

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





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Tektronix is pleased to acknowledge Mr Joan Mercade as the author of portions of this Tektronix RFXpress Software providing baseband and modulation functionality.

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RFXpress® RFX100 Online Help Version 3.X part number 076-0081-10.

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- Worldwide, visit [www.tektronix.com](http://www.tektronix.com) to find contacts in your area.

# Table of Contents

## Introduction

Welcome .....	1
Related Documentation .....	1
Conventions .....	2
Feedback .....	2

## Getting Started

Minimum System Requirements .....	3
Ordering RFXpress .....	3
Installation .....	4
Connection Setups	
Setup for RF Signal Generation .....	4
Setup for IF Signal Generation .....	5
Setup for AWG IQ Signal Generation .....	6

## Operating Basics

About Basic Operations .....	9
Overview of the Software .....	10
Starting the Software .....	12
Using the Software to Create a Signal .....	12
Exiting the Software .....	13
File Name Extensions and Directories .....	13
Applications, Setup Files, and Data Files .....	14
Menus and Toolbars	
Menu Bar .....	15
Standard Toolbar .....	18
Status Bar .....	19
Waveform List .....	19
Toolbar Options	
Select Application .....	22
Signal Type .....	22
Compile .....	22
On/Off .....	23
Run .....	23
Dialog Boxes	
Open Setup .....	23
Open Data .....	23
Save Setup .....	23

Save Data .....	24
Import Data from a File .....	24
Set Sampling Rate for Imported Waveforms .....	27
Resample Imported Waveform .....	27
Import from Tektronix Oscilloscope.....	28
Find Instruments .....	29
Graph.....	30
Compile Settings.....	32
Option Installation .....	36
Overview .....	37
Generic Signal Dialog Boxes	
PRBS Editor.....	41
Data Source Values .....	42
Modulation File1(Samples).....	43
Modulation File2(Symbols) .....	44
Symbol Map.....	45
Calibration Wizard	
Calibration for Generic, Radar, and OFDM signals.....	48
DUT Characterization	
DUT Characterization Wizard.....	52
UWB-WiMedia Dialog Boxes	
Calibration for UWB-WiMedia Signal.....	53
Marker Mapping .....	56
Tone Nulling.....	58
Hopping Pattern.....	59
Process Preferences.....	59
Custom Settings.....	61
Frame Payload .....	63
Radar Dialog Boxes	
Compile Settings for the Radar Application .....	64
Add Pulse Groups.....	66
OFDM Dialog Boxes	
Compile Settings for OFDM .....	66
Reed Solomon Coding .....	68
Scramble Editor .....	70
Convolution Coding.....	71
Tone Nulling.....	72
Frequency Hopping.....	72
Gated Noise .....	73

## Creating a Generic Signal

### Setup

Single Carrier.....	75
Multi Carriers .....	76
Editing Carrier Details .....	77
Selecting the Base Data .....	79
Modulation for Carriers .....	80
Filter for Carriers .....	81
Hopping	
Hopping Parameters .....	83
Power Ramping	
Power Ramping Parameters .....	85
I/Q Impairments	
Carrier Leakage for Single Carrier.....	86
Quadrature Error for Carriers.....	86
I/Q Imbalance for Carriers .....	87
Nonlinear Distortions for Carriers .....	88
Hardware Skew for Carriers.....	89
I/Q Swap for Carriers.....	89
Distortion Addition	
Amplifier Distortion for Carriers.....	89
MultiPath	
Multipath Parameters for Carriers .....	90
Interference Addition	
Signal Addition for Carriers .....	91
Offset for Carriers .....	93
Sinusoidal for Carriers .....	94
Additive Noise for Carriers.....	94
Subcarrier Modulation for Generic Signal	
Subcarrier Modulation .....	96
Scattering Parameter for Generic Signal	
S-Parameters .....	96

## Creating a UWB-WiMedia Signal

Conformance Mode .....	99
Custom Mode .....	99
Conformance Mode Setup	
Packet Group Details for Conformance Mode.....	100
Packet Details for Conformance Mode.....	102
Hopping Details for Conformance Mode .....	104
Custom Mode Setup	
Packet Group Details for Custom Mode .....	105
Setting PPDU Details .....	106
PLCP Preamble .....	107

PLCP Header .....	108
PSDU .....	109
Packet Sync Sequence .....	110
PHY Header .....	113
MAC Header .....	114
I/Q Impairments	
Carrier Leakage for UWB-WiMedia .....	115
Quadrature Error for UWB-WiMedia .....	115
I/Q Imbalance for UWB-WiMedia .....	116
Nonlinear Distortion for UWB-WiMedia .....	117
Hardware Skew for UWB-WiMedia .....	118
I/Q Swap for UWB-WiMedia .....	118
Distortion Addition	
Amplifier for UWB-WiMedia .....	118
MultiPath	
Multipath Parameters for UWB-WiMedia .....	119
Interference Addition	
Signal Addition for UWB-WiMedia .....	120
Offset for UWB-WiMedia .....	122
Gated Noise for UWB-WiMedia .....	123
Sinusoidal for UWB-WiMedia .....	125
Real-World Signal Interference .....	127

## Calibration for UWB-WiMedia Signals

Using Calibration for IF/RF Signals .....	129
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## Creating a Radar Signal

Carrier Setup .....	131
Pulse	
Pulse Setup .....	131
Pulse Envelope .....	132
Staggered PRI .....	134
Modulation .....	135
Hopping .....	140
Pulse Impairments .....	141
Multipath .....	142
Antenna .....	142
I/Q Impairments	
Hardware Skew for Radar .....	144
Carrier Leakage for Radar .....	144
Quadrature Error for Radar .....	145
I/Q Imbalance for Radar .....	145



I/Q Swap for Radar .....	145
Interference Addition	
Signal Addition .....	146
Noise .....	146
<b>Creating an OFDM Signal</b>	
Basic Setup .....	149
Symbols .....	150
Packets .....	152
Frames .....	153
Distortion .....	155
Using Presets .....	155
<b>Instrument Control</b>	
Controlling an Instrument .....	157
Controlling an Arbitrary Waveform Generator (AWG) .....	158
Connecting to and Controlling an Oscilloscope .....	160
Connecting to and Controlling a Performance Signal Generator (PSG) .....	161
Connecting to a Real-time Spectrum Analyzer .....	163
Instrument Control in the Radar Application	
Controlling an Arbitrary Waveform Generator from the Radar Application .....	166
Settings View .....	167
Sequence View .....	167
Trigger Options .....	169
Event Options .....	169
<b>Graphing</b>	
Zooming Graphs .....	171
Pulse Shape .....	171
I(t), Q(t) .....	172
CCDF Plot .....	173
Spectrum .....	174
Constellation Plotting .....	175
Eye Diagram .....	176
Spectrogram .....	177
FFT of Coherent Pulse Interval .....	178
<b>Reference</b>	
Error Messages	
Error Messages for Generic Signal .....	179
Error Messages for UWB-WiMedia .....	181
Error Messages for Radar .....	182

AWG Sequence Window-related errors .....	186
Error Messages for OFDM .....	186
DUT Characterization Errors .....	191
RTSA Connectivity-related Errors .....	192
Miscellaneous Error Messages .....	192
Miscellaneous Error Messages 2 .....	193
Shortcut Keys .....	195
RFXpress Options and AWG Models .....	195
AWG Specifications .....	197
Interleave .....	198
PRBS Editor Starting Values .....	200
Amplifier Distortions .....	200
Nonlinear Impairments .....	201
Image Calibration .....	202
Types of Modulation .....	203
Frequently Asked Questions .....	215

## Index

## Welcome

RFXpress RFX100 is a software application that creates digitally modulated baseband, IQ, IF, RF, UWB-WiMedia, and Radar signals that can be generated through arbitrary waveform generators (AWG). This software runs as an integral part of AWG5000 and AWG7000 series arbitrary waveform generators and can also run from an external PC.

Using RFXpress RFX100 (referred to as RFXpress), you can define baseband I and Q signals with various modulation schemes and create single or multi-carrier signals where each carrier can be independently defined. For each carrier, you can apply impairments such as quadrature error and I/Q imbalance, add interferences such as sinusoidal interference, and define the graphs to create. Upon compilation, the signal can be viewed as graphs, sent to an arbitrary waveform generator, and saved for later use. Compilation options include sending signals directly to the AWG and completely eliminating the wrap-around effects found in arbitrary waveform generators. This provides seamless signals that can be played back continuously without any discontinuity or glitch in the time, frequency, modulation, or channel coding domains. Waveform transfer and control of the AWG5000 and AWG7000 series can be performed directly from RFXpress.

Waveforms captured from oscilloscopes and real-time spectrum analyzers can be modified in RFXpress before they are regenerated.

You can create UltraWideBand WiMedia signals in the Conformance and Custom modes. In the conformance mode, you can either select a standard setup or define your own setup based on the UWB standards. In the Custom mode, you can create a customized signal by defining packet parameters and setting processing preferences. The Calibration feature for the UWB-WiMedia module allows you to create correction files and apply these correction files to channels during compilation.

The RFXpress RFX100 radar application supports basic pulse generation of different shapes and modulation types.

## Related Documentation

In addition to this RFXpress Online Help, the following documentation is included with the software:

- *RFXpress Installation Manual* (Tektronix part number 077-0160-XX). The installation manual has information about installing and upgrading the software.
- *RFXpress Printed Help Document (User Manual)* (Tektronix part number 077-0045-XX). The user manual is adapted from the online help and is available in PDF format.
- *RFXpress Quick Start User Manual* (Tektronix part number 077-0159-XX). The quick start user manual has information about using the software creating IF/IQ/RF signal output.
- *RFXpress Programmer Online Help* (Tektronix part number 076-0216-XX). The programmer online help has information about the available programmer commands for RFXpress.
- *RFXpress Programmer Manual* (Tektronix part number 077-0435-XX). The programmer manual is adapted from the programmer online help and is available in PDF format.

For WiMedia standards, please refer to the *MultiBand OFDM Physical Layer Specification Version 1.2* by WiMedia Alliance.

## Conventions

The online help uses the following conventions:

- 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.
- DUT refers to the Device Under Test
- Three dots (...) following a menu item indicates that the menu item will open a submenu.
- The terms "signal" and "waveform" are used interchangeably.

## Feedback

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- In North America, call 1-800-833-9200.
- Worldwide, visit [www.tektronix.com](http://www.tektronix.com) to find contacts in your area.

## Minimum System Requirements

RFXpress when installed on a personal computer runs in the offline mode. The minimum requirements for the offline version of the application are listed in the following table.

**Table 1: Minimum system requirements**

<b>Supported OS</b>	Windows XP Professional Service Pack 2.1 Windows 7 Professional Windows Vista Business Edition (English Language)
<b>Minimum Requirements</b>	2.0 GHz or higher 512 MB RAM 15 GB free disk space Microsoft Internet Explorer 6.01 or higher .NET 2.0 runtime 1024 x 768 display resolution with 120 dpi font size

### Prerequisites

- TekVisa version 3.3.2.7 or above to communicate with test instruments, such as oscilloscopes, over LAN. If TekVisa is not already installed in your system, you can download the software from [www.tektronix.com/software](http://www.tektronix.com/software).
- MATLAB Runtime version 7.9 installed on your instrument.
- .NET v2.0 installed on your instrument.

## Ordering RFXpress

RFXpress can be ordered as follows:

**Table 2: Ordering RFXpress**

<b>Part number</b>	<b>Description</b>
RFX100	Base Software: RFXpress for General Purpose IQ, IF, and RF signal creation
Opt. UWBCF	RFXpress plug-in for UWB-WiMedia IQ, IF, and RF conformance signal creation (requires RFX100 as prerequisite)
Opt. UWBCT	RFXpress plug-in for UWB-WiMedia IQ, IF, and RF custom and conformance signal creation (requires RFX100 as prerequisite and includes Option UWBCF)
Opt. RDR	RFXpress plug-in for RADAR signal creation (requires RFX100 as prerequisite)

**Table 2: Ordering RFXpress (cont.)**

Part number	Description
Opt. SPARA	RFXpress option for including S-Parameter for Generic Signal and DUT Characterization (requires RFX100 as prerequisite)
Opt OFDM	RFXpress option for including OFDM signal generation (requires RFX100 as prerequisite)
RFXUP OFDM	Upgrade option to include OFDM signal generation for RFX100

## Installation

An installation wizard installs RFXpress. If you have not installed TekVisa version 3.3.2.7, MATLAB Runtime version 7.9, and .NET 2.0, you will be notified during installation. You can cancel the installation any time during the process.

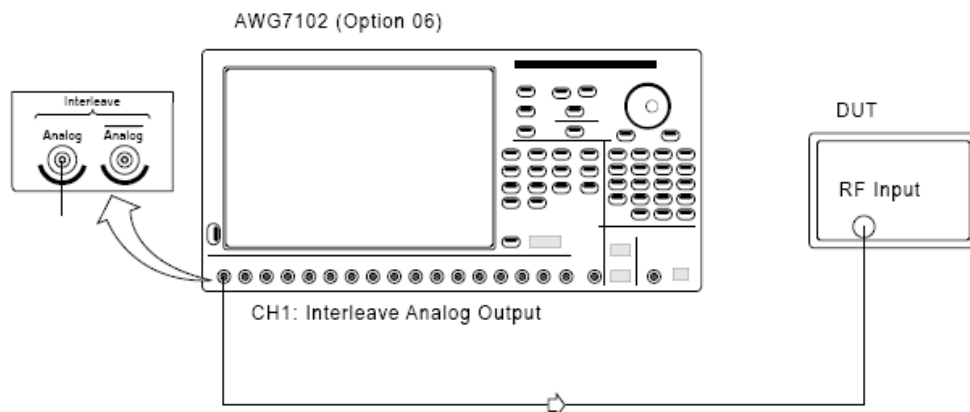
For details on how to install the software, refer to the *RFXpress Installation Manual* (Tektronix part number 077-0160-XX) available as a PDF on the CD-ROM.

You can uninstall RFXpress in either of the two ways:

- From Start > Programs > Tektronix RFXpress > Uninstall RFXpress.
- From Add/Remove programs in Control panel.

## Setup for RF Signal Generation

1. Start the RFXpress installed on the AWG.
2. From the toolbar, select the signal type as IF/RF.
3. Make connections as shown in the figure:
  - Connect the AWG Ch 1 Analog Output to the DUT where the RF Signal must be fed.
  - When using the Interleave mode, the RF output should be taken from Interleave Output as shown.



4. Click Compile. The waveform is compiled according to the default settings in the Compile Settings window. The compiled waveform is displayed in the Waveform List. This IF/RF waveform will be transferred to the AWG channel (Ch1) and this can also be seen in the Instrument Control > AWG tab.
5. Click On/Off to turn on the channel Ch1.
6. Click Run to generate the signal on the AWG.

See also:

[Calibration \(see page 129\)](#)

[Find Instruments \(see page 29\)](#)

## Setup for IF Signal Generation

1. Start the RFXpress installed on the AWG.
2. From the toolbar, select the signal type as IF/RF.
3. Connect the AWG Ch 1 Analog Output to the DUT where the IF Signal must be fed.
4. Click Compile. The waveform is compiled according to the default settings in the Compile Settings window. The compiled waveform is displayed in the Waveform List. This IF waveform will be transferred to the AWG channels (Ch1) and this can also be seen in the Instrument Control > AWG tab.
5. Click On/Off to turn on the channel Ch1.
6. Click Run to generate the signal on the AWG.

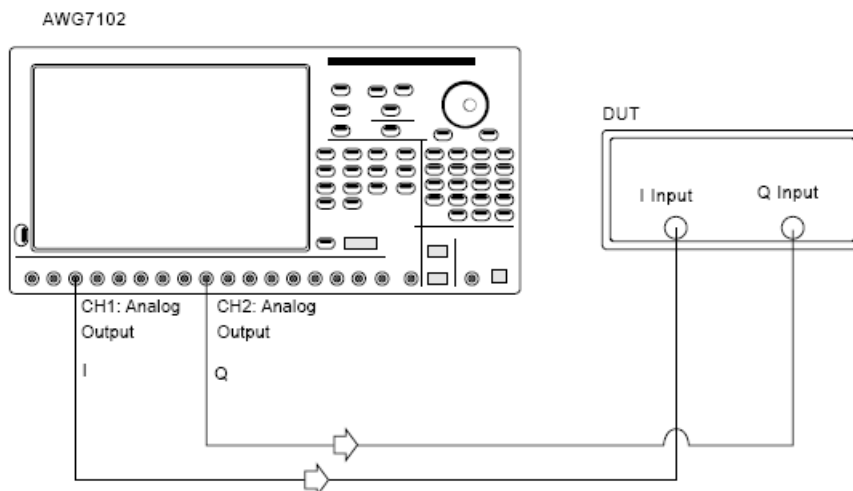
See also:

[Calibration \(see page 129\)](#)

[Find Instruments \(see page 29\)](#)

## Setup for AWG IQ Signal Generation

1. Start the RFXpress installed on the AWG.
2. From the toolbar, select the signal type as IQ.
3. Make connections as shown in the figure:
  - Connect the AWG Ch1 Analog Output to the DUT where the I Signal must be fed.
  - Connect the AWG Ch2 Analog Output to the DUT where the Q Signal must be fed.




---

**NOTE.** Both cables must be the same length, otherwise you would need to deskew them.

---

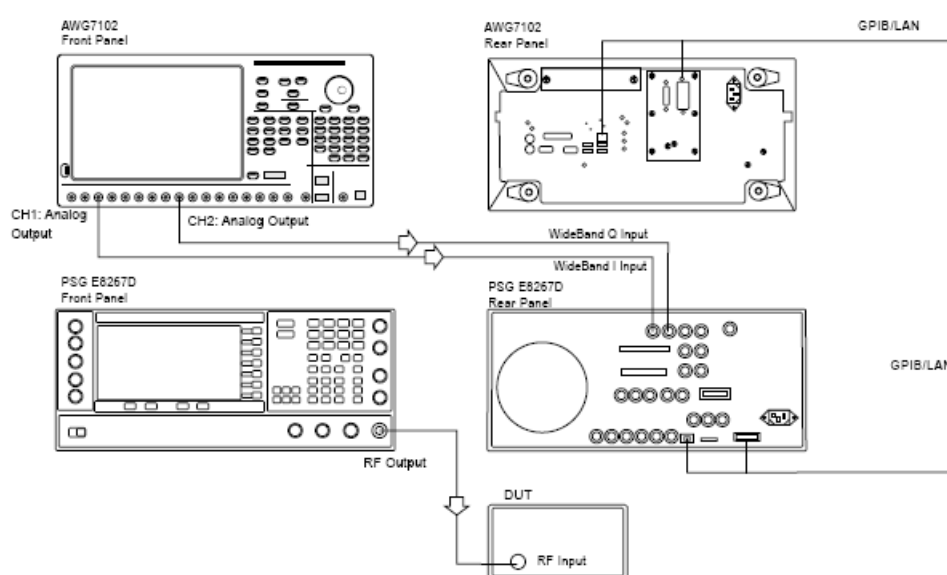
4. Click Compile. The waveform is compiled according to the default settings in the Compile Settings. The compiled waveform is displayed in the Waveform List. This waveform will be transferred to the AWG channels (Ch1 and Ch2). This can also be seen in the Instrument Control > AWG tab.
5. Click On/Off to turn on the channels Ch1 and Ch2.
6. Click Run to generate the signal on the AWG.

### Setup for AWG IQ Signal Generation with External Modulator

1. Start the RFXpress installed on the AWG.
2. Select the Signal type as IQ.



3. Make connections as shown in the figure:
  - Connect the AWG and Agilent performance signal generator® (E8267D with Option 015) through LAN or GPIB.
  - Connect the AWG Ch1 Analog Output to the Agilent performance signal generator's (PSG®) external I Input (in the rear panel).
  - Connect the AWG Ch2 Analog Output to the Agilent performance signal generator's (PSG®) external Q Input (in the rear panel).
  - Connect the PSG's RF output from the front to the DUT.




---

**NOTE.** Both cables must be the same length, otherwise you would need to deskew them.

---

4. Click Compile. The waveform is compiled according to the default settings in the Compile Settings window. The compiled waveform is displayed in the Waveform List. This waveform will be transferred to the AWG channels (Ch1 and Ch2). This can also be seen in the Instrument Control > AWG tab.
5. Click On/Off to turn on the channels Ch1 and Ch2.
6. Click Run to generate the signal on the AWG.

See also:

[Calibration \(see page 129\)](#)

[Find Instruments \(see page 29\)](#)



## About Basic Operations

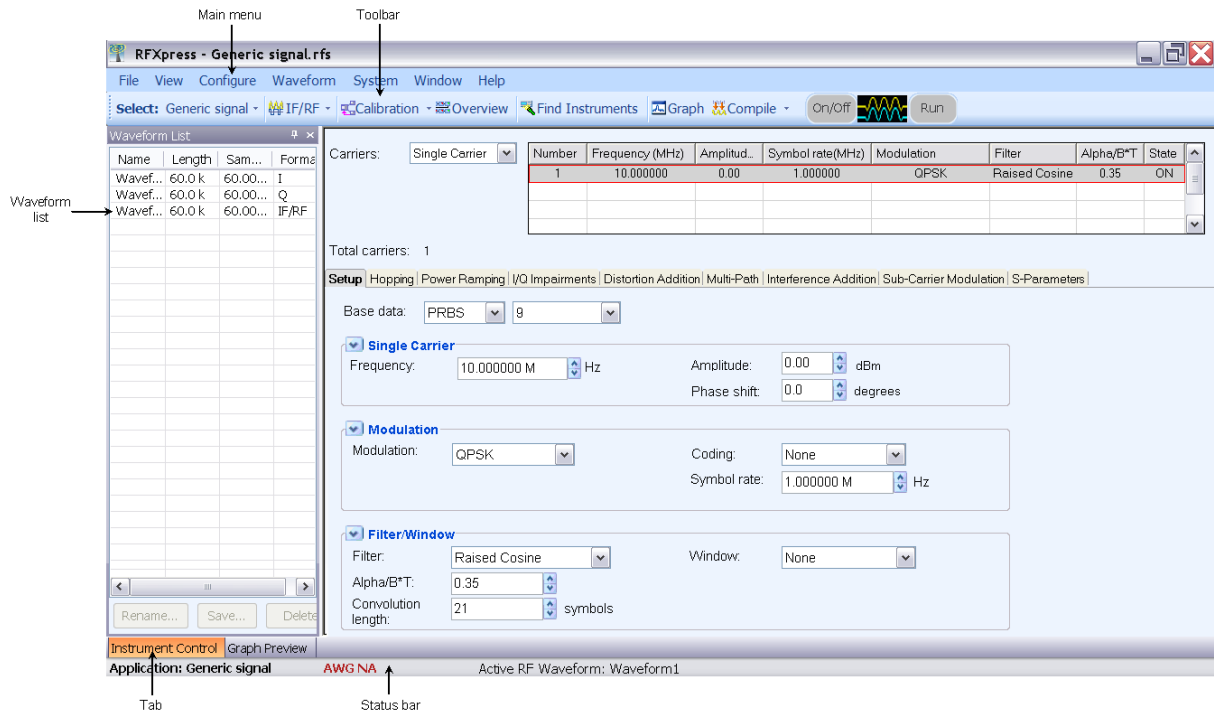
The basic operations section describes the software, tells how to start the software, use the menus and toolbars, and describes the dialog boxes.

In this online help, all menu selections are indicated with Menu name and Menu options separated by ">". You can access a command or a menu option in more than one way. Several main menu options are available in a toolbar that you can use instead of selecting the option from the main menu. Shortcut menus, which open with a right-click, are provided for editing, creating and viewing graphs, importing data from a file or a Tektronix oscilloscope, and transferring a waveform to an arbitrary waveform generator.

Some dialog boxes also have a Help button that displays help for that dialog box.

Detailed operations and parameters are described in the sections on Generic Signal, OFDM, UWB-WiMedia, Radar, Calibration for WiMedia Signals, Instrument Control, and Graphing. The References section lists Error Messages, Shortcut Keys, and provides a note on Interleaving and Types of Modulation.

The following figure shows the application screen, the menu, the toolbar, and other elements of the user interface.



## Overview of the Software

RFXpress is a software application that creates digitally modulated baseband, IQ, IF, RF, UWB-WiMedia, and Radar signals that can be generated through arbitrary waveform generators (AWG). This software runs as an integral part of AWG5000 and AWG7000 series arbitrary waveform generators and can also run from an external PC.

### Features of RFXpress

- Baseband data generation: Define baseband I and Q signals using a variety of modulation schemes such as No Mod, QPSK, PI/2 QPSK, BPSK, PI/4 QPSK, OQPSK, 8-PSK, O-8PSK, QAM-16, PI/2 QAM16, QAM-32, QAM-64, QAM-128, QAM-256, QAM-512, QAM-1024, GMSK, 2-FSK, 4-FSK, 8-FSK, 16-FSK, 32-FSK, ASK, AM, PM, FM, nDPSK, OOK, and Pi/2 BPSK.
- Multi-carrier setup: Define multiple RF/IF carriers in a single waveform. Each carrier can be independently defined with parameters such as carrier frequency, symbol rate, modulation type, and baseband filters.
- Single or multiple pulse groups to form a pulse train: Each pulse group can be independently defined with various predefined pulse shapes and user defined shapes for a pulse group.
- Allows you to apply various modulation schemes or define your own.
- Allows you to have Pulse- to-Pulse hopping within a pulse group and to apply impairments like Edge Jitter, Width Jitter, Overshoot, Ripple and Droop on a pulse group.
- IQ impairments: Apply impairments including quadrature error and quadrature imbalance.
- Generate the following graphs:
  - Frequency Domain: Spectrum
  - I v Q: Constellation
  - Time Domain: I(t) and Q(t) vs. time, and Pulse shape
  - Statistical: CCDF and Eye Diagram
  - Time vs Frequency: Spectrogram and Coherent Pulse Interval
- Distortion measurement for system calibration: To maintain system integrity and coherency with Amplitude, Phase inband flatness, and skew between separate channels. The setup includes capturing data from a TDS oscilloscope and a real-time spectrum analyzer and downloading the data to generate the correction data.
- Noise/interference generation and addition: Generate and add interference for waveforms. Generate gated noise on specific frames designated by the user.
- **Capture and Replay:** Waveforms captured from oscilloscopes and real-time spectrum analyzers can be modified in RFXpress before they are regenerated.

- **Wrap around:** RFXpress completely eliminates all the wrap-around effects found in arbitrary waveform generators, providing seamless signals that can be played back continuously without any discontinuity or glitch in the time, frequency, modulation, or channel coding domains.
- Connectivity between AWG, oscilloscope, and Agilent Performance Signal Generator® (PSG). The ability to identify and connect to a Tektronix Arbitrary Signal Generator (AWG), a Tektronix oscilloscope, and the Agilent PSG®, and to configure their setups remotely. The radar application uses the AWG sequence mode to optimize the memory and create large number of pulses. However if Option 08 is not purchased, the radar application uses the Continuous Mode instead of Sequence Mode.
- 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.
- Define antenna beam profile and simulate target returns for radar signals.
- Create multiple layers of modulation using subcarrier multiplexing.
- Define a staggered PRI with ramp and user-defined profiles, and add up to ten multipaths.
- Configure all parameters of OFDM
- Build custom OFDM frames from defining base data, symbols, packets, and frames
- Support Reed Solomon, Convolution coding, and Scrambling
- Add Impairments Phase noise, Multipath, and Quantization
- Define frequency hopping and gated noise
- Support a variety of sub-carrier modulation (BPSK, QPSK, QAM (16,32,64,256) and 8-PSK)
- Support Tone Nulling and Clipping
- Provide presets for WiFi and WiMax standards

## Starting the Software

From the Start menu, click All Programs > Tektronix RFXpress > RFXpress. You can also double-click the RFXpress shortcut on the desktop.

You can use the software in three modes:

- RFXpress on any AWG5000 or AWG7000 series instrument. In this case, the software automatically detects the AWG software. You can transfer data directly to the AWG. The status bar shows "AWGXXXX Online".
- RFXpress on a PC with the AWG software running in the offline mode. In this case, the AWG software has to be started before starting RFXpress. You can transfer data to the AWG offline software. The status bar shows "AWGXXXX Offline".
- RFXpress on a PC without the AWG software. In this case, the software does not detect the AWG software, and you cannot transfer data to the AWG (although you can create and store the waveform for later use). The status bar shows "AWGXXXX Not Available".

## Using the Software to Create a Signal

Using RFXpress, you can generate a signal as follows:

1. Select an application or module: Generic Signal, UWB-WiMedia, or Radar.
2. Select the signal type: IF/RF or IQ.
3. For a Generic signal, select the number of carriers: Single or Multi-carrier. For a UWB signal, select the mode: Conformance or Custom. For a Radar signal, select the number of pulses.
4. For a Generic signal, define the carrier parameters: Frequency, Modulation, Amplitude, Filter and others. For a UWB signal, select the setup and define the selected packet group and packet parameters. For a Radar signal, select the pulse envelope, frequency, and other pulse parameters.
5. Select the compilation options and compile the signal.

You can also specify the graphs that you want to create and view them in the Graph Preview window. You can transfer the signal to an arbitrary waveform generator in the Instrument Control window. Importing files and replicating waveform files work with only the following instruments:

- Oscilloscopes: Tektronix TDS6000, DPO/DSA70000, and DPO7000 series (\*.wfm)
- Arbitrary Waveform Generators: Tektronix AWG400, AWG500, AWG600, and AWG700 series (\*.wfm)
- Real-time Spectrum Analyzers: Tektronix RSA3000 and RSA60000 series (\*.iqt, \*.tiq)
- Others: MATLAB binary formats (\*.MAT)

## Exiting the Software

Select File > Exit to exit the application. If you have not saved the waveforms, you are prompted to do so.

## File Name Extensions and Directories

The software uses the following file name extensions:

**Table 3: File name extensions**

File name extension	Description
.rfs	Setup file of the selected application
.rfd	Data file of the waveform (generic signal and ultra wide band signal)
.smp	Symbol file
.rfc	Correction file

The software uses the following directories:

**Table 4: Directory names**

Directory	Description
C:\Program Files\Tektronix\RFXpress\System	Contains the application files and executables
C:\Program Files\Tektronix\RFXpress\Documentation	Contains the related documentation as text and PDF files
C:\Program Files\Tektronix\RFXpress\Samples	Contains sample waveform files

## Applications, Setup Files, and Data Files

An application is a module that you can use to create specific types of waveforms, for example Generic Signal and UWB-WiMedia. Applications that are available but have not been purchased appear in the Application list but are disabled.

You can only have one Setup File (.rfs) open at a time and only one application in use at a time. If you change the application, you will be prompted to save the open file.

**Selecting an application:** In the Select field, select an application from the list. When you select an application (Generic Signal, UWB-WiMedia, or Radar), the default settings are displayed for the currently selected application.

**Setup File (.rfs):** A Setup File is a collection of settings that describes a single or multiple waveforms. Once you compile the setup file (using Waveform > Compile), you can save the file as a Data File (.rfd). Compiled data files for the current session appear in the Waveform List. After you select the Application, a default Setup File opens automatically. If a setup file is open with unsaved changes and you try to create a new file or change applications, you are prompted to save the file. To open an existing setup file, select File > Open Setup.

The rfs file content varies depending on the selected application (Generic or UWB-WiMedia). By default, the name of the rfs file is derived from the application name.

**Data File (.rfd):** You can save a compiled Setup File as a Data File using File > Save Data or Save Data As. Files that you import from other instruments become data files. Select File > Save or Save As to save these data files. To open an existing data file, select File > Open Data.

---

**NOTE.** Each rfd file can store one of the three formats: IF/RF, I, and Q. An rfd file stores the version information and sampling rate.

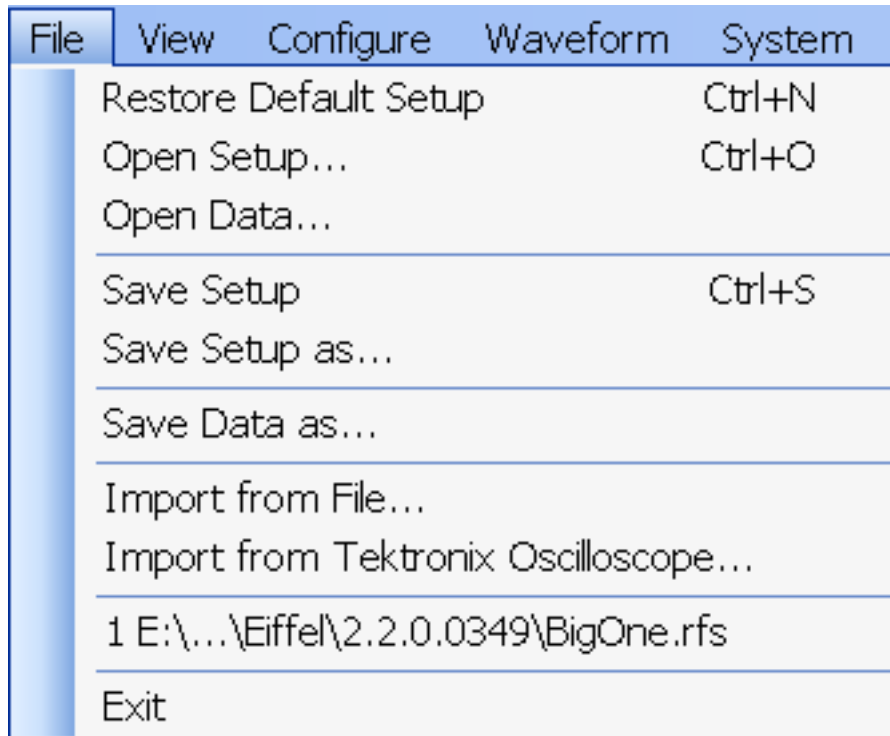
---



## Menu Bar

The RFXpress menu has the following items:

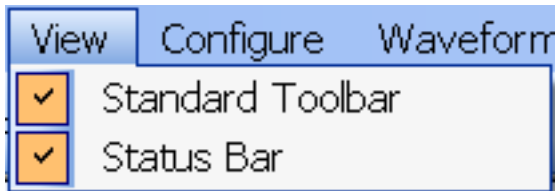
- File



Use the File menu to:

- Restore the default setup for the currently active application
- Create new waveform setups
- Open, close and save waveform setups (.rfs format)
- Open, close and save data files (.rfd format)
- Import data from a file (created by another software)
- Import data from a Tektronix oscilloscope
- Exit the software

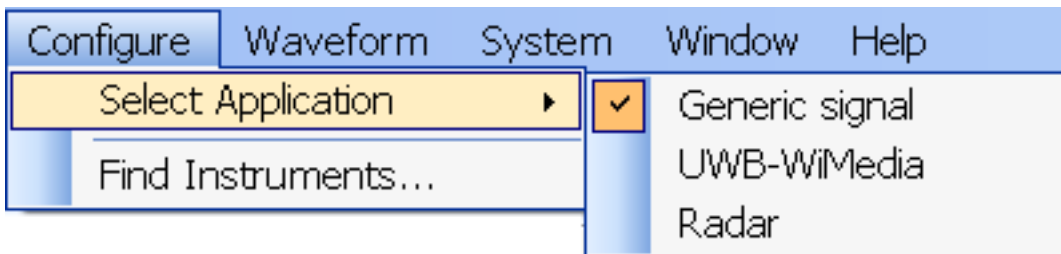
- View



Use the View menu to:

- View the Standard toolbar
- View the Status toolbar

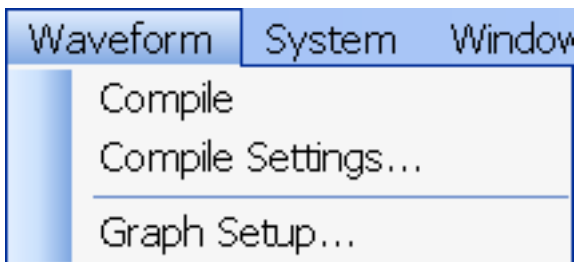
- Configure



Use the Configure menu to:

- Select an application: Generic Signal, UWB-WiMedia, or Radar. UWB-WiMedia and Radar are available only if they have been purchased
- Open the Find Instruments dialog box to make instrument connections

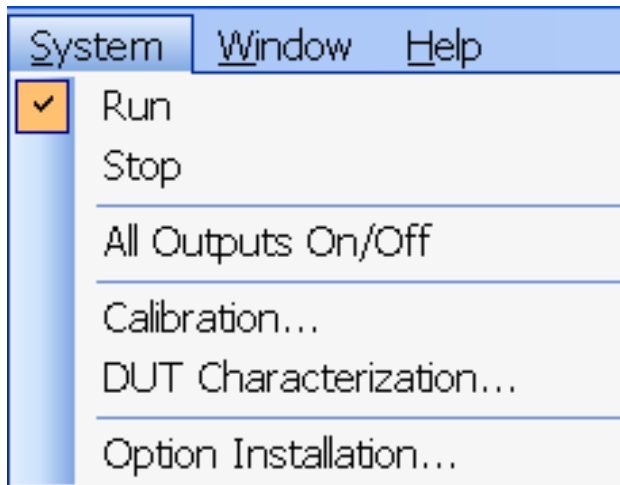
- Waveform



Use the Waveform menu to:

- Compile the currently active Waveform Setup
- Set Compilation options
- Open the Graph Setup dialog box to select the graphs

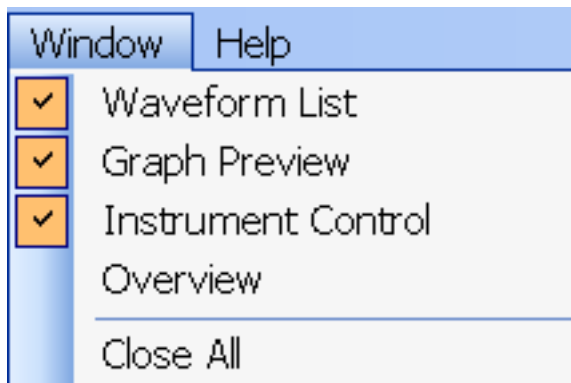
## ■ System



Use the System menu to:

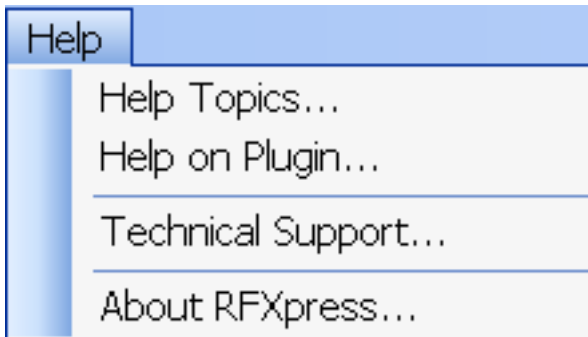
- Run
- Stop
- Turn all channel outputs on or off
- Open the Calibration wizard and set the parameters to calibrate the signal
- Open the DUT Characterization wizard

## ■ Window



Use the Window menu to:

- View the Waveform List window
  - Preview the Graphs
  - Open Instrument Control window
  - Open the Overview window
  - Close all windows
- Help



Use the Help menu to:

- Open the online help
- Display help specific to the currently active application
- Display technical support on the Tektronix Web site
- Display information about the application, such as version number

## Standard Toolbar

The Standard toolbar is always displayed by default. Select View > Standard toolbar to hide or show the toolbar.



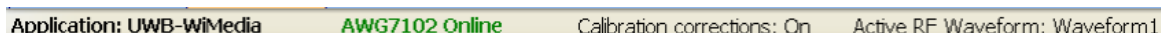
The Standard toolbar has the following options that you can select:

- [Select Application \(see page 22\)](#)
- [Signal Type \(see page 22\)](#)
- [Calibration \(see page 48\)](#) Calibration for Generic Signal
- [Overview \(see page 37\)](#)

- [Find Instruments \(see page 29\)](#)
- [Graph \(see page 30\)](#)
- [Compile \(see page 22\)](#) and [Compile Settings \(see page 32\)](#)

## Status Bar

The Status Bar is always displayed by default. Select View > Status Bar to hide or show the status bar. The status bar shows the selected application, the AWG mode, and the active waveform names. The status of calibration (On/Off) is also displayed.



Application: UWB-WiMedia    AWG7102 Online    Calibration corrections: On    Active RF Waveform: Waveform1

## Waveform List

Window > Waveform List

The Waveform List is a floating window and can be moved anywhere in the display area. By default it opens in the leftmost area of the display window. The Waveform List window can be kept open by pushing the pin in the top right corner, or closed and opened as you like. To view the waveform list, from the menu select Window > Waveform List.

After you select a signal to generate and set the parameters for it, you must compile it to create the data. Once you compile a signal (using Compile from the toolbar), waveform data is created and added to the waveform list. The Waveform list displays the Name, Length, Sampling Rate and Format of the waveform data. The maximum number of waveforms that can be displayed in the waveform list is 13,000. When the number of waveforms exceeds this limit, a warning message appears: Number of waveforms is over the maximum limit of 13,000.

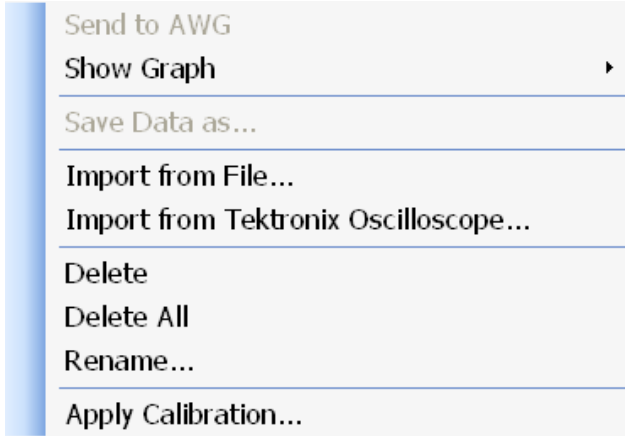
To save a waveform that is available in the list, select the waveform and select File > Save Data or Save Data As. You can also right-click the selected waveform and choose Save Data As. The compiled waveform or data file is saved as a data file (.rfd) in the specified location. The data files are stored in the path where the application is installed.

---

**NOTE.** *If you close the software without saving the compiled waveform, the waveform is lost. You can compile the waveform again from the setup, if you have saved the setup using File > Save Setup or Save Setup As. The setup file is an rfs file.*

---

You can select the following options from the shortcut menu:



**Table 5: Shortcut menu options**

Selection	Description
Send to AWG	Enabled only if the AWG software is running and when a waveform is selected. Sends the selected waveform data to an Arbitrary Waveform Generator. Select the channel to which to send the data.
Show Graph	Enabled only when a waveform is selected. Plots a graph of the selected type: Frequency Spectrum, Time Domain and CCDF. You can also select <a href="#">Graph Settings...</a> (see page 30) and choose the graphs from those available.
Save Data As...	Enabled only when a waveform is selected. Saves the selected waveform data as a .rfd file in the specified name and location.
<a href="#">Import from File...</a> (see page 24)	Imports data into the software from a file. Choose the file and location from which to import data.
<a href="#">Import from Tektronix Oscilloscope...</a> (see page 28)	Imports data from a Tektronix oscilloscope that is connected to the instrument on which the software is running.
Delete	Enabled only when a waveform is selected. Deletes the selected waveform.
Delete All	Enabled only when a waveform or waveforms are available in the Waveform List. Deletes all the waveforms shown in the waveform list.

**Table 5: Shortcut menu options (cont.)**

Selection	Description
Rename...	Enabled only when a waveform is selected. Opens a dialog box that allows you to enter a waveform name.
Apply Calibration	Enabled only when a waveform is selected. Opens a browser window where you can specify the correction file (.rfc) file to use for calibrating the selected waveform. The correction file must be generated using a generic signal with the same sampling rate as that of the signal you want to calibrate. You can also apply calibration to an imported waveform that was created using MATLAB.

You can also drag and drop a waveform from the Waveform List to Instrument Control. When you drag and drop a waveform, the sampling rate is automatically set in the instrument.

The Rename..., Save As... and Delete buttons appear at the bottom of the Waveform List. These buttons are available only when a waveform is selected.

**Table 6: Waveform list buttons**

Selection	Description
Rename...	Opens a dialog box and allows you to rename the selected waveform.
Save...	Saves the selected waveform as an .rfd file.
Delete	Deletes the selected waveform.

## Generating Graphs

In the shortcut menu, from the Graph option you can select the following graphs: Time Domain, Spectrum, and CCDF. Not all the graphs are available for all waveform formats and all applications. The following table lists the availability of the graphs for various waveform formats.

**Table 7: Waveform formats and available graphs**

Selected waveform format	Graphs		
	CCDF	Spectrum	Time domain
When both I and Q waveforms are selected	Available	Available	Not available
When I waveform is selected	Not available	Not available	Available
When Q waveform is selected	Not available	Not available	Available
When IF/RF waveform is selected	Not available	Available	Available

For the Radar application, the available graphs are Spectrum, Spectrogram, CPI, I Vs Time, and Q Vs time.

## Select Application

Configure > Select Application

Before you create a new Waveform Setup and Setup File, you must identify the application. Do this by clicking on the Application field and selecting either Generic Signal, UWB-WiMedia, or Radar. The default settings for the currently selected application will be displayed.

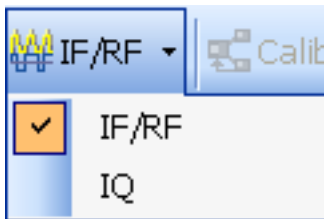
---

**NOTE.** *The UWB-WiMedia Custom Mode and Radar are enabled only if you have purchased the options.*

---

## Signal Type

Set the signal type from the drop-down list to either IF/RF or IQ. Another way to select the signal type is by using the [Compile Settings \(see page 32\)](#) dialog box.



## Compile

Waveform > Compile

To compile a currently active waveform:

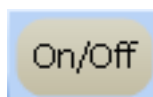
1. Click Compile in the Standard toolbar. The waveform is compiled and displayed in the Waveform List.



2. From the [Waveform List \(see page 19\)](#), you can select Send to AWG, Show Graph, Save Data as, Delete, or Rename the waveform.



## On/Off



Click the On/Off button to turn on or turn off the arbitrary waveform generator (AWG) channel output.

## Run



Click the Run button to turn on or turn off the Run state of the arbitrary waveform generator (AWG). If the application is running on an AWG or using an offline mode of the AWG software, the compiled waveform is directly output to the channel. The channel is turned on and generates the signal. The signal generation is indicated when the Run button changes to green.

## Open Setup

File > Open Setup

You can open a setup file from the selected location. All files have the file name extension .rfs.

## Open Data

File > Open Data

You can open a data file from the selected location. All files have the file name extension: .rfd.

## Save Setup

File > Save Setup, File > Save Setup As...

You can save the setup file in any of the following formats: .rfs and .txt.

Use File > Save Setup to save an existing setup file with the same name. If you are saving the setup for the first time, the Save Setup option works exactly as the Save Setup As... option.

Use File > Save Setup As... to save the setup file with another file name.

## Save Data

File > Save Data, File > Save Data As...

You can save the data file in either .rfd or .txt format. You must compile a setup before you can save the data. If you try to save a setup as data without compiling, you are prompted to compile the setup.

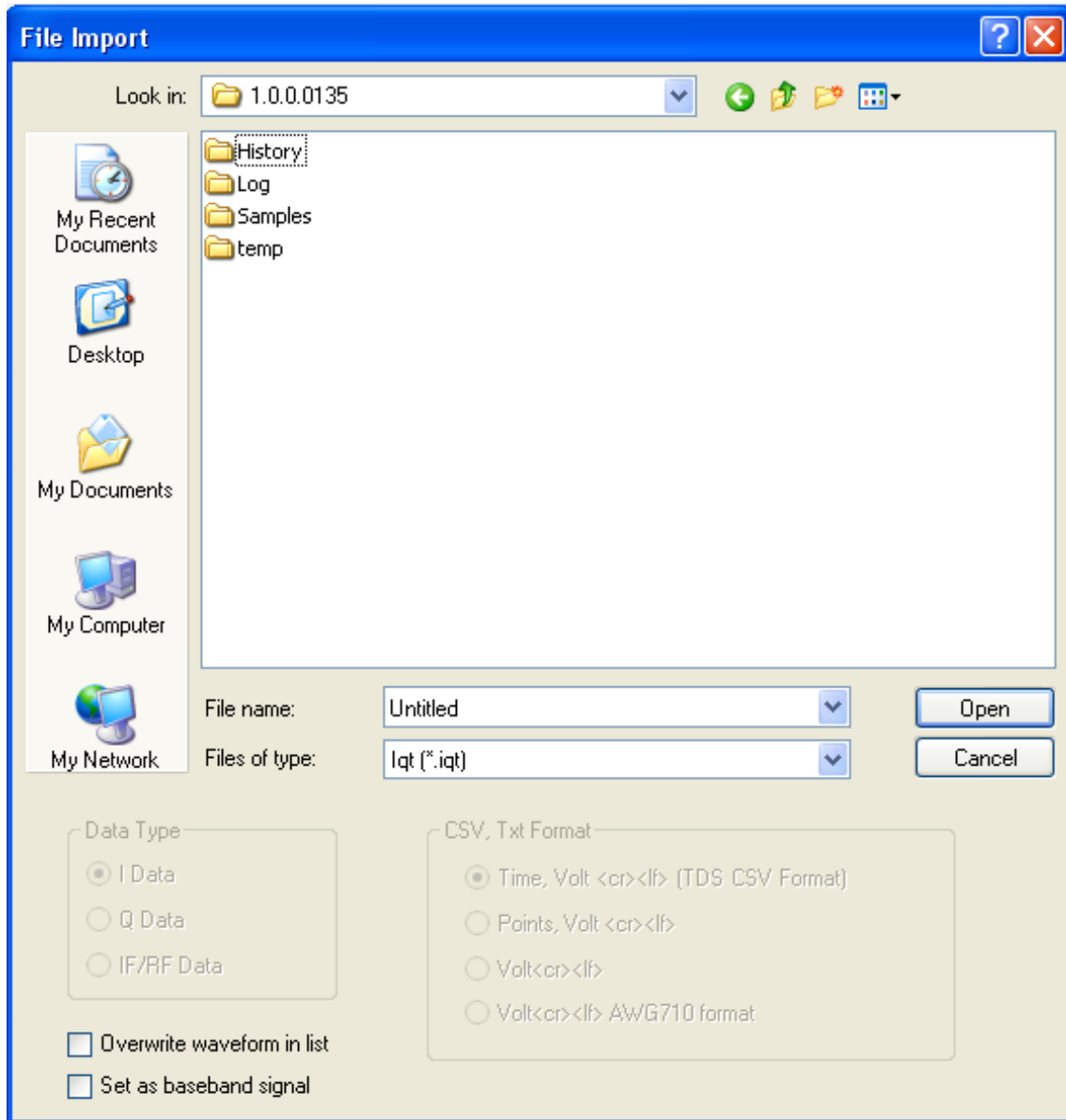
Use File > Save Data to save an existing data file with the same name. If you are saving the data for the first time, the Save Data option works exactly as the Save Data As... option.

