples: Generic Signal

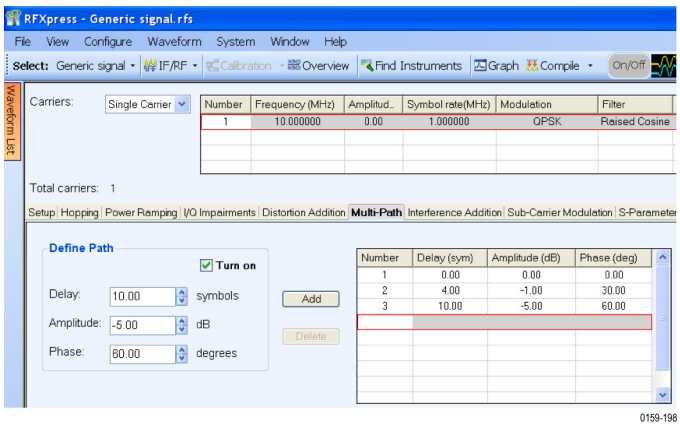
Simulating a Multi-Path Environment for a Generic Signal

You can simulate multi-path to test your receiver's response to multi-paths.

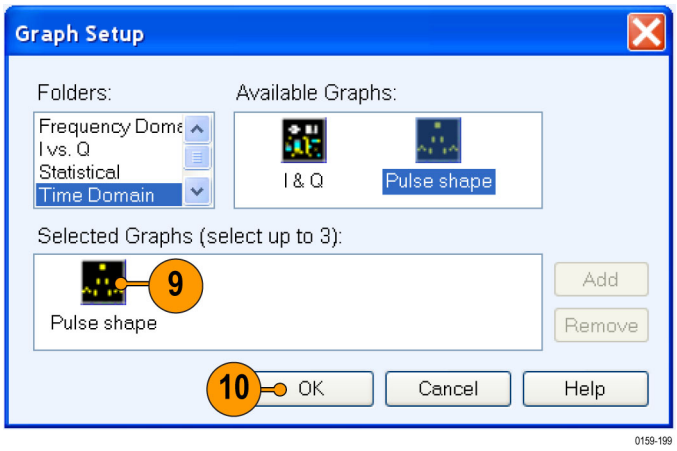
1. Start RFXpress.
2. From the toolbar, ensure that **Select > Generic signal** is selected.
3. Ensure that the signal type is set to **IF/RF**.
4. Ensure that **Single Carrier** is selected. Leave the default values for the carrier.
5. Click **Multi-Path** and select **Turn on**.



6. Set the following parameters:
   - **Delay** to 4 symbols.
   - **Amplitude** to –1 dB.
   - **Phase** to 30 degrees.
7. Click **Add**.
8. Repeat steps 6 and 7, setting the following parameters:
   - **Delay** to 10 symbols.
   - **Amplitude** to –5 dB.
   - **Phase** to 60 degrees.

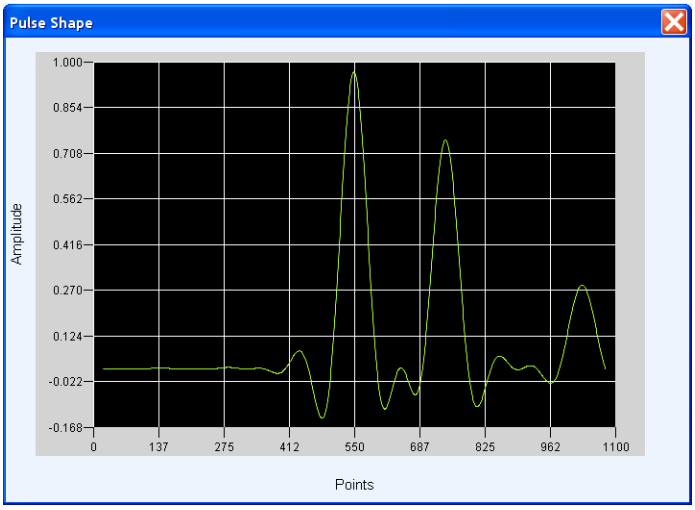


9. In Graph Setup, add the following graph: Time Domain: Pulse shape.
10. Click **OK**.



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

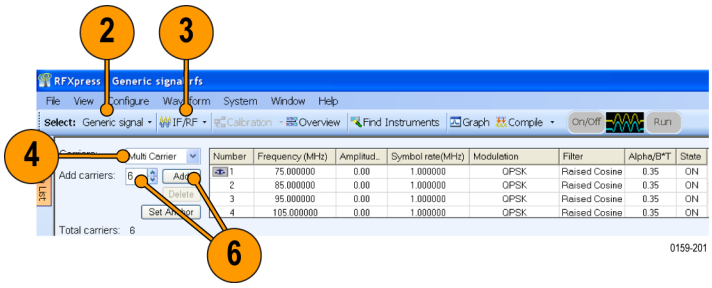
12. The pulse shape is as shown.

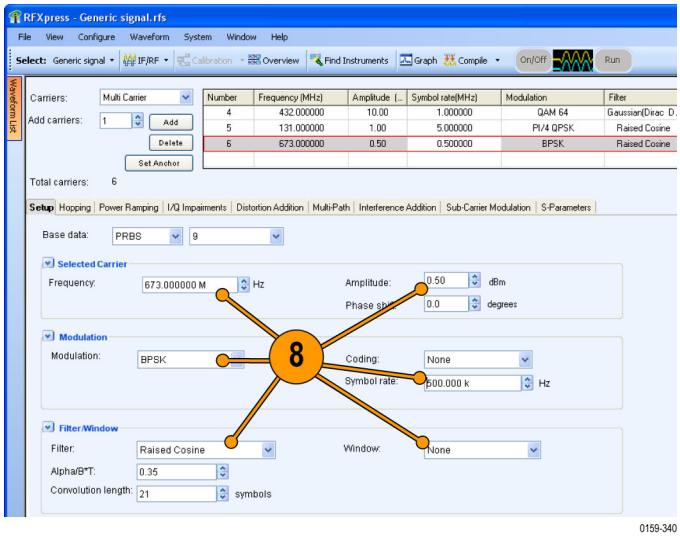


Creating a Hopping Waveform to Test Radio Signal Identification and Detection Systems

A radio signal identification and detection receiver is assigned to gather information about all transmissions in the radio band. The specific tasks of a receiver include the ability to detect and analyze the received transmission, estimate frequency and modulation type, extract intelligence (information), and locate the source. This example addresses the challenges in generating a wide range of real-world signals and hopping signals required to test these receivers.

1. Start RFXpress.
2. From the toolbar, click **Select > Generic signal**.
3. Ensure that the signal type is set to **IF/RF**.
4. Select **Carrier** to Multi-Carrier.
5. Select the carrier in the table and click Delete.
6. In **Add carriers**, enter 6 and click **Add**.
7. Select the carriers one after another, starting with the first carrier.
8. Enter the values for each carrier as in Table 1. (See page 39.)





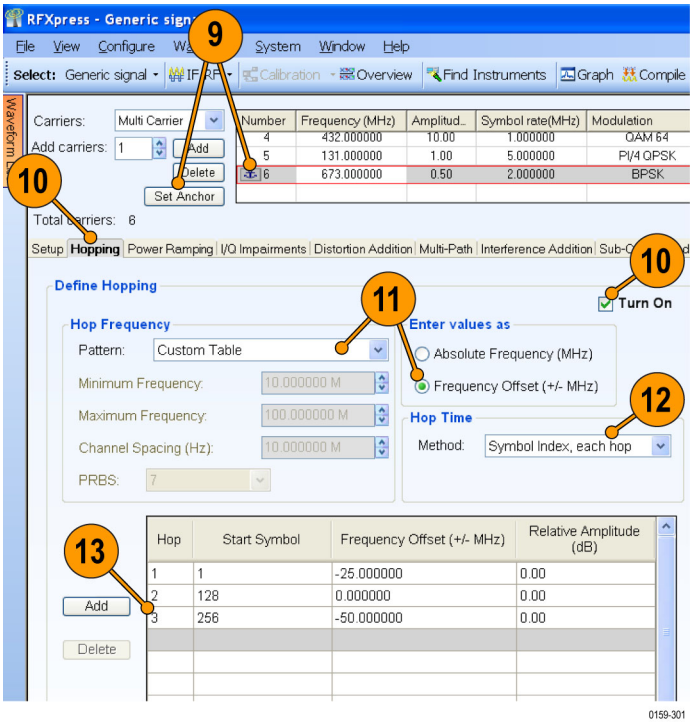
9. Select the sixth carrier and click **Set Anchor**.

10. Click the **Hopping** tab and select **Turn on**.

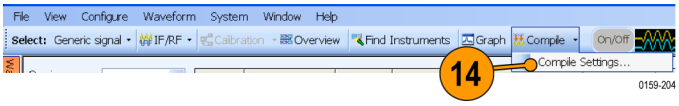
11. Ensure that the Hop Frequency **Pattern** is set to Custom Table and Enter values as is set to **Frequency Offset**.

12. Set the Hop Time **Method** to Symbol Index, each Hop.

13. Update the values as shown in Table 2 for each carrier: (See page 40.)

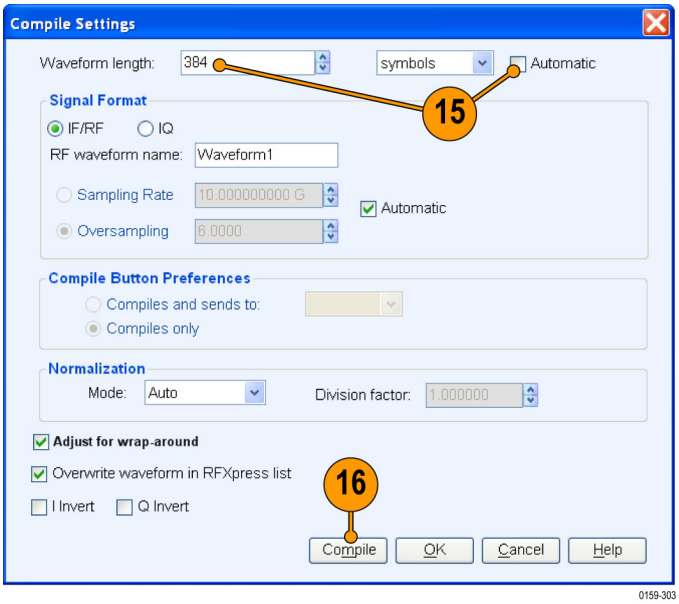


14. From the toolbar, click **Compile > Compile Settings**.

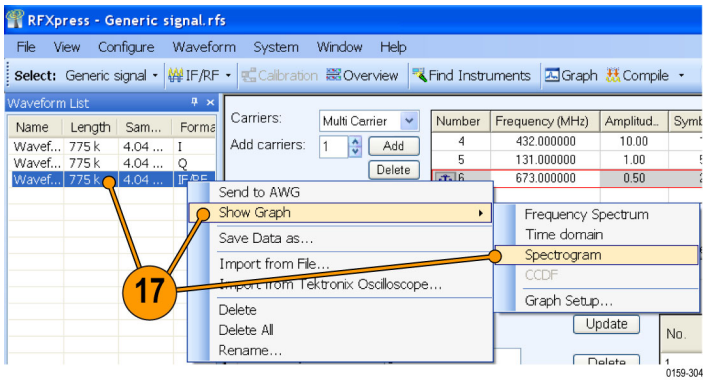


15. Disable **Automatic** and set **Waveform length** to 384 symbols.

16. Click **Compile**.



17. From the waveform list, select an IF/RF waveform. Right-click and select **Show Graph > Spectrogram**.



18. The spectrogram is as shown.

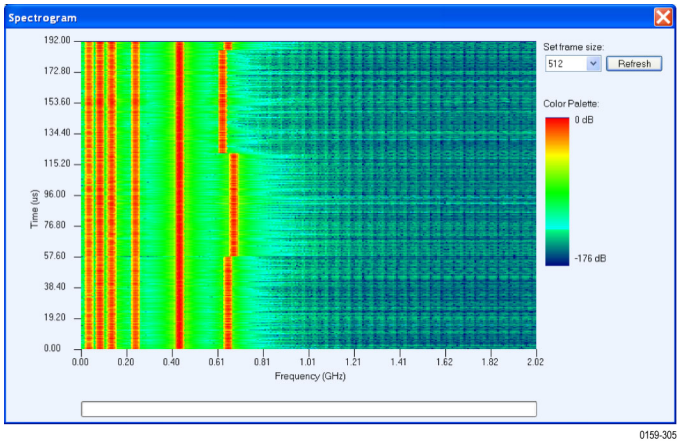


Table 1: Carrier parameters

Signal number	Carrier frequency (MHz)	Amplitude (dBm)	Modulation	Symbol rate (MHz)	Filter	Window
1	31	–6	QPSK	0.5	RC	Blackman
2	79	0	8-PSK	2	Root Raised Cosine	Hamming
3	237	4	FM	30 KHz	-	None
4	432	10	64-QAM	1	Gaussian (Dirac Delta)	Hamming
5	131	1	Pi 1/4 QPSK	5	RC	Blackman
6	673	0.5	BPSK	2	RC	None

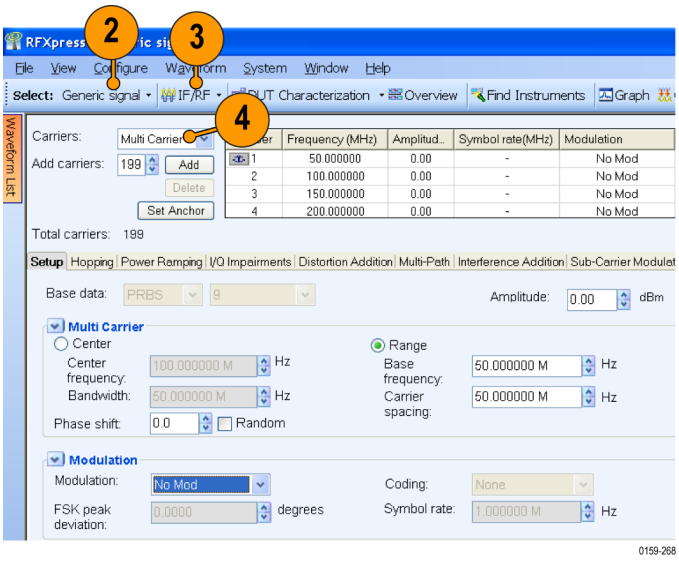
Table 2: Hopping parameters

Signal number	Start symbol	End symbol	Relative amplitude (dB)	Frequency offset (MHz)
1	1	127	0	–25
2	128	255	0	0
3	256	384	0	–50

S-Parameter Emulation of a High Pass Filter

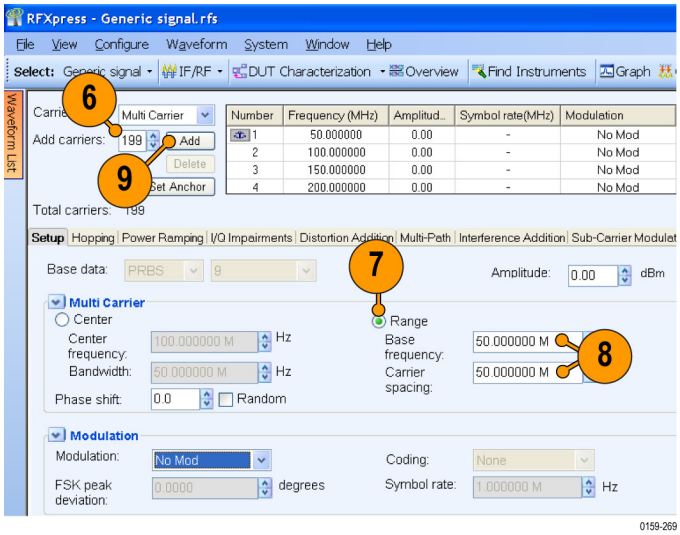
This example emulates the high pass filter on multitones from 50 MHz to 9.95 GHz and applies the high-pass filter S-parameter characteristics on a calibrated multitone signal. To calibrate a signal, see the calibration procedure. (See page 16, *Calibrating a Generic Signal*.)

