

## MaxEye ZigBee (IEEE 802.15.4) Measurement Suite

Version 1.0.5.3

# **Getting Started Guide**



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## **1. Introduction**

MaxEye Technologies provides generation and analysis functions in LabVIEW for generating and analyzing the IEEE 802.15.4 standard complaint signals using National Instruments Vector Signal Generators (NI VSG) and Vector Signal Analyzers (NI VSA) or Vector Signal Transceivers (NI VST). The IEEE 802.15.4 Standard supports multiple Physical Layer modes; the current version of the toolkits supports the following physical layer modes.

- i. OQPSK Physical Layer (2.4GHz)
- ii. BPSK Physical Layer (868/915 MHz)

Band	Frequency Range (MHz)	Modulation Type	Chip Rate (Kchips/sec)	Data Rate (Kbits/sec)	Pulse shaping Filter Type
2.4 GHZ	2400 to 2483	OQPSK	2000	250	Half Sine Wave Filter
868 MHZ	868 to 868.6	BPSK	300	20	Raised Cosine
915 MHz	902 to 928	BPSK	600	40	Raised Cosine

The standard defines different modulation types, data rates based on the frequency band.

This guide explains how to use the ZigBee Measurement Suite toolkit using the Soft Front Panel (SFP) and programming examples.

## 2. Installed File Location

## 2.1 Soft Front Panels

The ZigBee Generation soft front panel is located in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\ Executable\MaxEye ZigBee Signal Generation\ MaxEye ZigBee Signal Generation.exe

The ZigBee Analysis soft front panel is located in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\ Executable\MaxEye ZigBee Signal Analysis\ MaxEye ZigBee Signal Analysis.exe

You can also find a shortcut to the above location from the windows start menu. **Start->All Programs->MaxEye->ZigBee** 



#### **2.2 Programming Examples**

#### 2.2.1 OQPSK Signal Generation and Analysis

- 1. The OQPSK ZigBee signal generation example VIs are installed in, <LabVIEW>examples\MaxEye\ZigBee\Generation\OQPSK PHY
- 2. The OQPSK ZigBee signal analysis example VIs are installed in, <LabVIEW>examples\MaxEye\ZigBee\Analysis\OQPSK PHY.
- 3. The toolkit API VIs for OQPSK ZigBee signal generation are installed in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\Generation\OQPSK PHY\API.
- 4. The toolkit API VIs for OQPSK ZigBee signal analysis are installed in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\Analysis\OQPSK PHY\API.

You can also find a shortcut to the above location from the windows start menu. **Start->All Programs->MaxEye->ZigBee** 

#### 2.2.2 BPSK Signal Generation and Analysis

- 1. The BPSK ZigBee signal generation example VIs are installed in, <LabVIEW>examples\MaxEye\ZigBee\Generation\BPSK PHY.
- 2. The BPSK ZigBee signal analysis example VIs are installed in, <LabVIEW>examples\MaxEye\ZigBee\Analysis\BPSK PHY.
- 3. The toolkit API files for BPSK ZigBee signal generation are installed in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\Generation\BPSK PHY\API.
- 4. The toolkit API files for BPSK ZigBee signal analysis are installed in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\Analysis\BPSK PHY\API.

You can also find a shortcut to the above location from the windows start menu. **Start->All Programs->MaxEye->ZigBee** 

#### 2.3 Documentation

The toolkit help file is installed in, <LabVIEW>\help\MaxEye\ZigBee\MaxEye ZigBee Measurement Suite Help.chm

The toolkit documentation files are installed in, <LabVIEW>\vi.lib\addons\MaxEye\ZigBee\ Documentation.

You can also find a shortcut to the above location from the windows start menu. **Start->All Programs->MaxEye->ZigBee** 



## 3. Soft Front Panel

The soft front panel (SFP) for generator and analyzer allow engineers to quickly generate IEEE 802.15.4 complaint modulated RF signals and view, save, and perform measurements. ZigBee Generation SFP can be used to generate ZigBee signals of all supported frame types. Use ZigBee Analysis SFP to perform modulated or continuous waveform or spectral measurements.

#### 3.1 MaxEye ZigBee Signal Generation SFP

The figure below shows the ZigBee Signal Generation SFP.

Settings		Last Frame Waveform Preview (Power vs. Time)
Zigbee Settings	Waveform Format	10-
Waveform Format	Select Waveform Format	5- 
Hardware Settings Waveform Settings MAC Header Settings Frame Control Field	© BPSK © OQPSK	Ê -5 9 -10 8 -15
MAC Payload Settings	Generation Mode	-20
Impairments	Generate and Play Waveform Generate and Save waveform	-30- 0 0.0005 0.001 0.0015 0.002 0.0 Time (seconds) ->
	Play waveform from file	Generate Waveform Indicators
		Waveform Length (Samples) 0 Generating Frames 0 0
< <u> </u>		Status

#### 3.1.1 Generate and Save Waveform/ Generate and Play Waveform

Follow the procedure below to generate signals using SFP.

1. Select Waveform format as BPSK or OQPSK depending on the type of DUT you are testing. Select Generation mode as Generate and Play Waveform or Generate and Save Waveform. Generate and Play waveform is used to generate ZigBee RF signal using hardware. Generate and Save waveform is used to generate waveform and store in a file. For this configuration hardware is not required. The IQ baseband waveform is stored in a file. Play Waveform From File mode reads the ZigBee waveform from the file created using the Generate and Save Waveform and then downloads the waveform to NI RFSG Memory and then plays the waveform.

2. Select the hardware settings to configure the following parameters. This settings is needed to configure only when the Generation mode is Generate and Play waveform.



Settings		Last Frame Waveform Preview (Power vs. Time)
Ziabee Settinas	Hardware Settings	10-
Waveform Format Hardware Settings MAC Header Settings Frame Control Field Addressing Fields MAC Payload Settings Impairments	VSG Settings RFSG Resource Channel 11 - 2405 Channel 11 - 2405 Power Level (dBm) -10.00 External Attenuation (dB) 0.00 Headroom (dB) 3 Arb:Pre-filter Gain (dB) -1 Frequency Reference Reference Source PXL_CLK Frequency (Hz) 10.000E+6 Export Clock Settings Clk Output Terminal Do not export signal	5- - 0- 
* *		Status

**RFSG Resource-** Configure the resource name used in NI Measurement and Automation explorer for the NI PXIe-5673/5673E or NI PXIe 5644R/45R/46R or NI 5840 device.

**Carrier Frequency** (Hz)- Select Center Frequency of the ZigBee signal in MHz. . For BPSK the carrier frequency is ranging from channel 1 (868.3 MHz) to channel 10 (924MHz) and for OQPSK the carrier frequency is ranging from Channel 11 (2405 MHz) to channel 26(2480 MHz).

Power Level (dBm)- Average Power level of the signal in dBm.

**Headroom** (**dB**)- Configure the Headroom value higher than PAPR of the signal to be generated. Refer MaxEye ZigBee Measurement Suite Help.chm.

**External Attenuation (dB)-** Specifies the external amplification or attenuation, if any, between the NI RF signal generator and the device under test. Positive values for this property represent amplification, and negative values for this property represent attenuation.

**Arb: Pre-filter Gain (dB)-** Specifies the AWG prefilter gain. The prefilter gain is applied to the waveform data before any other signal processing. Reduce this value to prevent overflow in the AWG interpolation filters. Other gains on the NI-RFSG device are automatically adjusted to compensate for non unity AWG prefilter gain.

Reference Source- specifies the source of the Reference Clock signal

Frequency (Hz)- specifies the Reference Clock rate, in hertz (Hz).

**Clk Output Terminal-** specifies the terminal where the signal will be exported.

For more information Refer NI RFSG Signal Generators help file. For more information please contact info@maxeyetech.com



3. Select the waveform Settings.

Settings	Last Frame Waveform Preview (Power vs. Time)
iettings Igbee Settings Waveform Format Hardware Settings MAC Header Settings MAC Payload Settings Impairments Waveform Settings Addressing Fields MAC Payload Settings Inter Frame Spacing (Seconds) 0.0001 Samples Per Chip 20 Oversampling Enabled? False Output Sampling Rate 20M Power Ramp Up Time (Seconds) 5E-6 Power Ramp Down Time (Seconds) 5E-6 Waveform File Path	Last rame Waveform Preview (Power vs. Time)         10- 5- 0- 20- -25- -30- 0         -15- -20- -25- -30- 0         -20- -25- -30- 0         -30- 0         -30- 0         -25- -30- 0         -30- 0         -25- -30- 0         -30- 0         -25- -30- 0         -30- 0         -30- 0         -30- 0         Generate Waveform Indicators         Waveform Length (Samples) 0         0

**Number of Frames-** decides the length of waveform to be generated. To generate longer duration of the waveform, increase the Number of Frames value.

**MAC Framing Enabled-** To generate MAC frame set this to true, the toolkit adds MAC layer headers and then creates payload for the physical layer. If this is set to false then the toolkit generates waveform without MAC frame parameters.

**Data Rate-** For BPSK Select the data rate as 20 kbps or 40 kbps. For OQPSK the data rate is 250kbps.

Inter frame Spacing (Seconds)- specifies the gap duration in seconds between the frames.

**Samples Per Chip-** Specifies the number of samples per chip. Sampling Rate of generated waveform is equal to samples per chip multiplied by Chip Rate.

**Oversampling Enabled & Output Sampling Rate-** Use this configuration only when you want to resample the signal to different sampling rate. The default sampling rate is Samples per chip multiplied by Chip Rate. The toolkit resample's the generated signal to a sampling rate equal to the Output Sampling Rate only if the Over Sampling Enabled property is set to 1(True).

**The Power Ramp Up Time-** specifies the time duration during which the signal power gradually increases to the full value from zero.

**The Power Down Time-** specifies the time duration during which the signal power gradually reduces from the full value to close to zero.

**Waveform file path-** Select a path to save the waveform. Needs to be configured only when the generation mode is Generate and Save waveform.



#### 4. Select the MAC Header settings.

		Last Frame Waveform Preview (Power vs. Time)
Settings W Waveform Format Hardware Settings MAC Header Settings Frame Control Field Addressing Fields MAC Payload Settings Impairments	Frame Type Data Security Enabled False Frame Pending Field False Parme Pending Field False Ack Request Field False PAN ID Compression Inter-PAN Destination Address Mode Extended Address Frame Version Compatible with Source Address Mode Extended Address Frame Version Compatible with Source Address Total Sequence Number 0	10-         5-         • 0-         -5-         -10-         • -5-         -10-         • -15-         -20-         -20-         -20-         -30-         0         0.0005         0.001         0.0015         0.002         0         Generate Waveform Indicators         Waveform Length (Samples)         0         Generating Frames         0
	Frame Version Compatible with Source Address Mode Extended Address S Sequence Number 0	Generating

**Frame Type-** Select the frame type. Supported frame types are Beacon, Data, Acknowledgement and MAC Command.

Security Enabled- Select True if the frame is protected by the MAC sublayer and select False otherwise.

**Frame Pending Field-** Select True if the device sending the frame has more data for the recipient. This field shall be set to False otherwise.

Ack Request Field- specifies whether an acknowledgment is required from the recipient device on receipt of a data or MAC command frame. If this field is set to True, the recipient device shall send an acknowledgment frame only if, upon reception. If this field is set to False, the recipient device shall not send an acknowledgment frame.

**PAN ID Compression-** specifies whether the MAC frame is to be sent containing only one of the PAN identifier fields when both source and destination addresses are present. If this field is set to Intra-PAN and both the source and destination addresses are present, the frame shall contain only the Destination PAN Identifier field, and the Source PAN Identifier field shall be assumed equal to that of the destination. If this field is set to inter-PAN, then the PAN Identifier field shall be present if and only if the corresponding address is present.

Destination Address Mode- Select the required destination address mode.

Frame Version- specifies the version number corresponding to the frame.



Source Address Mode- Select the required source addressing mode.

**Sequence Number-** The Sequence Number field specifies the sequence identifier for the frame. For a beacon frame, the Sequence Number field shall specify a BSN (Beacon Sequence Number). For a data, acknowledgment, or MAC command frame, the Sequence Number field shall specify a DSN (Data Sequence Number) that is used to match an acknowledgment frame to the data or MAC command frame.

5. Select the addressing fields. This field is needed to configure when the frame type is data or beacon or MAC Command. For beacon frame type Destination PAN identifier and Destination MAC address fields are not present.



**Destination PAN Identifier-** specifies the unique PAN identifier of the intended recipient of the frame. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero.

**Destination MAC Address-** specifies the address of the intended recipient of the frame. Based on the Destination Address mode this field may be 16 bit or 64 bit. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero.

**Source PAN Identifier-** specifies the unique PAN identifier of the originator of the frame. This field shall be included in the MAC frame only if the Source Addressing Mode field is nonzero and the PAN ID Compression field is equal to zero..

Source MAC Address- specifies the address of the originator of the frame. This field shall

be included in the MAC frame only if the Source Addressing Mode field is nonzero.



6. Select the MAC Payload Settings. This fields are needed to configure only when the frame type is beacon or data.

Section TECHNOLO	GIES	www.maxeyetech.
ettings		Last Frame Waveform Preview (Power vs. Time)
ligbee Settings	Waveform Settings/MAC Payload Settings	10-
Waveform Format Hardware Settings Waveform Settings MAC Header Settings Frame Control Field Addressing Fields MAC Payload Settings Impairments	Payload Mode PN Sequence A0 Payload Length, bytes 40 Payload PN Order 9 Payload PN Seed BEEFBEEF Payload Test Pattern All 1s Payload User Defined Bits 0 Payload File Path	5- -5- -5- -5- -5- -10- -15- -20- -25- -30- 0 0.0005 0.001 0.0015 0.002 Time (seconds) -> Generate Waveform Indicators Waveform Length (Samples) 0 Generating Frames 0
· · · · · · · · · · · · · · · · · · ·		Statur

**Payload Mode-** Choose the appropriate mode. PN sequence is used to generate the PN sequence. In the User defined bits, user can configure the transmitting bits. In Test Pattern, some predefined bit patterns can be used for transmitting.

Payload Length ,Bytes- Specifies the number of bytes to be transmitted

**Payload PN Order-** specifies the order of the PN bit sequence to be generated. The valid values is 5 to 31, inclusive. Configure this field when the Payload mode is PN sequence.