Use File > Save Data As... to save the data file with another file name.

## Import Data from a File

File > Import from File

You can import a waveform file created in another software, and import the resulting waveform into RFXpress. To import data from a file, select File > Import from file. This dialog box is displayed. Navigate to the directory of choice and select the file to import.



You can import files of the following types:

- .wfm from oscilloscopes and arbitrary waveform generators
- .iqt from real-time spectrum analyzers (RSA3000 series)
- .tiq from real-time spectrum analyzers (RSA6000 series)
- .pat from arbitrary waveform generators
- .isf from oscilloscopes
- .csv (comma separated file)

- .txt (text file)
- .mat (MATLAB) file

The following options are available:

**Table 8: File import options**

Selection	Description	Default value
Data Type: I Data, Q Data, IF/RF Data	Select the data type to specify the type of data contained in the file. Enabled only when the file formats are .csv and .txt.	I Data
CSV, Txt Format	Specifies the parameters contained in the csv or text file: Time, Volt <cr><lf> (TDS CSV format) Points, Volt <cr><lf> Volt <cr><lf> Volt <cr><lf>, AWG710 format Time<tb>Volt<cr><lf>(ADS format) <sup>®</sup> Volt, Volt<cr><lf> (VSA CSV format) <sup>®</sup> Enabled only when the file format is .csv or .txt.	Time, Volt <cr><lf> (TDS CSV format)
<a href="#">Resample waveform in list</a>	When selected, transforms the imported waveform using the desired sampling rate you provided. This feature is available for all types of imported files.	When the AWG is in the online mode, the desired sampling rate must be within limits. In the offline mode, the sampling rate is restricted to within the AWG7122B (option 1, 6, 8) limits.
Overwrite waveform in list	When selected, overwrites the waveform present in the waveform list without any warning.	Disabled
Set as baseband signal	When selected, replaces any existing carriers with two carriers representing the baseband signal. This option is available only when an iqt or tiq file is selected for import and the selected application is Generic Signal.	Disabled

A MATLAB (.mat) file should meet the following conditions:

- It should contain a sampling rate and a variable with ‘n’ sample points or values (n > 1).
- The sampling rate should be of the format 1 x 1 and the points should be of the format 1 x n.
- For example,  
 SamplingRate = 15e9  
 SamplePoints = [ 0.5 0.3 0.2 0.7 ....]

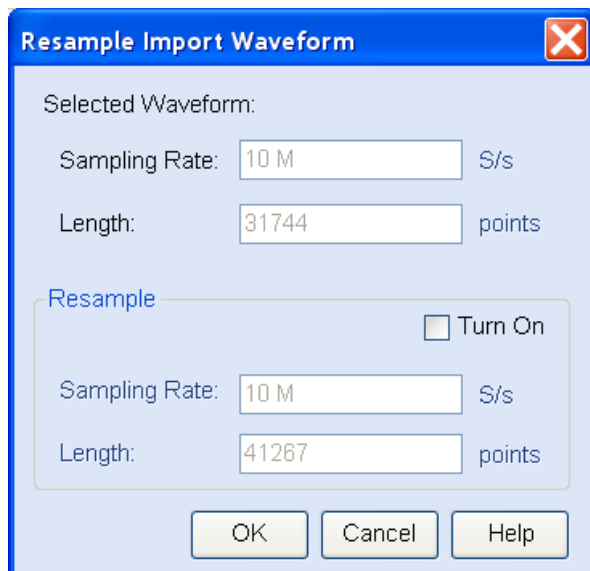
## Set Sampling Rate for Imported Waveforms

You can set the sampling rate for the waveform while importing it from a text file. This dialog box appears only when the text file does not have the sampling rate of the waveform stored in it. The application uses the default sampling rate (10 M S/s) if you do not enter a new sampling rate.

## Resample Imported Waveform

You can use a different sampling rate while importing a waveform file created in another software.

1. Select File > Import from file.
2. Select the Resample waveform in list option. A dialog box appears.



The sampling rate and the number of samples (length) of the waveform being imported is displayed.

3. To change the sampling rate, click Turn On.
4. Enter the new sampling rate. As the sampling rate is changed, the Length is correspondingly changed.

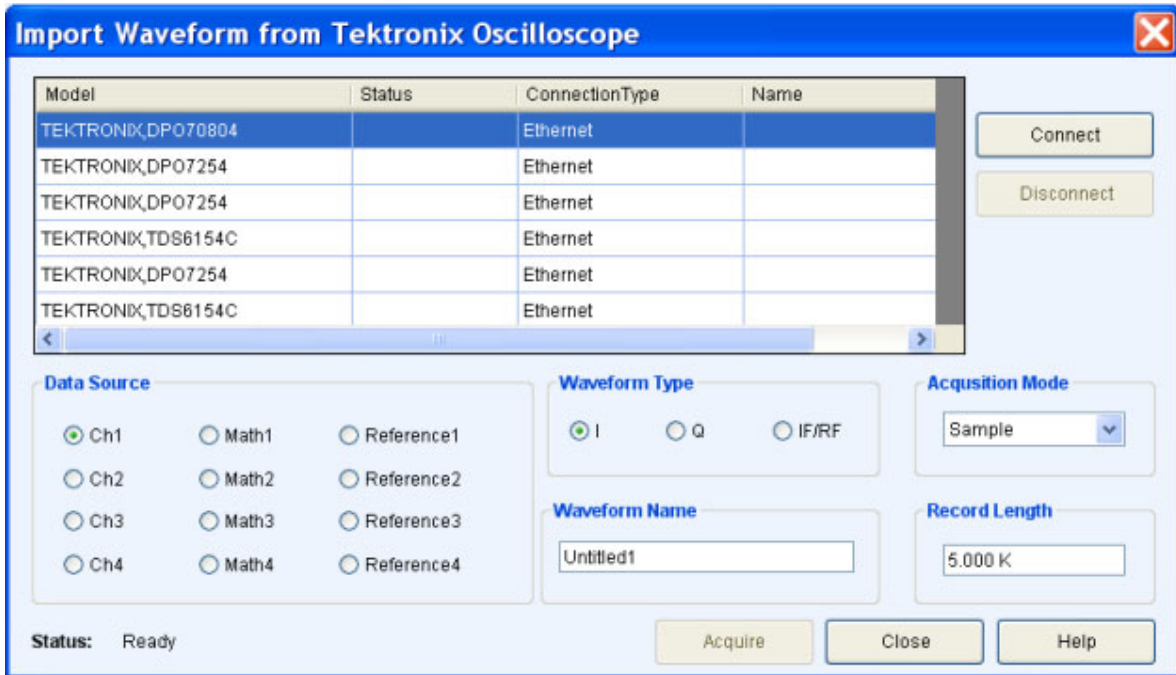
When the AWG is in the online mode, the desired sampling rate must be within limits. In the offline mode, the sampling rate is restricted to within the AWG7122B (option 1, 6, 8) limits.

5. Click OK. If you click Cancel, the waveform is imported without changing the sampling rate.

## Import from Tektronix Oscilloscope

File > Import from Tektronix Oscilloscope

You can import a waveform file from a Tektronix oscilloscope that is connected to your instrument into RFXpress. To do this, select File > Import from Tektronix Oscilloscope. This dialog box is displayed.



A table displays a list of oscilloscopes on the network. Select an oscilloscope in the table and click Connect to connect to it. You can connect to more than one oscilloscope at a time. Click Disconnect to disconnect from an oscilloscope.

For a connected oscilloscope, you can set the following parameters:

**Table 9: Waveform import options**

Selection	Description	Default value
Data Source	Select the data from which to acquire the waveform data: Ch1 to Ch4, Math1 to Math4, and Reference1 to Reference4.	Ch1
Waveform Type	Select the type of waveform: I, Q, or RFIF.	I
Waveform Name	Specify the waveform name. The imported waveform is saved in the specified name.	N/A

**Table 9: Waveform import options (cont.)**

Selection	Description	Default value
Acquisition Mode	Set the acquisition mode to one of the following: Samples, Peak Detect, Envelope, or Average.	Samples
Record Length	Displays the record length of the selected oscilloscope. Change the record length by entering a new value in the field.	N/A

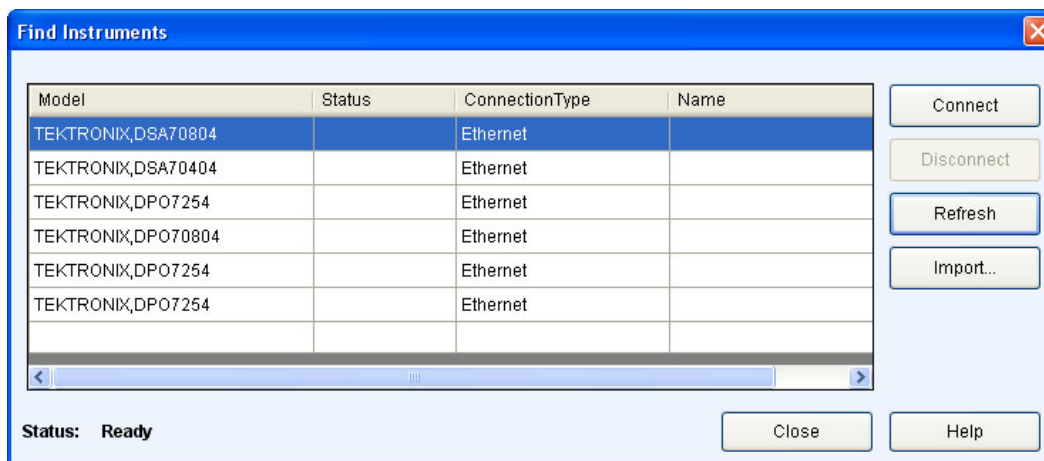
Click Acquire to import the data. The specified waveform name is used to list the waveform in the Waveform List.

## Find Instruments

Configure > Find Instruments

You can find instruments on the network and connect to them.

1. Click Find Instruments to find other instruments on the network. The following dialog box opens. A table lists the instruments found along with the Name of the instrument, Model, Status (connected or not), and the Connection type (Ethernet or GPIB).



2. Select an instrument from the table. Use the following buttons to:

**Table 10: Find instruments options**

Button	Description
Connect	Connect to the instrument selected in the table. Connect is enabled by default if an instrument is highlighted in the table; disabled if no instrument is highlighted.

**Table 10: Find instruments options (cont.)**

Button	Description
Disconnect	Disconnect the connected instrument. Enabled only if highlighted instrument is connected.
Refresh	Refresh the list of instruments.
<a href="#">Import... (see page 28)</a>	Open the Import from Tektronix Oscilloscope dialog box to select a file to import.

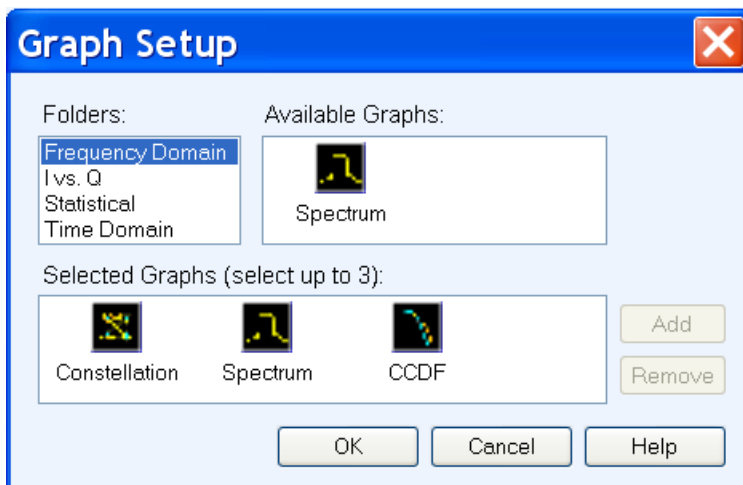
3. Click Connect to connect to the selected instrument. The Status provides the current status during the refresh operation: Searching Instruments or Ready.

## Graph

Waveform > Show Graph or Graph Settings

The software allows you to select the types of graphs before creating them. The graphs are displayed in two modes: as a set in a small window (for preview), and as individual graphs in large independent windows. At any time, a maximum of three graphs can be displayed in the small view.

To specify the graphs to create, click Graphs in the toolbar or Waveform > Graph from the menu. The Graph Setup dialog box opens.



Follow these steps to select the graphs to create:

1. Highlight a folder on the left. The graphs are grouped into the following folders: Frequency Domain, I Vs. Q, Statistical, and Time Domain.
2. Highlight a graph from Available Graphs on the right. Click Add to add the graph to the Selected Graphs area or drag and drop the graph to the Selected Graphs area.



The following folders and graphs are available:

- Frequency Domain: Spectrum
- I Vs Q: Constellation
- Statistical: CCDF and Eye Diagram
- Time Domain: I & Q vs. time, and Pulse shape
- Time vs Frequency: Spectrogram and Coherent Pulse Interval

The Spectrum (Frequency Domain), I & Q vs. time (Time Domain), and Spectrogram (Time vs Frequency) graphs are available for the Generic, UWB-WiMedia, and Radar applications. However, the Coherent Pulse Interval is specific to the radar application.

---

**NOTE.** *Once three graphs are added to Selected Graphs, the software will not allow you to add any more graphs. You must remove a graph before you can add another graph.*

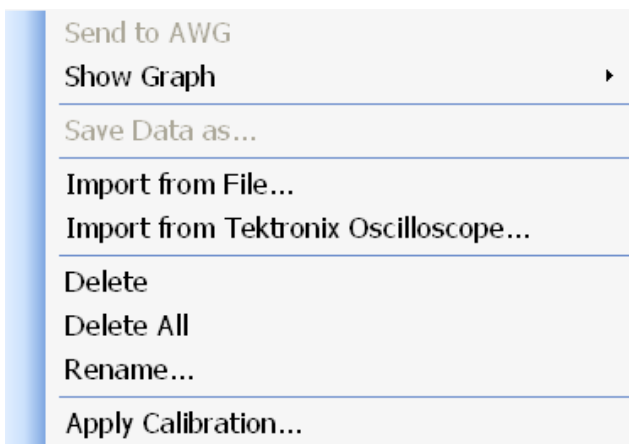
---

To remove a graph, highlight a graph in Selected Graphs and click Remove.

3. Click OK to view the graphs. the graphs are displayed in the Graph Preview tab. If you have selected fewer than three graphs, the other window (or windows) will be empty.

You can also create graphs from the [Waveform List \(see page 19\)](#) as follows:

1. Select a waveform from the Waveform List.
2. Right-click to view the shortcut menu.



3. Select Show Graph and select the type of graph to generate. The graph is displayed in a large independent window.

### Graph Preview

Graph Preview is a tab in a window that is shared with Instrument Control. Click the Graph Window tab to open it as a docked window.

When RFXpress first launches, Graph Preview is closed by default.

### Large Graph Windows

1. In the Graph Preview tab, click Maximize to view a graph in a larger window. The selected graph is displayed in a larger window.


---

**NOTE.** *When no graphs are selected, Maximize is not available.*

*The Zoom In and Zoom Out buttons are available in the following graphs: Spectrum, and I(t) Q(t)*

*Cursors, Cursor Readouts and the difference (Delta) between the cursors are available for the following graphs: Spectrum, I(t) Q(t), and CCDF.*

---

2. Click  to close the graph and return to the small view.

### Graphs from External Data

You can import data from a file (File > Import from File) and create graphs using the data. The imported file is displayed in the [Waveform List \(see page 19\)](#). Select the file from the Waveform List, right-click, and click Show Graph.

## Compile Settings

Waveform > Compile Settings

To specify compilation settings for the currently active Waveform Setup, click Compile Settings. This dialog box is displayed.

Waveform length:    Automatic

**Compile Button Preferences**

Compiles and sends to:   Compiles only

**Signal Format**

IF/RF  IQ

RF waveform name:

Sampling Rate   Automatic

Oversampling

**Correction Files**

When compiling, apply correction files to these channels

Ch1  Ch2

Select Correction File:

**Normalization**

Mode:

Adjust for wrap-around

Overwrite waveform in RFXpress list

I Invert  Q Invert

RFXpress supports generation of two signal types. The number of waveforms generated varies depending on the signal format selected.

- Baseband signals (IQ format): When the IQ signal format is selected, two baseband waveforms I and Q are generated. You must specify the names of each waveform.
- RF signals (IF/RF format): When the RF signal format is selected, the baseband waveforms I and Q are also generated. So after compiling, three different files are generated.

For example, if the waveform name is Test, the generated waveforms are: Test\_I, Test\_Q, and Test.

The Correction Files option is available only when the selected application is UWB-WiMedia and the Compile Button Prefs option is available only when the AWG software is detected.

**NOTE.** The following table describes all the parameters. Not all the parameters are available in all plug-ins.

**Table 11: Compile settings options**

<b>Selection</b>	<b>Description</b>	<b>Range, Default value</b>
Waveform length (Symbols, Samples) <sup>1</sup>	Specifies the time domain length of the resulting waveform. It can be expressed in Samples or Symbols.	Determined by the maximum waveform memory of the instrument.
Oversampling	This is available only when Automatic is disabled.	
Automatic	Automatically calculates the oversampling based on the setup parameters and the AWG model. To enter the oversampling value, disable this option.	Enabled
<b>Signal Format</b>		
IF/RF	Sets the signal format to IF/RF.	N/A
IQ	Sets the signal format to IQ.	N/A
Oversampling <sup>2</sup>	Specify the oversampling value.	Automatic
Automatic	Automatically calculates the oversampling based on the setup parameters and the AWG model. To enter the oversampling value, disable this option.	Enabled
RF Waveform Name	Enter the name of the waveform to be generated after compilation. Uses the name entered here for the generated RF waveform.	Waveform1
I Waveform Name	Enter the name of the I waveform to be generated after compilation. Uses the name entered here for the generated I waveform.	Waveform1_I
Q Waveform Name	Enter the name of the Q waveform to be generated after compilation. Uses the name entered here for the generated Q waveform.	Waveform1_Q
<b>Compile Button Prefs</b>		
Compiles and sends to	Compiles the currently active waveform setup and sends it to the specified channel.	Ch1
Compile only	Compiles the currently active waveform setup.	N/A
<b>Correction Files</b>		

**Table 11: Compile settings options (cont.)**

<b>Selection</b>	<b>Description</b>	<b>Range, Default value</b>
When compiling apply correction files to these channels: Ch1, Ch2, Ch3, Ch4	Available and enabled for each channel on the instrument. For two-channel instruments, only Ch1 and Ch2 are visible. When a channel is selected, the corrections are applied from the file during compilation. If no file exists, you are prompted to either create a correction file in the Calibration window, or compile without applying correction files.	Disabled
<b>Normalization</b>		
Mode	Select the normalization mode from the following: Auto, Manual. You can normalize a waveform such that all points on it lie between +1 and -1.	Auto
Division factor	Enabled when the Normalization Mode is Manual. Specify the division factor to use to divide the waveform values.	0.01 to 100, 1
Adjust for Wrap-Around	When selected, adjusts the waveform for wrap around during oversampling. When cleared, the following message appears: The signal generated from the AWG might have wrap-around artifacts in continuous mode.	Enabled
Overwrite waveform in list	When selected, overwrites any existing waveform of the same name in the waveform list. When this option is disabled, you are prompted to enter a waveform file name.	Enabled
I Invert	When selected, inverts the phase of the I signal.	Disabled
Q Invert	When selected, inverts the phase of the Q signal.	Disabled

<sup>1</sup> If the Waveform Length is expressed in symbols, the number of samples is approximately given by the product of the number of symbols and the sampling rate divided by the symbol rate.

<sup>2</sup> For IF/RF signals, the sampling rate is approximately the product of the maximum carrier frequency and the oversampling. For IQ signals, the sampling rate is approximately the product of the anchor carrier symbol rate and the oversampling. For UWB-WiMedia signals, sampling rate is approximately the product of the highest band group centre frequency and the oversampling.

Click **Compile** to compile the waveform. A progress bar is displayed during compilation. You can abort the compilation by clicking **Cancel**.

**NOTE.** When Adjust for Wrap-Around is enabled and the waveform length is set in samples, the symbol rate of the compiled waveform may be close to, and not exactly the same as, the value specified in the Setup tab. Similarly, when the waveform length is set in symbols, the carrier frequency of the compiled waveform may be close to, and not exactly the same as, the value specified in the Setup tab.

## Option Installation

System > Option Installation...

You can use the RFXpress application to generate waveforms but you cannot transfer the waveform unless you enable the function with a option (license) key.

Click System > Option Installation.... This dialog box is displayed.

The dialog box titled "Option Installation" contains the following fields and controls:

- User Name:
- Serial Number:
- Option Key String:
- Unique ID: 0x524658005ba0
- Option Information:

Index	Name	Option Information
1	Generic signal	Licensed
2	UWB-WiMedia-Conform...	Licensed
3	UWB-WiMedia-Custom	Licensed
4	Radar	Licensed

[Contact customer support](#)

**Table 12: Option installation information**

Selection	Description
User Name	Enter the user name.
Serial Number	Enter the serial number that is provided along with the software.
Option Key String	Enter the option key string that is provided along with the software.
Option Information	The option information is displayed in the table.

Click Copy Option Info to copy the information in the table to the clipboard. Click Apply to apply the entered values.

## Overview

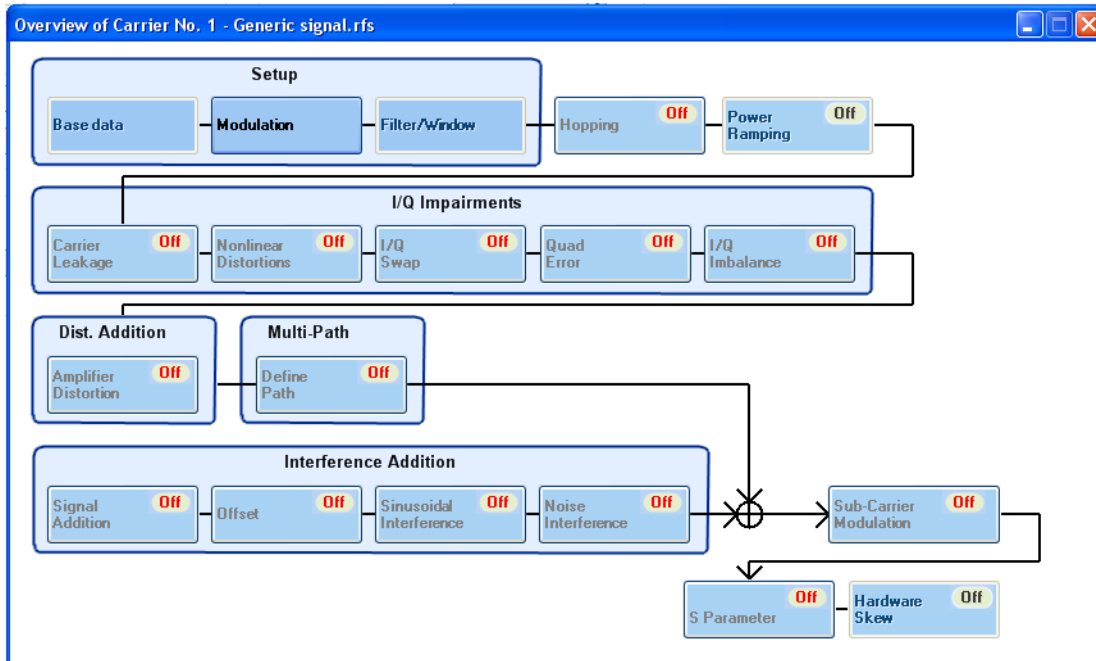
Window > Overview

Click Window > Overview to open the overview window. A block view of the active waveform appears in a new window. This window is a floating window and can be moved around the screen. Each larger grouping in the diagram corresponds to a tab.

The On/Off button in the upper right corner of each block in a block corresponds to the Turn On check box in the appropriate group.

- If the group does not have a Turn On check box, then no On/Off button appears on the block.
- If the check box is cleared, the button text is Off (red), and the block appears dimmed.
- If the check box is selected, the button text is On (green) and the block appears active. The button on the block and the check box in the group box are linked; if you change one, the change is reflected in the other. The on/off values for each block correspond to the currently selected carrier or packet group.

For a Generic signal, you must select a carrier before you select the Overview option. The Overview window for a carrier has the following blocks:



- Setup includes Base Data, Modulation, and Filter/Window
- Hopping
- Power Ramping
- I/Q Impairments includes Carrier Leakage, Nonlinear Distortions, I/Q Swap, Quad Error, and I/Q Imbalance
- Distortion Addition includes Amplifier Distortion
- Multi-Path includes Define Path
- Interference Addition includes Signal addition, Offset, Sinusoidal Interference, and Noise Interference
- Subcarrier modulation
- S-Parameter
- Hardware Skew

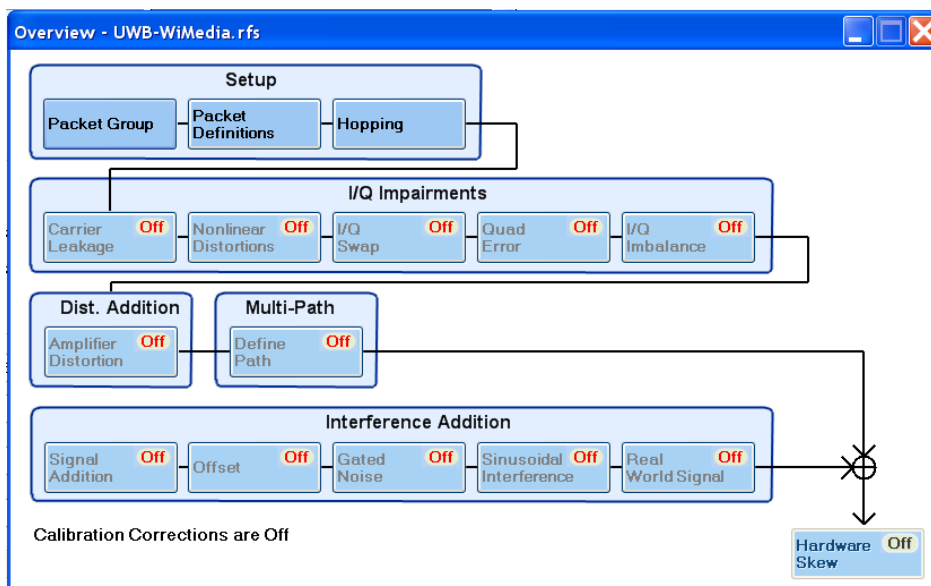
---

**NOTE.** When no carriers are selected in the Carrier table, selecting Overview will open the Overview Window with all the On/Off buttons set to Off (default). Clicking the On/Off buttons will not have any effect.

---

For a UWB signal, you must select a packet group before you select the Overview option. The Overview window has the following blocks:



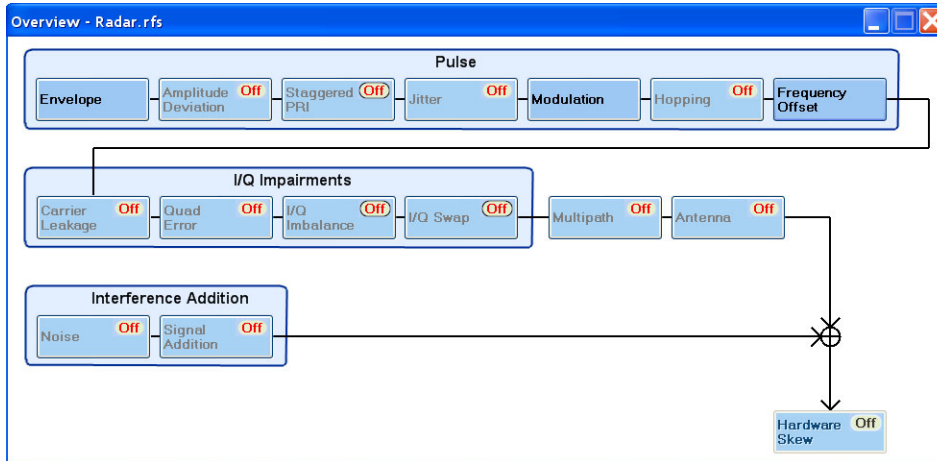


- Setup includes Packet Group, Packet Definitions, and Hopping
- I/Q Impairments includes Carrier Leakage, Nonlinear Distortions, I/Q Swap, Quad Error, and I/Q Imbalance
- Distortion Addition includes Amplifier Distortion
- Multi-Path includes Define Path
- Interference Addition includes Signal Addition, Offset, Gated Noise, Sinusoidal Interference, and Real World Signal
- Hardware Skew

Clicking a block (even if dimmed) brings the File window forward with the corresponding tab at front. Within the tab, the first setting in the group box that corresponds to the block is highlighted.

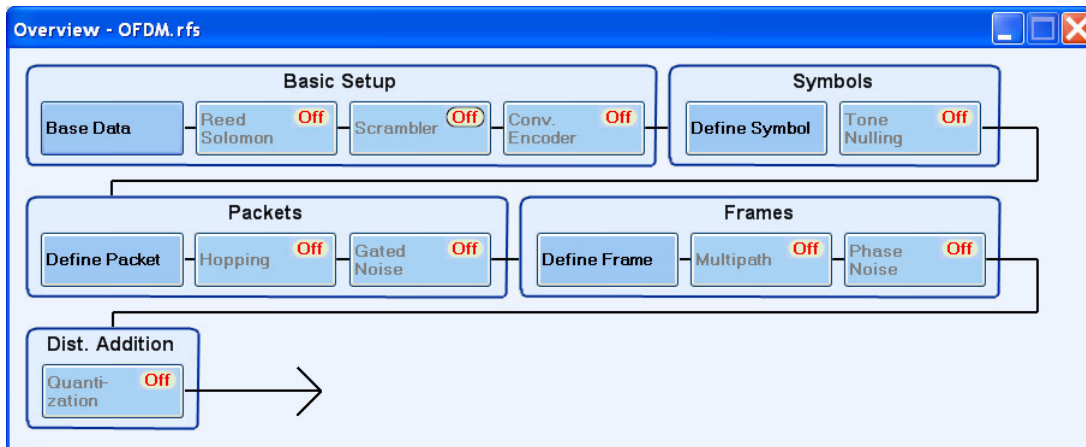
To turn on or turn off the calibration corrections, click Configure > [Calibration \(see page 48\)](#).

For a Radar signal, you must select a pulse before you select the Overview option. The Overview window has the following blocks:



- Pulse includes Envelope, Amplitude Deviation, Staggered PRI, Jitter, Modulation, Hopping, and Frequency Offset
- I/Q Impairments includes Carrier Leakage, Quad Error, I/Q Imbalance, and I/Q Swap
- Multi-Path
- Antenna
- Interference Addition includes Noise and Signal Addition
- Hardware Skew

For an OFDM signal, you must select a carrier before you select the Overview option. The Overview has the following blocks:

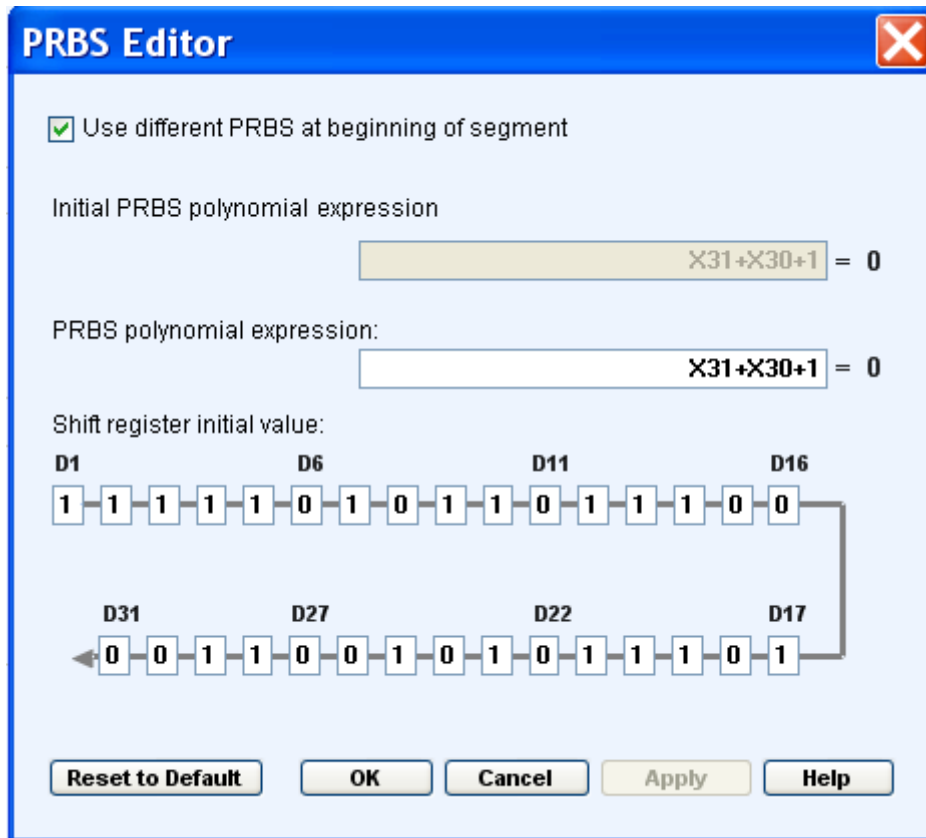


- Basic Setup includes Base Data, Reed Solomon, Scrambler, and Convolution Encoder
- Symbol Setup includes Symbol Definition and Tone Nulling
- Packet Setup includes Define Packet, Hopping, and Gated Noise

- Frame Setup includes Define Frame, Multipath, and Phase Noise
- Distortion Addition includes Quantization

## PRBS Editor

This dialog box is displayed upon clicking PRBS Editor when PRBS is set to User Defined in the Base Data field (Setup tab).



This data source can generate different pseudo-random binary sequences. You can select PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21 and PRBS 23 in the field to the right of the PRBS button.

PRBS sequences are generated by a feedback shift register. The number (#) following PRBS indicates the length of the generating shift register. For instance, a shift register with 16 memory cells is required to generate a PRBS 16 sequence. The pseudo-random sequence of a PRBS generator is determined by the number of registers and the feedback.

**Table 13: PRBS editor options**

Selection	Description	Default value
Use different PRBS at beginning of segment	When selected, allows you to define a PRBS polynomial expression. The polynomial that you define will be used at the beginning of every sequence. The value of X ranges between 1 and 31.	Disabled
Initial PRBS polynomial expression	Enter an expression in the format $Xn1+Xn2+1$ to add to the initial part of the PRBS polynomial expression. The value of Xn ranges between 1 and 31. Enabled when Use different PRBS at beginning of segment is disabled.	$X31+X30+1$
PRBS polynomial expression	Enter an expression in the format $Xn1+Xn2+1$ to generate the pseudo-random sequence. The value of Xn ranges between 1 and 31.	$X31+X30+1$
Shift register initial value D1– D31	Enter values in the shift registers to create the sequence. The registers D1 through D31 can take the values 0 and 1.	D1– D31

Click Apply to effect the changes. Click Reset to Default to restore the editor to the default values. Refer to the Appendix for more information on the the taps and the seed (starting values).

See also:

[PRBS Editor Starting Values \(see page 200\)](#)

## Data Source Values

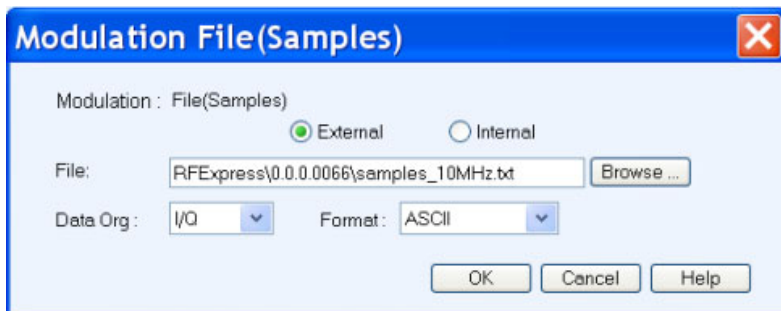
This dialog box is displayed when you set the Base Data selection to File and browse for the file. The file formats supported are .txt and .dat. Once you select a file, the data values are taken from that file.

The following conditions must be met for a valid file:

- Any ASCII file, delimited or not, can be used as the data source.
- The next bit will be generated by reading the file until a 0, 1, x, or X character is found. 0 and 1 will add the corresponding bit to the sequence; the x and X character will add a new random bit.
- Any other intermediate character will be ignored.
- When the end of the file has been reached, the file is read again from the beginning based on the record length.
- The data can be organized by columns or rows.
- Any number of space, tab, or comma characters can be used as a delimiter.
- Empty lines or invalid lines at the beginning and end of the file are ignored.

## Modulation File1(Samples)

This dialog box is displayed when File1(Samples) is selected in the Modulation field (Setup tab).



**Table 14: Modulation File1(Samples) options**

Selection	Description	Default value
External	Select External to specify an external file taken from a specified path.	External
Internal	Select Internal to specify a file to be taken from the Waveform List. Click the icon next to the File field and a list of waveforms appears.	N/A
File	Select the modulation file to be used by entering the path or browsing to the file. The file formats supported are: .txt, .dat, and .bin.	N/A
Data Org	Specify the organization of data within the selected file: I/Q, Q/I, I Only, or Q Only. When Internal is selected, the available options are I Only and Q Only.	I Only
Format	Specify the format of the selected file: ASCII, Binary(float), or Binary(double). This option is not available when External is selected.	ASCII

The Data Org field is used to indicate the organization of data as follows within the selected file:

- I/Q: The first value of data (until a delimiter) read is considered as I and the next as Q. This will continue to the end of the file.
- Q/I : The first value of data read (until a delimiter) is considered as Q and the next as I. This will continue to the end of the file.
- I Only: All the data read are considered as I, and Q is assigned to zero.
- Q Only: All the data read are considered as Q, and I is assigned to zero.

**NOTE.** *If you have defined different files for the I and Q components, then you must define two carriers in the list with the same basic parameters and select the corresponding component in the Data Organization field.*

The Format field is used to specify the file format. The following conditions must be met for a selected file format:

- When the file format is ASCII, the data should be in floating point precision. Spaces and tabs are ignored. Any other characters are considered invalid. RFXpress stops reading data when it encounters invalid data.
- When the file format is Binary(float), the data should be in binary format with floating point precision.
- When the file format is Binary(double), the data should be in binary format with double point precision.

When the end of the file has been reached, the file is read again from the beginning, based on the Record Length.

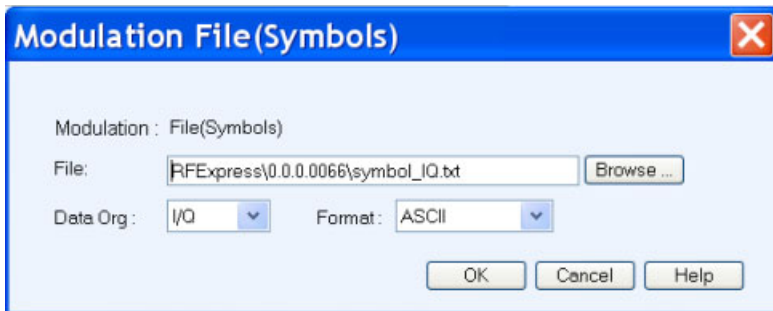
---

**NOTE.** *The external file should contain signals with average power of 1 Vrms. You should scale the data appropriately to ensure that the file contains signals with an average power of 1 Vrms.*

---

## Modulation File2(Symbols)

This dialog box is displayed when File2(Symbols) is selected in the Modulation field (Setup tab).



**Table 15: Modulation File2(Symbols) options**

Selection	Description	Default value
File	Select the modulation file to be used by entering the path or browsing to the file. The file formats supported are: .txt, .dat, and .bin	N/A
Data Org	Specify the organization of data within the selected file: I/Q, Q/I, I Only, or Q Only	I Only
Format	Specify the format of the selected file: ASCII, Binary(float), or Binary(double)	ASCII

The Data Org field is used to indicate the organization of data as follows within the selected file:

- I/Q: The first value of data read (until a delimiter) is considered as I and the next as Q. This will continue to the end of the file.
- Q/I : The first value of data read (until a delimiter) is considered as Q and the next as I. This will continue to the end of the file.
- I Only: All the data read are considered as I, and Q is assigned to zero.
- Q Only: All the data read are considered as Q, and I is assigned to zero.

---

**NOTE.** *If you have defined different files for the I and Q components, then you must define two carriers in the list with the same basic parameters and select the corresponding component in the Data Organization field.*

---

The Format field is used to specify the file format. The following conditions must be met for a selected file format:

- When the file format is ASCII, the data should be in floating point precision. Spaces and tabs are ignored. Any other characters are considered invalid. RFXpress stops reading data when it encounters invalid data.
- When the file format is Binary(float), the data should be in binary format with floating point precision.
- When the file format is Binary(double), the data should be in binary format with double point precision.

When the end of the file has been reached, the file is read again from the beginning, based on the Record Length.

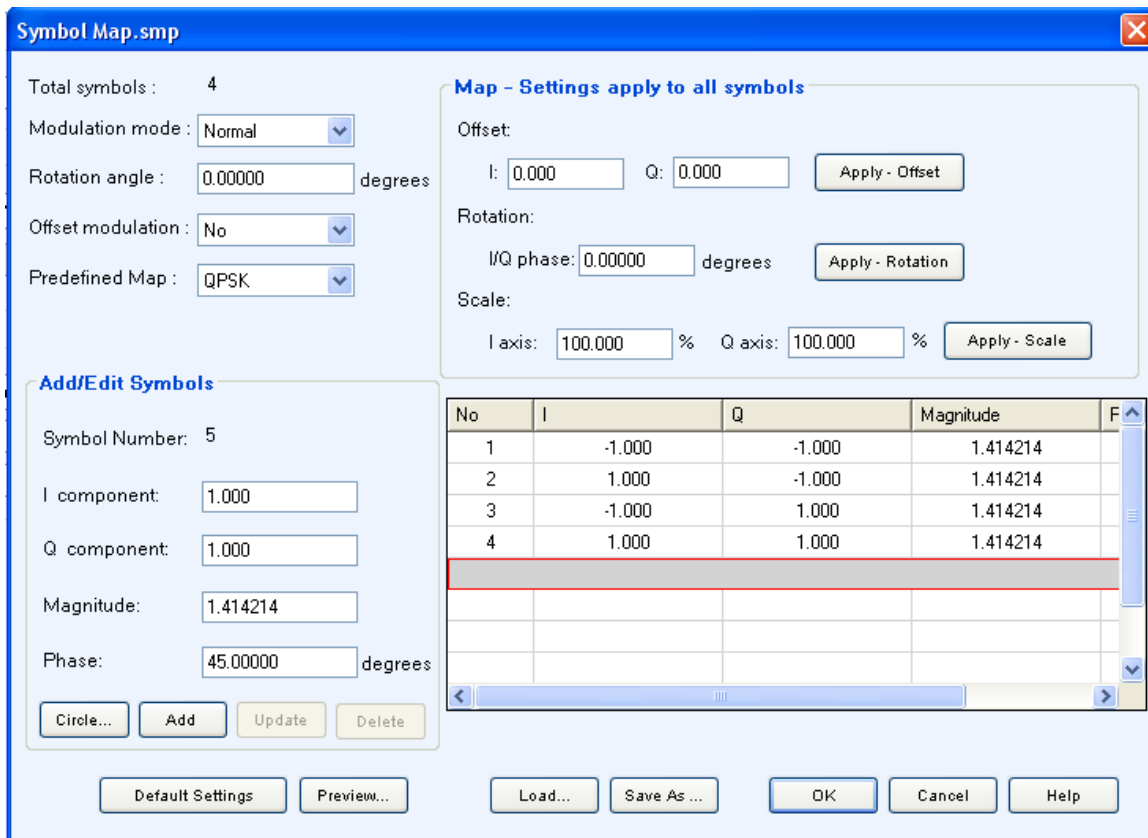
---

**NOTE.** *The external file should contain signals with average power of 1 Vrms. You should scale the data appropriately to ensure that the file contains signals with an average power of 1 Vrms.*

---

## Symbol Map

This dialog box is displayed when File3(Map) is selected in the Modulation field (Setup tab).



Use the symbol map editor to create user defined modulation schemes. The Symbol Map created is stored in a binary format. This is useful for unsupported modulation schemes and to introduce impairments with the simulated waveform.

**Table 16: Symbol map options**

Selection	Description	Range, Default value
Total symbols	Displays the total number of symbols entered.	2 to 512, 4
Modulation mode	Select the modulation mode: Normal, Diff (Continuous), Diff (Alternate). Sets the selected modulation mode.	Normal
Rotation angle	Specify the rotation angle between I and Q.	-180° to +180°, 0°
Offset modulation	Indicates whether to apply offset modulation or not: Yes, No. Selecting Yes applies offset modulation.	No
Predefined map	Causes a dropdown list to appear with the following selections: None, BPSK, QPSK, QAM16, QAM32, QAM64, QAM128, and QAM256.	QPSK
Add/Edit Symbols		



**Table 16: Symbol map options (cont.)**

Selection	Description	Range, Default value
I component	Specify the I component of the modulation.	-100 to +100, 1
Q component	Specify the Q component of the modulation.	-100 to +100, 1
Magnitude <sup>1</sup>	Specify the magnitude of the modulation.	0 to 141.421, 1.414214
Phase <sup>1</sup>	Specify the phase of the modulation.	-180° to +180°, 45°
Map - Settings apply to all symbols		
Offset I	Specify the offset for the I component.	-100 to +100, 0
Offset Q	Specify the offset for the Q component.	-100 to +100, 0
Rotation I/Q phase	Specify the phase rotation between I and Q.	-180° to +180°, 0°
Scale I axis (%)	Specify the scale factor for the I component.	0% to 500%, 100%
Scale Q axis (%)	Specify the scale factor for the Q component.	0% to 500%, 100%

<sup>1</sup> The Magnitude and Phase parameters depend on the value of the I and Q components. If you change the value of the I and Q components, the Magnitude and Phase values are recalculated and updated. Similarly, if you change the Magnitude and Phase values, the values of the I and Q components are recalculated and updated.

Clicking Apply Offset, Apply Rotation, and Apply Phase applies the values to the Map Settings parameters. The table is updated according to the newly applied values.

The following buttons work as listed:

**Table 17: Symbol map buttons**

Selection	Description
Circle...	Defines a circular constellation with equal magnitude. Opens a dialog box with the following parameters: Number of Symbols, Radius, Phase offset.
Add	Adds I, Q, Magnitude, and Phase values to the table.
Update	Updates the selected row from the table.
Delete	Deletes the selected row from the table.
Default Settings	Clears all the symbol map information and resets to default values. This is equivalent to opening the Symbol Map dialog box.
Preview...	Previews the table values as a plot.
Load	Loads a previously saved symbol file (.smp) and displays the values in the fields.
Save As	Saves all the parameters in a user-specified file (.smp) and location.

## Circle

Click Circle to define a constellation window that allows you to create equally spaced symbols in a circle of a specified radius. You can define an offset angle to rotate the constellation. The Circle dialog box has the following options:

**Table 18: Circle options**

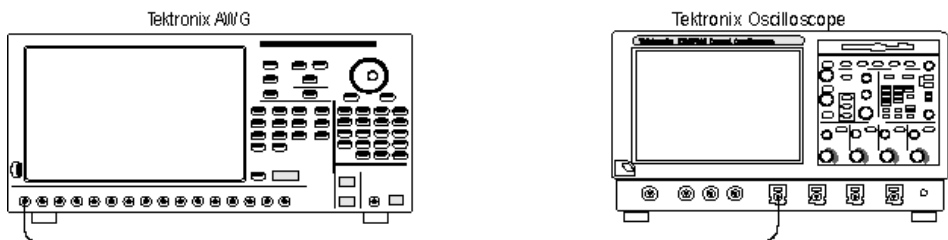
Selection	Description	Range, Default
Number of symbols	Enter the number of symbols to use while creating the constellation.	2 to 512, 4
Radius	Enter the radius of the circle.	-5.0 to +5.0, 1
Phase offset	Enter the phase offset.	-180° to +180°, 0°
Reset Phase Offset		
0 degrees	Select this option to set the phase offset to zero. Press Reset to set the phase to 0 degrees.	Selected
Half the angle between consecutive signals	Select this option to set the phase offset to half the angle between consecutive signals. Press Reset to set the phase to half the angle between consecutive signals.	N/A
Reset	Resets the phase offset to 0 or 90 depending on the selected phase offset.	N/A

**NOTE.** The external file should contain signals with average power of 1 Vrms. You should scale the data appropriately to ensure that the file contains signals with an average power of 1 Vrms.

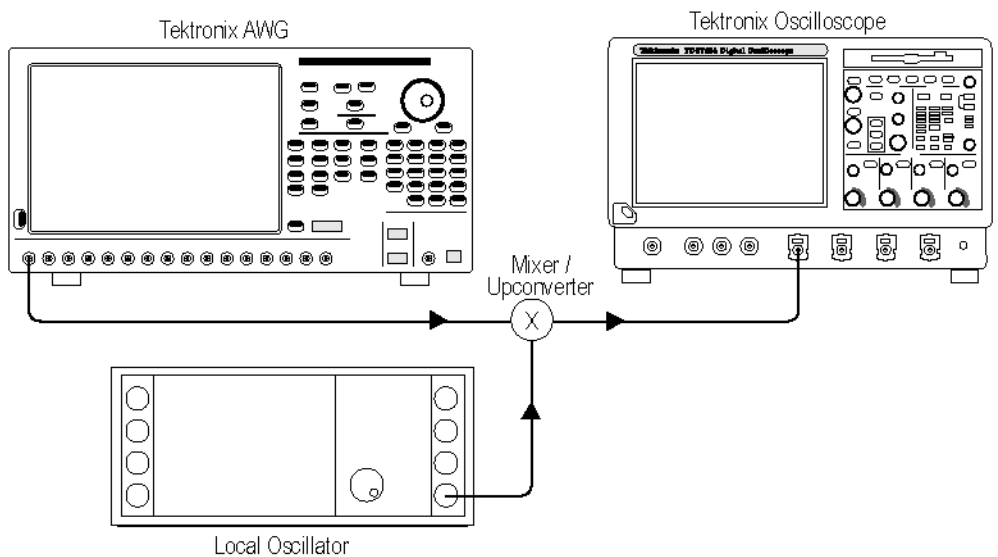
## Calibration for Generic, Radar, and OFDM signals

Click Calibration from the toolbar. The Calibration Wizard opens. The wizard helps you create a correction file that can be applied on a generated signal. The RF, IF, and IQ signals are supported and the steps are similar.

