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

Quick Start User Manual





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

Quick Start User Manual

Tektronix

www.tektronix.com 077-0159-05 Copyright © Tektronix. All rights reserved. Licensed software products are owned by Tektronix or its subsidiaries or suppliers, and are protected by national copyright laws and international treaty provisions.

Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specifications and price change privileges reserved.

TEKTRONIX and TEK are registered trademarks of Tektronix, Inc.

MATLAB®. Copyright 1984 - 2007 The MathWorks, Inc.

RFXpress® RFX100 is a registered trademark of Tektronix, Inc.

Contacting Tektronix

Tektronix, Inc. 14200 SW Karl Braun Drive P.O. Box 500 Beaverton, OR 97077 USA

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

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

Warranty

Tektronix warrants that the media on which this software product is furnished and the encoding of the programs on the media will be free from defects in materials and workmanship for a period of three (3) months from the date of shipment. If any such medium or encoding proves defective during the warranty period, Tektronix will provide a replacement in exchange for the defective medium. Except as to the media on which this software product is furnished, this software product is provided "as is" without warranty of any kind, either express or implied. Tektronix does not warrant that the functions contained in this software product will meet Customer's requirements or that the operation of the programs will be uninterrupted or error-free.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period. If Tektronix is unable to provide a replacement that is free from defects in materials and workmanship within a reasonable time thereafter, Customer may terminate the license for this software product and return this software product and any associated materials for credit or refund.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THE PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPLACE DEFECTIVE MEDIA OR REFUND CUSTOMER'S PAYMENT IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

[W9b - 15AUG04]

Table of Contents

General	Safety Summary
Preface.	
Key	/ Features
Doc	cumentation
Cor	nventions Used in This Manual
Installati	on
Sta	rting the Software
Clo	sing the Software
Sof	tware Upgrades
Using th	e Software
Get	tting Acquainted with the Software
Ger	nerating a Single Carrier Signal
Ger	nerating a Multi-Carrier RF Signal
Rep	olay a Captured Waveform to Test Receivers
Cal	ibrating a Generic Signal
App	blying Calibration to an Imported Custom Signal
Cha	aracterizing a Low-pass Wideband Filter (DUT)
Cre	ating a UWB Waveform to Test Your Receivers
Applicati	ion Examples: Generic Signal
Sim	nulating a Multi-Path Environment for a Generic Signal
Cre	ating a Hopping Waveform to Test Radio Signal Identification and Detection Systems
S-P	Parameter Emulation of a High Pass Filter
Applicati	ion Examples: UWB-WiMedia
Cha	aracterize Receiver Design for Receiver Verification and Stress Test
Usi	ng Calibration to Increase the Flatness of a UWB Signal Path to the DUT
Intr	oducing Real-World Impairments in a UWB Signal
Applicati	ion Examples: Radar
	nerating an LFM Waveform with Coherent Carrier for Pulse Compression Radar
Ger	nerating a Hopping Radar Waveform: Creating a Pulse-to-Pulse Frequency Hopping Signal
Cre	ating Costa's Modulation
Cre	ating a Radar Waveform using Staggered PRI for Better Range Ambiguity
Sim	nulating Multiple Targets for Radar Receiver Testing (Different Pulse Groups)
Sim	nulating a Scanning Antenna with a Gaussian Shape
Applicati	ion Examples: OFDM
	ate a TG3c Standard OFDM Symbol
Cre	ate a WiFi Signal using a Preset and Adding Impairments
Index	

Table of Contents

General Safety Summary

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

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

Only qualified personnel should perform service procedures.

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

To Avoid Fire or Personal Injury

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

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

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

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

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

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

Terms in This Manual

These terms may appear in this manual:



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



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

Preface

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

You can use RFXpress to:

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

Key Features

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

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

UWB-WiMedia

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

Radar

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

OFDM

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

Documentation

RFXpress RFX100 Online Help, English	Tektronix part number 076-0081-XX
RFXpress RFX100 User Manual, English, (PDF)	Tektronix part number 077-0045-XX
RFXpress RFX100 Quick Start User Manual, English (PDF)	Tektronix part number 077-0159-XX
RFXpress RFX100 Installation Manual, English (PDF)	Tektronix part number 077-0160-XX
RFXpress RFX100 Programmer Online Help, English	Tektronix part number 076-0216-XX
RFXpress RFX100 Programmer Manual (PDF), English	Tektronix part number 077-0435-XX

Conventions Used in This Manual

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

The document MultiBand OFDM Physical Layer Specification version 1.2 by WiMedia Alliance is referred to as the "WiMedia standard" or "WiMedia specification".

The term "DUT" refers to a device under test.

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

Preface

Installation

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

Starting the Software

Start the software in either of the following ways:

- From Start > Program Files > Tektronix RFXpress, click RFXpress.
- Double-click the RFXpress icon on your desktop.

Closing the Software

Click File > Exit to close the software.

Software Upgrades

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

To check for upgrades:

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

Using the Software

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

Getting Acquainted with the Software

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

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

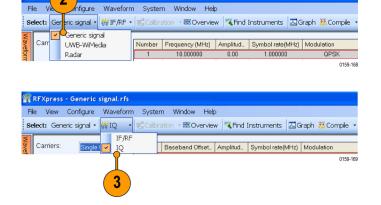
neric signal.rfs

Generating a Single Carrier Signal

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

- 1. Start RFXpress.
- From the toolbar, click Select > Generic signal.





- 4. Click Carriers > Single Carrier.
- 5. Select the carrier and set the following:
 - Baseband Offset to 0 Hz.
 - Amplitude to 1 Vrms.
- 6. Ensure that the following parameters are set:
 - Modulation is QPSK.
 - Filter is Raised Cosine.
 - Symbol rate is 1 MHz.
 - Alpha/B*T is 0.35.
 - Window is None.

🖁 RFXpress - Genei	ic signal rfs								
File View Configu	re Waveform	System	Window	Help					
Select: Generic signa	l • ₩IQ •	😴 Calibratio	on 🔹 🚟 Ove	rview	🌂 Find I	Instruments	🔼 Gra	oh 👯 Con	npile 🔹
Total carriers: 1 Setup Hopping Po Base data: P	RBS 🔽 9	1	aseband Offs 0.000000 Distortion Ac		mplitud 1.00 Multi-Path	Symbol rate(N 1.000000		Odulation QPSK Sub-Carrier	
Single Carr Baseband Offset:	0	H2	6	Am	nplitude:	1.00	Vrms		
Modulation: FSK peak deviation:	QPSK 1.000 k	v or	sre/s	>	iding: mbol rate	None 1.000000	M	✓ ✓ Hz	
Filter/Wind Filter: Alpha/B*T: Convolution length:	Raised Co 0.35 21	he symb	✓ ols	Vvi	ndow:	None		~	
									0159-1

Compiling a Signal

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

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

臔 RF	Xpres	s - Generic	signal.rfs						
File	View	Configure	Waveform	System	Window	Help			
Selec	t: Ge	neric signal •	₩IQ •	😴 Calbratio	n - 🔀 O	verview	Kind Instruments	Graph Compile	
8		_						Comp	le Settings
							(1	0159-171

2. Retain the default values as they are. **Compile Settings** Ensure that the Automatic options are symbols 🗸 🗸 Waveform length: 10.000 k Automatic selected. Signal Format 3. Click Compile. 2 🔘 IF/RF 🛛 💿 IQ I waveform name: Waveform1_I Q waveform name: vaveform1_Q O Sampling Rate 10.00000000 G Automatic Oversampling Compile Button Preferences Compiles and sends to: Compiles only Normalization Mode: Auto ~ Division factor: 1.000000 Adjust for wrap-around ☑ Overwrite waveform in RFXpress list 📃 l Invert 📃 Q Invert 3 ОK Compile Cancel Help 0159-32 4. The compiled waveform is displayed in 🌱 RFXpress - Generic signal.rfs the waveform list. File View Configure Waveform System Window Help Select: Generic signal - 🙀 IQ 🔹 🛒 Calbration 🐨 🚟 Overview 🛛 🤻 Find Instruments 🛛 🗔 Graph 👯 Compile Carriers: Single Carrier 💙 Number Baseband Offset.. Amplitud.. Syr Name Length Sa... Format Wavef... 10.0 k 10.0... I Wavef... 10.0 k 10.0... Q 1.00 4 0159-173

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

Generating a Multi-Carrier RF Signal

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

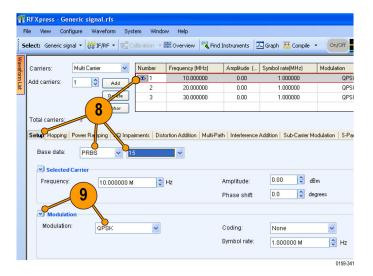


- 3. Select Multi Carrier.
- 4. You can either add carriers directly or delete the existing carrier and add new ones. Select the carrier in the table and click **Delete**.
- 5. Click Add carriers and type 3.
- 6. Click Range. Set the Base frequency to 10 M and the Carrier spacing to 10 M.
- 7. Click Add.

File View Configu 3 veform Svering Window Help	
File view configu 3 perorm survey window Fielp	
select: Generic signal F/RF + 4 Overview RFind Instruments AGraph 👯	Compile 🔹
Carriers: Multi Carrier	on
	PSK
Set Anchor	

P	RFXpress - Generic	signal.rfs						
Fi	le View Configure	Waveform	System	Window Help	þ			
Se	elect: Generic signal •	5	C alibra	tion 🔹 🚟 Overvie	w 💐 Find :	Instruments 🗔 G	iraph 👯Compile	•
Waveform List	Carriers: Multi C Add carriers: 3 Total carriers: 3 Setup Hopping Power Base data: PRB Multi Carrier Center Center Center frequency.	Add Delete et Anchor Ramping VO Ir S V 9	Number 1 7 npairment	Frequency (MHz) 10.00000 20.00000 30.00000 30.00000 5 Distortion A 2 4 4 5 4 5 4 5 6 6 7 6 7 7 6 7 7 6 7 7 7 7 7 7 7 7 7 7 7 7 7	Amplitud 0.00 0.00 0.00	Symbol rete(MHz) 1.000000 1.000000 1.000000 Interference Additio Amplitude: 0.000000 M	Modulation OPSK OPSK OPSK OPSK	dule
		50.000000 M 0.0	Random		Carrier spacing:	Ч 10.000000 М	🗘 Hz	
							0159-	-176

- Select the first carrier from the table. In the Setup tab, set the Base data to PRBS and select 15 from the adjacent field.
- 9. Set the Modulation for the carrier to QPSK.



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

Adding Power Ramping, I/Q Impairments, and Interference

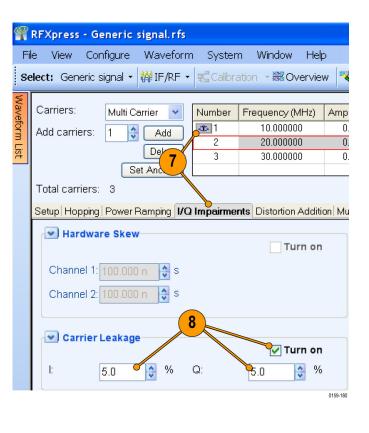
- Select the first carrier from the table. Select the Power Ramping tab.
- 2. Select Turn on.
- 3. Set the Ramp parameters:
 - Function to Linear.
 - Time to 100 ns.
- 4. Set the Position parameters:
 - Symbol to 0.
 - Level to 0.00.
- 5. Click Add.

P	RFX	(press -	Ger	eric :	signal. rfs								
Fi	e	View	Conf	gure	Waveform	n Syster	m Window	Help	6				
Se	elect	: Gener	ric siç	inal •	WIF/RF	- 🕵 Calibr	ation 🔹 🚟 O	verview	v 🤻 Find	Instruments	Z 6	iraph 👯 Co	mpile
Waveform List		rriers: d carrier	1	Mu 1	Add	Number 1 2	Frequency (10.00000 20.00000	00	Amplitud 0.00 0.00	Symbol rate(1 1.000000 1.000000		Modulation QPS QPS	K
ä				Se		3	30.00000	00	0.00	1.000000		QPS	К
		al carrie up Hopp Ramp Funct	oing F	3 Power		/Q Impairme	ents Distortion	Additio	n Multi-Path	Interference a	Additi	T	er Moc n on
		-				o		\checkmark	Number	Symbol		Level (dB)	^
		Time:		100 r		💲 s	Adu		1	0		0.00	-
		Positi	on				Delete				_		-
		Symbo	ol:	0				-			-		~
		Level:		0.00			4						
		Period	odica	lly exte	nded povve	er ramping							
												(159-178

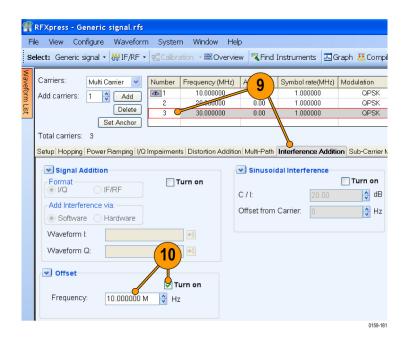
- 6. Repeat steps 4 and 5 two more times, adding these parameters:
 - Symbol = 100
 - Level = -60 dB and
 - Symbol = 200
 - Level = 0 dB

elect	: Generic s	signal 🔹 🙀 IF/	RF •	n Calbra	ation 🕞 🚟 Overvi	ew 🤻 Find	Instruments 🔼	Graph 👯 Compi
Ca	rriers:	Multi Carrier	*	Number	Frequency (MHz)	Amplitud_	Symbol rate(MH:) Modulation
Adu	d carriers:	1 3 Ad	d	3	10.000000	0.00	1.000000	QPSK
1	a camoro.			2	20.000000	0.00	1.000000	QPSK
		Dele Set Anch		3	30.000000	0.00	1.000000	QPSK
Tot Set	Ramp		ng (/C	2 Impairme	nts Distortion Addi	ion Multi-Pat	h Interference Add	iition Sub-Carrier M ✓ Turn o
	up Hopping Ramp Function:	Linear	*		nts Distortion Addi	ion Multi-Pat	h Interference Add	
	Ramp		ng (/0					V Turn o
	up Hopping Ramp Function:	Linear	*		nts Distortion Addi	Number	Symbol	C Turn o
	up Hopping Ramp Function:	Linear	*			Number 1	Symbol 0	Level (dB)
	nter the second	Linear	*	s	Add	Number 1 2	Symbol 0 100	Turn of Level (dB) 0.00 -60.00

- Select the second carrier from the table. Select the I/Q Impairments tab.
- 8. In the Carrier Leakage group, select **Turn on**. Set the following parameters:
 - I to 5.0.
 - **Q** to 5.0.



- Select the third carrier from the table. Select the Interference Addition tab.
- In the Offset group, select Turn on. Set the Frequency to 10 M.



Compile Settings and Compile

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

🎢 RF	Xpres	is - Generic	signal.rfs								
File	View	Configure	Waveform	System	Window	Help					
Sele	t: Ge	neric signal •	🙌 IQ 🔸	🖫 Calbratio	n - 🔀 O	verview	Kind Instruments	Graph	🖰 Compile 🕒	On/Off	-000
V.		_	-				1		Compile S	Settings	
								1)			0159-182

×

2

~

Automatic

3

5

samples

4

Automatic

Division factor: 1.000000

ОK

Cancel

Help

0159-328

0159-184

6

Compile

Set Anchor

Compile Settings

Signal Format

Normalization

Mode: Auto

Adjust for wrap-around

📃 l Invert 📃 Q Invert

Overwrite waveform in RFXpress list

💿 IF/RF

Waveform length: 500.000 k

🔘 IQ

RF waveform name: Naveform1

O Sampling Rate 10.00000

⊙ Oversampling 6.0000 Compile Button Preferences Compiles and sends to: Compiles only

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

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

🎢 RFXp	ress - G	eneric s	ignal. r fs								
File V	iew Co	nfigure	Wavefor	m System	Window	Help					
Select:	Generic	signal +	IE ARF	- 🕵 Calibratio	n - 🔀 Ov	verview	KFind Ins	truments	🔼 Grap	oh 👯 Comp	oile •
Waveforn	n List		7)	-	-			,		,	
Name	Length	Sam		Carriers:	Multi Car	rier 👻	Number	Frequency	/ (MHz)	Amplitud	Syn
Wavef	500 k	180.0	I	Add carriers:	1 3	Add	念 1	10.000	0000	0.00	
Wavef	500 k	180.0					2	20.000	0000	0.00	
Wavef	500 k	180.0	IF/RF		_	Delete	3	30.000	0000	0.00	

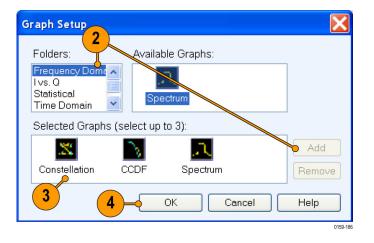
~

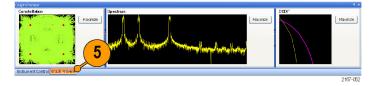
Previewing Graphs

1. From the toolbar, click Graph.



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





0159-187

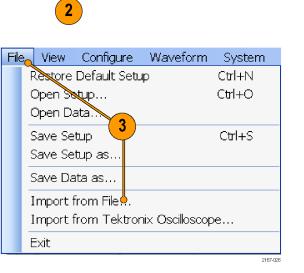
Replay a Captured Waveform to Test Receivers

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

File View Configure Waveform System Window Help

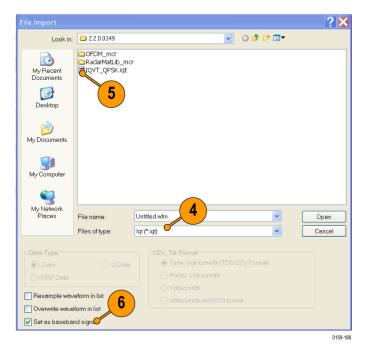
Import an RTSA File

- 1. Start RFXpress.
- 2. Ensure that the selected application is set to Generic signal and the signal type is IF/RF.
- 3. From the menu, click File > Import from File.