**Payload PN Seed-** specifies the initial state of the PN generator shift register. Configure this field when the Payload mode is PN Sequence

**Payload Test Pattern-** Select the required Test Pattern. Configure this field when the Payload mode is Test Pattern

Payload User Defined Bits- Configure this field when Payload mode is User Defined bits.

Payload File Path- Choose the file path when the payload mode is From File.

For Beacon frame one more additional MAC payload setting field is present. i.e the super frame specification.



		Last Frame Waveform Preview (Power vs. Time)
Settings Zigbee Settings Waveform Format Hardware Settings Waveform Settings Frame Control Field Addressing Fields MAC Payload Settings Superframe Specific Payload Settings Impairments	Vaveform Settings/MAC Payload Settings/Superframe Specific Beacon Order 0 Superframe Order 0	ication 10 5 - C - 5 - - 5 - - 10 - - 5 - - 10 - - 10 - - 15 - - 20 - - 25 - - 30 - 0 0.0005 0.001 0.0015 0.002 0.00 Time (seconds) -> Generate Waveform Indicators Waveform Length (Samples) 0 Generating Frames 0
4 [ [ [ ] ] •		Status

Beacon Order- specify the transmission interval of the beacon.

**Superframe Order-** specify the length of time during which the superframe is active (i.e., receiver enabled), including the beacon frame transmission time..

For MAC Command Frame type Select the MAC Payload settings.

Settings		Last Frame Wa	aveform Preview (	Power vs. Tim	e)		
Zigbee Settings Zigbee Settings Waveform Format Hardware Settings MAC Header Settings Frame Control Field Addressing Fields MAC Payload Settings Impairments Waveform Settings Command Frame Id Association Device Type Reduced Power Source AC Mains Receiver on when Id False Security Capability? Disabled Allocate Address? False	IAC Payload Settings	10- 5- 0- 10- 10- 15- 20- -25- -30- 0 Generate Wa Waveform 0 Generating Status	0.0005 iveform Indicator i Length (Samples	0.001 Time (se s	0.0015 cconds) ->	0.002	0.0

**Command Frame Identifier-** identifies the MAC command being used. According to this field, Configure the remaining controls as follows



• If Command frame Identifier is **Association Request**, then user has to configure the following. The association request command allows a device to request association with a PAN through the PAN coordinator or a coordinator.

Association	-
Association	19410
Device Type	
Reduced	-
ower Source	
AC Mains	*
Receiver on whe	n Idle
False	-
Security Capabili	ity?
Disabled	-
Allocate Address	?
New York 100	1000

**Device Type-** Select the device type as either full functioned device or Reduced Function Device.

Power Source- Select AC Mains, if the device is receiving power from the alternating current

mains. Otherwise, the Power Source field shall be set to Not From AC Mains.

Receiver on when Idle- Select True if the device does not disable its receiver to conserve

power during idle periods. Otherwise, Select False.

**Security Capability?-** Select Enabled, if the device is capable of sending and receiving cryptographically protected MAC frames; Otherwise select Disabled.

**Allocate Address?-** Select True, if the device wishes the coordinator to allocate a short address as a result of the association procedure. Otherwise, Select False.

• If Command frame Identifier is **Association Response**, then user has to configure the following. The association response command allows the PAN coordinator or a coordinator to communicate the results of an association attempt back to the device requesting association.

Association	-
Short Address	
ABCD	
Association Statu	is?
Association	-



**Short Address-** If the coordinator was able to associate the device to its PAN, this field shall contain the short address that the device may use in its communications on the PAN until it is disassociated.

Association status?- Select the Valid values of the Association Status field.

• If Command frame Identifier is **Disassociation Notification**, then user has to select the following.

Command Frame	Identifie			
Disassociation 💌				
Disassociation Re	ason?			
Reserved	-			

Disassociation reason?- Select the Valid values of the Disassociation reason.

• If Command frame Identifier is **Coordinator Realignment**, then user has to configure the following.



Realignment Command- Select the required Realignment Command.

**PAN Identifier-** shall contain the PAN identifier that the coordinator intends to use for all future communications. Valid values from 0000 to FFFF.

**Coordinator Short Address-** shall contain the value of *macShortAddress*. Valid values from 0000 to FFFF.

**Channel Number-** shall contain the channel number that the coordinator intends to use for all future communications. Valid values from 0 to 255.

**Short Address-** if the coordinator realignment command is broadcast to the PAN, the Short Address field shall be set to 0xffff and ignored on reception. If the coordinator realignment command is sent directly to an orphaned device, this field shall contain the short address that the orphaned device shall use to operate on the PAN. Valid values from 0000 to FFFF.



**Channel page-** shall contain the channel page that the coordinator intends to use for all future communications. This field may be omitted if the new channel page is the same as the previous channel page. Valid values from 0 to 255.

• If Command frame Identifier is **GTS Request**, then user has to configure the following . The GTS request command is used by an associated device that is requesting the allocation of a new GTS or the deallocation of an existing GTS from the PAN coordinator. Only devices that have a short address less than 0xfffe shall send this command.

Cor	mmand Frame	Identif
Į.	GTS Request	
GTS	Length(In Slo	ts)
	1	
GTS	Direction	- 503 103 - 104
	Tx only GTS	-
GTS	Characteristic	s Type
GT	S Deallocation	-

**GTS Length (In Slots)-** specifies the number of superframe slots being requested for the GTS. Valid values from 1 to 255

**GTS Direction-** Select Rx only GTS, if the GTS is to be a receive-only GTS. Conversely, this field shall be set to Tx only GTS if the GTS is to be a transmit-only GTS. GTS direction is defined relative to the direction of data frame transmissions by the device.

**GTS** Characteristics Type- Select GTS Characteristics type as GTS allocation or GTS deallocation.



7. Select the Impairments.



**Impairments Enabled-** If this property is set to True then the toolkit adds the impairments to the generated signal as per the user configuration for the supported impairments.

**Clock Offset (PPM)-** The toolkit applies the clock offset to the generated waveform based on this value. The applied clock offset is relative to the clock frequency of the signal generator. The default value is 0.

**Frequency Offset, Hz-** The toolkit applies frequency offset to the created waveform based on the value configured in this property. The applied frequency offset is relative to the signal generator's carrier frequency. The default value is 0.

**Quadrature skew-** Quadrature Skew specifies the deviation in angle from 90 degrees between the in-phase (I) and quadrature-phase (Q) signals. The default value for the Quadrature Skew is 0.

**IQ gain imbalance, dB-** This value specifies the ratio, in dB, of the mean amplitude of the inphase (I) signal to the mean amplitude of the quadrature-phase (Q) signal. The default value is 0.

**I DC offset, %-** The toolkit adds the DC offset to the in-phase signal component (I) of the complex waveform as a percentage of the root mean square magnitude of the unaltered I signal. The default value is 0.

**Q DC Offset, %-** The toolkit adds the DC offset to the quadrature-phase signal component (Q) of the complex waveform as a percentage of the root mean square magnitude of the unaltered Q signal. The default value is 0.

**AWGN Enabled-** If this property is set to True then the toolkit adds Additive White Gaussian Noise (AWGN) to the created waveform based on the value configured in the Carrier to Noise Ratio property.

**Carrier to Noise Ratio, dB-** This value specifies the Carrier to Noise ratio of the generated signal. The default value is 40dB.

8. To generate the waveform Click on the Generate button which is on the bottom side of the SFP. To stop Generation click on the Stop button.

9. To save all the configuration click on the save button. You can reload this configuration by using the load button. In order to exit the SFP always use the exit button.

#### 3.1.2 Play Waveform From File

Play Waveform From File mode reads the ZigBee waveform from the file created using the Generate and Save Waveform and then downloads the waveform to NI RFSG Memory and then plays the waveform.

![](_page_15_Picture_0.jpeg)

#### 1. Select Waveform Format. Then Choose Play Waveform From File

Settings	Last Frame Waveform Preview (Power vs. Time)
Settings Play Waveform File Settings Waveform Format Hardware Settings/Play Waveform From File Write Block Size in Samples 100000 Streaming Waveform Size in Samples Streaming Waveform Size in Samples Streaming Waveform File Sample Writth 16-bit Sample Writth 16-bit Sample Writth 16-bit Sample Writth 16-bit Sample Writth 16-bit Sample Writth 16-bit Waveform File Path (dialog if empty) File Path (di	Last name wereard in Preview (over 0.5. Initie)         5-         0         15-         30-         0.0005         0.001         0.0015         0.0015         0.001         0.0005         0.0015         0.0015         0.0015         0.001         0.0015         0.0015         0.0015         0.0015         0.0015         0.0015         0.0015         0.0015         0.0015         0.0015         0.0015         0.0016         0.0017         0.0018         0.0102         0.01         0.01         0.01         0.01         0.01         0.01         0.01         0.01         0.01         0.01         0.01         0.02         0.03         0.04         0.05         0.05         0.05         0.05         0.05         0.06

- 2. Select Hardware Settings. Refer 3.1.1 for configuration.
- 3. Select Play Waveform From File.

**Streaming Waveform Size in Samples-** specifies the total number of samples used to write the waveform to NI RFSG device or output DMA Stream.

Sample Width- use the same sample width value used for storing the waveform in the file.

**Start Trigger**- Configures the Output Stream Start trigger type. Software option configures the device to wait until a software trigger is received, before starting generation. PFI0 option configures the device to wait until a digital edge trigger is received from PFI0, before starting generation. Input Stream Start Trigger option asserts the trigger at the same time as the Input Start trigger, which can be used to synchronize the input stream with output stream. Output Stream FIFO primed option waits until the FPGA DMA FIFO has at least as many samples as the priming threshold, before triggering.

Waveform File Path- Select the saved waveform file path.

![](_page_16_Picture_0.jpeg)

### 3.2 MaxEye ZigBee Signal Analysis SFP

The figure given below is the ZigBee Signal Analysis SFP.

![](_page_16_Figure_3.jpeg)

The following are the measurements available in ZigBee Analysis SFP.

• **Modulated Waveform Measurement-** Performs demodulation measurements on the acquired I/Q complex waveform.

• **Spectral Measurements-** Spectrum measurements are implemented using time-domain acquisitions at multiple RF center frequencies, converting the acquired data to frequency domain using fast Fourier transform, and then stitching the various spectrums together to form the complete spectrum. The following spectral measurements can be performed at the same time.

 $\succ$  Spectral Mask Emission- SEM measurements measure out-of-band emissions in the neighboring bands of the carrier. SEM uses the spectral mask or limit you specify to measure the margin of the emission level from the limit and reports the measurement status.

> Transmit Power- TXP is a zero span measurement of transmitted power using the timedomain signal as seen through a resolution bandwidth (RBW) filter for the specified measurement interval.

• **Continuous Waveform Measurement-** This measurement is performed on continuous wave signals.

#### 3.2.1 Modulated Waveform Measurement

Follow the procedure for modulation accuracy measurements.

1. Select the Modulated Waveform measurement control from Measurement Tab.

![](_page_17_Picture_0.jpeg)

#### 2. Select the Waveform Tab.

![](_page_17_Figure_2.jpeg)

Modulation Scheme- Select the modulation scheme as same as transmitted signal.

**Chip Rate-** Configures the symbol rate for digital demodulation measurements. Need to configure Only for BPSK modulation .

**Samples per Chip-** specifies the samples per symbol used to acquire the signal for the measurement. Able to configure only when BPSK modulation is selected.

Acquisition Length, Seconds- Needs to be configured for OQPSK modulation. Number of Samples to Acquire= IQ Rate\* Acquisition Length

Number of frames- Configure the number of frames to be acquired.

Number of Symbols- Configure the number of symbols to be acquired.

**Reset PER measurement-** If this property is set to True the toolkit internal resets the Number of Packets Received and Number of Packet Errors to 0. To perform continuous PER measurement set this to False.

![](_page_18_Picture_0.jpeg)

#### 3. Select the Hardware Tab

![](_page_18_Figure_2.jpeg)

**Resource Name-** Configure the resource name used in NI Measurement and Automation explorer for the NI PXIe-5673/5673E device or NI PXIe 5644R/45R/46R or NI 5840 device.

**Channel Number-** Select Center Frequency of the ZigBee signal in MHz. . For BPSK the carrier frequency is ranging from channel 1 (868.3 MHz) to channel 10 (924MHz) and for OQPSK the carrier frequency is ranging from Channel 11 (2405 MHz) to channel 26(2480 MHz).

**Auto Level-** examines the input signal to calculate the peak power level and sets it as the value of the Reference Level property.

**Maximum Input Power-** Configures the reference level that represents the maximum expected power of an RF input signal. Configure this field only when Auto level is False.

**External Attenuation-** specifies the attenuation, in dB, of a switch (or cable) connected to the RF IN connector of the signal analyzer.

Reference Source- specifies the frequency reference source.

**Frequency-** specifies the Reference Clock rate when the Frequency Reference Source parameter is set to ClKIn or RefIn. This value is expressed in Hz. The default value is 10 MHz.

![](_page_19_Picture_0.jpeg)

4. Click Trigger button. Configure the trigger settings as follows.

![](_page_19_Picture_2.jpeg)

Trigger Enabled- specifies whether to enable the trigger.

**Trigger Delay-** Specifies the trigger delay time, in seconds. The trigger delay time is the length of time the IF digitizer waits after it receives the trigger before it asserts the Reference Event.

**Trigger Level-** Specifies the power level, in dBm, at which the device triggers. The device asserts the trigger when the signal exceeds the level specified by the value of this property, taking into consideration the specified slope.

**Minum Quiet Time-** Specifies a time duration, in seconds, for which the signal must be quiet before the device arms the IQ Power Edge trigger. The signal is quiet when it is below the trigger level if the trigger slope, specified by the Reference Trigger IQ Power Edge Slope property, is set to Rising Slope or when it is above the trigger level if the trigger slope is set to Falling Slope.

After configuring, click OK.

![](_page_19_Figure_8.jpeg)

5. Choose the required graph or results from the highlighted controls.

For more information please contact info@maxeyetech.com

![](_page_20_Picture_0.jpeg)

The following are measurement traces available,

- Constellation
- Offset EVM Vs Symbols
- EVM Vs Symbols
- Magnitude Error Vs Symbols
- Phase Error Vs Symbols
- ➢ I Vs Time
- > Q Vs Time
- Power Vs Time

The following are the results available,

Demodulated bits

Demodulated Bits	PHY Payload	MAC Payload
/IPDU (Bytes)		
Number of Packets I	Received MA	C CRC Status?
Number of Packets I 0	Received MA	C CRC Status?
Number of Packets I 0 Number of Packet E	Received MA	C CRC Status? nplete Packet Received :

MAC Frame- displays the extracted MAC frame . Choose the required MAC frame by selecting the frame number.