RF calibration requires an AWG5000 or AWG7000 series instrument and an oscilloscope or RSA. Set up the equipment as follows:



IF calibration requires an AWG5000 or AWG7000 series instrument, an oscilloscope or RSA, and devices to change the frequency range generated by the AWG. Set up the equipment as follows:



IQ calibration requires an AWG5000 or AWG7000 series instrument, an oscilloscope or RSA, and IQ modulator to upconvert the IQ signal to RF.

IQ calibration can be done in one of the two ways:

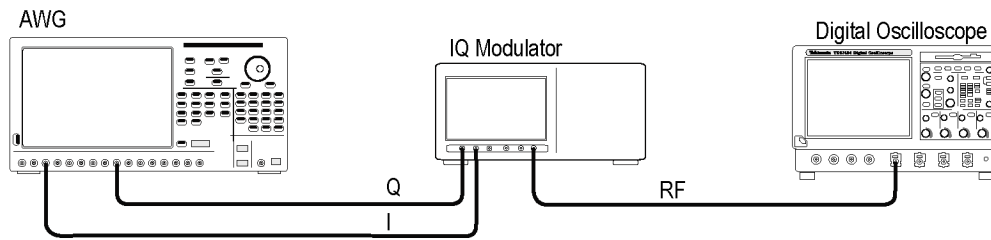
- Calibration using an IQ modulator: The I and Q signals generated from the AWG is upconverted to RF using an IQ modulator. In this case, the software provides the total system calibration up to RF output.
- Direct calibration: The I and Q signals generated from the AWG is directly calibrated without upconversion.

---

**NOTE.** Direct IQ calibration can be done only on an oscilloscope.

---

Set up the equipment as follows:



**NOTE.** To calibrate the RF, IF, and IQ signals using RSA, replace the Tektronix oscilloscope with RSA.

To calibrate the signal:

1. Select and connect to an oscilloscope. A table displays a list of instruments on the network. The instrument model, status, connection type, and instrument name (alias) are shown but they are not editable. The following buttons are available:

**Table 19: Instrument setup buttons**

Button	Description
Connect	Connects to the instrument selected in the table and updates the status to Connected in the table.
Disconnect	Disconnects the instrument selected in the table and updates the status in the table.
Test Connection	Returns the current status of the instrument selected in the table and displays the status as Connected (in green) or Not Connected (in red).
Refresh List	Refreshes the list of connected instruments.

2. Enter the AWG and calibration parameters.

- For an RF signal, enter the AWG parameters like sampling rate, select the Interleave/Zeroing modes, DAC resolution, and the channel (Ch1 or Ch2). [Interleave and Zeroing \(see page 198\)](#)

Select the signal or signal image to calibrate. [Calibrate the Signal Image \(see page 202\)](#)

Enter frequency parameters like Start Frequency, End Frequency, Frequency Resolution, Average iterations, and the name of the correction file.

- For an IF signal, enter the AWG parameters like sampling rate, select the Interleave/Zeroing modes, DAC resolution, and the channel (Ch1 or Ch2). Enter frequency parameters like IF Start Frequency, IF End Frequency, Frequency Resolution, LO Frequency, and Average iterations. Select the lower or upper side band to calibrate and enter the name of the correction file.
- For an IQ signal, enter the AWG parameters like sampling rate, select the I channel and Q channels, and enter the amplitude of the I and Q signals. Enter the Bandwidth, Baseband Offset, Frequency Resolution, Average iterations, Carrier frequency, and the name of the correction file.

**Table 20: Calibration setup options**

Selection	Description	Range, Default value
Calibration Setup		
Sampling rate (samples/sec)	Displays the sampling rate of the instrument. If you change the sampling rate, it is updated in the instrument.	N/A
Ch1, Ch2, Ch3, Ch4	Applies corrections to the selected channels when you click Compile. If the corrections file is not found, you are warned. However, you can continue without applying calibration.	Ch1
DAC Res (bits): 8, 10	Selects the DAC resolution	8
<a href="#">Interleave (see page 198)</a>	Enabled if the signal type is either RF or IF.	N/A
Zeroing	Enabled only when Interleave is available on the instrument.	N/A
Start Frequency	Enter the start frequency of the signal.	10 MHz to Sampling Rate*0.49 Hz, 10 MHz
End Frequency	Enter the end frequency of the signal.	10 MHz to Sampling Rate*0.49 Hz, Sampling Rate*0.49 Hz
LO Frequency	Enter the low oscillator frequency of the signal.	N/A
Lower Side Band/Upper Side Band	Select the frequency band which is to be calibrated.	Upper Side Band
Average (iterations)	Enter the number of times the software sends and captures the signal through the user defined configuration to create an average.	1 to 100, 1
Frequency Resolution	Enter the frequency resolution of the signal. This is used to pick the number of samples between start and end frequencies.	N/A
Calibrate the Signal	Select this to correct the actual signal.	N/A
Bandwidth	Enter the bandwidth of the signal.	10 MHz to Sampling rate/2, 10 MHz
Baseband Offset	Enter the baseband offset of the signal. This is the offset of the signal from the center frequency.	0 MHz to Sampling rate/2
Carrier Frequency	Enter the carrier frequency of the signal. The carrier signal is generated by the IQ modulator instrument.	N/A

**Table 20: Calibration setup options (cont.)**

Selection	Description	Range, Default value
<a href="#">Calibrate the Signal Image (see page 202)</a>	Select this to correct the image of the signal.	Disabled
Select the correction file	Browse and select the correction file. Only one correction file (rfc) is created; information on all the channels stored in it.	N/A

3. Select the instrument on which to perform calibration (oscilloscope and RSA).  
To perform calibration using oscilloscope, select the oscilloscope channel(s) to which the AWG channels are connected.
4. Proceed with the calibration. When the calibration is complete, the amplitude and phase plots are displayed.

Use the correction file in the Compile Settings dialog box to calibrate the signal.

## DUT Characterization Wizard

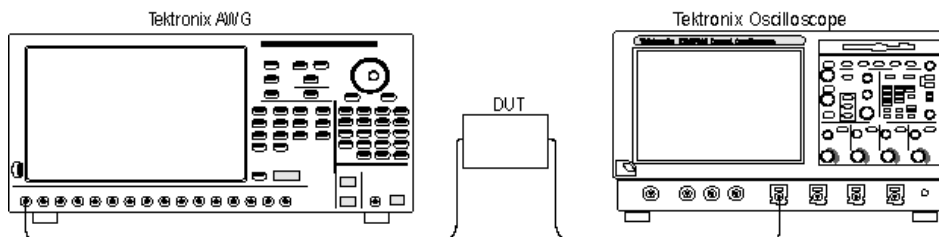
RFXpress allows you to get the characteristics of your DUT. The DUT indicates a Mixer or Amplifier, not receivers or IQ Modulators. From the toolbar, select Calibration > DUT Characterization. The DUT Characterization wizard opens and guides you through the process.

DUT Characterization is a two-step process. The first step calibrates the AWG and the creates the correction file. The second step determines the characteristics of the DUT and stores them in a file that is later used as an input to the S-parameter feature.

To calibrate the AWG:

1. Select and connect to an oscilloscope.
2. Enter the setup parameters. Enter the AWG parameters like sampling rate, select the Interleave/Zeroing modes, DAC resolution, and the channel (Ch1 or Ch2). Enter frequency parameters like Start Frequency, End Frequency, Frequency Resolution, and Average iterations.
3. Select the oscilloscope channel(s) to which the AWG is connected.
4. Proceed with the [calibration \(see page 48\)](#).

To determine the characteristics of the DUT:



5. Enter the DUT setup parameters. Enter the DUT Center Frequency, Upper or Lower Side Band, and select the output file.
6. Connect the DUT between the AWG and the oscilloscope.
7. Proceed with the characterization. During DUT characterization, the correction file from the calibration process is used to send a clean signal from AWG.

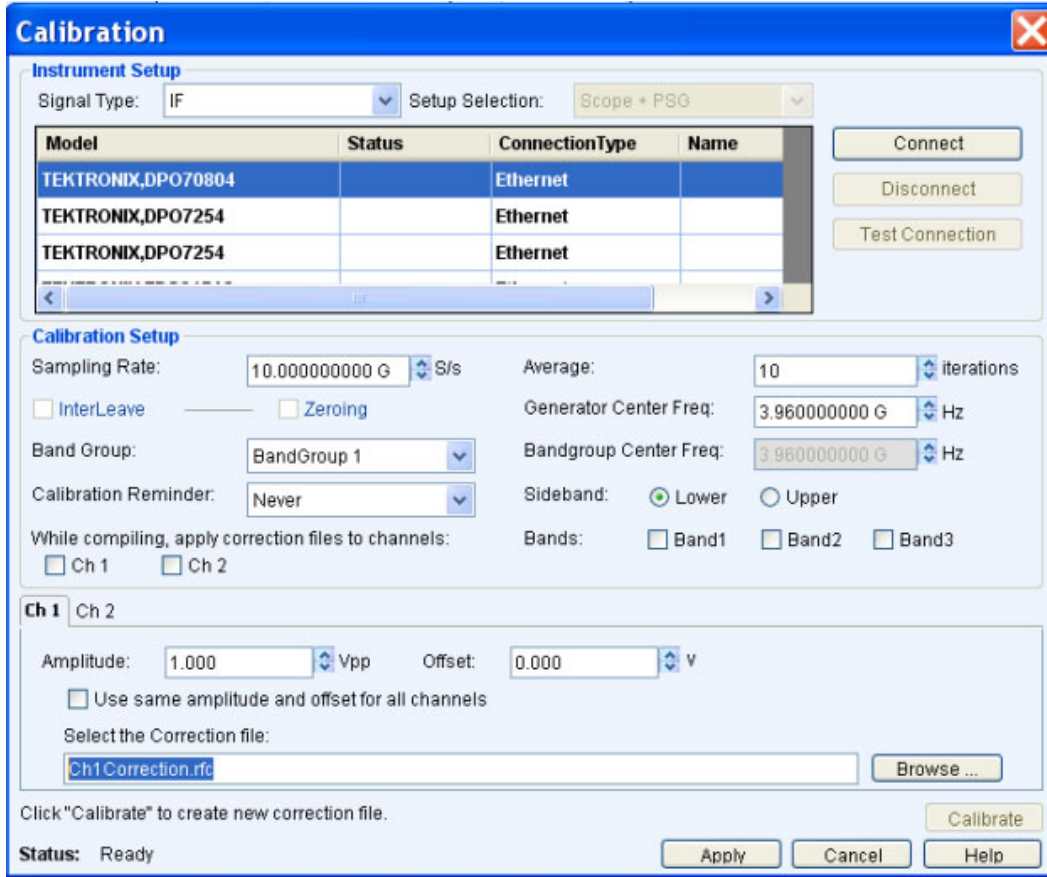
Once the characterization is complete, the wizard displays the Amplitude and Phase plots of the DUT.

## Calibration for UWB-WiMedia Signal

System > Calibration

To calibrate the signal, click System > Calibration. A set of parameters called Calibration Settings are common across channels. Channel-specific settings are provided in each channel tab. Before you start calibration, compile your setup so that the sampling rate is automatically set in the Calibration dialog box. You will be prompted with a message to compile your setup before you proceed with calibration. If you choose not to compile the setup, you must enter the sampling rate manually.

This dialog box is displayed. The calibration settings are as follows:



**Table 21: Instrument setup option**

Selection	Description	Default value
Instrument Setup		
Signal Type	Select the signal type for calibration: RF, IF	IF

The table displays a list of instruments on the network. The instrument model, status, connection type, and instrument name (alias) are shown but they are not editable. The following buttons are available:

**Table 22: Instrument setup buttons**

Button	Description
Connect	Connects to the instrument selected in the table and updates the status to Connected in the table.
Disconnect	Disconnects the instrument selected in the table and updates the status in the table.
Test Connection	Returns the current status of the instrument selected in the table and displays the status as Connected (in green) or Not Connected (in red).

The Calibration Settings and Channel-specific settings are as follows. All the calibration settings that are set in RFXpress are updated on the connected instrument.



**Table 23: Calibration setup options**

Selection	Description	Range, Default value
Calibration Setup		
Sample rate (samples/sec)	Displays the sampling rate of the instrument. If you change the sampling rate, the same is updated in the instrument.	N/A
<a href="#">Interleave (see page 198)</a>	Enabled if the signal type is either RF or IF.	N/A
Zeroing	Enabled only when Interleave is available on the instrument.	N/A
Band Group	Select the band group of the signal from the following options: User defined, BandGroup1, BandGroup2, BandGroup3, BandGroup4, BandGroup5, and BandGroup6.  For direct RF generation, the available options are: User Defined, BandGroup1 and BandGroup2.	BandGroup1
Calibration Reminder	Select a reminder to create calibration files periodically: Once a day, Once a week, Once a month, and Never.	Never
Average (iterations)	Enter the number of times the software sends and captures the signal through the user defined configuration to create an average.	1 to 100, 10
Generator Center Freq (MHz)	Enter the center frequency for the generated signal. This should be same as Band Group Center Frequency when the signal type is RF.  Enabled only for signal type IF with the range of 800 MHz to 10 GHz. Not available for signal types RF and IQ.	N/A
Bandgroup Center Freq (MHz)	Enter the center frequency for the user defined band group. Enabled only when BandGroup is set to User Defined for RF and IQ signals in the range of 500 KHz to 10 GHz and for IF signals in the range of 1 GHz to 20 GHz.	N/A
Sideband: Lower, Upper	Set the sideband value to the lower or the upper limit. Enabled only for IF signals.	Lower

**Table 23: Calibration setup options (cont.)**

Selection	Description	Range, Default value
When compiling, apply corrections to these channels: Ch1, Ch2, Ch3, Ch4 Bands: Band1, Band2, Band3	Applies corrections to the selected channels and bands (within the selected BandGroup) when you click Compile. If the corrections file is not found, you are warned. However, you can continue without applying calibration.	N/A
Channel-specific parameters		
Amplitude (Vpp)	Displays the amplitude of the channel. To change it, set a new value for the amplitude.	N/A
Offset (V)	Displays the offset of the channel. To change it, set a new value for the offset.	N/A
Use the same amplitude and offset for all channels	Uses the amplitude and offset set for a channel for all available channels.	N/A
Select the Correction file	Specify the correction file to create. The correction file that you specify will be used when you compile the signal.	N/A

The Calibration dialog box has an option to plot each band id. The amplitude and phase plot of the calibration file is plotted only for a valid rfc file. You can plot any of the three bands by selecting the band.

Click Calibrate to create the correction files. The correction file that is created can be used to pre-distort the signal so that the final signal that is generated is an ideal signal.

Click OK to set the correction file and parameters that will be used during compile. In [Compile Settings \(see page 32\)](#) if the option "When compiling apply correction files to these channels" is selected, the correction file specified in the Calibration dialog box is used to apply corrections.

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**NOTE.** *Interleave and Zeroing are available only on the AWG7000 series of instruments with Option 06.*

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## Marker Mapping

This dialog box is displayed when you click Marker Mapping... in the Setup tab (UWB-WiMedia) in both Custom and Conformance modes. The markers M1 and M2 are tightly coupled to the band ID. Marker mapping is used to provide hopping information to the external RF hopper. The marker information will be transferred along with IF/RF, I, and Q data. You can use marker information from any channel where analog data is generated.



You can set the following options for markers M1 and M2. The marker pattern generated, based on the following settings, can be used for triggering an external device.

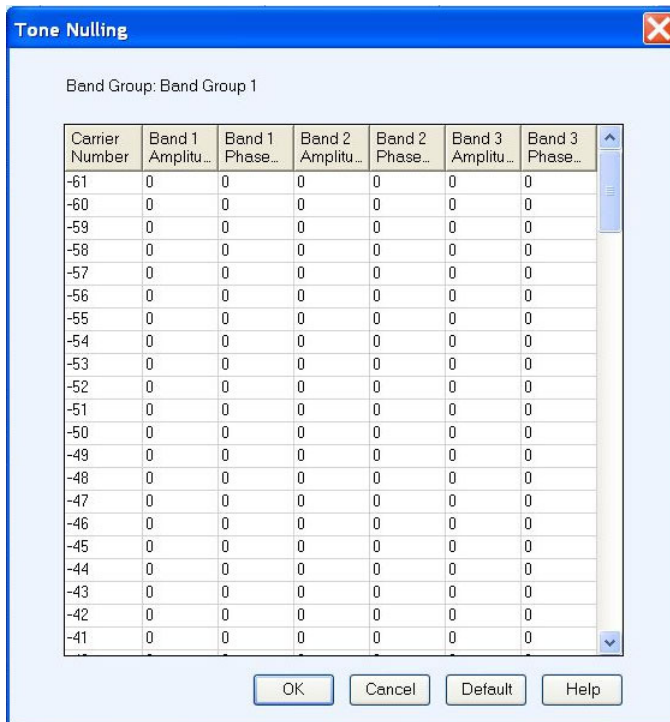
**Table 24: Marker mapping options**

Selection	M1, M2	Description	Default value
Band 1	Enter M1 and M2 values. The values can be 0 or 1	Sets the marker pattern for Band 1	0, 1
Band 2	Enter M1 and M2 values. The values can be 0 or 1	Sets the marker pattern for Band 2	1, 0
Band 3	Enter M1 and M2 values. The values can be 0 or 1	Sets the marker pattern for Band 3	1, 1
Marker delay (ns)	N/A	Enter the marker delay in nanoseconds. It defines the delay in marker transition with respect to the symbols.	Range: -312.5 to + 312.5 ns Default: 0.0 ns

**NOTE.** The Marker Mapping dialog box shows a warning message when the AWG is set with 10-bit DAC resolution.

## Tone Nulling

This dialog box is displayed when you click Tone Nulling... in the Setup tab (UWB-WiMedia) in both Custom and Conformance modes. For the selected Band Group, the tone nulling table shows the carrier number, the amplitudes, and the phases of Band 1, Band 2, and Band 3 in dB. The amplitude and phase fields are editable. Double-click the field and enter a new amplitude for the selected carrier and band.

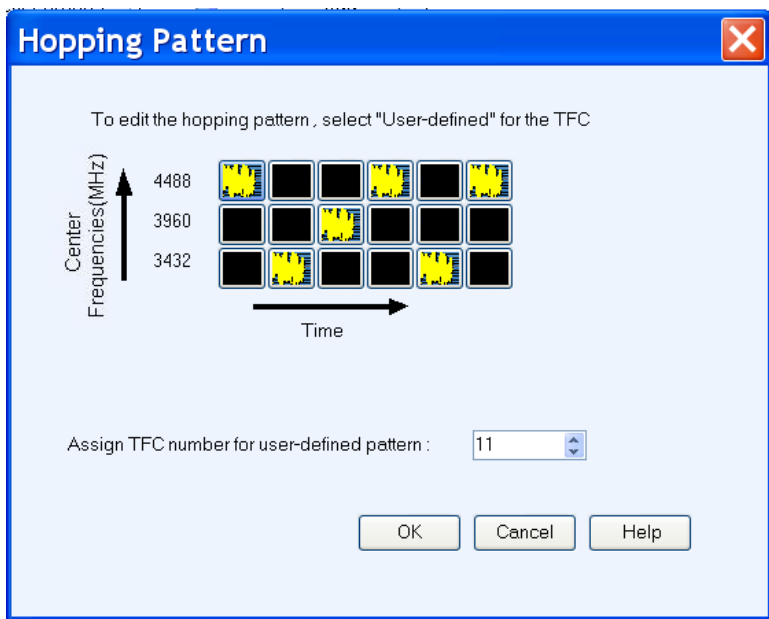


The amplitude values are relative to the amplitudes specified for each band. The tone nulling value ranges between  $-40$  dB and  $+20$  dB. For example, if a carrier or tone value is set to  $-40$  dB, the amplitude of the tone is 40 dB less than that specified for the band to which it belongs. The phase value ranges from  $-180$  degrees to  $+180$  degrees.

Click Default to restore the band values to their default values.

## Hopping Pattern

This dialog box is displayed when you set the TF Code and click Hopping... in the Setup tab in the Custom Mode (UWB-WiMedia). The hopping pattern for the selected Band Group and TF Code is displayed. The X-axis (horizontal) shows Time and the Y-axis (vertical) shows the Center Frequencies for the selected Band Group. The hopping pattern is not editable.



To customize a hopping pattern, set the TF Code to User Defined. You can define a hopping pattern by clicking the black squares in each column. This sets the frequency at which a packet is transmitted for each band in a band group. After you have defined the hopping pattern, assign a TFC number (between 1 to 15) to the pattern and click OK.

## Process Preferences

This dialog box is displayed when you click Process Preferences in the Setup tab (UWB-WiMedia) in the custom mode. The dialog box displays several parameters. In the custom mode, all these parameters can be set for each PPDU or packet listed in the PPDUs in Group table. The fields corresponding to the parameters are editable and take either Binary or Hexadecimal values. You can change these values and use your values when the packet is processed. When the parameters are enabled, the software uses your values while processing the packet. When the parameters are disabled, the software uses calculated values while processing the packet.

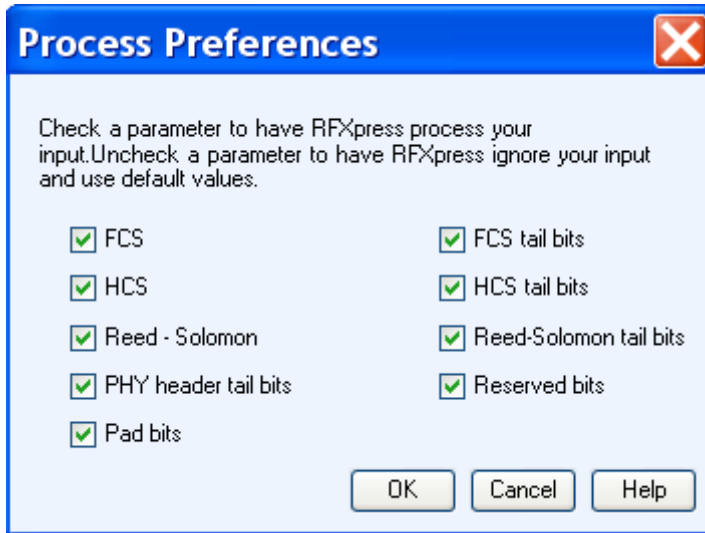


Table 25: Process preferences

Selection	Description	Default value
FCS	If selected, processes the FCS value set in the field. If cleared, the default value for FCS value is used.	Enabled
HCS	If selected, processes the HCS value set in the field. If cleared, the default value for HCS value is used.	Enabled
Reed-Solomon	If selected, processes the Reed-Solomon value set in the field. If cleared, the default value for Reed-Solomon value is used.	Enabled
PHY header tail bits	If selected, processes the PHY header tail bits value set in the field. If cleared, the default value for PHY header tail bits is used.	Enabled
Pad bits	If selected, processes the Pad tail bits value set in the field. If cleared, the default value for Pad bits is used.	Enabled
FCS tail bits	If selected, processes the FCS header tail bits value set in the field. If cleared, the default value for FCS header tail bits is used.	Enabled
HCS tail bits	If selected, processes the HCS tail bits value set in the field. If cleared, the default value for HCS header tail bits is used.	Enabled

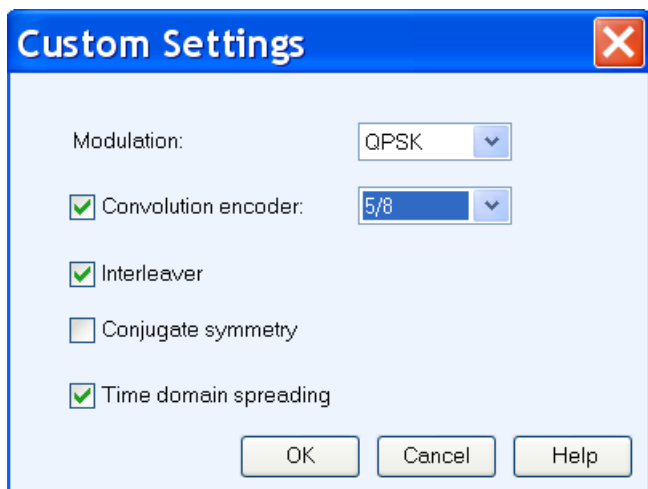
**Table 25: Process preferences (cont.)**

Selection	Description	Default value
Reed-Solomon tail bits	If selected, processes the Reed-Solomon tail bits value set in the field. If cleared, the default value for Reed-Solomon tail bits is used.	Enabled
Reserved bits	If selected, processes the Reserved bits value set in the field. If cleared, the default value for Reserved bits value is used.	Enabled

When you click Process This Packet in the custom mode, the software processes the packet and displays the output in the fields.

## Custom Settings

This dialog box is displayed when you click Rate (Selected PPDU Details) in the Setup tab (UWB-WiMedia) in the Custom mode. It displays the custom settings that directly affect the data rate of the selected PPDU.



The settings in the custom mode are as follows:

**Table 26: Custom settings**

Selection	Description	Default value
Modulation	Select the modulation to QPSK or DCM.	QPSK

**Table 26: Custom settings (cont.)**

Selection	Description	Default value
Convolution encoder	Select the convolution encoder and set it to one of the following selections: 1/3, 1/2, 5/8, 3/4.	Enabled, 5/8
Interleaver	Select or clear interleaver.	Enabled
Conjugate symmetry	Select or clear conjugate symmetry.	Disabled
Time domain spreading	Select or clear time domain spreading.	Enabled

The following table lists the PSDU data rate-dependent modulation parameters.

**Table 27: PSDU data rate-dependent modulation parameters**

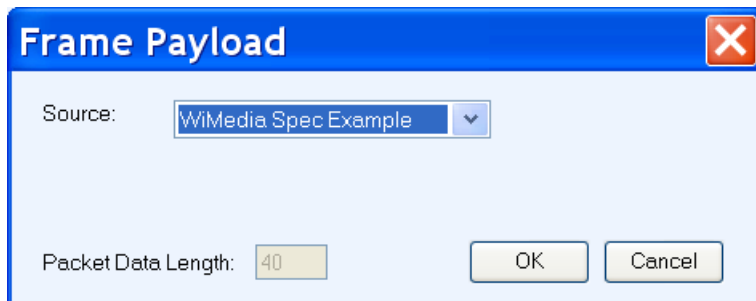
Data rate (Mb/s)	Modulation	Coding rate	Conjugate symmetry	TDS
53.3	QPSK	1/3	Yes	Yes
80	QPSK	1/2	Yes	Yes
106.7	QPSK	1/3	No	Yes
160	QPSK	1/2	No	Yes
200	QPSK	5/8	No	Yes
320	DCM	1/2	No	No
400	DCM	5/8	No	No
480	DCM	3/4	No	No

**NOTE.** If you select one of the standard settings that results in a standard data rate, the MAC for the data rate takes the bits from the standard. If the setting results in a non-standard data rate, the bit setting will be "11111".



## Frame Payload

This dialog box is displayed when you click Frame Payload (Selected PPDU Details) in the Setup tab (UWB-WMedia) in the Custom mode.



**Table 28: Frame payload options**

Selection	Description
Source	Select the source for the data to be transmitted from the following selections: WiMedia Spec Example, All 0, All 1, PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21, PRBS 23, and From File.
File	Select the file to be used by entering the path or browsing to the file. Uses the specified file (.txt or .dat) as the source of data to be transmitted.
Packet Data Length	Displays the packet data length. Used along with the payload data length and the number of packets to calculate the data to be sent in one packet.

The following conditions must be met for a valid file:

- Any ASCII file, delimited or not, can be used as the data source.
- The next bit will be generated by reading the file until a 0, 1, x, or X character is found. 0 and 1 will add the corresponding bit to the sequence while the x and X character will add a new random bit.
- Any other intermediate character will be ignored.
- When the end of the file has been reached, the file is read again from the beginning, based on the Record Length.
- The data can be organized in columns or rows.
- Any number of space, tab, comma characters can be used as a delimiter.
- Empty lines or invalid lines at the beginning and end of the file are ignored.

## Compile Settings for the Radar Application

Waveform > Compile Settings

To specify compilation settings for the currently active Waveform Setup, click Compile Settings. This dialog box is displayed.

RFXpress supports generation of two signal types. The number of waveforms generated varies depending on the signal format selected.

- Baseband signals (IQ format): When the IQ signal format is selected, two baseband waveforms I and Q are generated. You must specify the names of each waveform.
- RF signals (IF/RF format): When the RF signal format is selected, the baseband waveforms I and Q are also generated. So after compiling, three different files are generated.

For example, if the waveform name is Test, the generated waveforms are: Test\_1\_I, Test\_1\_Q, and Test\_1\_RF, where the number indicates the pulse index.

The Correction Files option is available for all applications and the Compile Button Prefs option is available only when the AWG software is detected.

**Table 29: Compile settings options for radar**

Selection	Description	Range, Default value
<b>Compile Button Preferences</b>		
Compiles and sends to	Compiles the currently active waveform setup and sends it to the specified channel.	Ch1
Compile only	Compiles the currently active waveform setup.	N/A
<b>Signal Format</b>		
IF/RF	Sets the signal format to IF/RF.	N/A
IQ	Sets the signal format to IQ.	N/A
Pulse Name	Enter the name of the pulse to be generated after compilation. Uses the name entered here for the generated RF waveform.	Waveform1
Sampling Rate	Specify the sampling rate.	Automatic
Oversampling	This is available only when Automatic is disabled.	
Automatic	Automatically calculates the oversampling based on the setup parameters and the AWG model. To enter the oversampling value, disable this option.	Enabled
Adjust Pulse Time/Frequency Parameters	Adjust the pulse parameters (Time parameters or Frequency parameters) of the signal to meet the AWG requirements like granularity, minimum sequence waveform length, coherency, and so on.	Time parameters
<b>AWG Run Mode</b>		
Continuous	When selected, the application uses the Continuous mode during compilation.  For the AWG B-series instruments without Option 08, the Continuous mode is the default setting. Override the default setting by selecting the AWG Run Mode Option.	Enabled

**Table 29: Compile settings options for radar (cont.)**

Selection	Description	Range, Default value
Sequence	When selected, the application uses the Sequence mode during compilation.  If Option 08 is present, by default the application uses Sequence mode. You can override the default by selecting the AWG Run Mode option.	Disabled
Overwrite waveform in RFXpress list	When selected, overwrites any existing waveform of the same name in the waveform list. When this option is disabled, you are prompted to enter a waveform file name.	Enabled
I Invert	When selected, inverts the phase of the I signal.	Disabled
Q Invert	When selected, inverts the phase of the Q signal.	Disabled

Click Compile to compile the waveform. A progress bar is displayed during compilation. You can abort the compilation by clicking Cancel.

## Add Pulse Groups

The Radar module allows to add two or more pulse groups. The time window of the largest pulse group in the list will have all the pulses added together.

---

**NOTE.** *Dead time is not a part of the added pulse groups.*

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In the radar module, click the Pulse tab and click Add Pulse Groups. This dialog box is displayed.

A table displays the pulses that make the pulse train. In the Check to add pulse column, select the pulse groups to add together. You can use the Check All button to select all pulse groups and Uncheck All to unselect all pulse groups.

## Compile Settings for OFDM

Waveform > Compile Settings

To specify compilation settings for the currently active Waveform Setup, click Compile Settings.

RFXpress supports generation of two signal types. The number of waveforms generated varies depending on the signal format selected.

- Baseband signals (IQ format): When the IQ signal format is selected, the waveforms are generated based on various parameters. If the AWG Run mode is set to Continuous, then two or three waveforms are generated. If phase noise and multipath are not specified, then a waveform is created for each packet. Spacing waveforms are also generated.
- RF signals (IF/RF format): When the RF signal format is selected, the baseband waveforms I and Q are also generated. So after compiling, three different files are generated.

The Correction Files option is available for all applications and the Compile Button Prefs option is available only when the AWG software is detected.

**Table 30: Compile settings options for OFDM**

Selection	Description	Range, Default value
<b>Signal Format</b>		
IF/RF	Sets the signal format to IF/RF.	N/A
IQ	Sets the signal format to IQ.	N/A
Waveform Name	Enter the name of the pulse to be generated after compilation. Uses the name entered here for the generated RF waveform.	Waveform1
Sampling Rate	You can specify either the Sampling Rate or Oversampling by disabling Automatic.	Automatic
Oversampling	This is available only when Automatic is disabled.	
Automatic	Automatically calculates the oversampling based on the setup parameters and the AWG model. To enter the oversampling value, disable this option.	Enabled
<b>Compile Button Prefs</b>		
Compiles and sends to	Compiles the currently active waveform setup and sends it to the specified channel.	Ch1–Ch4 (depending on the instrument)
Compile only	Compiles the currently active waveform setup.	N/A
<b>AWG Run Mode</b>		
Continuous	When selected, the application uses the Continuous mode during compilation.  For the AWG B-series instruments without Option 08, the Continuous mode is the default setting. Override the default setting by selecting the AWG Run Mode Option.	Enabled

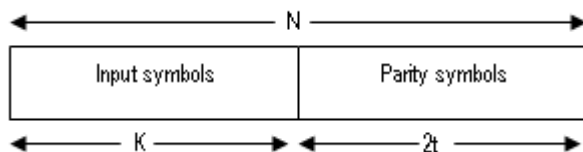
Table 30: Compile settings options for OFDM (cont.)

Selection	Description	Range, Default value
Sequence	When selected, the application uses the Sequence mode during compilation.  If Option 08 is present, by default the application uses Sequence mode. You can override the default by selecting the AWG Run Mode option.	Disabled
Overwrite waveform in RFXpress list	When selected, overwrites any existing waveform of the same name in the waveform list. When this option is disabled, you are prompted to enter a waveform file name.	Enabled
I Invert	When selected, inverts the phase of the I signal.	Disabled
Q Invert	When selected, inverts the phase of the Q signal.	Disabled

Click Compile to compile the waveform. A progress bar is displayed during compilation. You can abort the compilation by clicking Cancel.

## Reed Solomon Coding

Reed Solomon (RS) codes are a block-based error-correcting mechanism in a wide range of applications in digital transmission and storage. The Reed Solomon encoder takes a block of data and adds extra redundant bits. A block of Reed Solomon codes shown in the following figure consists of “K” information symbols added by “2t” parity symbols to make an N symbol codeword. The RS decoder can correct up to “t” symbols that contain errors in the codeword, and specified as RS(N,K). For a symbol size of m-bits, the maximum codeword length is  $N=2m-1$ .



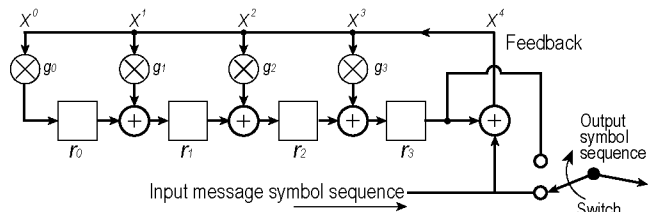
RFXpress uses a generic Reed-Solomon encoder, whose characteristics can be altered by modifying the parameters. They are: Number of symbols (K), length of parity symbol (2t), number of bits per symbol (m), primitive polynomial  $p(x)$ , and the initial power of the primitive element (b). The generator polynomial  $P(x)$  is automatically generated by RFXpress.

A Reed Solomon code is constructed by forming the code generator polynomial  $g(x)$ , consisting of 2t (or  $N-K$ ) factors.

Generator polynomial  $g(x) = (x - \alpha^b)(x - \alpha^{b+1})(x - \alpha^{b+2}) \dots (x - \alpha^{b+2t-1})$

where alpha is the primitive element.

Based on the application, b can take different values, and thus starting roots with different power. The starting value of b can be set using initial power of the primitive element which is provided as an input to RFXpress.



To use Reed Solomon coding:

1. Click the **Basic Setup** tab and define the base data.
2. For each base data, you can set Reed Solomon coding. Select **Reed Solomon Coding** and click **Turn On**. Set the following parameters:

**Table 31: Reed-Solomon coding options**

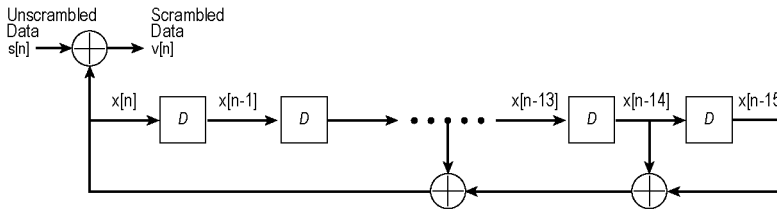
Selection	Description	Range, Default value
Bits per Symbol	Enter the number of bits in a symbol (m in the equation).	1 to 16, 8
Input number of Symbols	Enter the number of symbols (K in the equation).	1 to 100000, 17
Encoded number of Symbols	Enter the encoded number of symbols. N, $N = K + 2t$ , where 2t is the number of parity symbols. Note the number of parity symbols has to be even, thus N-K has to be even.	1 to 50000, 23
Primitive Polynomial	Enter the primitive polynomial.	None, $X^8 + X^4 + X^3 + X^2 + 1$
Initial power of the primitive element (b)	Enter the power (index) of the primitive polynomial.	0 to 100, 1
Generator Polynomial	Displays the polynomial based on the inputs provided.	$X^6 + 126X^5 + 4X^4 + 158X^3 + 58X^2 + 49X + 117$

3. Click **Apply**.

## Scramble Editor

You can apply scrambling on the defined data. The initial seed and the polynomial expression are required for the scrambling to be applied.

Scramblers are used in wireless standards to randomize the bits. This is done to avoid long sequence of ones and zeros.



1. Click the **Basic Setup** tab, and select **Scramble Editor**. Set the following parameters

**Table 32: Scramble editor options**

Selection	Description	Default value
Scramble polynomial express	Enter an expression in the format $Xn1+Xn2+1$ to generate the scramble sequence. The value of $Xn$ ranges between 1 and 31.	$X31+X30+ =0$
Shift register initial value	Enter values in the shift registers to create the sequence. The registers D1 through D31 can take the values 0 and 1.	D1–D31

2. Click **OK**.

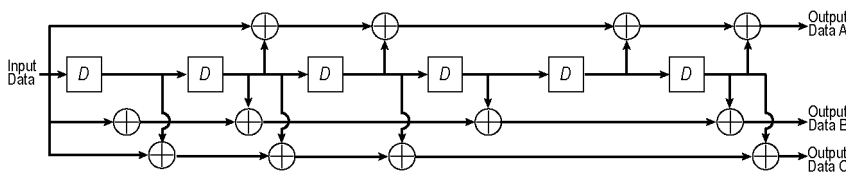


## Convolution Coding

The Convolution Coding dialog box is displayed when you click **Frequency Hopping** in the Packets tab (OFDM).

Convolutional code is a type of error-correcting code in which:

- Each m-bit information symbol (each m-bit string) to be encoded is transformed into an n-bit symbol, where m/n is the code rate ( $n \geq m$ ). So in a 1/2 mother rate, for every bit we have two bit output.
- The transformation is a function of the last k information symbols, where k is the constraint length of the code. The number of stages k is defined in the shift register.



1. Click the **Basic Setup** tab, and define the base data.
2. For each base data, you can set Convolution coding. Select **Convolution Coding** and click **Turn On**. Set the following parameters:

**Table 33: Convolution coding options**

Selection	Description	Range, Default value
Constraint	Enter the length of the constraint.	1 to 10, 1
Mother Rate	Select from the following: 1/2, 1/3, 1/4, 1/5.	1/2
Polynomial Value (Octal)	Enter the values (in Octal) in the table. The number of rows in the table depends on the selected Mother Rate.	
Puncturing Scheme	Define the puncturing scheme by changing the values in the table to 0.	

Puncturing is a process of omitting some of the encoded bits in the transmitter, thereby reducing the number of transmitted bits. This is done to obtain higher data rates.

3. Click **Apply**.

## Tone Nulling

The Tone Nulling dialog box is displayed when you click **Tone Nulling** in the Symbol tab (OFDM). For the selected symbol, the tone nulling table shows the carrier index, the amplitude (dB), and the phase (degrees).

Click **Turn On**. The amplitude and phase fields are editable. Double-click the field and enter a new amplitude for the selected carrier. The amplitude values range from  $-40$  dB to  $+20$  dB, with the default at  $0$  dB. The phase values range from  $-180^\circ$  to  $+180^\circ$ , with the default at  $0^\circ$ . If a user-defined file is the input (specified in User-defined Frequency Weight), the number of carriers shown depends on the I and Q values in the file.

## Frequency Hopping

The Frequency Hopping dialog box is displayed when you click **Frequency Hopping** in the Packets tab (OFDM).

1. Click the Packets tab.
  - a. Add the number of packets required. At least one packet is present in the table by default.
  - b. Specify the packet parameters.
2. For each packet, you can set frequency hopping.
  - a. Select **Frequency Hopping** and click **Turn On**.
  - b. Set the following parameters:

**Table 34: Frequency hopping options**

Selection	Description	Range, Default value
Start Symbol ID	Enter the symbol at which to start hopping. The start symbol cannot be greater than the end symbol.	N/A
End Symbol ID	Enter the symbol at which to end hopping.	N/A
Frequency Offset (+/- MHz)	Enter the relative frequency at which to hop. The frequency offset can be positive or negative.	Depends on the instrument and options, 0 kHz
Relative Amplitude (+/- dB)	Enter the relative amplitude at which to hop. The amplitude can be positive or negative.	$-60$ to $0$ dB, $0$ dB

3. Enable **Repeat frequency/amplitude hopping** to repeat the frequency offset and relative amplitude values for all the pulses. When disabled, the frequency offset and relative amplitude values are used for only those symbols and  $0$  is used for all other symbols.
4. Click **OK**.

## Gated Noise

The Gated Noise dialog box is displayed when you click **Gated Noise** in the Packets tab (OFDM).

You can apply gated noise to either certain segments of the packets or through a range of symbols. You can define a range of symbols to which to apply noise.

A negative signal-to-noise value indicates that the noise added will be greater than the signal amplitude. Conversely, a positive signal-to-noise value indicates that the noise added will be smaller than the signal amplitude.

1. Click the Packets tab.
  - a. Add the number of packets required. At least one packet is present in the table by default.
  - b. Specify the packet parameters.
2. For each packet, you can set gated noise.
  - a. Select **Gated Noise** and click **Turn On**.
  - b. Set the following parameters:

**Table 35: Gated noise options**

Selection	Description	Range, Default value
Start Symbol ID	Enter the symbol at which to apply noise. The start symbol cannot be greater than the end symbol.	N/A
End Symbol ID	Enter the symbol at which to end the noise.	N/A
S/N (dB)	Enter the signal-to-noise ratio to be applied. The value can be positive or negative.	-60 to +60 dB, 20 dB

3. Select **Repeat gated noise** to repeat the S/N (signal-to-noise ratio) values for all the symbols. When disabled, the S/N values are used for only those symbols and 0 is used for all other symbols.
4. Click **OK**.



## Single Carrier

In the Setup tab (Generic Signal) by default, Single Carrier is selected in the Carriers field. A carrier is displayed in the carrier table and is selected. When Single Carrier is selected, you cannot add another carrier; you must switch to Multi Carrier to add another carrier.

### IF/RF Signal

When the signal type is IF/RF, the table displays the following: Carrier number, Frequency (MHz), Amplitude (dBm), Symbol rate (MHz), Modulation, Filter, Alpha/B\*T parameter, and State (ON by default).

The Single Carrier group options show Frequency in Hz and Amplitude in dBm in 50-ohm load.

**Table 36: Single carrier group options for IF/RF signal**

Selection	Description	Range, Default value
Signal type: IF/RF		
Frequency (Hz)	Enter the carrier frequency in Hz.	Depends on the instrument bandwidth, 10M
Amplitude (dBm)	Enter the amplitude of output signal in dB.	-100.00 dBm to +30 dBm, 0

### IQ Signal

When the signal type is IQ, the table displays the following: Carrier number, Offset (MHz), Amplitude (Vrms), Symbol rate (MHz), Modulation, Filter, Alpha/B\*T parameter, and State (ON by default).

The Single Carrier group options show Baseband Offset in Hz and Amplitude in Vrms.

**Table 37: Single carrier group options for IQ signal**

Selection	Description	Range, Default value
Signal type: IQ		
Baseband Offset (MHz)	Enter the carrier frequency offset in Hz.	Depends on the instrument bandwidth, 0
Amplitude (Vrms)	Enter the amplitude of output signal in Vrms.	0 to 5 Vrms, 1

---

**NOTE.** None of the items in the shortcut menu are available in the single carrier table.

---

## Multi Carriers

In the Setup tab (Generic Signal), select Multi Carrier in the Carriers field. An anchor carrier is displayed in the table. To add a carrier, in the Add Carrier field, type the number of carriers to add. The maximum number of carriers you can have in the table is 1024. Each row in the table corresponds to one carrier. If you try to enter more than 1024 carriers, you will be reminded that the maximum number of carriers is 1024.

A signal must be repeated to obtain a continuous output for AWGs. To avoid discontinuities at the transition between the end and the beginning of any pair of segments, the application takes care to avoid all the “wrap-around” artifacts. For a modulated carrier, to have a signal free of wrap-around artifacts, a set of conditions must be met by the signal:

- An integer number of carrier cycles must be available in the segment for any given carrier.
- An integer number of symbols must be available in the segment for any given carrier.

In general, it is difficult to meet these criteria for any given set of carriers if the record length in the target instrument is a finite and integer number. This means that some rounding must be performed. You can select one of the carriers as an anchor carrier to act as a reference. The application calculates the output clock (sampling rate) to preserve some of the frequency characteristics of the anchor carrier. If record length is expressed in samples, the carrier frequency will be preserved. If record length is expressed in symbols, the symbol rate will be the preserved. The actual clock output will be also influenced by the maximum carrier frequency in the carrier table and the oversampling factor. The actual values for carrier frequencies and symbol rates will be shown in the carrier table after compilation.

---

**NOTE.** For each carrier, you can define the parameters in each of the tabs: Setup, Hopping, Power Ramping, I/Q Impairments, Distortion Addition, Multi-Path, and Interference Addition.

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### IF/RF Signal

When the signal type is IF/RF, the table displays the following: Carrier number, Frequency (MHz), Amplitude (dBm), Symbol rate (MHz), Modulation, Filter, Alpha/B\*T parameter, and State (ON by default).

Select the [Base Data \(see page 79\)](#) and set the Amplitude in dBm in 50-ohm load. The Multi Carrier group options allow you add carriers based on:

- Center frequency, where you must provide the Center frequency and Bandwidth.
- Range, where you must provide the Base Frequency and Carrier Spacing.

**Table 38: Multi carrier group options for IF/RF signal**

Selection	Description	Range, Default value
<b>Signal type: IF/RF</b>		

**Table 38: Multi carrier group options for IF/RF signal (cont.)**

Selection	Description	Range, Default value
Center		
Center Frequency (Hz)	Enter the center frequency of the carrier.	1 Hz to the maximum supported by the AWG, 50 MHz
Bandwidth (Hz)	Enter the bandwidth of the carrier.	1 Hz to the maximum supported by the AWG, 100 MHz
Range		
Base frequency (Hz)	Enter the base frequency of the carriers.	1 Hz to the maximum supported by the AWG, 10 MHz
Carrier spacing (Hz)	Enter the spacing between carriers.	1 Hz to the maximum supported by the AWG, 10 MHz
Phase shift	Enter the phase shift between the carriers (degrees). Disabled when Random is selected.	-180° to +180°, 0°
Random	When selected, uses a random phase shift value.	Disabled

## IQ Signal

When the signal type is IQ, the table displays the following: Carrier number, Offset (MHz), Amplitude (Vrms), Symbol rate (MHz), Modulation, Filter, Alpha/B\*T parameter, and State (ON by default).

Select the [Base Data \(see page 79\)](#) and set the Amplitude in Vrms. The Multi Carrier group options allow you to enter the Initial Offset (Hz) and Carrier Spacing (Hz).

**Table 39: Multi carrier group options for IQ signal**

Selection	Description	Range, Default value
Signal type: IQ		
Initial Offset (Hz)	Enter the initial offset of the carriers.	Depends on the instrument bandwidth
Carrier Spacing (Hz)	Enter the frequency spacing between carriers.	1 Hz to the maximum supported by the AWG, 10 MHz

## Editing Carrier Details

If you have more than one carrier and you select a carrier in the table, the Multi Carrier options change to Selected Carrier options. You can set the options for each selected carrier. To edit carrier parameters, highlight the carrier in the table, and then do one of the following:

- Change the values directly in the fields for the selected carrier. As you change the values in the fields, the new values are committed immediately.
- In the table, double-click the parameter that you want to change and directly enter new values. If you select File1 (samples), File2 (Symbols) or File3 (Maps), the corresponding dialog boxes open for you to edit the values. Changing the State to ON or OFF includes or excludes the carrier during compilation.

The Add, Delete and Set Anchor buttons work as follows:

**Table 40: Carrier editing options**

Selection	Description	State
Add	Adds one or more carriers to the table. All of the carrier parameters use default states.	Add is always enabled.
Delete	Deletes the selected carrier from the table. Select multiple carriers using the Shift or Control keys and dragging the pointer. The carriers are renumbered when you delete a carrier from within the sequence.	Delete is disabled when an empty row or no carrier is selected in the table.
Set Anchor	Sets the selected carrier as the anchor carrier. By default, the first carrier in the table is the anchor carrier.	Set anchor is disabled when an empty row or no carrier is selected in the table.

---

**NOTE.** *When you add more than one carrier at a time, the Setup tab automatically shows options to allow adding multiple carriers.*

---

If you change from Multi Carrier to Single Carrier, the following message appears: The current anchor carrier will become the single carrier. Do you want to continue? You can click Continue and make the anchor carrier the only carrier in the single carrier mode. You can click Cancel to cancel the operation.

Edit operations are available in the shortcut menu (when you right-click on a selected carrier in the table). The available operations are: Cut, Copy, Paste, Delete, Delete All, and Set Anchor.

**Table 41: Editing options in the shortcut menu**

Selection	Description	State
Cut	Cuts the current selected row (carrier) and copies the contents to clipboard.	Enabled when a carrier is selected.
Copy	Copies the current selected row (carrier) and copies the contents to clipboard.	Enabled when a carrier is selected.
Paste	Pastes the contents from memory on to the selected row or carrier (replaces the selected row).	Enabled only after a cut or copy operation.
Delete	Deletes the selected row (carrier).	Enabled when a carrier is selected.