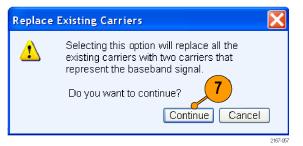


Select: Generic signal • 🙀 IF/RF • 式 Calibration • 🗟 Overview 🤻 Find Instruments 🗔 Graph 👯 Compile •

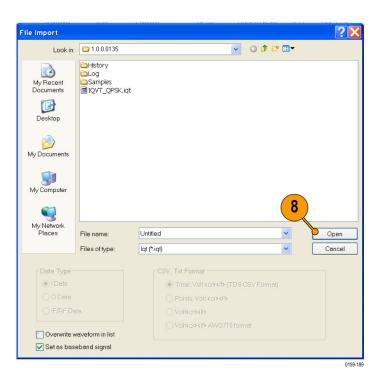
- 4. Select iqt in the Files of type field.
- 5. Select an iqt file.
- 6. Select Set as baseband signal.



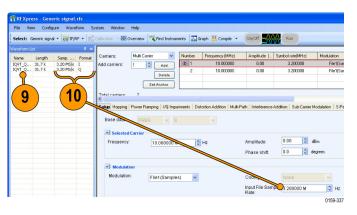
7. A message appears. Click Continue.



8. Click Open.



- **9.** The waveform list displays the I and Q signals.
- **10.** Note that the **Input File Sample Rate** automatically takes the value with which the iqt file was created.



- **11.** Select the first carrier and set the following:
 - Frequency to 50 M.
 - Amplitude to 0 dBm.

- 12. Click Interference Addition. In the Sinusoidal Interference group, select Turn on.
- 13. Set the following:
 - C/I to 0 dB.
 - Offset from Carrier to -10 M.

	RFXpress - Generic signal ile View Configure Wav		ndow Help			
Se	elect: Generic signal ▼ ∰ IF/			Instruments	🖫 Graph Compile	• • (
Waveform List		Number Add Delete tt Anchor	Frequency (MHz) 50.000000 10.000000	Amplitude (0.00 0.00	Symbol rate(MHz) 3.200000 3.200000	Mod
	Total carriers: 2 Setup Hopping Power Ramp Base data: PRBS	ing 1/Q Impairments	Distortion Addition Multi-P	ath Interference	Addition Sub-Carrie	r Modulati
	Selected Carrier	50.000000 M	Hz	Amplitude: Phase shift:	0.00	dBm degrees 0159-338

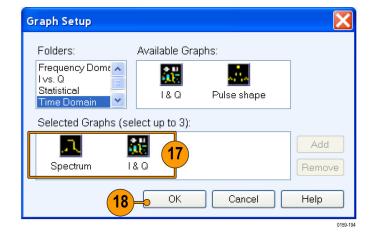
le View Cor	ifigure Wavef	orm Systen	n Window He	lp		
elect: Generic s	ignal 🔹 🙀 IF/R	= 🕶 🛒 Calibra	ation 🔹 🚟 Overvie	ew 🤻 Find	Instruments 🗔 🖾	àraph 👯 Comp
Carriers:	Multi Carrier	Number	Frequency (MHz)	Amplitud	Symbol rate(MHz)	Modulation
Add carriers:	1 👶 Add	3	50.000000	0.00	3.200000	File1(Sampl
Aud currers.	Delete	_	10.000000	0.00	3.200000	File1(Sampl
Total carriers: Setup Hopping	-	I/Q Impairment	Distortion Additio	n Multi-Path	Interference Additi	on Sub-Carrier
	Power Ramping	I/O Impairment			Interference Additi	on Sub-Orrier
Setup Hopping	Power Ramping		urn on		dal interference	Turn on
Setup Hopping Signal Av Format VQ Add Interfer	Dower Ramping		urn on	Sinusoi	dal Interference	Turn on
Setup Hopping Signal Av Format VQ Add Interfer	Power Ramping ddition IF/RF rence via:		urn on	Sinusoi	dal Interference	urn on

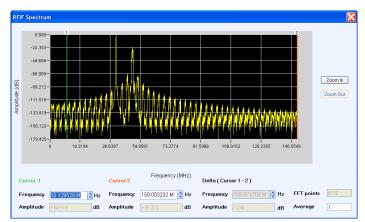
14. Select the second carrier and repeat steps 11 through 13.

- **15.** Click **Compile > Compile Settings**. Ensure that **Automatic** is selected.
- **16.** Click **Compile**. The software uses the default compile settings to generate the waveform.

Compile Settings
Waveform length: 31.744 k symbols 🗸 Katomatic
Signal Format
⊙ IF/RF ◯ IQ
RF waveform name: Naveform1
Sampling Rate 10.00000000 G
Oversampling 6.0000
Compile Button Preferences Compiles and sends to: Compiles only
Normalization
Mode: Auto Vision factor: 1.000000
Adjustfor wrap-around
✓ Overwrite waveform in RFXpress list
I Invert Q Invert
Compile OK Cancel Help
0159-323

- **17.** Add the following graphs in Graph Setup:
 - Frequency Domain: Spectrum.
 - Time Domain: I & Q.
- 18. Click OK.





19. The Spectrum graph is as shown.

Calibrating a Generic Signal

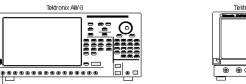
When creating signals for testing wideband receivers, it is important that the test equipment generate signals with flat frequency and linear phase response. As the signal bandwidth is increased, because of the DAC roll-off and bandwidth limitation of the arbitrary waveform generator, the signal that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

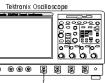
1. Set up the instruments as shown. The instruments must be connected over a LAN.

You will need:

- A Tektronix AWG7122B with Option 06, running RFXpress software.
- A Tektronix DPO oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
- Connecting cable.
- 2. Start RFXpress.
- From the toolbar, click Select > Generic signal and signal type to IF/RF.
- 4. For the carrier, set the following:
 - Base data to PRBS and User Defined.
 - Frequency to 6 GHz.
 - Symbol rate to 3 GHz.

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





0159-29

3 _{RFXpress} - Ge l. rf File Hel ignal 🔹 🕍 IF/RF 🗸 - 🗮 Overview 🍕 Find Instruments 🛛 🖾 Graph 👯 Compile 🝷 Op/Off oloct Single Carrie ~ Number Frequency (MHz) Amplitude (... Symbol rate(MHz) Carriers 6000 00000 走1 0.00 3000.000000 4 Intal carriers nping 1/Q Multi-Pa etup Hopping Base data User-define PRBS Edito Single Carri 😂 dBm 0.00 Frequency: 🝼 🚉 Hz Amplitu 6.000000000 G 😂 degr Phase sh 0.0 Modulati Modulation: QPSK ~ Coding: ~ None Symbol rate 3.000000000 Gl 🗘 Hz 0159-339



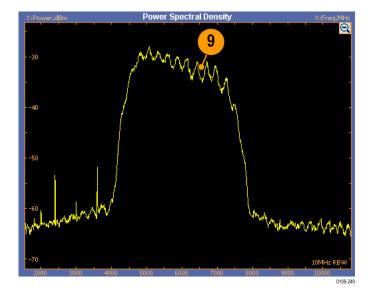
- 6. Disable Automatic and set the Waveform length to 200 k symbols.
- 7. Ensure that When compiling, apply correction files to these channels is disabled.

(

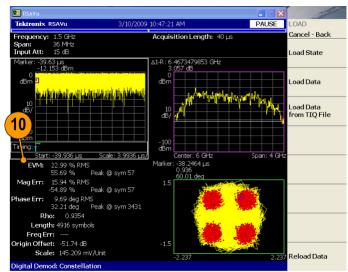
8. Click Compile.

Compile Settings
Waveform length: 200.000 k symbols v Automatic
Compile Button Preferences
Ocmpiles and sends to: Ch1
O Compiles only
Signal Format
⊙ IF/RF ◯ IQ
RF waveform name: Naveform1
O Remalian Data da accesso a
◯ Sampling Rate 10.00000000 G
Oversampling 6.0000
Correction Files When compiling, apply correction files to these channels
Select Correction File: ngstvraotDesktoptTesttmultitone.rfc Browse Plot
Normalization
Mode: Auto V Division factor: 1.000000
Division lactor. 1.000000
✓ Adjust for wrap-around
Comparishe constants in DED (some ser link
Overwrite waveform in RFXpress list
🗆 l Invert 🔲 Q Invert 🛛 🛛
<u> </u>
Co <mark>m</mark> pile <u>OK</u> Cancel <u>H</u> elp
0159-33

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



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



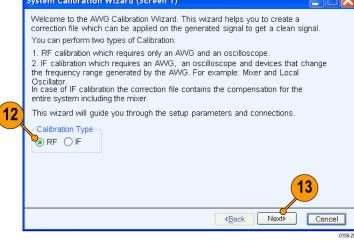
0159-250

11. From the toolbar, click Calibration.

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

- **12.** The Calibration wizard opens. Ensure that the signal type is RF.
- 13. Click Next.





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

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

15. Click Next.

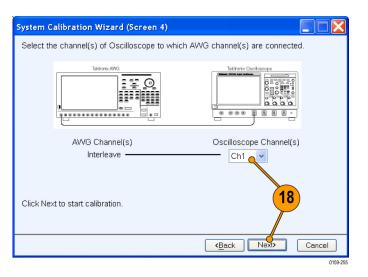
System Calibration Wi	zard (Scree	en 2)						
Please choose the oscil populated based on the TekVISA. Oscilloscope List Refresh List								
Model	Status	Connection Type	Name					
TEKTRONIX, DPO7	Connected	Ethernet	70K	Connect				
				Disconnect				
				Test Connection				
Connected								
Status: Ready		1	5					
		< <u>B</u> ac		lext> Cancel				
0159-253								

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

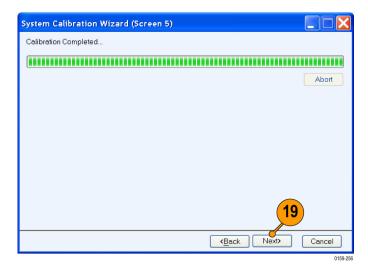
System Calibration Wizard (Screen 3)
Enter the setup parameters for calibration. The start frequency and end frequency is the bandwidth of the signal which will be calibrated. The frequency resolution indicates the frequency points which will be taken during calibration. Choose the Channel(s) of AWG which will be connected to Oscilloscope.
Setup 16 Settings pling Rate: 23.400120000 S/s Interleave Zeroing Ch1 Ch2
Calibrate the Signal O Calibrate the Signal Image Start Frequency: 3.500000000 (CHz End Frequency: 8.500000000 (CHz) Hz
Frequency Resolution: 10.000000 M Hz Average: 1 iterations Select the correction file: C:\Documents and Settings\vrao\Desktop\Q 17 Browse
Cancel 0159-2

17. Click Next.

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

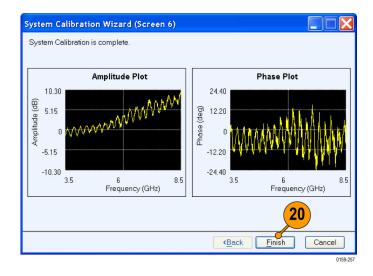


19. Once the calibration is complete, click **Next** to display the phase and amplitude plots.



21

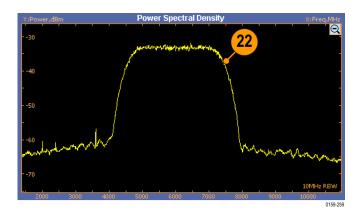
20. Click Finish to exit the wizard.



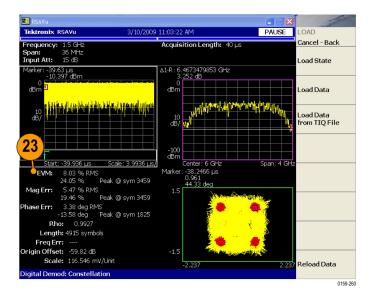
21. From the toolbar, click Compile.

									4)
Eile	View	<u>C</u> onfigure	W <u>a</u> veform	System	<u>W</u> indow	<u>H</u> elp			Ţ	
Selec	t: Gen	eric signal •	₩IF/RF •	😴 Calibratic	n • 🔀 Ov	erview	🕄 Find Instruments	🗷 Graph	👯 Compile	-
									015	9-258

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



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



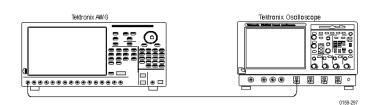
Applying Calibration to an Imported Custom Signal

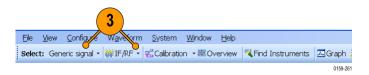
In this example, you import an OFDM signal (not created using RFXpress) and calibrate it.

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

You will need:

- A Tektronix arbitrary waveform generator, such as AWG7122B with Option 06, running RFXpress software.
- A Tektronix DPO oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
- Connecting cable.
- 2. Start RFXpress.
- From the toolbar, click Select > Generic signal and set the signal type to IF/RF.
- 4. Select File > Import from File.

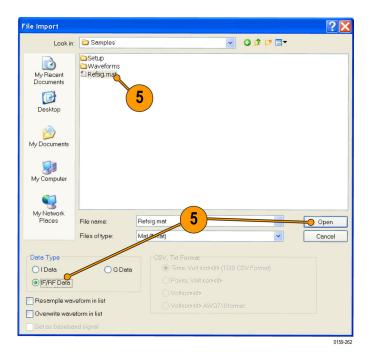




🖁 RF	Xpres	s - Gene	ric signa	l.rfs
File	View	Configure	Waveform	System
R	estore E)efault Setup		Ctrl+N
0	pen Set	up		Ctrl+O
0	pen Dat			
S	ave Setu	ф 4		Ctrl+S
S	ave Set	p as		
S	ave Data	aas		
Ir	nport fro	om File		
Ir	nport fro	om Tektronix	Oscilloscop	e
E	xit			
				0159-158

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

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



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

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

	press ·	- Ge	neric	signal. rfs	1				
Eile	<u>V</u> iew	<u>C</u> on	figure	W <u>a</u> vefor	m <u>S</u> ystem	<u>W</u> indow	Help		
Select	: Gene	ric s	ignal 🔹	🙀 IF/RF	🔹 🥵 Calibrati	on 🔹 🚟 Ov	verview	🔫 Fin	d Ins
Wa∨efor Name	rm List	յեի	Sam	₽× Forma	Carriers:	Single C	arrier 🗸	Nur	
Refsig	40.0		Show Save Impo	<mark>to AWG</mark> Graph Data as rt from File rt from Te		scope	ing	Ch 1	y
			Delete Delete Renai	e All			*	9	
			Apply	Calibration	l		000)0 M	0159-263

0159-265

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

- From the toolbar in RFXpress, click Calibration. The calibration wizard opens.
- 9. Ensure that the signal type is RF and click **Next**.
- **10.** From the table of instruments connected on the network, select a Tektronix oscilloscope and click **Connect**. Note that the status changes to Connected. Click **Next**.

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

- 11. Set the following:
 - Start Frequency to 3.5 GHz.
 - End Frequency to 6.5 GHz.

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

- Select the correction file name to generate the correction file.
- Select Ch1.
- 12. Click Next.

System Calibration Wizard (Screen 3)
Enter the setup parameters for calibration. The start frequency and end frequency is the bandwidth of the signal which will be calibrated. The frequency resolution indicates the frequency points which will be taken during calibration. Choose the Channel(s) of AWG which will be connected to Oscilloscope.
Settings pling Rate: 20.000000000 \$ \$/s Interleave Zeroing Ch1 Ch2 10 0 10
Calibrate the Signal Calibrate the signal Image
Start Frequency: 3.50000000 (, Hz End Frequency: 6.500000000 (Hz
Frequency Resolution: 10.000000 M
Select the correction file: C:\Documents and Settings\vrao\Desktop\Q. 12 Browse
(Back Next) Cancel
0159-266



- Once the calibration is complete, click Next to display the amplitude and phase plots. Click Finish to exit the wizard.
- 14. In the waveform list, select the signal and right-click. Select Apply Calibration.

礥 RFXpress - Ger	eric signal.rfs	
<u>Eile V</u> iew <u>C</u> onfi	gure W <u>a</u> veform <u>S</u> ystem <u>W</u> indow	<u>H</u> elp
Select: Generic sig	nal 🔹 🙀 IF/RF 🔹 🕵 Calibration 🔹 🚟 O	verview
Waveform List	Ф ×	
Name Length :	Sam Forma	Carrier 🔽
Refsig 40.0 k 2	Send to AWG Show Graph Save Data as Import from File Import from Tektronix Oscilloscope	۲ ۲
	Delete Delete All Rename	
	Apply Calibration	0159-267

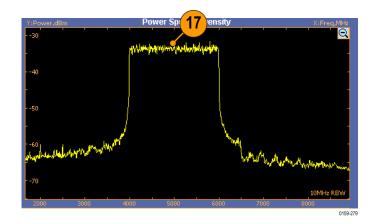
 Select the correction file that was created during calibration and click **Open**.
 The correction file is applied to the existing imported signal.