1. Start RFXpress.
2. From the toolbar, click **Select > Generic signal**.
3. Ensure that the signal type is set to **IF/RF**.
4. Set **Carriers** to Multi Carrier.



5. Select the carrier and click **Delete**.

6. In **Add carriers**, type 199 and press Enter.
7. Click **Range**.

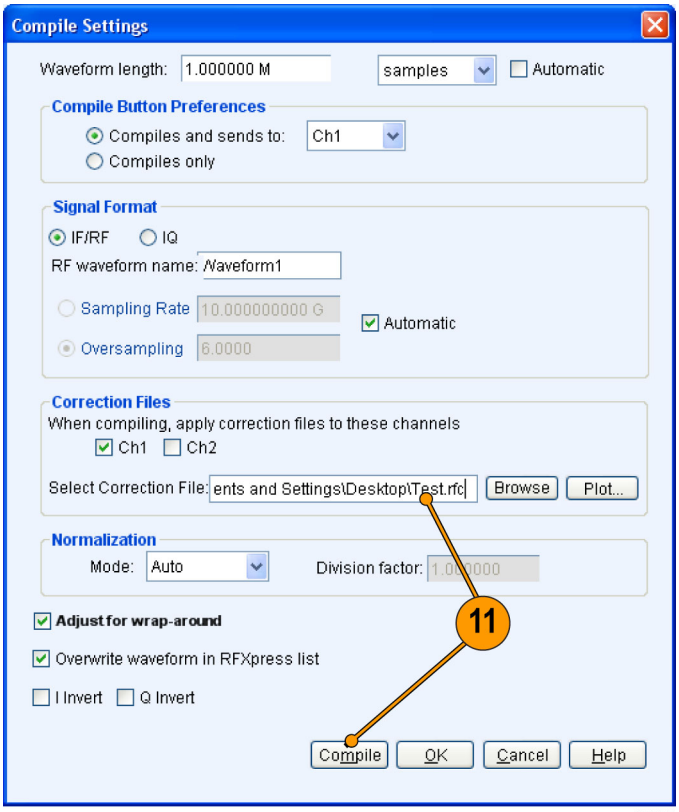


8. Set the following:
   - **Base frequency** to 50 M.
   - **Carrier spacing** to 50 M.
9. Click **Add**.

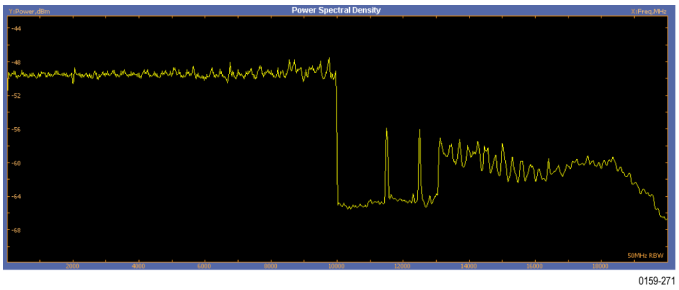
10. From the toolbar, click **Compile Settings**.

11. Select the correction file (created during calibration), and click **Compile**.

To create the correction file, refer to the calibration procedure. (See page 16, *Calibrating a Generic Signal*.)



12. Capture the waveform in the oscilloscope. The signal spectrum is observed using Tektronix Ultra Wideband Spectral Analysis software.



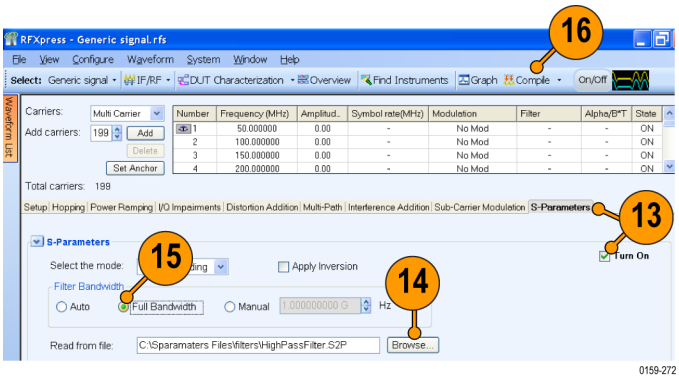
13. Click the **S-Parameters** tab and select Turn On.

14. Browse the Touchstone file to emulate. This example uses a .s2p file for a high-pass filter with a cut-off of 5.5 GHz.

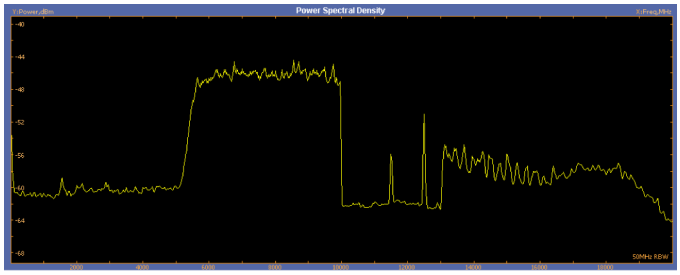
15. Select **Full Bandwidth**.

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

NOTE. *In the message box, click* ***Continue*** *to proceed.*

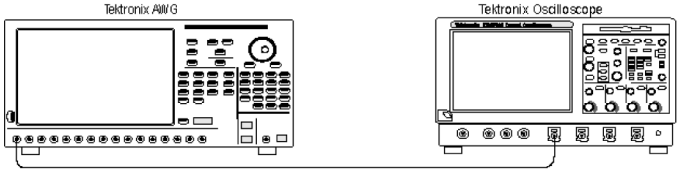


17. Observe the signal spectrum using Tektronix Ultra Wideband Spectral Analysis software.



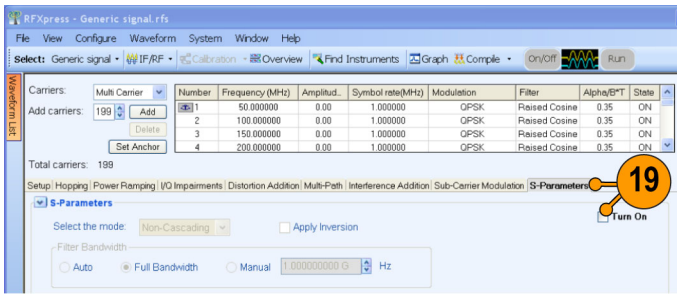
0159-273

18. To verify the spectrum and the S-parameter, connect a high-pass filter (DUT) as shown.



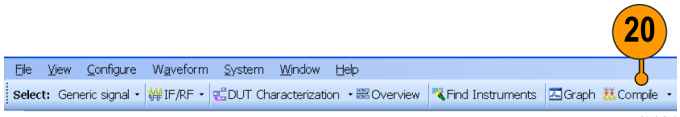
0159-297

19. Click the **S-Parameters** tab and select **Turn On** (to turn it off).



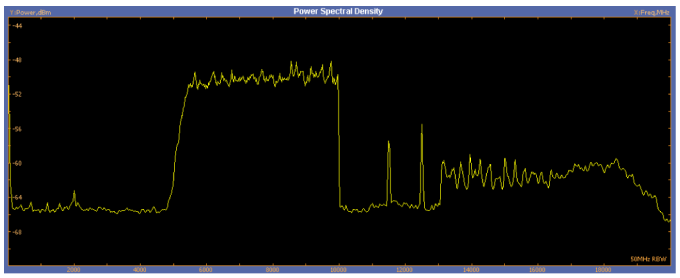
0159-296

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



0159-274

21. Observe the signal spectrum using Tektronix Ultra Wideband Spectral Analysis software.



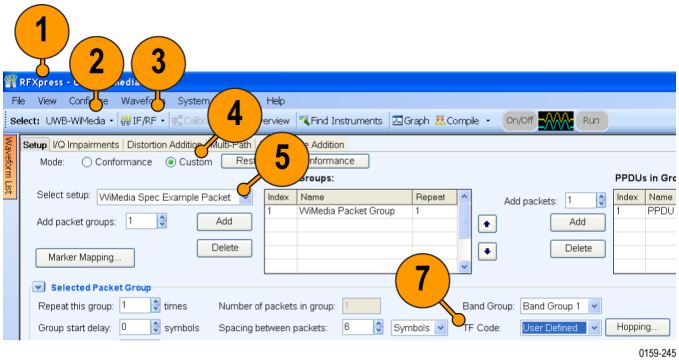
0159-275

Application Examples: UWB-WiMedia

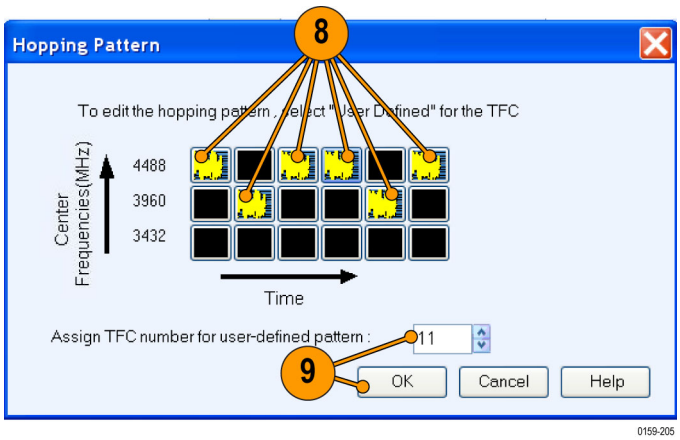
Characterize Receiver Design for Receiver Verification and Stress Test

You can generate a signal and use it to test your receiver at conditions just outside the boundary values specified by the WiMedia standard.

1. Start RFXpress.
2. From the toolbar, click **Select > UWB-WiMedia**.
3. Set the signal type to **IF/RF**.
4. Select **Custom**.
5. From the Select Setup, select **WiMedia Spec Example Packet**.
6. The default values for the selected setup and packet are shown graphically.
7. For the selected packet group, set **TF Code** to User Defined.

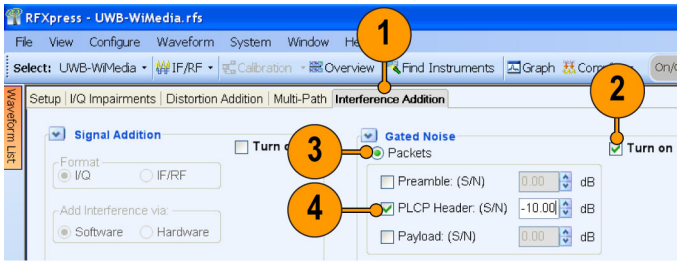


8. To define a hopping pattern: In each column, click the frequency that you want to use. Set the hopping pattern to: 323323.
9. Assign a TFC number for the pattern that you defined and click **OK**.



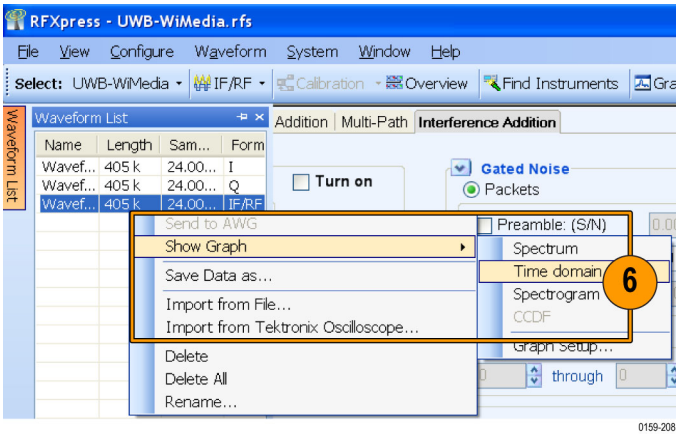
Adding Interference

1. Click **Interference Addition**.
2. In the Gated Noise group, select **Turn on**.
3. Click **Packets**.
4. Click **PLCP Header** and set it to –10.0.

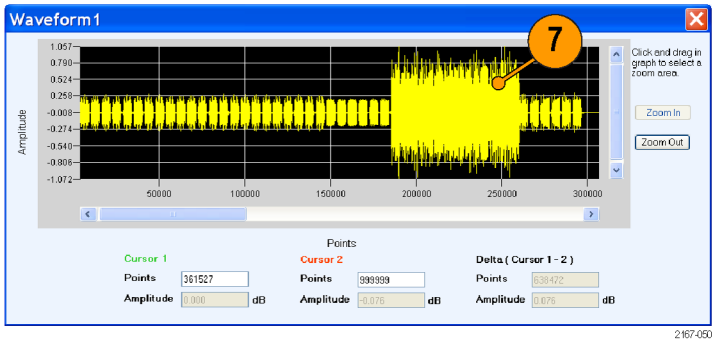


5. From the toolbar, click **Compile**.

6. In the Waveform List, select the IF/RF waveform and right-click. Select **Show Graph > Time domain**.



7. Observe the noise in the header. The noise of 10 dB is greater than the signal.



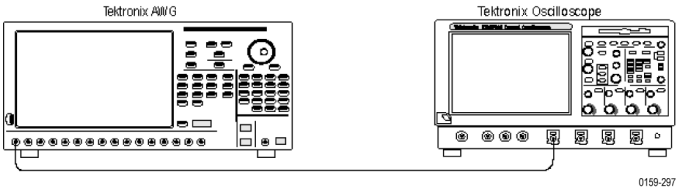
Using Calibration to Increase the Flatness of a UWB Signal Path to the DUT

The calibration feature allows you to generate correction files that you can use during compilation to predistort the signal, thereby increasing the flatness of the signal.

1. Set up the instruments as shown. The instruments must be connected over a LAN.

   You will need:

   - A Tektronix AWG7122B with Option 06, running RFXpress software.
   - A Tektronix DPO70804 oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
   - Connecting cable.

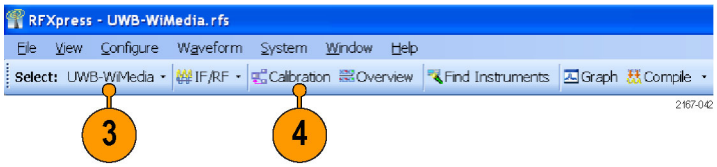


NOTE. *Ensure that the output of the AWG Interleave channel is connected to Channel 1 of the oscilloscope.*

2. Start RFXpress.

3. From the toolbar, click **Select > UWB-WiMedia**.

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



5. The Calibration window displays a table of instruments connected on the network. Select the DPO70804 oscilloscope and click **Connect**. Note that the status changes to Connected.