Modulation Accuracy Measurement Results- This include carrier measurements, EVM measurements, Magnitude Error measurements, Phase Error measurements, IQ Impairments measurements, etc.

6. To pause the measurement Click on the Stop button and to continue the measurement click on the Run button. To save all the configuration, click on the save button. To load the configuration click load button. To exit the SFP click Exit button.

## **3.2.2 Spectral Measurement**

Follow the procedure for Spectral measurements.

1. Select the Spectral measurement control from Measurement Tab. Below that Select the Spectral Mask Emission or Transmit Power or both.

- 2. Select the Waveform Tab and Choose the modulation Scheme
- 3. Select the hardware Tab and Refer 3.2.1 to configure.
- 4. Select Spectrum Tab

![](_page_21_Picture_0.jpeg)

Spectrum	Spectrum		Power Vs Time 💌	
유 Reference Type	-20-		-10-	
Peak 💌	-30 -		-20-	
Power Units(Spec Mask)	-40-		-25 -	
Ž dBm ▼	1		· -30-	
Power Units(Freq Offset)	Ê -20 -		-35- E -35-	
E dBm 👻	-60 -		3 -45 -	
E Limit Fail Mask	e		a -50-	
Abs AND Rel	-70-		-55 -	
	-80 -		-60 -	
Measurement Configuration —	-90-	بصابط بالمابط	-65-	
TXP Measurement	2.395G 2.3975G 2.4G 2.4025G 2.4 Frequenc	95G 2.4075G 2.41G 2.4125G 2.415 y (Hz) >	5 -200u 0 200u	1 1 1 400u 600u 800u 1r Time (seconds)>
SEM Measurement	SEM	Measurement Status	Transmit Power	
			Average Mean Dower(dPm)	0.000000
	Margin Absolute Power (dBm or dBm/F	Z, 🔺	Average inlean Power(dbm)	0.000000
SEM Offset Segments	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB)	Ζ,	Peak to Average Ratio (dB)	0.000000
SEM Offset Segments	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Frequency (Hz)	Ζ,	Peak to Average Ratio (dB) Peak Power (dBm)	0.000000 0.000000 0.0000000000000000000
통 SEM Offset Segments 상	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status	Z,	Peak to Average Ratio (dB) Peak Power (dBm)	0.000000
SEM Offset Segments	Margin Absolute Power (dBm) or dBm/F Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status	Z,	Peak to Average Ratio (dB) Peak Power (dBm)	0.000000 0.000000 0.000000
SEM Offset Segments	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status Upper Offset Segment Measurement Total Absolute Power (dBm or dBm/Hz)	5	Peak to Average Ratio (dB) Peak Power (dBm)	0.000000
SEM Offset Segments Run Load Save	Margin Absolute Power (dBm or dBm/F Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status Upper Offset Segment Measurement Total Absolute Power (dBm or dBm/Hz) Total Relative Power (dB)	s E	Peak to Average Ratio (dB) Peak Power (dBm)	0.000000
SEM Offset Segments           Run         Stop           Load         Save	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status Upper Offset Segment Measurement Total Absolute Power (dBm or dBm/Hz) Total Relative Power (dB) Peak Absolute Power (dBm or dBm/Hz)	5	Peak to Average Ratio (dB) Peak Power (dBm)	0.000000
SEM Offset Segments  Run Load Save Exit Status	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status Upper Offset Segment Measurement Total Absolute Power (dBm or dBm/Hz) Peak Absolute Power (dB) Peak Frequency (Hz)	5	Peak to Average Ratio (dB) Peak Power (dBm)	
SEM Offset Segments           Run         Stop           Load         Save           Exit         Status	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status Upper Offset Segment Measurement Total Absolute Power (dBm or dBm/Hz) Peak Absolute Power (dB) Peak Relative Power (dB)	5	Peak to Average Natio (dB) Peak Power (dBm)	
SEM Offset Segments  Run  Load  Save  Exit  Status	Margin Absolute Power (dBm or dBm/H Margin Relative Power (dB) Margin Frequency (Hz) Measurement Status Upper Offset Segment Measurement Total Absolute Power (dBm or dBm/Hz) Total Relative Power (dBm or dBm/Hz) Peak Absolute Power (dBm or dBm/Hz) Peak Relative Power (dB) Margin (dB)	5 5 	Peak to Average Natio (dB) Peak Power (dBm)	

**Reference Type-** Configures whether the power reference is the integrated power or the peak power in the closest carrier channel. Needs to be configured only foe SEM measurement.

**Power Units(Spec Mask)-** Configures the units for the absolute power. Needs to be configured only foe SEM measurement.

Limit Fail Mask- Specifies the criteria to determine the measurement fail status.

5. If Transmit Power Measurement is selected, Click on TXP measurement button.

Measurement	interval (s)
1.00m	
RBW Filte	r
RBW Filter Type	Flat 🔽
RBW (Hz)	20.000M
RRC Alpha	0.010
Averaging	18
Averaging Enabled	True 💌
Number of Averages	10

**Measurement Interval-** Specifies the acquisition time, in seconds, for the transmit power (TXP) measurement.

**RBW Auto-** specifies whether the measurement computes the resolution bandwidth (RBW) of the carrier.

![](_page_22_Picture_0.jpeg)

**RBW Filter Type-** specifies the response of the digital RBW filter.

**RBW-** specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

**RRC Alpha-** specifies the roll-off factor for the root-raised-cosine (RRC) filter.

**Averaging Enabled-** specifies whether to enable averaging for the measurement. The default value is False.

**Number of Averages-** specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

**Averaging Type-** specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

6. If the measurement Spectral Mask Emission is Selected ,Click on the SEM Measurement button.

Integration Ba	ndwidth
integration ba	indwiden
10.00N	Λ
RBW Filt	er
RBW Filter Type	Gaussian
RBW (Hz)	100.000k
Averagin	9
Averaging Enabled	True
Number of Averages	10

**Integration Bandwidth-** specifies the frequency range, in Hz, over which the measurement integrates the carrier channel power.

**RBW Filter Type-** specifies the response of the digital RBW filter.

**RBW** (**Hz**)- specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

**Averaging Enabled-** specifies whether to enable averaging for the measurement. The default value is False.

![](_page_23_Picture_0.jpeg)

**Number of Averages-** specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

**Averaging Type-** specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

After configuring Click OK.

7. Click on the SEM offset Segments button and configure the SEM offset segment properties in the dialog box. Click OK button after configuring all the settings for the SEM offset segments.

File Edit Oper	rate Tools	Window	Help											20
\$														Ľ
		Of	ffset Freque	ncy		RBW Filter		Ť.	Absolute Limit			Relative Limit		18
Segment No	Enabled	Start (Hz)	Stop (Hz)	Sideband	RBW Auto	RBW Filter Type	RBW (Hz)	Mode	Start(dBm)	Stop (dBm)	Mode	Start (dB)	Stop (dB)	-
1	True	3.5M	10M	Both	False	Gaussian	100k	Manual	-30	-30	Manual	-20	-20	9
													·	
														_
														-
														-
														•
< La.						10								

**Offset Frequency Enabled-** specifies whether to enable the offset segment for the SEM measurement. The default value is True.

**Offset Frequency Start-** specifies the array of start frequencies, in Hz, of each offset segment relative to the closest configured carrier channel bandwidth center or carrier channel bandwidth edge based on the value of the SEM Offset Freq Definition property.

**Offset Frequency Stop-** specifies the array of stop frequencies, in Hz, of each offset segment relative to the closest configured carrier channel bandwidth center or carrier channel bandwidth edge based on the value of the SEM Offset Freq Definition property.

**Offset Frequency Side band-** specifies whether the offset segment is present on one side, or on both sides of the carriers. The default value is Both.

**RBW** Auto- specifies whether the measurement computes the RBW.

**RBW** (**Hz**)- specifies the array of bandwidths, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired offset segment, when you set the RBW Auto parameter to False.

Absolute Limit Mode- specifies whether the absolute limit mask is a flat line or a line with a slope

**Absolute Limit Start-** specifies the array of absolute power limits, in dBm, corresponding to the beginning of the offset segment. The value of this parameter is also set as the stop limit for the offset segment when you set the Absolute Limit Mode parameter to Couple.

![](_page_24_Picture_0.jpeg)

**Absolute Limit Stop-** specifies the array of absolute power limits, in dBm, corresponding to the end of the offset segment. This parameter is ignored when you set the Absolute Limit Mode parameter to Couple

**Relative Limit Mode-** specifies whether the relative limit mask is a flat line or a line with a slope.

**Relative Limit Start-** specifies the array of relative power limits, in dB, corresponding to the beginning of the offset segment. The value of this parameter is also set as the stop limit for the offset segment when you set the Relative Limit Mode parameter to Couple

**Relative Limit Stop-** specifies the array of relative power limits, in dB, corresponding to the end of the offset segment. This parameter is ignored if you set the Relative Limit Mode parameter to Couple.

To add more segments, configure the values column wise. To configure Enabled, sideband, RBW Auto, RBW Filter Type, Mode Click on the appropriate box, then the selection window will display from that user can select. To configure other controls type the required values in each box. After that Click OK.

8. Choose the required graph or results from highlighted Controls shown below. In this SEM measurement the available graph is Spectrum(Power Vs Frequency) and available result is SEM measurement which includes carrier measurement, lower and upper offset segment measurements. In Transmit Power measurement the available graph is Power Vs Time and available result includes Average Mean Power, Peak to Average Ratio and Peak Power.

![](_page_24_Figure_7.jpeg)

9. To pause the measurement Click on to the Stop button and to continue the measurement click on to the Run button. To save all the configuration, click on to the save button. To load the configuration click on to the load button. To exit the SFP click on to the Exit button.

![](_page_25_Picture_0.jpeg)

#### 3.2.3 Continuous Waveform Measurement

- 1. Select Continuous Waveform Measurements from the Measurement Tab.
- 2. Select the Hardware Tab and Refer 3.2.1 to configure hardware settings.
- Select Spectrum Tab and configure CW measurement settings by clicking CW 3. measurement button.

RBW Filt	er
RBW Auto	True 💌
RBW Filter Type (CW)	Flat 💌
RBW (Hz)	10.000k
Averagin	9
Averaging Enabled	False 💌
Number of Averages	10
Averaging Type	RMS 💌
Sweep Tim	e
Sweep Time Auto	False 💌
Sweep Time Interval(s)	1.00m
FFT	
FFT	Flat Top 💌
	1.000

**RBW** Auto- specifies whether the measurement computes the resolution bandwidth (RBW) of the carrier.

**RBW Filter Type-** specifies the response of the digital RBW filter.

**RBW-** specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

Averaging Enabled- specifies whether to enable averaging for the measurement. The default value is False.

Number of Averages- specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

Averaging Type- specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

Sweep Time Auto- specifies whether the measurement computes the sweep time.

Sweep Time Interval- specifies the sweep time, in seconds, when you set the Sweep Time Auto parameter to False. The default value is 1 ms.

**FFT-** specifies the FFT window type to use to reduce spectral leakage.

![](_page_26_Picture_0.jpeg)

**FFT Padding-** specifies the factor by which the time-domain waveform is zero-padded before an FFT. The FFT size is given by the following formula: FFT size = waveform size \* padding. This parameter is used only when the acquisition span is less than the device instantaneous bandwidth.

After configuration all settings click OK.

4. Choose the required graph or results from highlighted Controls shown below. The following are the graphs available in this measurement.

- Power Vs Frequency
- Frequency Error Vs Time
- > The results available are Average Absolute Frequency and Frequency Offset

![](_page_26_Figure_7.jpeg)

7. To pause the measurement Click Stop button and to continue the measurement click on Run button. To save all the configuration, click the save button. To load the configuration, click load button. To exit the SFP, click Exit button.

## 4. Programming Examples

The ZigBee Signal generation contains examples for performing the following

- i. Creating the waveform based on the standard specific user input parameters and then downloads the waveform to NI VSG/NI VST.
- ii. Creating the waveform based on the standard specific user input parameters and then writes the waveform to the file.

The ZigBee Signal analysis contains examples for performing the following

- i. Modulation Accuracy Measurement
- ii. Spectral Emission Mask Measurement
- iii. Transmit Power Measurement
- iv. Continuous Waveform Measurement

![](_page_27_Picture_0.jpeg)

The programming examples are created using the LabVIEW API VIs. For more information about the API VI used in the example VIs refer to the MaxEye ZigBee Measurement Suite Help.chm document, accessible at Start->All Programs->MaxEye->ZigBee>Documentation.

#### 4.1. ZigBee Signal Generation

ZigBee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs. The toolkit has examples to demonstrate the functionality of creating ZigBee waveform, writing the waveform to the NI RFSG memory and then playing the waveform from the memory. According to IEEE 802.5.4 standard the frame type is classified into four:- Acknowledgement, Beacon, Data, MAC Command frame. So the toolkit has separate examples to generate each frame type. Separate examples are provided for both modulation schemes BPSK and OQPSK also.

#### 4.1.1 MaxEye ZigBee OQPSK Signal Generation

#### 4.1.1.1 MaxEye ZigBee OQPSK Signal Generation (Data Frame)

This Example is used to generate ZigBee Data Frame. The figure below shows the front panel of this example VI.

![](_page_27_Figure_7.jpeg)

The user configurations are divided into three categories

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments

![](_page_28_Picture_0.jpeg)

Follow the below procedure to run the example.

1. Select Hardware Configuration Tab and configure the following settings.

Hardware Settings		
RFSG Resource	RFSG	•
Carrier frequency (Hz)	Channel 11 - 2405 MHz	-
Power Level (dBm)	-10.00	- i
External Attenuation (dB)	0.00	
Headroom (dB)	3	
Arb:Pre-filter Gain (dB)	-1	
Frequency Reference		
Reference Source PX	I_CLK	T
Frequency (Hz)	10.000M	
Export Clock Settings		
Export clock Settings		

**RFSG Resource-** Configure the resource name used in NI Measurement and Automation explorer for the NI PXIe-5673/5673E or NI PXIe 5644R/45R/46R or NI 5840 device.