Select Corr	ection File	15				?×
Look in:	😂 Samples		~	G 🗊 🖻		
My Recent Documents	Ch1Correction	rfc				
My Documents						
My Computer					15	
My Network						
Places	File name:	Ch1Correction.rfc			· [Open
	Files of type:	*.rfc (RFC File)			~	Cancel
						0159-294

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

🚏 RF2	Xpress	- Ge	neric	signal. rfs					
File	View	Con	figure	Waveforr	n System	Window	Help		
Selec	t: Gen	eric si	ignal +	₩IF/RF •	式 Calibratio	on 🚟 Over	view 🍕	Find Inst	ruments
Navefo Name	orm List : Len	igth	Samp.	₽ × R Fc	Carriers:	Single C	arrier 🗸	Number	Freque
Refsig	40.0		Sho Sav Imp			lloscope		Ch 1	
			Rer	ete All name bly Calibratio	n			9 D M 😂	Hz
									0159-277

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



Characterizing a Low-pass Wideband Filter (DUT)

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

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

You will need:

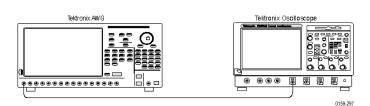
- A Tektronix AWG7122B with Option 06, running RFXpress software.
- A Tektronix DPO72004 oscilloscope to capture the signal. Ensure that the oscilloscope is calibrated.
- Connecting cable.
- A low-pass wideband filter (the device under test)

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

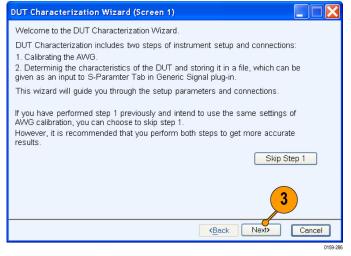
 Start RFXpress on the AWG7122B with Option 06.

Select **DUT characterization** from the toolbar.

 The DUT Characterization wizard opens. Click Next.







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

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

5. Click Next.

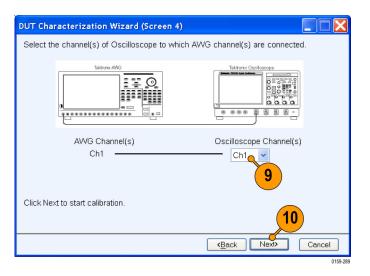
DUT Characterization Wi	zard (Scree	en 2)		
Please choose the oscilloso populated based on the ins TekVISA. Oscilloscope List Refresh List				
Model	Status	ConnectionTy	Name	
TEKTRONIX,DP072004	Connected	Ethernet	70K 💙	Connect
				Disconnect
				Test Connection
				Test Connection
<	III		>	
Status: Ready				5
			< <u>B</u> ack	Next> Cancel
				0159-287

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

DUT Characterization \	/izard (Screen 3)
bandwidth of the signal w frequency resolution indic the bandwidth. The time and number of iterations.	rs for calibration. The Start and End frequency is the hich will be generated from AWG and calibrated. The ates the number of frequency points being considered within taken to calibrate will depend upon the frequency resolution WG which will be connected to Oscilloscope.
Start Frequency:	10.000000 M Average: 1 iterations
End Frequency:	11.76000000 G 🕂 7
Frequency Resolution:	10.000000 M
	<back next=""> Cancel</back>
	0159-

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

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

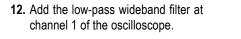


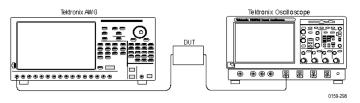
10. Click Next to start AWG calibration.

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

11. Once calibration is over, click Next.

DUT Characterization Wizard (Screen 5)	
Setting Oscilloscope	
	Abort
	11
	<back next=""> Cancel</back>





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

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

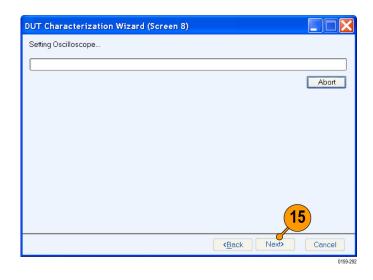
DUT Characterization Wizard (Screen 6)
Enter the setup paramters for the DUT. By default the DUT center frequency is based on the bandwidth selected during AWG calibration process. Select the text file to which the DUT characteristics are exported in S21 format.
DUT Setup
Local Oscillator Frequency. 10.00000000 G
Lower Side Band O Upper Side Band
Select the output file:
hents and Settings/vrao\Desktop\DUTivLF 6400.txt Browse
13 < <u>Back</u> Next> Cancel
0159.20

14. Click Next.

DUT Characterization Wizard (Screen 7)	
Connect the DUT in between AWG and scope. Make sure that the channel(s) of AWG Oscilloscope are the same as in the previous setup of AWG calibration.	i and
]
Click Next to start geting the characteristics of the DUT.	
14	
	Cancel
	0159-295

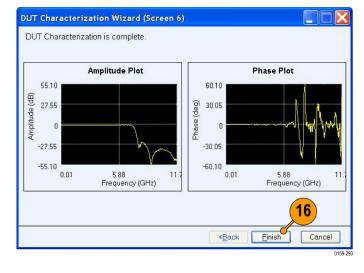
15. Click Next.

The wizard displays phase and amplitude plots.



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

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



Creating a UWB Waveform to Test Your Receivers

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

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

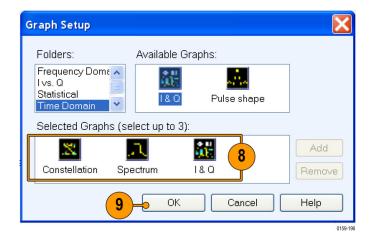


- The WiMedia Spec Example Packet settings (according to Annex A of the WiMedia specification document) are displayed in the fields in each tab.
- 6. Confirm the Hopping Pattern for TF Code 1.

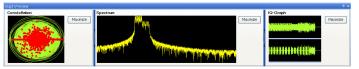
Band Group: Band Group 1
TF Code: 6 TFC 1 Channel Number: 9
Band group center frequency: 3960 😭 MHz
ĨZHY ▲ 4488
HW 3960 Image: Construction of the construc
3432
Time
2167-017
7
File View Configure Waveform Window Help Select: Generic signal • ₩ IF/RF • Thind Instruments ⊡Graph 础 Compile • On/Off WWW Run

7. Click Compile.

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



10. The graphs are as shown.

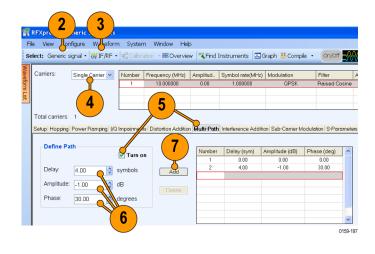


Application Examples: Generic Signal

Simulating a Multi-Path Environment for a Generic Signal

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

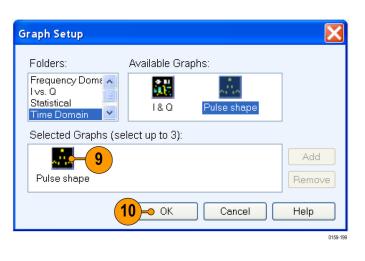
- 1. Start RFXpress.
- From the toolbar, ensure that Select > Generic signal is selected.
- 3. Ensure that the signal type is set to IF/RF.
- 4. Ensure that **Single Carrier** is selected. Leave the default values for the carrier.
- 5. Click Multi-Path and select Turn on.



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

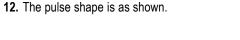
=ie				n Window Help					
el	lect: Generic signal •	₩ IF/RF •	E Calbra	ition - * 🛤 Overviev	v Kind I	nstruments 🗠	Graph 👯 Comp	ile • On/Off	
l	Carriers: Single	Carrier 🗸	Number	Frequency (MHz)	Amplitud	Symbol rate(MHz) Modulation	Filter	_
			1	10.000000	0.00	1.000000	QPSK	Raised C	osin
			· · · · ·						
L	Total carriers: 1								
L	Total carriers: 1	1 100		Inc. of the second				LUX loo	
L	Total carriers: 1 Setup Hopping Power P	Ramping 1/0	Impairments	Distortion Addition	Multi-Path	Interference Addit	tion Sub-Carrier M	fodulation S-Par	ame
L		Ramping //O	Impairments	Distortion Addition					_
	Setup Hopping Power F	Ramping VO	Impairments		Number	Delay (sym)	Amplitude (dB)	Phase (deg)	ame
	Setup Hopping Power F		Turn or		Number 1	Delay (sym) 0.00	Amplitude (dB) 0.00	Phase (deg) 0.00	
	Setup Hopping Power F				Number	Delay (sym)	Amplitude (dB)	Phase (deg)	_
	Setup Hopping Power F	A	Turn or	n	Number 1 2	Delay (sym) 0.00 4.00	Amplitude (dB) 0.00 -1.00	Phase (deg) 0.00 30.00	_
	Setup Hopping Power f Define Path Delay: 10.00 Amplitude: -5.00	\$ \$	✓ Turn or symbols dB	n	Number 1 2	Delay (sym) 0.00 4.00	Amplitude (dB) 0.00 -1.00	Phase (deg) 0.00 30.00	_
L	Setup Hopping Power F	\$ \$	Turn or symbols	Add	Number 1 2	Delay (sym) 0.00 4.00	Amplitude (dB) 0.00 -1.00	Phase (deg) 0.00 30.00	_
L	Setup Hopping Power f Define Path Delay: 10.00 Amplitude: -5.00	\$ \$	✓ Turn or symbols dB	Add	Number 1 2	Delay (sym) 0.00 4.00	Amplitude (dB) 0.00 -1.00	Phase (deg) 0.00 30.00	

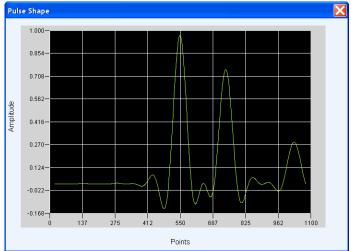
- **9.** In Graph Setup, add the following graph: Time Domain: Pulse shape.
- 10. Click OK.



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



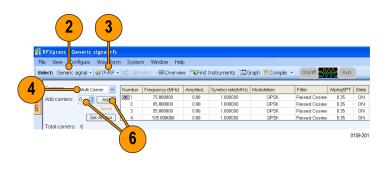


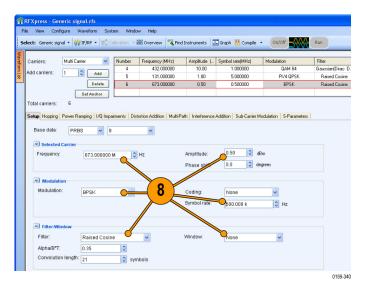


Creating a Hopping Waveform to Test Radio Signal Identification and Detection Systems

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

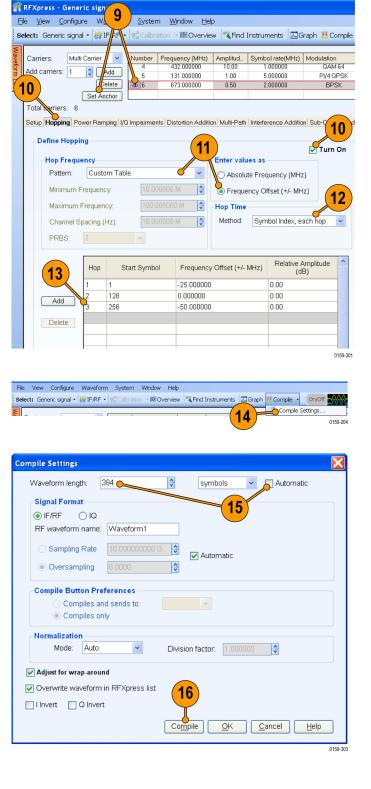
- 1. Start RFXpress.
- From the toolbar, click Select > Generic signal.
- 3. Ensure that the signal type is set to IF/RF.
- 4. Select Carrier to Multi-Carrier.
- 5. Select the carrier in the table and click Delete.
- 6. In Add carriers, enter 6 and click Add.
- **7.** Select the carriers one after another,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



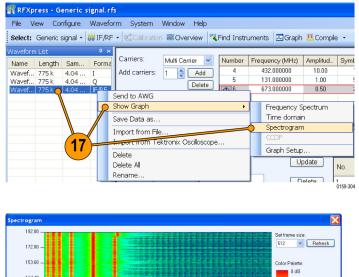


- 9. Select the sixth carrier and click Set Anchor.
- 10. Click the Hopping tab and select Turn on.
- 11. Ensure that the Hop Frequency Pattern is set to Custom Table and Enter values as is set to Frequency Offset.
- **12.** Set the Hop Time **Method** to Symbol Index, each Hop.
- **13.** Update the values as shown in Table 2 for each carrier: (See page 40.)

- From the toolbar, click Compile > Compile Settings.
- **15.** Disable **Automatic** and set **Waveform length** to 384 symbols.
- 16. Click Compile.



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



18. The spectrogram is as shown.

38.40	5760 - 176 dB	134.40 — 115.20 —	
57.60	57.60	ເŝj 96.00 — ≞ ⊢ 76.80 —	
1920 – 0.00 0.00 0.20 0.40 0.61 0.61 1.01 1.21 1.41 1.62 1.82 2.02	1920 – 0.00 0.00 0.20 0.40 0.61 0.61 1.01 1.21 1.41 1.62 1.82 2.02		-176 dB
	0.00 0.00 0.20 0.40 0.61 0.81 1.01 1.21 1.41 1.62 1.82 2.02		
		0.00	0.40 0.61 0.81 1.01 1.21 1.41 1.62 1.82 2.02

Table 1: Carrier parameters

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

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

Table 2: Hopping parameters

S-Parameter Emulation of a High Pass Filter

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

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

P	RFXpress 2	ic s	3					
Ð	ile ⊻iew <u>C</u> or	figure	Wavnor	n <u>S</u> yster	m <u>W</u> indow <u>H</u> el	р		
s	elect: Generic s	ignal •	₩IF/RF		Characterization 🔸	🚟 Overviev	v 🔫 Find Instrum	ents 🖾 Graph 👯
Waveform List	Carriers:	Multi Car	rrier	4	Frequency (MHz)	Amplitud	Symbol rate(MHz)	Modulation
orm	Add carriers:	199 🤤	Add	2	50.000000	0.00	-	No Mod
List			Delete	3	150.000000	0.00	-	No Mod
		Set	Anchor	4	200.000000	0.00	-	No Mod
	Total carriers:	199						
	Setup Hopping	Power P	amping /	Q Impairme	nts Distortion Additio	n Multi-Path	Interference Additio	n Sub-Carrier Modula
	Base data:	PRBS	¥ 8	}	~		Amplitude:	0.00 🛟 dBm
	Center	rrier			۲	Range		
	Center frequenc			IM 🔮	Ηz	Base frequency:	50.000000 M	🛟 Hz
	Bandwid			м 🛟 І		Carrier	50.000000 M	🛟 Hz
	Phase shif	t 0.	0	Randor	n	spacing:		
	💌 Modula	tion						
	Modulation	N	o Mod	~		Coding:	None	~
	FSK peak deviation:	0.	0000	*	degrees	Symbol rate	1.000000 M	+Hz
								0159-26

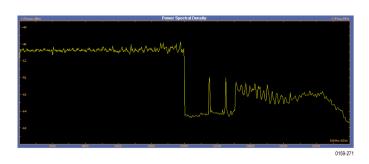
5. Select the carrier and click **Delete**.

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

P	RFXpress	- Generio	signal.rfs						
El	e <u>V</u> iew	Configure	W <u>a</u> veforn	n <u>S</u> yster	n <u>W</u> indow <u>H</u> e	lp			
Se	lect: Gen	eric signal ·	• 🙀 IF/RF •	CUU	Characterization •	- 🚟 Overview	Find Instrum	nents 🗵	Graph 👯
Waveform List	Carrie Add carrie Total carr	ers: 199 9 iers: 199		Number 2 3 4 Impairment	Frequency (MHz) 50.00000 100.00000 200.00000 200.00000 Tts Distortion Addition 7	Amplitud 0.00 0.00 0.00 0.00	Symbol rate(MHz) Interference Addition Amplitude:	Ni Ni Ni	o Mod o Mod o Mod o Mod
	Ce Ce free Ba	I lti Carrier enter nter quency: ndwidth: e shift:	100.000000 50.000000 N 0.0		Ηz	Range Base frequency: Carrier spacing:	50.000000 M (50.000000 M (8	
			No Mod 0.0000	× •	degrees	Coding: Symbol rate:	None 1.000000 M	✓	
									0159-269

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

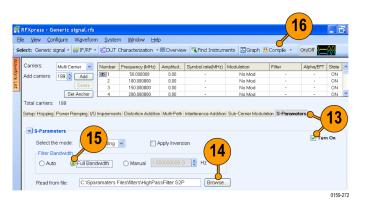
- **10.** From the toolbar, click **Compile Settings**.
- Select the correction file (created during calibration), and click Compile. To create the correction file, refer to the calibration procedure. (See page 16, *Calibrating a Generic Signal.*).
- **Compile Settings** Waveform length: 1.000000 M samples 🗸 📃 Automatic **Compile Button Preferences** Ocmpiles and sends to: Ch1 ~ O Compiles only Signal Format IF/RF 🔘 IQ RF waveform name: Naveform1 O Sampling Rate 10.00000000 G 🛃 Automatic Oversampling 6.0000 **Correction Files** When compiling, apply correction files to these channels 🗹 Ch1 📃 Ch2 Select Correction File: ents and Settings\Desktop\Test.rfc | Browse | Plot... Normalization Mode: Auto v Division factor: 1 11 Adjust for wrap-around ✓ Overwrite waveform in RFXpress list 📃 l Invert 📃 Q Invert <u>0</u>K Compile <u>C</u>ancel <u>H</u>elp 0159-333
- Capture the waveform in the oscilloscope. The signal spectrum is observed using Tektronix Ultra Wideband Spectral Analysis software.