**Table 41: Editing options in the shortcut menu (cont.)**

Selection	Description	State
Delete All	Deletes all the rows (carriers) in the table.	Always enabled.
Set Anchor	Sets the currently selected row's frequency as anchor frequency.	Enabled when a carrier is selected.

## Selecting the Base Data

Follow these steps to select the base data for a signal:

1. Select the Setup tab.
2. Select a carrier from the table.
3. In the Base Data field, select the data source. The following table lists the choices for the Base Data field:

**Table 42: Multi carrier options for IF/RF signal**

Selection	Description	Default value
Base data	Select the data source from the following: All 0, All 1, PRBS, Pattern, File.	PRBS
All 0	Sends a sequence of binary 0 symbols. An example is a data sequence with the length ten $\{d\} = \{0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}$ .	N/A
All 1	Sends a sequence of binary 1 symbols. An example is a data sequence with the length ten $\{d\} = \{1, 1, 1, 1, 1, 1, 1, 1, 1, 1\}$ .	N/A
PRBS	Select the PRBS type from the following: 7, 9, 15, 16, 20, 21, 23, and User Defined.  To edit the bit sequence, select User Defined in the PRBS dropdown menu. This causes the <a href="#">PRBS Editor...</a> (see page 41) button to appear.	9
Pattern	Enter a pattern of 0s and 1s up to a maximum of 80 digits in the text field that appears.	N/A
File	Select the base data file to be used by entering the path or browsing to the file. The supported formats are .txt and .dat.	N/A

**NOTE.** *If you try to compile the signal without specifying a base data file, the following message appears: RFXpress cannot compile. You must select a file for base data first or change the selection.*

## Modulation for Carriers

Follow these steps to select the modulation parameters for a signal:

1. Select the Setup tab.
2. Select a carrier from the table.
3. Set the following modulation parameters:

**Table 43: Modulation options for carriers**

Selection	Description	Range, Default value
Modulation	Select a modulation type from the following: No Mod, QPSK, PI/2 QPSK, BPSK, PI/4 QPSK, OQPSK, 8-PSK, O-8PSK, QAM-16, PI/2 QAM16, QAM-32, QAM-64, QAM-128, QAM-256, QAM-512, QAM-1024, GMSK, 2-FSK, 4-FSK, 8-FSK, 16-FSK, 32-FSK, ASK, AM, PM, FM, nDPSK, OOK, Pi/2 BPSK, and Gaussian Noise, <a href="#">File1(Samples) (see page 43)</a> , <a href="#">Modulation File2(Symbols) (see page 44)</a> , <a href="#">File3(Maps) (see page 45)</a> .	No Mod
FSK Peak Deviation (Hz)	Enter the FSK peak deviation value. Defined only when the modulation type is set to FSK.	Depends on the instrument bandwidth, 1000 KHz
ASK Mod Index (%)	Enter the ASK modulation index. Defined only when modulation type is set to ASK.	0 to 200%, 1%
AM Mod Index (%)	Enter the AM modulation index. Defined only when modulation type is set to AM.	0 to 200%, 50%
Phase Deviation (degrees)	Enter the phase deviation. Defined only when modulation type is set to PM.	0° to +180°, 10°
Phase Rotation	Set the phase in degrees for the Differential PSK Modulation. Defined only when the modulation type is set to n-DPSK.	0° to +180°, 45°
n	Set the n value of n-DPSK modulation. n can be only power of 2.	4
Frequency Deviation (Hz)	Enter the frequency deviation. Defined only when modulation type is set to FM.	0 KHz to 10 GHz, 100 KHz
Coding	Specify the coding parameter: None, Gray, Differential, Gray differential, NADC, TFTS, and MSAT. Defined when the modulation type is set to n-DPSK, PI/2 BPSK, PI/2 QPSK, PI/2 8-PSK, and PI/2 QAM16.	None

**Table 43: Modulation options for carriers (cont.)**

Selection	Description	Range, Default value
Symbol rate (Hz)	Enter the symbol rate for modulation. Defined when the modulation type is set to n-DPSK, OQPSK, PI/2 BPSK, PI/2 QPSK, PI/2 8-PSK and PI/2 QAM16.	Depends on the instrument bandwidth Default: 1 MHz
Bandwidth	Enter the bandwidth for the modulation. this appears only when the modulation type is Gaussian Noise.	1 Hz to 3.5 GHz, 1 MHz

When the Modulation parameter is set to File1 (Samples), Base Data, Coding and Filter parameters are not available. The Symbol Rate parameter changes to Input File Sample Rate. When the Modulation parameter is set to File 2 (Symbols), Base Data and Coding parameters are unavailable. When Modulation is set to AM, FM, or PM, the Symbol Rate parameter changes to Modulating Frequency.

You can edit the Modulation parameters from the table by selecting the values in the dropdown list for the parameter. If you select File1 (samples), File2 (Symbols), or File3 (Maps), the corresponding dialog boxes open for you to edit the values.

---

**NOTE.** *When the modulation type is Gaussian Noise, the Power Ramping, I/Q Impairments, Distortion Addition, Multi-Path, and Interference Addition features are not available.*

---

## Filter for Carriers

Follow these steps to select the filter and window parameters for a signal:

1. Select the Setup tab.
2. Select a carrier from the table.
3. Set the following Filter/Window parameters. The Filter/Window parameters are not available when the modulation type is Amplitude Modulation, Frequency Modulation or Phase Modulation.

**Table 44: Filter options for carriers**

Selection	Description	Range, Default value
Filter	Select the filter from the following options: Rectangular, Raised Cosine, Root Raised Cosine, Gaussian (Dirac Delta), Gaussian (Rectangular, Triangular, Edge), User defined, Half-Sine, and No Filter.	No Filter
Alpha/B*T	Enabled for Raised Cosine, Root Raised Cosine, Gaussian, and Gaussian-2.	Raised Cosine: 0.0 to 1, 0.35 Root Raised Cosine: 0.0 to 1, 0.35 Gaussian Filter B*T: 0.1 to 3.0, 0.5
Convolution length (symbols)	Enter the convolution length. Convolution length is used to calculate the FIR filters impulse response. To keep the pulse shape symmetric, the convolution length has to be given in odd number.	3 to 201, 21 (odd numbers only)
Window <sup>1</sup>	Select the window type from the following: None, Rectangular, Triangular, Hamming, Hanning, Blackman, Kaiser, Blackman-Harris, Exact Blackman, Flat Top, Tapered Cosine, and Chebyshev Ripple.  Enabled for Raised Cosine, Root Raised Cosine, Gaussian, Gaussian-2, Triangular, and Edge.	None
Kaiser Parameter (dB)	Enter the Kaiser parameter. Appears only when Window is set to Kaiser.	1 to 10, 2.2
Chebyshev ripple	Enter the Chebyshev Ripple. Appears only when Window is set to Chebyshev.	10 dB to 80 dB, 40 dB

<sup>1</sup> The window parameter is available only for Chebyshev and Kaiser Windows.

4. When Filter is set to User Defined, a dialog box appears where you can select a file. The supported file name extensions are .txt, .dat and .bin. The Format field is used to specify the file format. Ensure that the following conditions are met for a selected file format:
  - When the file format is ASCII, the data should be in floating point precision. Spaces and tabs are ignored. Any other characters are considered invalid. RFXpress stops reading data when it encounters invalid data.
  - When the file format is Binary(float), the data should be in binary format with floating point precision.
  - When the file format is Binary(double), the data should be in binary format with double point precision.
  - Filters must be defined with 50 samples per symbol time as the software will take care of resampling and interpolate these values to the resolution required by any specific settings.
  - Filter coefficients must be in columns.

You can edit the Filter parameters from the table by selecting the values in the dropdown list for the parameter.

## Hopping Parameters

Hopping allows you to add frequency and amplitude hopping for a selected carrier.

Follow these steps to define frequency/amplitude hopping:

1. Select a carrier and click Turn On.
2. Define the Hop Frequency parameters. Select the pattern from the following: Custom Table, Pseudo-Random (Range), Pseudo-Random (List), and Pseudo-Random (Avoid List). The default pattern is Custom Table.
  - If you select Custom Table, you must directly enter the values into the table. Click Add to add a row to the table and edit the values. You can enter values as Absolute Frequency (MHz) or as Frequency Offset ( $\pm$ MHz). The table columns change depending on the selected Hop Time Method. You can add up to 500 hops for a carrier.

The relative amplitude takes only negative values (0 to -60 dB) and frequency offset takes positive and negative values.

---

**NOTE.** *If the hop frequency is not defined for a time interval, then the application sets the hop frequency during that time interval to a frequency offset of 0 Hz with a relative amplitude of 0 dB.*

---

- If you select Pseudo-Random (Range), the signal will hop using the specified interval within the frequency range specified. Enter the following:

**Table 45: Hop frequency parameters for Pseudo-Random Range**

Selection	Description	Range, Default value
Minimum Frequency/Minimum Frequency Offset	Enter the frequency range within which to hop. Specify the start frequency for the range.	For IF/RF: 100 Hz to the maximum supported by the instrument and installed options, 10 MHz For IQ: Depends on the instrument and installed options, -10 MHz
Maximum Frequency/Minimum Frequency Offset	Specify the end frequency for the range.	For IF/RF: 100 Hz to the maximum supported by the instrument and installed options, 100 MHz For IQ: Depends on the instrument and installed options, +10 MHz
Channel Spacing (Hz)	Specify the minimum frequency intervals for hopping. The signal will hop in this interval or at multiples of this interval.	100 Hz to (Max freq-Min Freq), 10 MHz
PRBS	Select the PRBS pattern for hopping: 7, 9, 15, 16, 20, 21, 23, User-defined.	7 (default)

The signal will hop in the specified frequency range.

- If you select Pseudo-Random (List), the signal will hop randomly using the frequencies specified in the table. Click Add to add a row to the table and edit the frequency values. All frequency values are in absolute terms.
- If you select Pseudo-Random (Avoid List), the signal will avoid hopping in the frequencies specified in the table. Click Add to add a row to the table and edit the frequency values. Enter the following:

**Table 46: Hop frequency parameters for Pseudo-Random Avoid**

Selection	Description	Range, Default value
Minimum Frequency/Minimum Frequency Offset	Enter the frequency range within which to hop. Specify the start frequency for the range.	For IF/RF: 100 Hz to the maximum supported by the instrument and installed options, 10 MHz For IQ: Depends on the instrument and installed options, -10 MHz
Maximum Frequency/Minimum Frequency Offset	Specify the end frequency for the range.	For IF/RF: 100 Hz to the maximum supported by the instrument and installed options, 100 MHz For IQ: Depends on the instrument and installed options, +10 MHz
Channel Spacing (Hz)	Specify the minimum frequency intervals for hopping. The signal will hop avoiding the frequencies specified in the table in this interval or at multiples of this interval.	100 Hz to (Max freq-Min Freq), 10 MHz
PRBS	Select the PRBS pattern for hopping: 7, 9, 15, 16, 20, 21, 23, User-defined.	7 (default)

3. Define how the values are entered — Absolute Frequency (MHz) or Frequency Offset ( $\pm$ MHz). Both options are available for Custom Table. Only Absolute Frequency (MHz) is available for Pseudo-Random (List), and Pseudo-Random (Avoid List) for IR/RF signals and Frequency Offset ( $\pm$ MHz) for IQ signals.
4. Define the Hop Time parameters. Select the Method from the following: Symbols per hop (fixed), Hops per second (fixed), Symbol Index (each hop), and Time in hop (variable). All options are available for Custom Table. Only Symbols per hop (fixed) and Hops per second (fixed) are available for Pseudo-Random (Range), Pseudo-Random (List), and Pseudo-Random (Avoid). For the selected method, specify the Symbols per hop (fixed) or Hops per second (fixed).

**Table 47: Hop time methods and parameters**

Selection	Description	Range, Default value
Method	Select the hop time method from the following: Symbols per hop (fixed), Hops per second (fixed), Symbol Index (each hop), and Time in hop (variable).	Symbols per hop, fixed

**Table 47: Hop time methods and parameters (cont.)**

Selection	Description	Range, Default value
Symbols per hop (fixed)	Select this method to define the symbols per hop.	N/A
Symbols per hop	Enabled when the method is set to Symbols per hop (fixed).	1 to 5000000, 100
Hops per second (fixed)	Select this method to define the hops per second.	N/A
Hops per second	Enabled when the method is set to Hops per second (fixed).	1 to 1000000000, 1600
Symbol Index (each hop)	Provide start index in the table for each hop.	1 to the maximum supported by the instrument, 1
Time in hop, (variable)	For each hop, enter the Time in Hop ( $\mu$ secs) in the table.	10 nsec to 1 sec, 10e-6 sec

The hop duration in each of the methods is calculated as follows.

Duration for each hop when Symbols per Hop is selected is:

$$\text{Symbols per hop} / \text{Symbol rate}$$

Duration for each hop when Hops per second is selected is:

$$1 / \text{Hops per second}$$

Duration for  $n^{\text{th}}$  hop when Symbol Index is selected is:

$$(\text{Start Index}(n+1) - \text{Start Index}(n)) / \text{Symbol rate}$$

Duration for  $n^{\text{th}}$  hop when Time in Hop is selected is:

$$\text{Time in Hop}(n)$$

## Power Ramping Parameters

Power ramping allows you to define the power ramping profile for the signal to be transmitted. Follow these steps to define power ramping for a signal:

1. Select the Power Ramping tab.
2. Select a carrier from the table.
3. Select Turn On to include power ramping parameters. (Select Turn On again if you want to exclude power ramping parameters for the carriers. By default, Turn On is set to off.)
4. Set the following power ramping parameters:

**Table 48: Power ramping parameters for carriers**

Selection	Description	Range, Default value
Ramp		
Function	Select the power ramping function from the following: None, Linear and Cosine.	None
Time (secs)	Enter the duration of ramp.	1 ns to 1 sec, 0.1 usec
Position		
Symbol	Enter the location of the power ramping.	0 to depends on the instrument model and option installed , 0
Level / dB	Enter the level of the power ramping.	-60 dB to +20 dB, 0
Periodically extended power ramping	When selected, the time characteristic of the power ramping is continued periodically until the end of the signal.	Disabled

5. Click Add to add the power ramping parameters to the table and Delete to delete the power ramping parameters from the table. The table contains the Symbol and Level/dB values that you entered.

## Carrier Leakage for Single Carrier

Follow these steps to define carrier leakage for a signal:

1. Select the I/Q Impairments tab.
2. Select a carrier from the table.
3. Select Turn On to include carrier leakage (I and Q) impairments to the carrier. (Select Turn On again if you want to exclude carrier leakage (I and Q) impairments. By default, Turn On is set to off.)
4. Set the carrier leakage for I and Q modulator signal in percentage.

**Table 49: Carrier leakage parameters for carriers**

Selection	Description	Range, Default value
I (%)	Enter the carrier leakage for the I signal.	-50% to +50%, 0%
Q (%)	Enter the carrier leakage for the Q signal.	-50% to +50%, 0%

## Quadrature Error for Carriers

Quadrature Error allows you to control the phase angle between the I and Q signals. Follow these steps to define quadrature error for a signal:



1. Select the I/Q Impairments tab.
2. Select a carrier from the table.
3. Select Turn On to include quadrature error for the carrier. (Select Turn On again if you want to exclude quadrature error. By default, Turn On is set to off.)
4. Quadrature error is defined in degrees. A positive value indicates that the phase angle is greater than 90 degrees. Set the following parameter:

**Table 50: Quadrature error parameters for carriers**

Selection	Description	Range, Default value
Degrees	Enter the phase angle between the I and Q signals.	-30° to +30°, 0°

## I/Q Imbalance for Carriers

I/Q Imbalance allows you to create gain imbalance between I and Q. Follow these steps to define I/Q imbalance for a signal:

1. Select the I/Q Impairments tab.
2. Select a carrier from the table.
3. Select Turn On to include I/Q imbalance for the carrier. (Select Turn On again if you want to exclude I/Q imbalance. By default, Turn On is set to off.)
4. I/Q imbalance is defined in percentage. Set the following parameter:

**Table 51: I/Q imbalance parameters for carriers**

Selection	Description	Range, Default value
Percentage	Enter the imbalance between the I and Q signals.	-30% to +30%, 0%

## Nonlinear Distortions for Carriers

Nonlinear Distortions allow you to simulate the nonlinearity of IQ modulators. Follow these steps to define nonlinear distortions for a signal:

1. Select the I/Q Impairments tab.
2. Select a carrier from the table.
3. Select Turn On to include nonlinear distortions for the carrier. (Select Turn On again if you want to exclude nonlinear distortions. By default, Turn On is set to off.)
4. Set the following AM/AM and AM/PM parameters:

The variation of the signal amplitude with respect to the original amplitude is called AM/AM conversion.

**Table 52: AM/AM parameters for carriers**

Selection	Description	Range, Default value
k2 dB	Enter the second order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB
k3 dB	Enter the third order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB

The variation of the phase with respect to the original amplitude is called AM/PM conversion.

**Table 53: AM/PM parameters for carriers**

Selection	Description	Range, Default value
k2 degrees	Enter the second order coefficient for the phase.	-30° to +30°, 0°
k3 degrees	Enter the third order coefficient for the phase.	-30° to +30°, 0°

See also:

[Nonlinear Impairments \(see page 201\)](#)

## Hardware Skew for Carriers

Hardware skew is common for all carriers. The number of channels shown depends on the AWG model being used. Follow these steps to define hardware skew for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include hardware skew for the carrier. (Select Turn On again if you want to exclude hardware skew. By default, Turn On is set to off.)
3. Set the following parameters:

**Table 54: Hardware skew parameter for carriers**

Selection	Description	Range, Default value
Channel N (ps)	Enter a value for each channel. Adjusting the skew dynamically updates the dialog box display. The adjustment applies to analog output and marker output.	AWG7000: -100 ps to +100 ps, 0 ps AWG5000: -5 ns to +5 ns, 0 ns

## I/Q Swap for Carriers

1. Select the I/Q Impairments tab.
2. Enable I/Q Swap to interchange I and Q signal outputs.

## Amplifier Distortion for Carriers

Amplifier Distortion simulates the nonlinearity in the amplifier. You can set the amplifier distortion to Non-Linear, Hardlimiting, or Softlimiting. Hardlimiting and softlimiting amplifiers affect only the amplitude of the output signal. The phase of the output signal is not affected.

Follow these steps to define amplifier distortion for a signal:

1. Select the Distortion Addition tab.
2. Select a carrier from the table.
3. Select Turn On to include amplifier distortion for the carrier. (Select Turn On again if you want to exclude amplifier distortion. By default, Turn On is disabled.)
4. Set the following parameters:

**Table 55: Amplifier distortion parameters for carriers**

Selection	Description	Range, Default value
Amplifier	Select the amplifier distortion from the following: Non-Linear, Hardlimiting, and Softlimiting.	Non-Linear
Operating point	Enter the operating point of the nonlinear amplifier.	0.01 to 1000, 0.01
Limiting Level	Enter the limiting level for the Hardlimiting and Softlimiting amplifiers.	0.1 to 1000, 0.1

The following AM/AM parameters are available for a nonlinear amplifier:

**Table 56: AM/AM parameters for amplifier distortion**

Selection	Description	Range, Default value
k3 (dB)	Enter the third order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB
k5 (dB)	Enter the fifth order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB

The following AM/PM parameters are available for a nonlinear amplifier:

**Table 57: AM/PM parameters for amplifier distortion**

Selection	Description	Range, Default value
k3 (degrees)	Enter the third order coefficient for the phase.	-30° to +30°, 0°
k5 (degrees)	Enter the fifth order coefficient for the phase.	-30° to +30°, 0°

See also:

[Amplifier Distortions \(see page 200\)](#)

## Multipath Parameters for Carriers

Follow these steps to set multipath parameters for a signal:

1. Select the Multi-Path tab.
2. Select a carrier from the table.
3. Select Turn On to define the path for the carrier. (Select Turn On again if you want to exclude multipath parameters. By default, Turn On is disabled.)
4. Set the following parameters:

**Table 58: Multipath parameters for carriers**

Selection	Description	Range, Default value
Delay (symbols)	Enter the delay in symbols from the reference path. The delay can be positive or negative. The delay values cannot be repeated.	-80 to +80 symbols, 0 symbols

**Table 58: Multipath parameters for carriers (cont.)**

Selection	Description	Range, Default value
Amplitude (dB)	Enter the amplitude in dB from the reference path. The amplitude is always negative.	-60 to 0 dB, 0 dB
Phase (deg)	Enter the phase in degrees from the reference path. The phase can be positive or negative.	-180 to +180 degrees, 0 degree

5. Click Add to add the parameters to the table. Select one or more rows and click Delete to delete it from the table.

You can define a maximum of ten multipaths, including the reference path that has the delay, amplitude and phase values set to zero. You can neither delete the reference path with a delay of 0 symbols nor change the delay value. However, you can change the amplitude and phase values. No two paths can have the same delay value. The table rows are automatically sorted in the ascending order of the delay value. The table contains the Delay, Amplitude, and Phase that you entered.

## Signal Addition for Carriers

**NOTE.** *When the modulation type is Gaussian Noise, all the options in the Interference Addition tab are disabled.*

Follow these steps to define signal interference for a signal:

1. Select the Interference Addition tab.
2. Select Turn On to include signal interference for the carrier. (Select Turn On again if you want to exclude signal interference. By default, Turn On is disabled.)
3. Set the following parameters:

**Table 59: Signal addition parameters for carriers**

Selection	Description	Default value
Format		
I/Q	Specifies the signal format of the file to be added.	I/Q
IF/RF	Specifies the signal format of the file to be added.	N/A
Add Interference via:		
Software	Specifies that the interference addition will be through software.	Software
Hardware	Specifies that the interference addition will be through hardware.	N/A
Waveform_I	Click the icon next to the Waveform_I field and a list of waveforms appears. Select the I waveform to use.	N/A

**Table 59: Signal addition parameters for carriers (cont.)**

Selection	Description	Default value
Waveform_Q	Click the icon next to the Waveform_Q field and a list of waveforms appears. Select the Q waveform to use.	N/A
Waveform_RF	Click the icon next to the Waveform_RF field and a list of waveforms appears. Select the RF waveform to use.	N/A

When the Signal format is IQ, two interference channels are required, which means that an AWG5000 series with four channels is required. If you do not have a 4-channel AWG, the message appears: AWG has only X channels, cannot send interference data to channel.

When the Signal format is IF/RF, at least one channel should be available for interference, otherwise a message appears indicating that interleave mode cannot be used.

- If you set Add Interference via to Hardware, the interference should go to Ch2 and you need to connect Ch1 output to Ch2 external signal addition input.

---

**NOTE.** *The AWG7000 series does not support external signal addition via hardware.*

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### Signal Addition via Software

The following table shows the combinations of the signal you want to generate after compilation and the interference signal that you want to add.

**Table 60: Valid combinations of Signal Addition via Software**

Compilation format	Add signal format	Remarks
IQ	IQ	Valid combination.
IF/RF	IF/RF	Valid combination.
IF/RF	IQ	Valid combination. I/Q interference signals will be added before modulation.
IQ	IF/RF	Not a valid combination.

### Signal Addition via Hardware

The following table shows the combinations of the signal you want to generate after compilation and the interference signal that you want to add.

**Table 61: Valid combinations of Signal Addition via Hardware**

Compilation format	Add signal format	Remarks
IQ	IQ	Valid combination.
IF/RF	IF/RF	Valid combination.

**Table 61: Valid combinations of Signal Addition via Hardware (cont.)**

Compilation format	Add signal format	Remarks
IF/RF	IQ	Not a valid combination.
IQ	IF/RF	Not a valid combination.

## Offset for Carriers

**NOTE.** When the modulation type is Gaussian Noise, all the options in the Interference Addition tab are disabled.

Follow these steps to add frequency offsets to a signal:

1. Select the Interference Addition tab.
2. Select a carrier from the table.
3. Select Turn On to include frequency offsets for the carrier. (Select Turn On again if you want to exclude frequency offsets. By default, Turn On is set to off.)
4. Enter the frequency (in Hz) offset to add. Refer to the following table for the instrument model and range:

Model	Option	Range
AWG7101, AWG7102	Standard	-5 GHz to 5 GHz
	02/06	-10 GHz to 10 GHz
AWG7051, AWG7052	Standard	-2.5 GHz to 2.5 GHz
	02/06	-2.5 GHz to 2.5 GHz
AWG7061B, AWG7062B	Standard	-3 GHz to 3 GHz
	02/06	-3 GHz to 3 GHz
AWG7121B, AWG7122B	Standard	-6 GHz to 6 GHz
	02/06	-12 GHz to 12 GHz
AWG5002, AWG5004, AWG5002B, AWG5004B	Standard	-300 MHz to 300 MHz
AWG5012, AWG5014, AWG5012B, AWG5014B	Standard	-600 MHz to 600 MHz

## Sinusoidal for Carriers

---

**NOTE.** When the modulation type is Gaussian Noise, all the options in the Interference Addition tab are disabled.

---

Follow these steps to add sinusoidal interference to a signal:

1. Select the Interference Addition tab.
2. Select a carrier from the table.
3. Select Turn On to include sinusoidal interference for the carrier. (Select Turn On again if you want to exclude sinusoidal interference. By default, Turn On is set to off.)
4. Set the following parameters:

**Table 62: Sinusoidal parameters for carriers**

Selection	Description	Range, Default value
C/I (dB)	Enter the carrier-to-interference ratio.	-40 dB to 40 dB, 20 dB
Offset from Carrier (Hz)	Enter the offset from the carrier frequency.	Refer to the following table for the instrument model and range.

Model	Option	Range
AWG7101, AWG7102	Standard	-5 GHz to 5 GHz
	02/06	-10 GHz to 10 GHz
AWG7051, AWG7052	Standard	-2.5 GHz to 2.5 GHz
	02/06	-2.5 GHz to 2.5 GHz
AWG7061B, AWG7062B	Standard	-3 GHz to 3 GHz
	02/06	-3 GHz to 3 GHz
AWG7121B, AWG7122B	Standard	-6 GHz to 6 GHz
	02/06	-12 GHz to 12 GHz
AWG5002, AWG5004, AWG5002B, AWG5004B	Standard	-300 MHz to 300 MHz
	Standard	-600 MHz to 600 MHz

## Additive Noise for Carriers

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**NOTE.** When the modulation type is Gaussian Noise, all the options in the Interference Addition tab are disabled.

---



You can simulate additive Gaussian noise by defining the noise in terms of Signal to Noise Ratio (SNR) or bit Energy per Noise power (Eb/No). You can also define the bandwidth of the noise. A rectangular filter of bandwidth is applied on the noise signal.

Eb/No is converted to SNR using the following equation:

$$\text{SNR} = \text{Eb/No (dB)} + 10 \log (\text{Symbol rate} * \text{bits per symbol/Noise Bandwidth}).$$

Bits per symbol is based on the Modulation used for the carrier.

Follow these steps to include additive noise to a signal:

1. Select the Interference Addition tab.
2. Select a carrier from the table.
3. Select Turn On to include additive noise for the carrier. (Select Turn On again if you want to exclude additive noise. By default, Turn On is set to off.)
4. Select either SNR or Eb/No. Set the following parameters:

**Table 63: Additive noise parameters for carriers**

Selection	Description	Range, Default value
SNR	Select this to specify the signal to noise ratio.	-40.00 dB to +40 dB, 20.00 dB
Eb/No	Select this to specify the energy or Noise power.	-40.00 dB to +40 dB, 20.00 dB
Bandwidth	Enter the bandwidth of the noise to be added.	1 Hz to the maximum supported by the AWG, 1 MHz

---

**NOTE.** *The graphs will not show the added noise.*

---

### **EVM Measurement**

For a given SNR or Eb/No, EVM on the RTSA can be calculated using following equation:

$$\text{EVM} \sim -\text{SNR} - 10 * \log(\text{Noise Bw/Symbol Rate})$$

$$\text{EVM} \sim -(\text{Eb/No} + 10 \log(\text{symbol rate} * \text{bits per symbol/Noise bandwidth}) + 10 * \log(\text{Noise Bw/Symbol Rate}))$$

### **Generating Noise from 0 to Fs/2**

To generate white noise (from 0 to Sampling Rate/2) using Gaussian Noise set Carrier = Bandwidth. In the Compile Settings dialog box, set Oversampling to 1.

## Subcarrier Modulation

You can set the sub carrier frequency and modulate the signal using AM by giving the modulation index (in percentage) or FM by giving the frequency deviation (in Hertz) or PM by giving the phase deviation (in degrees) as the input.

Follow these steps to specify the modulation for an already modulated signal:

1. Click the Sub-Carrier Modulation tab.
2. Select Turn On to apply modulation on the signal. (Select Turn On again if you do not want to apply modulation. By default, Turn On is set to off.)
3. Set the following parameters:

**Table 64: Subcarrier modulation parameters**

Selection	Description	Range, Default value
Modulation	Select the modulation to apply: AM, FM, or PM.	AM
Carrier frequency	Enter the carrier frequency.	500 kHz to 12 GHz, 1.00000 Hz
AM Modulation index (%)	Enter the AM modulation index. This field is available only when the modulation type is AM.	0% to 200%, 50%
Frequency deviation (Hz)	Enter the frequency deviation. This field is available only when the modulation type is FM.	0 kHz to the maximum supported by the instrument, 100 kHz
Phase deviation (degrees)	Enter the phase deviation. This field is available only when the modulation type is PM.	0° to +180°, 10°

---

**NOTE.** *Subcarrier modulation is not available for IQ signals.*

---

## S-Parameters

Follow these steps to specify the scattering parameter for the signal:

1. Click the S-Parameters tab.
2. Select Turn On to include the scattering parameter for the carrier. (Select Turn On again if you want to exclude the scattering parameter. By default, Turn On is set to off.)
3. Select the mode: Non-Cascading or Cascading. In the non-cascading mode, you can apply S-parameter characteristics on the signal from only one S-parameter file. In the cascading mode, you can cascade up to six S-parameter files and apply the characteristics on the signal. You can select the files to apply them by turning on or turning off the corresponding blocks shown in the display.

When the selected mode is cascading, all the selected files should be of the same type. The settings depends on the selected type of file (\*.s1p , \*.s2p or \*.s4p). The settings are common to all the files (in cascading).

The default mode is Non-Cascading.

4. Select the bandwidth of the filter. Set it to Auto, Full Bandwidth, or Manual. In Manual, enter the bandwidth in Hz. A bandwidth limit filter is applied to the response of the Touchstone file to limit the bandwidth of the filter. The cutoff frequency of this bandwidth limit filter is calculated depending on the selection.
5. Select Invert to invert magnitude and phase response given in S-parameter file. By default, the Invert check box is disabled.
6. In the non-cascading mode, from the Read From File field browse and select the file from which to read the filter. The files supported are s1p, s2p, and s4p. In the cascading mode, select the files by clicking inside the boxes and browsing to the file. Click On/Off to include or exclude the file.
7. Select the Touchstone 4-Port Data Type: Single-ended or Differential.

Files with data for four ports may contain single-ended or differential data. These are Touchstone 4-port files (s4p). By default, the application assumes the file to be single-ended data type. If the data is single-ended, you must map the port numbers as used in the file to physical locations in your link. A default mapping is assumed. The application will use this mapping to compute the  $S_{dd21}$  parameter (for transmission of a differential signal) from the appropriate four S-parameters measured using single-ended data.

8. Select the port for both transmitter and receiver from the drop-down list. Each drop-down list has ports from 1 to 4. The default port number assignment is as follows:

Type	Default port
Tx+	1
Tx-	3
Rx+	2
Rx-	4

9. If the data is differential, you must select the data layout in the file: Typical or Alternate. By default, RFXpress assumes the file to use the Typical data location format.



## Conformance Mode

For a selected signal type (IF/RF or IQ), you can generate a signal in either of these modes:

- Conformance Mode
- Custom Mode

In the conformance mode, all packet group settings conform to those defined in the standard. However, you can change some of the parameters for a packet group conforming to the standard.

1. In the Select Setup field, select one of the following standard setups or select My Setup to create your own setup:
  - WiMedia Spec Example Packet
  - 53.3, 80, and 106 Mbps Packets
  - 480 Mbps Burst Mode Packets

When you change the setup selection from one standard to another selection, any changes that you may have made are lost unless you save the setup. The following message is displayed: All altered settings will be lost. Do you wish to continue?

However, when you change the setup selection from My Setup to another, changes to My Setup are saved.

2. In the Add Number of Packet Groups field, type the number of packet groups to add. The maximum number of packets is 100. Click Add to Table to add the packet group to the table. The newly added packet group can be renamed by clicking the field and typing new text. Use the Up and Down arrow buttons to move the packet group up or down.

Select a packet group from the table and click Delete to delete it. The subsequent packet groups in the table are renumbered.

3. Click [Marker Mapping...](#) (see page 56) to set the marker (M1 and M2) levels to On (1) or Off (0) for each packet group. Keeping M1 and M2 on indicate when symbols in each frequency hopping band are being output. If the signal format is RF/IF, M1 and M2 of the channel where the RF/IF signal is output will be used. If the signal format is IQ, M1 and M2 of the channel where the I signal is output will be used.

## Custom Mode

For a selected signal type (IF/RF or IQ), you can generate a signal in either of these modes:

- Conformance Mode
- Custom Mode

In the custom mode, you can define packet parameters for a packet group. Most packet group settings will be carried from the packet group parameters defined in the conformance mode.

1. In the Select Setup field, select one of the following standard setups or select My Setup to create your own setup:
  - WiMedia Spec Example Packet
  - 53.3, 80, and 106 Mbps Packets
  - 480 Mbps Burst Mode Packets

When you change the setup selection from one standard to another selection, any changes that you may have made are lost unless you save the setup. The following message is displayed: All the altered settings will be lost. Do you wish to continue?

However, when you change the setup selection from My Setup to another, changes to My Setup are saved.

2. In the Add Number of Packet Groups field, type the number of packet groups to add. The maximum number of packets is 100. Click Add to Table to add the packet group to the table. The newly added packet group can be renamed by clicking the field and typing new text. The newly added packet group will have one packet (or PPDU).

Select a packet group from the table and click Delete to delete it. The subsequent packet groups in the table are renumbered. Use the Up and Down arrow buttons to move the packet group up or down.

For a selected packet group, the packets or PPDUs are displayed in a table.

3. In the Add Number of Packets field, type the number of packets to add. The maximum number of packets in a packet group is 30. Click Add to Table to add the packets to the table. Use the Up and Down arrow buttons to move the PPDUs up or down.

For a selected packet, the [PPDU details \(see page 106\)](#) are displayed graphically. You can set or edit these values, process a selected packet, or set process preferences.

4. Click [Marker Mapping... \(see page 56\)](#) to set the marker (M1 and M2) levels to On (1) or Off (0) for each packet group. Keeping M1 and M2 on indicate when symbols in each frequency hopping band are being output. If the signal format is RF/IF, M1 and M2 of the channel where the RF/IF signal is output will be used. If the signal format is IQ, M1 and M2 of the channel where the I signal is output will be used.
5. Click Restore All to Compliance to restore all the settings as set in the conformance mode.
6. Click [Process Preferences \(see page 59\)](#) to set the processing preferences for the selected packet.

---

**NOTE.** *When you switch to the Custom mode, settings from the Conformance mode are carried over. If you switch back to Conformance mode, the settings will be the same as when you left the Conformance mode. All the custom mode settings will be lost.*

---

## Packet Group Details for Conformance Mode

The packet group details in the conformance mode are as follows:

**Table 65: Packet Group Details for Conformance mode**

Selection	Description	Range, Default value
Repeat this group (times)	Enter the number of times the group is repeated.	1 to 100, 1
Group start delay (symbols)	Enter the delay in symbols at the start of a group.	0 to 200, 32 symbols
Group end delay (symbols)	Enter the delay in symbols at the end of a group.	0 to 200, 0 symbols
Number of packets in group	Enter the number of packets in a group. The maximum number would be limited by the memory size of AWG that is the number of samples. This will depend on the oversampling, signal format (RF or IQ) and the center frequency.	1 to 30, 1 The maximum number would be limited by the memory size of AWG (the number of samples). The number of samples will depend on the oversampling, signal format (RF or IQ) and the center frequency.
Spacing between packets	Enter the distance between the packets to the specified value in symbols, pMIFS, or pSIFS. The value defines the time between packets.	Standard Mode: 6 to 200, 6 symbols Burst Mode: 6 symbols If Payload length is zero, the Packet separation is fixed to 32 symbols (1 pSIFS).
Payload data source	Enter the source for the packet group from the following selections: WiMedia Spec Example, All 0 (Zeros), All 1 (Ones), PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21, PRBS 23, and User Defined.	WiMedia Spec Example
File	Select the payload data file (.txt or .dat) to be used by entering the path or browsing to the file. Enabled when payload data source is set to User Defined.	N/A

Click [Tone Nulling \(see page 72\)](#) to set the amplitudes for the bands in each packet group.

The following conditions must be met for a valid file:

- Any ASCII file, delimited or not, can used as the data source.
- The next bit will be generated by reading the file until a 0, 1, x, or X character is found. 0 and 1 will add the corresponding bit to the sequence; the x and X character will add a new random bit.
- Any other intermediate character will be ignored.

- When the end of the file is reached, the file is read again from the beginning, based on the Record Length.
- The data can be organized in columns or rows.
- Any number of space, tab, or comma characters can be used as a delimiter.
- Empty lines or invalid lines at the beginning and end of the file are ignored.

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**NOTE.** When a packet group is repeated many times, the end delay of one packet group and the start delay of the next packet group are added.

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**NOTE.** If Payload length is zero, the Packet separation is fixed to 32 symbols (1 pSIFS).

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## Packet Details for Conformance Mode

The packet details in the conformance mode are as follows:

The screenshot shows a configuration window titled "Packet Details" with a light blue background. It contains several settings:

- MAC header:** A dropdown menu set to "WiMedia Spec Example" with a small blue arrow icon on the right. Below it is an empty text input field.
- Packet mode:** A dropdown menu set to "Burst" with a small blue arrow icon on the right.
- Data rate:** A dropdown menu set to "200" with a small blue arrow icon on the right, followed by the text "Mbps".
- Preamble Type:** A dropdown menu set to "Standard" with a small blue arrow icon on the right.
- Packet size:** A numeric input field set to "40" with small blue up and down arrow icons on the right, followed by the text "bytes".



**Table 66: Packet Details for Conformance mode**

Selection	Description	Default value
MAC header	Select the MAC header type from the following: WiMedia Spec Example, All Zeros, All Ones, PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21, PRBS 23, User Defined Data (in Hex), and User Defined File.	The maximum length of the MAC header is 10 bytes. If you enter values less than 10 bytes, the rest will be padded with zeros. A user specified file has the path C:\Program Files\Tektronix\RFXpress\System\Samples\Mac.txtby default.
Data (HEX)	Enter the MAC Header data in hexadecimal. Enabled when MAC Header is set to User Defined Data (in Hex).	Maximum length is 10 bytes.
Packet mode	Select the transmission mode for the packet from the following: Standard, Burst.	The default value depends on the selected setup.
Data rate (Mbps)	Select the data rate for the packet from the following: 53.3, 80, 106.7, 160, 200, 320, 400, and 480 Mbps.	The default value depends on the selected setup.
Preamble type	Select the preamble type from the following: Standard, Burst. A Standard preamble has 24 symbols and a Burst preamble has 12 symbols.	When the Packet mode is set to Standard, the preamble type is always Standard. When the Packet mode is set to Burst and the data rate $\leq 200$ Mbps, the preamble type is always Standard. When the Packet mode is set to Burst and the data rate $> 200$ Mbps, preamble type can be Standard or Burst.
Packet size (bytes)	Enter the size of the packet in bytes.	Standard Mode: 0 to 4095 Burst Mode: 1 to 4095 The default values depend on the selected setup.

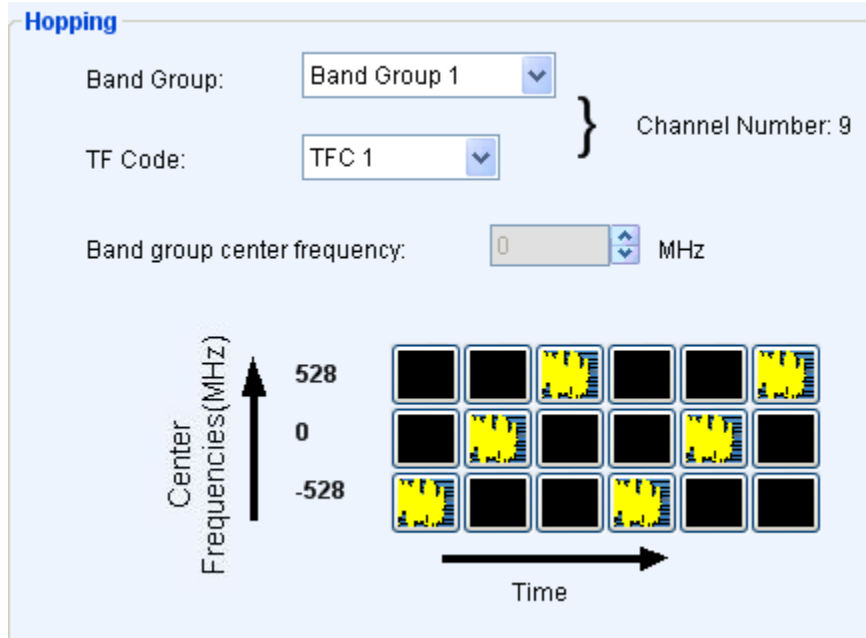
**NOTE.** *If Payload length is zero, the Packet separation is fixed to 32 symbols (1 pSIFS).*

A user defined file must meet the following conditions:

- Input files are ASCII files with .txt extension.
- The data should contain hexadecimal values and arranged in a single row (with no spaces or tabs). Any other characters are invalid (including tab and space). The application stops reading data when it encounters invalid data.
- The maximum length of the file is 600 hex characters.

## Hopping Details for Conformance Mode

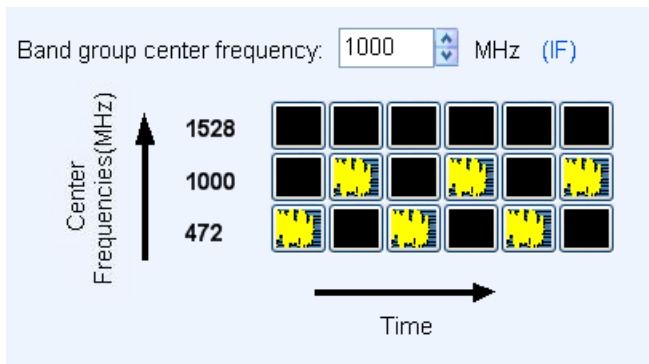
The hopping details in the conformance mode are as follows:



**Table 67: Hopping Details for Conformance mode**

Selection	Description	Range, Default value
Band group	Select a band group from the following: BandGroup 1, BandGroup 2, BandGroup 3, BandGroup 4, BandGroup 5, and BandGroup 6. Sets the band group to use for transmission for the select packet or PPDU.	1 to 6. The default values depend on the quick setup selected. For a newly added packet group, the default value is 1.
TF code	Select the TF code from the following: TFC 1, TFC 2, TFC 3, TFC 4, TFC 5, TFC 6, TFC 7, TFC 8, TFC 9, and TFC 10. Sets the time frequency code to use to define the hopping sequence of the packet group.	1 to 10. The default values depend on the quick setup selected. For a newly added packet group, the default value is 1.
Band group center frequency (MHz)	Displays the center frequency for the selected band group. You can change the center frequency to your requirement.	The center frequency is restricted by the sampling rate set for the instrument and oversampling.

For a selected combination of Band Group and TF Code, the software displays the channel number. For example, for Band Group 4 and TFC 8, the channel number is 96. The hopping pattern is dynamically shown in the Time Vs Centre frequency table. The hopping pattern is as shown:



## Packet Group Details for Custom Mode

The packet group settings in the custom mode are as follows:

**Selected Packet Group**

Repeat this group: 1 times      Number of packets in group: 1      Band Group: Band Group 1

Group start delay: 0 symbols      Spacing between packets: 6 Symbols      TF Code: TFC 1      Hopping...  No hopping

Group end delay: 6 symbols      Tone Nulling...      Band group center frequency: 0 MHz

**Table 68: Packet Group Details for Custom Mode**

Selection	Description	Range, Default value
Repeat this group (times)	Enter the number of times the group is repeated.	1 to 100
Group start delay (symbols)	Enter the delay in symbols at the start of a group.	0 to 200 symbols, 32
Group end delay (symbols)	Enter the delay in symbols at the end of a group.	0 to 200 symbols, 0
Number of packets in group	Enter the number of packets in a group.	1 to 100 The maximum number is limited by the memory size of AWG (the number of samples). The number of samples depends on the oversampling, signal format (RF or IQ) and the center frequency.
Spacing between packets (symbols)	Enter the distance between the packets to the specified value in symbols, pMIFS, or pSIFS. Indicates the time between packets.	Standard Mode: 6 to 200, 6 symbols. Burst Mode: 6 symbols.

**Table 68: Packet Group Details for Custom Mode (cont.)**

Selection	Description	Range, Default value
Band group	Select a band group from the following: BandGroup 1, BandGroup 2, BandGroup 3, BandGroup 4, BandGroup 5, and BandGroup 6. Sets the band group to use to transmit the selected packet or PPDU.	N/A
TF code	Select the TF code from the following: User defined, TFC 1, TFC 2, TFC 3, TFC 4, TFC 5, TFC 6, TFC 7, TFC 8, TFC 9, and TFC 10. Sets the time frequency code to use to define the hopping sequence of the packet group. For Band Group 5, the selections are TFC 5, TFC 6, TFC 8, and User Defined.	When User defined TFC is selected, you can set your own hopping pattern along with TFC number ranging between 0 to 15. For standard TFCs, TFC 1 to TFC 10, the hopping sequence cannot be changed.
No hopping	Select this option to generate signals for the selected TF code without hopping. However, markers still continue to hop based on the TFC pattern.	Disabled
Band group center frequency (MHz)	Displays the center frequency for the selected band group. You can change the center frequency to your requirement. The changed frequency is updated in the Hopping Pattern dialog box.	N/A

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**NOTE.** When a packet group is repeated many times, the end delay of one packet group and the start delay of the next packet group are added.

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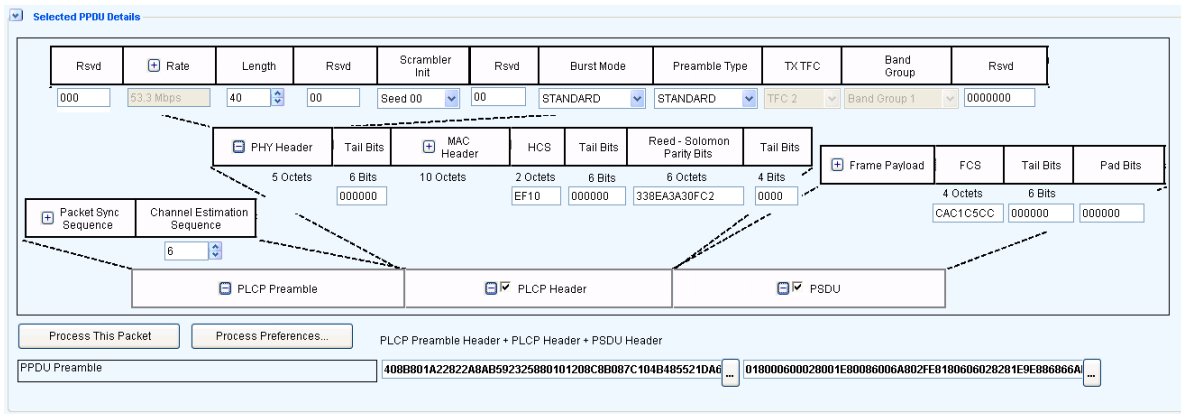
**NOTE.** If you change the TF Code, the change is not reflected in the Packet Sync Sequence (Base Time Domain Sequence and the Cover Sequence).

---

When the TF Code is set to User Defined, the [Hopping Pattern \(see page 59\)](#) dialog box is displayed. You can define the hopping pattern by clicking on the frequency bands. Assign a TFC number for the pattern and click OK to save the hopping pattern.

## Setting PPDU Details

The packet parameters for a selected packet are displayed graphically.



For a packet, you can set the [PLCP Preamble \(see page 107\)](#), [PLCP Header \(see page 108\)](#) and [PSDU \(see page 109\)](#) parameters. Many parameters have either a dropdown list to select values from, or a text box to enter values (in hexadecimal or binary). Other parameters open the next level of choices or a dialog box.

Click [Process Preferences \(see page 59\)](#) to set your preferences for the selected parameters. When you select a particular parameter in the process preferences, your input for that parameter is used (instead of the computed values).

When you clear a particular parameter in the process preferences, your input for that parameter is ignored. The software will use the computed values.

You can include the PLCP Header and PSDU while processing the packet. By default they are enabled. To exclude the PLCP Header, disable it. The resulting packet after processing will not include PLCP Header information. Similarly, to exclude the PSDU, disable it. The resulting packet after processing will not include PSDU Header information. Both you disable both, then resulting packet will not include PLCP Header and PSDU Header information.

When you click Process This Packet, the PPDU frame is formed according to your preferences. After processing, the packet value is displayed at the lower end of the box.

## PLCP Preamble

You can view the PLCP Preamble parameters by clicking the + sign in the PLCP box. The following options can be set the PLCP Preamble parameters:

**Table 69: PLCP Preamble options for Custom Mode**

Selection	Displays
<a href="#">Packet Sync Sequence (see page 110)</a>	Opens a dialog box with two tabs: Base Time Domain Sequence and Cover Sequence.
Channel Estimation Sequence	Displays the default channel estimation sequence value. Enter a value between 1 and 1000.

## PLCP Header

You can choose whether to include the PLCP Header in the packet. Select the check box to include the PLCP Header in the packet. Clear the check box to exclude the PLCP Header in the packet.