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

6. Set the signal type to **RF**.

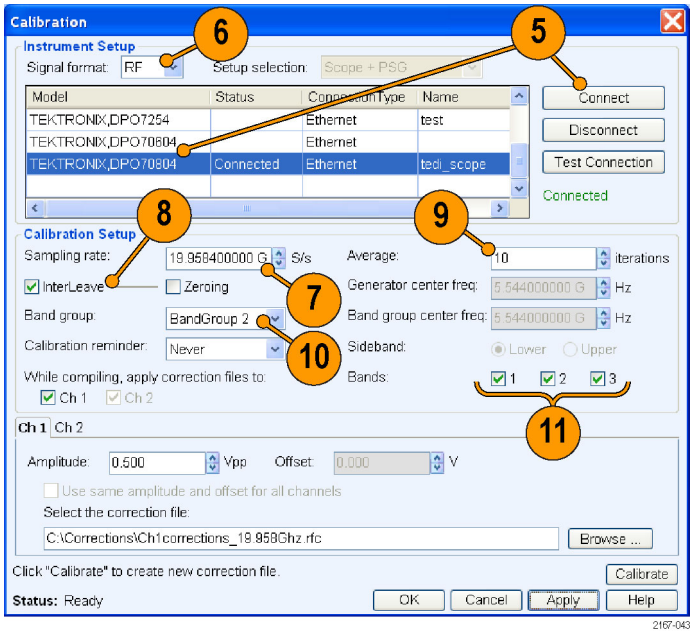
7. Set the **Sampling rate** to 19.996576 GS/s.

8. Select **InterLeave**.

9. Set the **Average** to 10.

10. Set the **Band group** to 2.

11. Select **Bands**: 1, 2, and 3.



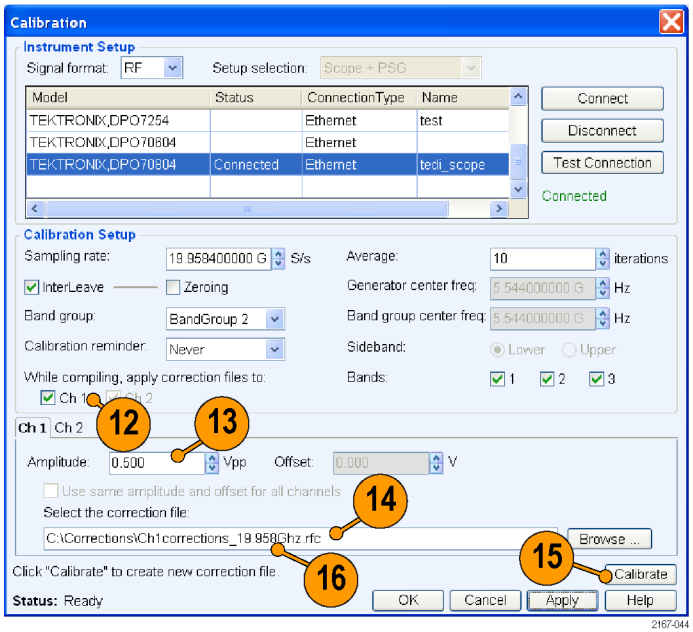
12. Set **While compiling, apply correction files to** to Ch1.

13. Set the **Amplitude** for Ch 1 to 0.5 Vpp.

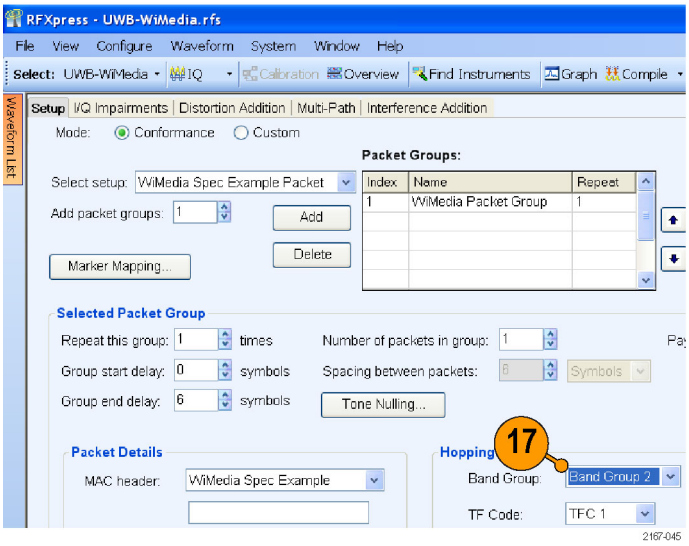
14. Set the path for **Select the correction file**.

15. Click **Calibrate** to create the correction file (.rfc). The calibration status is continually updated.

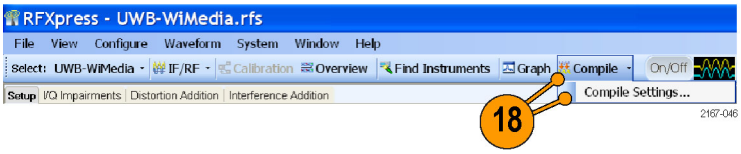
16. Confirm that the correction file that was just generated is selected.



17. Set **Band Group** to Band Group 2.



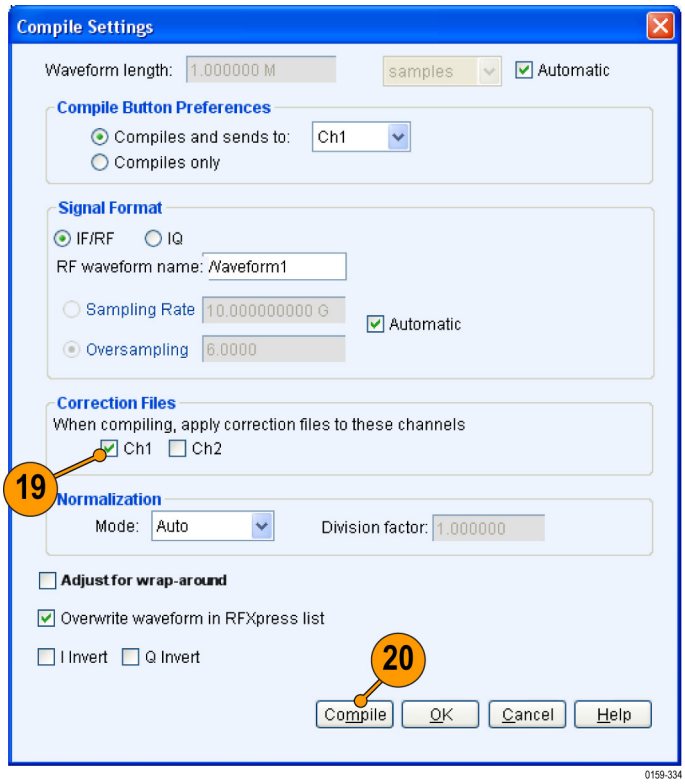
18. From the toolbar, click **Compile > Compile Settings**.



19. Ensure that the correction file created during calibration is applied to Ch1.

NOTE. *Oversampling is calculated automatically to achieve a sampling rate of 19.996576 GS/s.*

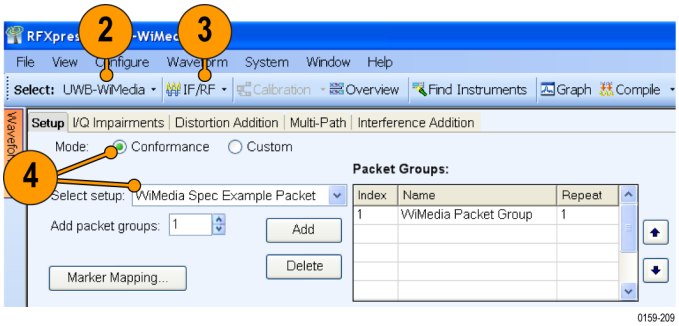
20. Click **Compile**.



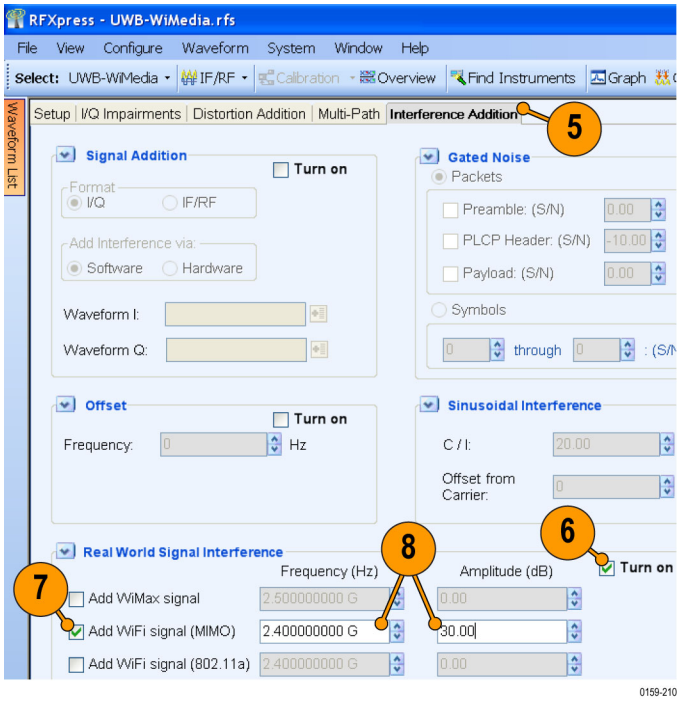
Introducing Real-World Impairments in a UWB Signal

You can introduce real-world impairments in a UWB signal to test your receiver in a simulated real-world environment.

1. Start RFXpress.
2. From the toolbar, click **Select > UWB-WiMedia**.
3. Ensure that the signal type is set to **IF/RF**.
4. Ensure that the **Mode** is Conformance and the **Selected setup** is WiMedia Spec Example Packet. Leave the default values for the selected setup.

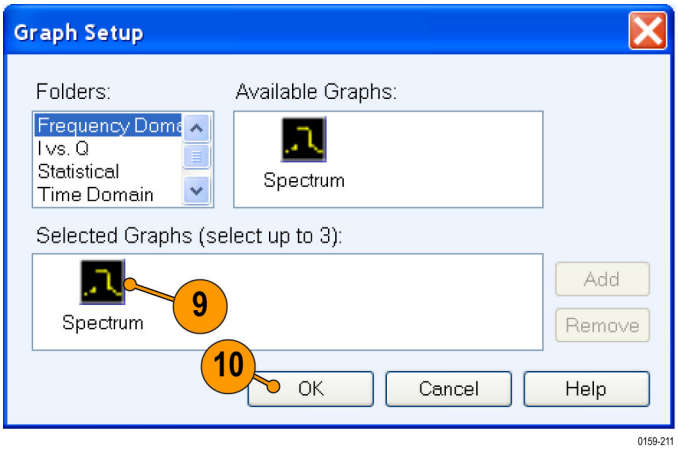


5. Click **Interference Addition**.
6. In the Real World Signal Interference group box, click **Turn on**.
7. Click **Add WiFi signal (MIMO)**.
8. Set the following parameters:
   - **Frequency** to 2.4 GHz (default).
   - **Amplitude** to 30 dB.



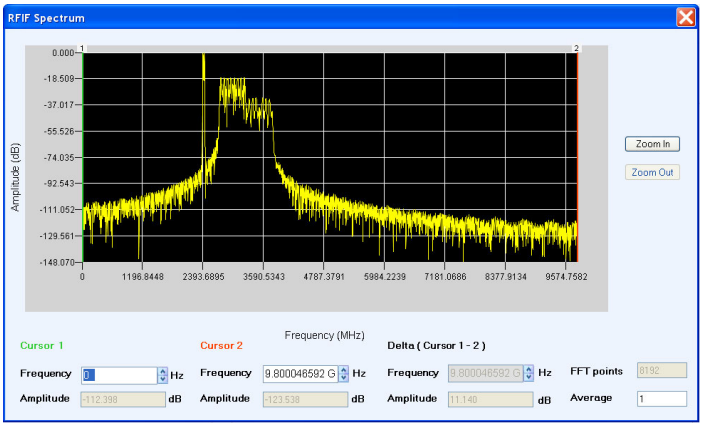
9. In Graph Setup, add the following graph: Frequency Domain: Spectrum

10. Click **OK**.



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

12. The spectrum is as shown.

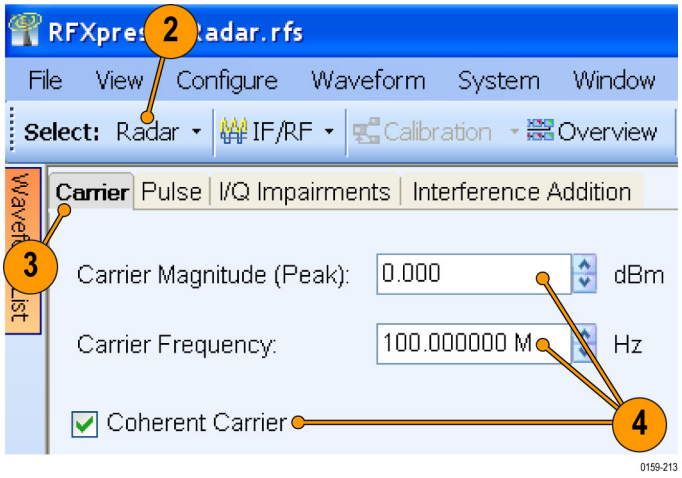


Application Examples: Radar

Generating an LFM Waveform with Coherent Carrier for Pulse Compression Radar

Use the Radar plug-in to generate an LFM waveform with coherent carrier for pulse compression radar.

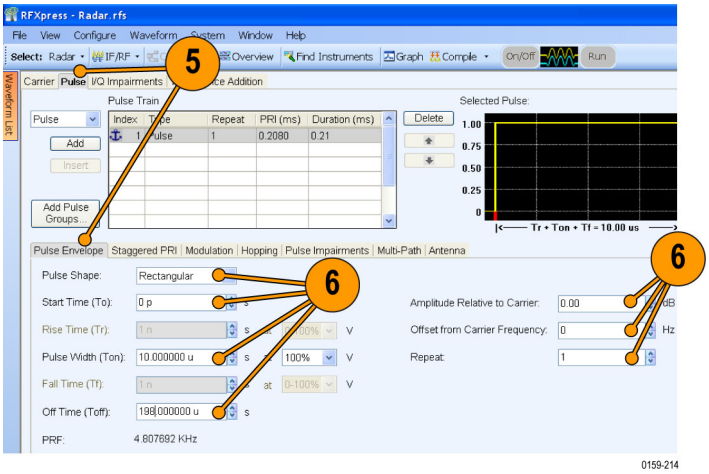
1. Start RFXpress.
2. From the toolbar, click **Select > Radar**.
3. Click the **Carrier** tab.
4. Keep the following defaults:
   - **Carrier Magnitude (Peak)** to 0 dBm.
   - **Carrier Frequency** to 100 MHz.
   - **Coherent Carrier** is selected.



5. Select the **Pulse** tab and select the **Pulse Envelope** tab.

6. Set the following:

   - **Pulse Shape** to Rectangular (default).
   - **Start Time** to 0 ps (default).
   - **Pulse Width** to 10 µs at 100%.
   - **Off Time** to 198 µs.



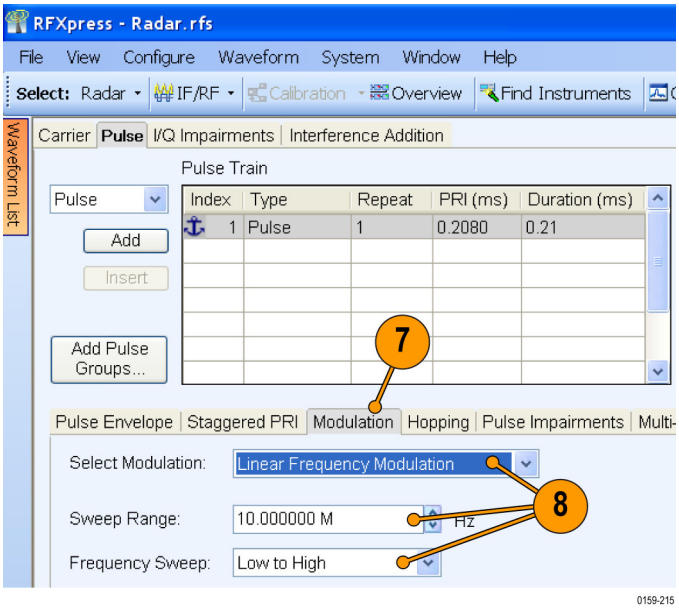
NOTE. The PRF and PRI values are calculated and automatically updated based on the parameters that you just set. In this case, the PRF is 4.807 KHz and the PRI (in the table) is 0.2080 ms.