- **13.** Click the **S-Parameters** tab and select Turn On.
- **14.** Browse the Touchstone file to emulate. This example uses a .s2p file for a high-pass filter with a cut-off of 5.5 GHz.
- 15. Select Full Bandwidth.

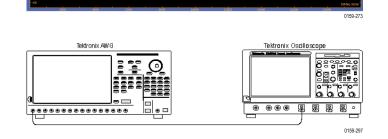
16. From the toolbar, click Compile.

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



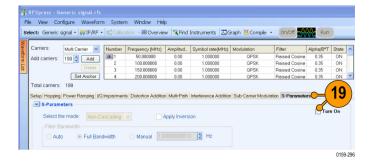
17. Observe the signal spectrum using Tektronix Ultra Wideband Spectral Analysis software.

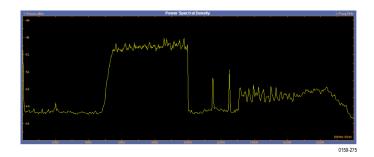
 To verify the spectrum and the S-parameter, connect a high-pass filter (DUT) as shown.



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

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





Select: Generic signal • 👹 IF/RF • 式 DUT Characterization • 🗟 Overview 🤻 Find Instruments 🖾 Graph 👯 Comple

Ele View Configure Waveform System Window Help

0159-274

Application Examples: UWB-WiMedia

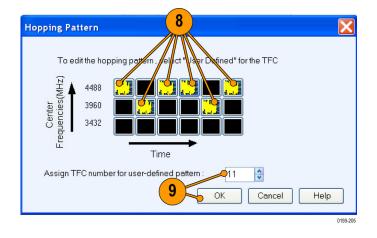
Characterize Receiver Design for Receiver Verification and Stress Test

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

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

1	AFXpress - Lad	
	File View Confighe Waveford System Hep	
	Select: UWB-WMedia • 🖗 IF/RF • 📽 Calor 📕 erview 🤻 Find Instruments 🖾 Graph 🐰 Compile • 🛛 Cn/Off 🎎 Run	
Waveform List	Select setup: WMedia Conformance Addition Select setup: WMedia Spec Example Packet Index Name Add packet groups: 1 WMedia Packet Group Marker Mapping. Delete Index Index	PPDUs in Grc Index Neme 1 PPDU
	Selected Packet Group	
	Repeat this group: 1 2 times Number of packets in group: 1 Band Group: Band Group: Band Group 1	
	Group start delay: 0 🔅 symbols Spacing between packets: 8 🔮 Symbols 🗸 TF Code: User Defined 🗸	Hopping
		0159-245

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



Adding Interference

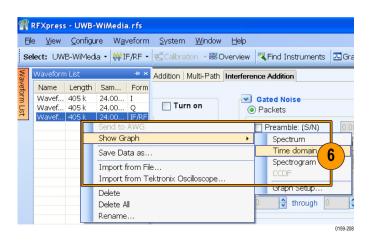
- 1. Click Interference Addition.
- 2. In the Gated Noise group, select Turn on.
- 3. Click Packets.
- 4. Click PLCP Header and set it to -10.0.
- 5. From the toolbar, click Compile.

4 Format Preamble: (S/N) 0.00 () dB Add Interference via: PLCP Header: (S/N) 10.00 () dB Software Hardware Payload: (S/N) 0.00 () dB	File Selec	at: UWB	Configu -WiMedi	ire Wa ia∙¦∰a	aveform IF/RF •	System	n - 🔣 O			nstruments	⊡Graph	X Corr	2
	aveform list	Form VC	gnal Ad nat ມ	dition O IF/ nce via:	RF		3 4)- ~	Gated No Packets Pream PLCP	bise ble: (S/N) Header: (S/N) -10.00	dB	Turn on
													0159-20

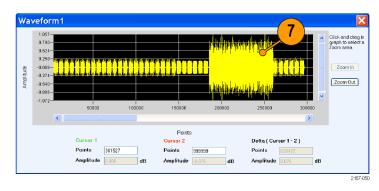
Select: UWB-WiMedia • ₩ IF/RF • Calbration • 🗟 Overview 🤻 Find Instruments 🖾 Graph 👯 Compile •

0159-207

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



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



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

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

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

You will need:

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

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



- 2. Start RFXpress.
- From the toolbar, click Select > UWB-WiMedia.
- 4. From the toolbar, click Calibration.
- The Calibration window displays a table of instruments connected on the network. Select the DPO70804 oscilloscope and click **Connect**. Note that the status changes to Connected.

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

- 6. Set the signal type to RF.
- **7.** Set the **Sampling rate** to 19.996576 GS/s.
- 8. Select InterLeave.
- 9. Set the Average to 10.
- 10. Set the Band group to 2.
- 11. Select Bands: 1, 2, and 3.
- 12. Set While compiling, apply correction files to to Ch1.
- 13. Set the Amplitude for Ch 1 to 0.5 Vpp.
- 14. Set the path for Select the correction file.
- **15.** Click **Calibrate** to create the correction file (.rfc). The calibration status is continually updated.
- **16.** Confirm that the correction file that was just generated is selected.



Calibration	6			5 🛛 🖾
Instrument Setup				
Signal format: RF 🤟	Setup selection	n: Scope + PSG	~	
Model	Status	ConcessionType	Name 🔼	Connect
TEKTRONIX, DP07254		Ethernet	test	Disconnect
TEKTRONIX, DP070604		Ethernet		Test Connection
TEKTRONIX, DPO70804	Connected	Ethernet	tedi_scope	lest Connection
< 8	ш			Connected
Calibration Setup				
	58400000 G 😂 🤅	S/s Average:	10	🗘 iterations
🔽 InterLeave 🗸 📃 Ze	eroing	Generator	center freq: 5.5440	100000 G 🛟 Hz
Band group: Band	lGroup 2 🔍	🛃 Band group	o center freq: 5.5440	100000 G 😫 Hz
Calibration reminder: Neve	er 🗸	10 Sideband:	() Low	ver O Upper
While compiling, apply correct Ch 1 Ch 2	tion files to:	Bands:	1	
Ch 1 Ch 2			(11
Amplitude: 0.500	🗘 Vpp – Off:	set: 0.000	• V	
Use same amplitude a	nd offset for all c	hannels		
Select the correction file:				
C:\Corrections\Ch1correc	ctions_19.958Gh	z.rfc		Browse
Click "Calibrate" to create new	correction file.			Calibrate
Status: Ready			K Cancel	Apply Help

Calibration						X
Signal format:	~	Setup selection	n: Scope + PSG	~		
Model		Status	ConnectionType	Name	^	Connect
TEKTRONIX, DP07254			Ethernet	test		Disconnect
TEKTRONIX, DP07060	14		Ethernet			
TEKTRONIX, DP07080	14	Connected	Ethernet	tedi_scope	=	Test Connection
<		ш			¥ >	Connected
Calibration Setup Sampling rate: InterLeave Band group: Calibration reminder: While compiling, apply c	Zerc BandG Never	roup 2 🗸	Generator (center freq:		
Ch 1 Ch 2 Ch 1 Ch 2 Amplitude: 0.500 Use same amplitu		Vpp Offs offset for all ch		¢ V		
Select the correction	file:					
C:\Corrections\Ch1c Click "Calibrate" to create		- 🔍	rfc 16		(15 Browse Calibrate
Status: Ready				Canc	cel	Apply Help

17. Set Band Group to Band Group 2.

R	Xpress - UWB-WiMedia.rfs
File	View Configure Waveform System Window Help
Sele	t: UWB-WiMedia • 👹 IQ 🛛 • 🕵 Caloration 🕮 Overview 🛛 🤻 End Instruments 🖾 Graph 👯 Compile 🕚
5	tup VQ Impairments Distortion Addition Multi-Path Interference Addition
	Mode: 💿 Conformance 🔵 Custom
	Packet Groups:
	Select setup: Willedia Spec Example Packet 🔽 Index Name Repeat 🛆
	Add packet groups: 1 3 Add
	Delete
	Marker Mapping
	Selected Packet Group
	Repeat this group: 1 🔅 times Number of packets in group: 1 🔅 Pa
	Group start delay: 0 😌 symbols Spacing between packets: 8 😌 Symbols 🗸
	Group end delay: 6 😋 symbols Tone Nulling
	47
	Packet Details Hopping
	MAC header: WiMedia Spec Example V Band Group: Band Group 2 V
	TF Code: TFC 1 V

Select: UWB-WiMedia - 👹 IF/RF - 🗟 Calibration 🗟 Overview 🧏 Find Instruments 🖾 Graph 🦉 Compile - 💽 On/Off

Compile Settings.

18

2167-046

RFXpress - UWB-WiMedia.rfs

(

File View Configure Waveform System Window Help

Setup VQ Impairments | Distortion Addition | Interference Addition

- 18. From the toolbar, click Compile > Compile Settings.
- **19.** Ensure that the correction file created during calibration is applied to Ch1.

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

20. Click Compile.

ompile Settings	
Waveform length: 1.000000 M	samples 🗸 Automatic
Compile Button Preferences © Compiles and sends to: © Compiles only	Ch1 💌
Signal Format	
⊙ IF/RF 🛛 🔾 IQ	
RF waveform name: Naveform1	
 Sampling Rate 10.00000000 Oversampling 6.0000 	0 G Automatic
Correction Files When compiling, apply correction	files to these channels
9 Normalization	
Mode: Auto 🗸	Division factor: 1.000000
Adjust for wrap-around	
Overwrite waveform in RFXpress	list
📃 l Invert 📃 Q Invert	20
	Compile <u>OK</u> <u>Cancel</u> <u>H</u> elp
	0159-33

Introducing Real-World Impairments in a UWB Signal

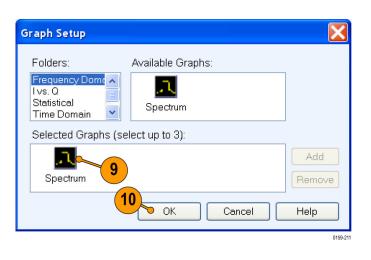
You can introduce real-world impairments in a UWB signal to test your receiver in a simulated real-world environment.

- 1. Start RFXpress.
- From the toolbar, click Select > UWB-WiMedia.
- 3. Ensure that the signal type is set to IF/RF.
- 4. Ensure that the **Mode** is Conformance and the **Selected setup** is WiMedia Spec Example Packet. Leave the default values for the selected setup.
- 5. Click Interference Addition.
- 6. In the Real World Signal Interference group box, click **Turn on**.
- 7. Click Add WiFi signal (MIMO).
- 8. Set the following parameters:
 - Frequency to 2.4 GHz (default).
 - Amplitude to 30 dB.

RFXpres 2 -WiMec 3					
File View Crinfigure Waverprin Sy	vstem Window	Help			
Select: UWB-WiMedia • 👹 IF/RF • 🕵	Calibration 🕞 🚟 🕻	Overview	Find Instruments	🖂 Graph 👯	Compile 🔹
Setup VQ Impairments Distortion Addi Mode: Conformance C	ustom		ence Addition Groups:		
Select setup: WiMedia Spec Examp	ple Packet 🛛 🔽	Index	Name	Repeat	^
Add packet groups: 1	Add	1	WiMedia Packet Group	1	
Marker Mapping	Delete				*
					0159-209

P	RFX	press	- UWB-	WiMedia.rfs						
Fil	е	View	Configu	re Waveform	System	Window	Help			
Se	lect	: UWE	3-WiMedi	a 🔹 🙀 IF/RF 🔹	Calibrati	on 👻 🔀 O	verview	💐 Find Inst	ruments	🖂 Graph 👯 (
Wav	Set	up I/G	lmpairm ג	ents Distortion	Addition M	lulti-Path	Interfere	nce Addition	5	
Waveform List		💌 s	ignal Ad o mat	dition	Turn	on		Gated Nois Packets		
		• V	Q	○ IF/RF				Preamble	: (S/N)	0.00 🛟
		r Add	Interferer	nce via:				PLCP He	ader: (S/N	l) -10.00 🛟
		• S	oftware	 Hardware 				Payload: I	(S/N)	0.00 🛟
		Wavi	eform I:		4]]) Symbols		
		Wavi	eform Q:		•]			0 🛟 th	nrough 🚺	🔹 : (S/N
		₩ 0	ffset		🔲 Turn	on	¥	Sinusoidal	Interferer	nce
		Freq	uency:	0	😫 Hz			C / I:	20.0	0
								Offset from Carrier:		\$
		💌 R	eal World	l Signal Interfer	ence	(8		6	
	7					ncy (Hz)	\mathbf{X}	Amplitude		🛃 Turn on
		<□ ^	\dd WiMa	× signal	2.5000000	100 G			*	
		م 🖌	Add WiFi :	signal (MIMO)	2.4000000	100 G 💛		30.00	*	
		<u> </u>	dd WiFi :	signal (802.11a)	2.4000000	100 G	•	0.00	*	
										0159-210

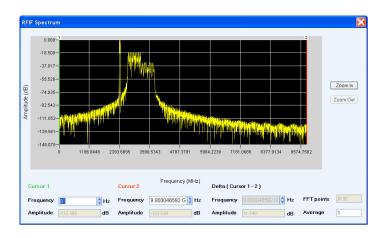
- 9. In Graph Setup, add the following graph: Frequency Domain: Spectrum
- 10. Click OK.



11. From the toolbar, click Compile.



12. The spectrum is as shown.



Application Examples: Radar

Generating an LFM Waveform with Coherent Carrier for Pulse Compression Radar

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

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

P	RFXpres 2 ladar.rfs
Fi	e View Configure Waveform System Window
Se	lect: Radar → 🙀 IF/RF → 式 Calibration → 🚟 Overview
Wavef 3	Carrier Pulse I/Q Impairments Interference Addition
3 List	Carrier Magnitude (Peak): 0.000
<u></u>	Carrier Frequency: 100.000000 M
	Coherent Carrier
	0159-21

- Select the Pulse tab and select the Pulse Envelope tab.
- 6. Set the following:
 - Pulse Shape to Rectangular (default).
 - Start Time to 0 ps (default).
 - Pulse Width to 10 µs at 100%.
 - Off Time to 198 µs.

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

- Amplitude Relative to Carrier to 0 dB (default).
- Offset from Carrier Frequency to 0 Hz (default).
- Repeat to 1 (default).
- 7. Click the Modulation tab.
- 8. Set the following:
 - Select Modulation to Linear Frequency Modulation.
 - Sweep Range to 10 MHz.
 - Frequency Sweep to Low to High.

View Configure	Waveform Sys	tem Win	ndow Help	•						
ect: Radar 🔹 🙀 IF/RF	· ± 5	Cver 🗟	view 🤻 Fir	nd Instruments	Gr	aph 👯 Con	npile • On/Of		Run	
Carrier Pulse I/Q Impai		ce Additio	on							_
Pulse	e Train						Selected Pulse:			
	ex Type	Repeat	PRI (ms)		<u>^</u>	Delete	1.00			
Add	1 ulse	1	0.2080	0.21		*	0.75			
Insert						+	0.50			
							0.25			
Add Pulse							0.23			
Groups					~			Tr + Ton + T	Tf = 10.00 us	_
Pulse Envelope Stag	agered PRI Modu	lation Ho	nning Puls	e Imnairments	Multi-P	ath Antenn	a.			
Pulse Shape:			pping in dis		in alteri	un partern				-(
	Rectangular			6						
r aloc chape.										1
Start Time (To):	0 p	000				Amplitude I	Relative to Carrie	er: 0.00	ď	
	-	s s		096 V			Relative to Carrie		1	H:
Start Time (To): Rise Time (Tr):	0 p		1	0% Y		Offset from		icy: 0	3	
Start Time (To):	0 p	S S	1009	0% Y						
Start Time (To): Rise Time (Tr):	0 p			0% Y		Offset from		icy: 0	ł	
Start Time (To): Rise Time (Tr): Pulse Width (Ton):	0 p 1 n 10.000000 u	s s		10% - V % - V		Offset from		icy: 0	- 	
Start Time (To): Rise Time (Tr): Pulse Width (Ton): Fall Time (Tf):	0 p 1 n 10.000000 u 1 n	5		10% - V % - V		Offset from		icy: 0	J	

P	FXpress - Radar. rfs View Configure Waveform System Window Help	
Waveform List	Carrier Pulse I/Q Impairments Interference Addition Pulse Train	
m List	Pulse Index Type Repeat PRI (ms) Duration (ms) Add 1 Pulse 1 0.2080 0.21	•
	Add Pulse Groups	*
	Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments M Select Modulation: Linear Frequency Modulation	ulti
	Sweep Range: 10.000000 M	
	Frequency Sweep: Low to High	
	9	9-21

Select: Radar • 👹 IF/RF • 🥵 Calibration • 😹 Overview 🤻 Find Instruments 🖾 Graph 👯 Compile •

Carrier Pulse VQ Impairments Interference Addition

9. From the toolbar, click Compile Settings.

Compile Se

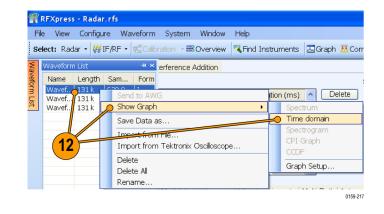
0159-216

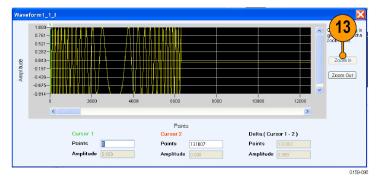
- 10. Ensure the following:
 - **Signal Format** is IF/RF.
 - Automatic is selected.
- 11. Click Compile.