**Carrier Frequency** (Hz)- Select Center Frequency of the ZigBee signal in MHz. . For BPSK the carrier frequency is ranging from channel 1 (868.3 MHz) to channel 10 (924MHz) and for OQPSK the carrier frequency is ranging from Channel 11 (2405 MHz) to channel 26(2480 MHz).

**Power Level (dBm)-** Average Power level of the signal in dBm.

**Headroom** (**dB**)- Configure the Headroom value higher than PAPR of the signal to be generated. Refer MaxEye ZigBee Measurement Suite Help.chm.

**External Attenuation (dB)-** Specifies the external amplification or attenuation, if any, between the NI RF signal generator and the device under test. Positive values for this property represent amplification, and negative values for this property represent attenuation.

**Arb: Pre-filter Gain (dB)-** Specifies the AWG prefilter gain. The prefilter gain is applied to the waveform data before any other signal processing. Reduce this value to prevent overflow in the AWG interpolation filters. Other gains on the NI-RFSG device are automatically adjusted to compensate for non unity AWG prefilter gain.

Reference Source- specifies the source of the Reference Clock signal

Frequency (Hz)- specifies the Reference Clock rate, in hertz (Hz).

**Clk Output Terminal-** specifies the terminal where the signal will be exported.

![](_page_29_Picture_0.jpeg)

2. Select Signal Configuration Tab and configure the following settings.

The figure below shows the signal configuration for OQPSK ZigBee Signal Generation Data frame example.

MAC Framing Enabled	Addressing	Number of Frames
True	Destination PAN Identifier	1
	× ABCD	Inter Frame Spacing (Seconds)
-rame Control Fields	Destination MAC Address	0.0001
Frame Type	× AAAAEEEEEEEEEE	Samples Per Chip
Data	Source PAN Identifier	20
Security Enabled	AFFC	Oversampling Enabled?
False	Service MAC Address	False 👻
Frame Pending Field	Source MAC Address	Output Sampling Rate
T False	* AAAACCCCCCCCCC	20M
Ack Request Field	Power Ramp Up Time (Seconds)	Power Ramp Down Time (Seconds
False	5E-6	5E-6
Intra-PAN/PAN ID Compression	Payload Control	
/ Inter-PAN	Payload Mode Payl	oad Test Pattern
Destination Addr Mode	() PN Sequence ()	All 1s
+ Extended Address	Payload Length bytes	Payload User Defined Bits
Frame Version	A 40	
Compatible with	5 40	121 - 21 -
Source Addr Mode	Payload PN Order Paylo	ad File Refnum
Extended Address	9 🧊	
	Payload PN Seed Payloa	id File Path
Sequence Number	BEEEBEEE 8	

**MAC Framing Enabled-** To generate MAC frame set this to true, the toolkit adds MAC layer headers and then creates payload for the physical layer. If this is set to false then the toolkit generates waveform without MAC frame parameters.

**Number of Frames-** decides the length of waveform to be generated. To generate longer duration of the waveform, increase the Number of Frames value.

Inter frame Spacing (Seconds)- specifies the gap duration in seconds between the frames.

**Samples Per Chip-** Specifies the number of samples per chip. Sampling Rate of generated waveform is equal to samples per chip multiplied by Chip Rate.

**Oversampling Enabled & Output Sampling Rate-** Use this configuration only when you want to resample the signal to different sampling rate. The default sampling rate is Samples per chip multiplied by Chip Rate. The toolkit resample's the generated signal to a sampling rate equal to the Output Sampling Rate only if the Over Sampling Enabled property is set to 1(True).

**The Power Ramp Up Time-** specifies the time duration during which the signal power gradually increases to the full value from zero.

**The Power Down Time-** specifies the time duration during which the signal power gradually reduces from the full value to close to zero.

The frame control fields can be configured as follows

Frame Type- Select the frame type as Data.

![](_page_30_Picture_0.jpeg)

**Security Enabled-** shall be set to True if the frame is protected by the MAC sublayer and shall be set to False otherwise.

**Frame Pending Field-** shall be set to True if the device sending the frame has more data for the recipient. This field shall be set to False otherwise.

Ack Request Field- specifies whether an acknowledgment is required from the recipient device on receipt of a data or MAC command frame. If this field is set to True, the recipient device shall send an acknowledgment frame only if, upon reception. If this field is set to False, the recipient device shall not send an acknowledgment frame.

**PAN ID Compression-** specifies whether the MAC frame is to be sent containing only one of the PAN identifier fields when both source and destination addresses are present. If this field is set to Intra-PAN and both the source and destination addresses are present, the frame shall contain only the Destination PAN Identifier field, and the Source PAN Identifier field shall be assumed equal to that of the destination. If this field is set to inter-PAN, then the PAN Identifier field shall be present if and only if the corresponding address is present.

Destination Address Mode- Select the required destination address mode.

Frame Version- specifies the version number corresponding to the frame.

**Source Address Mode-** Select the required source addressing mode.

Sequence Number- The Sequence Number field specifies the sequence identifier for the frame.

The addressing fields can be configured as follows.

**Destination PAN Identifier-** specifies the unique PAN identifier of the intended recipient of the frame. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero.

**Destination MAC Address-** specifies the address of the intended recipient of the frame. Based on the Destination Address mode this field may be 16 bit or 64 bit. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero

**Source PAN Identifier-** specifies the unique PAN identifier of the originator of the frame. This field shall be included in the MAC frame only if the Source Addressing Mode field is nonzero and the PAN ID Compression field is equal to zero.

**Source MAC Address-** specifies the address of the originator of the frame. This field shall be included in the MAC frame only if the Source Addressing Mode field is nonzero.

MaxEye ZigBee Measurement Suite Toolkit allows you to configure various payload settings. The possible payload options are

![](_page_31_Picture_0.jpeg)

- i. **PN Sequence-** In this mode configure Sync Insertion Enabled, Payload PN order and PN Seed properties and the toolkit ignores other properties in the ZigBee Payload Control. The toolkit generates pseudo random sequence based on the PN order and seed value, the generated bit sequence is used as a payload for generating the signal. Use this mode for testing the receiver performance for random payload values.
- ii. **User defined bits-** In this mode configure Sync Insertion Enabled and Payload User Defined Bits property and the toolkit ignores other properties in the ZigBee Payload Control.
- iii. **Test Pattern-** In this mode configure Sync Insertion Enabled and Payload Test Pattern property and the toolkit ignores other properties in the ZigBee Payload Control. The possible values for the Test Pattern are All 1s, All 0s, 10101010 and 01010101. This mode is used for generating signal with known test patterns.
- iv. **Test File-** In this mode configure the Sync Insertion Enabled and Payload File Path property and the toolkit ignores other properties in the ZigBee Payload Control. This mode is used for generating signal with the data from the file.

The payload settings can be configured as follows.

**Payload Mode** : Choose the appropriate mode. PN sequence is used to generate the PN sequence. In the User defined bits, user can configure the transmitting bits. In Test Pattern, some predefined bit patterns can be used for transmitting.

Payload Length ,Bytes- Specifies the number of bytes to be transmitted

**Payload PN Order-** specifies the order of the PN bit sequence to be generated. The valid values is 5 to 31, inclusive. Configure this field when the Payload mode is PN sequence.

**Payload PN Seed-** specifies the initial state of the PN generator shift register. Configure this field when the Payload mode is PN Sequence

**Payload Test Pattern-** Select the required Test Pattern. Configure this field when the Payload mode is Test Pattern

Payload User Defined Bits- Configure this field when Payload mode is User Defined bits.

Payload File Path- Choose the file path when the payload mode is From File.

The impairments can be configured as follows.

**Impairments Enabled-** If this property is set to True then the toolkit adds the impairments to the generated signal as per the user configuration for the supported impairments.

**Clock Offset (PPM)-** The toolkit applies the clock offset to the generated waveform based on this value. The applied clock offset is relative to the clock frequency of the signal generator.

![](_page_32_Picture_0.jpeg)

**Frequency Offset, Hz-** The toolkit applies frequency offset to the created waveform based on the value configured in this property. The applied frequency offset is relative to the signal generator's carrier frequency.

**Quadrature skew-** Quadrature Skew specifies the deviation in angle from 90 degrees between the in-phase (I) and quadrature-phase (Q) signals.

**IQ gain imbalance, dB-** This value specifies the ratio, in dB, of the mean amplitude of the inphase (I) signal to the mean amplitude of the quadrature-phase (Q) signal.

**I DC offset, %-** The toolkit adds the DC offset to the in-phase signal component (I) of the complex waveform as a percentage of the root mean square magnitude of the unaltered I signal.

**Q DC Offset, %-** The toolkit adds the DC offset to the quadrature-phase signal component (Q) of the complex waveform as a percentage of the root mean square magnitude of the unaltered Q signal.

**AWGN Enabled-** If this property is set to True then the toolkit adds Additive White Gaussian Noise (AWGN) to the created waveform based on the value configured in the Carrier to Noise Ratio property.

Carrier to Noise Ratio, dB- This value specifies the Carrier to Noise ratio of the generated signal.

## 4.1.1.2 MaxEye ZigBee OQPSK Signal Generation (Beacon Frame)

This Example is used to generate ZigBee Beacon Frame. The figure given below shows the front panel of the example VI.

![](_page_32_Figure_10.jpeg)

![](_page_33_Picture_0.jpeg)

The user configurations are divided into three categories

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments
- 1. Select Hardware Configuration and Refer 4.1.1.1 for configuration.
- 2. Select Signal Configuration Tab

Frame Type- Select the frame type as Beacon.

The superframe specifications can be configured as follows.

Frame Control Fields	Addressing Fields	Number of Frames
Frame Type	Source PAN Identifier	1
+) Beacon	× ABCD	Inter Frame Spacing (Seconds)
Security Enabled	Source MAC Address	0.0001
False	× AAAAEEEEEEEEEE	Samples Per Chip
Frame Pending Field	Super Frame Specification	20
False	Beacon Order	Oversampling Enabled?
Ack Request Field	0	False 💌
Acchequestitien	Superframe Order	Output Sampling Rate
J Faise	0	20M
Intra-PAN/PAN ID Compression	Bower Pamp Up Time (Seconds)	Bower Pamp Down Time (Second
T Inter-PAN	5E-6	SE-6
Destination Addr Mode	52-0	52-0
Extended Address	Payload Control	
Frame Version	Payload Mode Pay	load Test Pattern
Compatible with	(†) PN Sequence (†)	All 1s
Source Addr Mode	Pauload Length buter	Payload User Defined Bits
Extended Address		0 4 0
Sequence Number	Payload PN Order Paylo	oad File Refnum
0	9 19	
	S/ Paulo	ad Eile Dath
	Payload PN Seed	
	BEEFBEEF 8	

Beacon Order- specify the transmission interval of the beacon.

**Superframe Order-** specify the length of time during which the superframe is active (i.e., receiver enabled), including the beacon frame transmission time.

For rest of the configuration, Refer 4.1.1.1.

3. Select the Impairments Tab. Refer 4.1.1.1 for configuration.

![](_page_34_Picture_0.jpeg)

## 4.1.1.3 MaxEye ZigBee OQPSK Signal Generation (MAC Command)

This Example is used to generate ZigBee MAC Command Frame. The figure given below shows the front panel of the example VI.

rdware Configuration	signal configuration	Impairments					Waveform Grap	h					
ZigBee OQPSK Signa	Configuration						7.5-						
Frame Control Fields	Number	of Frames		Inter Frame Spacing	g (Seconds)	Addressing	5-						
Frame Type		1		0.0001		Destination PAN Identifier	2.5-						
A MAC Command	Samples	Per Chip		Oversampling Enab	led?	× ABCD	0-						
Security Enabled		20		False	-	Destination MAC Address	A 95						
False	Power R	amp Up Time (Se	conds)	Output Sampling R	ate	× AAAAEEEEEEEEEEE	e -2.5-						
Frame Pending Fiel	d	5E-6		20M		Source PAN Identifier	lag -5−						
False	Power R	amp Down Time	(Seconds)	Command Frame In	dentifier	× AEFC	te -7.5-						
Ack Request Field		5E-6		Association	•	Source MAC Address	od -10-						
False				have a series of the second		× AAAACCCCCCCCC	-12.5-						
Intra-PAN/PAN ID (	Compression						-15-						
Inter DAN	MAC Co	mmand Frame Fi	elds Configu	ration			15						
JIIICEIFFAIN	Coordi	nator Realignme	nt		GTS Request		-17.5-						
Destination Addr M	ode Associa	tion Request	Asso	ciation Response	Disas	sociation Notification	-20	0.01	0.02 0.03	0.04 0.0	5 0.06 0.0	7 0.09	0.00
Extended Address								0.01	0.02 0.03	Time (sec	onds)->	/ 0.00	0.09
Frame Version	Devi	се Туре	Securit	v Capability?			AL			Time (see	cinas)		
Compatible with		Function Device	Disah	led									
Source Addr Mode	Pow	er Source	Allocat	re Address?									
Extended Address	AC	Mains	True	C / Iddi C251						Stop			
	Rece	eiver On When Id	e?										
Sequence Number	Tru	0					This VI (1) crea	tes ZigBe	e OQPSK Phy	sical waveform	n (2) download	s the wavef	orm to
0	51.14	-					RFSG Memory	and then	(3) plays the	waveform.			
ierating Frames						0	-						
						U							

The user configurations are divided into three categories

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments
- 1. Select Hardware Configuration and Refer 4.1.1.1 for configuration.
- 2. Select Signal Configuration Tab

Frame Type- Select the frame type as MAC Command.

The MAC Command Frame Field Configuration can be configured as follows

**Command Frame Identifier-** Select the appropriate Command frame identifier. According to this field, Configure the remaining controls as follows

1. If Command frame Identifier is Association Request, then user has to configure the following.

Coordinator Realignment		GTS	Request
Association Request	Association Response		Disassociation Notification
Device Type	Security Capability?		
Full Function Device	Disabled		
Power Source	Allocate Address?		
AC Mains	AC Mains		
Receiver On When Idle?	SP		
True			

![](_page_35_Picture_0.jpeg)

Device Type- Select the device type as either full functioned device or Reduced Function Device.

**Power Source-** Select AC Mains, if the device is receiving power from the alternating current mains. Otherwise, the Power Source field shall be set to Not From AC Mains.