The following options are available to set the PLCP Header parameters:

**Table 70: PLCP Header options for Custom Mode**

Selection	Displays	Default value
<a href="#">PHY Header (see page 113)</a>	Displays a set of parameters.	N/A
Tail Bits	Displays the current value of the tail bits. Use the text box to set another value.	000000 bits
<a href="#">MAC Header (see page 114)</a>	Opens a dialog box where you can set there MAC Header from the following: WiMedia Spec Example, All Zeros, All Ones, PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21, PRBS 23, User Defined Data (in Hex), and User Defined File.	The maximum length of the MAC header is 10 bytes. If you enter values less than 10 bytes, the rest will be padded with zeros. The Mac header can be set for individual packets by giving separate files.
HCS	Displays the current HCS value. HCS is either a calculated value or is determined by the inputs. Use the text box to set another value.	HCS depends on Non-Scrambled MAC Header and PHY Header.
Tail Bits	Displays the current value of the tail bits. Use the text box to set another value.	000000 bits
Reed-Solomon Parity Bits	Displays the current value of the Reed-Solomon Parity bits. Reed-Solomon Parity is either a calculated value or is determined by the inputs. Use the text box to set another value.	Reed-Solomon Parity bits depends on Scrambled MAC Header+ HCS + PHY Header.
Tail Bits	Displays the current value of the tail bits. Use the text box to set another value.	0000 bits

You can set the following parameters in [Process Preferences \(see page 59\)](#) to take your input: Tail Bits, HCS Tail Bits, Reed Solomon Parity Bits, and Tail Bits.

A user defined file MAC header must meet the following conditions:

- Input files are ASCII files with .txt extension.
- The data should be hexadecimal values and arranged in a single row (with no spaces or tabs). Any other characters are invalid (including tab and space). The application stops reading data when it encounters invalid data.
- The maximum length of the file is 600 hex characters.

## PSDU

You can choose whether to include the PSDU in the packet. Select the check box to include the PLCP Header in the packet. Clear the check box to exclude the PSDU in the packet.

The following options are available to set the PSDU. PSDU is enabled only if the Length field in PHY header is not zero.

**Table 71: PSDU options for Custom Mode**

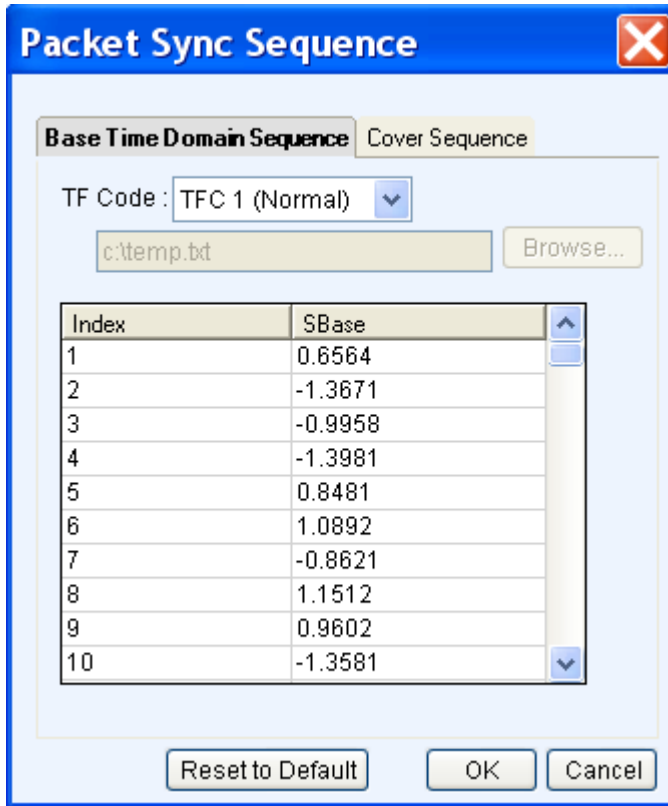
Selection	Displays
Frame Payload	Displays the current value of the frame payload (data source). Click within the box to open a dialog box where you can choose the payload data source from the following: WiMedia Spec Example, All Zeros, All Ones, PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21, PRBS 23, and User Defined.
File	Select the payload data file (.txt or .dat) to be used by entering the path or browsing to the file. Enabled when payload data source is set to User Defined.
FCS	Displays the current value of the FCS. Use the text box to set another value. FCS is either a calculated value or is determined by the inputs. FCS is calculated on the Payload data.
Tail Bits	Displays the current value of the tail bits. Use the text box to set another value.
Pad Bits	Displays the current value of the pad bits. Use the text box to set another value.

You can set the following parameters in [Process Preferences \(see page 59\)](#) to take your input: FCS, Tail Bits, and Pad Bits.

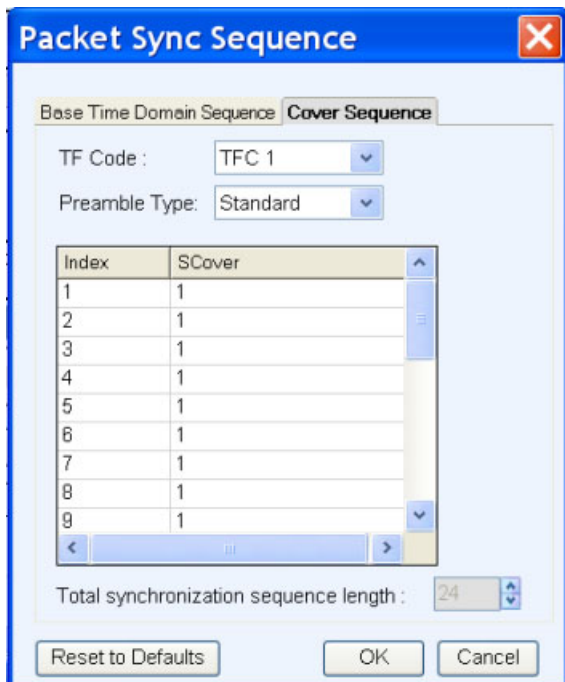
The length of payload for each packet is taken from the Length field in the PHY header.

## Packet Sync Sequence

The Packet Sync Sequence dialog box has two tabs: Base Time Domain Sequence and Cover Sequence. The Packet Sync File consists of the Base time domain sequence. It will consist of 128 values, which will be used as the preamble.







The parameters that can be set are as follows:

**Table 72: Packet Sync Sequence parameters for Custom Mode**

Selection	Displays	Default value
<b>Base Time Domain Sequence</b>		
TF Code	Select the TF Code from the following selections: User defined, TFC 1 (Normal), TFC 2 (Normal), TFC 3 (Normal), TFC 4 (Normal), TFC 5 (Normal), TFC 6 (Normal), TFC 7 (Normal), TFC 8 (Normal), TFC 9 (Normal), TFC 10 (Normal), TFC 1 (Alternate), TFC 2 (Alternate), TFC 3 (Alternate), TFC 4 (Alternate), TFC 5 (Alternate), TFC 6 (Alternate), and TFC 7 (Alternate). If you set the TF code to User Defined, browse and select the file from which to take values.	TFC 1 (Normal)
<b>Cover Sequence</b>		
TF Code	Select the TF Code from the following selections: User defined, TFC 1, TFC 2, TFC 3, TFC 4, TFC 5, TFC 6, TFC 7, TFC 8, TFC 9, and TFC 10. When you set the TF code to User Defined, you can set the total synchronization length.	TFC 1

**Table 72: Packet Sync Sequence parameters for Custom Mode (cont.)**

Selection	Displays	Default value
Preamble type	Select the preamble type: Standard or Burst. Depending on the preamble type, the index will change to 24 or 12.	Standard
Total synchronization sequence length	Displays the value of the synchronization sequence length. For Standard Preamble, the synchronization length is 24 and for Burst Preamble the synchronization length is 12. If you set the TF Code to User Defined, you can set the synchronization value between 1 and 24.	1 to 24, 1

The Alternate TFC information is available in Appendix D of the latest release of MultiBand OFDM Physical Layer Specification.

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**NOTE.** *The number of symbols in the time domain synchronization sequence is equal to the length of the cover sequence.*

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The Time Domain Sequence table displays the Index and standard SBase values for the selected TF Code. You can double-click on the SBase value in any row and edit it. When the TF Code is set to User Defined, you must specify a file from which to take data.

The following conditions must be met for a valid file:

- The file name extensions are .txt and .dat. The file consists of the Base Time Domain sequence of 128 values which are used as the preamble.
- Time domain sequence values must be stored in columns. The file with the Base Time Domain sequence should contain 128 data values. If the file contains more than 128 values, the other values will be ignored. If it contains less than 128 values, zeros will be added to make up the 128 values.
- The data should be in floating point precision. Spaces and tabs are ignored. Any other characters, including blank lines, are considered invalid. RFXpress stops reading data when it encounters invalid data.

The Cover Sequence table displays the Index and standard SCover values for the selected TF Code. You can double-click the SCover value in any row and edit it. The total sequence synchronization length is displayed. When the values are taken from an ASCII file, if file contains more than 128 values, the rest are ignored.

Click Reset to Default to restore the SCover and SBase values to their default values.

## PHY Header

The PHY Header parameters that can be set are as follows:

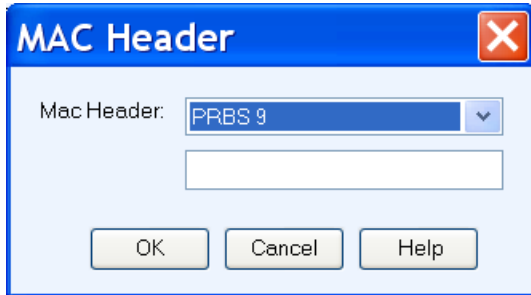
**Table 73: PHY Header parameters for Custom Mode**

Selection	Displays
Rsvd	Displays the current value in the text box. Use this box to set another value.
<a href="#">Rate (see page 61)</a>	Displays the data rate of the PHY header. Click Rate to display a dialog box to set the Modulation to DCM or QPSK, Convolution Encoder to 1/3, 1/2, 5/8, or 3/4, Interleaver, Conjugate Symmetry, and Time Spreading.
Length	Displays the length of the PHY header in bytes between 0 to 4095. Use this field to set another length.
Rsvd	Displays the current value in the text box. Use this box to set another value.
Scrambler INIT	Displays the initial value for scrambling. To change this, select from Seed 00, Seed 01, Seed 10, and Seed 11.
Rsvd	Displays the current value in the text box. Use this box to set another value.
Burst Mode	Displays the Burst Mode for the next packet. In each packet, the next packet can be configured to: Standard and Burst. The first packet is always Standard.
Preamble Type	Displays the Preamble Type. To change this, select from Standard and Burst.
TX TFC	Displays the TX TFC number.
Band Group	Displays the Band Group.
Rsvd	Displays the current value in the text box. Use this box to set another value.

You can set the Rsvd bits in [Process Preferences \(see page 59\)](#) to take your input.

## MAC Header

This dialog box is displayed when you click MAC Header (Selected PPDU Details) in the Setup tab (UWB-WiMedia) in the Custom mode. The MAC Header parameters that can be set are as follows:



**Table 74: MAC Header parameters for Custom Mode**

Selection	Displays	Default value
MAC Header	Displays the default MAC Header. To change this, select from the following: WiMedia Spec Example, All Zeros, All Ones, PRBS 7, PRBS 9, PRBS 15, PRBS 16, PRBS 20, PRBS 21, PRBS 23, and User Defined Data (in Hex).	The maximum length of the MAC header is 10 bytes. If you enter values less than 10 bytes, the rest will be padded with zeros.
Field	Enter the MAC Header data in hexadecimal. Enabled when MAC Header is set to User Defined Data (in Hex).	D3C2368C8F360DBBEDBA

## Carrier Leakage for UWB-WiMedia

Follow these steps to define carrier leakage for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include carrier leakage (I and Q) impairments to a packet group. (Select Turn On again if you want to exclude carrier leakage (I and Q) impairments. By default, Turn On is disabled.)
3. Set the carrier leakage for I and Q modulator signal in percentage.

**Table 75: Carrier leakage parameters for UWB-WiMedia**

Selection	Description	Range, Default value
I (%)	Enter the carrier leakage for the I signal.	-50% to +50%, 0%
Q (%)	Enter the carrier leakage for the Q signal.	-50% to +50%, 0%

## Quadrature Error for UWB-WiMedia

Quadrature Error allows you to control the phase angle between the I and Q signals. Follow these steps to define quadrature error for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include quadrature error for a packet group. (Select Turn On again if you want to exclude quadrature error. By default, Turn On is disabled.)
3. Quadrature error is defined in degrees. A positive value indicates that the phase angle is greater than 90 degrees. Set the following parameter:

**Table 76: Quadrature error parameters for UWB-WiMedia**

Selection	Description	Range, Default value
Degrees	Enter the phase angle between the I and Q signals.	-30° to +30° , 0°

## I/Q Imbalance for UWB-WiMedia

I/Q Imbalance allows you to create gain imbalance between I and Q. Follow these steps to define I/Q imbalance for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include I/Q imbalance for a packet group. (Select Turn On again if you want to exclude I/Q imbalance. By default, Turn On is disabled.)
3. I/Q imbalance is defined in percentage. Set the following parameter:

**Table 77: I/Q imbalance parameters for UWB-WiMedia**

<b>Selection</b>	<b>Description</b>	<b>Range, Default value</b>
Percentage	Enter the imbalance between the I and Q signals.	-30% to +30%, 0%

## Nonlinear Distortion for UWB-WiMedia

Nonlinear Distortions allow you to simulate the non-linearity of IQ modulators. Follow these steps to define nonlinear distortions for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include nonlinear distortions for a packet group. (Select Turn On again if you want to exclude nonlinear distortions. By default, Turn On is disabled.)
3. Set the following AM/AM and AM/PM parameters:

The variation of the signal amplitude with respect to the original amplitude is called AM/AM conversion.

**Table 78: AM/AM parameters for UWB-WiMedia**

Selection	Description	Range, Default value
k2 dB	Enter the second order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB
k3 dB	Enter the third order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB

The variation of the phase with respect to the original amplitude is called AM/PM conversion.

**Table 79: AM/PM parameters for UWB-WiMedia**

Selection	Description	Range, Default value
k2 degrees	Enter the second order coefficient for the phase.	-30° to +30°, 0°
k3 degrees	Enter the third order coefficient for the phase.	-30° to +30°, 0°

See also:

[Nonlinear Impairments \(see page 201\)](#)

## Hardware Skew for UWB-WiMedia

The number of channels shown depends upon the AWG being used. Follow these steps to define hardware skew for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include hardware skew for a packet group. (Select Turn On again if you want to exclude hardware skew. By default, Turn On is disabled.)
3. Set the following parameters:

**Table 80: Hardware skew parameters for UWB-WiMedia**

Selection	Description	Range, Default value
Channel N (ps)	Enter a value for each channel. Adjusting the skew dynamically updates the dialog box display. The adjustment applies to analog output and marker output.	AWG7000: -100 ps to +100 ps, 0 ps AWG5000: -5 to +5 ns, 0 ns

## I/Q Swap for UWB-WiMedia

1. Select the I/Q Impairments tab.
2. Enable I/Q Swap to interchange I and Q signal outputs.

## Amplifier for UWB-WiMedia

Amplifier Distortion simulates the non-linearity in the amplifier. You can set the amplifier distortion to Non-Linear, Hardlimiting, or Softlimiting. Hardlimiting and softlimiting amplifiers affect only the amplitude of the output signal. The phase of the output signal is not affected.

Follow these steps to define amplifier distortion for a signal:

1. Select the Distortion Addition tab.
2. Select a carrier from the table.
3. Select Turn On to include amplifier distortion for a packet group. (Select Turn On again if you want to exclude amplifier distortion. By default, Turn On is disabled.)
4. Set the following parameters:



**Table 81: Amplifiers parameters for UWB-WiMedia**

Selection	Description	Range, Default value
Amplifier	Select the amplifier distortion from the following: Non-Linear, Hardlimiting, and Softlimiting.	Non-Linear
Operating point	Enter the operating point of the nonlinear amplifier.	0.01 to 1000, 0.01
Limiting Level	Enter the limiting level for the Hardlimiting and Softlimiting amplifiers.	0.1 to 1000, 0.1

The following AM/AM parameters are available for a nonlinear amplifier:

**Table 82: AM/AM parameters for UWB-WiMedia**

Selection	Description	Range, Default value
k3 (dB)	Enter the third order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB
k5 (dB)	Enter the fifth order coefficient for the magnitude.	-3 dB to +3 dB, 0 dB

The following AM/PM parameters are available for a nonlinear amplifier:

**Table 83: AM/PM parameters for UWB-WiMedia**

Selection	Description	Range, Default value
k3 (degrees)	Enter the third order coefficient for the phase.	-30° to +30°, 0°
k5 (degrees)	Enter the fifth order coefficient for the phase.	-30° to +30°, 0°

See also:

[Amplifier Distortions \(see page 200\)](#)

## Multipath Parameters for UWB-WiMedia

Follow these steps to set multipath parameters for a signal:

1. Select the Multi-Path tab.
2. Select Turn On to define the path. (Select Turn On again if you want to exclude multipath parameters. By default, Turn On is disabled.)
3. Set the following parameters:

**Table 84: Multipath parameters for UWB-WiMedia**

Selection	Description	Range, Default value
Delay (symbols)	Enter the delay in symbols from the reference path. The delay can be positive or negative. The delay values cannot be repeated.	-2 to +2 symbols, 0 symbols

**Table 84: Multipath parameters for UWB-WiMedia (cont.)**

Selection	Description	Range, Default value
Amplitude (dB)	Enter the amplitude in dB from the reference path. The amplitude is always negative.	-60 to 0 dB, 0dB
Phase (deg)	Enter the phase in degrees from the reference path. The phase can be positive or negative.	-180 to +180 degrees, 0 degree

4. Click Add to add the parameters to the table. Select a row and click Delete to delete it from the table.

You can define a maximum of ten multipaths, including the reference path that has the delay, amplitude and phase values set to zero. You can neither delete the reference path with a delay of 0 symbols nor change the delay value. However, you can change the amplitude and phase values. No two paths can have the same delay value. The table rows are automatically sorted in the ascending order of the delay value. The table contains the Delay, Amplitude, and Phase that you entered.

Depending on the entered delay value, the application might have to recompute the convolution length. This happens if convolution length provided is not enough for the given multipaths. In this case, the following message appears: Convolution length will be adjusted to take care of multipaths. Do you want to adjust? You can choose to adjust or not adjust the convolution length.

Multi-path is created by applying the right algorithm to the baseband I and Q signals. The application generates a new complex isolated pulse by convolving the direct isolated pulse and the channel impulse response (it is a complex impulse response at the baseband level). This implies that to have the right convolution, the total length of the resulting process must be long enough to accommodate the new isolated pulse.

## Signal Addition for UWB-WiMedia

Follow these steps to define signal interference for a signal:

1. Select the Interference Addition tab.
2. Select Turn On to include signal interference for a packet group. (Select Turn On again if you want to exclude signal interference. By default, Turn On is disabled.)
3. Set the following parameters:

**Table 85: Signal addition parameters for UWB-WiMedia**

Selection	Description	Default value
Format		
I/Q	Specifies the signal format of the file to be added.	I/Q
IF/RF	Specifies the signal format of the file to be added.	N/A
Add Interference via:		
Software	Specifies that the interference addition will be through software.	Software

**Table 85: Signal addition parameters for UWB-WiMedia (cont.)**

Selection	Description	Default value
Hardware	Specifies that the interference addition will be through hardware.	N/A
Waveform_I	Click the icon next to the Waveform_I field and a list of waveforms appears. Select the I waveform to use.	N/A
Waveform_Q	Click the icon next to the Waveform_Q field and a list of waveforms appears. Select the Q waveform to use.	N/A
Waveform_RF	Click the icon next to the Waveform_RF field and a list of waveforms appears. Select the RF waveform to use.	N/A

When the Signal format is IQ, two interference channels are required, which means that an AWG5000 series with four channels is required. If you do not have a 4-channel AWG, then the warning message appears: AWG has only X channels, cannot send interference data to channel.

When the Signal format is IF/RF, at least one channel should be available for interference, otherwise a message appears indicating that the interleave mode cannot be used.

4. If you set Add Interference via to Hardware, the interference should go to Ch2 and you need to connect Ch1 output to Ch2 external signal addition input.

---

**NOTE.** *The AWG7000 series does not support external signal addition via hardware.*

---

### Signal Addition via Software

The following table shows the combinations of the signal you want to generate after compilation and the interference signal that you want to add.

**Table 86: Valid combinations of signal addition via software for UWB-WiMedia**

Compilation format	Add Signal format	Remarks
IQ	IQ	Valid combination.
IF/RF	IF/RF	Valid combination.
IF/RF	IQ	Valid combination. I/Q interference signals will be added before modulation.
IQ	IF/RF	Not a valid combination.

### Signal Addition via Hardware

The following table shows the combinations of the signal you want to generate after compilation and the interference signal that you want to add.

**Table 87: Valid combinations of signal addition via hardware for UWB-WiMedia**

Compilation format	Add Signal format	Remarks
IQ	IQ	Valid combination.

**Table 87: Valid combinations of signal addition via hardware for UWB-WiMedia (cont.)**

Compilation format	Add Signal format	Remarks
IF/RF	IF/RF	Valid combination.
IF/RF	IQ	Not a valid combination.
IQ	IF/RF	Not a valid combination.

## Offset for UWB-WiMedia

Follow these steps to add frequency offsets to a signal:

1. Select the Interference Addition tab.
2. Select Turn On to include frequency offsets for a packet group. (Select Turn On again if you want to exclude frequency offsets. By default, Turn On is disabled.)
3. Enter the frequency (in Hz) offset to add. Refer to the following table for the instrument model and range:

Model	Option	Range
AWG7101, AWG7102	Standard	-5 GHz to 5 GHz
	02/06	-10 GHz to 10 GHz
AWG7051, AWG7052	Standard	-2.5 GHz to 2.5 GHz
	02/06	-2.5 GHz to 2.5 GHz
AWG7061B, AWG7062B	Standard	-3 GHz to 3 GHz
	02/06	-3 GHz to 3 GHz
AWG7121B, AWG7122B	Standard	-6 GHz to 6 GHz
	02/06	-12 GHz to 12 GHz
AWG5002, AWG5004, AWG5002B, AWG5004B	Standard	-300 MHz to 300 MHz
AWG5012, AWG5014, AWG5012B, AWG5014B	Standard	-600 MHz to 600 MHz

## Gated Noise for UWB-WiMedia

You can apply gated noise to either certain segments of the packets or through a range of symbols. The packet segments that you can apply noise to are: Preamble, PLCP Header, or the Payload. You can define a range of symbols to which to apply noise.

A negative signal to noise value indicates that the noise added will be greater than the signal amplitude. Conversely, a positive signal to noise value indicates that the noise added will be smaller than the signal amplitude.

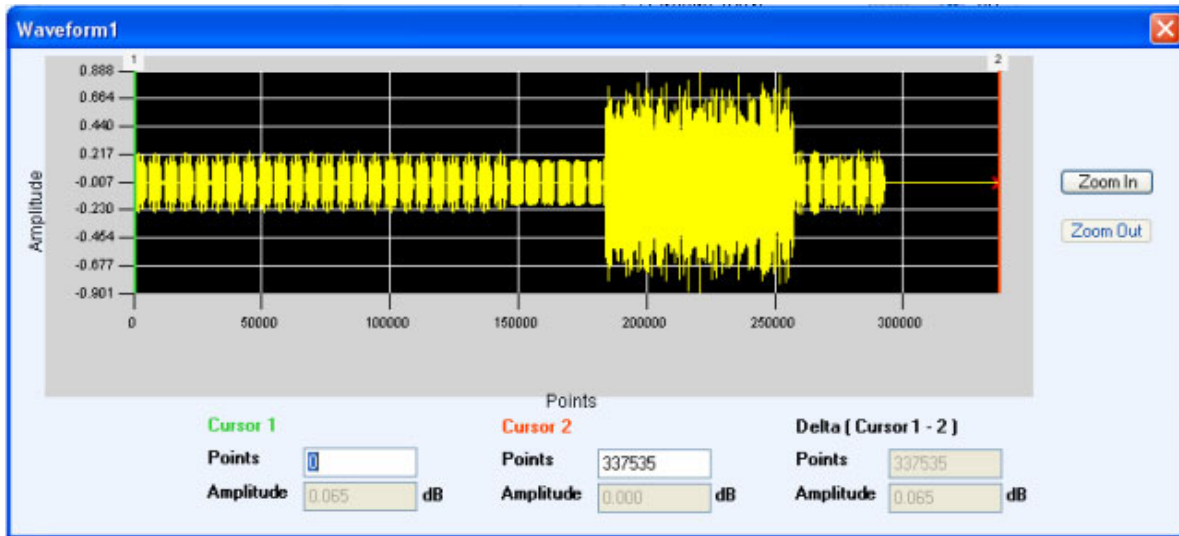
Follow these steps to add gated noise to a signal:

1. Select the Interference Addition tab.
2. Select Turn On to include gated noise for a packet group. Select Turn On again to exclude gated noise. By default, Turn On is disabled.
3. Set the following parameters:

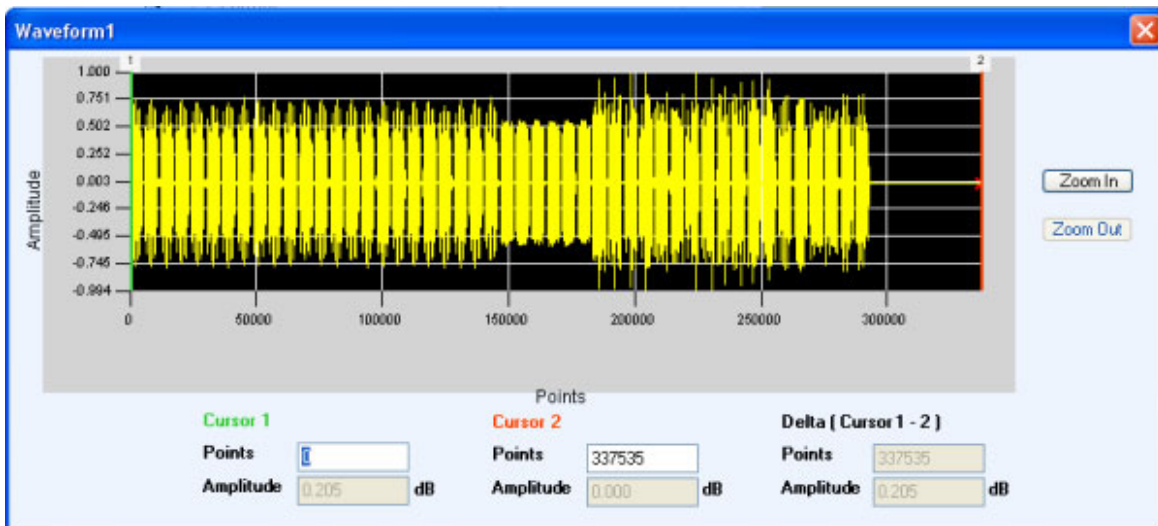
**Table 88: Gated noise parameters for UWB-WiMedia**

Selection	Description	Range, Default value
<b>Packets</b>	Select Packets to define the packet parameters.	Enabled
Preamble (S/N) (dB)	Enable the option and enter the signal to noise ratio for the preamble.	-40 to +20 dB, 0
PLCP Header (S/N) (dB)	Enable the option and enter the signal to noise ratio for the PLCP header.	-40 to +20 dB, 0
Payload (S/N) (dB)	Enable the option and enter the signal to noise ratio for the payload.	-40 to +20 dB, 0
Symbols	Select Symbols to define the symbol parameters.	Disabled
Packet range	Enter the range of packets from the start packet through the end packet.	From: 0 to 59039, 0 To: 0 to 59039, 0
S/N (dB)	Enter the signal to noise ratio.	-40 to +20 dB, 0

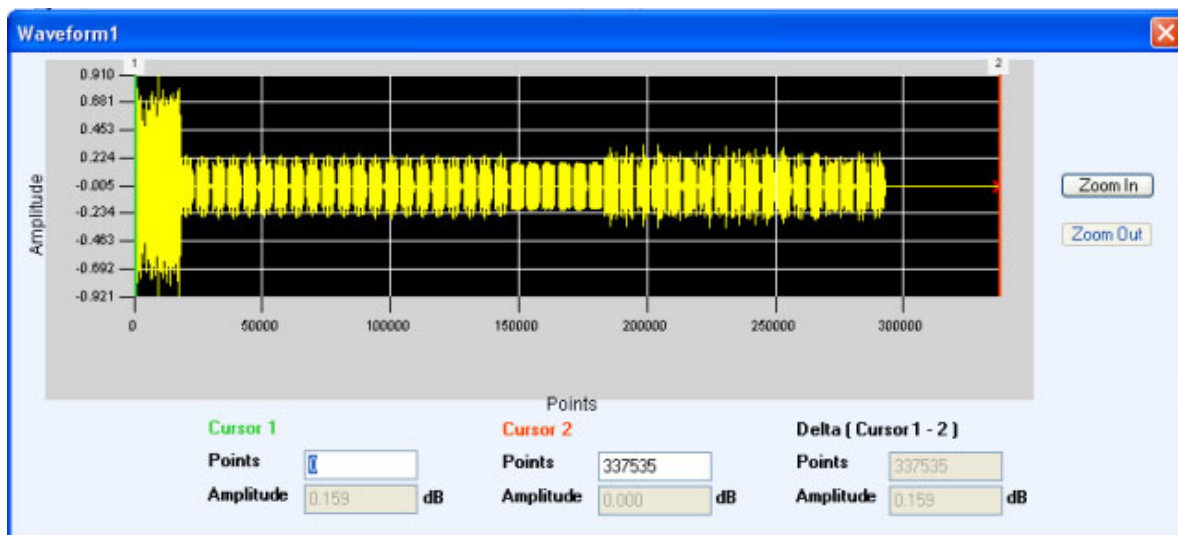
The following figure shows an example of a signal with gated noise.



The following figure shows an example of a signal without gated noise.



The following figure shows an example of a gated noise applied to a range of symbols.



## Sinusoidal for UWB-WiMedia

Follow these steps to add sinusoidal interference to a signal:

1. Select the Interference Addition tab.
2. Select Turn On to include sinusoidal interference for a packet group. (Select Turn On again if you want to exclude sinusoidal interference. By default, Turn On is set to off.)
3. Set the following parameters:

**Table 89: Sinusoidal parameters for UWB-WiMedia**

Selection	Description	Default value
C/I (dB)	Enter the carrier-to-interference ratio.	-60 dB to 60 dB
Offset from Carrier (Hz)	Enter the offset frequency of the interferer sample.	Refer to the following table for the instrument model and range.

Model	Option	Range
AWG7101, AWG7102	Standard	-5 GHz to 5 GHz
	02/06	-10 GHz to 10 GHz
AWG7051, AWG7052	Standard	-2.5 GHz to 2.5 GHz
	02/06	-2.5 GHz to 2.5 GHz
AWG7061B, AWG7062B	Standard	-3 GHz to 3 GHz
	02/06	-3 GHz to 3 GHz

<b>Model</b>	<b>Option</b>	<b>Range</b>
AWG7121B, AWG7122B	Standard	-6 GHz to 6 GHz
	02/06	-12 GHz to 12 GHz
AWG5002, AWG5004, AWG5002B, AWG5004B	Standard	-300 MHz to 300 MHz
AWG5012, AWG5014, AWG5012B, AWG5014B	Standard	-600 MHz to 600 MHz



## Real-World Signal Interference

Follow these steps to add real-world interference to a signal:

1. Select the Interference Addition tab.
2. Select Turn On to include real-world interference for a packet group. (Select Turn On again if you want to exclude real-world interference. By default, Turn On is set to off.)
3. Set the following parameters:

**Table 90: Real world signal parameters for UWB-WiMedia**

Selection	Description	Range, Default value
Add WiMax signal	Enable this option to add WiMax interference to the UWB signal.	Disabled
Frequency (Hz)	Enter the frequency of the WiMax signal to add.	Depends on the instrument bandwidth, 2.5 GHz
Amplitude (dB)	Enter the amplitude of the WiMax signal to add.	-60 dB to + 60 dB, 0 dB
Add WiFi signal (MIMO)	Enable this option to add WiFi (MIMO) interference to the UWB signal.	Disabled
Frequency (Hz)	Enter the frequency of the WiFi (MIMO) signal to add.	Depends on the instrument bandwidth, 2.4 GHz
Amplitude (dB)	Enter the amplitude of the WiFi (MIMO) signal to add.	-60 dB to + 60 dB, 0 dB
Add WiFi signal (802.11a)		Disabled
Frequency (Hz)	Enter the frequency of the WiFi (802.11a) signal to add.	Depends on the instrument bandwidth, 2.4 GHz
Amplitude (dB)	Enter the frequency of the WiFi (802.11a) signal to add.	-60 dB to + 60 dB, 0 dB
Add radar signal	Enable this option to add radar interference to the UWB signal.	Disabled
Frequency (Hz)	Enter the frequency of the radar signal to add.	Depends on the instrument bandwidth, 1 GHz
Amplitude (dB)	Enter the amplitude of the radar signal to add.	-60 dB to +60 dB, 0 dB
Add IQ Interference signal	Enable this option to add IQ interference to the UWB signal.	Disabled
Waveform_I	Select an I waveform then the waveform list.	N/A
Waveform_Q	Select a Q waveform then the waveform list.	N/A
Frequency (Hz)	Enter the frequency of the IQ signal you want to add.	
Amplitude (dB)	Enter the amplitude of the IQ signal you want to add.	

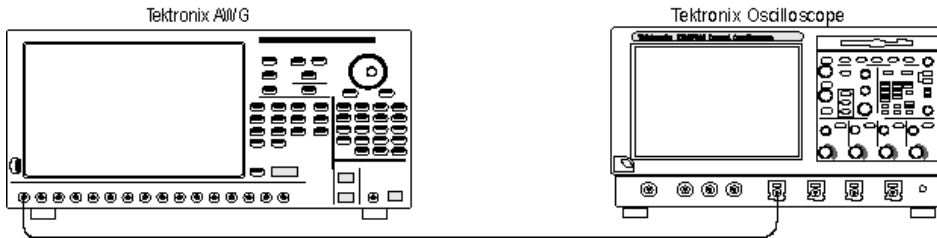
The radar signal that the application adds has the following properties:

- Modulation: LFM (Linear Frequency Modulated) Pulse.
- Pulse width: 5 usec
- Frequency sweep: 20 MHz
- PRI: 800 usec

## Using Calibration for IF/RF Signals

Calibration is available only when the software is running on an AWG7000 series instrument with option 06.

For IF/RF signals connect the arbitrary waveform generator and oscilloscope as follows:



### Creating Correction Files

1. Select Calibration from the toolbar.
2. Select the Signal Type.
3. From the list of instruments, highlight an oscilloscope and click Connect.
4. Set the Calibration parameters. The calibration parameters are: Sampling Frequency, Interleave, Zeroing, Calibration Reminder, Average, Generator Center Frequency, Band Group Center Frequency, and Sideband. You can leave these parameters with their default values or set them as you like.

However, you must set the following parameters: Band Group, Bands, and Channels to which correction files apply.

---

**NOTE.** *Interleave and Zeroing are available on the AWG7000 series with Option 06.*

---

The following table lists the Band Groups and their center frequencies for IF and RF signals.

---

**NOTE.** *Refer to the tables in [UWBWiMedia \(see page 196\)](#) section on BandGroups availability for the AWG models.*

---

**Table 91: Band groups and center frequencies for IF and RF signals**

Band Group	RF Center Frequency	IF Center Frequency
1	3960 MHz	1000 MHz
2	5544 MHz	1000 MHz
3	7128 MHz	1000 MHz
4	8712 MHz	1000 MHz

**Table 91: Band groups and center frequencies for IF and RF signals (cont.)**

Band Group	RF Center Frequency	IF Center Frequency
5	10296 MHz	1000 MHz
6	8184 MHz	1000 MHz
User Defined	Band Group Center Frequency is enabled when user defined band group is selected. You can enter any frequency value within the range of 500 KHz to 10 GHz.	Band Group Center Frequency is enabled when user defined band group is selected. You can enter any frequency value within the range of 1 GHz to 20 GHz.

- For each channel, set the path and file name of the correction file. The correction files will be created in the specified location.
- Click Calibrate. A status message displays the status of processing. The AWG creates a signal averaged (the number of iterations) as specified by Average field and sends it to the oscilloscope.  
The reference signal is generated using the oscilloscope parameters.

---

**NOTE.** *The difference between the generated signal and the reference signal is calculated for each iteration.*

---

- The corrections files (.rfc) created contain both Magnitude and Phase information specific for the selected channel, band group and bands.

### Applying Correction Files During Compilation

To apply the correction files creation by calibration, follow these steps:

- Click Compile > Compile Settings from the toolbar.
- In the [Compile Settings \(see page 32\)](#) dialog box, select the When compiling apply correction files to these channels option and select the channels depending on the AWG model.
- Click Compile. The correction files are applied while compiling the signal. The signal is displayed in the Waveform List.

## Carrier Setup

The carrier may or may not be a coherent carrier. A coherent carrier is a continuous wave signal, the frequency and phase of which have a fixed relationship to the frequency and phase of the reference signal. Set the following carrier parameters:

**Table 92: Radar carrier parameters**

Selection	Description	Range, Default value
Carrier Magnitude (Peak)/Amplitude (Vpp)	For an I/RF signal, enter the peak amplitude of the carrier in dBm. For an IQ signal, enter the amplitude in volts.	Based on the instrument and the options installed, 0.00 dBm
Carrier Frequency (Hz)	Enter the frequency of carrier in Hz, KHz, MHz, and GHz. This is not available for an IQ signal.	Based on the instrument and the options installed, 100 MHz
Coherent Carrier	Select this to make the carrier as a coherent carrier. This is not available for an IQ signal.	Available and enabled for signal type I/RF

## Pulse Setup

Define the Pulse Train by selecting Pulse or Dead Time from the drop-down list and clicking Add. When you select a pulse, all tabs containing pulse-related parameters are available.

A pulse group is a group of pulses. The pulses may be one or more depending on the number of times the pulse is repeated (repeat value).

A pulse train is a set of pulse groups and the dead times within a pulse group.

Dead time is the time (equivalent to off time) between pulse groups.

The relationship between pulse train, pulse group, and dead time is as follows:

$$PulseTrain = PulseGroup + DeadTime$$

The following buttons are available:

- Add: Click Add to add the pulse or dead time to the pulse train table.
- Insert: Click Insert to insert a pulse below a selected row.
- Delete: Click Delete to delete a selected pulse or pulses.

---

**NOTE.** You cannot delete all the rows (pulses) in the table. The table must contain at least one pulse.

For each of the pulses, you can define the parameters in each of the tabs: Pulse Envelope, Staggered PRI, Modulation, Hopping and Pulse Impairments.

---

- Up and Down Arrows: Use the arrow buttons to move a selected pulse up or down the table.
- [Add Pulse Groups](#): Click this button to open a dialog box where you can select the pulse groups to add in time.

The maximum number of pulses that can be added to the Pulse Train table is 4096. You can make any pulse be an anchor. There can be only one anchor in the pulse train. You cannot make dead time be an anchor. If you cut or delete an anchor pulse, the first pulse of the train is made the anchor. You can set the anchor pulse using the shortcut menu.

The Pulse Graph is a visual representation of a pulse and the properties that define it. The display changes dynamically based on the parameters.

## Pulse Envelope

This tab has controls that define the envelope of a selected pulse. Pulse Envelope parameters define the Pulse Shape, Start Time, Rise Time, Pulse Width, Fall Time, Off Time, Amplitude Relative to Carrier, Offset from Carrier Frequency, and the number of times to Repeat a pulse. When you select Dead Time, only Dead Time ( $T_{off}$ ) is available.

Select a pulse from the table and set the following parameters:

---

**NOTE.** *The available Pulse Envelope parameters will depend on the selected pulse shape. Not all parameters are available for a selected pulse shape.*

---

**Table 93: Pulse envelope parameters**

Selection	Description	Range, Default value
Pulse Shape	Select the pulse shape from the following: Trapezoidal, Raised Cosine, Exponential, Rectangular, Saw tooth, and Custom.	Rectangular
Start Time	Enter the initial off time (start of the pulse from the reference) for the pulse in ps, ns, $\mu$ s, ms, or seconds.	The range depends on the instrument and options installed. The default values will change based on the pulse shape.
Rise Time	Enter the rise time for the pulse. Define the rise time between 0–100%, 10–90% or 20–80% of the voltage level. Available only for Trapezoidal, Raised Cosine, Exponential, and Saw Tooth pulse shapes.	The range depends on the instrument and options installed. The default values will change based on the pulse shape.

**Table 93: Pulse envelope parameters (cont.)**

<b>Selection</b>	<b>Description</b>	<b>Range, Default value</b>
Fall Time	Enter the fall time for the pulse. Define the fall time between 0–100%, 10–90% or 20–80% of the voltage level. Available for all pulse shapes except Saw Tooth and Custom.	The range depends on the instrument and options installed. The default values will change based on the pulse shape.
Pulse Width	Enter the pulse width. Define the width at 50% or 100% voltage. Available for all pulse shapes except Saw Tooth and Custom.	The range depends on the instrument and options installed. The default values will change based on the pulse shape.
Off Time/Dead time	Enter the off time after the fall time.	The range depends on the instrument and options installed. The default values will change based on the pulse shape.
Sampling Rate	Available only when the pulse shape is Custom. Enter the sampling rate at which the custom pulse has been generated in KHz, MHz, GHz, or Hz.	The range depends on the instrument and options installed. The default values will change based on the pulse shape.
Amplitude Relative to Carrier/Relative Amplitude	For an IF/RF signal, enter the amplitude relative to the carrier magnitude. For an IQ signal, enter the relative amplitude.	0
Offset from Carrier Frequency/Baseband Offset	For an IF/RF signal, enter the offset from the carrier frequency. For an IQ signal, Enter the offset from the baseband. If you have repeated this pulse, then all the pulses will have the same offset.	0
Repeat	Enter the number of times to repeat a pulse.	1
PRF	The Pulse Repetition Frequency (PRF) value is automatically generated based on the pulse envelope parameters and is displayed to a resolution of six decimal places in KHz. The PRF value is updated whenever the values of any of the pulse envelope parameters are changed.	N/A

A custom pulse shape file must meet the following conditions:

- Input files are ASCII files (.txt) or MATLAB files (.mat).
- Only positive numbers are allowed. All other characters are invalid (including tab and space). The application stops reading data when it encounters invalid data.
- The maximum length of the file is 1M samples.

- In case of an ASCII file, the data should be in floating point and the values should be arranged in a single column and several rows with one value in each row.
- A MATLAB file should contain a variable with ‘n’ sample points or values of the format 1 x n. For example,  
`SamplePoints = [ 0.5 0.3 0.2 0.7 ....]`

## Staggered PRI

Use Staggered PRI to create multiple PRIs and define pulse-to-pulse staggering in the Staggered PRI tab.

Follow these steps to specify multiple PRIs for a pulse group:

1. Click Turn on.
2. Set the following parameters for the selected pulse:

**Table 94: PRI/PRF parameters**

Options	Description	Range, Default value
Staggered PRI Type	Select from Ramp and User Defined. If you select Ramp, you must specify the PRI Deviation Slope.	None
PRI Deviation Slope (degrees)	Enter the deviation slope in degrees. Available only when the Staggered PRI Type is Ramp.	-180° to +180°, 0°
Repeat PRI Deviations	When enabled, the application repeats the PRI deviation values for all the pulses. When disabled, PRI deviation values are used for only those pulses and 0 is used for all others pulses.	Disabled

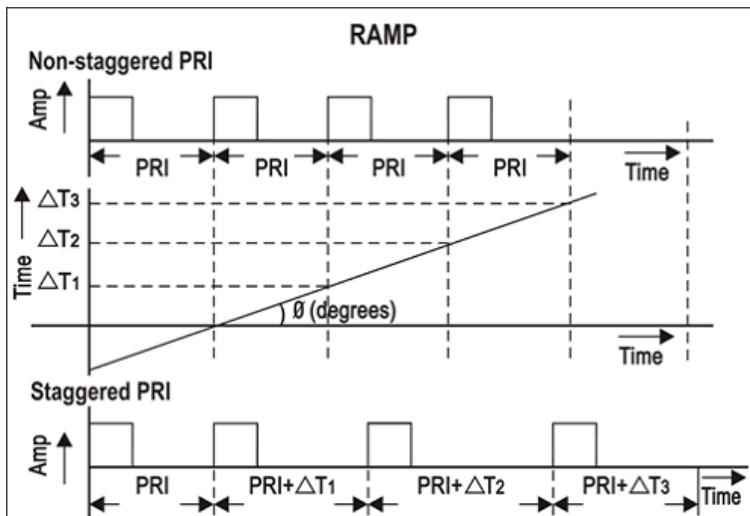
**NOTE.** If the Staggered PRI type is Ramp, the deviation  $\Delta T$  is calculated as follows:

$$\Delta T = (y * PRI * (i - 1)), \text{ where } y = \tan(\text{slope}) \text{ in radians and } i = 1 \text{ to Repeat value}$$

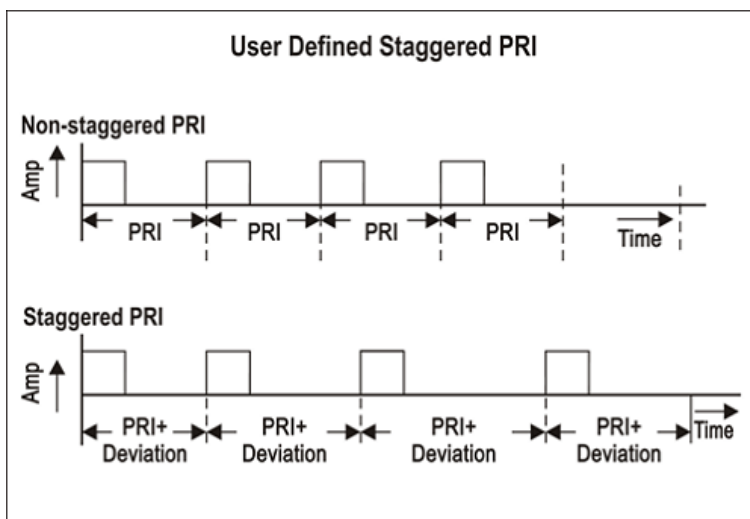
3. If you have selected User Defined, click Add to add a row to the table. Edit the deviation values directly in the table. The number of rows in the table is limited to the value in the Repeat pulse envelope parameter

Staggered PRI Type Ramp is shown as follows:





Staggered PRI Type User Defined is shown as follows:



## Modulation

The Pulse Modulation tab allows you to provide the different modulation schemes that can be applied to the pulse width for a selected pulse. The available modulation schemes are: No Modulation, Linear Frequency Modulation (LFM), Up Down Chirp Modulation, Biphasic Coded pulse-Barker, Polyphase Codes, Frank Code, P1 Polyphase Code, P2 Polyphase Code, P3 Polyphase Code, P4 Polyphase Code, User Defined Step PM AM, Step Frequency Modulation, Non Linear FM, User Defined Step FM AM, BPSK, QPSK, and Custom Modulation. By default, the modulation scheme is No Modulation. For more information on modulation types, refer to the topic [Types of Modulation \(see page 203\)](#).

---

**NOTE.** *No Modulation is the same as continuous modulation.*

---

Modulation parameters for Linear Frequency Modulation (LFM)

**Table 95: Linear Frequency Modulation parameters**

Selection	Description	Range, Default value
Sweep Range	Enter the sweep range in Hz, KHz, MHz, or GHz.	Range is dependent on the instrument, 10 MHz
Frequency Sweep	Enter the frequency sweep: High to Low, or Low to High.	Low to High

Up-Down Chirp Modulation

**Table 96: Up-Down Chirp Modulation parameters**

Selection	Description	Range, Default value
Sweep Range	Enter the sweep range in Hz, KHz, MHz, or GHz.	Range is dependent on the instrument, 10 MHz
Number of Up-Downs	Enter the number of peaks (ups) and troughs (downs) in the modulation.	1 to 12, 1
Invert	Select (enable) to create Down-Up chirp.	Disabled

Biphase Coded Pulse

**Table 97: Biphase Coded Pulse parameters**

Selection	Description	Range, Default value
Barker Code	Enter the length of the Barker code. The options are: 2, 3, 4, 5, 7, 11, and 13.	2

Polyphase Codes

**Table 98: Polyphase Codes parameters**

Selection	Description	Range, Default value
Number of Steps	Enter the number of phase entries.	1 to 200, 2
Initial Offset	Enter the initial offset in degrees.	-180° to +180°, 45°
Phase Offset	Enter the phase offset in degrees.	-180° to +180°, 90°

Frank Code

**Table 99: Frank Code parameter**

Selection	Description	Range, Default value
Code Length	Enter the length of the code.	1 to 10, 1

## P1 Polyphase Code

**Table 100: P1 Polyphase Code parameter**

Selection	Description	Range, Default value
Code Length	Enter the length of the code.	1 to 10, 1

## P2 Polyphase Code

**Table 101: P2 Polyphase Code parameter**

Selection	Description	Range, Default value
Code Length	Enter the length of the code.	1 to 10, 1

## P3 Polyphase Code

**Table 102: P3 Polyphase Code parameter**

Selection	Description	Range, Default value
Code Length	Enter the length of the code.	1 to 10, 1

## P4 Polyphase Code

**Table 103: P4 Polyphase Code parameter**

Selection	Description	Range, Default value
Code Length	Enter the length of the code.	1 to 10, 1

## User Defined Step PM AM

**Table 104: User Defined Step PM AM parameters**

Selection	Description	Range, Default value
Step	Enter the number of steps.	1 to 200, 1
Duration (ns)	Enter the duration of the subpulse width in ns.	Cannot be greater than the pulse duration
Duration (%)	Automatically calculated based on the pulse width and the duration of the subpulse.	N/A
Phase (deg)	Enter the phase offset in degrees for the subpulse.	-180° to +180°, 90°
Amplitude (dB)	Enter the amplitude in dB for the subpulse.	-60 dB to 0 dB, 0 dB

---

**NOTE.** Duration in percentage is calculated automatically up to three decimal places. This can cause rounding of the actual duration entered.

---

## Step Frequency Modulation

**Table 105: Step Frequency Modulation parameters**

Selection	Description	Range, Default value
Number of Steps	Enter the number of phase entries.	1 to 200, 4
Initial Step	Enter the initial step of the phase in Hz, KHz, MHz, or GHz.	Based on the instrument and the installed options, 10 MHz
Step Size	Enter the step size of the phase in Hz, KHz, MHz, or GHz.	Based on the instrument and the installed options, 10 MHz

## Nonlinear Frequency Modulation

Non Linear FM uses the coefficients to create the instantaneous frequencies for modulation.

