MaxEye Wi-SUN (IEEE 802.15.4g) Measurement Suite

Version 1.1.0

Getting Started Guide

Table of Contents

List Of Abbreviations

Wi-SUN: Wireless Smart Utility Network

RFSG: Radio Frequency Signal Generator

SFP: Soft Front Panel

VSG: Vector Signal Generator

VST: Vector Signal Transceiver

1. Introduction

MaxEye Technologies provides generation and analysis functions in LabVIEW and C# .NET for generating and analyzing the IEEE 802.15.4g 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 mode.

i. MR OFDM Physical Layer (2.4GHz)

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

Parameter	OFDM Option 1	OFDM Option 2	OFDM Option 3	OFDM Option 4
Nominal bandwidth (kHz)	1094	552	281	156
Channel spacing (kHz)	1200	800	400	200
DFT size	128	64	32	16
Active tones	104	52	26	14
# Pilot tones	8	4	2	2
# Data tones	96	48	24	12
MCS0 (kb/s) (BPSK rate 1/2 with 4x frequency repetition)	100	50	—	—
MCS1 (kb/s) (BPSK rate 1/2 with 2x frequency repetition)	200	100	50	—
MCS2 (kb/s) (QPSK rate 1/2 and 2x frequency repetition)	400	200	100	50
MCS3 (kb/s) (QPSK rate 1/2)	800	400	200	100
MCS4 (kb/s) (QPSK rate 3/4)	—	600	300	150
MCS5 (kb/s) (16-QAM rate 1/2)	—	800	400	200
MCS6 (kb/s) (16-QAM rate 3/4)	—	—	600	300

This guide explains how to use the Wi-SUN Measurement Suite toolkit using the programming examples.

2. Installed File Location

2.1 Soft Front Panel

The Wi-SUN Generation soft front panel is located in, C:\Program Files (x86)\MaxEye\Wi-SUN\Application\Generation\MaxEye Wi-SUN Signal Generation.exe
(***Note***: - *For 32-bit Operating System*, SFP is located in C:\Program Files\MaxEye\Wi-SUN\Application\Generation\MaxEye Wi-SUN Signal Generation.exe)

The Z-Wave Analysis soft front panel is located in C:\Program Files (x86)\MaxEye\Wi-SUN\Application\Analysis\MaxEye Wi-SUN Signal Analysis.exe
(***Note***: - *For 32-bit Operating System*, SFP is located in C:\Program Files\MaxEye\Wi-SUN\Application\Analysis\MaxEye Wi-SUN Signal Analysis.exe) You can also find a shortcut to the above location from the windows start menu.
Start->All Programs->MaxEye-> Z-Wave
Note: - *For Windows 10*, **Start ->MaxEye**

2.2 LabVIEW Programming Examples

2.1.1 Wi-SUN MR OFDM Signal Generation and Analysis

1. The Wi-SUN MR OFDM signal generation example VIs are installed in, <LabVIEW>\examples\MaxEye\Wi-SUN\Generation\MR OFDM PHY

2. The Wi-SUN MR OFDM signal analysis example VIs are installed in, <LabVIEW>\examples\MaxEye\Wi-SUN\Analysis\MR OFDM PHY.

3. The toolkit API VIs for Wi-SUN MR OFDM signal generation are installed in, <LabVIEW>\vi.lib\addons\MaxEye\Wi-SUN\Generation\MR OFDM PHY\API.

4. The toolkit API VIs for Wi-SUN MR OFDM signal analysis are installed in, <LabVIEW>\vi.lib\addons\MaxEye\Wi-SUN\Analysis\MR OFDM PHY\API.

You can also find a shortcut to the above location from the windows start menu.
Start->All Programs->MaxEye->Wi-SUN
Note: - *For Windows 10*, **Start ->MaxEye**

2.3 DotNet Programming Examples

1. The Wi-SUN MR OFDM signal generation example are installed in, C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Generation\CS
   (Note: - *For 32-bit Operating System*, Generation Examples are located in C:\Program Files\MaxEye\Wi-SUN\Examples\Generation\CS)
2. The Wi-SUN MR OFDM signal analysis example VIs are installed in, C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Analysis\CS
   (Note: - *For 32-bit Operating System*, Analysis Examples are located in C:\Program Files\MaxEye\Wi-SUN\Examples\Analysis\CS)

You can also find a shortcut to the above location from the windows start menu.
Start->All Programs->MaxEye->Wi-SUN
Note: - *For Windows 10*, **Start ->MaxEye**

2.4 Documentation

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

The toolkit documentation files are installed in, C:\Program Files (x86)\MaxEye\Wi-SUN\Documentation.