   - **Amplitude Relative to Carrier** to 0 dB (default).
   - **Offset from Carrier Frequency** to 0 Hz (default).
   - **Repeat** to 1 (default).

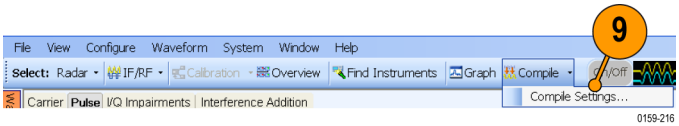
7. Click the **Modulation** tab.

8. Set the following:

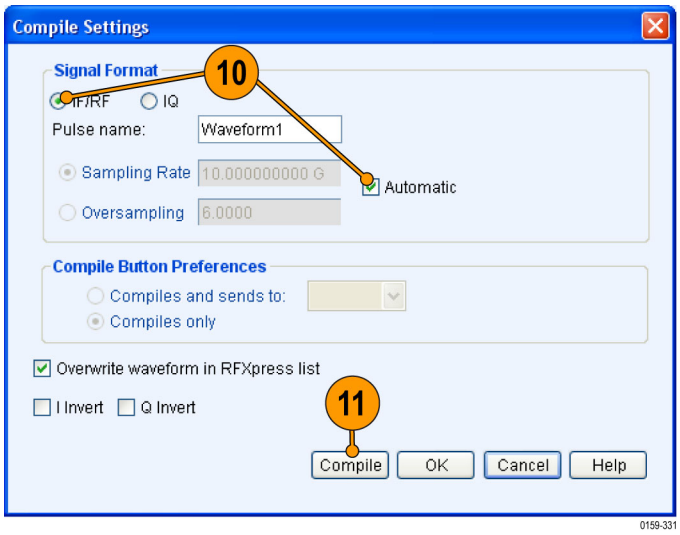
   - **Select Modulation** to Linear Frequency Modulation.
   - **Sweep Range** to 10 MHz.
   - **Frequency Sweep** to Low to High.



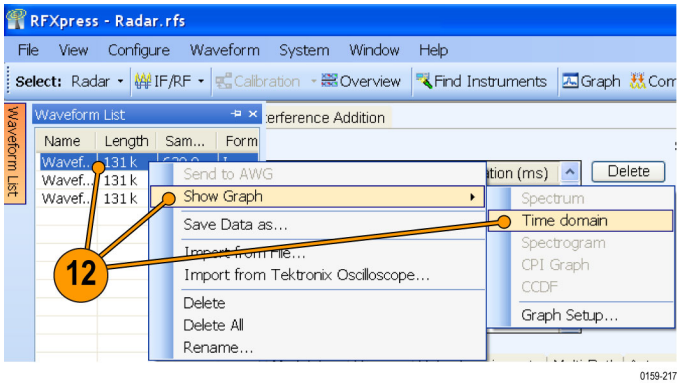
9. From the toolbar, click **Compile Settings**.



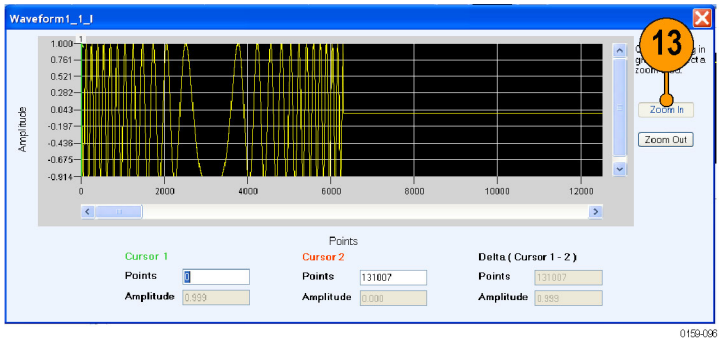
10. Ensure the following:
    - **Signal Format** is IF/RF.
    - **Automatic** is selected.
11. Click **Compile**.



12. The compiled pulse is displayed in the Waveform List. In the Waveform List, select the I signal and right-click. Select **Show Graph > Time domain** to display the graph of the pulse.



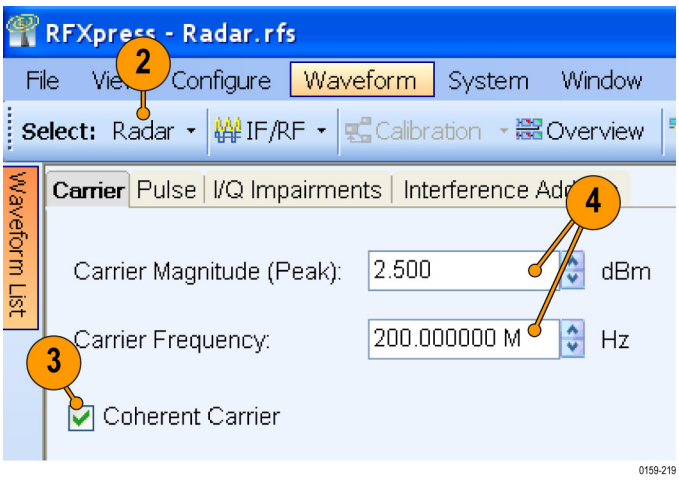
13. Click **Zoom In** and select an area to zoom.



Generating a Hopping Radar Waveform: Creating a Pulse-to-Pulse Frequency Hopping Signal

Pulse-to-pulse hopping radar signals are also known as frequency agile waveforms. Pulse-to-pulse hopping is used in electronic counter measures by rapidly switching the frequency of the transmitted energy and receiving only that frequency during the receiving time window.

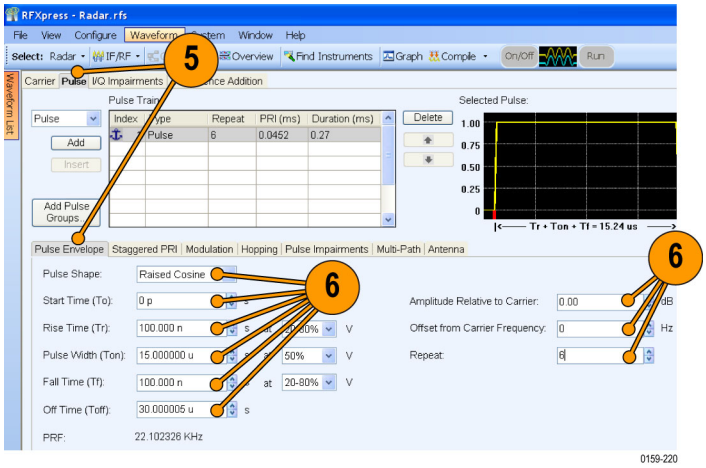
1. Start RFXpress.
2. From the toolbar, click **Select > Radar**.
3. In the **Carrier** tab, ensure that **Coherent Carrier** is selected (default).
4. Set the following:
   - **Carrier Magnitude (Peak)** to 2.5 dBm.
   - **Carrier Frequency** to 200 MHz.



5. Select the **Pulse** tab and select the **Pulse Envelope** tab.

6. Set the following:

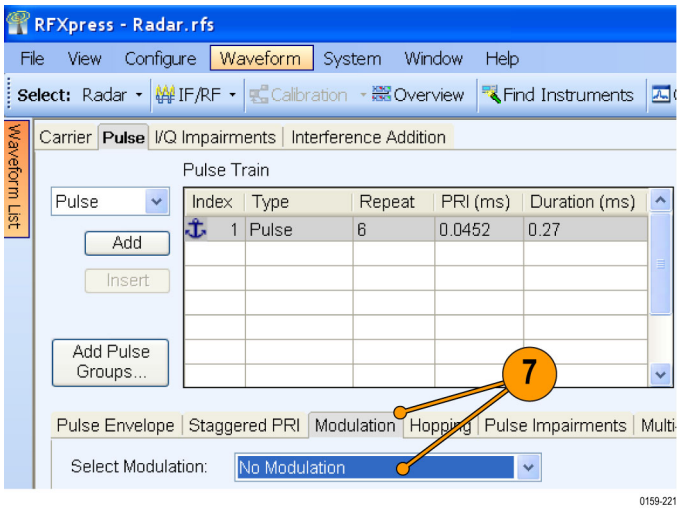
   - **Pulse Shape** to Raised Cosine.
   - **Start Time** to 0 ps (default).
   - **Rise Time** to 0.1 µs at 20–80%.
   - **Pulse Width** to 15 µs at 50%.
   - **Fall Time** to 0.1 µs at 20–80%.
   - **Off Time** to 30 µs.



NOTE. The PRF and PRI values are calculated and automatically updated based on the parameters that you just set. In this case, the PRF is 22.102 KHz and the PRI (in the table) is 0.0452 ms.

   - **Amplitude Relative to Carrier** to 0 dB (default).
   - **Offset from Carrier Frequency** to 0 Hz (default).
   - **Repeat** to 6.

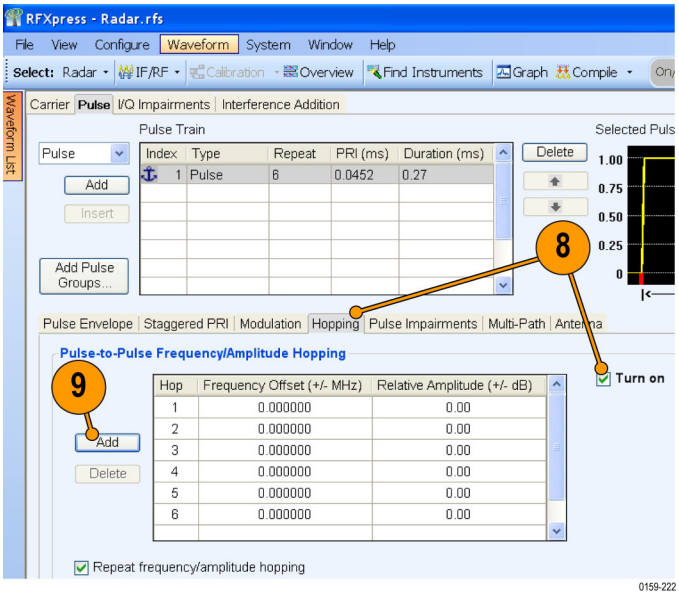
7. Click the **Modulation** tab and set **Select Modulation** to No Modulation.



8. Click the **Hopping** tab and select Turn on.

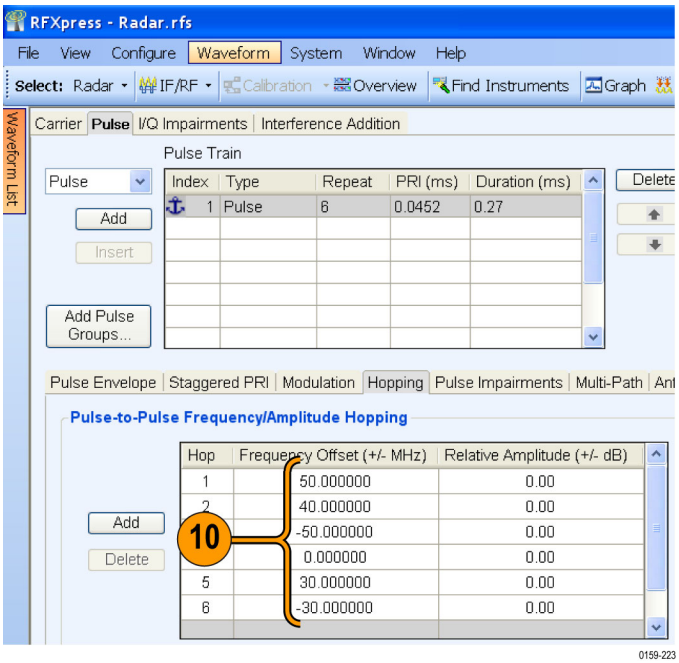
9. In the table, click **Add** to add rows.

NOTE. *You cannot add more rows than the repeat value (6 in this case).*

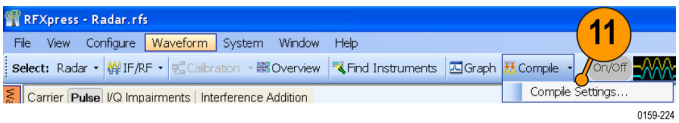


10. Set the following:

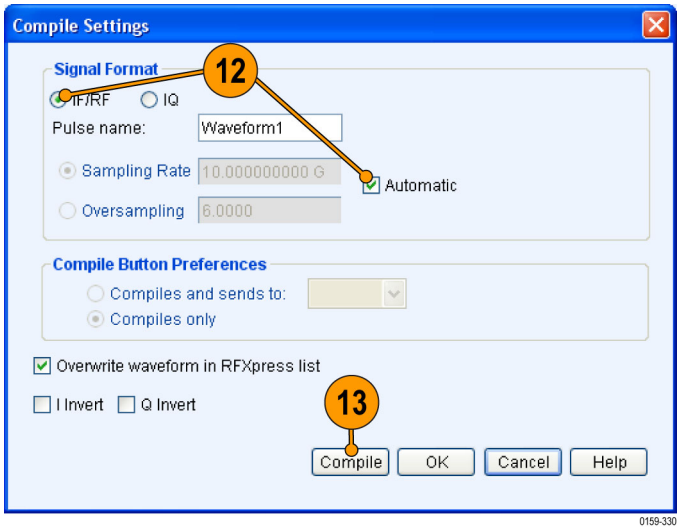
- Frequency Offset for the first hop to 50 MHz.
- Frequency Offset for the second hop to 40 MHz.
- Frequency Offset for the third hop to –50 MHz.
- Frequency Offset for the fourth hop to 0 MHz.
- Frequency Offset for the fifth hop to 30 MHz.
- Frequency Offset for the sixth hop to –30 MHz.



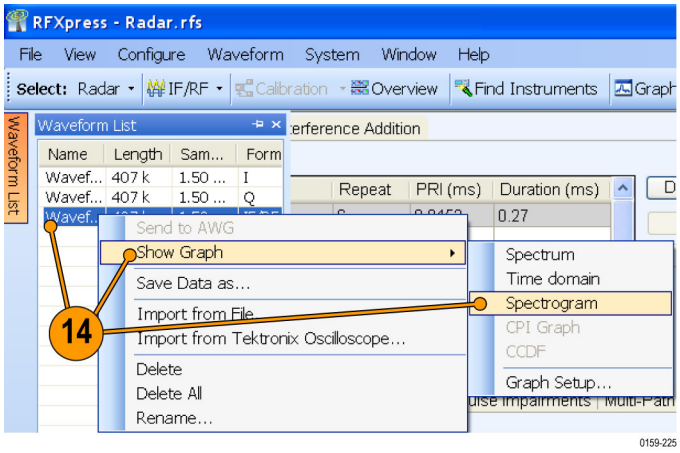
11. From the toolbar, click **Compile Settings**.