$F(t) = 2\pi C(t)t$ , where  $C(t)$  is the instantaneous frequency

Instantaneous frequency  $C(t)$  can be defined by following polynomial:

$C(t) = c_0 + c_1t + c_2t^2 + c_3t^3 + \dots$ , where  $c_0$ ,  $c_1$ , and  $c_2$  and others are the coefficients with order 0, 1, 2, and others.

To provide a constant instantaneous frequency and an offset, enter the offset value in the 0th order and rest of the coefficients as zeros.

**Table 106: Nonlinear Frequency Modulation parameters**

Selection	Description	Range, Default value
Order	Enter the order of the polynomial.	0 to 100, 0
Coefficients	Enter the coefficient of the polynomial.	-10e100 to +10e100, 1e-10

## User Defined Step FM AM

Add the number of steps. Once the number of steps are entered then the user will have the option to enter the duration (in ns) and frequency for each of the step. The duration will indicate a percentage of the pulse width

**Table 107: User Defined Step AM FM parameters**

Selection	Description	Range, Default value
Step	Enter the number of steps.	1 to 200, 1
Duration (ns)	Enter the duration of the subpulse width in ns.	Cannot be greater than the pulse duration
Duration (%)	Automatically calculated based on the pulse width and the duration of the subpulse.	N/A

Selection	Description	Range, Default value
Frequency Offset (+/-MHz)	Enter the phase offset in degrees for the subpulse.	Based on the instrument and the installed options, 10 MHz
Amplitude (dB)	Enter the amplitude in dB for the subpulse.	-60 dB to 0 dB, 0 dB

**NOTE.** *Duration in percentage is calculated automatically up to three decimal places. This can cause rounding of the actual duration entered.*

### QPSK Modulation

Enter the number of symbols for the pulse. Enable the option Same symbols for all pulses to have the same number of symbols for all the pulses in the pulse group.

**Table 108: QPSK parameters**

Selection	Description	Range, Default value
Number of Symbols	Enter the number of symbols in the pulse.	1 to 200, 4
Same symbols for all pulses	Enable this to use the same number of symbols for all the pulses in the modulation. This option is available only when the Repeat parameter (in the Pulse Envelope tab) is greater than 1.	Disabled

### BPSK Modulation

Enter the number of symbols for the pulse. Enable the option Same symbols for all pulses to have the same number of symbols for all the pulses in the pulse group.

**Table 109: BPSK parameters**

Selection	Description	Range, Default value
Number of Symbols	Enter the number of symbols in the pulse.	1 to 200, 4
Same symbols for all pulses	Enable this to use the same number of symbols for all the pulses in the modulation. This option is available only when the Repeat parameter (in the Pulse Envelope tab) is greater than 1.	Disabled

### Custom Modulation

Select a MATLAB file or text file. This file should contain Time vs Phase values. in the specified format.

A custom modulation file must meet the following conditions:

- Input files are ASCII files (.txt) or MATLAB (.mat).
- Both positive and negative numbers are allowed. All other characters are invalid (including tab and space). The application stops reading data when it encounters invalid data.
- The maximum length of the file is 1M samples.

- When ASCII file is chosen, the data should be in floating point format and the values should be arranged in a single column and several rows with one value in each row.
- A MATLAB file (\*.mat) should contain a variable with 'n' sample points or values of the format 1 x n.  
For example, SamplePoints = [ 0.5 0.3 0.2 0.7 ....]

## Hopping

This tab allows you to define the hopping pattern from pulse-to-pulse. You can provide frequency offset and amplitude deviation only if the pulse is repeated more than once.

Frequency hopping can be used to create frequency agile waveforms. Frequency is changed from one pulse to another pulse. Frequency 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.

Amplitude hopping can be used to create different amplitudes from one pulse to another. Amplitude hopping can be used to create different swirling models.

Follow these steps to define pulse-to-pulse frequency/amplitude hopping:

1. Click Turn on.
2. Click Add to add frequency offset and relative amplitude deviation with the value 0 to the table. The number of rows that you can add is determined by the Repeat parameter set in the pulse envelope tab. You can specify up to eight different frequencies to hop.
3. For each hop, enter the frequency offset in Hz (depending on the instrument) and relative amplitude in dB. These can be a positive or a negative value.
4. Enable "Repeat frequency/amplitude hopping" to repeat the frequency offset and relative amplitude values for all the pulses. When disabled, the frequency offset and relative amplitude values are used for only those pulses and 0 is used for all other pulse groups.

## Pulse Impairments

This tab allows you to set the impairments for the selected pulse. Two groups are available: Jitter and Amplitude Deviation.

Follow these steps to add jitter impairments:

1. Click Turn on.
2. Set the following jitter parameters to apply jitter on the pulse:

**Table 110: Jitter parameters**

Options	Description	Range, Default value
Edge Jitter	Select from None, Gaussian, and Uniform. If you select Gaussian or Uniform, you must specify the deviation.	None
Deviation	Enter the deviation in us, ps, or ns.	0 to 100 millis, 1 ns
Width Jitter	Select from None, Gaussian, and Uniform. If you select Gaussian or Uniform, you must specify the deviation.	None
Deviation	Enter the deviation in $\mu$ s, ps, or ns.	0 to 100 millis, 1 ns

Width jitter is described as the change in the time duration, or on-time, of the pulse. The width of the pulse is changed by jitter. Width jitter is applied to the falling edge of the pulse; the leading edge is not changed by this parameter. Edge jitter describes differences in the repetition intervals of pulses.

Follow these steps to add amplitude deviation:

1. Click Turn on.
2. Set the following amplitude parameters to specify droop and ripple for the pulse:

**Table 111: Amplitude deviation parameters**

Options	Description	Range, Default value
Droop	Enter the droop in percentage of power.	-50 % to 0, 0
Overshoot	Enter the overshoot in percentage of voltage.	0 to 50 %, 0
Ripple	Enter the ripple in percentage of voltage.	0 to 50 %, 0
Ripple Frequency	Enter the ripple frequency in Hz, KHz, MHz, or GHz.	Based on the instrument and the options installed , 3 MHz

## Multipath

Follow these steps to set multipath parameters for a signal:

1. Select the Multi-Path tab.
2. Select Turn On to define the path. (Select Turn On again if you want to exclude multipath parameters. By default, Turn On is disabled.)
3. Click Add to add a row to the table. To delete a row, select the row and click Delete.

In the table, edit or set the following parameters:

**Table 112: Multipath parameters for radar**

Selection	Description	Range, Default value
Delay (µs)	Enter the delay in symbols from the reference path. The delay can be positive or negative. The delay values cannot be repeated.	-2 to +2 µs, 0 µs
Amplitude (dB)	Enter the amplitude in dB from the reference path. The amplitude is always negative.	-60 to 0 dB, 0 dB
Phase (deg)	Enter the phase in degrees from the reference path. The phase can be positive or negative.	-180 to +180 degrees, 0 degree

You can define a maximum of ten multipaths, including the reference path that has the delay, amplitude and phase values set to zero. You can neither delete the reference path with a delay of 0 symbols nor change the delay value. However, you can change the amplitude and phase values. No two paths can have the same delay value. The table rows are automatically sorted in the ascending order of the delay value. The table contains the Delay, Amplitude, and Phase that you entered.

## Antenna

RFXpress allows antenna beam pattern settings to be applied. It allows some standard beam patterns and also a custom beam pattern. The custom beam pattern is a file containing values for angle vs. amplitude. The standard beam patterns are Linear Array and Pencil Beam.

Follow these steps to set the antenna parameters for a signal:

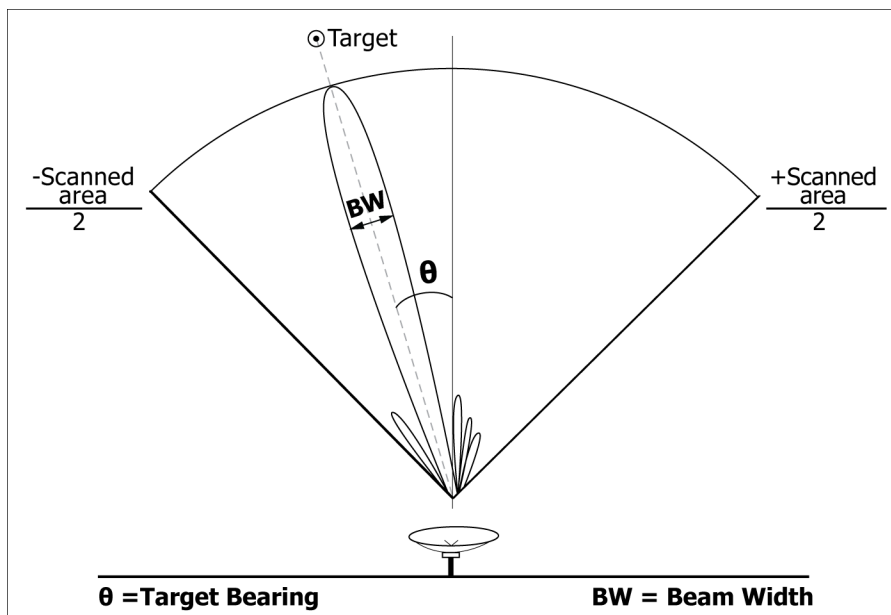
1. Select the Antenna tab.
2. Select Turn On to define the antenna parameters. (Select Turn On again if you want to exclude antenna parameters. By default, Turn On is disabled.)
3. Set the following parameters:



**Table 113: Antenna parameters for radar**

Selection	Description	Range, Default value
Beam Type	Select the beam type from the following: Sinc, Gaussian, and User defined.	Sinc
Beam Width (degrees)	Enter the beam width.	0.001 to 180 degrees, 0 degree
Target Bearing (degrees)	Enter the maximum radial axis.	-180 to +180 degrees, 0 degree
Scan Rate (degrees/sec)	Enter the rate at which the scan takes place.	0.001 to 180 degrees, 0 degree
Beam File	Enabled only when the beam type is User Defined. Select a file that contains the beam pattern.  The values in the beam file ranges between 0 and 1 and can have up to seven decimal places. The maximum length of the beam file is 1 M samples.	\\Samples\\SimpleBeamProfile.txt

The following illustration shows the antenna parameters.



## Hardware Skew for Radar

Hardware skew is common for all pulses. The number of channels shown depends on the AWG model being used. Follow these steps to define hardware skew for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include hardware skew for all pulses. (Select Turn On again if you want to exclude hardware skew. By default, Turn On is set to off.)
3. Set the following parameters:

**Table 114: Hardware skew parameter for radar**

Selection	Description	Range, Default value
Channel N (ps)	Enter a value for each channel. Adjusting the skew dynamically updates the dialog box display. The adjustment applies to analog output and marker output.	AWG7000: -100 ps to +100 ps, 0 ps AWG5000: -5 ns to +5 ns, 0 ns

## Carrier Leakage for Radar

Follow these steps to define carrier leakage for all pulses:

1. Select the I/Q Impairments tab.
2. Select Turn On to include carrier leakage (I and Q) impairments to the pulse. (Select Turn On again if you want to exclude carrier leakage (I and Q) impairments. By default, Turn On is set to off.)
3. Set the carrier leakage for I and Q modulator signal in percentage.

**Table 115: Carrier leakage parameters for radar**

Selection	Description	Range, Default value
I (%)	Enter the carrier leakage for the I signal.	-50% to +50%, 0
Q (%)	Enter the carrier leakage for the Q signal.	-50% to +50%, 0

## Quadrature Error for Radar

Quadrature Error allows you to control the phase angle between the I and Q signals. Follow these steps to define quadrature error for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include quadrature error for all pulse. (Select Turn On again if you want to exclude quadrature error. By default, Turn On is set to off.)
3. Quadrature error is defined in degrees. A positive value indicates that the phase angle is greater than 90 degrees. Set the following parameter:

**Table 116: Quadrature error parameter for radar**

Selection	Description	Range, Default value
Degrees	Enter the phase angle between the I and Q signals.	-30° to +30°, 0°

## I/Q Imbalance for Radar

I/Q Imbalance allows you to create gain imbalance between I and Q. Follow these steps to define I/Q imbalance for a signal:

1. Select the I/Q Impairments tab.
2. Select Turn On to include I/Q imbalance for all pulses. (Select Turn On again if you want to exclude I/Q imbalance. By default, Turn On is set to off.)
3. I/Q imbalance is defined in percentage. Set the following parameter:

**Table 117: I/Q imbalance parameters for radar**

Selection	Description	Range, Default value
Percentage	Enter the imbalance between the I and Q signals.	-30% to +30%, 0%

## I/Q Swap for Radar

1. Select the I/Q Impairments tab.
2. Enable I/Q Swap to interchange I and Q signal outputs.

## Signal Addition

The software allows you to add an imported waveform to the generated waveform.

Follow these steps to add a signal to a waveform:

1. Select a pulse from the table.
2. Select the Interference Addition tab.
3. Select Turn On to add signal file for the pulse. (Select Turn On again if you want to exclude signal file. By default, Turn On is disabled.)
4. Set the following parameters:

**Table 118: Signal addition parameters for radar**

Selection	Description	Default value
Format		
I/Q	Specifies the signal format of the file to be added.	I/Q
IF/RF	Specifies the signal format of the file to be added.	N/A
Add Interference via:		
Software	Specifies that the interference addition will be through software.	Software
Hardware	Specifies that the interference addition will be through hardware.	N/A
Waveform_I	Click the icon next to the Waveform_I field and a list of waveforms appears. Select the I waveform to use.	N/A
Waveform_Q	Click the icon next to the Waveform_Q field and a list of waveforms appears. Select the Q waveform to use.	N/A
Waveform_RF	Click the icon next to the Waveform_RF field and a list of waveforms appears. Select the RF waveform to use.	N/A

## Noise

Follow these steps to add noise to a waveform.

1. Select a pulse from the table.
2. Select the Interference Addition tab.
3. Select Turn On to add noise to the pulse. (Select Turn On again if you want to exclude noise. By default, Turn On is disabled.)
4. Set the following parameters:

**Table 119: Signal addition parameters for radar**

<b>Selection</b>	<b>Description</b>	<b>Range, Default value</b>
SNR (dB)	Enter the signal-to-noise ratio.	+60 dB to -60 dB, 20 dB
Bandwidth (fs)	Enter the bandwidth of the noise.	0.01 fs to 0.5 fs, 0.5 fs



## Basic Setup

Use the Basic Setup tab to define the carrier setup. Define the following parameters:

**Table 120: Basic setup parameters for OFDM**

Selection	Description	Range, Default value
Frequency (Hz)	Enter the frequency of carrier in Hz, KHz, MHz, and GHz. This is not available for an IQ signal.	100 Hz to maximum supported by the instrument, 1 GHz
Carrier Magnitude (Peak)/Amplitude	For an IF/RF signal, enter the amplitude of the carrier in dBm. For an IQ signal, enter the amplitude in volts.	For IF/RF signals: The range depends on the instrument and options installed, 0 dBm  For IQ signals: Minimum and Maximum $V_{pp}$ of the instrument, $0.5 V_{pp}$

You can define up to eight base data types for a carrier. For each selected base data, define the following:

**Table 121: Basic setup parameters for base data**

Selection	Description	Default value
Name	Enter a name for the base data, or use the default name provided.	Base data <n>
Data Source	Select the data source for the selected base data. Select from one of the following: All 0, All 1, Pattern, PRBS, and User defined file.	All 0
Pattern Data	Enter a pattern of zeros and ones up to a maximum of 80 digits in the text field that appears.  Available only when the data source is set to Pattern.	10101010
PRBS Type	Select the PRBS type from the following: 7, 9, 15, 16, 20, 21, 23, and User Defined. To edit the bit sequence, select User Defined in the PRBS drop-down menu. This causes the PRBS Editor... button to appear.  Available only when the data source is set to PRBS.	7
PRBS Editor	Click this to define a PRBS polynomial expression.  Available only when the PRBS Type is set to User Defined.	$X^{31}+X^{30}+1$

To apply [Reed Solomon Coding \(see page 68\)](#), [Scrambling \(see page 70\)](#), and [Convolution Coding \(see page 71\)](#), select the base data and select the corresponding buttons.

## Symbols

Use the Symbols tab to define the symbols. At least one symbol is present in the symbol tab. Click **Add** to add a symbol to the table. To rename a symbol, select the symbol, double-click it and type a name.

Define the following symbol parameters:

**Table 122: Symbol parameters for OFDM**

Selection	Description	Range, Default value
Symbol Name	Enter a name for the symbol, or use the default name provided.	Symbol <n>
Spacing between carriers	Enter the frequency interval between carriers.	1 Hz to the maximum supported by the instrument, 100 kHz
User-defined Frequency Weight	Specify the file from which to load symbol data. You still have to specify the Frequency Offset, Carrier spacing, and Prefix/Padding information.	userdefinedsymbol_IQ.txt
<b>Subcarrier table (disabled for user defined frequency)</b>		
- to +	Select - to + to display the subcarriers from -x to +x.	Selected
all+	Select all+ to displays the subcarriers from 0 to x.	Not selected
Add new subcarriers	Enter the number of subcarriers to add for a symbol. Enter values as multiples of 2.	2 to 65536, 2
<b>Padding/Prefix</b>		
Zero Padding	Select this to pad zeros at the end of the symbol. You can specify the length of zero padding in time or in percent.	Selected
Cyclic Prefix	Select this to have a copy of the end-of-the-symbol to be prefixed at the beginning of the symbols. You can specify the length of cyclic prefixing in time or in percent.	Not selected
Time	Enter the time (in seconds) for cyclic prefixing or zero padding.	0 ns to 1 sec, 1 $\mu$ sec
Percent	Enter the percent for cyclic prefixing or zero padding.	0 to 1000, 150
Frequency Offset	Enter the frequency offset value for the selected symbol.	0 M
Clipping	Select the option and specify the clipping ratio. Clipping Ratio is the Clip power level divided by Average Power.	0.01 to 50, 1
<b>Edit selected subcarriers</b>		
Edit Subcarrier	Enter the subcarrier to edit. Depending on how the subcarriers are viewed, enter a positive or negative value. You can also select the subcarrier from the table.	Depends on the instrument and options, 0 KHz
Type	Select the subcarrier type from the following: Data, Guard, Pilot, and Null.	Data



**Table 122: Symbol parameters for OFDM (cont.)**

Selection	Description	Range, Default value
Modulation	Select the modulation type from the following: BPSK, QPSK, 16-QAM, 32-QAM, 64-QAM, 256-QAM, and 8-PSK.	BPSK
Base Data	Select the base data to which the subcarrier belongs. The base data list is the same as that defined in the basic setup.	Base Data 1

Clipping Ratio is defined as the Clip power level / Average Power.

$$\text{Clipping Ratio} = \text{Clip power level} / \text{Average power}$$

The magnitude for clipping is obtained by:

$$\text{Clip magnitude level} = \sqrt{\text{Clipping Ratio} * \text{Average power}}$$

The signal above the clipping magnitude level is clipped to the specified clipping level and the phase is retained as it is.

Click [Tone Nulling \(see page 72\)](#). For the selected carrier, the tone nulling table shows the carrier index, the amplitude (dB), and the phase (degrees). Click **Turn On** to edit the amplitude and phase fields. Double-click the field and enter a new amplitude for the selected carrier.

Each of the modulations is normalized by a factor given by  $\sqrt{3/(2*(\text{Constellation points}-1))}$

The following table lists the normalization factor for each of the modulations:

**Table 123: Normalization factor for Modulations**

Modulation	Normalization factor
BPSK	1
QPSK	$1/\sqrt{2}$
16-QAM	$1/\sqrt{10}$
32-QAM	$\sqrt{3/(2*31)}$
64-QAM	$\sqrt{1/42}$
256-QAM	$\sqrt{1/170}$
8-PSK	$\sqrt{3/(2*3)}$

## Packets

Use the Packets tab to combine different OFDM symbols as a packet. At least one symbols is present in the symbol list. Click **Add** to add a packet to the table. Define the following packet parameters:

1. Enter the number of packets and click **Add Packet**. You can add up to 100 packets.

---

**NOTE.** *The packet table must have at least one symbol. You cannot delete all packets from the table.*

---

2. Enter the number of packets and click **Add Packet**. You can add up to 100 packets.
3. A list of available symbols is displayed. These symbols are those you defined in the Symbols tab. Click Add or Insert to define the symbols in the selected packet.

4. Select a packet from the table. Add the symbols in the packet by clicking **Add** or **Insert**.

In the symbol list of the packet, click the Repeat column and enter a value (the default is 1). The symbol IDs for the packet are updated to reflect the repeat count.

5. Set the following parameters:

**Table 124: Packet parameters for OFDM**

Selection	Description	Range, Default value
Preamble/Postamble		
Preamble	Enable this option to provide a preamble symbol file.	preamblesymbol_IQ.txt
Sampling Rate (Hz)	Enter the sampling rate for the data in the preamble file.	10 kHz to 100 GHz, 528 MHz
Postamble		
Postamble	Enable this option to provide a postamble symbol file.	postamblesymbol_IQ.txt
Sampling Rate (Hz)	Enter the sampling rate for the data in the postamble file.	10 kHz to 100 GHz, 528 MHz
Spacing/Overlapping		
Spacing between symbols	Select this option and enter the spacing between symbols in seconds.	0 to 1 sec, 0 sec
Overlap between symbols	Select this option and enter the overlap between symbols in percentage.	0 to 50%, 0
Overlap Window	Select the overlap window type from the following: None, Trapezoidal, Hanning, Hamming, and Blackmann. This option is available only when Overlap between symbols is enabled.	None

6. Click the **Frequency Hopping** button to define the symbols between which the signal will hop, the frequency offset, and relative amplitude. [Frequency Hopping \(see page 72\)](#).
7. Click the **Gated Noise** button to apply noise to specific symbols in the packet. Select the start and end index of the symbol, and the noise to be applied. [Gated Noise \(see page 73\)](#).

## Frames

Use the Frames tab to combine packets into frames and to create multiple frames.

Click **Add** to add a frame to the Frame List. You can add up to 100 frames. Double-click the frame to highlight and rename the frame.

Set the following frame parameters:

1. Select a frame from the frame list.
2. Specify the spacing in seconds between packets.
3. A list of available packets is displayed. These packets are those you defined in the Packets tab. Click Add or Insert to define the packets in the selected frame.
4. In the selected Frame table, enter the Repeat value. The repeat value defines the number of times the packet is repeated. You can also add the same packet more than once.
5. For each frame you can set multi-path parameters.
  - a. Select the Multi-Path tab.
  - b. Select a frame from the table.
  - c. Select **Turn On** to define the path for the frame. (Select Turn On again if you want to exclude multipath parameters. By default, Turn On is disabled.)
  - d. Set the following parameters:

**Table 125: Multipath parameters for frames**

Selection	Description	Range, Default value
Delay ( $\mu$ s)	Enter the time delay from the reference path. The delay can be positive or negative. The delay values cannot be repeated.	Depends on the instrument and options, 0 symbols

**Table 125: Multipath parameters for frames (cont.)**

Selection	Description	Range, Default value
Amplitude (dB)	Enter the amplitude in dB from the reference path. The amplitude is always negative.	-60 to 0 dB, 0 dB
Phase (deg)	Enter the phase in degrees from the reference path. The phase can be positive or negative.	-180 to +180 degrees, 0 degree

6. For each frame you can set phase noise parameters.
  - a. Select the Phase Noise tab.
  - b. Select a frame from the table.
  - c. Select **Turn On** to define the phase noise. (Select Turn On again if you want to exclude phase noise parameters. By default, Turn On is disabled.)
  - d. Select the phase noise model: **Time**, or **Frequency Profile**.

The Time Model or  $1/f^\alpha$  method provides for adding noise with different roll off after the VCO bandwidth. The integrated phase noise in specified degrees. The noise generated would be integrated across Sampling Rate/2.

- $1/f^0$ : Adds white Gaussian phase noise to the signal.
- $1/f^1$ : Adds Gaussian phase noise with a roll-off of 10 dB/decade to the signal after the VCO bandwidth (cutoff).
- $1/f^2$ : Adds Gaussian phase noise with a roll-off of 20 dB/decade to the signal after the VCO bandwidth (cutoff).
- $1/f^4$ : Adds Gaussian phase noise with a roll-off of 40 dB/decade to the signal after the VCO bandwidth (cutoff).

Set the following parameters for Time Model:

**Table 126: Time model parameters for phase noise**

Selection	Description	Range, Default value
Profile	Select the profile from the following: $1/f^0$ , $1/f^1$ , $1/f^2$ , and $1/f^4$ .	$1/f^0$
VCO Bandwidth	Enter the bandwidth (VCO cutoff) for the selected profile. This field is not available if the selected profile is $1/f^0$ .	1 Hz to the maximum supported by the instrument, 100 kHz
Phase noise (RMS)	Enter the phase in degrees for the selected profile.	0.01 to 60 degrees, 3 degree

In the Frequency Profile method, you can provide five frequency points and define the phase noise in dBc/Hz. The application adds phase noise with this profile to the signal. Set the following

parameters for Frequency Profile Model. The table displays five rows and you cannot delete or add new rows. However, you can edit the values in the table.

**Table 127: Frequency profile model parameters for phase noise**

Selection	Description	Range, Default value
Frequency Offset (+/- Hz)	Displays five frequency offsets. Edit the frequency values if needed.	1 Hz to the maximum supported by the instrument 10 kHz, 100 kHz, 1 MHz, 10 MHz, 100 MHz
dBc/Hz	Displays five phase noise values. Edit the values if needed.	-50 to -80 dBc/Hz -58, -71, -98, -118, -118

## Distortion

Use the Distortion tab to quantize the signal to the specified bits (less than the maximum allowed by the instrument). It reduces the resolution of the signal keep the peak-to-peak value same.

For a 4-bit DAC, the resolution would be  $2/2^4=0.125$ . All I, Q, and RF signals are quantized. This is useful when you want to test your DUT with quantized data because the real hardware would be of a lower DAC resolution.

1. Select Turn On to define quantization. (Select Turn On again if you want to exclude quantization. By default, Turn On is disabled.)
2. Enter the Resolution (in bits). The value ranges from 1 to the maximum instrument resolution and the default value is 8.

## Using Presets

The Preset menu appears in the menu bar only in the OFDM module. This menu offers preset files that you can use to create WiFi and WiMax signals according to standards.

To load a WiFi preset, do the following:

1. Select the setup from Preset > WiFi > 802.11a 36 Mbit/s QAM16. For more information on the setup, refer to the WiFi standards.
2. Click Compile.

To load a WiMax preset, do the following:

1. Select a setup from Preset > WiMax. The following setups are available: 802.16-2004 Downlink 5 MHz QAM16, 802.16-2004 Downlink 10 MHz QAM64, and 802.16-2004 Downlink 20 MHz QAM64. For more information on the setup, refer to the WiMax standards.
2. Click Compile.



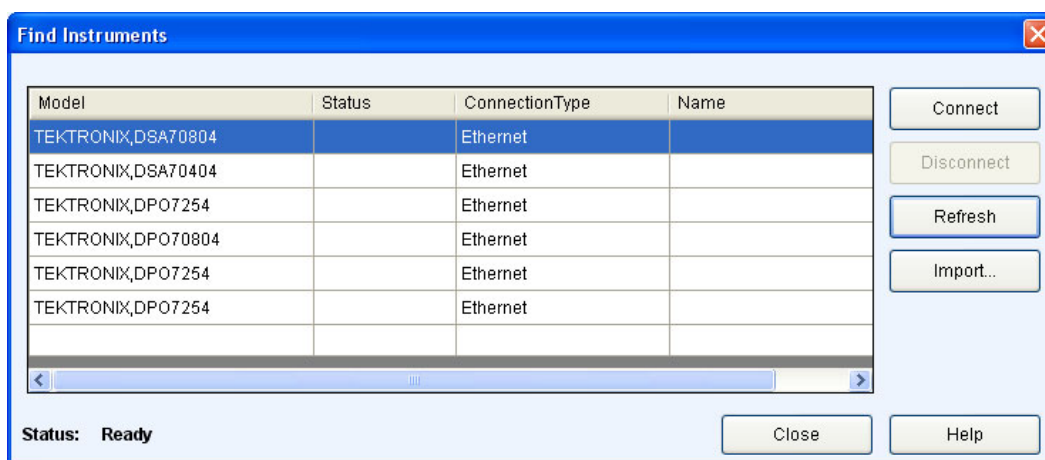
## Controlling an Instrument

RFXpress can be used to control a connected instrument (for example a Tektronix oscilloscope or an Agilent Performance Signal Generator E8267D with Option 015) in many ways: You can:

- Install RFXpress on an AWG5000 or AWG7000 series instrument. RFXpress can directly send and receive data from the AWG.
- Install an offline version of RFXpress on a PC with an offline version of the AWG software. In this case, RFXpress can detect the presence of the AWG and send data to it. This data can be opened and viewed in the AWG.
- Install RFXpress on a PC and use it to control an Agilent E8267D and any Tektronix oscilloscope. The software uses TekVisa version 3.3.2.7 to interface with the Agilent E8267D and the oscilloscope. The instruments can be connected using LAN or GPIB.

Follow these steps to find other instruments connected to the instrument on which RFXpress is running:

1. Click Find Instruments. The following dialog box opens.



The table lists the instruments found along with the name of the instrument, model, status (connected or not), and the connection type (Ethernet or GPIB).

2. Select an instrument from the table. Use the following buttons to:

**Table 128: Find instruments options**

Button	Description
Connect	Allows you to Connect to the instrument selected in the table. Enabled is default if an instrument is highlighted in the table; disabled if no instrument is highlighted.
Disconnect	Allows you to Disconnect the connected instrument. Enabled only when an instrument is connected.
Refresh	Refreshes the list of instruments.
<a href="#">Import...</a> (see <a href="#">page 28</a> )	Opens the Import from Tektronix Oscilloscope dialog box.

3. Click Connect to connect to the selected instrument.

## Controlling an Arbitrary Waveform Generator (AWG)

Waveform transfer and control of the AWG5000 or AWG7000 series can be performed directly from RFXpress. You can run the software on an AWG5000 or AWG7000 series arbitrary waveform generator and control it.

1. Select Window > Instrument Control.
2. From the AWG tab, you can modify the values of the following AWG parameters:

**Table 129: AWG parameters**

Selection	Description	Default value
Sampling Rate	Displays the sampling rate of the arbitrary waveform generator.	The default is as set in the AWG.
<a href="#">Interleave</a> (see <a href="#">page 198</a> )	Sets the interleave option to On or Off.	Off
<a href="#">Zeroing</a> (see <a href="#">page 199</a> )	Enabled only when Interleave is set to On.	Cleared or unchecked.
Channel (On/Off)	Select the channel or channels to receive the output from these channels.	This depends on the number of channels present on the AWG.
Amplitude (Vpp)	Displays the amplitude of the selected channel. Change the amplitude in this field to change the amplitude on the channel.	The default is as set in the AWG.
Offset (V)	Displays the amplitude offset of the selected channel. Change the amplitude in this field to change the amplitude offset on the channel.	The default is as set in the AWG.
Waveform button	Opens the Waveform List and allows you to select the waveform to be output.	Cleared or unchecked.
Waveform	Displays the selected waveform name. You can drag and drop the waveform from the Waveform List. When you drag and drop a waveform, the sampling rate is automatically set.	N/A



The following button is available:

**Table 130: AWG option**

Button	Description
Advanced	Opens a dialog box where you can set the advanced options.

3. When you click Advanced, the following options are available for each channel:



**Table 131: Advanced AWG parameters**

Selection	Description
<b>DAC Resolution</b>	
8 bits	Sets the DAC resolution to 8 bits.
10 bits	Sets the DAC resolution to 10 bits. When the DAC resolution is set to 10 bits, the marker options are not available.
<b>Markers (M1 and M2)</b>	
High (V)	Enter the high value for the markers.
Low (V)	Enter the low value for the markers.
Delay (s)	Enter the maker delay.

**NOTE.** When connected to the AWG5000 series instruments, DAC resolution is fixed to 14 bits and cannot be changed.

## Connecting to and Controlling an Oscilloscope

You can connect to and control a Tektronix oscilloscope using RFXpress.

1. Select Window > Instrument Control.
2. A table lists the connected oscilloscopes. From the Oscilloscope tab, you can modify the values of the following oscilloscope parameters:

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**NOTE.** *Ensure that the Sampling mode on the oscilloscope is set to Real Time. If the Sampling mode is set to Interpolation (either automatically or manually), the parameter values in RFXpress Instrument control and the oscilloscope may not match.*

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**Table 132: Oscilloscope parameters**

Selection	Description
Vertical settings	
Channel	Displays the channel to which to output the signal. To change this setting, select another channel.
Scale (V)	Displays the vertical scale set in the oscilloscope for the selected channel. Change the value in this field to change the vertical scale on the connected instrument.
Horizontal settings	
Scale (s)	Displays the horizontal scale set in the oscilloscope. Change the value in this field to change the horizontal scale on the connected instrument.
Record length	Displays the record length set in the oscilloscope. Change the value in this field to change the record length on the connected instrument.
Sampling rate (Samples/sec)	Displays the sampling rate set in the oscilloscope. Change the value in this field to change the sampling rate on the connected instrument.
Acquisition	
Run	Starts the acquisition of data in on the oscilloscope.
Stop	Stops the acquisition of data on the oscilloscope.
Single	Sets the oscilloscope to acquire one full record length and then stop.

The following buttons are available in this tab:

**Table 133: Oscilloscope options**

Button	Description
Autoset	Performs Autoset on the oscilloscope.
Refresh Settings	Refreshes the display with the current instrument settings.
Refresh List	Refreshes the connection status of the instruments.
Find Instruments	Finds instruments on the network.

## Connecting to and Controlling a Performance Signal Generator (PSG)

You can connect to and control an Agilent performance signal generator (E8267D with Option 015) using RFXpress.

1. Select Window > Instrument Control.
2. In the PSG tab, the following parameters as set on PSG are displayed. However, you can modify the values of the PSG parameters:

**Table 134: PSG parameters**

Selection	Description
Signal	
Frequency (GHz)	Displays the frequency of the signal. Change the frequency in this field to change the frequency on the connected instrument.
Frequency offset (Hz)	Displays the frequency offset of the signal. Change the frequency offset in this field to change the frequency offset on the connected instrument.
Amplitude (dBm)	Displays the amplitude of the signal. Change the amplitude in this field to change the amplitude on the connected instrument.
Amplitude offset (dB)	Displays the amplitude offset of the signal. Change the amplitude offset in this field to change the amplitude offset on the connected instrument.
Output	
RF	Select On to set the output format of the signal to RF.
Mod	Select On to set the output format of the signal to MOD.

The following buttons are available:

**Table 135: PSG options**

Button	Description
Advanced	Opens a dialog box where you can set the advanced options.
Refresh	Refreshes the display with the current instrument settings.
Test Connection...	Checks the state of the connection and displays the status.
Find Instruments	Finds instruments on the network.

3. When you click Advanced, the following options are available:

Table 136: Advanced PSG parameters

Selection	Description
<b>Signal</b>	
Source Type	Displays the source type of the signal. To change this select one of the following: EXT, INT, BBG1, EXT600, and OFF.
Frequency Mode	Displays the frequency mode of the signal. To change this, select on of the following: FIX, CW, SWE, and LIST.
<b>ALC</b>	
ALC: On, Off	Sets ALC to On or Off.
ALC Mode	Displays the ALC mode of the signal. To change this, select on of the following: FIX, SWE, and LIST.
ALC Bandwidth (Hz)	Displays the ALC bandwidth.
ALC Level (dBm) (Volts)	Displays the ALC level.
ALC Power	Displays the ALC power of the signal. To change this, select on of the following: ON, OFF, and ONCE.
Attenuation (dB)	Displays the attenuation.
<b>Carrier Leakage Suppression</b>	
IQ State	When set to On, suppresses the IQ State.
IQ Adjustment	When set to On, suppresses the IQ Adjustment.
I Offset (volts)	Offsets the I signal.
Q Offset (volts)	Offsets the Q signal.

You must click Refresh to update any new settings on the performance signal generator.

## Connecting to a Real-time Spectrum Analyzer

You can connect to a Tektronix Real-time Spectrum Analyzer (RSA) and use it directly from the application. You can change the values of the RTSA parameters that are enabled only when the RTSA is in the online mode.

Follow these steps to establish the Ethernet connection:

1. Establish communication between RFXpress and RSA using a cross-over Ethernet cable. You can also use an Ethernet router or switch.
2. Set the Firewall option on the real-time spectrum analyzer to Off before connecting to it.
3. Test the connection by "pinging" each unit from the other in a "DOS" command window.
4. Use Windows file sharing allows the AWG and RFXpress to directly load TIQ files that are physically located on the RSA.

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**NOTE.** *When communicating with an RSA3000 series spectrum analyzer, the spectrum analyzer must have write permission on the PC/AWG running RFXpress application.*

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Follow these steps to establish the TekVISA connection:

1. Ensure that the same version of TekVISA is installed on both the AWG and the RSA.
2. On the RSA, start the VXI-11 Server.
3. On the AWG, open the Instrument Manager application and search for VISA devices by clicking the Update button. You can also specify the search criteria to locate the instruments.
4. Select the RSA instrument and click ID.

In RFXpress, do the following:

1. Select Window > Instrument Control.
2. Click the RSA tab. A table lists the available real-time spectrum analyzers. Click the List RSA button to refresh the table.

The following buttons are available:

**Table 137: RSA options**

Button	Description
Preset	Resets the instrument settings to the factory defaults. This button is enabled only after selecting a connected real-time spectrum analyzer from the table.
Refresh	Updates settings on the selected instrument on to the real-time spectrum analyzer. This button is enabled only after selecting a connected real-time spectrum analyzer from the table.

**Table 137: RSA options (cont.)**

Button	Description
List RSA	Lists the connected instruments once the real-time spectrum analyzer is found and connected using the Find Instruments dialog box.
Acquire	Imports I & Q trace data from the instrument and I & Q waveforms in the waveform list. This button is enabled only after selecting a connected real-time spectrum analyzer from the table.

3. The Settings tab contains controls to set the values of the parameters present in the Settings tab of the RSA when the “RF I & Q vs Time” display is shown and selected. In the Settings tab, set the following parameters:

**Table 138: Settings parameters**

Selection	Description
Center Frequency (Hz)	Enter the center frequency on the RSA.
Start Frequency (Hz)	Enter the start frequency on the RSA.
Stop Frequency (Hz)	Enter the stop frequency on the RSA.
Step Size (Hz)	Enter the step size on the RSA.
Span	Enter the span.
Max Trace Points	Set the maximum trace points setting for IQVTime graph in the RSA. The choices are: <ul style="list-style-type: none"> <li>■ 1 K sets the maximum trace points to 1 K.</li> <li>■ 10 K sets the maximum trace points to 10 K.</li> <li>■ 100 K sets the maximum trace points to 100 K.</li> <li>■ Never decimate never limits the trace points.</li> </ul>
Auto	Enable Auto to set the step size automatically. When the state is changed from enabled to disabled, the instrument resets the parameter value of Step Size.
Set as Baseband	This option is available and displayed only when the active module is Generic Signal. This is used to set the imported I and Q waveforms directly as baseband signals in the multi-carrier table.

---

**NOTE.** Alternately, to read a TIQ file that was saved on the RSA, you can select *File > Import from file...* and navigate to the shared folder on the RSA to read the file directly.

---

4. The Acquire tab is enabled only when a real-time spectrum analyzer is connected. Set the following parameters:

**Table 139: Acquire parameters**

Selection	Description
Run	Select the mode of the instrument to either Continuous, Single, or Stop.  <b>NOTE.</b> <i>Selecting Stop forces any ongoing acquisition to stop. Pressing Acquire after choosing this option, does not force a new acquisition while importing IQ data. The IQ data loaded into the spectrum analyzer acquisition memory using a file can be directly imported .</i>
Waveform Name	Enter the names of the imported I and Q waveforms. The default name provided is Untitled1. The imported I and Q waveforms will have the names Untitled1_I and Untitled1_Q.
Adjust	Set the acquisition mode: All Auto, Samples, and Length. <ul style="list-style-type: none"> <li>■ All Auto disables the controls Acq BW, Acq Samples, and Acq Length.</li> <li>■ Samples enables the controls Acq BW, Acq Samples and disables Acq Length.</li> <li>■ Length enables the controls Acq BW, Acq Length, and disables Acq Samples.</li> </ul> <p>The values of all the three parameters are sometimes reset by the instrument. These values are queried from the instrument and updated.</p>
Acq BW (Hz)	Set the acquisition bandwidth of the instrument.
Acq Samples	Set the number of samples acquired over the acquisition time of the instrument.
Acq Length (s)	Set the time over which the acquisition occurs in the instrument.

5. The Analysis tab is enabled only when a real-time spectrum analyzer is connected. Set the following parameters:

**Table 140: Analysis parameters**

Selection	Description
Analysis Offset	Set the analysis offset time of the instrument.
Analysis Offset Auto	The analysis offset field is disabled when this check box is selected.
Analysis Length	Set the analysis length of the instrument.

**Table 140: Analysis parameters (cont.)**

Selection	Description
Analysis Length Auto	The analysis length field is disabled when this check box is selected. When the check box state is enabled (checked), the instrument resets the analysis length parameter value. Whenever this parameter value is changed, the values of Acq BW, Acq Length and Acq Samples are queried and updated.
Time Zero Ref	Select the analysis time reference: <ul style="list-style-type: none"> <li>■ Acq Start specifies the acquisition start as the time zero reference.</li> <li>■ Trigger specifies the trigger point as the time zero reference.</li> </ul>
<b>Amplitude</b>	
Ref Level	Set the amplitude level in the instrument.
Units	Sets the amplitude fundamental unit of power to: dBm, dBV, Volts, Watts, dBμW, dBW, dBμV, dBmV, dBμA, dBμV/m, dBμA/m, and Amps.

## Controlling an Arbitrary Waveform Generator from the Radar Application

The radar application requires the sequence mode feature of AWG. The instrument control feature has all the necessary controls to use the sequence mode of AWG directly from the application.

Instrument control provides two views:

- The [Settings view \(see page 167\)](#) which contains controls to set up the channel information
- The [Sequence view \(see page 167\)](#) which contains controls to set up the table, trigger, and event

In both views, you can click the Advanced button to set the marker values for each channel.

**Table 141: Advanced AWG options**

Selection	Description
DAC Resolution	
8 bits	Sets the DAC resolution to 8 bits.
10 bits	Sets the DAC resolution to 10 bits. When the DAC resolution is set to 10 bits, the marker options are not available.
Markers (M1 and M2)	
High (V)	Enter the high value for the markers.



**Table 141: Advanced AWG options (cont.)**

Selection	Description
Low (V)	Enter the low value for the markers.
Delay (s)	Enter the maker delay.

## Settings View

When you select the application by default the Settings view is displayed in the Instrument Control tab. Controls to change the values of parameters related to AWG are available. These controls are enabled only if the AWG is in the online or offline mode. The channel controls that appear depend on the AWG model. The following controls are available in the Settings view:

**Table 142: Settings view options**

Control	Description	State
Sampling Rate	Enter the sampling rate. This is used to set the sampling rate of the AWG.	Enabled for the AWG online and offline versions.
Interleave On/Off	If the Interleave option is on, the AWG will output the signal from the Interleave channel.	Enabled when the AWG has Opt 06 installed.
Zeroing	This option allows you to handle each waveform as RZ (Return to Zero) or NRZ (Non Return to Zero).	This option is enabled only if the Interleave option is enabled and set to On.
Chx	Select this check box to set the output of channel to On or Off. Depending on the AWG model, x is be the channel number.	The channel group box appears only if the AWG model has the channel number.
Amplitude	Enter the amplitude. This is used to set the Amplitude for the waveform output from the channel.	If the waveform is visible it is always enabled.
Offset	Enter the offset. This is used to set the offset to the signal.	This option is enabled only if Opt 06 is not available.

## Sequence View

The Sequence view allows you to control the parameters related to the sequence window of the AWG. You will be able view this settings only if the AWG is in online or offline mode. The following controls are available in the Sequence view:

**Table 143: Sequence view options**

Control	Description	State
Sampling Rate	Enter the sampling rate. This is used to set the sampling rate of the AWG.	Enabled for the AWG online and offline versions.
Interleave On/Off	If the Interleave option is on, the AWG will output the signal from the Interleave channel.	Enabled when AWG has Opt 06.
Zeroing	This option allows you to handle each waveform as RZ (Return to Zero) or NRZ (Non Return to Zero).	This option is enabled only if the Interleave option is enabled and set to On.

The sequence table allows you to set the waveforms for the channel in a sequence and generate waveforms one after the other depending on the sequence. The table behavior is similar to the table view of Sequence run mode.

**Table 144: Sequence table options**

Control	Description	State
Index	This column indicates the order in which the waveform will be output from the channel.	Always enabled but cannot be edited.
Chx Waveform	This column indicates the waveform that is being generated for the particular channel. The number of columns representing this information will depend on the channels supported by the AWG.	Always enabled.
Wait	This column allows you to set the wait to On/Off. If you set the wait to On, then the waveform will be played after the wait trigger has occurred.	Always enabled.
Repeat	This column allows you to specify a value which will be used to repeat the waveform before going to the next waveform in the sequence. You can also choose to repeat the waveform infinitely.	Always enabled.
Event Jump To	This column allows you to specify a value which is used to specify the jump destination when an event takes place.	Always enabled.
Go To	This column allows you to specify a value which is used to specify the jump destination after this waveform is output.	Always enabled.

The following buttons are available: [Advanced \(see page 166\)](#), [Trigger \(see page 169\)](#), and [Event \(see page 169\)](#).

## Trigger Options

You can click the Trigger button in Sequence view to set trigger source. The trigger source provides the signal that triggers waveform output action.

**Table 145: Trigger options in the Sequence view**

Option	Description	State
Internal	Select this to specify that the trigger source is internal.	Always enabled.
Interval	Enter the interval for internal trigger.	Enabled only if Internal is selected.
External	Select this to specify that the trigger source is external.	Always enabled.
Level	Enter the trigger level. The trigger level determines the voltage level where the trigger point occurs.	Enabled only if External is selected.
Slope	Select the trigger slope: Positive or Negative. The trigger slope determines whether the instrument finds the trigger point on the rising edge or falling edge of the signal.	Enabled only if External is selected.
Impedance	Select the impedance. It specifies external trigger impedance (50 $\Omega$ or 1 K $\Omega$ ).	Enabled only if External is selected.

## Event Options

You can click the Event button in Sequence view to set event controls.

**Table 146: Event options in the Sequence view**

Option	Description	State
Level	Set the external event input threshold level.	Always enabled.
Polarity	Select the polarity of external event input signal: Positive or Negative.	Always enabled.
Jump Timing	Select the jump timing: Async or Sync.	Always enabled.
Event Impedance	Select the event impedance: 50 $\Omega$ or 1 K $\Omega$ .	Always enabled.



## Zooming Graphs

You can zoom in or zoom out on a graph. You can zoom in on a plot by selecting an area of interest. RFXpress supports four levels of zoom.

The following graphs provide zoom buttons that help you zoom the plot:

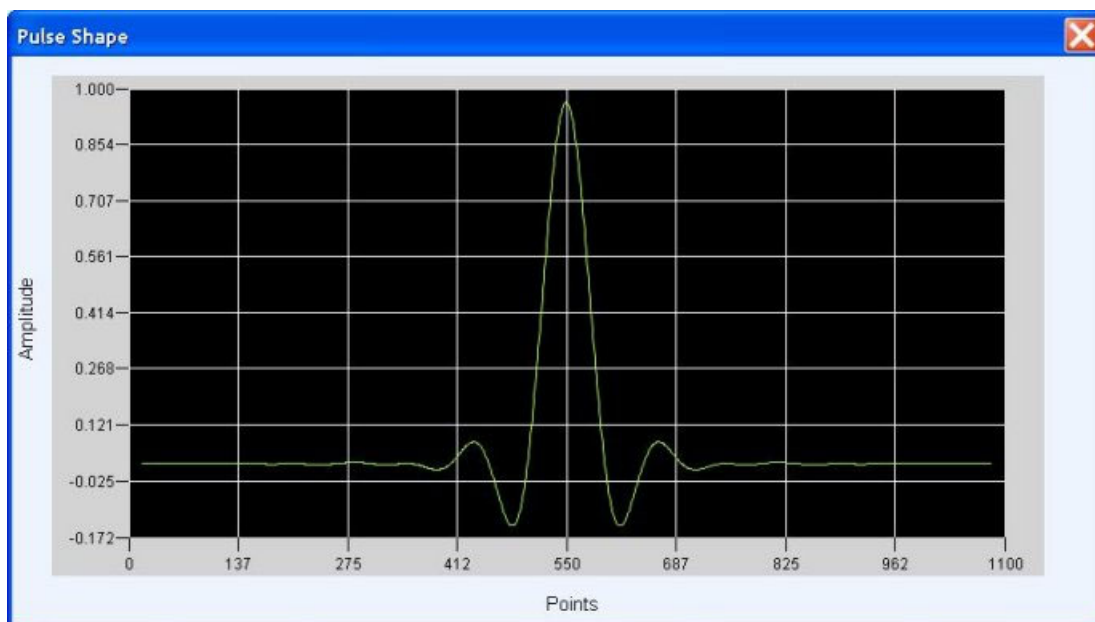
- [Spectrum \(see page 174\)](#)
- [I\(t\), Q\(t\) \(see page 172\)](#)

See also:

[Graph \(see page 30\)](#)

## Pulse Shape

The pulse shape graph shows the plot of Points (X-axis) and Amplitude (Y-axis).