***(Note**: - For 32-bit Operating System*, Documentation are located in C:\Program Files\MaxEye\Wi-SUN\Documentation)

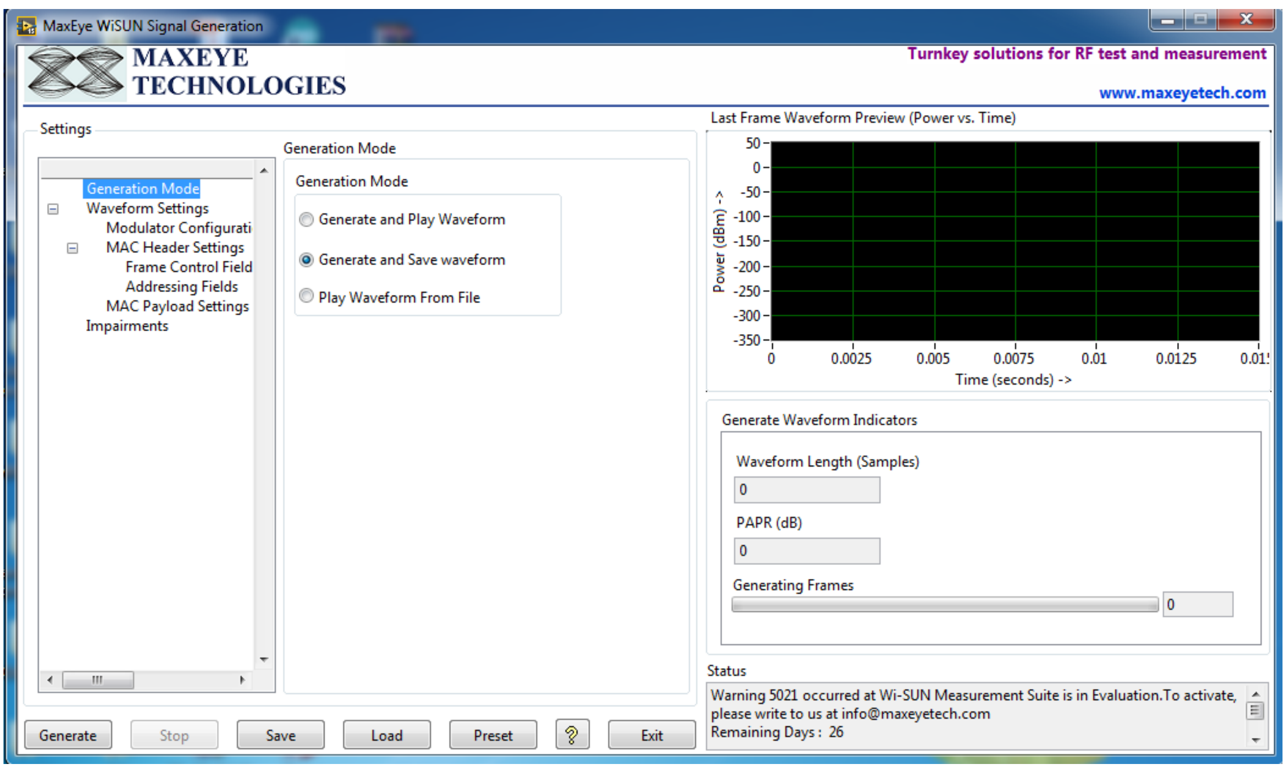
You can also find a shortcut to the above location from the windows start menu.
Start->All Programs->MaxEye->Wi-SUN
***<u>Note</u>**: - For Windows 10,* **Start ->MaxEy**

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. Wi-SUN Generation SFP can be used to generate Wi-SUN signals of all supported frame types. Use Wi-SUN Analysis SFP to perform modulated or continuous waveform or spectral measurements.