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

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

Compile Settings
Signal Format GHF/RF O IQ Pulse name: Waveform1
Sampling Rate 10.00000000 G Automatic Oversampling 6.0000
Compile Button Preferences Compiles and sends to: Compiles only
Overwrite waveform in RFXpress list I Invert Q Invert Compile OK Cancel Help
445.00





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

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

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

P	RFXpress - Radar.rfs											
Fi	le Vie Configure [Waveform	System	Window								
Se	elect: Radar - 🙀 IF/Rf	= 🔸 式 Calibr	ation , 🚟 (Dverview 🖡								
Wav	Carrier Pulse I/Q Impa	airments Int	erference A	d (4)								
Waveform List	Carrier Magnitude (Pe	eak): 2.500		dBm								
	Carrier Frequency:	200.0	00000 M 🗸	🛟 Hz								
	Coherent Carrier											
	-			0159-219								

- 5. Select the **Pulse** tab and select the **Pulse Envelope** tab.
- 6. Set the following:
 - Pulse Shape to Raised Cosine.
 - Start Time to 0 ps (default).
 - **Rise Time** to 0.1 µs at 20–80%.
 - **Pulse Width** to 15 µs at 50%.
 - Fall Time to 0.1 µs at 20–80%.
 - Off Time to 30 µs.

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

- Amplitude Relative to Carrier to 0 dB (default).
- Offset from Carrier Frequency to 0 Hz (default).
- Repeat to 6.
- 7. Click the Modulation tab and set Select Modulation to No Modulation.

RFXpress - Radar.rfs											
ile View Configure	Waveform	em Wind	low Help								
elect: Radar - 👹 IF/RF	- 5	CVerv 🕄	iew 🌂 Fi	nd Instruments		Graph 👯 Cor	mpile •	On/Off	R R	un	
Carrier Pulse VQ Impa	irments	ice Addition	n								
	e Train						Selected	Pulse:			
Pulse 🖌 Inde	1.		PRI (ms)	Duration (ms)	^	Delete	1.00				
Add	Pulse	6	0.0452	0.27		•	0.75				
Insert	/				1		0.50				
					-		0.25				
Add Pulse							0				
Groups.					*			+ 1T>	Ton + Tf	= 15.24 us	_
Pulse Envelope Sta	gered PRI Modul	lation Hop	ping Puls	e Impairments	Multi	-Path Antenr	na				
Pulse Shape:	Raised Cosine										
				6					-		
Start Time (To):	0 p					Amplitude	Relative t	o Carrier:	0.00	/	//de
Rise Time (Tr):	100.000 n	S IN		0% 🖌 V		Offset from	n Carrier I	Frequency:	0	<u> </u>	🔏 н
Pulse Width (Ton):	15.000000 u		50%	• V		Repeat			6		0
Coll Trace (TO	400.000										
Fall Time (Tf):	100.000 n	5/	at 20-8	0% 🗸 V							
Off Time (Toff):	30.000005 u	🍼 🕄 s									
PRF:	22.102326 KHz										
										c	159-2

P	RFXpress - Rada	r. r fs					
Fi	ile View Configu	re 🛛 Wa	aveform S	ystem Win	dow Help		
Se	elect:Radar 🕶 🙀	IF/RF •	😴 Calibratio	on 🔹 🚟 Over	view 🔻 Fir	nd Instruments	
Wa	Carrier Pulse I/Q	Impairm	ents Interf	erence Additic	<mark>n</mark>		
Waveform List		Pulse T	rain				
шШ	Pulse 🔽	Index	Туре	Repeat	PRI (ms)	Duration (ms)	^
st	Add	Ů 1	Pulse	6	0.0452	0.27	
	Insert						=
	Insert						
	Add Pulse Groups				(7	~
		L				<u> </u>	Ľ
	Pulse Envelope	Stagge	red PRI M	odulation Ho	oping Pulsi	e Impairments	Multi
	Select Modulat	ion:	No Modulatio	on 🧹		*	
						()159-221

- Click the Hopping tab and select Turn on.
- 9. In the table, click Add to add rows.

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

Pulse Index Type Repeat PRI (ms) Duration (ms) Delete 1.00 Add 1 Pulse 6 0.0452 0.27 0 0.75 Add 1 Pulse 6 0.0452 0.27 0 0.75 Add Pulse 6 0.0452 0.27 0 0 0.25 0 Add Pulse 0 0 0 0 0 0 0 0 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Anterna Pulse-to-Pulse Frequency/Amplitude Hopping 0 0 0	Carrier Pulse I/O Impairments Interference Addition Pulse Train Pu	File	View Configur	re Wa	veform S	System Wir	ndow He	lelp			
Add 0.75 Insert 0.75 Add Pulse 0.80 Groups 0 Pulse Envelope Staggered PRI Modulation Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Offset (+/- MHz) Relative Amplitude (+/- dB) 1 0.000000 0.00 2 0.000000 0.00 0.00 2 0.000000 0.00 0.00 3 0.000000 5 0.000000	Pulse Train Selected Pul Pulse Index Type Repeat PRI (ms) Duration (ms) Delete 1.00 Add I Pulse 6 0.0452 0.27 0.75 0.50 Add Insert Image: Pulse for pulse 0.0452 0.27 0.75 0.75 Add Image: Pulse for pulse Image: Pulse for pulse 0.0452 0.27 0.075 0.050 Add Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antexna Pulse-to-Pulse Frequency/Amplitude Hopping Pulse Hopping Image: Pulse Train on Image: Pulse Train on <th>Sele</th> <th>ct: Radar • 🙀 I</th> <th>F/RF •</th> <th>🖫 Calibrati</th> <th>on 🔹 🚟 Over</th> <th>view 🤻</th> <th>Find Instruments</th> <th>🖂 Grap</th> <th>h 👯 Co</th> <th>ompile 🔹 Or</th>	Sele	ct: Radar • 🙀 I	F/RF •	🖫 Calibrati	on 🔹 🚟 Over	view 🤻	Find Instruments	🖂 Grap	h 👯 Co	ompile 🔹 Or
Add 0.75 Insert 0.75 Add Pulse 0.80 Groups 0 Pulse Envelope Staggered PRI Modulation Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Offset (+/- MHz) Relative Amplitude (+/- dB) 1 0.000000 0.00 2 0.000000 0.00 0.00 2 0.000000 0.00 0.00 3 0.000000 5 0.000000	Pulse Index Type Repeat PRI (ms) Duration (ms) Delete 1.00 Add 1 Pulse 6 0.0452 0.27 0 0.75 0.50 Add Insert 0 0.452 0.27 0 0.75 0.50 Add Pulse 0 0.452 0.27 0 0.25 0 0.25 0 0.25 0 0.25 0 0.25 0 0 0.25 0 0 0.25 0 0 0.25 0 0 0.25 0 0 0.25 0 0 0.25 0	С	arrier Pulse I/Q I	mpairme	ents Interf	erence Additi	on				
Add 0.75 Insert 0.75 Add Pulse 0.80 Groups 0 Pulse Envelope Staggered PRI Modulation Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Offset (+/- MHz) Relative Amplitude (+/- dB) 1 0.000000 0.00 2 0.000000 0.00 0.00 2 0.000000 0.00 0.00 3 0.000000 5 0.000000	Add 1 Pulse 0.0452 0.27 0.75 Insert 0.0452 0.27 0.75 0.50 Add Pulse 0.0452 0.27 0.75 0.50 Add Pulse 0.0452 0.27 0.75 0.50 Add Pulse 0.05 0.25 0 0.25 0 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Anterna Pulse-to-Pulse Frequency/Amplitude Hopping Pulse Amplitude (+/- dB) 1 0.000000 0.00 2 0.000000 0.00 2 0.000000 0.00 2 0.000000 0.00 2 0.000000 0.00 4 0.000000 0.00 4 0.000000 0.00 0			Pulse Tr	ain						Selected Pul
Add 0.75 Insert 0.75 Add Pulse 0.80 Groups 0 Pulse Envelope Staggered PRI Modulation Hopping Pulse Envelope Staggered PRI Modulation Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Frequency/Offset (+/- MHz) Relative Amplitude (+/- dB) 1 0 0.00000 2 0.000000 0 0.00 2 0.000000 0.00 0.00 3 0.000000 5 0.000000	Add 0.75 Insert 0.75 Add Pulse 0.75 Groups 0.25 Pulse Envelope Staggered PRI Modulation Hopping Pulse to-Pulse Frequency/Amplitude Hopping 1 0.000000 2 0.000000 3 0.000000 4 0.00000 5 0.00000 6 0.00000		Pulse 💌	Index	Туре	Repeat	PRI (ms	s) Duration (ms)		Delete	1.00
Insert 0.50 Add Pulse 0.50 Groups 0 Pulse Ervelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenta Pulse Ervelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenta Pulse-to-Pulse Frequency/Amplitude Hopping 0.00 Add 0.00000 Add 0.00000 0 0.00 2 0.000000 3 0.00000 4 0.00000 5 0.00000	Insert		bba	Ĵ 1	Pulse	6	0.0452	0.27		+	0.75
Add Pulse Groups 8 0.25 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Anterna Pulse-to-Pulse Frequency/Amplitude Hopping Pulse-to-Pulse Turn 1 0.000000 0.00 2 0.000000 0.00 Turn Add 0 0.000000 0.00 0.00 1 0.000000 0.00 1 0.000000 0.00 1 0.000000 0.00 1 0.000000 0.00 1 0.000000 0.00 1 0.000000 0.00 1 0.000000 0.00 1 0.000000 0.00 1 1 0.000000 0.00 1<	Add Pulse Groups 8 0.25 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Anterna Pulse to-Pulse Frequency/Amplitude Hopping Pulse Impairments Multi-Path Anterna 9 Add 0.00000 0.00 0.00 2 0.000000 0.00 3 0.000000 0.00 3 0.000000 0.00 6 0.000000 0.00 4 0.000000 0.00 0.00 6 0.000000 0.00 v v									+	
Add Pulse Groups Image: Construction of the second	Add Pulse Groups V Image: Constraint of the state		Insert						_		0.50
Add Pulse Groups Image: Construction of the second	Add Pulse Groups V Image: Constraint of the state									8	0.25
Groups V Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Anterna Pulse-to-Pulse Frequency/Amplitude Hopping Multi-Path Anterna Pulse-to-Pulse Frequency/Amplitude Hopping Impairments Multi-Path Anterna Add 0.000000 0.00 Add 0.000000 0.00 Delete 4 0.000000 5 0.00000 0.00	Groups Image: Construction of the second se		Add Pulse								
Pulse-to-Pulse Frequency/Amplitude Hopping Turn Add 0.000000 0.00 Add 0.000000 0.00 Delete 4 0.000000 0.00 5 0.00000 0.00	Pulse-to-Pulse Frequency/Amplitude Hopping 9 Hop Frequency/Offset (+/- MHz) Relative Amplitude (+/- dB) 1 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 4 0.000000 0.00 5 0.000000 0.00 6 0.000000 0.00										
Pulse-to-Pulse Frequency/Amplitude Hopping Turn Add 0.000000 0.00 Add 0.000000 0.00 Delete 4 0.000000 0.00 5 0.000000 0.00	Pulse-to-Pulse Frequency/Amplitude Hopping 9 Hop Frequency/Offset (+/- MHz) Relative Amplitude (+/- dB) 1 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 4 0.000000 0.00 5 0.000000 0.00 6 0.000000 0.00		Groups						*	T	۳ «—
Hop Frequency Offset (+/- MHz) Relative Amplitude (+/- dB) Turn Add 1 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 3 0.000000 0.00 4 0.000000 0.00 5 0.000000 0.00 <	9 Hop Frequency Offset (+/- MHz) Relative Amplitude (+/- dB) Turn on 1 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 3 0.000000 0.00 3 0.000000 0.00 3 0.000000 0.00 6 0.000000 0.00		<u> </u>	Stagger	red BBL M	adulation Us			Multi Dot	h	- I<
Add 1 0.000000 0.00 2 0.000000 0.00 3 Delete 4 0.000000 0.00 5 0.000000 0.00	Hop Frequency Offset (*/- MHZ) Relative Amplitude (*/- db) A 1 0.000000 0.00 2 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 3 0.000000 0.00 5 0.000000 0.00 6 6 0.000000 0.00 v v v		Pulse Envelope	00				ulse Impairments	Multi-Pati	h Anter	- I<
1 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 4 0.000000 0.00 5 0.000000 0.00	1 0.000000 0.00 2 0.000000 0.00 3 0.000000 0.00 4 0.000000 0.00 5 0.000000 0.00 6 0.000000 0.00		Pulse Envelope	00				ulse Impairments	Multi-Pati	h Anter	- I<
Add 3 0.00000 0.00 4 Delete 4 0.00000 0.00 6 5 0.00000 0.00 0.00 6	Add 3 0.000000 0.00 4 Delete 4 0.000000 0.00 5 0.000000 0.00 6 0.000000 0.00 4 0.000000 0.00 6 0.000000 0.00 4 0.000000 0.00 4 0.000000 0.00 6 0.000000 0.00 4 0.000000 0.00 4 0.000000 0.00 4 0.000000 0.00 4 0.00 4 0.00 4 0.00 4 0.00 4 0.00 4 0.00 0.00 4 0.00 4 0.00 4 0.00 4 0.00 4 4 0.00 4 0.00 4 4 0.00 4		Pulse Envelope	se Freq	uency/Amp	litude Hopp	ing				na IK
Bit Delete 3 0.000000 0.00 4 0.000000 0.00 0.00 5 0.000000 0.00 0.00	3 0.000000 0.00 Delete 4 0.000000 0.00 5 0.000000 0.00 0.00 6 0.000000 0.00 v		Pulse Envelope	se Frequence	uency/Amp	litude Hopp cy Offset (+/-	ing	Relative Amplitude			na IK
5 0.00000 0.00	5 0.000000 0.00 - 6 0.000000 0.00 v		Pulse Envelope	Hop 1	uency/Amp	litude Hopp cy Offset (+/- 0.000000	ing	Relative Amplitude 0.00			na IK
	6 0.000000 0.00 v		Pulse Envelope	Hop 1 2	uency/Amp	litude Hopp cy Offset (+/- 0.000000 0.000000	ing	Relative Amplitude 0.00 0.00			na IK
6 0.00000 0.00	v		Pulse Envelope Pulse-to-Pulse 9 Add	Hop 1 2 3	uency/Amp	litude Hopp cy Offset (+/- 0.000000 0.000000 0.000000	ing	Relative Amplitude 0.00 0.00 0.00			na IK
			Pulse Envelope Pulse-to-Pulse 9 Add	Hop 1 2 3 4	uency/Amp	litude Hopp cy Offset (+/- 0.000000 0.000000 0.000000 0.000000	ing	Relative Amplitude 0.00 0.00 0.00 0.00			na IK
	Repeat frequency/amplitude hopping		Pulse Envelope Pulse-to-Pulse 9 Add	56 Frequencies 1	uency/Amp	litude Hopp cy Offset (+/- 0.000000 0.000000 0.000000 0.000000 0.000000	ing	Relative Amplitude 0.00 0.00 0.00 0.00 0.00			na IK

- 10. Set the following:
 - Frequency Offset for the first hop to 50 MHz.
 - Frequency Offset for the second hop to 40 MHz.
 - Frequency Offset for the third hop to -50 MHz.
 - Frequency Offset for the fourth hop to 0 MHz.
 - Frequency Offset for the fifth hop to 30 MHz.
 - Frequency Offset for the sixth hop to -30 MHz.
- **11.** From the toolbar, click **Compile Settings**.

P	RFXpress - R	adaı	r. r fs								
Fi	ile View Cor	nfigu	re Wa	aveform	System Wir	ndow Help	L.				
Se	elect: Radar •	₩	IF/RF •	🖫 Calibra	ation 🔹 🚟 Over	rview 🤻 Fi	nd Instruments	🖂 Graph 👯			
Wa	Carrier Pulse	I/Q	Impairm	ients Inte	erference Additi	on					
Waveform List			Pulse T	rain							
3	Pulse	~	Index	Туре	Repeat	PRI (ms)	Duration (ms)	Delete			
st	Add 1 Pulse 6 0.0452 0.27										
	Insert										
	Add Pulse										
	Groups v										
	Pulse Envel	ope	Stagge	red PRI	Modulation Ho	pping Puls	e Impairments	Multi-Path Ant			
	Pulse-to	-Pul	se Freq	uency/Ar	nplitude Hopp	ing					

	Нор	Freque	y Offset (+/- MHz)	Relative Amplitude (+/- dB)	^
	1		50.000000	0.00	
	2		40.000000	0.00	
Add	10		-50.000000	0.00	=
Delete			0.000000	0.00	
	5		30.000000	0.00	
	6		-30.000000	0.00	
			4		*

0159-223

File View	- Radar.rfs		System	Window	Help		(11) —
					Rind Instruments	🔼 Graph	👯 Compile 🔹	
Carrier Pulse VQ Impairments Interference Addition					Compile S	ettings		

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

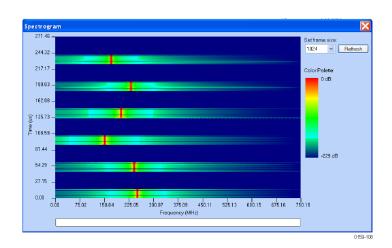
14. The compiled pulse is displayed in the Waveform List. In the Waveform List, select the IF/RF signal and right-click. Select Show Graph > Spectrogram to display the graph of the pulse.