**Receiver on when Idle-** Select True if the device does not disable its receiver to conserve power during idle periods. Otherwise, Select False.

**Security Capability?-** Select Enabled, if the device is capable of sending and receiving cryptographically protected MAC frames; Otherwise select Disabled.

**Allocate Address?-** Select True, if the device wishes the coordinator to allocate a short address as a result of the association procedure. Otherwise, Select False.

2. If Command frame Identifier is Association Response, then user has to configure the following

Coordinator Realignment		GTS Request
Association Request	Association Response	Disassociation Notification
Short Address		
ABCD		
A		
Association Status:		

**Short Address-** If the coordinator was able to associate the device to its PAN, this field shall contain the short address that the device may use in its communications on the PAN until it is disassociated.

Association status?- Select the Valid values of the Association Status field.

3. If Command frame Identifier is Disassociation Notification, then user has to select the following.

Coordinator Realignment		GTS Request
Association Request	Association Response	Disassociation Notification
isassociation Reason?		
he coordinator		

Disassociation reason?- Select the Valid values of the Disassociation reason.

4. If Command frame Identifier is Coordinator Realignment, then user has to configure the following.

![](_page_36_Picture_0.jpeg)

Association Request	Association Response	Disassociatio	on Notification
Coordinator Realignment		GTS Request	
Realignment Command	Channel Number		
Broadcast to the	7 1		
PAN Identifier	Short Address		
ABCD	AACC		
Coordinator Short Address	Channel Page		
AABB	1		

Realignment Command- Select the required Realignment Command.

**PAN Identifier-** shall contain the PAN identifier that the coordinator intends to use for all future communications. Valid values from 0000 to FFFF.

**Coordinator Short Address-** shall contain the value of *macShortAddress*. Valid values from 0000 to FFFF.

**Channel Number-** shall contain the channel number that the coordinator intends to use for all future communications. Valid values from 0 to 255

**Short Address-** if the coordinator realignment command is broadcast to the PAN, the Short Address field shall be set to 0xffff and ignored on reception. If the coordinator realignment command is sent directly to an orphaned device, this field shall contain the short address that the orphaned device shall use to operate on the PAN. Valid values from 0000 to FFFF.

**Channel page-** shall contain the channel page that the coordinator intends to use for all future communications. This field may be omitted if the new channel page is the same as the previous channel page. Valid values from 0 to 255

5. If Command frame Identifier is GTS Request, then user has to configure the following

![](_page_36_Picture_9.jpeg)

**GTS Length (In Slots)-** specifies the number of superframe slots being requested for the GTS. Valid values from 1 to 255.

**GTS Direction-** Select Rx only GTS, if the GTS is to be a receive-only GTS. Conversely, this field shall be set to Tx only GTS if the GTS is to be a transmit-only GTS. GTS direction is defined relative to the direction of data frame transmissions by the device.

**GTS** Characteristics Type- Select GTS Characteristics type as GTS allocation or GTS deallocation.

![](_page_37_Picture_0.jpeg)

For rest of the configuration, Refer 4.1.1.1.

3. Select Impairments Tab. Refer 4.1.1.1 for configuration.

## 4.1.1.4 MaxEye ZigBee OQPSK Signal Generation (Acknowledgement)

The figure given below shows the front Panel of example VI.

ZigBee OQPSK Signal Configuration	New York	7.5-					
Frame Control Fields	Number of Frames	5-					
Frame Type		2.5-					
Acknowledgment	Inter Frame Spacing (Seconds)	0 -					
Security Enabled	0.0001	↑ -2.5 -					
False	Samples Per Chip	Ê -5-					ر عمد
Frame Pending Field	20	P 75-					
False	Oversampling Enabled?						
Ack Request Field	False 💌	a -10-					
T False	Output Sampling Rate	-12.5 -					
Intra-PAN/PAN ID Compression	20M	-15 -					
Ther-PAN	Power Ramp Up Time (Seconds)	-17.5 -					
Destination Addr Mode	5E-6	-20 -					
(r) Extended Address	Power Ramp Down Time (Seconds)	0	0.0001	0.0002	0.0003	0.0004	0.000
Frame Version	5E-6			time (se	conus)->		
Compatible with							
Source Addr Mode							
Extended Address				Stop			
Concernant New York		This MT (1) sector 7				1.1.	
0		RFSG Memory and	then (3) plays th	nysical wavefor ne waveform.	m (z) downioa	us the waveron	11.00
U,							

The user configurations are divided into three categories

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments

1. Select Hardware Configuration and Refer 4.1.1.1 for configuration.

2. Select Signal Configuration Tab.

Frame Type- Select the frame type as Acknowledgement. Refer 4.1.1.1 for rest of the configuration

3. Select Impairments Tab and Refer 4.1.1.1 for configuration.

#### 4.1.1.5 MaxEye ZigBee OQPSK Signal Generation (Data) Save Waveform in file

This Example is used to generate multiple ZigBee Data transmission frames and the generated waveform is stored in a file for play back. Use this example

- To generate and store the custom waveforms based on your test requirement.
- To avoid generating the waveform at the beginning of your test every time. This reduces your test starting time as some of the signal configuration will take longer to generate the waveform.
- For generating the longer duration waveform as the RFSG memory size is limited.

![](_page_38_Picture_0.jpeg)

- For testing your receiver for continuous signal reception.
- For receiver sensitivity measurement (BER) for longer duration.

The figure below shows the front panel.

![](_page_38_Figure_4.jpeg)

The toolkit configurations are same as specified in section 4.1.1.1. This example is used to store data frame waveform.

This example requires the following additional input parameters.

1. **Waveform File Path-** The toolkit writes the generated waveform in a file specified by this file path control.

If the Output Waveform File Path for the combined waveform containing multiple carriers is not specified then a file dialog box opens prompting the user to enter the file name.

- 2. Oversampling Enabled- set this property value to TRUE if re sampling is required.
- **3.** Output Sampling Rate (Hz)- Configure this control to a suitable value if Oversampling Enabled property is set to TRUE.
- **4. Output Sample Width-** The default sample width of the output waveform is 8-bits. The available options are 8-bits and 16-bits. We recommend 16-bits sample width for better signal quality of the generated waveform.

![](_page_39_Picture_0.jpeg)

#### 4.1.1.6 MaxEye ZigBee OQPSK RFSG Play Waveform From File

This example reads the ZigBee waveform from the file created using the previous example in section 4.1.1.5 and then downloads the waveform in real-time to NI RFSG Memory and then plays the waveform. This example is created using the NI RFSG streaming example available in the NI website.

This example uses NI RFSG in streaming mode for playing the waveform in real-time. The performance of this example is related to the performance of your CPU and available RAM memory.

The figure below shows the front panel of the Example VI. For more information about NI RFSG streaming refer to the web link below.

http://zone.ni.com/reference/en-XX/help/371025K-01/rfsg/streaming/

Hardware Configuration	Waveform Settings	
Hardware Settings	Frequency Reference	NOT GENERATING
Resource Name	Reference Source PXI_CLK	# elements in queue 0
Center Frequency (Hz) 91.50000M	Frequency (Hz) 10.000E+6	File Progress
Power Level (dBm) 0.00 Pre-filter Gain (dB) -3.00	Export Clock Settings Clk Output Terminal Do not export	0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 Space Available in Streaming Waveform (S) -1 1000000 2000000 3000000 375000
		waveform file path (dialog if empty)

This example requires the following additional input parameters.

Hardware Configuration Waveform Settings	
	NOT GENERATING
Write Block Size in Samples	# elements in queue
10405/0	0
Streaming Waveform Size in Samples	File Progress
Sample Width 8-bit	0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
	Space Available in Streaming Waveform (S)
	-1 1000000 2000000 3000000 3750000
	waveform file path (dialog if empty)
	<u>_</u> B
	STOP

![](_page_40_Picture_0.jpeg)

**Streaming Waveform Size in Samples-** specifies the total number of samples used to write the waveform to NI RFSG device or output DMA Stream.

Sample Width- use the same sample width value used for storing the waveform in the file.

### 4.1.1.7 MaxEye ZigBee OQPSK RFSG VST Play Waveform From File

This example reads the ZigBee waveform from the file created using the previous example in section 4.1.1.5 using VST. This example deploy the bit file dynamically to the respective target(FPGA) and configures a stream from the Host to the FPGA target and writes waveform data to the streaming DMA FIFO.

Hardware Configuration	Waveform Settings	
RIO Device	Start Trigger	NOT GENERATING
1/2 ·	Software 💌	# elements in queue
Center Frequency (Hz)	Prefilter Gain (dB) 0	0
2.4056		File Progress
Peak Power Level (dB)		
0		0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
reference clock source		waveform file path (dialog if empty)
OnboardClk		1
		STOP

This example requires the following additional input parameters.

Hardware Configuration Waveform Settings	
Streaming FIFO Depth	NOT GENERATING
1000000	# elements in queue
Write Block Size in Samples	0
100000	File Progress
Sample Width	
16-bit	0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
	waveform file path (dialog if empty)
	<u>1</u>
	STOP

**Streaming Waveform Size in Samples-** specifies the total number of samples used to write the waveform to output DMA Stream.

Sample Width- use the same sample width value used for storing the waveform in the file.

![](_page_41_Picture_0.jpeg)

### 4.1.2 MaxEye ZigBee BPSK Signal Generation

## 4.1.2.1 MaxEye ZigBee BPSK Signal Generation (Data Frame)

This Example is used to generate ZigBee Data Frame.

That uware configuration	Impaintens		Waveform Graph
MAC Framing Enabled True   Frame Control Fields  Frame Type  Data  Security Enabled  False Frame Pending Field  False Ack Request Field False Intra-PAN/PAN ID Comp Intra-PAN/PAN ID Comp Compatible with Source Addr Mode Extended Address Sequence Number 0	Addressing Destination PAN Identifier × ABCD Destination MAC Address × AAAAEEEEEEEEEE Source PAN Identifier × AEFC Source MAC Address × AAAACCCCCCCCCC Power Ramp Up Time (Second SE-6 Payload Length, bytes Payload PN Sequence Payload PN Seed Payload PN Seed	Number of Frames 1 Data Rate (kbps) 20 ▼ Inter Frame Spacing (Seconds) 0.0001 Samples Per Chip 4 Oversampling Enabled? False ▼ Output Sampling Rate SM s) Power Ramp Down Time (Second 5E-6 Payload User Defined Bits 0 0 0 0 0 0 0 0 0 0 0 0 0	Wavelow Graph         20- -20- -40- -20- -40- -20- -40- -20- -40- -20- -40- -20- -40- -20- -40- -20- -40- -20- -40- -100- -140- -140- -140- -140- -180- -200- 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1 Time (seconds) ->         ds)
enerating Frames		0	

The user configurations are divided into three categories

- 1. Hardware Settings
- 2. ZigBee Signal Configuration
- 3. Impairments
- 1. Select the Hardware Configuration Tab and configure the following settings.

![](_page_41_Picture_10.jpeg)

**RFSG Resource-** Configure the resource name used in NI Measurement and Automation explorer for the NI PXIe-5673/5673E device or NI PXIe 5644R/45R/46R or NI 5840 device.

Carrier Frequency (Hz)- Center Frequency of the ZigBee signal in MHz.

Power Level (dBm)- Average Power level of the signal in dBm.

**Headroom** (**dB**)- Configure the Headroom value higher than PAPR of the signal to be For more information please contact info@maxeyetech.com

![](_page_42_Picture_0.jpeg)

generated. Refer MaxEye ZigBee Measurement Suite Help.chm.

External Attenuation (dB), Arb: Pre-filter Gain (dB), Reference Source, Frequency (Hz), Clk Output Terminal – Refer NI RFSG Signal Generators help file.

2. Select the signal configuration Tab.

MAC Framing Enabled	Addressing	Number of Frames
True	Destination PAN Identifie	Data Rate (kbps)
Frame Control Fields	× ABCD	20
Frame Type	Destination MAC Address	Inter Frame Spacing (Seconds)
A Data	× AAAAEEEEEEEEEE	0.0001
Security Enabled	Source PAN Identifier	Samples Per Chip
A False	× AFFC	4
Frame Banding Field	Source MAC Address	Oversampling Enabled?
A second se		False
False	AAAACCCCCCCCCC	Output Sampling Rate
Ack Request Field		5M
False	Power Ramp Up Time (Seco	nds) Power Ramp Down Time (Second
Intra-PAN/PAN ID Compression	5E-6	5E-6
/ Inter-PAN	Payload Mode	Payload Test Pattern
Destination Addr Mode	PN Sequence	All 1s
Extended Address		Payload User Defined Bits
Frame Version	Payload Length, bytes	
Compatible with	3 40	
Source Addr Mode	Payload PN Order	Payload File Refnum
Extended Address	(j) 9	9
	Payload PN Seed	Payload File Path
Sequence Number	A DECEDECE	g 🗁
0	JA DEEFBEEF	

**MAC Framing Enabled-** To generate MAC frame set this to true, the toolkit adds MAC layer headers and then creates payload for the physical layer. If this is set to false then the toolkit generates waveform without MAC frame parameters.

**Number of Frames-** decides the length of waveform to be generated. To generate longer duration of the waveform, increase the Number of Frames value.

Inter frame Spacing (Seconds)- specifies the gap duration in seconds between the frames.

**Samples Per Chip-** Specifies the number of samples per chip. Sampling Rate of generated waveform is equal to samples per chip multiplied by Chip Rate.

**Oversampling Enabled & Output Sampling Rate-** Use this configuration only when you want to resample the signal to different sampling rate. The default sampling rate is Samples per chip multiplied by Chip Rate. The toolkit resample's the generated signal to a sampling rate equal to the Output Sampling Rate only if the Over Sampling Enabled property is set to 1(True).

**The Power Ramp Up Time-** specifies the time duration during which the signal power gradually increases to the full value from zero.

**The Power Down Time-** specifies the time duration during which the signal power gradually reduces from the full value to close to zero.

The frame control fields can be configured as follows.

![](_page_43_Picture_0.jpeg)

Frame Type- Select the frame type as Data.

**Security Enabled-** shall be set to True if the frame is protected by the MAC sublayer and shall be set to False otherwise.

**Frame Pending Field-** shall be set to True if the device sending the frame has more data for the recipient. This field shall be set to False otherwise.