3.1 MaxEye Wi-SUN Signal Generation SFP

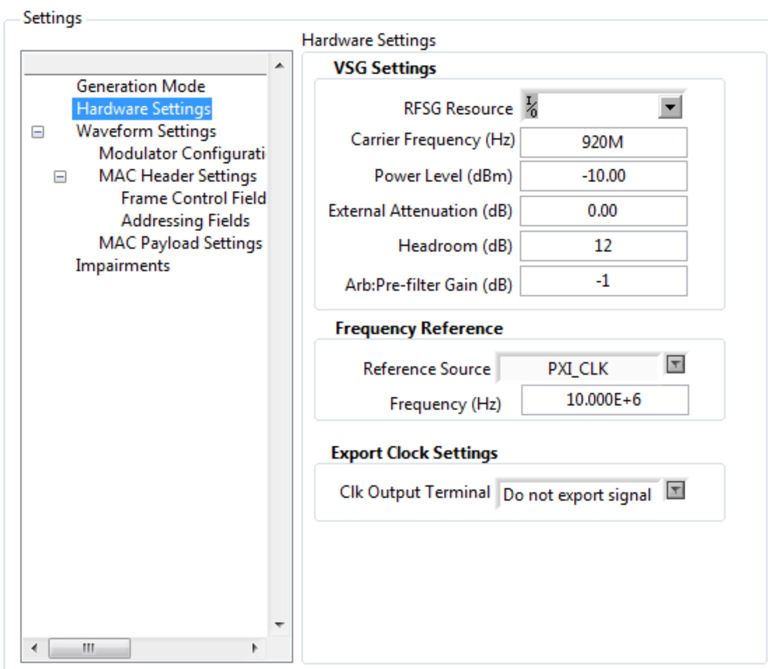
The figure below shows the Wi-SUN Signal Generation SFP.



3.1.1 Generate and Save Waveform/ Generate and Play Waveform

Follow the procedure below to generate signals using SFP.

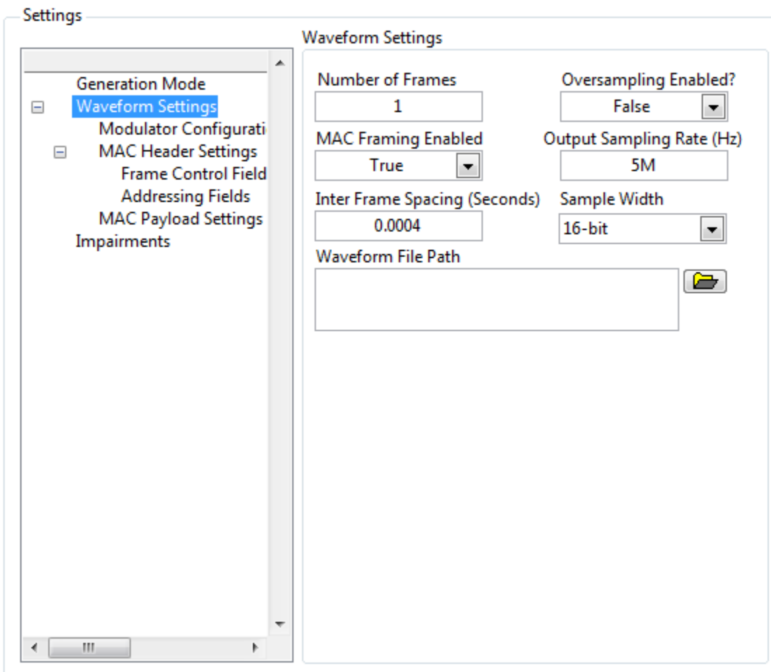
1. Select Generation mode as Generate and Play Waveform or Generate and Save Waveform. Generate and Play waveform is used to generate Wi-SUN RF signal using hardware. Generate and Save waveform is used to generate waveform and store in a file. For this configuration hardware is not required. The IQ baseband waveform is stored in a file. Play Waveform From File mode reads the Wi-SUN 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.



- **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 Wi-SUN signal in Hz. .
- **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 Wi-SUN 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).