12. Ensure the following:
    - **Signal Format** is IF/RF.
    - **Automatic** is selected.
13. Click **Compile**.

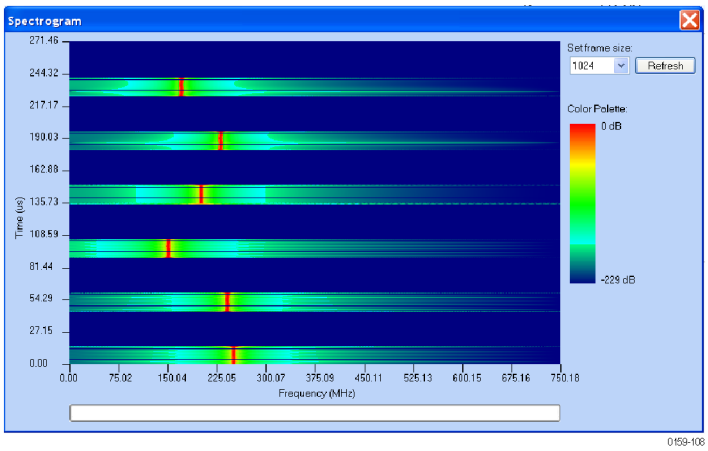


14. The compiled pulse is displayed in the Waveform List. In the Waveform List, select the IF/RF signal and right-click. Select **Show Graph > Spectrogram** to display the graph of the pulse.

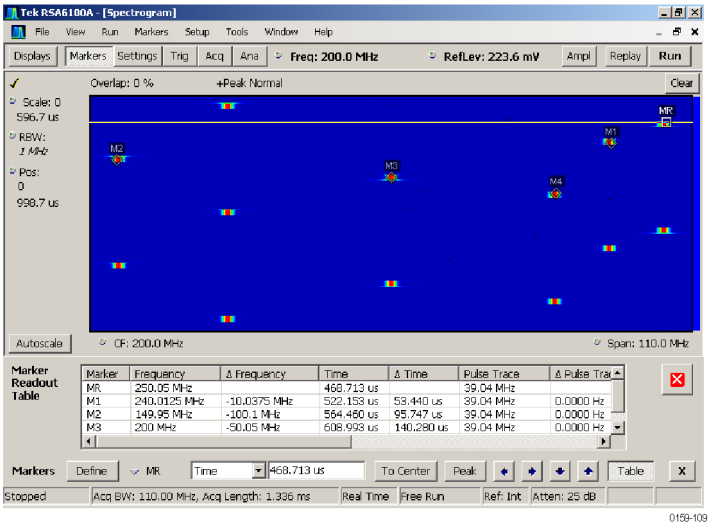


15. The spectrogram is as shown.

NOTE. *For better resolution, increase the frame size and click Refresh.*



16. The spectrogram as seen in a Tektronix RSA6100A is as shown.

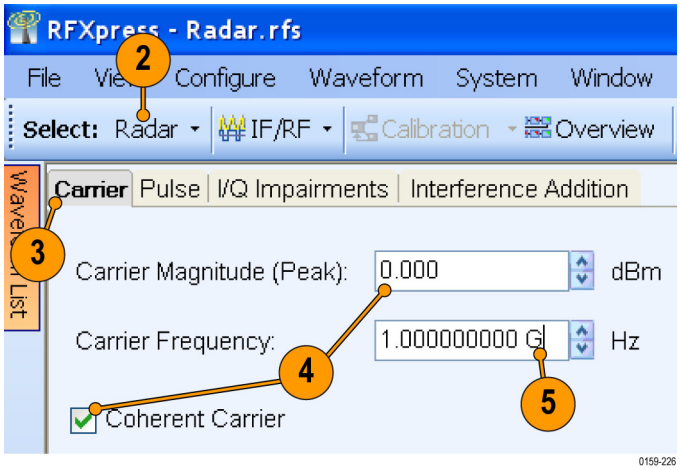


Creating Costa's Modulation

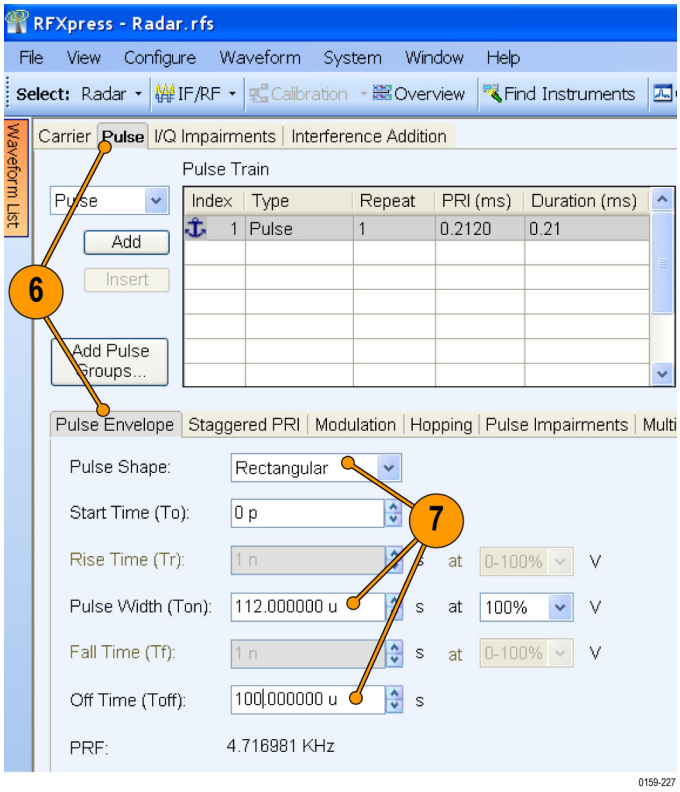
Use RFXpress to test receivers with Costa's modulation, which are used for better range and Doppler resolution.

1. Start RFXpress.

2. From the toolbar, click **Select > Radar**.
3. Click the **Carrier** tab.
4. Leave the defaults for **Coherent Carrier** (enabled) and **Carrier Magnitude (Peak)**.
5. Set the desired **Carrier Frequency**, for example to 1 GHz.



6. Select the **Pulse** tab and select the **Pulse Envelope** tab.
7. Set the following:
   - **Pulse Shape** to Rectangular.
   - **Pulse Width** to 112 µs.
   - **Off Time** to 100 µs.



8. Click the **Modulation** tab and set **Select Modulation** to User Defined Step FM AM.

   You will create a Costa's code of seven steps with Δf = 42.4 MHz. The code that will be used is 3605412.

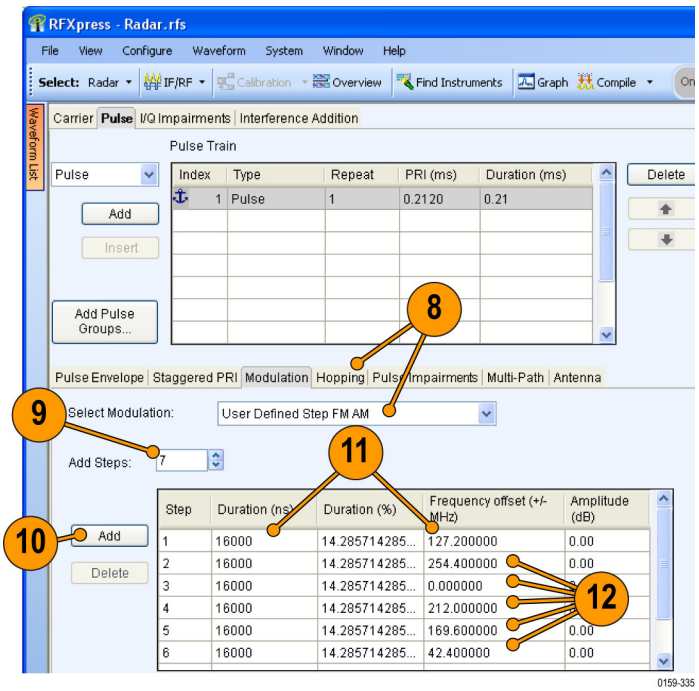
9. In **Add Steps** enter 7.

10. Click **Add**.

11. In the table, enter the following:

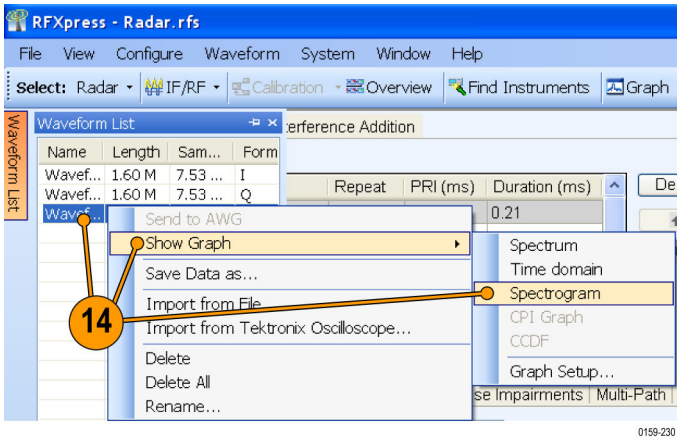
    - **Duration** to 16000 ns.
    - **Frequency** to 127.2 MHz.

12. Repeat step 11 for all the steps in the code. Keep the duration constant (16000 ns) and calculate the frequency using the formula Δf * code (for example 42.4 * 3, 42.4 * 6, 42.4 * 0, and the rest).

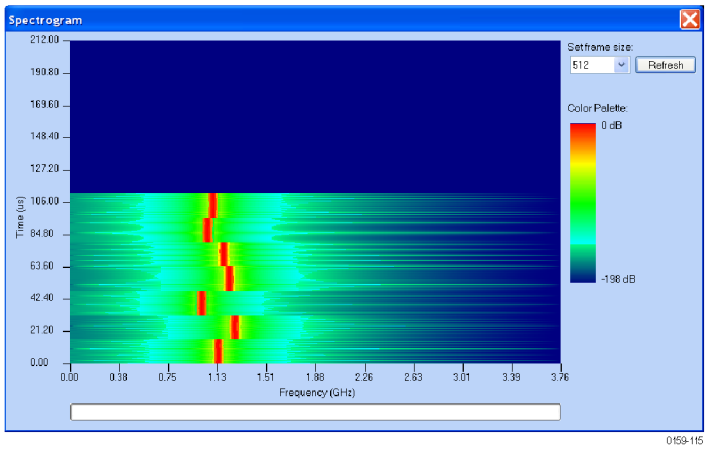


13. From the toolbar, click **Compile**.

14. In the waveform list, select IF/RF. Right-click and select **Show Graph > Spectrogram**.



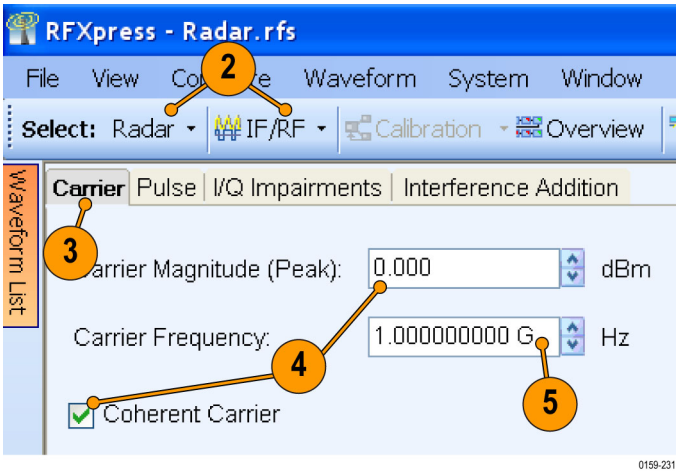
15. The spectrogram is as shown.



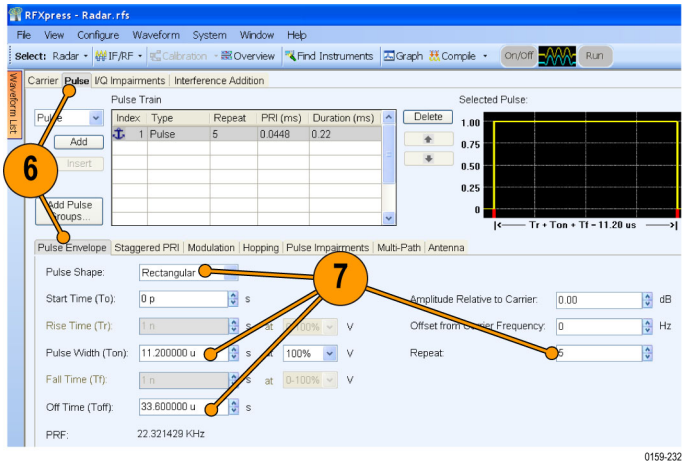
Creating a Radar Waveform using Staggered PRI for Better Range Ambiguity

One of the applications of Staggered PRI is in Moving Target Indication (MTI) Radars which have to resolve range and Doppler ambiguities. This example shows how to create pulse-to-pulse staggering.

1. Start RFXpress.
2. From the toolbar, click **Select > Radar**. Select the signal type as **IF/RF**.
3. Click the **Carrier** tab.
4. Leave the defaults for **Coherent Carrier** (enabled) and **Carrier Magnitude (Peak)**.
5. Set the **Carrier Frequency** to 1 GHz.



6. Select the **Pulse** tab and select the **Pulse Envelope** tab.
7. Set the following:
   - **Pulse Shape** to Rectangular.
   - **Pulse Width** to 11.2 µs.
   - **Off Time** to 33.6 µs.
   - **Repeat** to 5.



8. Click the **Staggered PRI** tab and select **Turn on**.

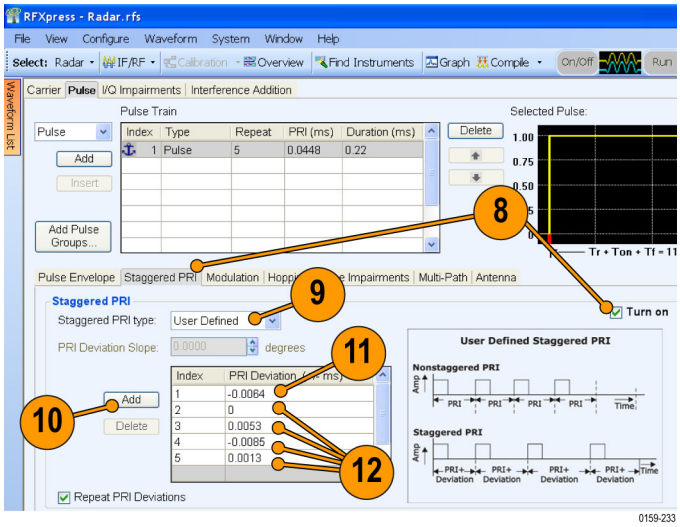
9. Set **Staggered PRI type** to User Defined.

   You will change the PRI for each pulse by adding a deviation. The PRI is calculated as follows: Current PRI + deviation. The deviation is specified in the table.

10. Click **Add** to add a row to the table.

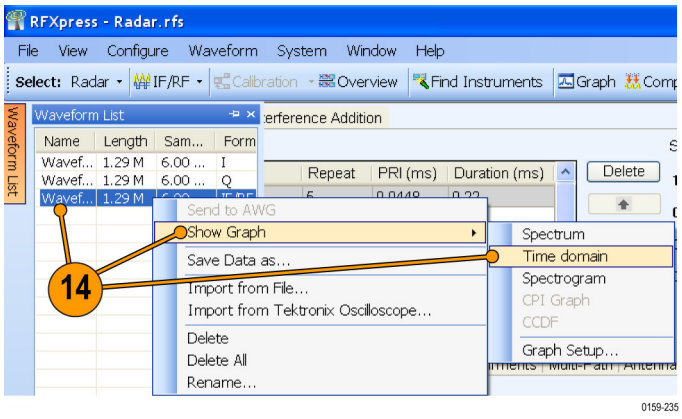
11. Enter the deviation –0.0064 (in ms) for the first pulse.