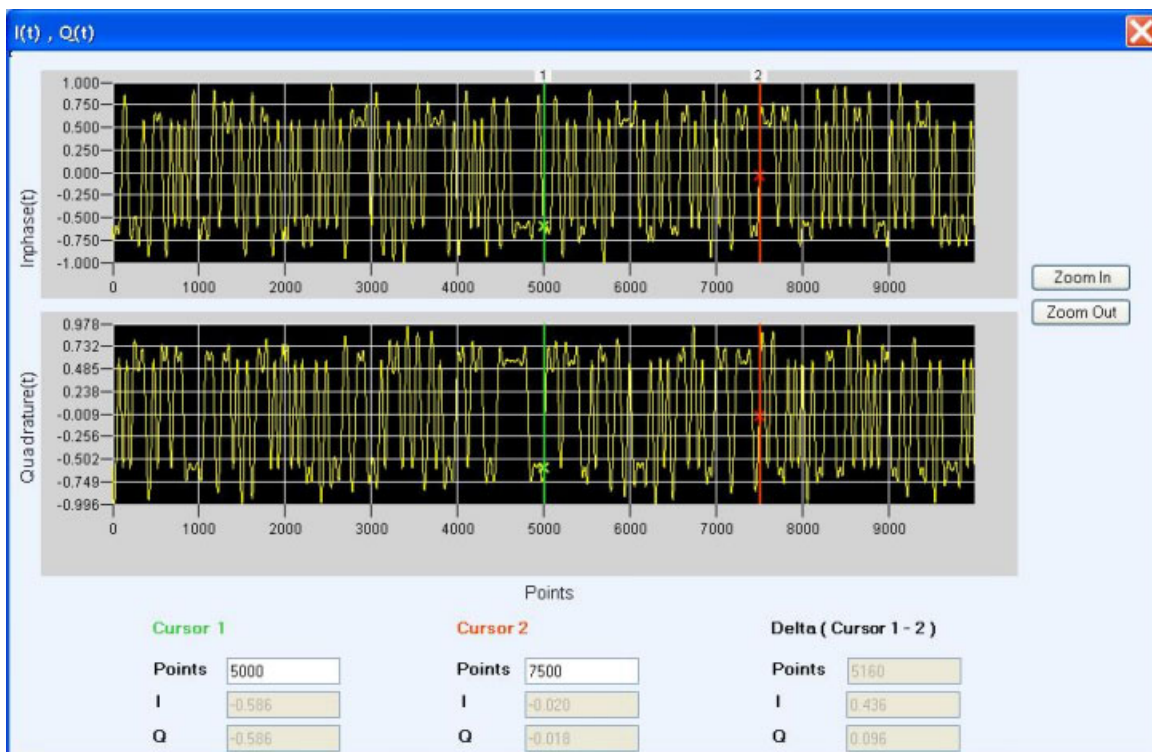
## I(t), Q(t)

The I (t), Q(t) graph shows two plots: Points (X-axis) against Inphase(t) (Y-axis), and Points (X-axis) against Quadrature(t) (Y-axis).

The cursor readouts show the X and Y values and delta of the cursor positions. Moving the cursors causes the cursor readouts and the delta values to be updated. You can also specify the points values in the fields to position the cursors. This graph is available for the Generic, UWB-WiMedia, Radar, and OFDM applications.

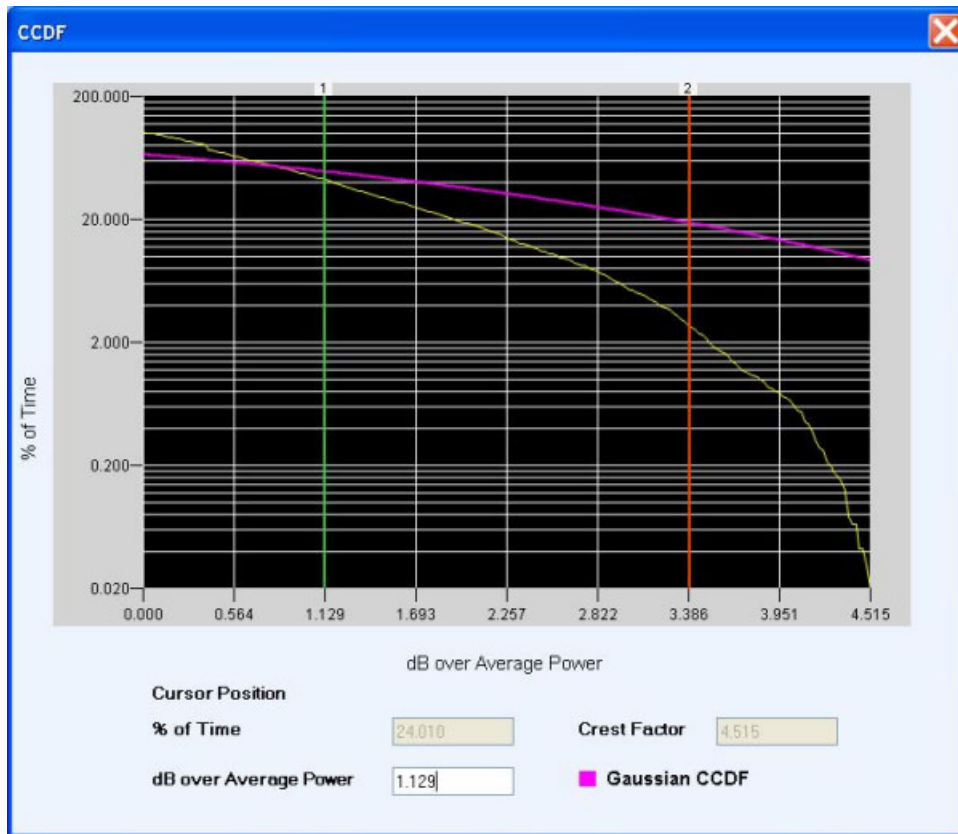
The following controls are available:

- **Zoom In:** Click Zoom In. Select an area on the plot to zoom in on. You can use the horizontal scroll bar to scroll through the plot while in the zoom mode.
- **Zoom Out:** Click Zoom Out to zoom out in the same manner that you zoomed in.



## CCDF Plot

The CCDF graph shows the plot of dB over Average Power (X-axis) and % of Time (Y-axis). The readouts show the % of Time, the dB over Average Power, and the Crest Factor. You can specify the dB over Average Power value in the field to position the cursor.



## Spectrum

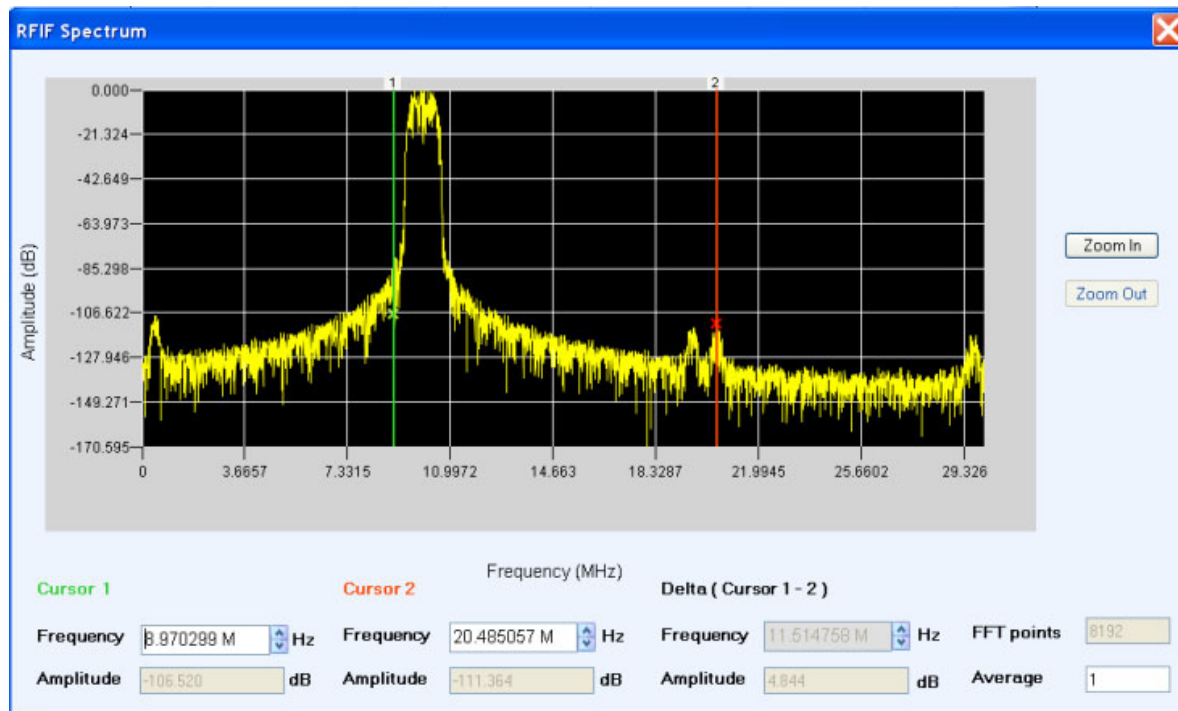
The Spectrum graph shows a plot of Frequency (MHz) on the X-axis and Amplitude (dB) on the Y-axis. The Cursor 1 and Cursor 2 positions, and the Delta (between the cursor positions) are displayed. Moving the cursors causes the cursor readouts and the delta values to be updated. You can also specify the frequency values in the fields to position the cursors. The number of FFT points (8192) and average points are also shown. This graph is available for the Generic, UWB-WiMedia, Radar, and OFDM applications.

The following controls are available:

- **Zoom In:** Click Zoom In. Select an area on the plot to zoom in on. You can use the horizontal scroll bar to scroll through the plot while in the zoom mode.
- **Zoom Out:** Click Zoom Out to zoom out in the same manner that you zoomed in.

### Averaging

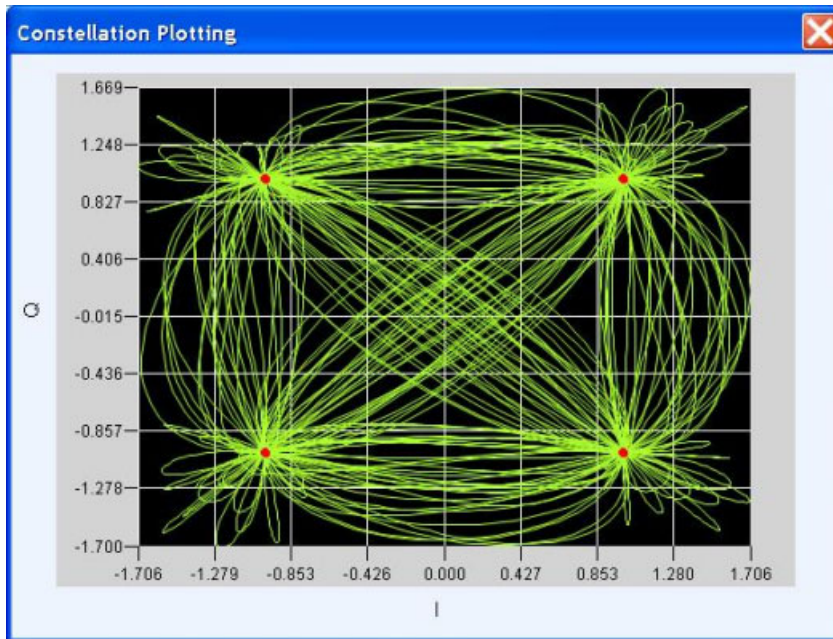
If the number of sample points is high, you can use the Average field to enter a value and average the FFT data. The value entered in the average field can range from 1 to 1024.





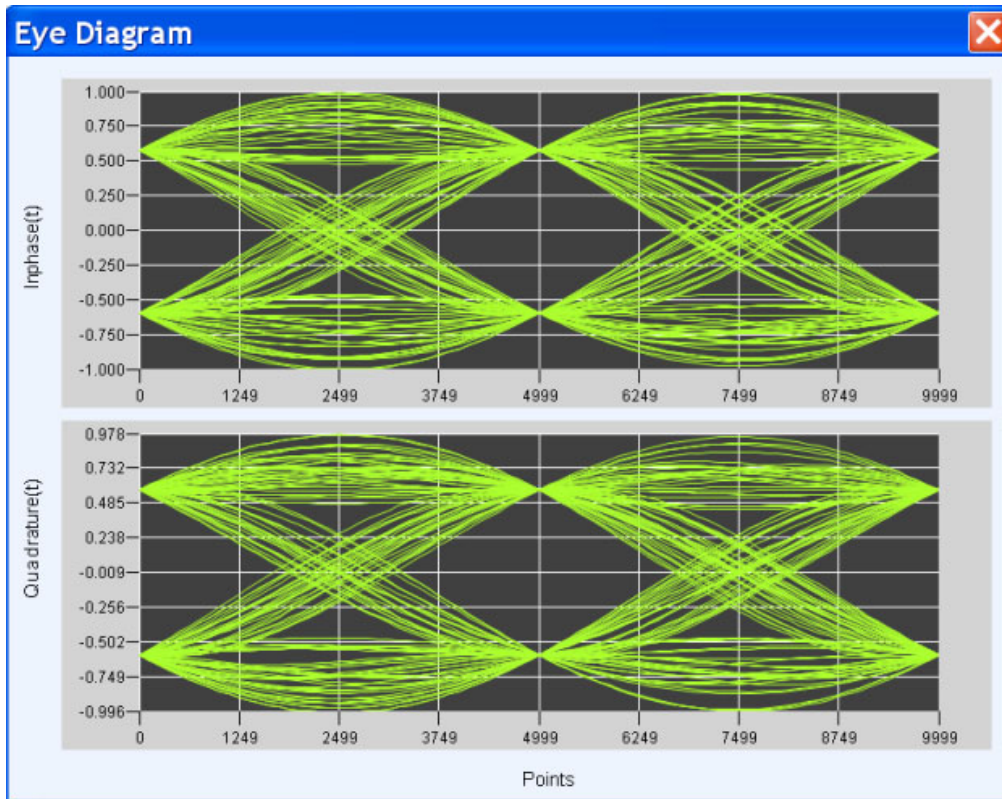
## Constellation Plotting

The constellation graph shows the plots of Points (X-axis) against I and Q (Y-axis). It is a graphical representation of permissible modulation states at the I/Q level.



# Eye Diagram

The Eye Diagram shows the plots of Points (X-axis) against I and Q (Y-axis).

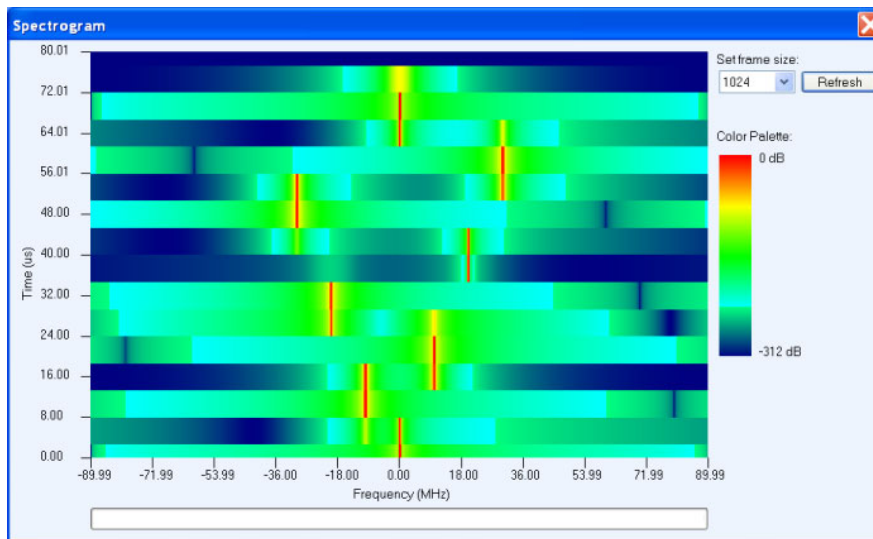


## Spectrogram

The Spectrogram is available for all the applications.

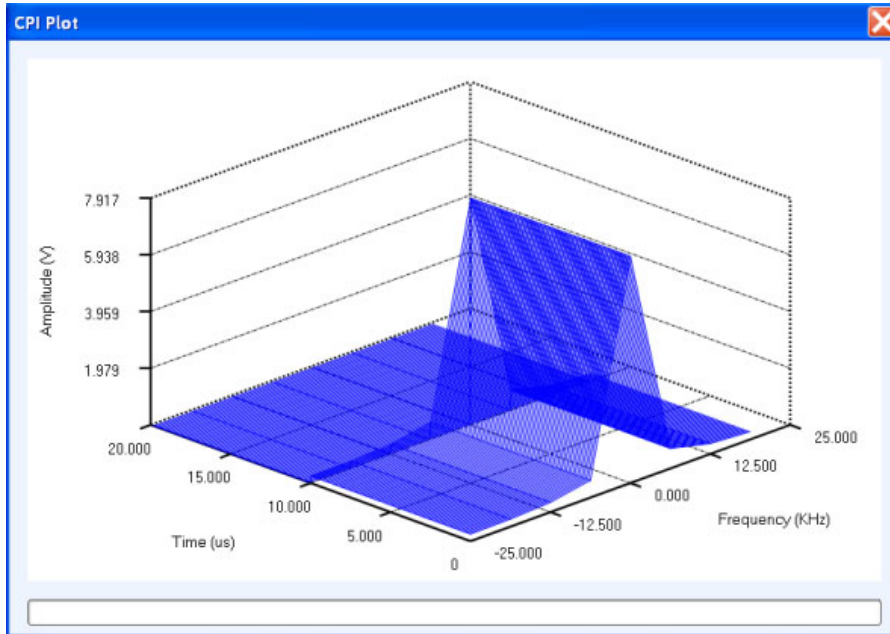
It is a 3-dimensional plot with Frequency along the X axis, Time along the Y axis, and the Amplitude of the point shown by the brightness of the color. The points with the highest amplitude are plotted in red and the points with lowest amplitude are plotted in blue. The color palette containing the color grading is shown on the right of the plot. The palette also shows the highest amplitude values present in the spectrogram.

The frame size can be selected to specify the chunk size to be used while plotting the frequency spectrogram. On clicking the Refresh button, the spectrogram is re-plotted based on the chunk size.



## FFT of Coherent Pulse Interval

The FFT of Coherent Pulse Interval (CPI) is available only for the radar application. It is a 3-dimensional plot with Frequency on X axis, Time on Y axis, and Amplitude on Z axis. This plot gives a 3-dimensional representation of a radar pulse. The number of pulse repeats must be greater than four for plotting the coherent pulse interval (CPI) of a pulse. The pulse should have no impairments or modulation specified. This plot is only applicable for IQ waveforms and not IF/RF waveforms.



## Error Messages for Generic Signal

Error message	Description	Possible solution
<b>Waveform Errors</b>		
Error generating waveform.	An exception occurred while running the application.	Restart the application.
Waveform does not exist.	Operation in an illegal state.	Delete all the waveforms.
Memory failed.	<ul style="list-style-type: none"> <li>■ Operation in an illegal state.</li> <li>■ Memory overflow.</li> </ul>	Try one of the following: <ul style="list-style-type: none"> <li>■ Restart the application.</li> <li>■ Free space on the hard disk.</li> </ul>
Data not found.	Accessing data beyond range.	Delete all the waveforms.
Invalid size.	The waveform length is beyond the range.	Check the range help page for valid range.
Maximum number of waveforms: 13000.	The limit of 13000 is reached on completing the selected operation.	Delete waveforms which are not in use.
Invalid sampling rate.	The clock rate from the file is incorrect.	Check the format of the file being imported.
Unable to access data.	The application is the invalid state.	Restart the application.
<b>Generic Signal Errors</b>		
Symbol Map table cannot be empty.	The table should have valid entries.	Check the parameters in the Modulation Symbol map table.
Maximum number of carriers: 1024.	The maximum carriers that can be generated by the application is reached.	Delete the carriers that are not in use.
No carrier available.	At least one carrier is required to produce data.	Try one of the following: <ul style="list-style-type: none"> <li>■ Add at least one carrier to the table.</li> <li>■ At least one carrier should have the State turned 'ON'</li> </ul>
User defined file name cannot be empty.	Valid files need to be present.	Valid files need to be present.
File does not exist.	The file does cannot be found. The file may be deleted.	Select existing files.
The interference input signal waveforms cannot be the same as the compile waveforms.	The waveform will be overwritten.	Try one of the following: <ul style="list-style-type: none"> <li>■ Select a different name for the compilation waveform.</li> <li>■ Rename the waveform in the list and select the waveform again.</li> </ul>
Base data file not found.	The file was deleted after updating the setup.	Select existing base data files.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
Filter file not found.	The user defined filter file was not selected.	Select a user defined filter file.
Modulation Symbol file not found.	The user defined symbol file was not found.	Select a user defined symbol file.
Modulation Sample file not found.	The user defined sample file was not found.	Select a user defined sample file.
Maximum total symbols: 512.	The total number of symbols of 512 is exceeded.	N/A
Error on parsing PRBS polynomial.	The PRBS polynomial syntax is incorrect.	Enter the correct PRBS polynomial.
Symbol rate should be less than carrier frequency.	The specified symbol rate is greater than the carrier frequency.	Enter a symbol rate that is less than the carrier frequency.
The entries cannot have the same symbol values.	No two entries in the power ramp table can have the same symbol values.	Enter unique symbol values for each entry in the table.
Port selected in the S-parameter file is not supported.	The port selected in the S-parameter file is not supported.	Select a port (one, two, or four) that is supported.
Sub-carrier frequency should be greater than the maximum of the individual carrier frequencies.		Enter a frequency that is greater than the maximum carrier frequency.
S-parameter file has an invalid port. RFXpress supports one, two, and four port networks.	The port in the S-parameter file is not supported.	Select a port (s1p, s2p, or s4p) that is supported.
Not a valid S-parameter file.	The S-parameter is invalid.	Select a valid S-parameter file.
Invalid option line in the S-parameter file.	The option line in the S-parameter file is incorrect.	Ensure that the option line in the S-parameter file is correct.
Not a valid one/two/four-port S-parameter file.	The files provided are invalid S-parameter files.	Provide valid one-, two-, and four-port S-parameter files.
S-parameter file does not exist.	The entered file does not exist.	Enter a file that exists.
No two physical ports assigned for a single-ended connection can be same.	In a four-port TouchStone file, a port is assigned to a physical location more than once.	Assign each port to a unique location.
The number of points in the S-parameter file exceeds the maximum number of points (32769).		Reduce the number of points in the S-parameter file.
The number of points in the S-parameter file does not have the minimum number of points (1).		The number of points must be non-zero.
All the cascading files need to have the same number of ports.	The S-parameter files provided for cascading do not have the same number of ports.	Ensure that all the files have the same number of ports (s1p, s2p, or s4p).

Error message	Description	Possible solution
S-parameter cascading should at least have one S-parameter file enabled.	S-parameter cascading requires at least one file to be available.	Enable at least one file for S-parameter cascading.
S-parameter file does not exist for File {0}.	The S-parameter file(s) specified for cascading does not exist.	Ensure that the specified S-parameter file exists.

## Error Messages for UWB-WiMedia

Error message	Description	Possible solution
Length of arrays does not match the size in RFC file.	The correction file may be corrupt.	Calibrate again.
Select at least one band for calibration.	The band data is required for calibration.	Select at least one band.
Enter valid correction file path in Ch N tab.	The path does not exist.	Select an existing file path.
Select at least one channel to apply corrections.	Choose the channel to which the calibration should be applied.	N/A
Select both the channels to apply corrections.	IQ Signal format requires two channels for signal generation.	Select appropriate I and Q channels.
Initialization for the test signal generation is failed.	Invalid parameters were used.	Rerun the calibration after closing and opening the window.
Error in generating Test Signal.	The test signal file was corrupt.	Restart the application.
Failed to set calibration signal parameters.	Invalid parameters were used.	Rerun the calibration after closing and opening the window.
Initialization for the reference signal generation has failed.	Invalid parameters were used.	Rerun the calibration after closing and opening the window.
Error in generating Reference Signal.	The reference signal file was corrupted.	Restart the application.
Error in setting Reference Signal.	Invalid parameters were used.	Rerun the calibration after closing and opening the window.
Failed to set oscilloscope parameters.	The oscilloscope communication was not successful.	Check the oscilloscope connections. Try one of the following: <ul style="list-style-type: none"> <li>■ Refresh the list in Find Instruments window.</li> <li>■ Refresh the TekVisa instrument manager.</li> <li>■ Close the application. Restart TekVisa. Restart the application.</li> <li>■ Restart the oscilloscope.</li> </ul>
Error in acquiring signal from oscilloscope.		
Error in setting oscilloscope signal.		
Error in averaging the signal.		

Error message	Description	Possible solution
Correction file does not exist. Please calibrate to generate correction files.	Correction files need to be given if correction is chosen.	Try one of the following: <ul style="list-style-type: none"> <li>■ Select existing correction files to apply for correction.</li> <li>■ Choose not to give correction files.</li> </ul>
Invalid correction file.	Correction file format is incorrect.	Apply valid correction files.
Correction file not found.	The correction file was deleted after updating the values in window.	Select existing correction files.
Compilation aborted. One or more user defined file(s) does not exist.	The user defined payload data source file in the conformance mode is incorrect.	Select the correct payload data source data file.
Payload file does not exist.	Payload data source user defined file custom mode is incorrect.	Select the correct payload data source data file.
No packets present in the current configuration.	At least one packet is necessary for generating data.	Select at least one valid packet.
Compilation aborted.	The correction files do not match with the selected channel.	Calibrate and choose appropriate correct correction files.

## Error Messages for Radar

Error message	Description	Possible solution
Cannot delete all pulse elements. At least one pulse should be present.	At least one pulse must be present in the pulse train. You cannot delete all the pulses.	Maintain at least one pulse in the pulse train.
Cannot cut all pulse elements. At least one pulse element should be present.	At least one pulse must be present in the pulse train. You cannot cut all the pulses.	Maintain at least one pulse in the pulse train.
Maximum number of phase codes reached.	You can add N number of steps for "User defined codes" modulation. When N is exceeded, this message indicates that the maximum number of steps than can be added is reached.	N/A
Maximum number of nonlinear coefficients reached.	You can add N number of steps for "Nonlinear FM" modulation. When N is exceeded, this message indicates that the maximum number of steps than can be added is reached.	N/A
Maximum number of steps reached.	You can add N number of steps for "User Defined Step FM" modulation. When N is exceeded, this message indicates that the maximum number of steps than can be added is reached.	N/A



<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
Reached maximum number of pulse elements.	This message appears when you try to add pulse elements that exceed the maximum capacity of the pulse table.	N/A
Cannot add more than 100% of pulse width (inclusive of rise and fall times).	This message appears when you try to add a duration less than or greater than 100% of the pulse width for the modulation types "User Defined Codes" or "User Defined Step FM".	Ensure that the sum of subdurations of all steps is 100% of pulse width.
RFXpress cannot compile. At least one pulse element should be present.	This message appears when you try to compile without having at least one pulse in the pulse table.	Maintain at least one pulse in the pulse train.
RFXpress cannot compile. Enough memory is not available on application drive.	This message appears when the memory required to generate the waveform is not available in the drive where the application is running.	Increase the free space in the drive where the application is running.
RFXpress cannot compile. Could not create temporary files.	This is an internal error.	Try compiling again or restart the application.
Memory clean up failed.	This is an internal error.	Try compiling again or restart the application.
Modulation is not set for the entire pulse width (inclusive of rise and fall times).	This message appears when you set the modulation to User Defined Codes or User Defined Step FM and define the steps for only part of the duration.	Set the modulation width to 100% of the pulse width.
Memory initialization failed.	This is an internal error.	Try compiling again or restart the application.
RFXpress cannot compile. The waveform length is longer than the maximum supported length of the instrument.	This message appears when you try to compile a waveform that is longer than the maximum supported length.	Change the values of the pulse parameters or sampling rate.
RFXpress cannot compile. The waveform length is shorter than the minimum supported length of the instrument.	This message appears when you try to compile a waveform that is shorter than the minimum supported length.	Change the values of the pulse parameters or sampling rate.
RFXpress cannot compile. At least one deviation in staggered PRI should be present.	This message appears when you set Staggered PRI to User Defined but do not add any deviations before compiling.	Add at least one deviation.
RFXpress cannot compile. At least one nonlinear FM coefficient in modulation should be present.	This message appears when you set Modulation to Nonlinear FM but do not add any coefficients before compiling.	Add at least one coefficient.
Custom pulse shape file for pulse group <x> is not found.	This message appears when you set Pulse Shape to Custom, provide a file which does not exist, and try to compile.	Enter an existing file.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
Custom modulation file for pulse group <x> is not found.	This message appears when you set pulse Modulation to Custom, provide a file which does not exist, and try to compile.	Enter an existing file.
Custom pulse shape file for pulse group <x> is invalid.	This message appears when you select pulse shape as custom, provide a file which is invalid, and try to compile.	Enter a valid file.
Custom modulation file for pulse group <x> is invalid.	This message appears when you select pulse modulation as custom, provide a file which is invalid, and try to compile.	Enter a valid file.
The number of samples in the custom pulse shape file for pulse group <x> exceeds the maximum number of samples.	This message appears when you select pulse shape as custom, provide a file in which the number of points/values exceeds the points expected, and try to compile.	Reduce the number of samples in the file. The maximum number of samples is 1 M.
The number of samples in the custom modulation file for pulse group <x> exceeds the maximum number of samples.	This message appears when you select pulse modulation as custom, provide a file in which the number of points/values exceeds the points expected, and try to compile.	Reduce the number of samples in the file. The maximum number of samples is 1 M.
RFXpress cannot compile. At least one hopping offset should be present.	This message appears when the pulse hopping feature is turned on and no hopping value is added to the table.	Either turn off the hopping feature or add hopping values to the table.
The total number of hops cannot exceed the pulse repeat value.	This message appears when you try to add more hops than the pulse repeat value.	To add more hops, increase the repeat value for each pulse.
The total number of hops cannot exceed eight hops.	The maximum number of hops is eight. This message appears when the try to add more than eight hops.	The maximum number of hops is eight. You cannot add more than this.
RFXpress cannot compile. The waveform length is longer than the maximum supported.	This message appears when you try to compile a waveform that is longer than the maximum supported length.	Reduce the waveform length.
RFXpress cannot compile. The waveform length is shorter than the minimum supported.	This message appears when you try to compile a waveform that is shorter than the minimum supported length.	Increase the waveform length.
Maximum number of staggered PRI deviations cannot exceed the repeat value.	This message appears when you set Staggered PRI to User Defined and then try to add deviations that exceed the number of pulse repeats.	The number of PRIs cannot exceed the repeat value.
Invalid MATLAB file. It should have the sampling rate and waveform samples. Refer to the online help for the file format.	This message appears when you try to import an invalid MATLAB file.	Use a valid file.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
RFXpress cannot compile. Tr is less than zero.	This message appears when the rise time is negative. The application cannot create samples for this value.	Change the sampling rate or increase the rise time.
RFXpress cannot compile. Tf is less than zero.	This message appears when the fall time is negative. The application cannot create samples for this value.	Change the sampling rate or increase the fall time.
RFXpress cannot compile. Ton is less than zero.	This message appears when the pulse width time is negative. The application cannot create samples for this value.	Change the sampling rate or increase the pulse width time.
RFXpress cannot compile. Offtime is less than zero.	This message appears when the offtime is negative. The application cannot create samples for this value.	Change the sampling rate or increase the offtime.
RFXpress cannot compile. Start time is less than zero.	This message appears when the start time is negative. The application cannot create samples for this value.	Change the sampling rate or increase the start time.
Compilation failed.	This message appears when the application was unable to compile the waveform.	Report the problem to customer support attaching the log.txt file and error code.
RFXpress cannot compile. Resampled data too large. Increase custom sampling rate or reduce file size.	This message appears when the custom file size is too big and RFXpress cannot handle resampling of so much data.	Reduce file size or the sampling frequency.
RFXpress compilation failed. Mem mapped file not found.	This message appears when the memory mapped files are not found.	Make sure files are not deleted and recompile.
RFXpress compilation failed. Sample rate might not be good enough.	This message appears when the sample rate calculated is less than 2.5 times the highest frequency to be generated.	Reduce the frequency and recompile.
RFXpress compilation failed. Waveform Length too short, increase sampling rate or the PRI.	This message appears when the number of samples required to create this file is less than minimum waveform length required by instrument.	Increase the sampling rate and recompile.
Compilation aborted.	This message appears when you cancel the compilation.	N/A
Subpulse time too small.	This message appears when the subpulse time is too small to create any samples.	Increase the pulse width or decrease the number of subpulses.
RFXpress cannot compile. The waveform length is shorter than the minimum supported for pulse group X.	This message appears if any one of the pulse groups in the pulse train is shorter than the minimum waveform length.	Increase the sampling rate or change the pulse parameters.
RFXpress compilation failed. Could not combine all waveforms.	This is an internal error that occurs when combining waveforms.	Recompile the waveform.
RFXpress compilation failed. Could not clear pulse group data.	This is an internal error that occurs after combining waveforms and trying to clear pulse group data.	Recompile the waveform.

Error message	Description	Possible solution
RFXpress cannot compile. At least one user defined step must be present.	This occurs when the modulations, User-Defined Step FM AM and User-Defined Step PM AM, contain no steps (the table is empty).	Add at least one step in the table for the compilation to proceed.
IQ calibration requires two channels. Cannot be done on a single channel instrument.	This message appears when the instrument has one channel or the instrument is in the Interleave mode.	Disable Interleave option in the Instrument control window or from the AWG.

## AWG Sequence Window-related errors

Error message	Description	Possible solution
Invalid value for Wait.	Wait accepts only On or Off. Any other value is not accepted.	Enter either On or Off.
Invalid value for Repeat.	This message appears when you enter an invalid value in the Repeat column. The repeat value has to be an integer value or Infinite. The repeat value should be between 0 and the maximum repeat value allowed by instrument.	Select Infinite or a valid repeat value.
Invalid value for Event Jump To.	This message appears when you enter an invalid value in the Event Jump To column. Event Jump To can be set to a valid sequence index or to the next sequence element.	Select a valid sequence element index.
Invalid value for Go To.	This message appears when you enter an invalid value in the Go To column. Go To can be set to a valid sequence element index.	Select a valid sequence element index.
Software sequencer error. Waveform length exceeds instrument memory. Reduce pulse parameters.	This message appears when the AWG software sequencer is unable to run the waveform.	Reduce the pulse parameters and recompile.

## Error Messages for OFDM

Error message	Description	Possible solution
Compile failed.	This message appears when the application was unable to compile the waveform.	Report the problem to customer support attaching the log.txt file and the error code. The file log.txt is present in the system folder of the directory where RFXpress is installed.
Compilation aborted.	This message appears when you cancel the compilation.	N/A
Convolution Code length is greater than constraint length.	The code length does not match the constraint length.	Change the convolution encoder polynomial or the constraint length.

Error message	Description	Possible solution
Convolution Code length is less than constraint length.	The code length does not match the constraint length.	Change the convolution encoder polynomial or the constraint length.
Reed Solomon Primitive polynomial has to be less than $2^{(\text{number of bits})-1}$ .	The primitive polynomial is greater than $2^{(\text{number of bits})-1}$ .	Change the primitive polynomial or the bits per symbol.
Reed Solomon is not a primitive polynomial.	The polynomial is not a primitive polynomial.	Provide a primitive polynomial.
Number of parity symbols must be a multiple of 2.	Number of Encoded Symbols--Number of Input Symbols should be multiple of 2.	Change the number of input or output symbols.
Reed Solomon number of encoded symbols should be greater than input.	Input number of symbols should be less than output.	Ensure that the number of input symbols is less than the output.
Encoded symbol should be less than $2^{(\text{number of bits})-1}$ .	Maximum Number of Encoded symbols is $2^{(m-1)}$ .	N/A
Size of the encoded data in each block is too large to handle.	Number of bits for each block of Reed Solomon should be less than 1 M bits.	N/A
Multipath delay is greater than the waveform length.	This message appears when the multipath delay provided is greater than the waveform duration.	Decrease the multipath delay or increase the waveform duration.
Phase noise VCO bandwidth is greater than sampling rate/2.	The filter cut-off must be less than the sampling rate/2.	Reduce the cut-off or increase the sampling rate.
Sample rate might not be good enough.	Samples rate is less than 2.5 times the maximum signal bandwidth.	Reduce the signal bandwidth.
Symbol name must be unique.	This message appears if the user tries to provide a symbol name which is already present in the symbol list.	Provide a unique name.
Cannot delete all symbols. At least one symbol should be present.	This message appears when the user tries to delete all the symbols in the symbol list.	N/A
Subcarrier index is out of range.	This message appears when the user enters an invalid subcarrier range in the edit box.	Provide a range based on the number of subcarriers present for the symbol.
Invalid range. Ensure that range is entered as shown in the example.	The format of the range is invalid.	Provide the range with a valid format.
Packet name must be unique.	The packet name provided is already present in the packet list.	Provide a unique name.
Cannot delete all packets. At least one packet should be present.	This message appears if the user tries to delete all the packets in the packet list.	N/A
Invalid file.	This message appears if the user provides an invalid file for preamble/postamble or user defined frequency weight file.	Provide a valid file with a proper format.
Frame name must be unique.	This message appears if the user provides a frame name which is already present in the frame list.	Provide a unique name.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
Cannot delete all frames. At least one frame should be present.	This message appears if the user tries to delete all the frames in the frame list.	N/A
All puncture bits for an output tap cannot be zero.	This message appears if the user punctures all the bits in the puncturing scheme of convolution coding.	Have at least one bit with a value 1.
Base data name must be unique.	This message appears if the user provides a name for base data which is already present in the base data list.	Provide a unique name.
Cannot delete all subcarriers. At least two subcarriers should be present.	This message appears if the user tries to delete all the subcarriers of the symbol.	N/A
Cannot delete all hop frequency entries. At least one entry should be present.	This message appears if the user tries to delete all the frequency hops from the frequency hopping dialog.	N/A
Maximum number of symbols: 100.	This message appears if the user tries to add more than the maximum number of symbols supported.	Delete symbols that are not used and try adding again.
Maximum number of packets: 100.	This message appears if the user tries to add more than the maximum number of packets supported.	Delete packets that are not used and try adding again.
Maximum number of frames: 100.	This message appears if the user tries to add more than the maximum number of frames supported.	Delete frames that are not used and try adding again.
Data source file name for <base_data> is not found in the specified path.	This message appears if the path provided (by the user) for source file name of an base data is invalid.	Provide a valid path.
Data source file name of <base_data> contains more than 1M points.	This message appears if the data source file contains more than 1M points.	Delete some of the data in the file such that it has only 1M points.
Data source file name of <base_data> contains invalid data.	This message appears if the format of the data source file is not valid.	Follow the file format for the data source file.
Internal error: No entries are present in the hash table of memory mapped files.	N/A	Restart the application.
User defined Frequency weight file for <symbol_name> Symbol is not found in the specified path.	This message appears if the path provided for "user defined frequency weight" file of a symbol is invalid.	Provide a valid path.
Preamble file for <packet_name>packet is not found in the specified path.	This message appears if the path provided for "preamble" file of a packet is invalid.	Provide a valid path.
Postamble file for <packet_name> packet is not found in the specified path.	This message appears if the path provided for "postamble" file of an packet is invalid.	Provide a valid path.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
RFXpress cannot compile. The waveform length is shorter than the minimum supported for <instrument_name>.	This message appears if the parameters provided generate a waveform that is less than the minimum supported.	Increase the sampling rate in compile settings, or increase the duration of the waveform.
Start symbol cannot be more than End symbol.	This message appears if the user provides the value of start symbol ID more than the end symbol ID.	Provide a value for Start symbol ID less than End Symbol ID, or increase the value of End Symbol ID and then provide Start Symbol ID.
End symbol cannot be less than Start symbol.	This message appears if the user provides the value of end symbol ID less than the start symbol ID.	Provide a value for End symbol ID more than Start Symbol ID OR Decrease the value of Start Symbol ID and then provide End Symbol ID.
Cannot add more than {n} subcarriers.	This message appears if the user tries to add more than maximum number of subcarriers.	Delete subcarriers that are not used.
Select a subcarrier to delete.	This message appears if the user clicks on the delete button without selecting the carrier.	Select a carrier in the Symbol setup to delete it.
Cannot delete odd number of subcarriers.	This message appears if the user tries to delete carriers resulting in an odd number of carriers left for the symbol.	Delete carriers such that the number of remaining carriers are even.
The paste operation cannot be done since the number of subcarriers will not be a multiple of 2.	This message appears if the user pastes the carriers resulting in an odd number of carriers for the symbol.	Do the paste operation such that the number of remaining carriers are even.
Number of carriers in the file are not multiple of 2.	This message appears if the number of carriers in the "User Defined Frequency weight" file is not even.	Either add more carriers or delete some to keep the number even.
Number of carriers in the file are more than <max_number_of_carriers>.	This message appears if the number of carriers in the "User Defined Frequency weight" file is more than the maximum supported.	Delete some of the carriers.
Invalid User defined frequency weight file for <symbol_name>.	This message appears if the user provides an file which does not match the format of "User defined Frequency weight" file.	Provide a file with the correct format.
The number of carriers in the User defined frequency weight file are not multiple of 2 for <symbol_name>.	This message appears if the number of carriers in the "User Defined Frequency weight" file is not even.	Either add more carriers or delete some to keep the number even.
Number of carriers in the User defined frequency weight file are more than 65536 for <symbol_name>.	This message appears if the number of carriers in the "User Defined Frequency weight" file is more than the maximum supported.	Delete some carriers.
Invalid amplitude value.	If the amplitude value in the Tone Nulling dialog box is not valid.	Enter a valid value.
Invalid phase value.	This message appears if the phase value in the Tone Nulling dialog box is not valid.	Enter a valid value.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
Invalid Preamble file for <packet_name>.	This message appears if the file provided for "Preamble" file of an packet is invalid.	Provide a valid file with proper format.
Preamble file length is more than 2 M for <packet_name>.	This message appears if the file provided for "Preamble" is more than 2 M points.	Delete some values to make it within 2M points.
Invalid Postamble file for <packet_name>.	This message appears if the file provided for "Postamble" file of an packet is invalid.	Provide a valid file with proper format.
Postamble file length is more than 2 M for <packet_name>.	This message appears if the file provided for "Postamble" is more than 2 M points.	Delete some values to make it within 2M points.
Internal error. Could not resample the preamble file.	N/A	Save the RFS file. Restart RFXpress. Load the RFS file and compile.
Internal error. Could not resample the postamble file.	N/A	Save the RFS file. Restart RFXpress. Load the RFS file and compile.
Internal error. RFXpress Compilation failed. Could not clear waveform data.	N/A	Save the RFS file. Restart RFXpress. Load the RFS file and compile.
Internal error. Could not load the preset files.	N/A	Restart RFXpress.
Internal error. Not a valid preset.	N/A	Restart RFXpress.
Internal error. Could not load the values. Compile failed.	N/A	Save the RFS file. Restart RFXpress. Load the RFS file and compile.
Frequency offset value cannot be repeated.	This message appears when the user tries to enter the same frequency value in the frequency model table for phase noise.	Enter a unique frequency offset value.
RFXpress cannot compile. At least one hopping element should be present for <packet_name> packet.	This message appears if the user has turned on Frequency Hopping and has not provided any hop element.	Either turn off Frequency Hopping or add at least one hop element.
RFXpress cannot compile. At least one noise element should be present for <packet_name> packet.	This message appears if the user has turned on Gated Noise and not provided any noise element.	Either turn off Gated Noise or add at least one noise element.



## DUT Characterization Errors

Error message	Description	Possible solution
Connect to an oscilloscope before proceeding.	This message appears when you click Next before selecting and connecting to an oscilloscope.	Select an oscilloscope from the list and click Connect.
Connect to only one oscilloscope which will be used for calibration.	This message appears if you have connected to more than one oscilloscope from the list.	Ensure that you are connected to only one oscilloscope. Disconnect the others.
Internal Error: Failed to allocate memory.	This is an internal error.	Restart the application.
Internal Error: Exception occurred during calibration.	This is an internal error.	Restart the application.
Choose the AWG channel to connect to the oscilloscope.	This message appears when you click Next before selecting the AWG channel to connect to.	Select a channel to connect to the oscilloscope.
Start Frequency has to be less than End Frequency.	The specified Start Frequency is greater than the specified End Frequency.	Change the Start Frequency so that it is less than the End Frequency.
Enter the file name to export the characteristics of DUT.	This message appears when no name is given.	Enter a valid file name.
Cannot skip Step 1. The required correction file is missing.	This message appears when you skip Step 1 (calibration) and the internal correction file is missing.	Run Step 1.
Start Frequency cannot be less than Frequency Resolution.	The specified Frequency Resolution is greater than the specified Frequency Resolution.	Change the Start Frequency so that it is more than the Frequency Resolution.
Error in communicating with the oscilloscope.	This appears when the communication between the AWG and scope is not available.	<ul style="list-style-type: none"> <li>■ Check the connections.</li> <li>■ Restart the application and try again.</li> </ul>

## RTSA Connectivity-related Errors

Error message	Description	Possible solution
Waveform name not entered.	The waveform name has not been entered.	Enter a waveform name.
Unable to communicate with Spectrum Analyzer. The I and Q data cannot be imported. Please check the instrument connection.	This error appears when you press the Acquire button and the application is unable to communicate with the spectrum analyzer.	Check the instrument connection and acquire again.
Error creating waveform.	This error appears when a memory shortage or an internal error occurs.	Restart the instrument.
Error creating shared directory.	This error appears when the application is unable to create a shared folder for copying the iqt file.	Ensure that you have administrator rights on the machine on which the application is running.
Error in transferring the IQT file from Spectrum Analyzer.	This error appears when the file transfer is unsuccessful.	<ul style="list-style-type: none"> <li>■ Check the instrument connections.</li> <li>■ Restart TekVisa on the spectrum analyzer.</li> </ul>
Unable to communicate with Spectrum Analyzer. Please check the instrument connection.	This error appears when the application is unable to communicate with the spectrum analyzer.	Check the instrument connections.

## Miscellaneous Error Messages

Error message	Description	Possible solution
Compile failed.	Invalid parameters were found during compilation.	<ul style="list-style-type: none"> <li>■ Check compilation parameters before compiling.</li> <li>■ Restart the application.</li> </ul>
Compile failed	The correction factors cannot be applied to the channel.	<ul style="list-style-type: none"> <li>■ Increase the length of the waveform.</li> <li>■ Create a correction file with lower resolution.</li> </ul>
Maximum number of averages: 1024.	The total number of averages exceeds 1024 in the spectrum plot.	N/A
Invalid file extension.	This file type is not supported by the application for import.	Select the correct format supported by the application.
Invalid file type. Data cannot be imported.	<ul style="list-style-type: none"> <li>■ The file contains wrong data.</li> <li>■ The data (in the file) does not match the file type specified during file import.</li> </ul>	<p>Use a valid file.</p> <p>Specify the type of data in the file correctly.</p>
Unable to retrieve the file size.	The file size could not be computed based on the data in the file.	Use a valid file.

Error message	Description	Possible solution
Unable to create buffer for the imported file.	The software is unable to allocate the required memory for importing the file.	Release memory by deleting some waveforms in the waveform list.
Unable to load the setup file. Application not available.	The selected setup file cannot be loaded because the application (UWB-WiMedia) is not available.	Use a valid file. Purchase the UWB-WiMedia application.
Error opening setup file. File cannot be opened.	The setup file is corrupt and cannot be opened.	Use a valid file.
Invalid data in the setup file. File may be corrupted.	The setup file contains invalid data or may be corrupt.	Use a valid file.
Error loading data from the setup file. File cannot be loaded.	The data contained in the setup file is not usable.	Use a valid file.
Error writing the setup file. File cannot be written.	The setup file is not writable. The setup file may be read only.	<ul style="list-style-type: none"> <li>■ Check whether the file is being used by another program.</li> <li>■ Check the file properties.</li> </ul>
Error opening the data file. File cannot be opened.	The data file is corrupt and cannot be opened.	Use a valid file.
Error writing the data file. File cannot be written.	The data file is not writable. The data file may be read only.  Enough disk space may not be available on the disk drive to which you are writing the file.	<ul style="list-style-type: none"> <li>■ Check whether the file is being used by another program.</li> <li>■ Check the file properties.</li> <li>■ Free some disk space on the drive or save the file on another disk drive.</li> </ul>
Error reading the data file. File cannot be read.	The data contained in the file is not usable.	Use a valid file.
No waveform selected in the waveform list.	No waveform has been selected to save.	Select a waveform to save.
Compilation aborted. Waveform length exceeds the instrument memory in the AWG waveform list. Delete some of the waveforms in the list and compile.	This message appears when the total waveform length in the AWG waveform list and the waveform to be generated by RFXpress exceeds the maximum instrument capacity.	Delete some waveforms from the list and compile again.
You cannot transfer data for the currently selected unlicensed option.	This message appears when you have not entered a valid license for the plugin and are using the Compiles and Sends option in the Compile Settings dialog box.	Enter the valid license key in Option Installation dialog box.

## Miscellaneous Error Messages 2

Error message	Description	Possible solution
Invalid selection of waveforms. Only one waveform must be selected.	More than one waveform is selected to save.	Select only one waveform at a time to save.

<b>Error message</b>	<b>Description</b>	<b>Possible solution</b>
Error opening the IQT file. File cannot be opened.	The .iqt file is corrupt and cannot be opened.	Use a valid file.
Error reading the IQT file. File cannot be read.	<ul style="list-style-type: none"> <li>■ The .iqt file is corrupt and cannot be opened.</li> <li>■ The data contained in the .iqt file is not usable.</li> </ul>	Use a valid file.
Error opening the TIQ file. File cannot be opened.	The .tiq file is corrupt and cannot be opened.	Use a valid file.
Invalid data in the TIQ file. File may be corrupted.	The .tiq file contains invalid data or may be corrupt.	Use a valid file.
Error reading the TIQ file. File cannot be read.	<ul style="list-style-type: none"> <li>■ The .tiq file is corrupt and cannot be opened.</li> <li>■ The data contained in the .tiq file is not usable.</li> </ul>	Use a valid file.
Selected waveforms have different length.	Spectrum calculation requires waveforms of same length.	Select I and Q format waveforms of same length from the waveform list.
Unable to retrieve the license information.	The option key string or the serial number is incorrect.	Enter the correct option key string or serial number.
Invalid option string. CRC error in option string.	Incorrect option key string.	Enter the correct option key string.
Invalid option string. Incorrect unique ID.	Mismatch of the option key string and the associated serial number.	Enter the correct option key string and associated serial number.
Invalid option string.	Incorrect option key string.	Enter the correct option key string.
Compilation aborted. Waveform length exceeds the instrument memory.	The combination of waveform length and oversampling is such that the number of samples to be generated exceeds the maximum memory.	Change either the waveform length or the oversampling value so that the product does not exceed the instrument memory.
Compilation aborted. Waveform length exceeds the generation limit.	The combination of waveform length and oversampling is such that the number of samples to be generated exceeds the maximum memory.	Change either the waveform length or the oversampling value so that the product does not exceed the instrument memory.
Maximum number of entries in multipath table:10	The maximum number of paths that you can define in 10.	Do not define more than ten paths.
The delay cannot be the same for different paths.	No two paths can have the same delay value.	Change the delay to a unique value.
Invalid waveform name entered.	An invalid waveform name has been entered.	Enter a valid waveform name.
File name cannot exceed 30 characters. File cannot be imported.	The file name is too long.	Rename the file. Make sure that the new name is 30 characters or less.
Error while setting the oscilloscope record length.	RFXpress could not set the required oscilloscope record length.	Try the operation again. Ensure that the SignalVu Vector Signal Analysis software is not running on the oscilloscope.