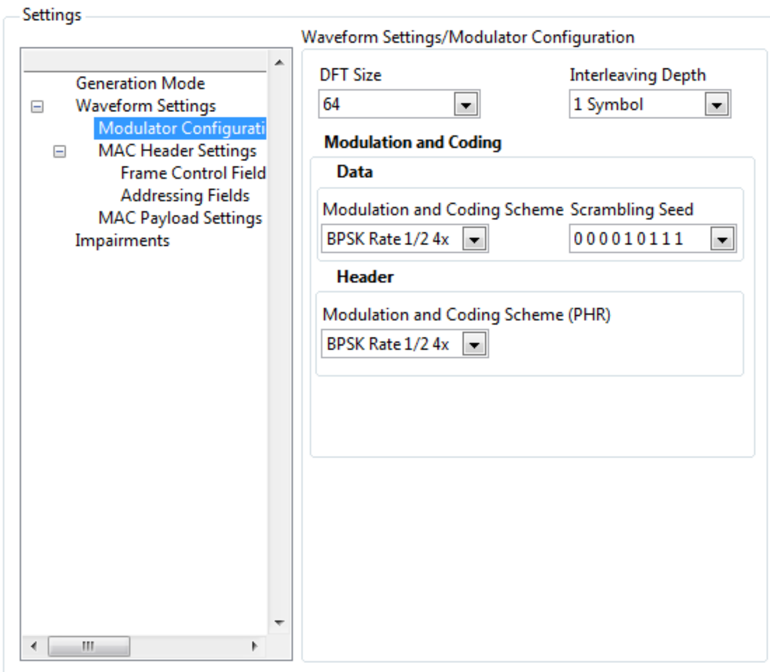
- **Clk Output Terminal-** specifies the terminal where the signal will be exported.

3. Select the waveform Settings.



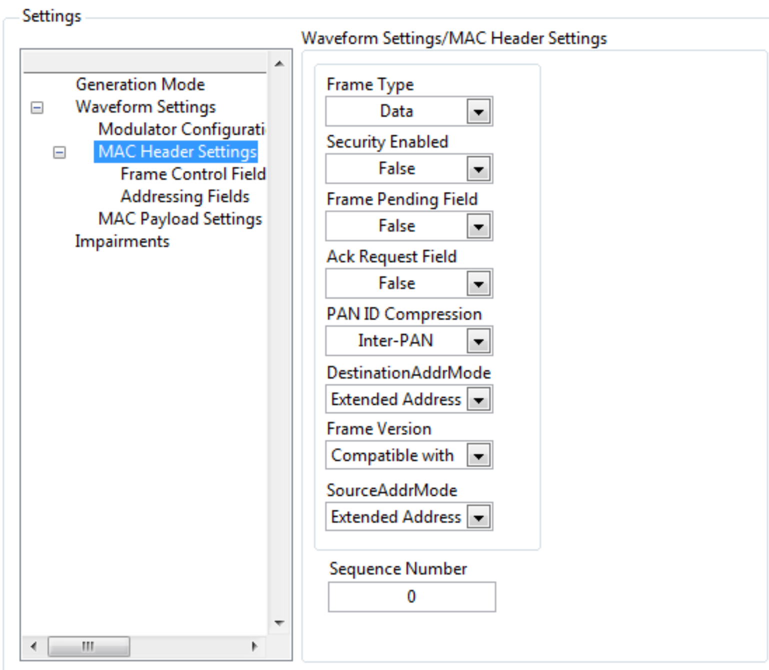
- **Number of Frames-** Decides the length of waveform to be generated. To generate longer duration of the waveform, increase the Number of Frames value.
- **MAC Framing Enabled-** To generate MAC frame set this to true, the toolkit adds MAC layer headers and then creates payload for the physical layer. If this is set to false then the toolkit generates waveform without MAC frame parameters.
- **Inter frame Spacing (Seconds)-** Specifies the gap duration in seconds between the frames.
- **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).
- **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.
- **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 Modulator Configuration