Compile Settings
Signal Format 12 GIF/TRF IQ Pulse name: Waveform1
Sampling Rate 10.00000000 G Automatic Oversampling 6.0000
Compile Button Preferences
 ○ Compiles and sends to: ▼ ● Compiles only
✓ Overwrite waveform in RFXpress list
□ I Invert □ Q Invert 13
Compile OK Cancel Help

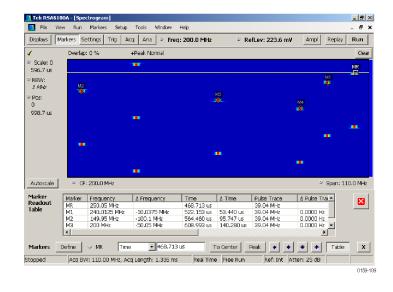
File View Configure Waveform System Window Help	
Select: Radar • 👹 IF/RF • 🥵 Calibration • 🗟 Overview 🔍 Find Instruments 🖾	Graph
Waveform List - * × reference Addition	
Waveform List P × reference Addition Name Length Sam Form Wavef 407 k 1.50 I	
Wavef. 407 k 1.50 Q Repeat Profiles Duration (ins)	
Show Graph • Spectrum	
Save Data as Time domain	
Import from File	
14 Import from Tektronix Oscilloscope	
Delete CCDF	
Delete All Graph Setup	
uise impairments Muto	Patr
Rename	0159-225

15. The spectrogram is as shown.

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



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



Creating Costa's Modulation

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

1. Start RFXpress.

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

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

礥 RFXpress - Ra	dar.rfs	
File Vie Cont	figure Waveform	System Window
Select: Radar -	🙀 IF/RF 🝷 式 Calibra	ation 🔹 🚟 Overview
Carrier Pulse	I/Q Impairments Inte	erference Addition
Carrier Magni	tude (Peak):	🗘 dBm
Carrier Frequ	ency: 1.000	00000 G 🕃 Hz
Coherent C		5
		0159-226

P	RF)	(pres	s - Ra	adar	r. r fs									
Fi	ile	View	Cor	nfigu	re	Wa	veform Sys	tem)	Win	dow	Help			
se	elect	: Rac	lar •	₩	IF/RF	•	😴 Calibration	- 100 O	verv	/iew	🔫 Fir	id Instru	uments	
Waveform List	Са	rrier	ulse		•		ents Interfere	nce Ad	ditio	n				
forn		_/_		_	Pulse									_
n Lis	E	vse		*	Inde		Туре	Repea	at		(ms)	Duratio	on (ms)	^
a,			Add		Ĵ.	1	Pulse	1		0.212	20	0.21		
	K		Insert		<u> </u>									=
	6)					_								
	\checkmark			_										
			Pulse ups											~
			apo											×.
	F	Pulse E	Envel	ope	Stag	iger	ed PRI Modu	lation	Нор	ping	Pulse	e Impairi	ments	Multi
		Pulse	e Sha	pe:		R	ectangular 🤇	~						
		Start	Time	(To):	0	р	**		7				
		Rise	Time	(Tr)		1	n	7	T	at	0-100)% 🗸	V	
		Pulse	e Wid	th (T	"on):	1	12.000000 u 🄇	<u>/</u>	s	at	100%	5 v	V	
		Fall T	Fime ((Tf):		1	n		s	at	0-100)% 🗸	V	
		Off T	ïme (Toff)	:	1	00.000000 u 🔇		s					
		PRF:				4.7	716981 KHz							
													0	159-227

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

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

- 9. In Add Steps enter 7.
- 10. Click Add.
- **11.** In the table, enter the following:
 - Duration to 16000 ns.
 - Frequency to 127.2 MHz.
- 12. Repeat step 11 for all the steps in the code. Keep the duration constant (16000 ns) and calculate the frequency using the formula Δf^* code (for example 42.4 * 3, 42.4 * 6, 42.4 * 0, and the rest).

13. From the toolbar, click Compile.

	ile View Config									
5	elect:Radar 🕶 💡	F/RF	Calibration	Overview	🔻 Find Instru	uments 🛛 🔼 Grap	oh 👯 (Comp	oile 🔹	0
	Carrier Pulse I/G	Impairm	nents Interference	Addition						
		Pulse	Train							
	Pulse 🗸	Inde	х Туре	Repeat	PRI (ms)	Duration (ms	6)	^	Delet	te
		Ĵ	1 Pulse	1	0.2120	0.21				
	Add							=		
	Insert								+	
					8					
	Add Pulse Groups				0					
	Add Pulse Groups				P			*		
	Groups	Staggere	d PRI Modulation	Hopping Puls	γ	ts Multi-Path /	Antenna	✓		
	Groups Pulse Envelope				γ	ts Multi-Path /	Antenna	v		
)	Groups Pulse Envelope		d PRI Modulation		γ	ts Multi-Path /	Antenna	•		
)	Groups Pulse Envelope Select Modulat		User Defined S	tep FM AM	γ	ts Multi-Path A	Antenna	•		
9	Groups Pulse Envelope				γ	ts Multi-Path A	Antenna	•		
	Groups Pulse Envelope Select Modulat		User Defined S	tep FM AM	Freque	ts Multi-Path /	Ampl		8	
	Groups Pulse Envelope Select Modulat	ion: 7 Step	User Defined S	ttep FM AM	Freque	ency offset (+/-	Ampl (dB)		8	
	Groups Pulse Envelope Select Modulat Add Steps:	ion: 7	User Defined S	itep FM AM	Freque MHz) 36 127.20	ency offset (+/-	Ampl		8	
	Groups Pulse Envelope Select Modulat Add Steps:	ion: 7 Step 1	User Defined S User Duration (ns) 16000	ttep FM AM	Freque MHz) 35 127.20 35 254.40	ency offset (+/- 0000 0000	Ampl (dB) 0.00	litudi	8	
	Groups Pulse Envelope Select Modulat Add Steps:	on: 7 Step 1 2	User Defined S User Duration (ns) 16000 16000	tep FM AM	Freque MHz) 35 127.20 35 254.40 35 0.0000	ency offset (+/- 0000 0000	Ampl (dB) 0.00			
9	Groups Pulse Envelope Select Modulat Add Steps:	7 7 Step 1 2 3	User Defined S	tep FM AM	Freque MH2) 35 127.20 35 254.40 35 0.0000 35 212.00	ency offset (+/- 0000 0000 0000	Ampl (dB) 0.00	litudi		

							13
File	View	Configure	Waveform	System	Window	Help	T
Sele	c t: Rad	ar 🔹 🙀 IF/R	RF 🔹 🕵 Calibr	ation 🔹 🚟	Overview	🍕 Find Instruments	🖾 Graph 👯 Compile 🝷
							0159-229

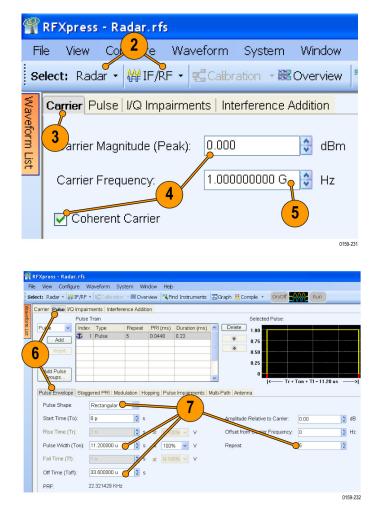
- In the waveform list, select IF/RF. Right-click and select Show Graph > Spectrogram.
- 🎢 RFXpress Radar.rfs File View Configure Waveform System Window Help Select: Radar • 🙀 IF/RF • 🕵 Calibration • 😹 Overview 🤻 Find Instruments 🗷 Graph 😁 🔀 erference Addition Name Length Sam... Form Wavef. 1.60 M 7.53 ... 7.53 ... Repeat | PRI (ms) | Duration (ms) De Wavef... 1.60 M 0 List 0.21 Show Graph Spectrum Time domain Save Data as... 0 Spectrogram Import from Eile CPI Graph 14 Import from Tektronix Oscilloscope... CCDF Delete Graph Setup... se Impairments Multi-Path Delete All Rename.. 0159-230
- Spectrogram 212.00 -Setframe size Refresh 512 190.80 169.60 Color Palette 0 dB 148.40 -127.20 -(m) 106.00 -∰ ⊨ 84.80 -63.60 42.40 21.20 0.00 0.38 0.75 1.13 1.51 1.88 2.26 Frequency (GHz) 0.00 3.01 3.39 2.63 3.76 0159-115
- **15.** The spectrogram is as shown.

Creating a Radar Waveform using Staggered PRI for Better Range Ambiguity

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

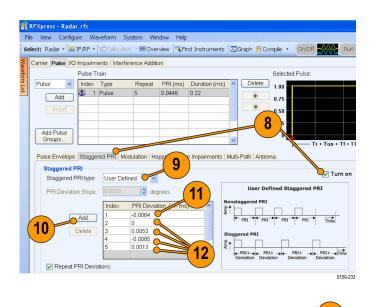
- 1. Start RFXpress.
- From the toolbar, click Select > Radar. Select the signal type as IF/RF.
- 3. Click the Carrier tab.
- Leave the defaults for Coherent Carrier (enabled) and Carrier Magnitude (Peak).
- 5. Set the Carrier Frequency to 1 GHz.

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

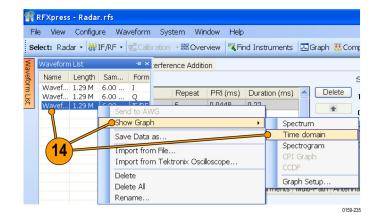


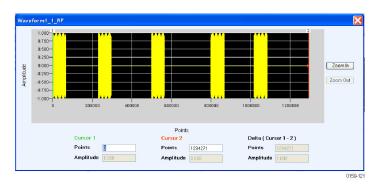
- 8. Click the Staggered PRI tab and select Turn on.
- 9. Set Staggered PRI type to User Defined. You will change the PRI for each pulse by adding a deviation. The PRI is calculated as follows: Current PRI + deviation. The deviation is specified in the table.
- 10. Click Add to add a row to the table.
- **11.** Enter the deviation –0.0064 (in ms) for the first pulse.
- Repeat steps 10 and 11 to enter the deviation for the remaining pulses as: 0, 0.0053, -0.0085, and 0.0013.
- **13.** From the toolbar, click **Compile**.
- In the waveform list, select IF/RF. Right-click and select Show Graph > Time domain.

15. The time domain graph is as shown.



								(13)	
File	View	Configure	Waveform	System	Window	Help		T	
Selec	t: Rada	ar 🔹 🙀 IF/R	F 🔹 🛒 Calibr	ation 👻 🚟	Overview	🌂 Find Instruments	🔼 Graph	tompile 👯	•
								015	9-234



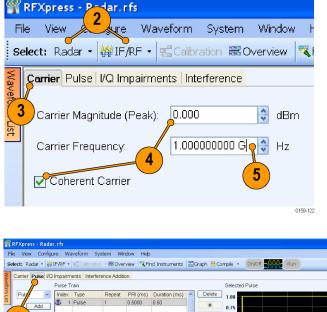


Simulating Multiple Targets for Radar Receiver Testing (Different Pulse Groups)

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

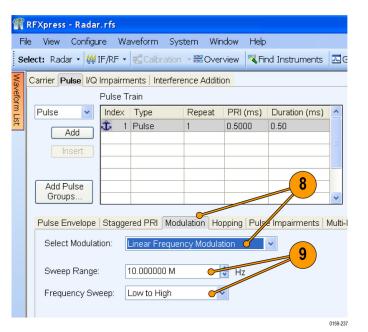
- 1. Start RFXpress.
- 2. From the toolbar, click Select > Radar. Set the signal type to IF/RF.
- 3. Click the Carrier tab.
- Leave the defaults for Coherent Carrier (enabled) and Carrier Magnitude (Peak).
- 5. Set the Carrier Frequency to 1 GHz.
- 6. Select the **Pulse** tab and select the **Pulse Envelope** tab.
- 7. Set the following:
 - Pulse Shape to Rectangular.
 - Start Time to 40 µs.
 - Pulse Width to 5 µs at 100%.
 - Off Time to 455 µs.
 - Amplitude Relative to Carrier to 0 dB (default).

Observe that the PRI is 500 μ s.



🔐 R	FXpress - Radar.rfs							
File	View Configure	Waveform Syst	em Window	Help				
Sele	ect: Radar - 👹 IF/RF	- Calbration	- 🚟 Overview	KFind Instrum	ents 🖾 Graph 👯 C	Compile - On/Off 🚽	Run	_
Waveform I kt	Puls	irments Interferen e Train ex Type 1 Pulse	Repeat PR	1 (ms) Duration (000 0.50	ms) Delete * * * * * * * * * * * * * * * * * * *	Selected Pulse: 1.00 0.75 0.50 0	Ton + TI - 5.00 us -	dB Hz
								0159-236

- Click the Modulation tab and set Select Modulation to Linear Frequency Modulation.
- 9. Set the following:
 - Sweep Range to 10 MHz.
 - Frequency Sweep to Low to High.



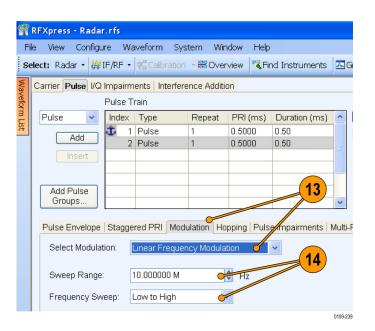
- **10.** Click **Add** to add a pulse. Select the newly added pulse.
- 11. Select the Pulse Envelope tab.
- **12.** Select the pulse and set the following:

(

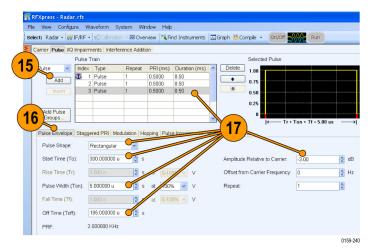
- Pulse Shape to Rectangular.
- Start Time to 120 µs.
- Pulse Width to 5 µs at 100%.
- Off Time to 375 µs.
- Amplitude Relative to Carrier to -2 dB.

View Configu	re Wa	aveform Sy	stem Wi	ndow Help)							
ect: Radar • 🙀 i	IF/RF •	Calbration	n - 🔣 Ove	rview 🥄 Fi	nd Instruments	⊠G	raph 👯 Co	mpile •	on/off	RI.	n	
Carrier Pulse I/Q	Impairm	ents Interfe	rence Addit	ion								
	Pulse T	rain						Selected P	ulse:			
ulse 💌	Index	Туре	Repeat	PRI (ms)	Duration (ms)	^	Delete	1.00				
Add		Pulse	1	0.5000	0.50		+	0.75				
	2	Pulse	1	0.5000	0.50	Ξ	*					
Insert								0.50				
								0.25				
dd Pulse iroups						~	\frown	0				
Procepts	L		_					14-	Tr +	Ton + Tf =	5.00 us	_
Pulse Envelope	Stagge	red PRI Mor	dulation H	opping Puls	e Imnairment		12					
Pulse Envelope Pulse Shape:		red PRI Moi Rectangular	dulation He	opping Puls	e Imnairment		12					
Pulse Shape:	F	Rectangular	<pre>V</pre>	opping Puls	e Impairment					~		
	F		<pre>V</pre>	opping Puls				Relative to (Carrier.	2.00		< v
Pulse Shape:); 1	Rectangular	<pre>V</pre>	opping Puls	e Innaire-		Amplitude					<> <>
Pulse Shape: Start Time (To Rise Time (Tr)): []	Rectangular 20.000000 u .000 n		1	V		Amplitude Offset fro	Relative to 0		0		*
Pulse Shape: Start Time (To): []	Rectangular 20.000000 u	v s		V		Amplitude	Relative to 0				
Pulse Shape: Start Time (To Rise Time (Tr)	F i): 1): 1 Fon): 5	Rectangular 20.000000 u .000 n		at 0-10 at 1009	V		Amplitude Offset fro	Relative to 0		0		* *
Pulse Shape: Start Time (To Rise Time (Tr) Pulse Width (T	F): 1): 5 Fon): 5	Rectangular 20.000000 u .000 n .000000 u		at 0-10 at 1009 at 0-10	V 10 V 16 V		Amplitude Offset fro	Relative to 0		0		* *

- Click the Modulation tab and set Select Modulation to Linear Frequency Modulation.
- 14. Set the following:
 - Sweep Range to 10 MHz.
 - Frequency Sweep to Low to High.