12. Repeat steps 10 and 11 to enter the deviation for the remaining pulses as: 0, 0.0053, –0.0085, and 0.0013.

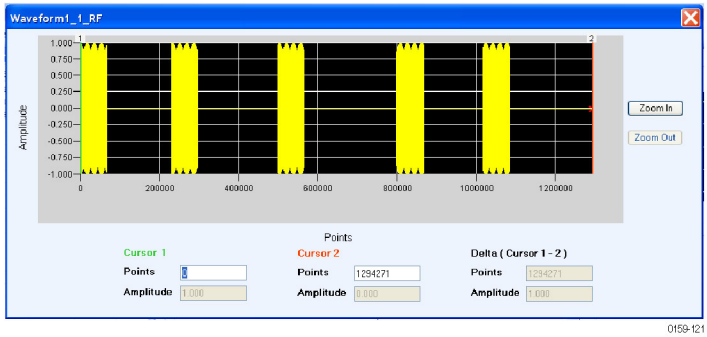


13. From the toolbar, click **Compile**.

14. In the waveform list, select IF/RF. Right-click and select **Show Graph > Time domain**.



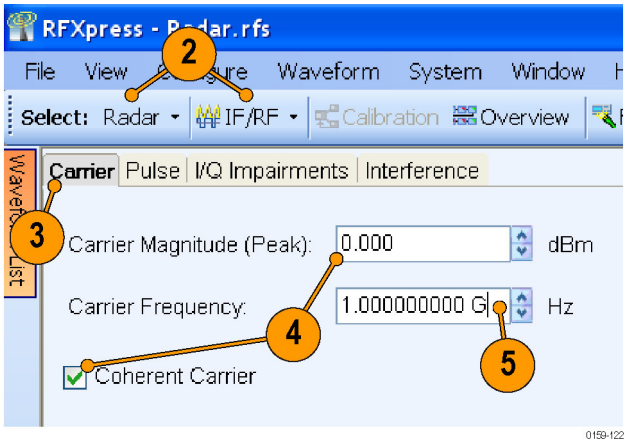
15. The time domain graph is as shown.



Simulating Multiple Targets for Radar Receiver Testing (Different Pulse Groups)

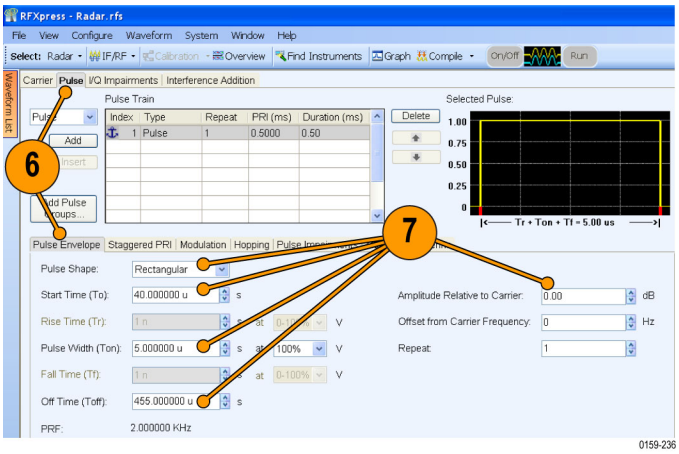
Use RFXpress to simulate three targets. With the transmitter sending a pulse of duration 5 µs with a PRI of 500 µs, this example will simulate three targets – the first at 40 µs from the reference, the second at 120 µs, and the third at 300 µs.

1. Start RFXpress.
2. From the toolbar, click **Select > Radar**. Set the signal type to **IF/RF**.
3. Click the **Carrier** tab.
4. Leave the defaults for **Coherent Carrier** (enabled) and **Carrier Magnitude (Peak)**.
5. Set the **Carrier Frequency** to 1 GHz.



6. Select the **Pulse** tab and select the **Pulse Envelope** tab.
7. Set the following:
   - **Pulse Shape** to Rectangular.
   - **Start Time** to 40 µs.
   - **Pulse Width** to 5 µs at 100%.
   - **Off Time** to 455 µs.
   - **Amplitude Relative to Carrier** to 0 dB (default).

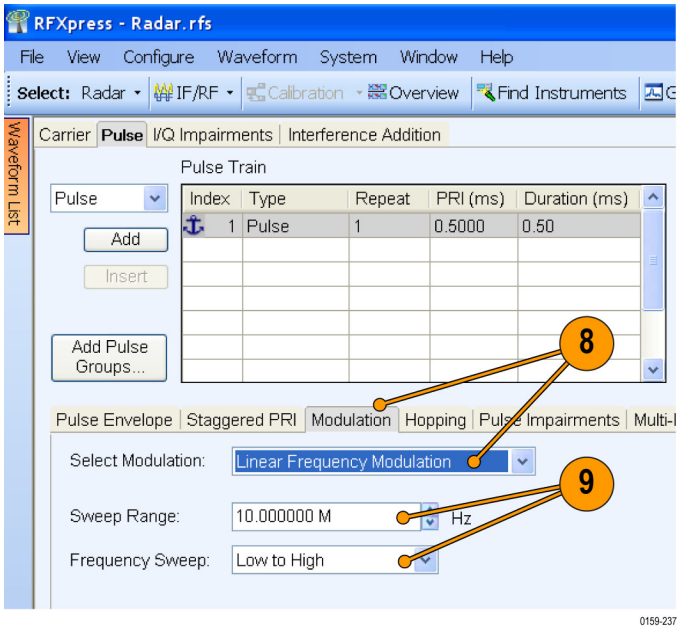
   Observe that the PRI is 500 µs.



8. Click the **Modulation** tab and set **Select Modulation** to Linear Frequency Modulation.

9. Set the following:

   - **Sweep Range** to 10 MHz.
   - **Frequency Sweep** to Low to High.

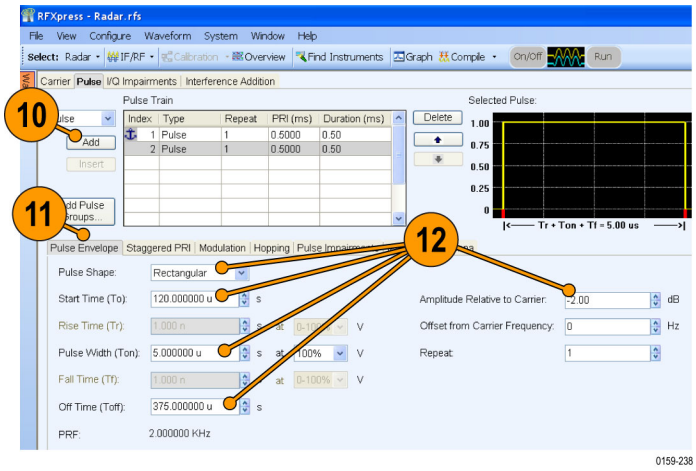


10. Click **Add** to add a pulse. Select the newly added pulse.

11. Select the **Pulse Envelope** tab.

12. Select the pulse and set the following:

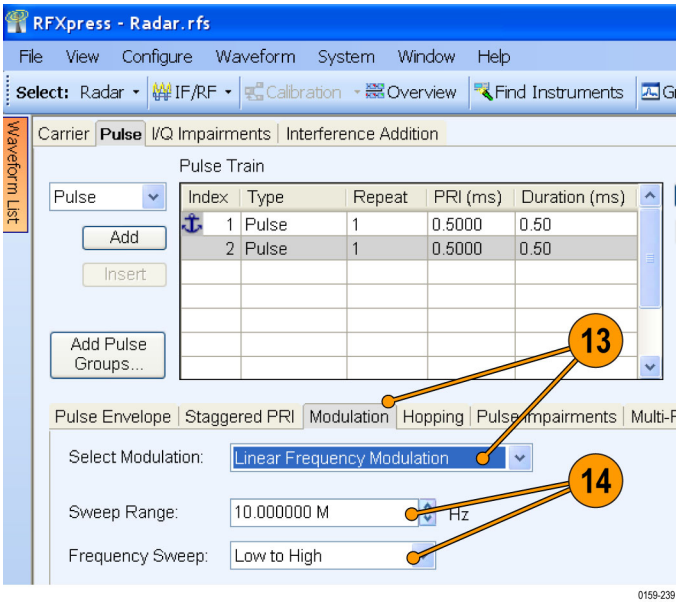
    - **Pulse Shape** to Rectangular.
    - **Start Time** to 120 µs.
    - **Pulse Width** to 5 µs at 100%.
    - **Off Time** to 375 µs.
    - **Amplitude Relative to Carrier** to –2 dB.



13. Click the **Modulation** tab and set **Select Modulation** to Linear Frequency Modulation.

14. Set the following:

    - **Sweep Range** to 10 MHz.
    - **Frequency Sweep** to Low to High.

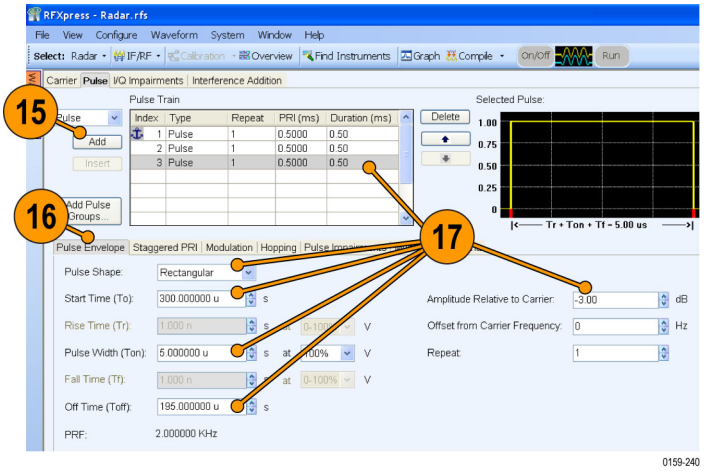


15. Click **Add** to add a pulse.

16. Select the **Pulse Envelope** tab.

17. Select the pulse and set the following:

    - **Pulse Shape** to Rectangular.
    - **Start Time** to 300 µs.
    - **Pulse Width** to 5 µs at 100%.
    - **Off Time** to 195 µs.
    - **Amplitude Relative to Carrier** to –3 dB.

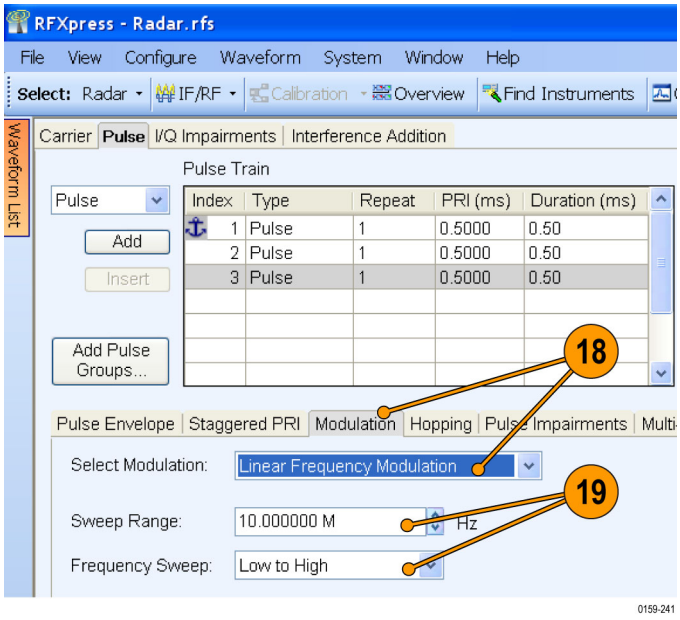


18. Click the **Modulation** tab and set **Select Modulation** to Linear Frequency Modulation.

19. Set the following:

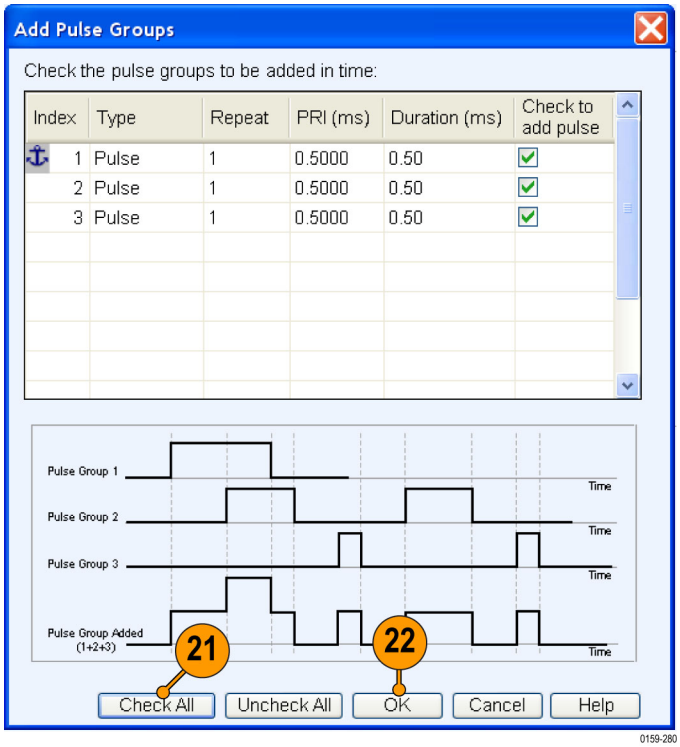
    - **Sweep Range** to 10 MHz.
    - **Frequency Sweep** to Low to High.

20. Click **Add Pulse Groups**.



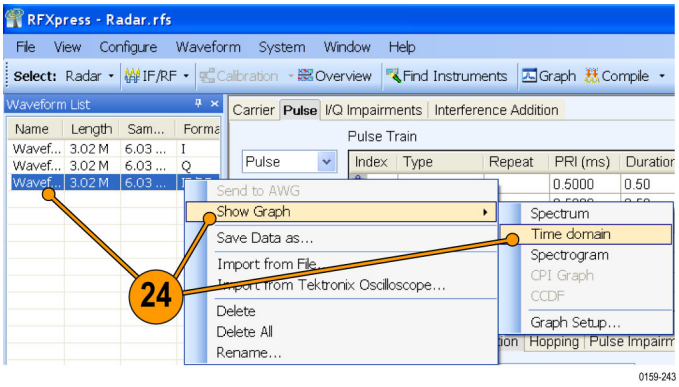
21. Click **Check All**.

22. Click **OK**.

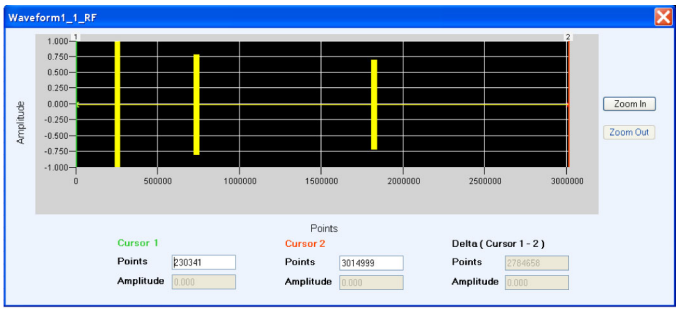


23. From the toolbar, click **Compile**.

24. Select an IF/RF waveform from the waveform list. Right-click and select **Show Graph > Time domain**.



25. The time domain graphs are as shown.



Simulating a Scanning Antenna with a Gaussian Shape

RFXpress can be use to simulate different types of beam patterns like Sinc, Gaussian, or User-defined scan patterns. In this example, you will simulate a Gaussian Beam pattern for a stationary target with Maximum Radial Axis (MRA) at 0 degrees.