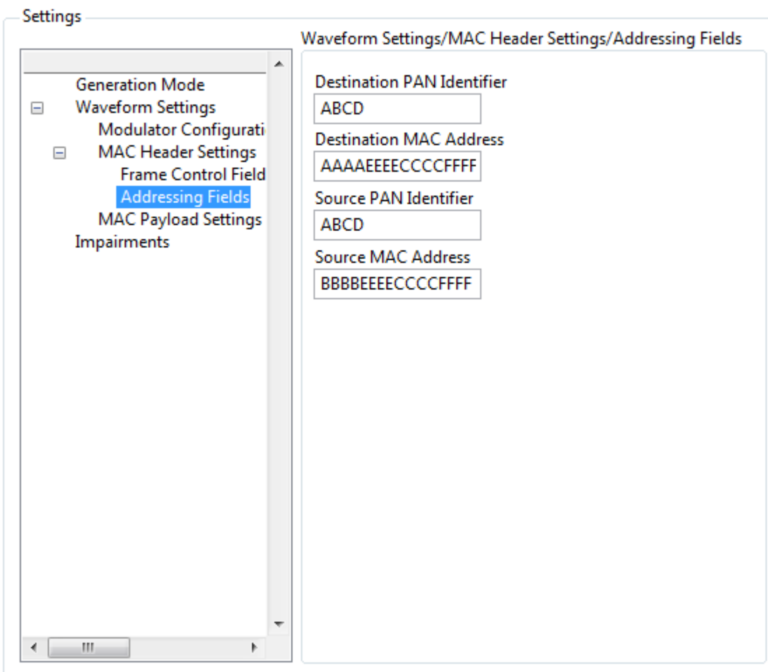
- **DFT Size –** Select the required DFT Size. The possible DFT sizes are 128, 64, 32, 16.
- **Interleaving Depth -** A value of one indicates an interleaving depth of one symbol. A value of SF Symbols indicates an interleaving depth of the number of symbols equal to the frequency domain spreading factor (SF).
- Modulation and Coding can be configured as follows
- **Modulation and Coding Scheme(Data)-** This VI configures the Modulation and Coding Scheme for Data Symbols.The possible Modulation and Coding Schemes are
- BPSK 1/2 Rate 4x (4x frequency spreading)
- BPSK 1/2 Rate 2x (2x frequency spreading)
- QPSK 1/2 Rate 2x (2x frequency spreading)
- QPSK 1/2 Rate (No frequency spreading)
- QPSK 3/4 Rate (No frequency spreading)
- 16 QAM 1/2 Rate (No frequency spreading)
- 16 QAM 3/4 Rate (No frequency spreading)
- **Scrambling Seed -** The scrambler uses PN sequence and the PN9 scrambleris initialized by one of the four seeds.
- **Modulation and Coding Scheme(Header)-** Configures the Modulation and Coding Scheme for PHY Header. Please check the modulation and coding scheme(Header) description for the possible values.

5. Select the MAC Header settings.



- **Frame Type-** Select the frame type as Data.
- **Security Enabled-** Select True if the frame is protected by the MAC sublayer otherwise select False.
- **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.

6. 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.

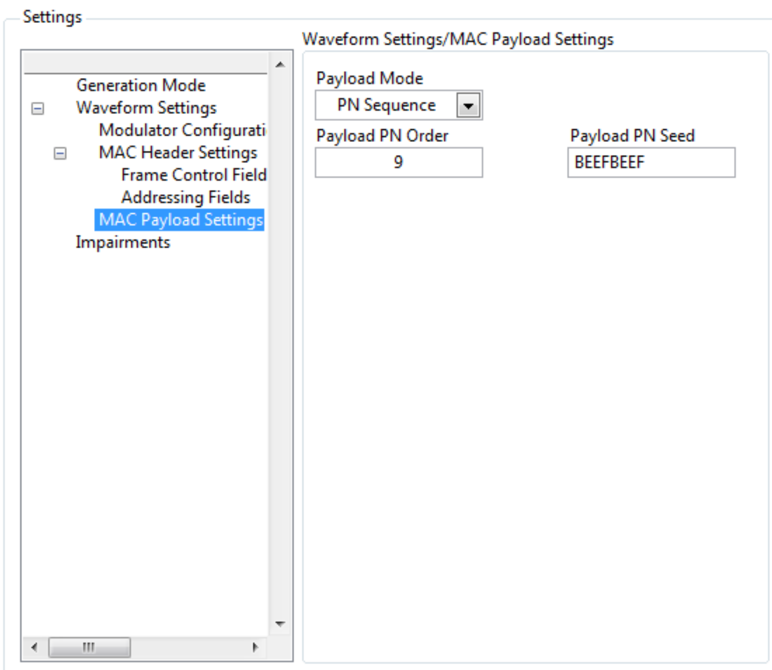


- **Destination PAN Identifier-** specifies the unique PAN identifier of the intended recipient of the frame. This field shall be included in the MAC frame only if the Destination Addressing Mode field is nonzero.
- **Destination MAC Address-** specifies the address of the intended recipient of the frame.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