Ack Request Field- specifies whether an acknowledgment is required from the recipient device on receipt of a data or MAC command frame. If this field is set to True, the recipient device shall send an acknowledgment frame only if, upon reception. If this field is set to False, the recipient device shall not send an acknowledgment frame.

**PAN ID Compression-** specifies whether the MAC frame is to be sent containing only one of the PAN identifier fields when both source and destination addresses are present. If this field is set to Intra-PAN and both the source and destination addresses are present, the frame shall contain only the Destination PAN Identifier field, and the Source PAN Identifier field shall be assumed equal to that of the destination. If this field is set to inter-PAN, then the PAN Identifier field shall be present if and only if the corresponding address is present.

Destination Address Mode- Select the required destination address mode.

Frame Version- specifies the version number corresponding to the frame.

Source Address Mode- Select the required source addressing mode.

Sequence Number- The Sequence Number field specifies the sequence identifier for the frame.

The addressing fields can be configured as follows,

**Destination PAN Identifier-** specifies the unique PAN identifier of the intended recipient of the frame. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero.

**Destination MAC Address-** specifies the address of the intended recipient of the frame. Based on the Destination Address mode this field may be 16 bit or 64 bit. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero

**Source PAN Identifier-** specifies the unique PAN identifier of the originator of the frame. This field shall be included in the MAC frame only if the Source Addressing Mode field is nonzero and the PAN ID Compression field is equal to zero.

**Source MAC Address-** specifies the address of the originator of the frame. This field shall be included in the MAC frame only if the Source Addressing Mode field is nonzero.

MaxEye ZigBee Measurement Suite Toolkit allows you to configure various payload settings. The For more information please contact info@maxeyetech.com

![](_page_44_Picture_0.jpeg)

possible payload options are

- i. **PN Sequence-** In this mode configure Sync Insertion Enabled, Payload PN order and PN Seed properties and the toolkit ignores other properties in the ZigBee Payload Control. The toolkit generates pseudo random sequence based on the PN order and seed value, the generated bit sequence is used as a payload for generating the signal. Use this mode for testing the receiver performance for random payload values.
- ii. **User defined bits-** In this mode configure Sync Insertion Enabled and Payload User Defined Bits property and the toolkit ignores other properties in the ZigBee Payload Control.
- iii. **Test Pattern-** In this mode configure Sync Insertion Enabled and Payload Test Pattern property and the toolkit ignores other properties in the ZigBee Payload Control. The possible values for the Test Pattern are All 1s, All 0s, 10101010 and 01010101. This mode is used for generating signal with known test patterns.
- iv. **Test File-** In this mode configure the Sync Insertion Enabled and Payload File Path property and the toolkit ignores other properties in the ZigBee Payload Control. This mode is used for generating signal with the data from the file.

The payload settings can be configured as follows.

**Payload Mode** : Choose the appropriate mode. PN sequence is used to generate the PN sequence. In the User defined bits, user can configure the transmitting bits. In Test Pattern, some predefined bit patterns can be used for transmitting.

Payload Length ,Bytes- Specifies the number of bytes to be transmitted

**Payload PN Order-** specifies the order of the PN bit sequence to be generated. The valid values is 5 to 31, inclusive. Configure this field when the Payload mode is PN sequence.

**Payload PN Seed-** specifies the initial state of the PN generator shift register. Configure this field when the Payload mode is PN Sequence.

**Payload Test Pattern-** Select the required Test Pattern. Configure this field when the Payload mode is Test Pattern

Payload User Defined Bits- Configure this field when Payload mode is User Defined bits.

Payload File Path- Choose the file path when the payload mode is From File.

The impairments can be configured as follows.

**Impairments Enabled-** If this property is set to True then the toolkit adds the impairments to the generated signal as per the user configuration for the supported impairments.

![](_page_45_Picture_0.jpeg)

**Clock Offset (PPM)-** The toolkit applies the clock offset to the generated waveform based on this value. The applied clock offset is relative to the clock frequency of the signal generator. The default value is 0.

**Frequency Offset, Hz-** The toolkit applies frequency offset to the created waveform based on the value configured in this property. The applied frequency offset is relative to the signal generator's carrier frequency. The default value is 0.

**Quadrature skew**- Quadrature Skew specifies the deviation in angle from 90 degrees between the in-phase (I) and quadrature-phase (Q) signals. The default value for the Quadrature Skew is 0.

**IQ gain imbalance, dB-** This value specifies the ratio, in dB, of the mean amplitude of the inphase (I) signal to the mean amplitude of the quadrature-phase (Q) signal. The default value is 0.

**I DC offset, %-** The toolkit adds the DC offset to the in-phase signal component (I) of the complex waveform as a percentage of the root mean square magnitude of the unaltered I signal. The default value is 0.

**Q DC Offset, %-** The toolkit adds the DC offset to the quadrature-phase signal component (Q) of the complex waveform as a percentage of the root mean square magnitude of the unaltered Q signal. The default value is 0.

**AWGN Enabled**- If this property is set to True then the toolkit adds Additive White Gaussian Noise (AWGN) to the created waveform based on the value configured in the Carrier to Noise Ratio property.

**Carrier to Noise Ratio, dB**- This value specifies the Carrier to Noise ratio of the generated signal. The default value is 40dB.

## 4.1.2.2 MaxEye ZigBee BPSK Signal Generation (Beacon Frame)

This Example is used to generate ZigBee Beacon Frame. The figure given below shows the front panel of example VI.

![](_page_45_Figure_11.jpeg)

For more information please contact info@maxeyetech.com

![](_page_46_Picture_0.jpeg)

The user configurations are divided into three categories

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments
- 1. Select Hardware Configuration and Refer 4.1.1.1 for configuration.
- 2. Select Signal Configuration Tab

Cigoee bi Sk Signal Configuration		Number of Frames
rame Control Fields	Addressing Fields	- 1
Frame Type	Source PAN Identifier	Data Rate (kbps)
Beacon	× ABCD	20 💌
Security Enabled	Source MAC Address	Inter Frame Spacing (Seconds)
Talse	× AAAAEEEEEEEEEE	0.0001
Frame Pending Field	Super Frame Specification	on Samples Per Chip
False	Beacon Order	4
Ack Request Field	0	Oversampling Enabled?
False	Superframe Order	False 💌
Jahrs DANI/DANID Company	0	Output Sampling Rate
Intra-PAN/PAN ID Compression		5M
Inter-PAN	Power Ramp Up Time (Sec	onds) Power Ramp Down Time (Secon
Destination Addr Mode	5E-6	5E-6
Extended Address	Payload Control	
Frame Version	Pavload Mode	Payload Test Pattern
Compatible with	2) PN Sequence	All 1s
Source Addr Mode		Payload User Defined Bits
Extended Address	Payload Length, bytes	
	40	
equence Number	Payload PN Order	Payload File Refnum
0	9	
	9	Pavload File Path
	Payload PN Seed	
	BEFEBEEE	8

Frame Type- Select the frame type as Beacon.

The superframe specifications can be configured as follows.

Beacon Order- specify the transmission interval of the beacon.

**Superframe Order-** specify the length of time during which the superframe is active (i.e., receiver enabled), including the beacon frame transmission time.

Refer 4.1.2.1 to configure rest of the Settings.

3. Select the impairments and Refer 4.1.2.1 to configure the impairments Settings

![](_page_47_Picture_0.jpeg)

## 4.1.2.3 MaxEye ZigBee BPSK Signal Generation (MAC Command)

This Example is used to generate ZigBee MAC Command Frame.

Hardware Configuration Signal C	onfiguration Impairments			Waveform Graph
MAC Framing Enabled True Frame Control Fields Frame Type TraMa Command Security Enabled False Frame Pending Field False Ack Request Field False Leter Bield	Number of Frames     Data Rate (kbps)       1     20       Samples Per Chip     Inter Frame Spacing (Seconds)       4     0.0001       Power Ramp Up Time (Seconds)     Oversampling Enabled?       5E-6     False       Power Ramp Down Time (Seconds)     Output Sampling Rate       5E-6     5M       Command Frame Identifier     SM       Association     Implicit Market Sampling Configuration		Addressing Destination PAN Identifier × ABCD Destination MAC Address × AAAAAEEEEEEEEE Source PAN Identifier × AEFC Source MAC Address × AAAACCCCCCCCCC	20- 0- -20- -40- -40- -40- -40- -40- -40
Inter-PAN     Destination Addr Mode     Extended Address     Frame Version     Compatible with     Source Addr Mode     Extended Address Sequence Number     0	Coordinator Realignment Association Request Device Type Full Function Device ACMains Receiver On When Idle?	G1S Reque Association Response Disa ecurity Capability? Disabled Ilocate Address? True	st sssociation Notification	0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 Time (seconds) → STOP This VI (1) creates ZigBee BPSK Physical Layer waveform (2) downloads the waveform to RFSG Memory and then (3) plays the waveform.
Generating Frames			0	-

The user configurations are divided into three categories

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments
- 1. Select Hardware Configuration and Refer 4.1.1.1 for configuration.
- 2. Select Signal Configuration Tab

Frame Type- Select the frame type as MAC Command.

The MAC Command Frame Field Configuration can be configured as follows

**Command Frame Identifier**- Select the appropriate Command frame identifier. According to this field, Configure the remaining controls as follows.

1. If Command frame Identifier is Association Request, then user has to configure the following.

Coordinator Realignment	t	GT	S Request
Association Request	Association Response	).	Disassociation Notification
Device Type	Security Capability?		
Full Function Device	Disabled		
Power Source	Allocate Address?		
AC Mains	/ True		
Receiver On When Idle	?		
True			

![](_page_48_Picture_0.jpeg)

Device Type- Select the device type as either full functioned device or Reduced Function Device.

**Power Source-** Select AC Mains, if the device is receiving power from the alternating current mains. Otherwise, the Power Source field shall be set to Not From AC Mains.

**Receiver on when Idle-** Select True if the device does not disable its receiver to conserve power during idle periods. Otherwise, Select False.

**Security Capability?-** Select Enabled, if the device is capable of sending and receiving cryptographically protected MAC frames; Otherwise select Disabled.

**Allocate Address?-** Select True, if the device wishes the coordinator to allocate a short address as a result of the association procedure. Otherwise, Select False.

2. If Command frame Identifier is Association Response, then user has to configure the following

Coordinator Realignment	GTS Request		
Association Request	Association Response	Disassociation Notification	
Short Address			
() ABCD			
Association Status?			

**Short Address-** If the coordinator was able to associate the device to its PAN, this field shall contain the short address that the device may use in its communications on the PAN until it is disassociated.

Association status?- Select the Valid values of the Association Status field.

3. If Command frame Identifier is Disassociation Notification, then user has to select the following.

Coordinator Realignment	GTS Request	
Association Request	Association Response	Disassociation Notification
isassociation Reason?		
The coordinator		

**Disassociation reason?-** Select the Valid values of the Disassociation reason.

4. If Command frame Identifier is Coordinator Realignment, then user has to configure the following.

![](_page_49_Picture_0.jpeg)

Association Request	Association Response	esponse Disassociatio	
Coordinator Realignment		GTS F	Request
Realignment Command	Channel Number		
Broadcast to the	1		
PAN Identifier	Short Address		
ABCD	AACC		
Coordinator Short Address	Channel Page		
AABB	1		

Realignment Command- Select the required Realignment Command.

**PAN Identifier -** shall contain the PAN identifier that the coordinator intends to use for all future communications. Valid values from 0000 to FFFF

**Coordinator Short Address-** shall contain the value of *macShortAddress*. Valid values from 0000 to FFFF

**Channel Number-** shall contain the channel number that the coordinator intends to use for all future communications.

**Short Address-** if the coordinator realignment command is broadcast to the PAN, the Short Address field shall be set to 0xffff and ignored on reception. If the coordinator realignment command is sent directly to an orphaned device, this field shall contain the short address that the orphaned device shall use to operate on the PAN.

**Channel page-** shall contain the channel page that the coordinator intends to use for all future communications. This field may be omitted if the new channel page is the same as the previous channel page.

5. If Command frame Identifier is GTS Request, then user has to configure the following

![](_page_49_Picture_9.jpeg)

GTS Length (In Slots)- specifies the number of superframe slots being requested for the GTS.

**GTS Direction-** Select Rx only GTS, if the GTS is to be a receive-only GTS. Conversely, this field shall be set to Tx only GTS if the GTS is to be a transmit-only GTS. GTS direction is defined relative to the direction of data frame transmissions by the device.

**GTS** Characteristics Type- Select GTS Characteristics type as GTS allocation or GTS deallocation.

![](_page_50_Picture_0.jpeg)

Refer 4.1.2.1 for rest of the configurations

3. Select Impairments Tab, Refer 4.1.2.1 to configure.

## 4.1.2.4 MaxEye ZigBee BPSK Signal Generation (Acknowledgement)

The user configurations are divided into three categories . The figure given below shows the front panel of the example VI.

![](_page_50_Figure_5.jpeg)

- i. Hardware Settings
- ii. ZigBee Signal Configuration
- iii. Impairments
- 1. Select Hardware Configuration Tab, Refer 4.1.2.1 to configure the hardware Settings.
- 2. Select the signal Configuration Tab.

Frame Type- Select the frame type as Acknowledgement.

3. Select the Impairments. Refer 4.1.2.1 for configuration.

## 4.1.2.5 MaxEye ZigBee BPSK Signal Generation (Data) Save Waveform in file

This Example is used to generate multiple ZigBee Data transmission frames and the generated waveform is stored in a file for play back. Use this example

- To generate and store the custom waveforms based on your test requirement.
- To avoid generating the waveform at the beginning of your test every time. This reduces your test starting time as some of the signal configuration will take longer to generate the waveform.
- For generating the longer duration waveform as the RFSG memory size is limited.
- For testing your receiver for continuous signal reception.
- For receiver sensitivity measurement (BER) for longer duration.