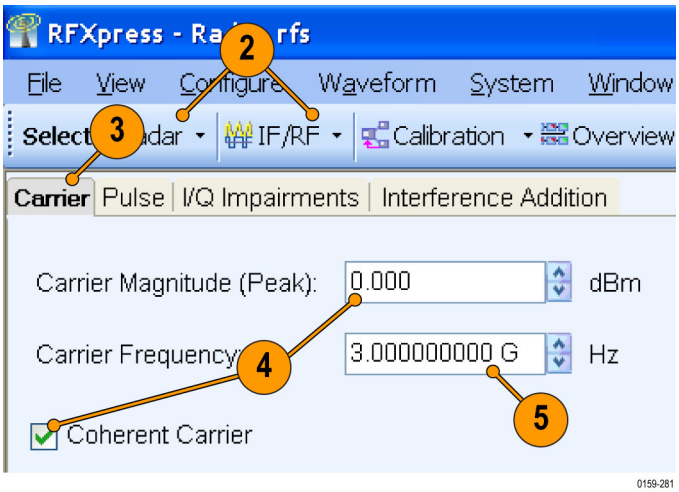
1. Start RFXpress.

2. From the toolbar, click **Select > Radar**. Select the signal type as **IF/RF**.

3. Click the **Carrier** tab.

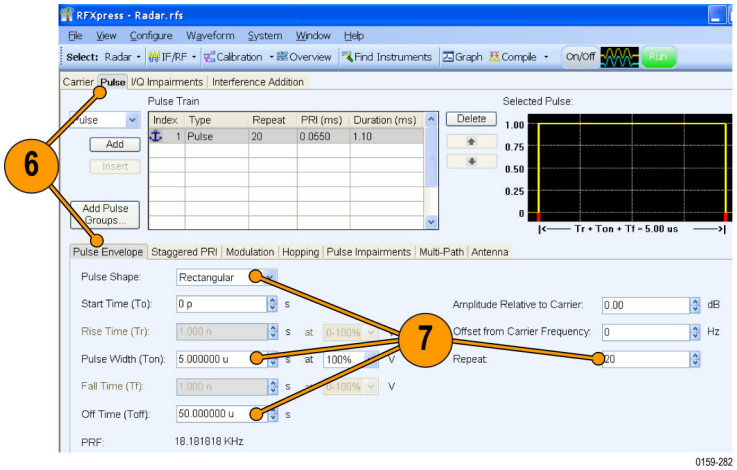
4. Leave the defaults for **Coherent Carrier** (enabled) and **Carrier Magnitude (Peak)**.

5. Set the **Carrier Frequency** to 3 GHz.



6. Select the **Pulse** tab and select the **Pulse Envelope** tab.

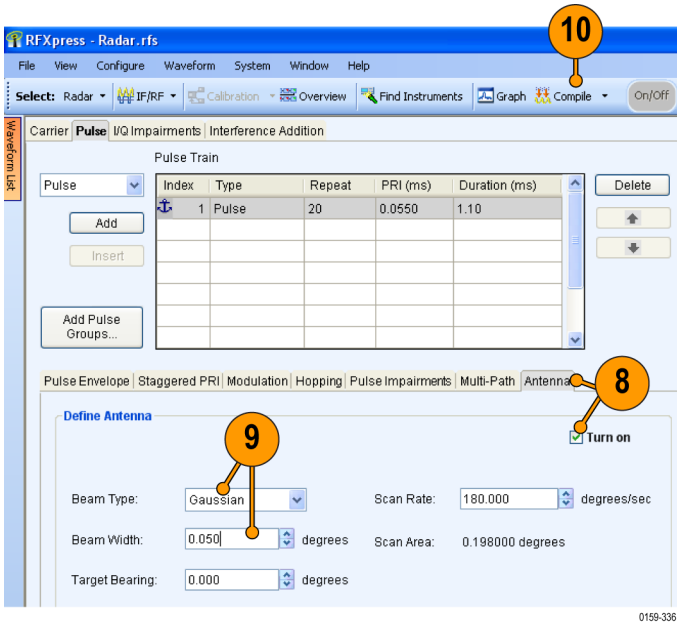
7. Set the following:
   - **Pulse Shape** to Rectangular.
   - **Pulse Width** to 5 µs.
   - **Off Time** to 50 µs.
   - **Repeat** to 20.



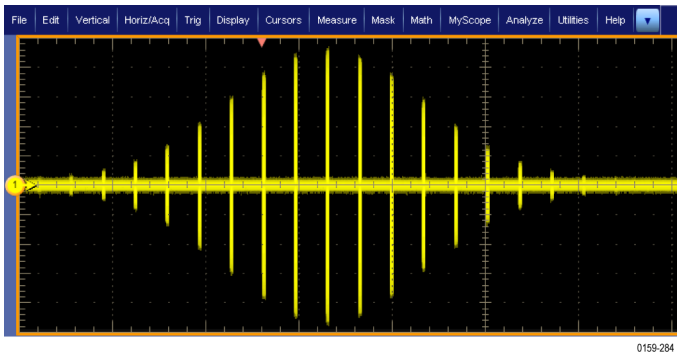
8. Click the **Antenna** tab and click Turn On.

9. Set the following:
   - **Beam Type** to Gaussian.
   - **Beam Width** to 0.05 degree.

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



11. Capture the waveform on the oscilloscope and observe the signal spectrum using Tektronix Ultra Wideband Spectral Analysis software.

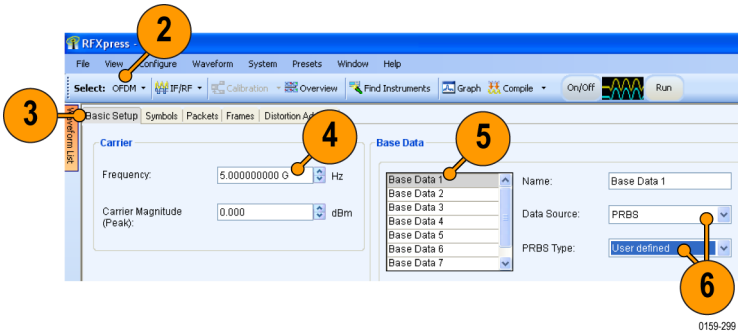


Application Examples: OFDM

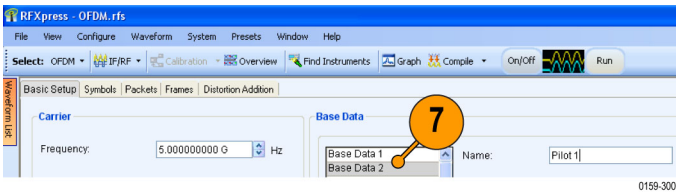
Create a TG3c Standard OFDM Symbol

This example creates a 512-subcarrier OFDM symbol according to the timing and subcarrier frequency allocation in the TG3c draft specification (refer to the timing and frequency allocation tables).

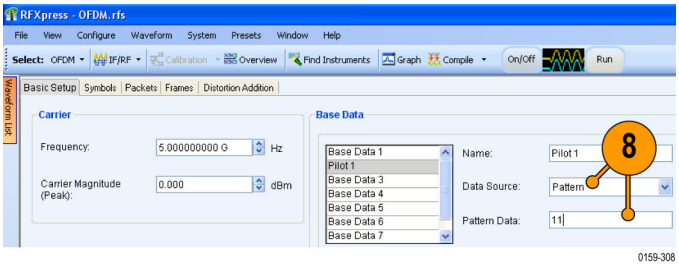
1. Start RFXpress.
2. From the toolbar, click **Select > OFDM**.
3. Click the **Basic Setup** tab.
4. Set the **Frequency** to 5 GHz.
5. Select Base Data 1 from the list.
6. Set the **Data Source** to PRBS and **PRBS Type** to User Defined.



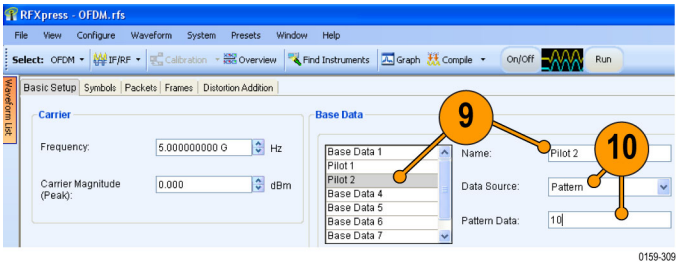
7. Select Base Data 2 from the list and enter the **Name** as Pilot 1.



8. Set the **Data Source** to Pattern and **Pattern Data** to 11.

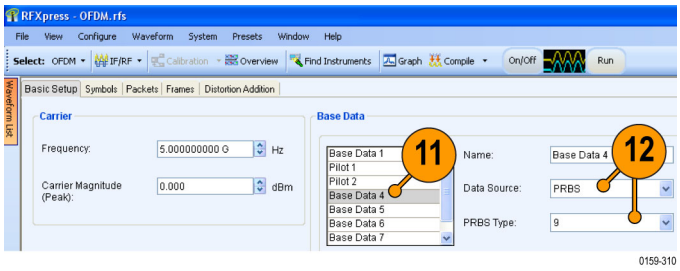


9. Select Base Data 3 from the list and enter the **Name** as Pilot 2.
10. Set the **Data Source** to Pattern and **Pattern Data** to 10.



11. Select Base Data 4.

12. Set the **Data Source** to PRBS and **PRBS Type** to 9.

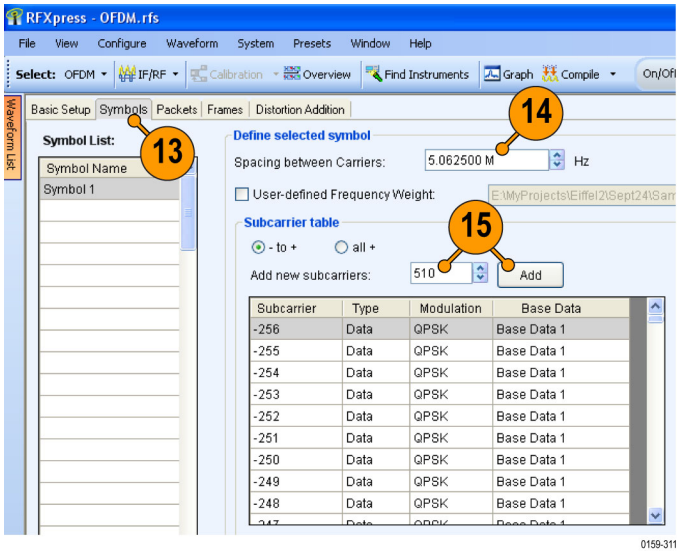


13. Click the **Symbols** tab.

14. Set **Spacing between Carriers** to 5.0625 M.

15. In **Add new subcarriers**, enter 510 and click **Add**.

NOTE. *The total number of subcarriers in the list is 512.*

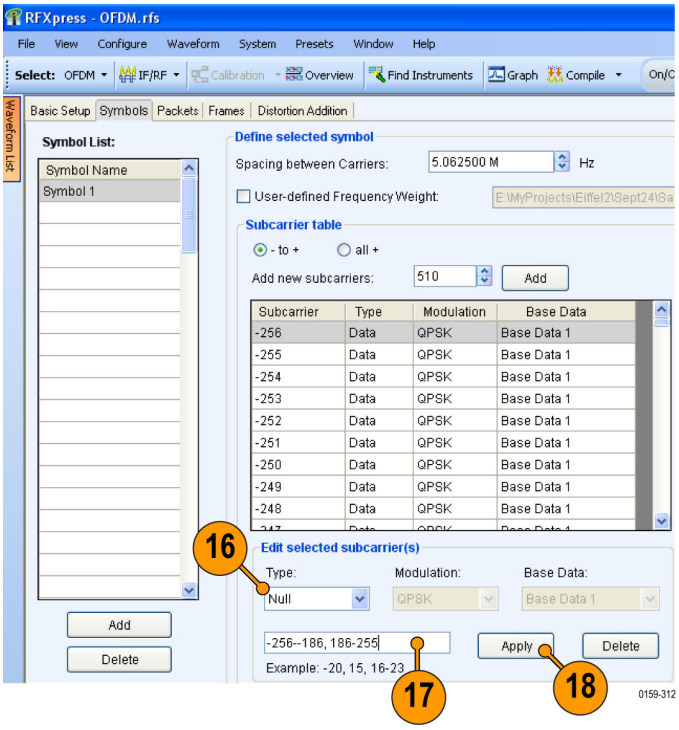


16. Set **Type** to Null.

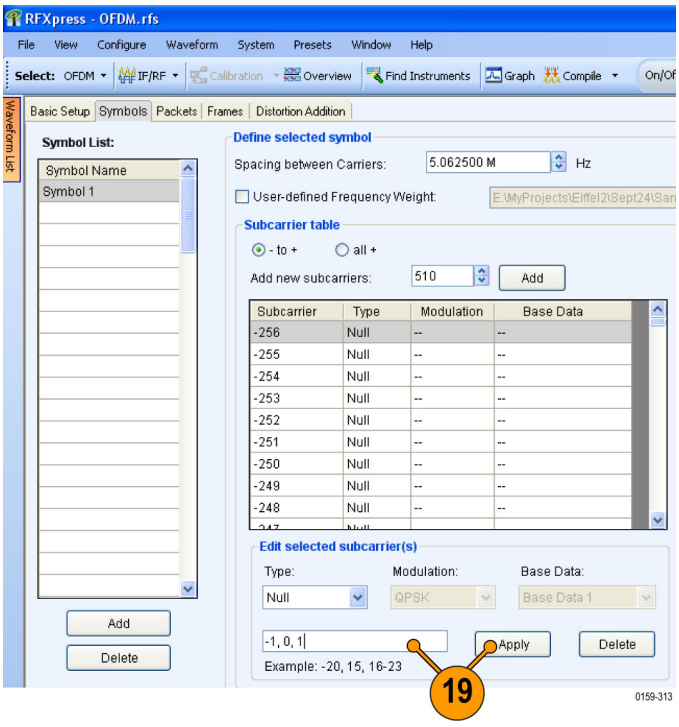
17. Enter the subcarriers: –256 – –186, 186 – 255.