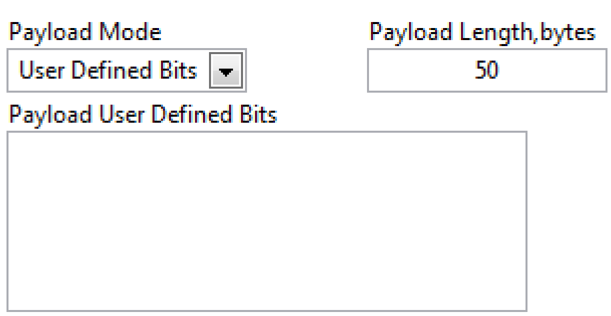
7. Select the MAC Payload Settings. This fields are needed to configure only when the frame type is beacon or data. MaxEye Wi-SUN Measurement Suite SFP allows you to configure various payload settings. The possible payload options are
   - **PN Sequence-** In this mode configure Sync Insertion Enabled, Payload PN order and PN Seed properties and the toolkit ignores other properties in the Wi-SUN 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.
   - **User defined bits-** In this mode configure Sync Insertion Enabled and Payload User Defined Bits property and the toolkit ignores other properties in the Wi-SUN Payload Control.
   - **Test Pattern-** In this mode configure Sync Insertion Enabled and Payload Test Pattern property and the toolkit ignores other properties in the Wi-SUN 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.

- **Test File-** In this mode configure the Sync Insertion Enabled and Payload File Path property and the toolkit ignores other properties in the Wi-SUN Payload Control. This mode is used for generating signal with the data from the file.

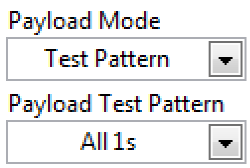
The payload settings can be configured as follows.



- **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



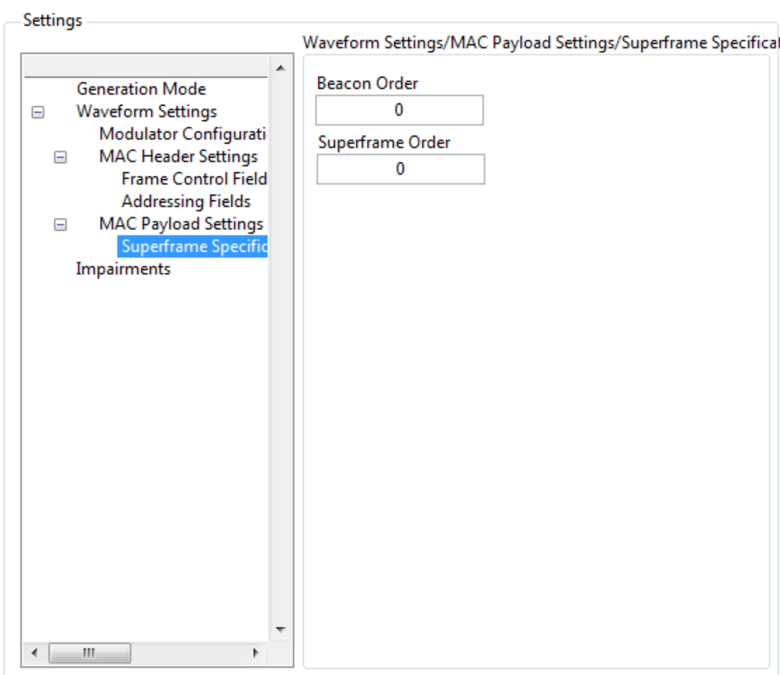
- **Payload User Defined Bits-** Configure this field when Payload mode is User Defined bits.