Error message	Description	Possible solution
Invalid ADS® file.	The provided ADS® format file is invalid.	Provide a valid ADS® file.
Invalid VSA® file.	The provided VSA® format file is invalid.	Provide a valid VSA® file.
Waveform length exceeds the instrument memory. Please enter a new sampling rate.	This message appears when the application runs in the offline mode (that is on the PC).	Enter a new sampling rate such that the resulting waveform length lies within the instrument memory limit.
Waveform length exceeds the generation limit. Please enter a new sampling rate.	This message appears when the application runs in the online mode (that is on the AWG).	Enter a new sampling rate such that the resulting waveform length lies within the AWG memory limit.
Unable to import a file with the sampling rate equal to zero.	This message appears when the sampling rate specified in the file is zero.	Enter a non-zero sampling rate.

## Shortcut Keys

Menu/Menu item	Shortcut key
File	Alt+F
File> Open Setup...	Ctrl+O
File> Save Setup	Ctrl+S
View	Alt+V
Configure	Alt+C
Waveform	Alt+A
System	Alt+S
Window	Alt+W
Help	Alt+H

## RFXpress Options and AWG Models

### Generic and Radar Signals

The following tables list the AWG models and options to generate generic and radar signals using RFXpress.

**Table 147: AWG models and options for generic and radar signal generation**

Instrument model	Direct RF	IF from AWG	IQ from AWG	Hardware signal addition
AWG7102	Yes	Yes	Yes	No
AWG7101	Yes	Yes	No	No
AWG7052	No	Yes	Yes	No

**Table 147: AWG models and options for generic and radar signal generation (cont.)**

Instrument model	Direct RF	IF from AWG	IQ from AWG	Hardware signal addition
AWG7051	No	Yes	No	No
AWG5014	No	Yes	Yes	Yes
AWG5012	No	Yes	Yes	Yes
AWG5004	No	Yes	Yes	Yes
AWG5002	No	Yes	Yes	Yes

**Table 148: AWG B Series models and options for generic and radar signal generation**

Instrument model	Direct RF	IF from AWG	IQ from AWG	Hardware signal addition
AWG7122B	Yes	Yes	Yes	No
AWG7121B	Yes	Yes	No	No
AWG7062B	No	Yes	Yes	No
AWG7061B	No	Yes	No	No
AWG5014B	No	Yes	Yes	Yes
AWG5012B	No	Yes	Yes	Yes
AWG5004B	No	Yes	Yes	Yes
AWG5002B	No	Yes	Yes	Yes

## UWB-WiMedia

The following tables list the AWG models and options to generate UWB-WiMedia signals using RFXpress.

**Table 149: AWG models and options for UWB-WiMedia signal generation**

Instrument model	Direct RF	IF from AWG	IQ from AWG	Calibration	Remarks
AWG7102 – Opt 06	Yes, BandGroup1 and BandGroup2	Yes	Yes	Yes	Recommended option for Direct RF generation.
AWG7102 – Standard	No	Yes	Yes	Yes	Not recommended for Direct RF generation.
AWG7101– Standard	No	Yes	No	Yes	N/A
AWG7101– Opt 02	Yes, BandGroup1	Yes	No	Yes	Not recommended for Direct RF generation.
AWG7052	No	Yes	Yes	Yes	N/A
AWG7051	No	Yes	No	Yes	N/A
AWG5014	No	No	Yes	No	Only Non hopping IQ.
AWG5012	No	No	Yes	No	Only Non hopping IQ.

**Table 149: AWG models and options for UWB-WiMedia signal generation (cont.)**

Instrument model	Direct RF	IF from AWG	IQ from AWG	Calibration	Remarks
AWG5004	No	No	No	No	N/A
AWG5002	No	No	No	No	N/A

**Table 150: AWG B Series models and options for UWB-WiMedia signal generation**

Instrument model	Direct RF	IF from AWG	IQ from AWG	Calibration <sup>1</sup>
AWG7122B – Opt 06	Yes, all BandGroups (BandGroup1 to BandGroup6)	Yes	Yes	Yes
AWG7122B – Opt 02	Yes, BandGroup1, BandGroup2	Yes	Yes	Yes
AWG7122B – Std	Yes, BandGroup1	Yes	Yes	Yes
AWG7121B – Opt 02	Yes, BandGroup1, BandGroup2	Yes	No	Yes
AWG7121B – Std	Yes, BandGroup1	Yes	No	Yes
AWG7062B	No	Yes	Yes	Yes
AWG7061B	No	Yes	No	Yes
AWG5014B	No	No	Yes <sup>2</sup>	No
AWG5012B	No	No	Yes <sup>2</sup>	No
AWG5004B	No	No	No	No
AWG5002B	No	No	No	No

<sup>1</sup> Supports RF/IF calibration

<sup>2</sup> Supports non-band hopping IQ signals

## AWG Specifications

For information on the specifications of the AWG5000 and AWG7000 series instruments, refer to the following documents:

- *AWG5000 Series Arbitrary Waveform Generators Specifications and Performance Verification Technical Reference*, Tektronix part number 071-2082-XX.
- *AWG5000B Series Arbitrary Waveform Generators Specifications and Performance Verification Technical Reference*, Tektronix part number 071-2486-XX.
- *AWG7000 Series Arbitrary Waveform Generators Specifications and Performance Verification Technical Reference*, Tektronix part number 071-1853-XX.
- *AWG7000B Series Arbitrary Waveform Generators Specifications and Performance Verification Technical Reference*, Tektronix part number 071-2487-XX.

You can view the documents from Start > All Programs > Tektronix > AWG > Documentation.

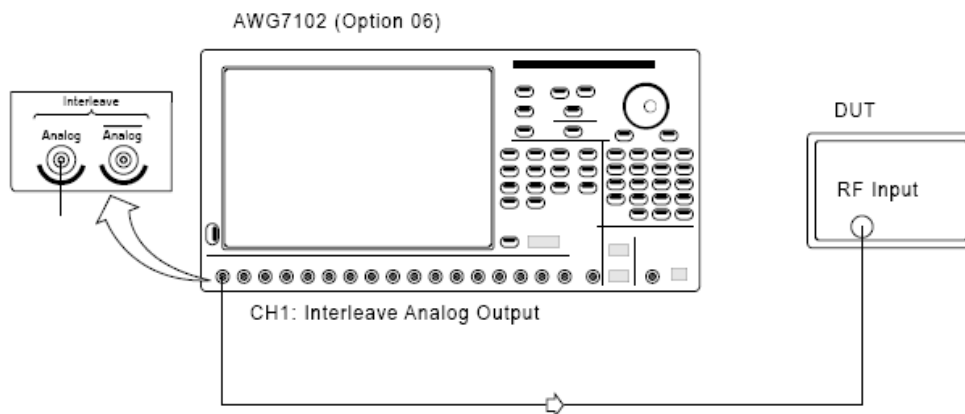
## Interleave

The AWG7000 with Option 06 supports the interleaving mode. Interleaving is a mode where the sampling rate ranges from 10 GS/s to 20 GS/s. The following table shows the amplitude and sampling rates for the interleaving and non-interleaving modes.

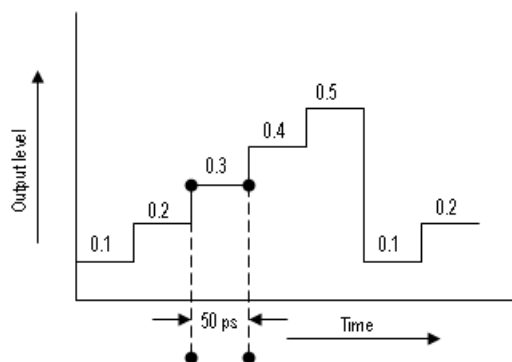
**Table 151: Amplitude and sampling rates in Non-Interleave and Interleave modes**

Non-Interleaving		Interleaving	
Amplitude (min, max)	Sampling rate (min, max)	Amplitude (min, max)	Sampling rate (min, max)
500 mVpp, 1 Vpp	10 MS/s, 10 GS/s (for AWG7102)	500 mVpp, 1 Vpp	10 GS/s, 20 GS/s (for AWG7102)
	10 MS/s, 12 GS/s (for AWG7122B)		12 GS/s, 24 GS/s (for AWG7122B)

In the Interleaving mode, the output is available in a separate interleave connector as shown in the figure.



As an example, in the non-interleave mode let the sampling rate be 20 GS/s and the original amplitude samples be 0.1, 0.2, 0.3, 0.4, 0.5, 0.1, 0.2. This can be represented graphically as shown in the following figure (not drawn to scale).

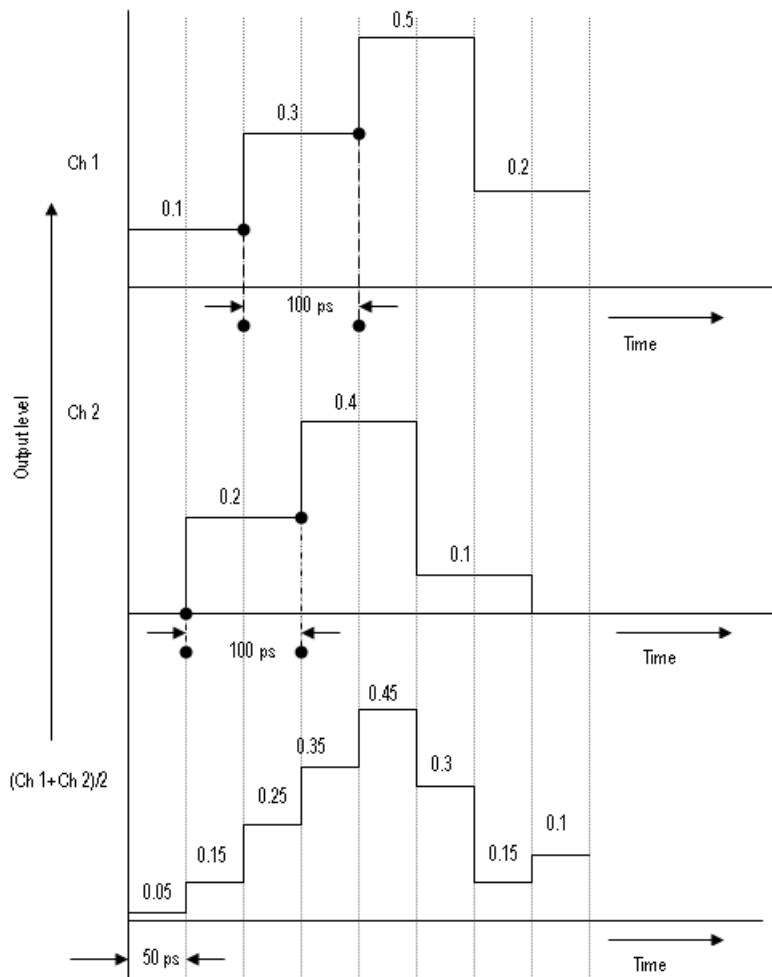




In the interleave mode, alternate samples are output from each channel. The samples are distributed between the two channels as shown below:

Ch1	Ch2
0.1	0.2
0.3	0.4
0.5	0.1
0.2	0

This can be represented graphically as shown in the following figure (not drawn to scale).



### Zeroing

When Interleave is on, you can turn Zeroing on or off. This function is only available when Interleave is available. If you compose waveform data that is divided into two channels, the zeroing function allows you to select whether you want to handle each waveform as RZ (Return to Zero) or NRZ (Non Return to Zero).

If you turn the zeroing function on, the bandwidth increases. However, spurious characteristics will worsen (increase in the frequency spectra that should not be output) and the amplitude range will be halved.

## PRBS Editor Starting Values

When the option **Use different PRBS at the beginning** is selected, the starting value for each PRBS varies. The following table gives the initial shift register values and the PRBS polynomial expression:

**Table 152: Initial shift values and PRBS polynomial expressions**

PRBS	Initial PRBS	Polynomial for the Standard PRBS
PRBS 7	0 0 0 0 0 0 1	$X^7+X^6+1=0$
PRBS 9	0 0 0 0 0 0 0 0 1	$X^9+X^5+1=0$
PRBS 15	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	$X^{15}+X^{14}+1=0$
PRBS 16	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	$X^{16}+X^{14}+X^{13}+X^{11}+1=0$
PRBS 20	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	$X^{20}+X^{17}+1=0$
PRBS 21	0 1	$X^{21}+X^{19}+1=0$
PRBS 23	0 1	$X^{23}+X^{18}+1=0$

## Amplifier Distortions

Nonlinear amplifier distortions (AM/AM and AM/PM) are calculated using the following equations:

$$Distortion_{AM/AM} = k3_{AM/AM} \times Magnitude_{Norm}^3 + k5_{AM/AM} \times Magnitude_{Norm}^5$$

$$Distortion_{AM/PM} = k3_{AM/PM} \times Magnitude_{Norm}^3 + k5_{AM/PM} \times Magnitude_{Norm}^5$$

## Nonlinear Impairments

### AM/AM

Nonlinear modulator AM/AM impairments are calculated using the following equations:

$$InphaseError_{Mag} = k2_{AM/AM} \times InphaseComp^2 + k3_{AM/AM} \times InphaseComp^3$$

$$QuadratureError_{Mag} = k2_{AM/AM} \times QuadratureComp^2 + k3_{AM/AM} \times QuadratureComp^3$$

The inphase and quadrature distortions are applied to the signal as follows:

$$NewInphase = InphaseComp + InphaseError_{Mag}$$

$$NewQuadrature = QuadratureComp + QuadratureError_{Mag}$$

### AM/PM

Nonlinear modulator AM/PM impairments are calculated using the following equations:

$$InphaseError_{Phase} = k2_{AM/PM} \times InphaseComp^2 + k3_{AM/PM} \times InphaseComp^3$$

$$QuadratureError_{Phase} = k2_{AM/PM} \times QuadratureComp^2 + k3_{AM/PM} \times QuadratureComp^3$$

The inphase and quadrature distortions are applied to the signal as follows:

$$NewInphase = InphaseComp \times \cos(InphaseError_{Phase}) - QuadratureComp \times \sin(QuadratureError_{Phase})$$

$$NewQuadrature = QuadratureComp \times \cos(QuadratureError_{Phase}) + InphaseComp \times \sin(InphaseError_{Phase})$$

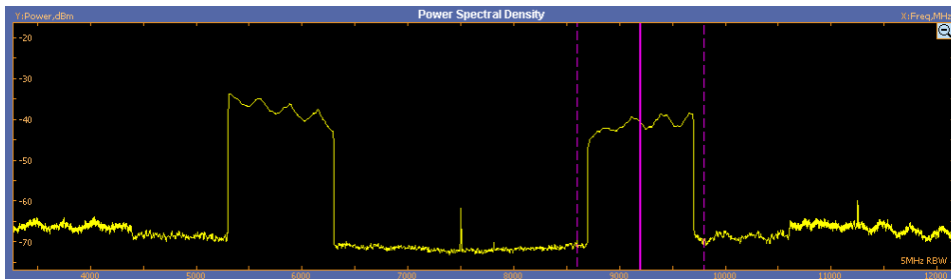
## Image Calibration

When a digital signal is converted to an analog signal through the DAC, the signal spectrum will repeat every harmonic of the sampling rate ( $F_s$ ). The spectrum of the reconstructed signal will show the signal spectrum and its image around the sampling rate.

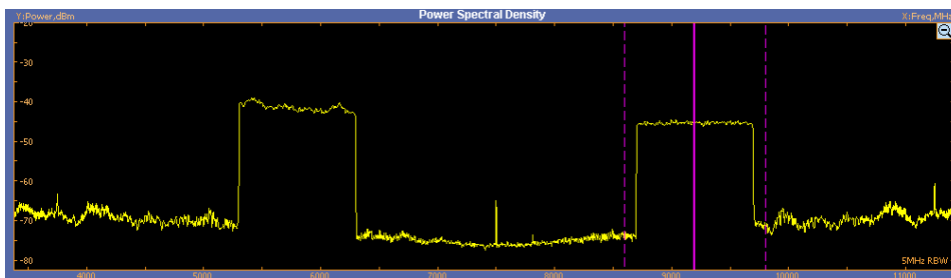
For example, if a signal with a center frequency of 5.8 GHz and a bandwidth of 1 GHz is created with a sampling rate 15 GHz, the positive signal spectrum out of the DAC will show spectral components at:

- 5.8 GHz with a bandwidth of 1GHz
- 9.2 GHz with a bandwidth of 1 GHz (This is an image with I and Q swapped and inverted in phase)
- 20.8 GHz with a bandwidth of 1 GHz
- 24.2 GHz with a bandwidth of 1 GHz (This is an image with I and Q swapped and inverted in phase)

The following figure shows the image signal at 9.2 GHz.



RFXpress can create a signal above Nyquist ( $F_s/2$ ) using undersampling. Calibration would allow you to get a flat frequency and linear phase response in the first image of the signal, in this example at 9.2 GHz. RFXpress also provides for swapping of I and Q (in the IQ impairments tab) and phase inversion of I and Q (in the Compile Settings dialog box) to create undersampled signals.



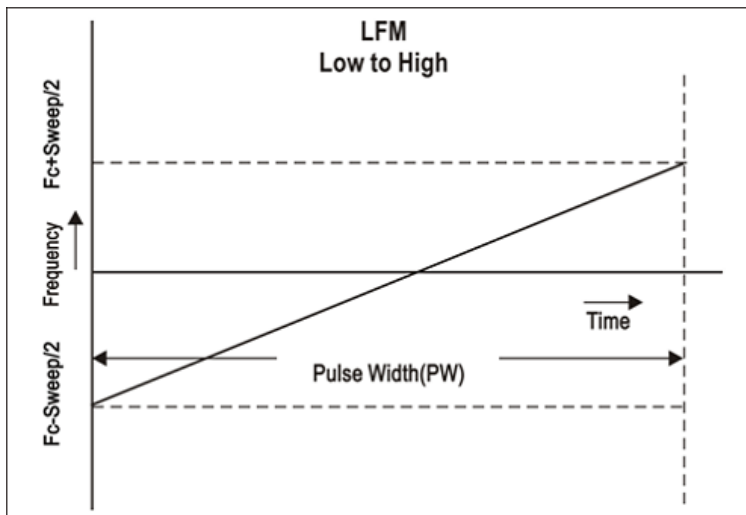
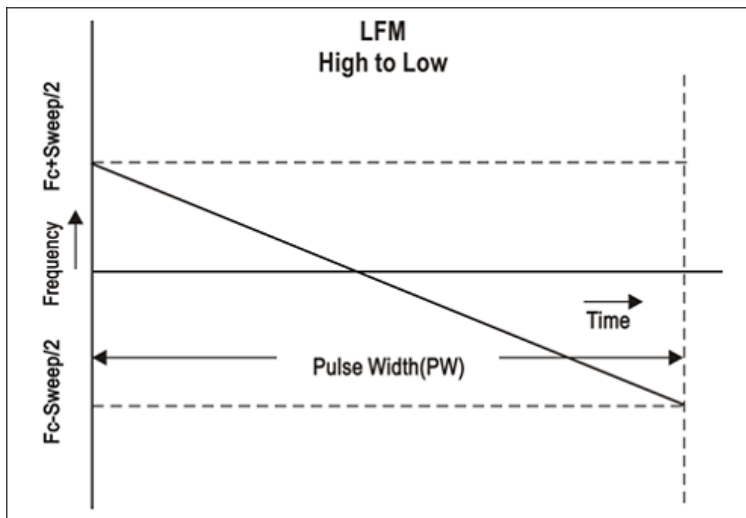
## Types of Modulation

### No Modulation

This modulation will generate a simple, constant-frequency pulsed waveform. The carrier frequency is not modulated.

### Linear Frequency Modulation (LFM)

In Linear Frequency Modulation or Chirp Modulation, the frequency is swept linearly across the pulse width. The sweep can be Low to High (upward) or High to Low (downward). You provide the frequency sweep range. LFM is used to achieve higher bandwidths in pulse compression radars.



### Up Down Chirp Modulation

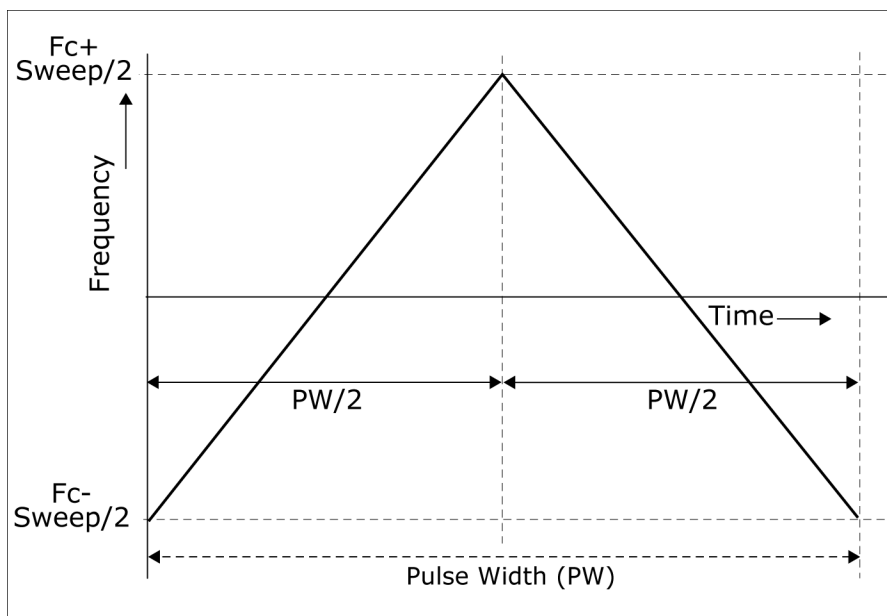
Up-down chirp modulation varies the frequency of the carrier from  $-\text{Sweep Range}/2$  to  $+\text{Sweep Range}/2$  and then again from  $+\text{Sweep Range}/2$  to  $-\text{Sweep Range}/2$ .

For Number of Up-downs = 1 and Invert = OFF, the pulse width is divided into two. The first half of the pulse will have linear chirp from  $-\text{Sweep}/2$  to  $+\text{Sweep}/2$  and the second half of the pulse will have linear chirp from  $+\text{Sweep}/2$  to  $-\text{Sweep}/2$  creating an inverted 'V' chirp within the total pulse width.

When Invert is enabled (set to ON), the modulation creates a 'V' shaped frequency profile. When the Number of Up-downs is greater than 1 ( $n > 1$ ), the modulation creates multiple (n) number of 'V's or Inverted 'V's. The subpulse width of each V is equal to  $\text{Pulse Width}/n$ .

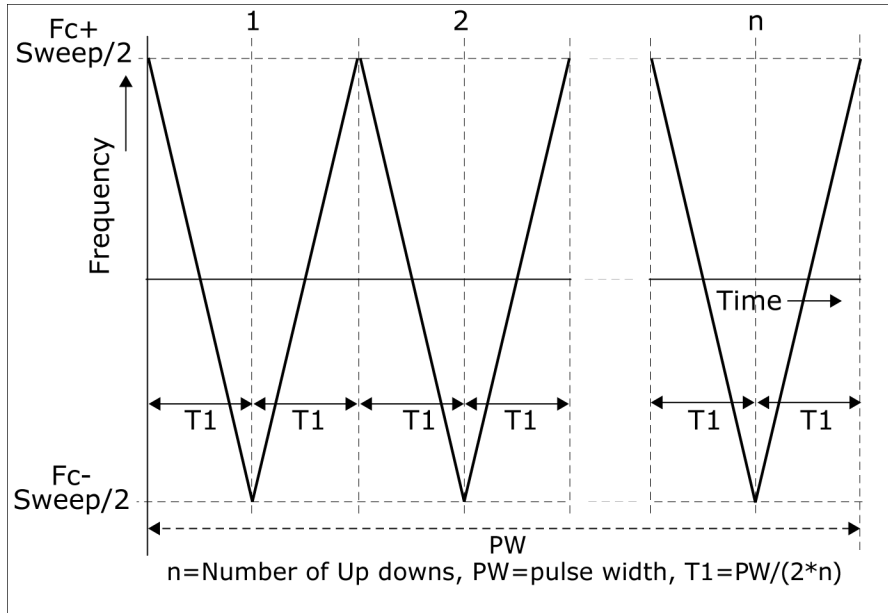
RFXpress uses four types of Up-Down Chirp modulation. They are:

- Up Down Chirp with a single up-down





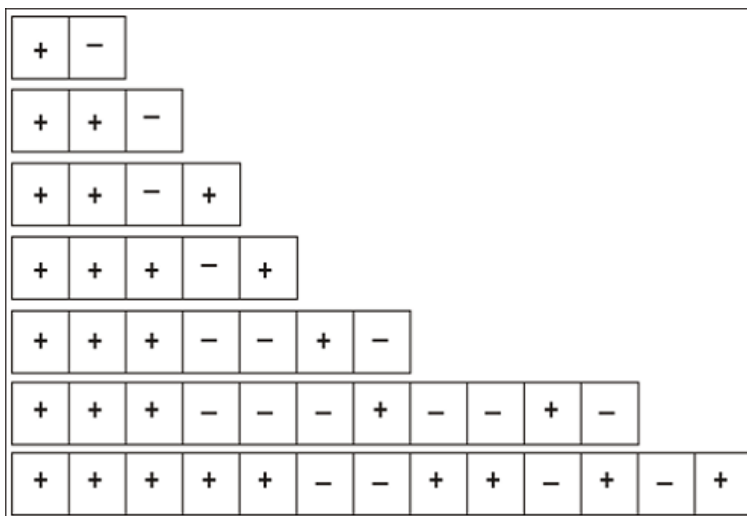
- Up Down Chirp with multiple up-downs inverted



### Biphase Coded Pulses and Barker Codes

Biphase codes refer to a type of phase-coded pulse waveforms. In phase-coded waveforms, the frequency of the pulse width is held constant, but the absolute phase is switched between one of the N fixed values. Each pulse width is divided into M subpulses (or chips), where each of the subpulses are switched between one of the N phase values.

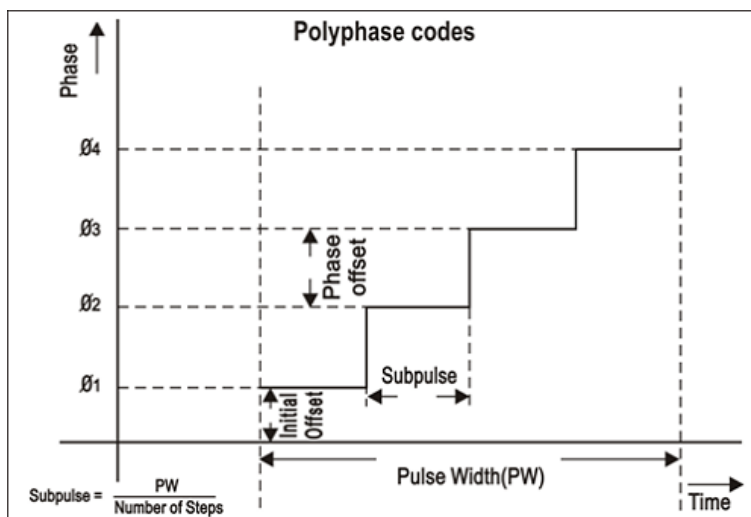
In Biphase Coded Pulses, N=2. The most important biphase codes are Barker codes, where the phase is switched between 0 and 180 degrees. The number of subpulses is defined by the Barker Code number, for example Barker 11 has eleven subpulses. The Barker codes are predefined.





### Polyphase Codes

Polyphase codes are a type of phase-coded pulse waveforms. You can define the number of subpulses by providing number of steps. An initial offset provides the phase for the first pulse and the phase offset provides the offset in phase for subsequent subpulses.

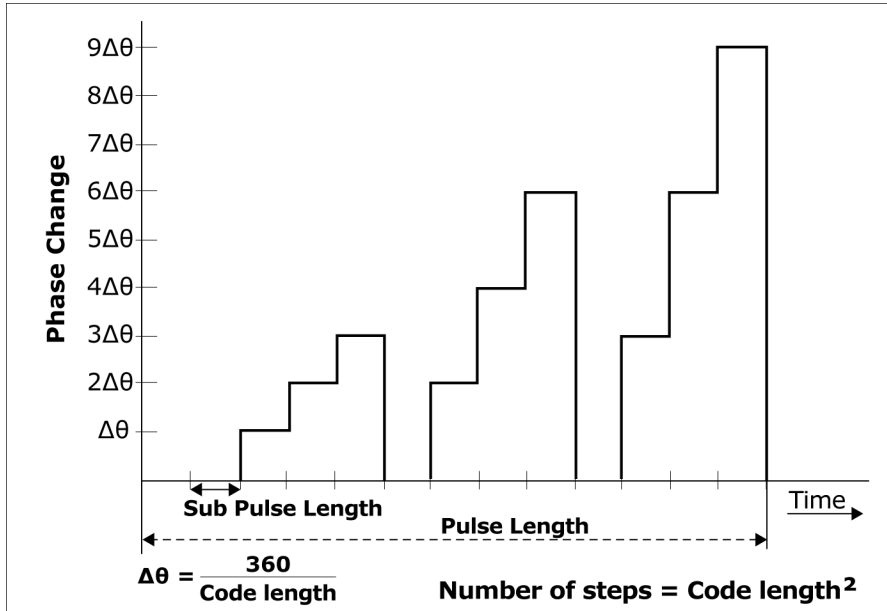


### Frank Code

Frank code is a type of Polyphase code, where the pulse width is divided into  $(\text{Code length})^2$  subpulses. For example, a code length of 4 will have 16 subpulses of equal width. The phase for each of the subpulses is derived from the formula:

$$\text{Phase}(p,q) = 2 \cdot \pi \cdot p \cdot q / \text{Code length}$$

where  $p=0, 1, 2, \dots, \text{code length}-1$  and  $q=0, 1, 2, \dots, \text{code length}-1$



### P1 Polyphase Code

P1 code is another type of Polyphase code, where the pulse width is divided into (Code length)<sup>2</sup> subpulses. For example, a code length of 4 will have 16 subpulses of equal width. The phase for each of the subpulses is derived from the formula:

$$\text{Phase}(p,q) = -180/\text{Codelength} * (\text{Codelength} - 2 * p - 1) * [(p-1) * \text{Codelength} + (q-1)]$$

where  $p=1, 2, \dots, \text{code length}$  and  $q=1, 2, \dots, \text{code length}$

$$\text{Phase}(i,j) = \frac{-180}{\text{CL}} \times [\text{CL} - (2j-1)] \times [(j-1) \times \text{CL} + (i-1)]$$

**Where:**

$i$  &  $j$  are integers ranging from 1 to Code length

**CL** = Code length

### P2 Polyphase Code

P2 code is yet another type of Polyphase code, where the pulse width is divided into (Code length)<sup>2</sup> subpulses. For example, a code length of 4 will have 16 subpulses of equal width. The phase for each of the subpulses is derived from the formula.

$$\text{Phase}(p,q) = \left[ \left( \frac{180}{\text{Code length}} \right) * \left( \frac{\text{Code length} - 1}{\text{Code length}} \right) - \left( \frac{180}{\text{Code length}} \right) * (p-1) \right] * [\text{Code length} + 1 - (2 * q)]$$

where p=1, 2, ... code length and q=1, 2, .. code length.

$$\text{Phase (i,j)} = \left[ \left( \frac{180}{2} \right) * \frac{(\text{CL}-1)}{\text{CL}} \right] * \left[ \left( \frac{180}{N} \right) i - 1 \right] * [\text{CL} + 1 - 2j]$$

**Where:**

i & j are integers ranging from 1 to Code length

**CL** = Code length

### P3 Polyphase Code

P3 code is yet another type of Polyphase code, where the pulse width is divided into (Code length)<sup>2</sup> subpulses. For example, a Code length of 4 we will have 16 subpulses of equal width. The phase for each of the subpulses is derived from the formula:

$$\text{Phase}(p) = 180 * (p-1)^2 / \text{code length}^2$$

where p=1, 2, .....code length<sup>2</sup>.

$$\text{Phase (i)} = \frac{180 \times (i-1)^2}{(CL)^2}$$

**Where:**

i is an integer ranging from 1 to Code length<sup>2</sup>

**CL** = Code length

**P4 Polyphase Code**

P4 code is yet another type of Polyphase code, where the pulse width is divided into (Code length)<sup>2</sup> subpulses. For example, a Code length of 4 we will have 16 subpulses of equal width. The phases for each of the subpulses is derived from the formula:

$$\text{Phase(p)} = [180 \times (p-1)^2 / \text{code length}^2] - [180 \times (p-1)]$$

where p=1, 2, .....code length<sup>2</sup>.

$$\text{Phase (i)} = \left[ \frac{180 \times (i-1)^2}{CL^2} \right] - [180 \times (i-1)]$$

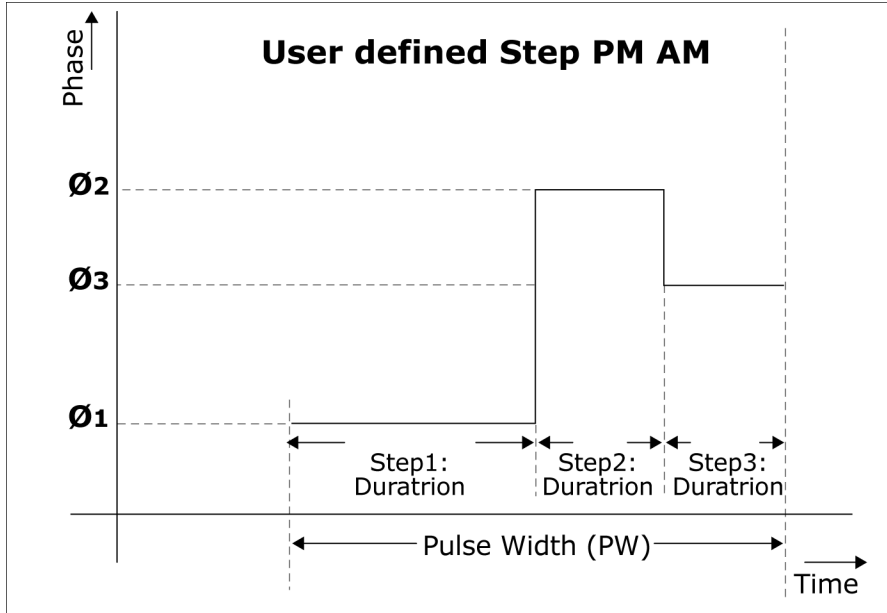
**Where:**

i is an integer ranging from 1 to Code length<sup>2</sup>

**CL** = Code length

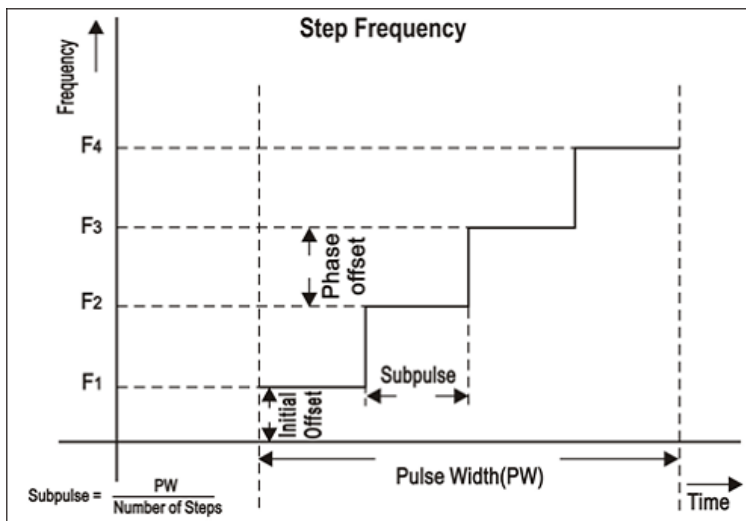
### User Defined Step PM AM

User defined codes allow you to define your own phase coding. The number of subpulses is defined by the total number of steps. You define the duration, phase, and amplitude of each subpulse. Use user defined codes to create Biphase codes that are not predefined or to create Frank's code.



### Step Frequency Modulation

Step Frequency creates a frequency modulated pulse waveform. The pulse width is divided into subpulses and each subpulse can have a different frequency. The number of subpulses can be defined by number of steps. The initial step provides the frequency for the first subpulse and the step size provides the frequency offset for subsequent subpulses.



### Nonlinear Frequency Modulation

Nonlinear FM can be used to define a frequency modulation which can have a nonlinear profile unlike the Linear FM under LFM.

Nonlinear FM uses the coefficients to create the instantaneous frequencies for modulation.

$F(t) = 2\pi C(t)t$ , where  $C(t)$  is the instantaneous frequency.

Instantaneous frequency  $C(t)$  can be defined by following polynomial:

$C(t) = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots$ , where  $c_0, c_1, c_2$  and others are the coefficients with order 0, 1, 2, ... and others.

The following MATLAB code generates the Taylor weighting curve.

```
function coeff = createcoeff_nonSymmetrical(Pulsewidth,BW,NoofCoefficients);
% Tektronix
% This function will create coeffecients for
% non-symmetrical Non linear FM profile.(with 40dB Taylor weighting)
% Reference : Radar Handbook: Merrill Skolnik
% This free software may not have gone through Tektronix normal quality
% control or production processes, but is provided to users as an
% accommodation to respond to user requests. The free software is provided
% hereunder on an As-Is basis without any representation or warranty.
% TEKTRONIX DISCLAIMS ALL WARRANTIES, WHETHER EXPRESS OR IMPLIED, INCLUDING
% WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE,
% AND NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT SHALL
% TEKTRONIX
% BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL
% DAMAGES IN ANY WAY ARISING OUT OF, OR CONNECTED WITH, THE USE OF THIS
% FREE SOFTWARE.
%Example:

%Pulsewidth=30e-6;
%NoofCoefficients=15;
%BW=10e6; % Bandwidth

NumberofSamples=100000;
Fs=NumberofSamples/Pulsewidth; % Sampling Rate

curve=zeros(1,NumberofSamples); % This will contain the frequency vs time
profile
t=-NumberofSamples/(2*Fs):1/Fs:(NumberofSamples-1)/(2*Fs);

K(1) = -0.1145;
K(2) = 0.0396;
K(3) = -0.0202;
K(4) = 0.0118;
K(5) = -0.0082;
K(6) = 0.0055;
```

```

k(7) = -0.0040;

for k=1:1:NumberOfSamples,
    y=sum(K(1:7).*(sin(2*pi*(1:7)*t(k)/Pulsewidth)));
    curve(k)=BW*((t(k)/Pulsewidth) + y);
end

timeindex=[0:Pulsewidth/(NumberOfSamples-1):Pulsewidth];
s = warning('off', 'MATLAB:polyfit:RepeatedPointsOrRescale');
coeff = polyfit(timeindex,curve,NoofCoefficients-1);
warning(s.state, s.identifier);
coeff=coeff(end:-1:1);

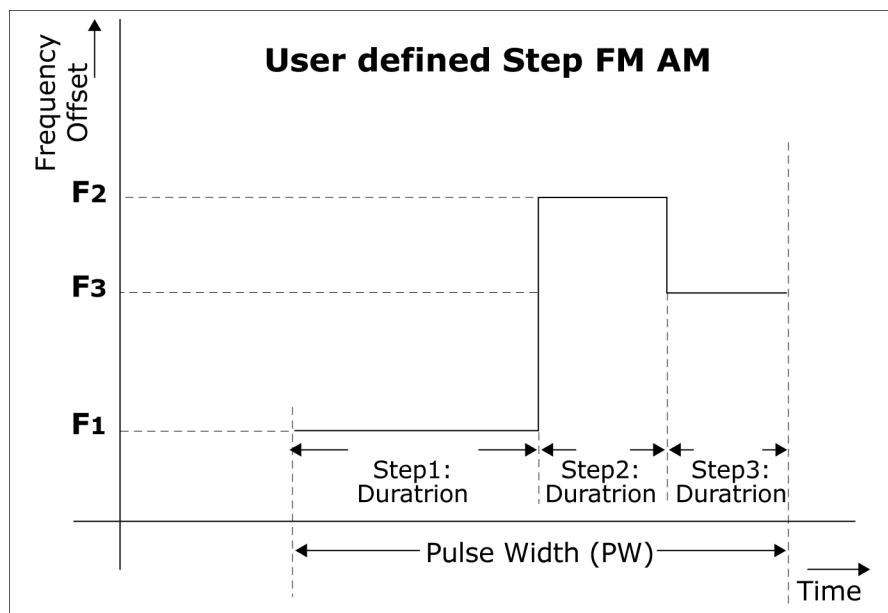
testcurve = zeros(1,NumberOfSamples);
for n = 1:NoofCoefficients
    testcurve = testcurve + coeff(n) * (timeindex .^ (n-1));
end

figure(1);
plot(curve, 'b');hold on; plot(testcurve, 'r'); hold off;
legend('Original NLFM Curve', 'From Coefficients');

```

### User Defined Step FM AM

User defined codes allows you to define your own frequency agile signals or frequency hopping within the pulse width. The number of subpulses is defined by the total number of steps. You define the duration, the frequency offset from the carrier, and the amplitude of each subpulse. User defined step FM AMs can be used to create Costa's Code modulation.



### QPSK

Each pulse is divided into number of symbols where the duration of each subpulse is equal to Pulse Duration/Number of Symbols. Random symbols are generated and the phase for each of the symbols is based on the following equation. You can have the same symbols for all the pulses in the pulse group or can select to have different symbols.

$$\text{Phase} = \frac{(360 \times n_k + 45)}{4}$$

**Where:**

$n_k$  (integers) are random symbols with values ranging from 0 to 3

### BPSK

Each pulse is divided into number of symbols where the duration of each subpulse is equal to Pulse Duration/Number of Symbols. Random symbols are generated and the phase for each of the symbols is based on the following equation. You can have the same symbols for all the pulses in the pulse group or can select to have different symbols.



$$\text{Phase} = \frac{(360 \times n_k)}{2}$$

**Where:**

$n_k$  (integers) are random symbols with values ranging from 0 to 1

**Custom Modulation**

Custom Modulation accommodates user defined phase modulation by providing a phase profile in ASCII or in MATLAB .mat files.

## Frequently Asked Questions

1. How do you set your own Biphase and Polyphase codes?

Under Modulation, use the User Defined Codes option to define your own phase codes. Define the number of subpulses by the total number of steps and define the phase for each sub-pulse.

2. How many pulse definitions can you have?

You can define upto 4096 pulse groups.

3. Is the number of pulse definitions really just limited by the waveform memory used by each definition?

You can define upto 4096 pulse groups. But the overall waveform length (total waveform length of all the pulse groups) cannot exceed the maximum waveform memory.



# Index

## A

- About basic operations, 9
- Adjust Frequency Parameters, 65
- Adjust Pulse Time Parameters, 65
- Advanced settings
  - AWG, 158
  - PSG, 161
- AM/AM parameters, 119
- AM/PM parameters, 119
- Amplifier distortion
  - AM/AM, 200
  - AM/PM, 200
  - generic signal, 89
  - UWB-WiMedia, 118
- Antenna
  - radar, 142
- Application, 14
  - Generic signal, 22
  - Radar, 22
  - select, 22
  - UWB-WiMedia, 22
- AWG, 10
  - control, 158
  - event options, 169
  - interleave, 198
  - models, 195
  - sequence view, 167
  - settings view, 167
  - specifications, 197
  - trigger options, 169
- AWG Run Mode, 65

## B

- Basic setup
  - OFDM, 149
- Biphase coded pulse
  - Barker, 135
- BPSK, 135

## C

- Calibration, 53
  - IF/RF signals, 129

## Clip

- magnitude, 151
- Clipping
  - ratio, 151
- Coherent carrier, 131
- Coherent pulse interval, 178
- Compile, 22
  - preferences, 67
- Compile settings, 32
  - automatic, 65
  - for OFDM, 66
  - for radar, 64
- Conformance mode, 99
  - hopping details, 104
  - packet details, 102
  - packet group details, 100
- Conventions, 2
- Convolution coding, 71
  - OFDM, 150
- Correction files, 34
  - applying, 130
  - creating, 129
- Custom mode, 99
  - MAC header, 114
  - packet group details, 105
  - packet sync sequence, 110
  - PHY header, 113
  - PLCP header, 108
  - PLCP preamble, 107
  - PPDU details, 106
  - PSDU, 109
- Custom modulation, 135
- Custom settings, 61

## D

- Data
  - importing, 24
  - opening, 23
  - organization within a file, 44
  - saving, 24
- Data files, 14
  - .rfd, 13

- Data source values
  - from file, 42
- Distortion
  - amplifier, 118
  - OFDM, 155
- Distortion addition
  - amplifier distortion, 118
- DUT Characterization, 52

## E

- Editing carrier details, 77
- Error messages
  - AWG sequence window, 186
  - DUT characterization, 191
  - generic signal, 179
  - miscellaneous, 192
  - OFDM, 186
  - radar, 182
  - RTSA connectivity, 192
  - UWB-WiMedia, 181
- Exiting the software, 13
- Eye diagram, 176

## F

- File
  - data, 14
  - File(1)Samples, 43
  - File(2)Symbols, 44
  - menu, 15
  - setup, 14
  - .smp, 13
- File name extensions and application directories, 13
- Frame payload, 63
- Frames
  - OFDM, 153
- Frank code, 135
- Frequency hopping, 72
  - generic signal, 83
  - OFDM, 72

**G**

- Gated noise, 73
  - OFDM, 152
  - UWB-WiMedia, 123
- Generic signal
  - frequency hopping, 83
- Graphs, 30
  - CCDF, 173
  - coherent pulse interval, 178
  - constellation, 175
  - eye diagram, 176
  - from external data, 32
  - $I(t)$ ,  $Q(t)$ , 172
  - previewing, 31
  - pulse shape, 171
  - spectrogram, 177
  - spectrum, 174

**H**

- Hop time
  - methods, 84
- Hopping
  - generic signal, 83
  - Pseudo-Random (Avoid List), 84
  - Pseudo-Random (Range), 83
  - radar, 140
- Hopping pattern, 59
  - UWB-WiMedia, 59

**I**

- I/Q impairments
  - carrier leakage, 144
  - hardware skew, 144
  - I/Q Swap, 145
  - quadrature error, 145
- I/Q Impairments
  - carrier leakage, 86
  - hardware skew, 89
  - I/Q Imbalance, 116
  - nonlinear distortion, 88
  - quadrature error, 115
- I/Q Swap, 145
- imported waveform, 21
- Importing data from a file or an oscilloscope, 24
- Installation, 4

Installation Manual, 4

**Instruments**

- AWG, 166
  - control, 161
  - find, 29
  - importing data, 28
  - oscilloscope, 160
- Interference addition**
- gated noise, 123
  - I/Q signal, 127
  - noise, 146
  - offset addition, 122
  - radar, 127
  - real-world signal, 127
  - signal addition, 91
  - sinusoidal interference, 95
  - WiFi (802.11a), 127
  - WiFi (MIMO), 127
  - WiMax, 127
- Interleave, 198

**L**

Linear frequency modulation, 135

**M**

- Marker mapping, 56
- Menu bar, 155
- Minimum system requirements, 3
- Modulation, 135
  - biphase coded pulse, 135
  - BPSK, 135
  - custom, 135
  - Frank code, 135
  - linear frequency, 135
  - no modulation, 135
  - nonlinear FM, 135
  - P1 Polyphase code, 135
  - P2 Polyphase code, 135
  - P3 Polyphase code, 135
  - P4 Polyphase code, 135
  - polyphase codes, 135
  - QPSK, 135
  - step frequency, 135
  - User defined FM AM, 135
  - user defined step PM AM, 135
  - wide band LFM, 135

**Multipath**

- generic signal, 90
- OFDM, 153
- parameters for carriers, 90
- radar, 142
- reference path, 91
- UWB-WiMedia, 119

**N**

- Nonlinear FM, 135
- Nonlinear impairments, 201
- Normalization, 35

**O****OFDM**

- basic setup, 149
  - clipping, 151
  - distortion, 155
  - frames, 153
  - packets, 152
  - symbols, 150
- On/Off, 23
- Open data, 23
- Open setup, 23
- Option
  - installation, 36
  - RFXpress and AWG models, 195
  - software, 3
- Ordering options, 3
- Oversampling, 34
- Overview window, 37

**P**

- P1 Polyphase code, 135
  - P2 Polyphase code, 135
  - P3 Polyphase code, 135
  - P4 Polyphase code, 135
- Packets**
- OFDM, 152
- Phase noise**
- OFDM, 154
- Polyphase codes, 135
- Power ramping, 85
- PRBS editor, 41
  - starting values, 200

- Preset
    - menu, 155
  - Preset menu
    - OFDM module, 155
  - Process preferences, 59
  - Pulse
    - modulation, 135
    - pulse envelope, 132
    - pulse impairments, 141
    - setup, 131
    - staggered PRI, 134
  - Pulse envelope, 132
  - Pulse impairments
    - amplitude, 141
    - jitter, 141
- Q**
- QPSK, 135
  - Quantization, 155
- R**
- Reed Solomon coding, 68
    - OFDM, 68
  - Reference path
    - values, 142
  - Related documentation, 1
  - RFXpress Options and AWG
    - models, 195
  - Run, 23
- S**
- S-Parameter, 96
  - Scramble editor, 70
    - OFDM, 70
  - Scrambling, 150
    - OFDM, 150
  - Sequence view, 167
    - event options, 169
    - trigger options, 169
  - Setup
    - base data, 79
    - carrier, 131
    - file, 14
    - filter, 81
    - IF signal generation, 5
    - IQ signal generation, 6
    - modulation, 80
    - multi carrier, 76
    - pulse, 131
    - radar, 131
    - RF signal generation, 4
      - .rfs, 14
      - saving, 23
      - single carrier, 75
  - Shortcut keys, 195
  - Signal addition
    - hardware, 121
    - software, 92
  - Signal format, 67
  - Signal generation, 12
    - conformance mode, 99
    - custom mode, 99
  - Software features, 10
  - Spectrogram, 177
  - Staggered PRI, 134
  - Starting the software, 12
  - Status bar, 19
  - Step frequency modulation, 135
  - Symbol map, 45
  - Symbols
    - OFDM, 150
- T**
- Tone nulling, 151
    - OFDM, 72
    - UWB-WiMedia, 58
  - Toolbar, 18
- U**
- User defined step FM AM, 135
  - User defined step PM AM, 135
- W**
- Waveform length, 34
  - Waveform list, 19
  - Welcome, 1
  - Wide band LFM, 135
- Z**
- Zoom, 171
    - I(t), Q(t), 172
    - spectrum, 174