![](_page_51_Picture_0.jpeg)

The figure below shows the front panel of the Example

Signal Configuration Impairment	ts		Waveform Graph	Plot 0
ZigBee BPSK Signal Configuration Frame Control Fields Frame Control Fields False Frame Pending Field False Frame Pending Field False Ack Request Field False Intra-PAN/PAN ID Compression	Deta Rate (kbps) 20 Addressing Destination PAN Identifier × ABCD Destination MAC Address × AAAAEEEECCCCFFFF Source PAN Identifier × AEFC Source MAC Address × DROPERFORMED	Number of Frames 1 Inter Frames Spacing (Seconds) 0.0001 Samples Per Chip 4 Oversampling Enabled? False SM Headroom (dB)	Waveform Graph 10- -10	Plot0
Dinter-PAN Destination Addr Mode Extended Address Frame Version Compatible with Source Addr Mode Extended Address	× BBBBEEEECCCCFFF       Power Ramp Up Time (Second SE-6       Payload Control       Payload Mode       PN Sequence       +       Payload Length, bytes       +       40       Payload PN Order	3 s) Power Ramp Down Time (Seconds SE-6 ayload Test Pattern All 1s Payload User Defined Bits 0 0 0 0 yload File Refnum	0.01 Time (seconds)	0.02 0.03 ->
Sequence Number 0 Generating Frames	Payload PN Seed BEEFBEEF	load File Path	This VI (1) creates ZigBee BPSK Physical Layer waveform (2 file	!) saves the waveform in the

The user configurations are divided into two categories .

- i. ZigBee Signal Configuration
- ii. Impairments
- 1. Select Signal Configuration Tab

**Waveform File Path-** The toolkit writes the generated waveform in a file specified by this file path control. If the Output Waveform File Path for the combined waveform containing multiple carriers is not specified then a file dialog box opens prompting the user to enter the file name.

**Oversampling Enabled-** set this property value to TRUE if re sampling is required.

**Output Sampling Rate (Hz)-** Configure this control to a suitable value if Oversampling Enabled property is set to TRUE.

**Output Sample Width-** The default sample width of the output waveform is 8-bits. The available options are 8-bits and 16-bits. We recommend 16-bits sample width for better signal quality of the generated waveform.

Refer 4.1.2.1 for rest of the configuration.

2. Select Impairments. Refer 4.1.2.1 for configuration.

![](_page_52_Picture_0.jpeg)

## 4.2 ZigBee Signal Analysis

### 4.2.1 MaxEye ZigBee OQPSK Signal Analysis

### 4.2.1.1 MaxEye ZigBee OQPSK RFSA Measure Modulation Accuracy

This example VI is to find out various carrier measurements, EVM measurements, magnitude and phase error measurements, impairments measurement, etc. The user Configurations are divided into three

- i. Hardware Settings
- ii. Trigger Settings
- iii. Signal Configuration

![](_page_52_Figure_8.jpeg)

1. Hardware Settings can be configured as follows.

**Resource Name-** Configure the resource name used in NI Measurement and Automation explorer for the NI PXIe-5673/5673E device or NI PXIe 5644R/45R/46R or NI 5840 device.

**Auto Level-** examines the input signal to calculate the peak power level and sets it as the value of the Reference Level property.

**Maximum Input Power-** Configures the reference level that represents the maximum expected power of an RF input signal. Configure this field only when Auto level is False.

**External Attenuation-** specifies the attenuation, in dB, of a switch (or cable) connected to the RF IN connector of the signal analyzer.

![](_page_53_Picture_0.jpeg)

Reference Source- specifies the frequency reference source.

**Frequency-** specifies the Reference Clock rate when the Frequency Reference Source parameter is set to ClKIn or RefIn. This value is expressed in Hz.

2. Trigger Settings can be configured as follows.

Trigger Enabled- specifies whether to enable the trigger.

**Trigger Delay-** Specifies the trigger delay time, in seconds. The trigger delay time is the length of time the IF digitizer waits after it receives the trigger before it asserts the Reference Event.

**Trigger Level-** Specifies the power level, in dBm, at which the device triggers. The device asserts the trigger when the signal exceeds the level specified by the value of this property, taking into consideration the specified slope.

**Minum Quiet Time-** Specifies a time duration, in seconds, for which the signal must be quiet before the device arms the IQ Power Edge trigger. The signal is quiet when it is below the trigger level if the trigger slope, specified by the Reference Trigger IQ Power Edge Slope property, is set to Rising Slope or when it is above the trigger level if the trigger slope is set to Falling Slope.

3. Signal Configuration can be configured as follows.

**Channel Number**- Select Center Frequency of the ZigBee signal in MHz. . For OQPSK the carrier frequency is ranging from Channel 11 (2405 MHz) to channel 26(2480 MHz). Choose the Channel Number as same as transmitted signals channel number.

Acquisition Length, Seconds- Needs to be configured for OQPSK modulation. Number of Samples to Acquire= IQ Rate\* Acquisition Length

Number of frames- Configure the number of frames to be acquired.

Number of Symbols- Configure the number of symbols to be acquired.

**Reset PER measurement-** If this property is set to True the toolkit internal resets the Number of Packets Received and Number of Packet Errors to 0. To measure PER measurement continuously set this property to True only in the first iteration.

4. In Measurement Traces, Traces1 Include Constellation Graph, Offset EVM Vs Symbols, EVM Vs Symbols, Demodulated Bits.

![](_page_54_Picture_0.jpeg)

Demodulated		
Demodulated Bits	PHY Payload	MAC Payload
MPDU (Bytes)		
Number of Packets R	Received MA	C CRC Status?
Number of Packets R 0	Received MA	C CRC Status?
Number of Packets R 0 Number of Packet Er	Received MA	C CRC Status? nplete Packet Received

To see the transmitted payload, select the MAC Payload which is in hexadecimal format.

Number of Packets Received- This shows the total number of Packets received

MAC CRC Status- this will turn ON when CRC check failed.

Number of Packet Errors- It will display the total number of error packets

Complete Packet Received- his will turn on if packet reception is completed.

5. Traces 2 include Magnitude Error Vs Symbols, Phase Error Vs Symbols, I Vs Time, Q Vs Time

![](_page_54_Figure_8.jpeg)

6. MAC Frame Parameters include the MAC frame. This extract the transmitted MAC frame and displays the MAC frame Parameters to the user. Array index refers to the frame number.

![](_page_55_Picture_0.jpeg)

Hardware Configuration	Measurem	ent Traces				Measurement Results	
Resource Name	Traces 1	Traces 2 MAC Frame Parame	ters			Sync Found?	Mean RMS Offset EVM (%)
Auto Level	M	AC Frame Parameters					
False 💌	0	Sequence Number	Destination PAN Identifier	MAC Command		Mean RIVIS EVINI (%)	Maximum Rivis Offset EVIVI (%)
Maximum Input Power (dBm) 0.00 External Attenuation (dB)	ş	0 Frame Control Fields Frame Type	0 Destination MAC Address	Command Frame Identifier Association Request Association Request		Maximum RMS EVM (%)	Mean Peak Offset EVM (%) 0
0.00 Reference Source PJ_CCIk Trigger Settings Trigger Fabled Truger Delay (sec) - 30.00 Minum Quiet Time (sec) 1.00E-6 Signal Configuration Channel Number Channel 1 - 2405 MHz ↓ Acquisition Length, Seconds 0.005 Number of Frames 1 Number of Symbols 2048 Reset PER measurement? False ♥		Frame Type Data Security Enabled False Frame Pending Field False Ack Request Field False Intra-PAN/PAN ID Compression Inter-PAN Destination Addr Mode PAN Id and Address Frame Version Compatible with Source Addr Mode PAN Id and Address	O     Source PAN Identifier     O     Source MAC Address     O     Source MAC Address     O     Superframe Specification     Beacon Interval     O     Superframe Order     O     Superframe Duration     O	Association Request Device Type Reduced Function Power Source AC Mains Receiver On When Idle? False Coordinator Realignment Realianment Command Broadcast to the PAN Identifier 0 Coordinator Short Address 0 GTS Request GTS Length (in Slots) 0 GTS Direction Tx only GTS GTS Characteristics Type GTS Characteristics Type	Security Capability? Disabled Allocate Address? False Channel Number 0 Short Address 0 Channel Page 0 Association Response Short Address 0 Association Status? Association Reason? Reserved	Mean Peak EVM (%) 0 Mean Modulation Error Ratio (dB) 0 Masimum Peak EVM (%) 0 Mean Amplitude Droop (dB/Symbol) 0 Mean Amplitude Droop (dB/Symbol) 0 Mean Augustrature Skew (dg) 0 Mean IQ Gain Imbalance (dB) 0 Mean IQ Origin Offset (dB) 0 error out status code 0 0 0	Maximum Peak Offset EVM (%) 0 Mean Frequency Offset (H2) 0 Mean Prequency Drift (H2) 0 Mean Phase Offset (deg) 0 Maximum Magnitude Error (%) 0 Maximum Phase Error (deg) 0

Measurement Results displays various carrier measurements, EVM measurements, magnitude and phase error measurements, impairments measurement, etc.

### 4.2.1.2 MaxEye ZigBee OQPSK RFSA Measure Spectral Emission Mask

In this example SEM measurement which includes carrier measurement, lower and upper offset segment measurements are calculated.

The user configuration can be divide into three parts

- i. Hardware settings
- ii. Trigger Settings
- iii. Measurement Configuration
- 1. Refer 4.2.1.1 for Hardware Settings and Trigger Settings.
- 2. Measurement Configuration can be configured as follows.

![](_page_55_Figure_11.jpeg)

![](_page_56_Picture_0.jpeg)

**Integration Bandwidth-** specifies the frequency range, in Hz, over which the measurement integrates the carrier channel power

**RBW Filter Type-** specifies the response of the digital RBW filter.

**RBW** (**Hz**)- specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

**Reference Type-** Configures whether the power reference is the integrated power or the peak power in the closest carrier channel. Needs to be configured only foe SEM measurement.

**Power Units(Spec Mask)-** Configures the units for the absolute power. Needs to be configured only foe SEM measurement.

Limit Fail Mask- Specifies the criteria to determine the measurement fail status.

**Averaging Enabled-** specifies whether to enable averaging for the measurement. The default value is False.

**Number of Averages-** specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

Averaging Type- specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement

3. Offsets Segments can be configured as follows.

**Offset Frequency Enabled-** specifies whether to enable the offset segment for the SEM measurement. The default value is True.

**Offset Frequency Start-** specifies the array of start frequencies, in Hz, of each offset segment relative to the closest configured carrier channel bandwidth center or carrier channel bandwidth edge based on the value of the SEM Offset Freq Definition property.

**Offset Frequency Stop-** specifies the array of stop frequencies, in Hz, of each offset segment relative to the closest configured carrier channel bandwidth center or carrier channel bandwidth edge based on the value of the SEM Offset Freq Definition property.

**Offset Frequency Side band-** specifies whether the offset segment is present on one side, or on both sides of the carriers. The default value is Both.

**RBW** Auto - specifies whether the measurement computes the RBW.

**RBW** (**Hz**)- specifies the array of bandwidths, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired offset segment, when you set the RBW Auto parameter to False.

Absolute Limit Mode- specifies whether the absolute limit mask is a flat line or a line with a slope For more information please contact info@maxeyetech.com

![](_page_57_Picture_0.jpeg)

**Absolute Limit Start-** specifies the array of absolute power limits, in dBm, corresponding to the beginning of the offset segment. The value of this parameter is also set as the stop limit for the offset segment when you set the Absolute Limit Mode parameter to Couple.

**Absolute Limit Stop-** specifies the array of absolute power limits, in dBm, corresponding to the end of the offset segment. This parameter is ignored when you set the Absolute Limit Mode parameter to Couple

**Relative Limit Mode-** specifies whether the relative limit mask is a flat line or a line with a slope.

**Relative Limit Start-** specifies the array of relative power limits, in dB, corresponding to the beginning of the offset segment. The value of this parameter is also set as the stop limit for the offset segment when you set the Relative Limit Mode parameter to Couple.

**Relative Limit Stop-** specifies the array of relative power limits, in dB, corresponding to the end of the offset segment. This parameter is ignored if you set the Relative Limit Mode parameter to Couple.

4. The measurement results include Carrier Measurements, Lower and Upper Offset Segment Measurements. The available graph is Power Vs frequency.

#### 4.2.1.3 MaxEye ZigBee OQPSK RFSA Measure Transmit Power

Transmit Power is a zero span measurement of transmitted power using the time-domain signal as seen through a resolution bandwidth (RBW) filter for the specified measurement interval.

This example is used to find out Average Mean Power, Peak to Average Ratio and Peak Power of the transmitted signal. The user configurations are divided into three.

- i. Hardware Settings
- ii. Trigger Settings
- iii. Measurement Configuration
- 1. Refer 4.2.1.1 for Hardware Settings and Trigger Settings.
- 2. Measurement Configuration can be configured as follows.

![](_page_58_Picture_0.jpeg)

Hardware Configuration	Measurement Configura	tion	Measurement Results
Resource Name	Measurem	ent Interval (s)	Power vs Time
KFSA	1.	00m	-10 -
Channel Number	RBW	Filter	-20-
Channel 11 - 2405 MHz 💌	KUW	r nicer	-30 -
Auto Level	RBW Filter Type	Flat 💌	
False 💌	RBW (Hz)	20.000M	튭 -50
Maximum Input Power (dBm	PPC Alaba	0.010	
0.00	KKC Alpha	0.010	a -70-
External Attenuation (dB)			-80 -
0.00	Avera	aging	-90 -
Reference Source	Conversion Franklad		-100-
PXI_Clk	Averaging Enabled		0 500 1000 1500 2000 2500 3000
rigger Settings	Number of Averages	10	nime (seconds)>
Trigger Enabled	Averaging Type	RMS 💌	
True			
Trigger Delay (sec)			Measurements
-10,0u			Average Mean Dewer (dRm) 0.00
Trigger Level			
-30.00			Peak to Average Ratio (dB) 0.00
Minum Quiet Time (sec)			Peak Power (dBm) 0.00
1.00E-6			

**Measurement Interval-** Specifies the acquisition time, in seconds, for the transmit power (TXP) measurement. Needs to be configured only for Transmit Power Measurements

**RBW Filter Type-** specifies the response of the digital RBW filter.

**RBW-** specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

**RRC** Alpha- specifies the roll-off factor for the root-raised-cosine (RRC) filter.

**Averaging Enabled-** specifies whether to enable averaging for the measurement. The default value is False.

**Number of Averages-** specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

**Averaging Type-** specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

3. The measurement Results consists of Average Mean Power, Peak to Average Ratio, Peak Power. The available graph is Power Vs Time.

#### 4.2.1.4 MaxEye ZigBee OQPSK RFSA Measure CW Frequency Offset

This example is used to find out absolute frequency and frequency offset of transmitted continuous wave signal. The user configurations are divided into two.