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

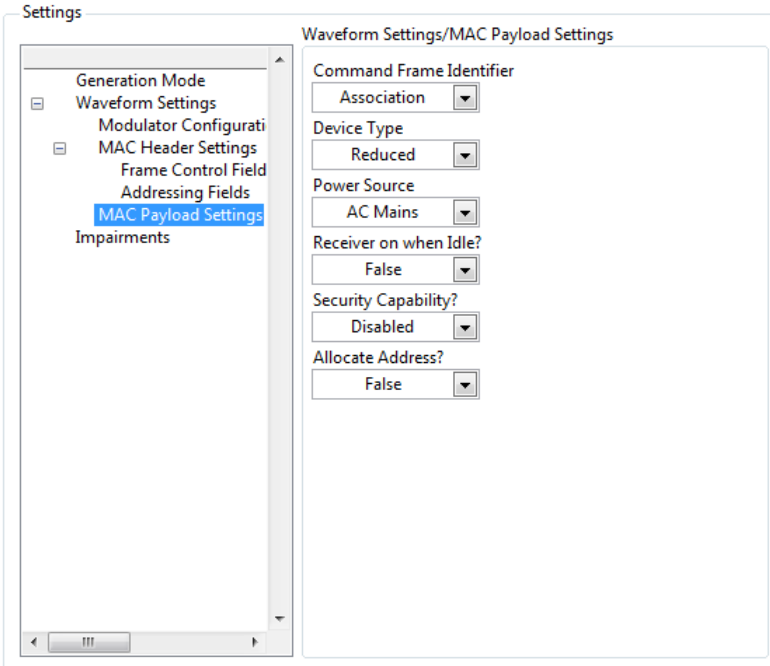
- **Payload File Path-** Choose the file path when the payload mode is From File.

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



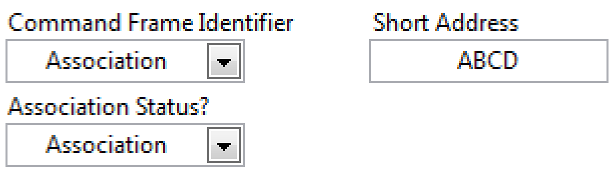
- **Beacon Order-** Specify the transmission interval of the beacon.
- **Superframe Order-** Specify the length of time during which the superframe is active (i.e., receiver enabled), including the beacon frame transmission time.

9. For MAC Command Frame type Select the MAC Payload settings.



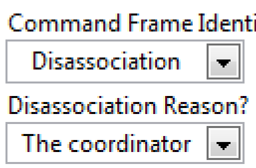
- **Command Frame Identifier-** identifies the MAC command being used. According to this field, Configure the remaining controls as follows

  - 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.
  - **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.



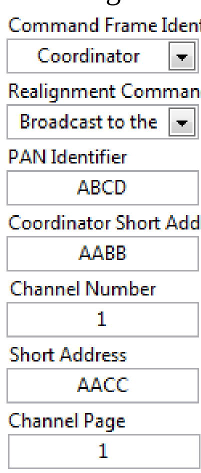
- **Short Address-** If the coordinator was able to associate the device to its PAN, this field shall contain the short address that the device may use in its communications on the PAN until it is disassociated.
- **Association status?-** Select the Valid values of the Association Status field.

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



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

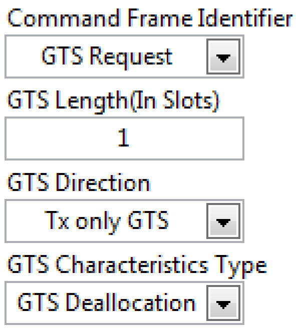
- If Command frame Identifier is **Coordinator Realignment**, then user has to configure the following.