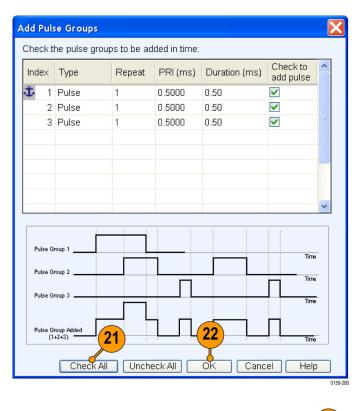
- 15. Click Add to add a pulse.
- 16. Select the Pulse Envelope tab.
- **17.** Select the pulse and set the following:
 - Pulse Shape to Rectangular.
 - Start Time to 300 µs.
 - Pulse Width to 5 µs at 100%.
 - Off Time to 195 µs.
 - Amplitude Relative to Carrier to -3 dB.



- Click the Modulation tab and set Select Modulation to Linear Frequency Modulation.
- 19. Set the following:
 - Sweep Range to 10 MHz.
 - Frequency Sweep to Low to High.
- 20. Click Add Pulse Groups.

P	RFXpress - Rada	r.rfs					
Fi	le View Configu	ure Wa	veform Sys	tem Win	dow Help		
Se	elect:Radar 🕶 👹	IF/RF •	式 Calibration	- 🚟 Over	view 🔻 Fir	d Instruments	二(
Wa	Carrier Pulse I/Q	Impairm	ents Interfere	nce Additio	<mark>on</mark>		
Waveform List		Pulse Ti	rain				
m Li	Pulse 🗸	Index	Туре	Repeat	PRI (ms)	Duration (ms)	^
Ħ	Add	Ĵ 1	Pulse	1	0.5000	0.50	
	Insert	2	Pulse Pulse	1	0.5000	0.50	=
	insen		ruise	1	0.0000	0.00	
	Add Pulse Groups Pulse Envelope Select Modula Sweep Range Frequency Sw	tion:	red PRI Modu inear Frequen 0.000000 M .ow to High			18 Impairments 1 19	Multi
		eep. L	LOW LO Y HIGH				
						01	159-241

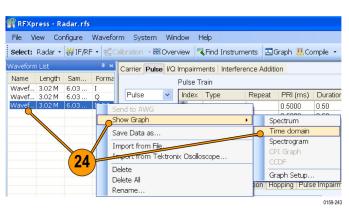
- 21. Click Check All.
- 22. Click OK.

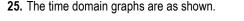


23. From the toolbar, click Compile.



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



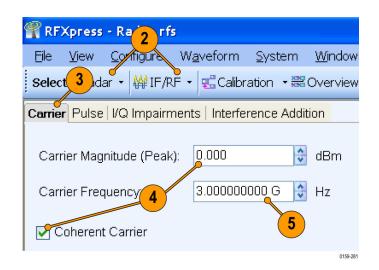




Simulating a Scanning Antenna with a Gaussian Shape

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

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



- 6. Select the Pulse tab and select the Pulse Envelope tab.
- 7. Set the following:
 - Pulse Shape to Rectangular.
 - Pulse Width to 5 µs.
 - Off Time to 50 µs.
 - Repeat to 20.

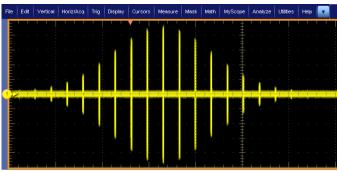
File View Confi	igure V	Vaveform	System	Window H	<u>H</u> elp				
Select: Radar • 🕴	#IF/RF	• 🕵 Calibr	ation 🔹 🔀 i	Overview	Find Instruments	s 🖾 Graph 👌	👯 Compile 🔹	on/off	Run
Carrier Pulse VQ Ir	mpairmer	nts Interfe	rence Addit	on					
	Pulse Trai	in					Selected Puls	e:	
	Index T		Repeat	PRI (ms)	Duration (ms)	Delete	1.00		
Add	🗘 1 P	Pulse	20	0.0550	1.10	+	0.75		
Insert							0.50		
							0.25		
Add Pulse									
Groups						~	0		
							K		
Pulse Envelope	Stannere	d PRI Mo	dulation H	apping Puls	e Impairments Mu	Iti-Path Ante		— Tr + Ton + `	11 = 5.00 i
			dulation He	opping Puls	e Impairments Mu	ulti-Path Ante		— Tr + Ton + `	11 - 5.00 1
Pulse Envelope Pulse Shape:		d PRI Mo		opping Puls	<mark>e Impairments Mu</mark>	ulti-Path Ante		— Tr + Ton + `	11 = 5.00 1
	Re	ctangular	dulation He	ppping Puls	e Impairments Mu				1 t = 5.00 i
Pulse Shape: Start Time (To):	Re 0 p	ctangular	s			Amplitud	nna e Relative to Car	rrier: 0.00	11 - 5.00 1
Pulse Shape:	Re 0 p	ectangular 100 n	~	at 0-10	7	Amplitud	nna	rrier: 0.00	11 - 5.00
Pulse Shape: Start Time (To):	Re 0 p	ctangular	s		7	Amplitud	nna e Relative to Car	rrier: 0.00	11 - 5.00 1
Pulse Shape: Start Time (To): Rise Time (Tr):	Re 0 p 1.0 on): 5.0	ectangular 100 n	s	at 0-10 at 1009	7	Amplitud	nna e Relative to Car	rrier: 0.00 uency: 0	1 = 5.00
Pulse Shape: Start Time (To): Rise Time (Tr): Pulse Width (To	Re 0 p 1.0 on): 5.0	octangular 00 n 100000 u		at 0-10 at 1009	0% 7	Amplitud	nna e Relative to Car	rrier: 0.00 uency: 0	1 - 5.00
Pulse Shape: Start Time (To): Rise Time (Tr): Pulse Width (To Fall Time (Tf):	Re 0 p 1.0 5.0 10 50	octangular 100 n 100000 u 100 n		at 0-10 at 1009	0% 7	Amplitud	nna e Relative to Car	rrier: 0.00 uency: 0	1 = 5.00 0

- 8. Click the Antenna tab and click Turn On.
- 9. Set the following:
 - Beam Type to Gaussian.
 - Beam Width to 0.05 degree.

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

File View Configure Waveform System Window Help	_							10	
Select: Radar • @ IF/RF • Calbration • 🗟 Overview Find Instruments Information (ms) • (model) Carrier Pulse Ivaliant (ms) Interference Addition • (model) Pulse Index Type Repeat PRI (ms) Duration (ms) • (model) Add Insert Index Type Repeat PRI (ms) Duration (ms) • (model) Add Insert Insert Insert • (model) • (model) • (model) Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antennation 8 Define Antennation 9 Scan Rate: 180.000 © degrees/sec Beam Type: Gaussian Scan Area: 0.198000 degrees 198000 degrees	i	RFXpress - Radar.rf	s						
Carrier Pulse UQ Impairments Interference Addition Pulse Train Pulse Index Type Repeat PRI (ms) Duration (ms) Add Insert Add Pulse Groups Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna Beam Type: Beam Type: Beam Width: 0.050 Gaussian Gaussia	F	ile View Configure	Wavefor	m System	Window Hel	Þ		T	
Add Insert Add Uilse Groups Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Define Antenna 9 Beam Type: Gaussian Scan Rate: 180.000 © degrees/sec Beam Width: 0.050 © degrees Scan Area: 0.198000 degrees	5	elect: Radar 🝷 🙀 IF/F	₹F • 🖫	Calibration 💌	Overview	💐 Find Instrume	nts 🔼 Graph 👯	Compile 🝷	On/Off
Add Insert Add Uilse Groups Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Define Antenna 9 Beam Type: Gaussian Scan Rate: 180.000 © degrees/sec Beam Width: 0.050 © degrees Scan Area: 0.198000 degrees	Ę	Carrier Pulse I/Q Imp	airments	Interference.	Addition				
Add Insert Add Ulse Groups Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna Beam Type: Gaussian Scan Rate: 180.000 degrees/sec Beam Width: 0.050 degrees Scan Area: 0.198000 degrees	-		Pulse Tra	in					
Add Insert Add Pulse Groups Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Pulse Impairment Impairments Multi-Path Antenna 9 Pulse Impairment Impairments Multi-Path Impairments Mul	÷	Pulse 🗸	Index	Туре	Repeat	PRI (ms)	Duration (ms)		elete
Insert Insert Add Pulse Insert Add Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna Beam Type: Gaussian Beam Width: 0.050 Gegrees Scan Area: 0.198000 degrees	-	0.44	Ů 1	Pulse	20	0.0550	1.10		•
Add Pulse Groups Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Define Antenna 9 Beam Type: Beam Width: 0.050 0 degrees 180.000 0 degrees sec Beam Width: 0.050 0 degrees 180.000 degrees 180.000 0 degrees 180.000		Add							
Groups Image: Construction of the second sec		Insert							•
Groups Image: Construction of the second sec									
Pulse Envelope Staggered PRI Modulation Hopping Pulse Impairments Multi-Path Antenna 8 Define Antenna 9 Beam Type: Gaussian Scan Rate: 180.000 @ degrees/sec Beam Width: 0.050 @ degrees Scan Area: 0.198000 degrees		Add Pulse						-	
Define Antenna 9 Turn on Beam Type: Gaussian Scan Rate: 180.000 degrees/sec Beam Width: 0.050 degrees Scan Area: 0.198000 degrees		Groups						~	
Define Antenna 9 Turn on Beam Type: Gaussian Scan Rate: 180.000 degrees/sec Beam Width: 0.050 degrees Scan Area: 0.198000 degrees		Dutes Environment	a second D	DI Manualatia	al Hanninal Du		La sulti Di alla La sulta u		
Beam Type: Gaussian Scan Rate: 180.000 @ degrees/sec Beam Width: 0.050 @ degrees Scan Area: 0.198000 degrees		Pulse Envelope Sta	iggered P	RI Modulatio	n Hopping Pu	ise impairment	s Multi-Path Anter		
Beam Type: Gaussian Scan Rate: 180.000 C degrees/sec Beam Width: 0.050 C degrees Scan Area: 0.198000 degrees		Define Antenna							
Beam Width: 0.050 Carees Scan Area: 0.198000 degrees				9				Turn or	n
Beam Width: 0.050 Carees Scan Area: 0.198000 degrees				\mathbf{X}					
		Beam Type:	Ga	ussian	*	Scan Rate:	180.000	😂 degrees	/sec
					-				
Target Bearing: 0.000		Beam Width:	0.0	50 💛	👻 degrees	Scan Area:	0.198000 degre	35	
		Target Bearing	: 0.0	00	degrees				
									0450.22

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



Application Examples: OFDM

Create a TG3c Standard OFDM Symbol

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

3

• 14 IF/RF •

Frequency

Carrier Magnitude (Peak):

sic Setup Symbols Packets Frames Dis

Cvervier Overvier

5.00000000 G

0.000

Configure Waveform System Presets Window Help

Select: OFDM • 👹 IF/RF • 🕵 Calibration • 🗟 Overview 🍕 Find Instruments 🖾 Graph 👯 Compile •

4

🗘 dBm

💐 Find Instruments

Base Data

Base Data Base Data Base Data

Basel

🗔 Graph 🐰 Compile

5

Name

Data Source

PRBS Type

On/Of

Run

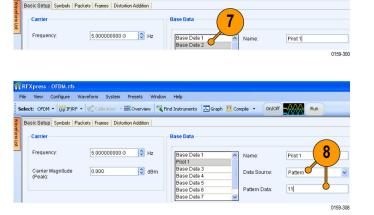
6

0159-299

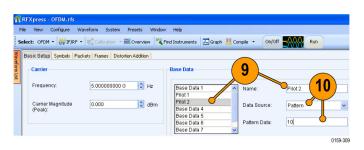
Base Data 1

PRBS

- 1. Start RFXpress.
- 2. From the toolbar, click Select > OFDM.
- 3. Click the Basic Setup tab.
- 4. Set the Frequency to 5 GHz.
- 5. Select Base Data 1 from the list.
- 6. Set the Data Source to PRBS and PRBS Type to User Defined.
- 7. Select Base Data 2 from the list and enter the **Name** as Pilot 1.
- 8. Set the Data Source to Pattern and Pattern Data to 11.



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



12

Base Data 4

PRBS

- 11. Select Base Data 4.
- 12. Set the Data Source to PRBS and PRBS Type to 9.

f RFX press

Frequency:

File View Configure Waveform System Presets Window Help

0.000

Basic Setup Symbols Packets Frames Distortion Addition

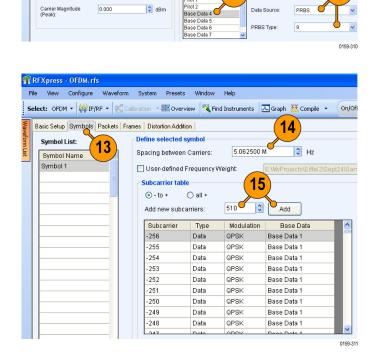
Select: OFDM • 👹 IF/RF • 🛫 Calibration - 🚟 Overview 🤻 Find Instruments 🗔 Graph 👯 Compile •

🗘 dBm

5.00000000 G 🗘 Hz

- 13. Click the Symbols tab.
- 14. Set Spacing between Carriers to 5.0625 M.
- 15. In Add new subcarriers, enter 510 and click Add.

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



Base Data

Base Data 1

lot '

Pilot 2

11

Name

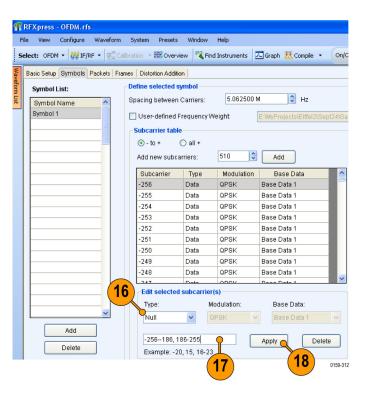
Data Source:

16. Set Type to Null.

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

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

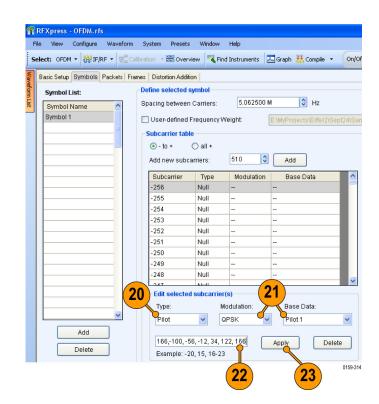
18. Click Apply.