- i. Hardware Settings
- ii. Measurement Configuration

![](_page_59_Picture_0.jpeg)

- 1. Refer 4.2.1.1 for Hardware Settings.
- 2. Measurement Configuration can be configured as follows.

![](_page_59_Figure_3.jpeg)

**RBW Filter Type-** specifies the response of the digital RBW filter.

**RBW** Auto- specifies whether the measurement computes the resolution bandwidth (RBW) of the carrier.

**RBW** (**Hz**)- specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

Sweep Time Auto- specifies whether the measurement computes the sweep time.

**Sweep Time Interval-** specifies the sweep time, in seconds, when you set the Sweep Time Auto parameter to False. The default value is 1 ms.

**Averaging Enabled-** specifies whether to enable averaging for the measurement. The default value is False.

**Averaging Count-** specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

**Averaging Type-** specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

**FFT window-** specifies the FFT window type to use to reduce spectral leakage.

![](_page_60_Picture_0.jpeg)

**FFT Padding-** specifies the factor by which the time-domain waveform is zero-padded before an FFT. The FFT size is given by the following formula: FFT size = waveform size \* padding. This parameter is used only when the acquisition span is less than the device instantaneous bandwidth.

3. The measurement Results consists of Average Absolute frequency and frequency offset. The available graphs are Frequency Error Vs Time and Power Vs Frequency.

4.2.2 MaxEye ZigBee BPSK Signal Analysis

#### 4.2.2.1 MaxEye ZigBee BPSK RFSA Measure Modulation Accuracy

This example VI is to find out various carrier measurements, EVM measurements, magnitude and phase error measurements, impairments measurement, etc. The user Configuration s are divided into three

- i. Hardware Settings
- ii. Trigger Settings
- iii. Signal Configuration

![](_page_60_Figure_9.jpeg)

1. Hardware Settings can be configured as follows.

**Resource Name-** Configure the resource name used in NI Measurement and Automation explorer for the NI PXIe-5673/5673E device or NI PXIe 5644R/45R/46R or NI 5840 device..

**Auto Level-** examines the input signal to calculate the peak power level and sets it as the value of the Reference Level property.

![](_page_61_Picture_0.jpeg)

**Maximum Input Power-** Configures the reference level that represents the maximum expected power of an RF input signal. Configure this field only when Auto level is False.

**External Attenuation-** specifies the attenuation, in dB, of a switch (or cable) connected to the RF IN connector of the signal analyzer.

**Reference Source-** specifies the frequency reference source.

**Frequency-** specifies the Reference Clock rate when the Frequency Reference Source parameter is set to ClKIn or RefIn. This value is expressed in Hz. The default value is 10 MHz.

2. Trigger Settings can be configured as follows.

Trigger Enabled- specifies whether to enable the trigger.

**Trigger Delay-** Specifies the trigger delay time, in seconds. The trigger delay time is the length of time the IF digitizer waits after it receives the trigger before it asserts the Reference Event.

**Trigger Level-** Specifies the power level, in dBm, at which the device triggers. The device asserts the trigger when the signal exceeds the level specified by the value of this property, taking into consideration the specified slope.

**Minum Quiet Time-** Specifies a time duration, in seconds, for which the signal must be quiet before the device arms the IQ Power Edge trigger. The signal is quiet when it is below the trigger level if the trigger slope, specified by the Reference Trigger IQ Power Edge Slope property, is set to Rising Slope or when it is above the trigger level if the trigger slope is set to Falling Slope.

3. Signal Configuration can be configured as follows.

**Channel Number-** Select Center Frequency of the ZigBee signal in MHz. . For BPSK the carrier frequency is ranging from channel 1 (868.3 MHz) to channel 10 (924MHz) .Choose the Channel Number as same as transmitted signal.

Acquisition Length, Seconds- Needs to be configured for OQPSK modulation. Number of Samples to Acquire= IQ Rate\* Acquisition Length

Number of frames- Configure the number of frames to be acquired

Number of Symbols- Configure the number of symbols to be acquired.

**Reset PER measurement-** If this property is set to True the toolkit internal resets the Number of Packets Received and Number of Packet Errors to 0. To measure PER measurement continuously set this property to True only in the first iteration.

![](_page_62_Picture_0.jpeg)

In Measurement Traces, Traces1 Include Constellation Graph, Offset EVM Vs Symbols, EVM Vs Symbols, Demodulated Bits.

![](_page_62_Figure_2.jpeg)

To see the transmitted payload, select the MAC Payload which is in hexadecimal format.

Number of Packets Received- This shows the total number of Packets received

MAC CRC Status- this will turn ON when CRC check failed.

Number of Packet Errors- displays the total number of error packets

Complete Packet Received- displays LED ON if packet reception is completed.

Traces 2 include Magnitude Error Vs Symbols, Phase Error Vs Symbols, I Vs Time, Q Vs Time

![](_page_62_Figure_9.jpeg)

MAC Frame include the MAC frame. This extract the transmitted MAC frame and displays the MAC frame Parameters to the user. Array index refers to the frame number.

![](_page_63_Picture_0.jpeg)

Hardware Configuration	Measurement Traces		Measurement Results	* = 2 = 2 = 2 = 2 = 2 = 2
Resource Name	Traces 1 Traces 2 MAC Frame Parameters MAC Frame Parameters	Sync Found? Mean Modulation Error Ratio		
Maximum Ingut Power (dBm) 0.00 External Attenuation (dB) 0.00 Reference Source PAL_Clk ■ Tigger Settings. Tingger Enabled Trager Level - 1.0.0. 1.0.0. Siggal Configuration Channel 0866.3MHz ● Channel 0866.3MHz ●	Destination PAN Ident       0       Frame Control Fields       Frame Type       0       Data       Security Enabled       False       Frame Pending Field       False       Ack Request Field       False       Intra-PAN VPAN ID Compression       Intra-PAN Ident       Destination Addr Mode       PAN Id and Address       Frame Version       Source Addr Mode       PAN Id and Address       PAN Id and Address       PAN Id and Address	file       MAL Command         Command Frame Identifier       Association Request         Association Request       Disabled         Power Source       Allocate Address?         AC Manis       False         Receiver On When Idle?       False         PaNI Identifier       Short Address         Image: Image Internation Internation Internation       Image Internation         Image Internation       Image Internation	0 Maximum RMS EVM (%) 0 Mean Peak EVM (%) 0 Mean Frequency Offset (Hz) 0 Mean Amplitude Droop (dB/Symbol) 0 Mean Amplitude Droop (dB/Symbol) 0 Mean Quadrature Skew (dg) 0 Mean IQ Gain Imbalance (dB) 0 Mean IQ Origin Offset (dB) 0 error out status code 0 source	0 Maximum Peak EVM (%) 0 Mean Frequency Drift (H2) 0 Mean Magnitude Error (%) 0 Maximum Magnitude Error (%) 0 Maximum Phase Error (deg) 0 Maximum Phase Error (deg)

Measurement Results displays various carrier measurements, EVM measurements, magnitude and phase error measurements, impairments measurement, etc.

#### 4.2.2.2 MaxEye ZigBee BPSK RFSA Measure Spectral Emission Mask

In this example SEM measurement which includes carrier measurement, lower and upper offset segment measurements are calculated.

The user configuration can be divide into three parts

- i. Hardware settings
- ii. Trigger Settings
- iii. Measurement Configuration

![](_page_63_Figure_9.jpeg)

![](_page_64_Picture_0.jpeg)

Refer 4.2.2.1 for Hardware Settings and Trigger Settings. Measurement Configuration can be configured as follows.

**Integration Bandwidth**- specifies the frequency range, in Hz, over which the measurement integrates the carrier channel power

**RBW Filter Type**- specifies the response of the digital RBW filter.

**RBW** (**Hz**)- specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

**Reference Type-** Configures whether the power reference is the integrated power or the peak power in the closest carrier channel. Needs to be configured only foe SEM measurement.

**Power Units**(**Spec Mask**) - Configures the units for the absolute power. Needs to be configured only foe SEM measurement.

Limit Fail Mask- Specifies the criteria to determine the measurement fail status.

**Averaging Enabled**- specifies whether to enable averaging for the measurement. The default value is False.

**Number of Averages**- specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

Averaging Type- specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement

#### Offset Segment Configuration

**Offset Frequency Enabled**- specifies whether to enable the offset segment for the SEM measurement. The default value is True.

**Offset Frequency Start**- specifies the array of start frequencies, in Hz, of each offset segment relative to the closest configured carrier channel bandwidth center or carrier channel bandwidth edge based on the value of the SEM Offset Freq Definition property.

**Offset Frequency Stop**- specifies the array of stop frequencies, in Hz, of each offset segment relative to the closest configured carrier channel bandwidth center or carrier channel bandwidth edge based on the value of the SEM Offset Freq Definition property.

**Offset Frequency Side band**- specifies whether the offset segment is present on one side, or on both sides of the carriers. The default value is Both.

**RBW** Auto **RBW** Filter Type- specifies whether the measurement computes the RBW.

![](_page_65_Picture_0.jpeg)

**RBW** (**Hz**)- specifies the array of bandwidths, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired offset segment, when you set the RBW Auto parameter to False.

Absolute Limit Mode- specifies whether the absolute limit mask is a flat line or a line with a slope

**Absolute Limit Start**- specifies the array of absolute power limits, in dBm, corresponding to the beginning of the offset segment. The value of this parameter is also set as the stop limit for the offset segment when you set the Absolute Limit Mode parameter to Couple.

**Absolute Limit Stop**- specifies the array of absolute power limits, in dBm, corresponding to the end of the offset segment. This parameter is ignored when you set the Absolute Limit Mode parameter to Couple

**Relative Limit Mode**- specifies whether the relative limit mask is a flat line or a line with a slope.

**Relative Limit Start**- specifies the array of relative power limits, in dB, corresponding to the beginning of the offset segment. The value of this parameter is also set as the stop limit for the offset segment when you set the Relative Limit Mode parameter to Couple.

**Relative Limit Stop**- specifies the array of relative power limits, in dB, corresponding to the end of the offset segment. This parameter is ignored if you set the Relative Limit Mode parameter to Couple.

The measurement results include Carrier Measurements, Lower and Upper Offset Segment Measurements. The available graph is Power Vs frequency.

#### 4.2.2.3 MaxEye ZigBee BPSK RFSA Measure Transmit Power

Transmit Power is a zero span measurement of transmitted power using the time-domain signal as seen through a resolution bandwidth (RBW) filter for the specified measurement interval.

This example is used to find out Average Mean Power, Peak to Average Ratio and Peak Power of the transmitted signal. The user configurations are divided into three.

- i. Hardware Settings
- ii. Trigger Settings
- iii. Measurement Configuration

![](_page_66_Picture_0.jpeg)

Hardware Configuration	on	Measurement Configuration			Measurement Results			
Resource Name		Measurement Interval (s)		)	Power vs Time			
K RFSA	-	1.00m			-10			
Channel Number Channel 0 - 868.3MH	z 💌	RBW Fi	lter		-20			
Auto Level		RBW Filter Type	Flat	-	÷ -40-			
False		RBW (Hz)	1.200M		φ -50-			
Maximum Input Pow 0.00	er (dBm)	RRC Alpha	0.010		-60- 			
External Attenuation	(dB)				-80-			
0.00		Averac	ling		-90-			
Reference Source		Averag	ing		-100			
PXI_Clk		Averaging Enabled	True		0 500 1000 1500 2000 2500 3000			
Trigger Settings		Number of Averages	10		lime (seconds)>			
Trigger Enabled		Averaging Type	RMS	•				
True	•				<u> </u>			
Trigger Delay (sec)					Measurements			
-10.0u								
Trigger Level					Average Mean Power (dBm) 0.00			
-30.00	1000				Peak to Average Ratio (dB) 0.00			
Minum Quiet Time (s 0.00E+0	sec)				Peak Power (dBm) 0.00			

- 1. Refer 4.2.2.1 for Hardware Settings and Trigger Settings.
- 2. Measurement Configuration can be configured as follows.

**Measurement Interval** - Specifies the acquisition time, in seconds, for the transmit power (TXP) measurement. Needs to be configured only for Transmit Power Measurements

**RBW Filter Type**- specifies the response of the digital RBW filter.

**RBW**- specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

**RRC** Alpha- specifies the roll-off factor for the root-raised-cosine (RRC) filter.

**Averaging Enabled**- specifies whether to enable averaging for the measurement. The default value is False.

**Number of Averages**- specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

**Averaging Type**- specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

3. The measurement Results consists of Average Mean Power, Peak to Average Ratio, Peak Power. The available graph is Power Vs Time.

![](_page_67_Picture_0.jpeg)

#### 4.2.2.4 MaxEye ZigBee BPSK RFSA Measure CW Frequency Offset

This example is used to find out absolute frequency and frequency offset of transmitted continuous wave signal. The user configurations are divided into two.

- i. Hardware Settings
- ii. Measurement Configuration

![](_page_67_Picture_5.jpeg)

- 1. Refer 4.2.2.1 for Hardware Settings.
- 2. Measurement Configuration can be configured as follows.

**RBW Filter Type**- specifies the response of the digital RBW filter.

**RBW** Auto- specifies whether the measurement computes the resolution bandwidth (RBW) of the carrier.

**RBW** (**Hz**)- specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, when you set the RBW Auto parameter to False.

Sweep Time Auto- specifies whether the measurement computes the sweep time.

**Sweep Time Interval**- specifies the sweep time, in seconds, when you set the Sweep Time Auto parameter to False. The default value is 1 ms.

**Averaging Enabled**- specifies whether to enable averaging for the measurement. The default value is False.

![](_page_68_Picture_0.jpeg)

**Averaging Count**- specifies the number of acquisitions used for averaging when you set the Averaging Enabled parameter to True.

**Averaging Type**- specifies the averaging type for averaging multiple spectrum acquisitions. The averaged spectrum is used for the measurement.

**FFT window**- specifies the FFT window type to use to reduce spectral leakage.

**FFT Padding**- specifies the factor by which the time-domain waveform is zero-padded before an FFT. The FFT size is given by the following formula: FFT size = waveform size \* padding. This parameter is used only when the acquisition span is less than the device instantaneous bandwidth.

3. The measurement Results consists of Average Absolute frequency and frequency offset. The available graphs are Frequency Error Vs Time and Power Vs Frequency.