NOTE. *Separate the range with a dash (-) and the ranges with a comma.*

18. Click **Apply**.



19. Enter –1, 0, 1 in the field and click **Apply** to set the DC subcarriers to Null.

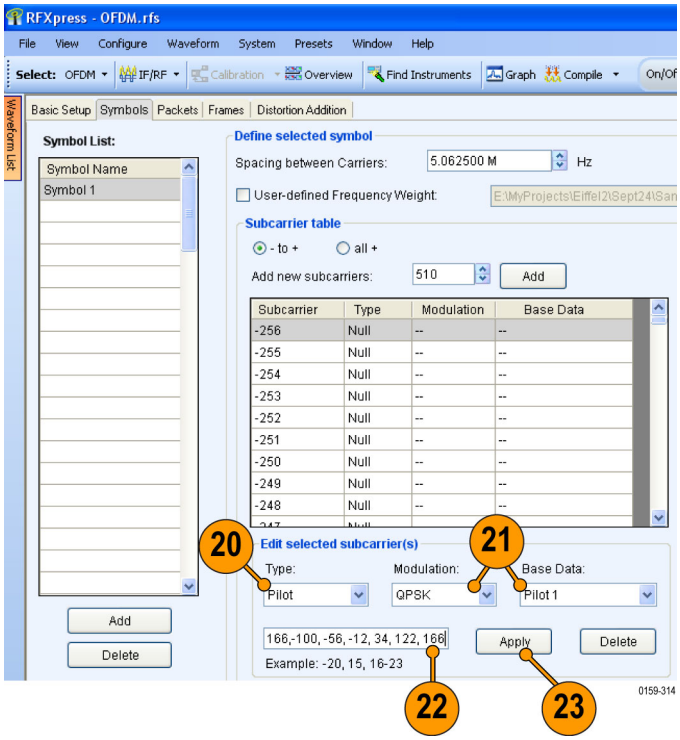


20. Set **Type** to Pilot.

21. Keep the **Modulation** as QPSK and set the **Base Data** to Pilot 1.

22. Enter the subcarriers:–166, –100, –56, –12, 34, 122, 166.

23. Click **Apply**.

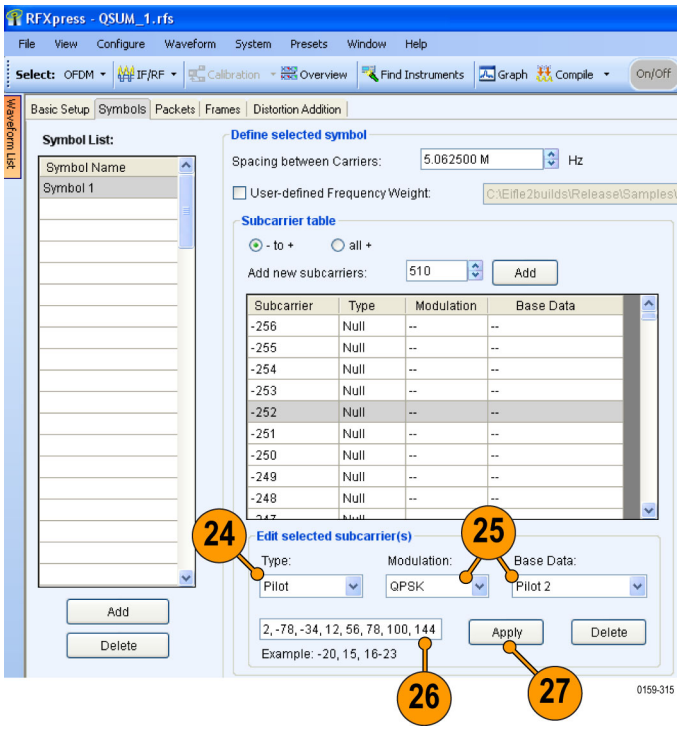


24. Set **Type** to Pilot.

25. Keep the **Modulation** as QPSK and set the **Base Data** to Pilot 2.

26. Enter the subcarriers: –144, –122, –78, –34, 12, 56, 78, 100, 144.

27. Click **Apply**.

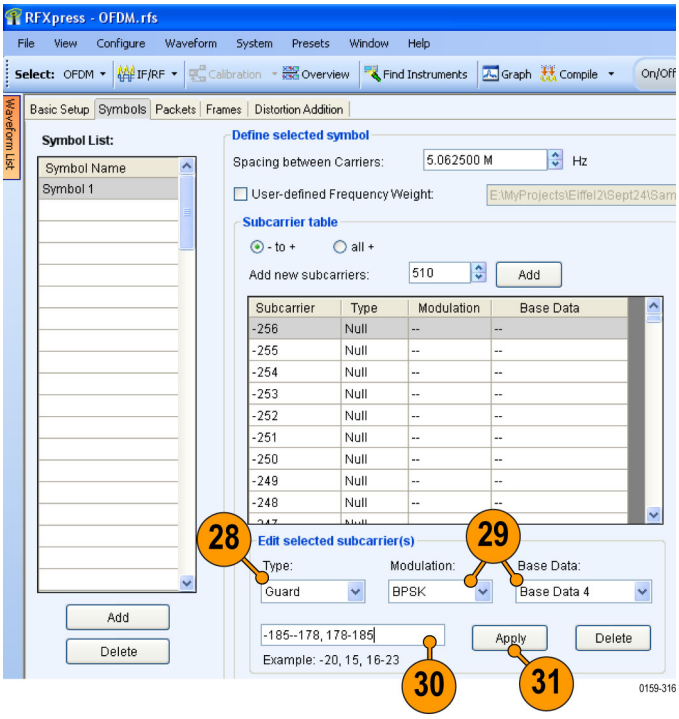


28. Set **Type** to Guard.

29. Set the **Modulation** to BPSK and set the **Base Data** to Base Data 4.

30. Enter the subcarriers: –185 – –178, 178 – 185.

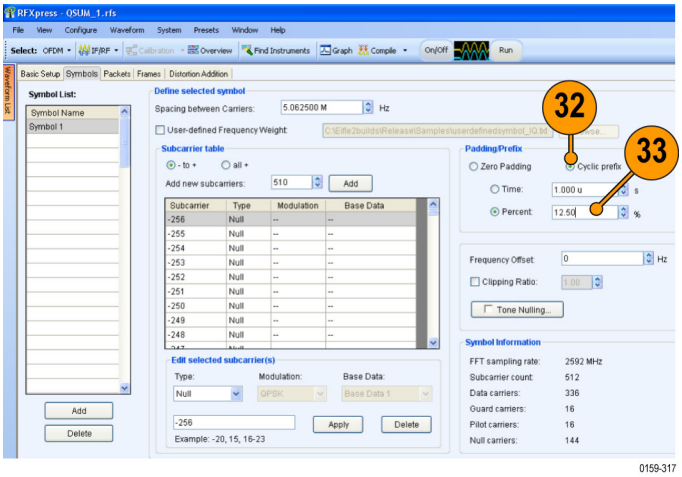
31. Click **Apply**.



32. Select **Cyclic Prefix**.

33. Select **Percent** and enter 12.5.

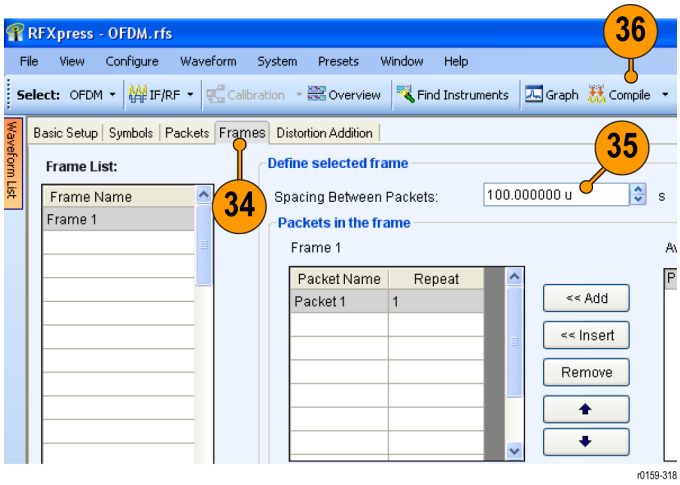
This works out to 24.69 ns when cyclic prefix is specified in time.



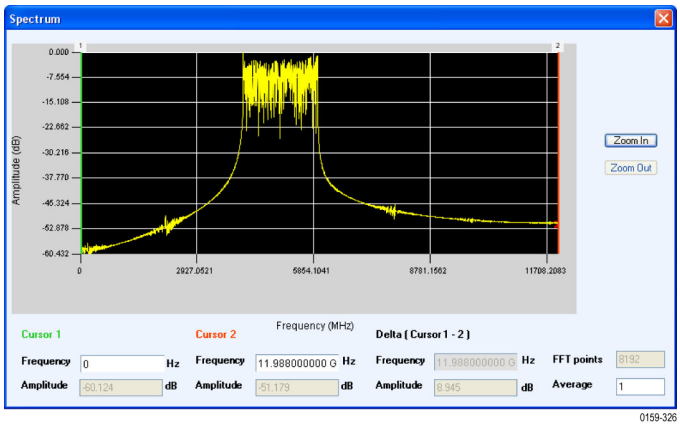
34. Click the **Frames** tab.

35. Set **Spacing between Packets** to 100 µs.

36. Click **Compile**.



37. Observe the Spectrum graph.



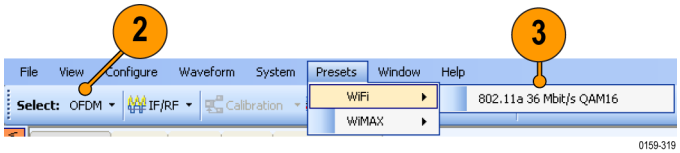
Create a WiFi Signal using a Preset and Adding Impairments

Use this example to create a WiFi signal using the provided preset file and add clipping, gated noise, and phase noise to the signal.

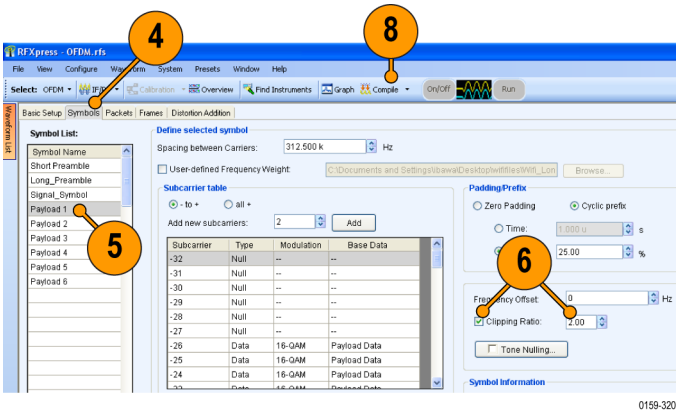
1. Start RFXpress.

2. From the toolbar, click **Select > OFDM**.

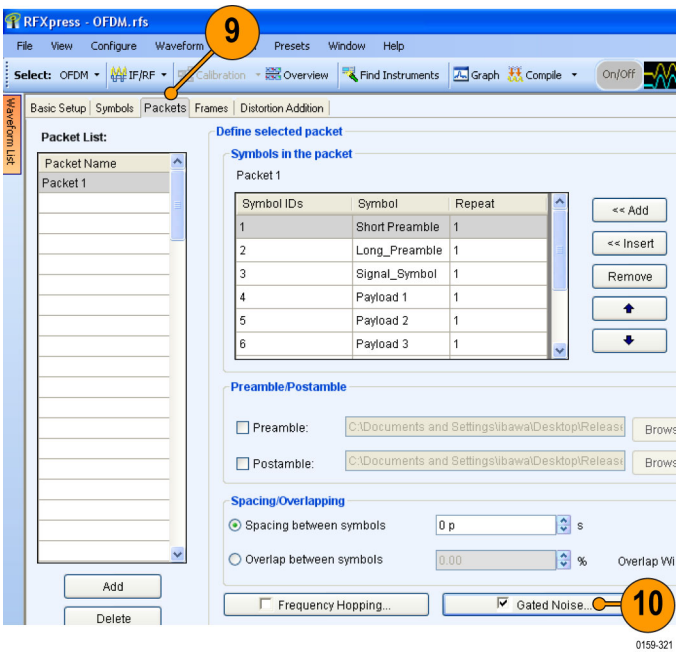
3. From the menu, select **Presets > WiFi > 802.11a 36 Mbit/s QAM16**



4. Click the **Symbols** tab.
5. In the **Symbol List**, select Payload1.
6. Enable **Clipping Ratio** and enter 2.
7. Repeat steps 4 and 5 for each of the payloads in the symbol list.
8. Click **Compile**.



9. Click the **Packets** tab.
10. Turn on **Gated Noise** and click the button to open the dialog box.



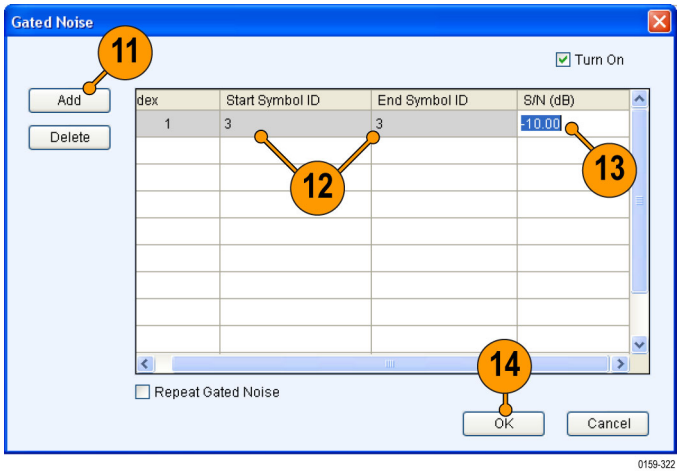
11. Click **Add**.

12. Set **Start Symbol ID** and **End Symbol ID** to 3.

13. Set **S/N** to –10 dB.

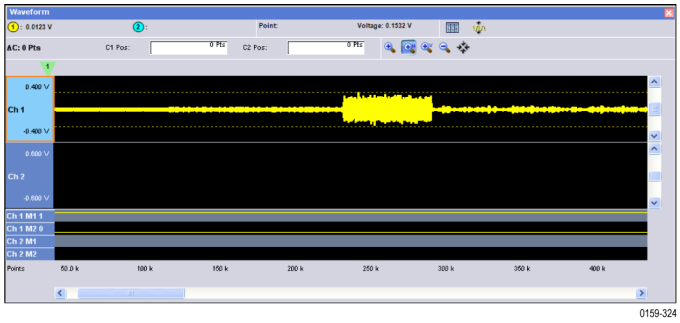
This adds noise to the third symbol or header (SIGNAL_Symbol) of the packet.

14. Click **OK**.



15. Click **Compile**.

16. Observe the signals on the AWG.



17. Click the **Frames** tab.

18. Click the **Phase Noise** tab.

19. Click **Turn On**.

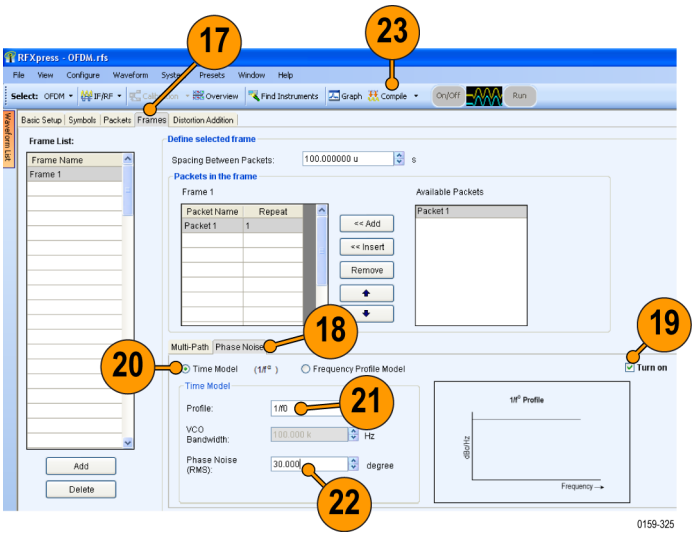
20. Ensure that **Time Model (1/f$^{\alpha}$)** is selected.

21. Select **Profile** as 1/f^{0}.

NOTE. *The VCO Bandwidth field is not available for this profile.*

22. Set **Phase Noise** to 30 degrees (integrated over a bandwidth of Sampling Frequency/2).

23. Click **Compile**.



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