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

Select: OFDM • ₩ IF/RF • Cabradon • ₩ Overview Find Instruments Carph ₩ Comple • Only Basic Setup Symbols Packets Frames Distortion Addition Symbol List: Spacing between Carriers: 5.062500 M • Hz Symbol 1 User-defined Frequency Weight: E:MyProjects/Effel2/Sept24/S Subcarrier table • 10 + ○ all + Add Subcarrier Type Add			- OFDM.rf								
Basic Setup Symbols Packets Frames Distortion Addition Symbol List: Symbol Name Symbol Name Symbol 1 User-defined Frequency Weight: Either Selected Symbol Subcarrier table Image: State of the selected symbol Subcarrier Type Modulation Basic Setup Symbol 1 User-defined Frequency Weight: Either Selected Symbol Subcarrier Type Modulation Basic Setup Site Subcarrier Type Mull -251 Null -252 Null -253 Null -254 Null -250 Null -251 Null -253 Null -254 Null -250 Null -251 Null -253 Null -254 Null -255	File	View	Configure	Waveform	System	Presets	Window	Help			
Symbol 1 User-defined Frequency Weight E:WeyProjects/E:Iffel2USept24/S Subcarrier table • • • • • • all + Add new subcarriers: 510 Add Subcarrier Type Modulation Base Data -255 Null - • - -255 Null - • - -254 Null - • - -251 Null - • - -252 Null - • - -251 Null - • - -250 Null - • - -254 Null - • - -251 Null - • - -252 Null - • - -254 Null - • - -253 Null - • - -254 Null - • - -251 Null - • - -249 Null - • - -248 Null - • - -248 Null - • Mull • • • Mull • • • Mull • • • Pelete <	Sele	ct: OFDM	1 🕶 🙀 IF/	RF 🕶 🖫 Ca	libration	🚟 Overvie	ew 🤻 Fir	nd Instruments	🛴 Graph	n 👯 Compile 🔹	On/Ol
Symbol 1 User-defined Frequency Weight: E:MeyProjects/E:Iffel2/Sept24/S Subcarrier table • -10 + • all + Add new subcarriers: 510 • Add Subcarrier Type Modulation Base Data -256 -255 Null -254 Null -253 Null -251 Null -252 Null -251 Null -249 Null -248 Null -248 Null -248 Null -248 Null -248 Null -249 Null -249 Null -249 Null -249 Null -50 Null -249 Null	Way B.	asic Setup	Symbols	Packets Fra	ames Dist	ortion Addition	n				
Symbol 1 User-defined Frequency Weight E:MeyProjects/E:Iffel/2/Sept24/S Subcarrier table • • • • • all + Add • • • • • all + Add new subcarriers: 510 • Add Subcarrier Type Modulation Base Data -256 Null • • • -255 Null • • • -253 Null • • • -251 Null • • • -251 Null • • • -253 Null • • • -254 Null • • • -253 Null • • • -254 Null • • -251 Null • • -248 Null • • -248 Null • • -248 Null • • -248 Null • • Mull • • • Mull • • • • • • • • • • • • • • •	vefor	Symbol	list:		Define	selected sy	mbol				
Symbol 1 User-defined Frequency Weight E:WeyProjects/E:Iffel/2/Sept24/S Subcarrier table • • • • • all + Add • • • • • all + Add new subcarriers: 510 • Add Subcarrier Type Modulation Base Data -256 Null • • • • -255 Null • • • -253 Null • • • -251 Null • • • -251 Null • • • -253 Null • • • -254 Null • • • -251 Null • • • -253 Null • • • -254 Null • • • -251 Null • • • -248 Null • • • -248 Null • • • Null • • • • Modulation: Base Data: • Null • • Add • • Letter • • Add • • •	m Lis	-		^	Spacin	g between (Carriers:	5.062500	м	🗘 Hz	
Control requery vergin. Exempt to be Control to September 2000 percent to 2000 p	<u> </u>										
Image: Construction of the second		0,111001		=				weight:	EXMyPt	rojects\Eiffel2\S	ept24\Sa
Add new subcarriers: 510 Add Subcarrier Type Modulation Base Data -256 Null -255 Null -253 Null -251 Null -252 Null -251 Null -250 Null -248 Null -248 Null -248 Null -248 Null -248 Null -248 Null -247 Modulation: Base Data -248 Null -247 Modulation: Base Data VIII QPSK Base Data -20, 15, 16-23 Acply Delete											
Subcarrier Type Modulation: Base Data -256 Null					•	to + (🔵 all +				
-256 Null -255 Null -254 Null -253 Null -253 Null -251 Null -251 Null -250 Null -249 Null -248 Null Null -248 Null -248 Null -248 Null Null Base Data: Null Base Data: Null -1,0,1 Apply Delete					Add	new subcar	rriers:	510 🗘	A	bt	
-255 Null				_	Sul	ocarrier	Type	Modulation	В	ase Data	^
-254 Null -253 Null -252 Null -251 Null -250 Null -250 Null -249 Null -248 Null -248 Null -248 Null -248 Null -248 Null Aud -248 Null Null -247 Modulation: Base Data Null Add - Example: -20, 15, 16-23 Apply Delete				_	-25	i .	Null				
-253 Null -252 Null -251 Null -250 Null -250 Null -243 Null -248 Null Add Add Low -248 Null Null -248 Null Null -247 Null -248 Null -249 Null -248 Null Add - - - Low - - - Kull - - - Low - - <				_	-25	i	Null				
-252 Null -251 Null -250 Null -250 Null -249 Null -243 Null -243 Null -243 Null -243 Null -243 Null -243 Null -245 Modulation: Base Data: Vpe: Modulation: Base Data: Null OPSK Base Data: 1.0,1 Opsk Delete				_	-25	ŧ	Null				
-251 Null -250 Null -249 Null -248 Null -248 Null -248 Null -248 Null -248 Null -247 Modulation: Base Data: Null OPSK Base Data: Null OPSK Delete				_	-25	3	Null				
-250 Null -249 Null -248 Null -248 Null -248 Null -247 Julue -248 Null -247 Julue -248 Null -247 Julue -248 Null -247 Modulation: Base Data: Null Mull QPSK Base Data: Null QPSK Base Data: Example: -20, 15, 16-23 Apply Delete				_	-25	2	Null				
249 Null				_	-25		Null				
Add Delete -248 Null				_	-25)	Null				
Add Delete Attribute Add 1,0,1 Example: -20, 15, 16-23 Apply Delete				_	-24	a	Null				
Edit selected subcarrier(s) Type: Modulation: Base Data 1 Add -1,0,1 Delete Example: -20, 15, 16-23				_	-24	3	Null				
Add -1,0,1 Delete Apply Delete				_							
Add Delete Add Add Add Add Add Add Add Add Add Ad				_							
Add -1, 0, 1 Delete Delete Example: -20, 15, 16-23 Delete				_	T)	pe:		Modulation:	Ba	ase Data:	
-1,0,1 Delete Example: -20, 15, 16-23				~	N	ull	*	QPSK 💉	в	ase Data 1	~
Delete Example: -20, 15, 16-23			Add		_						
Example: -20, 15, 16-23		2	Delete	5	-1	, 0, 1			Apply	Del	lete
			Delete		E	ample: -20	, 15, 16-2				
0159-3								(19)			0159-313

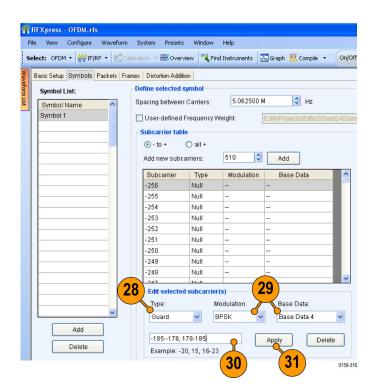
- 20. Set Type to Pilot.
- 21. Keep the Modulation as QPSK and set the Base Data to Pilot 1.
- **22.** Enter the subcarriers:-166, -100, -56, -12, 34, 122, 166.
- 23. Click Apply.



- 24. Set Type to Pilot.
- 25. Keep the Modulation as QPSK and set the Base Data to Pilot 2.
- **26.** Enter the subcarriers: -144, -122, -78, -34, 12, 56, 78, 100, 144.
- 27. Click Apply.

File	Xpress - QSU View Config		form Sy	stem Presets	Window	Help		
Sele	ect: OFDM 🕶 🕌	IF/RF 🕶	Calibrati	on 🔹 🚟 Overvie	ew 🔻 Find	Instruments	🔄 Graph Compile	• On/Of
В	asic Setup Symt	ols Packet	Frames	Distortion Additio	n			
В	Symbol List:		_ De	fine selected sy	mbol			
	-		1 Sp	acing between (Carriers:	5.062500 N	1 🗘 Hz	
	Symbol Name Symbol 1			-				
	aymbori			User-defined F	requency W	eight:	C:\Eifle2builds\Rele	ase\Sample
			S	Subcarrier table				
				💽 - to + 🔹 🤇	🔵 all +			
				Add new subca	rriers:	510 🗘	Add	
		_		Subcarrier	Туре	Modulation	Base Data	~
		_		-256	Null			
				-255	Null			
		_		-254	Null			
		_		-253	Null			
		_		-252	Null			
				-251	Null			_
				-250	Null			_
		_		-249	Null			_
		_		-248	Null			~
			24	Edit selected	subcarrior(. 2	5	
			47					
		~		Type:		odulation:	Base Data:	
11			1	Pilot	✓ Q	PSK 🗸	Pilot 2	*
	Ado	ł		2 70 24 41	0 60 70 40	0.444		
	Dele	te		2, -78, -34, 12			Apply D	elete
				Example: -20	, 15, 16-23			
						26	(27)	0159-3

- 28. Set Type to Guard.
- 29. Set the Modulation to BPSK and set the Base Data to Base Data 4.
- **30.** Enter the subcarriers: -185 -178, 178 185.
- 31. Click Apply.



- 32. Select Cyclic Prefix.
- **33.** Select **Percent** and enter 12.5. This works out to 24.69 ns when cyclic prefix is specified in time.

nt: OFDM • 👹 IF/RF • 🖫 😋			1			Run	
asic Setup Symbols Packets Fra	mes Distortion Addi	ion					
Symbol List:	Define selected	symbol					
Symbol Name	Spacing between	Carriers:	5.062500	M 🗘 Hz		(32)	
Symbol 1	-						
Ophiod 1	User-defined	Frequency	Weight			luserdefinedsymbol_IQ.bd	
	Subcarrier tab	le				Padding/Prefix	(3)
	• to +	O all +				O Zero Padding	c prefix
	Add new subo	arriare.	510	Add			
	Add liew subt	anners.		700		Time: 1.000 u	S 8
	Subcarrier	Type	Modulation	Base Data	^	Percent 12.50	
	-256	Null				12.00	× %
	-255	Null		-			
	-254	Null					
	-253	Null				Frequency Offset: 0	0
	-252	Null				Clipping Ratio: 1.00	6
	-251	Null					ei -
	-250	Null				Tone Nulling	
	-249	Null					
	-248	Null				- Symbol Information	
	247	Alasti	1		~	Symbol mormation	
	Edit selecte	d subcarrie	r(s)			FFT sampling rate: 2592 MH	tz
	Type:		Modulation:	Base Data:		Subcarrier count 512	
*	Null	~		Base Data 1		Data carriers: 336	
Add						Guard carriers: 16	
Had	-256			Apply Dele	te	Pilot carriers: 16	
Delete				(por	10		

- 34. Click the Frames tab.
- **35.** Set **Spacing between Packets** to 100 µs.
- 36. Click Compile.

- 36 ¶ RFXpress - OFDM.rfs File View Configure Waveform System Presets Window Help Select: OFDM - 👹 IF/RF - 🕵 Calibration - 🐯 Overview 🤻 Find Instruments 🗔 Graph 👯 Compile Basic Setup Symbols Packets Frames Distortion Addition 35 Define selected frame Frame List: • Frame Name 100.000000 u Spacing Between Packets: 34 Frame 1 Packets in the fram Frame 1 Packet Name Repeat Packet 1 << Add << Insert Remove 4 ÷ r0159-318
- 0.000 -7.554 15.108 -22.662 Zoom In -30.21 Zoom Out -37.770 45.324 52 87 6854 1041 8781 166 Frequency (MHz) Cursor 2 Delta (Cursor 1 - 2) Curso Hz Frequency 11.988000000 G Hz Frequency 11.988000000 G Hz FFT points 8192 Frequency 0 Amplitude -60.124 dB Amplitude -51.179 dB Amplitude 8.945 dB Average 1 0159-32
- **37.** Observe the Spectrum graph.

Create a WiFi Signal using a Preset and Adding Impairments

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

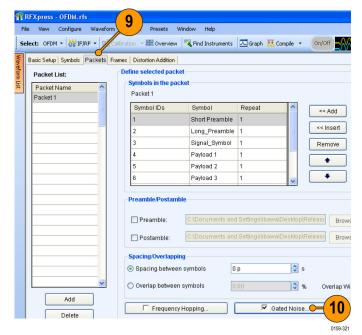
- 1. Start RFXpress.
- 2. From the toolbar, click Select > OFDM.
- From the menu, select Presets > WiFi > 802.11a 36 Mbit/s QAM16



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

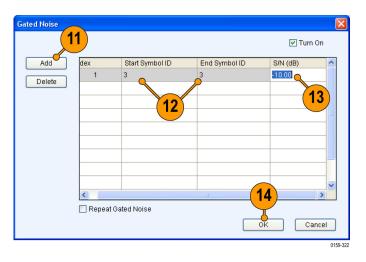


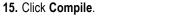
- 9. Click the Packets tab.
- **10.** Turn on **Gated Noise** and click the button to open the dialog box.



11. Click Add.

- 12. Set Start Symbol ID and End Symbol ID to 3.
- Set S/N to -10 dB. This adds noise to the third symbol or header (SIGNAL_Symbol) of the packet.
- 14. Click OK.







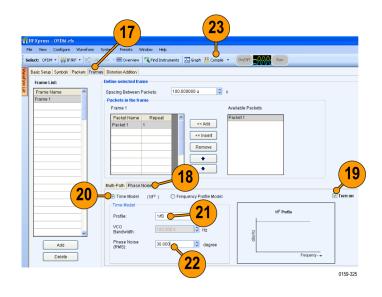
16. Observe the signals on the AWG.

Waveform								
1 : 0.0123 V	(2):	Point	Voltaj	e: 0.1532 V	🔟 🐝			
AC: 0 Pts	C1 Pos:	0 Pts C2 Pos:	0 Pts	۹ 💽 ۲	ې 🖈			
1								
0.400 V								^
ch 1							-	
			Lecture,	factor ber far				
-0.400 V								~
0.000 V								^
Ch 2								
-0.800 V								~
3h 1 M1 1								-
h 1 M2 0								
Ch 2 M1								
Ch 2 M2 Nones 60.0 k	100 k	150 k	200 k 250		300 k	350 k	400 k	
Points 60.0 k	100 K	100 K	200 K 250	*	300 K	300 K	ADD K	
<								>

- 17. Click the Frames tab.
- 18. Click the Phase Noise tab.
- 19. Click Turn On.
- 20. Ensure that Time Model (1/f°) is selected.
- 21. Select Profile as 1/f⁰.

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

- 22. Set Phase Noise to 30 degrees (integrated over a bandwidth of Sampling Frequency/2).
- 23. Click Compile.



Index

Α

Add new subcarriers, 71 Add pulse groups, 67 Adding impairments, 6 interference, 6, 13, 45, 49 power ramping, 6 Alpha/B*T, 3 Amplitude, 3, 13, 35, 47, 49 Amplitude relative to carrier, 52, 55, 64, 65, 66 Anchor carrier, 38 Antenna, vi, 69 Gaussian, 68 Arbitrary waveform generator AWG7122B, 16, 23, 28, 46 Automatic, 17, 53 Average, 29, 47 AWG sequence mode, vi

В

Band group, 47, 48 Bands, 47 Base data, 6, 70, 71 PRBS, 16 Base frequency, 5, 41 Baseband offset, 3 Baseband signal, 11 Baseband signals I, Q, V IQ, 2 Basic setup, 70 Beam type, 69 Beam width, 69

С

C/I, 13 Calibrate, 47 Calibration, 16, 18, 25, 46, 47 imported signal, 23 Carrier frequency, 51, 54, 59, 62, 64, 68 magnitude (peak), 51, 54, 59, 62, 64, 68 offset, 13 Carrier spacing, 5, 41 Closing the software, 1 Coherent carrier, 51, 54, 59, 62, 64, 68 Compile, 14, 21, 33, 36, 42, 43, 45, 48, 50, 53, 60, 63, 67, 69 settina. 8 Compile settings, 3, 8, 16, 38, 42, 48, 52, 56 Conformance, 49 Correction file, 19, 25, 47, 48 calibration, v path, 47 Correction files, 17

D

DAC resolution, 29 Data source, 70, 71 Delay, 35 Documentation, vi DUT characterization, v, 28 wizard, 28

E

End frequency, 19, 25, 29 EVM, 18, 22 Exit, 1

F

Fall time, 55 File import, 11 iqt, 11, 12 sample rate, 12 Filter, 3 Frequency, 13, 49, 70 Frequency offset, 56 Frequency resolution, 19, 29 Frequency sweep, 52, 65, 66, 67 Full bandwidth, 42

G

Gated noise, v, 45 Generic signal, 2, 16, 23, 40 IF/RF, 11 Graphs, 9 CCDF, 10 constellation, 10, 34 I & Q, 15, 34 pulse shape, 36 spectrogram, 39, 57, 61 spectrum, 10, 15, 34, 50 time domain, 46, 53, 63, 68

Η

Hopping, 37, 38 pulse-to-pulse, 56 Hopping pattern, 33 user defined, 45

I/Q Impairments tab, 7 IF/RF, 35, 37, 40, 49, 53, 57, 62, 64, 68 Impairments, v, 6 adding, 6 real-world, 49 Import from file, 11, 23 RTSA file, 11 Input file sample rate, 12 Installation, 1 Interference, v, 6, 45 adding, 6, 45 sinusoidal. 13 Interference Addition tab, 8, 13, 45, 49 Interleave, 29, 47

Κ

Key features baseband, v OFDM, vi radar, vi UWB-WiMedia, v

Μ

Manuals, vi **RFXpress RFX100** Installation, vi, 1 **RFXpress RFX100** Programmer, vi RFXpress RFX100 User, vi Modulation, 3, 6, 52, 55, 60, 65, 66, 67 duration, 60 frequency, 60 Mulit-carrier, 40 Multi-Carrier add carrier, 5 Multi-Carrier signals, v RF, 4 multi-path simulating, 35 Multi-path tab, 35

0

OFDM, vi, 70 Off time, 52, 55, 59, 62, 64, 65, 66, 69 Offset from carrier, 13 Offset from carrier frequency, 52, 55 Online help, vi Oscilloscope, 16, 23 DPO70804, 46 DPO72004, 28 Oversampling, 9

Ρ

Packets, 45 Pattern data, 70 Phase, 35 PLCP Header, 45 Power ramping, 6, 45 adding, 6 Power ramping tab, 6 PRBS Type, 70, 71 Preface, v Presets, vi Previewing Graphs, 9 PRF, 52, 55 PRI, 52, 55 Pulse envelope, 52, 55, 59, 62, 64, 65, 66, 69 width, 52, 55, 59, 62, 64, 65, 66, 69 Pulse hopping, vi

R

Range, 5, 41 Real-time spectrum analyzer, v Repeat, 52, 55, 62, 69 Rise time, 55

S

S-parameter, v, 40 S-Parameters tab, 42, 43 Safety Summary, iii Sampling rate, 29, 47 Scanning antenna, 68 Setup tab, 6 Signal compiling, 3 generating, 2 previewing, 9 Signal type IQ, 2 RF, 4, 18, 47 Single carrier signals, v generating, 2

Software upgrades, 1 Spacing between carriers, 71 Spectrogram, 39 Staggered PRI, 63 type, 63 Start frequency, 19, 25, 29 Start time, 52, 55, 64, 65, 66 Starting the software, 1 Sub-carrier modulation, v Sweep range, 52, 65, 66, 67 Symbol rate, 3 Symbols, 71

T

TF Code user defined, 44

U

UWB, v UWB-WiMedia, v, 33, 44, 47 conformance mode, 33 custom mode, 44

W

Waveform length automatic, 38 Waveform list, 4, 46 WiFi signal, 49 WiMedia spec example packet, 33, 44 WiMedia specification, vii Window, 3