- **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 **.**

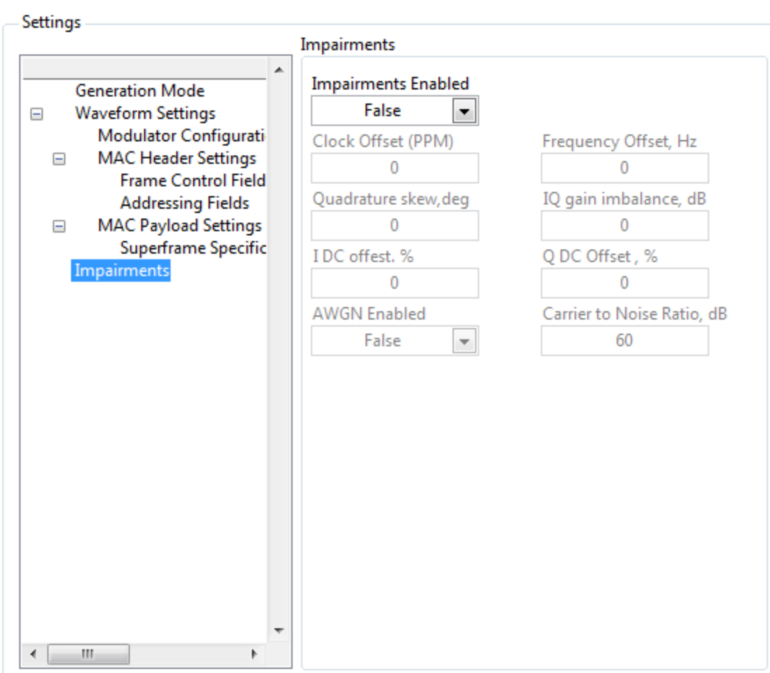
- **Channel page-** shall contain the channel page that the coordinator intends to use for all future communications. This field may be omitted if the new channel page is the same as the previous channel page. Valid values from 0 to 255 **.**

- 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.



  - **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 Characterstics type as GTS allocation or GTS deallocation.

10. 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 in-phase (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 60dB.

3.1.2 Play Waveform From File

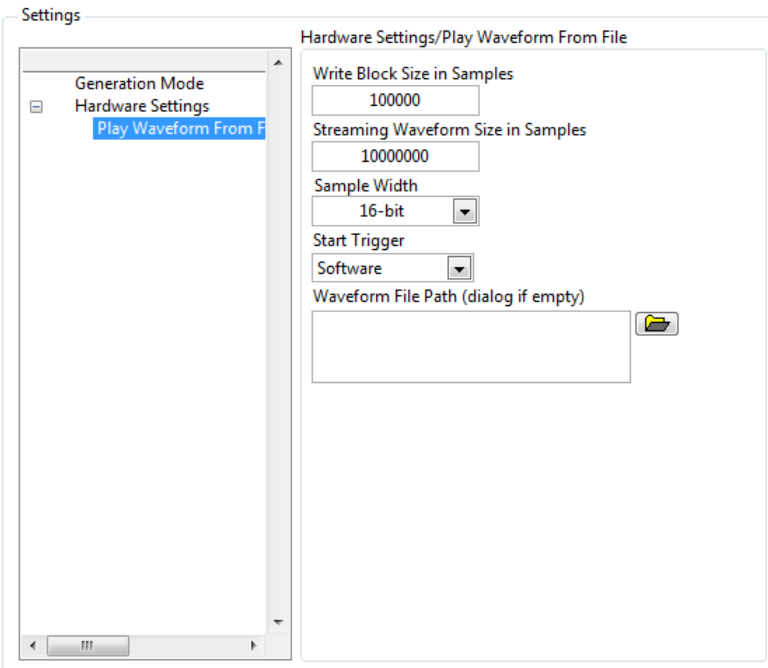
Play Waveform From File mode reads the Wi-SUN waveform from the file created using the Generate and Save Waveform and then downloads the waveform to NI RFSG Memory and then plays the waveform.

Follow the procedure below to generate waveform using this generation mode

1. Select **Waveform Format** -> **Generation Mode** -> **Play Waveform from File**
2. Select **Hardware Settings** to configure the following parameters.

Refer section 3.1.1 of this document to configure the desired hardware.

3. Select **Play Waveform from File** to configure the following parameters



- **Write Blocks Size (Samples) –** The waveform is written in the hardware as blocks. This parameter configures the size of the block in samples.
- **Streaming Waveform Size in Samples** – Specifies the total memory allocated in the hardware for streaming the waveform in samples.
- **Sample Width –** Use the same sample width value used for saving 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** – Give the absolute path of the saved waveform intended to play in this generation mode.

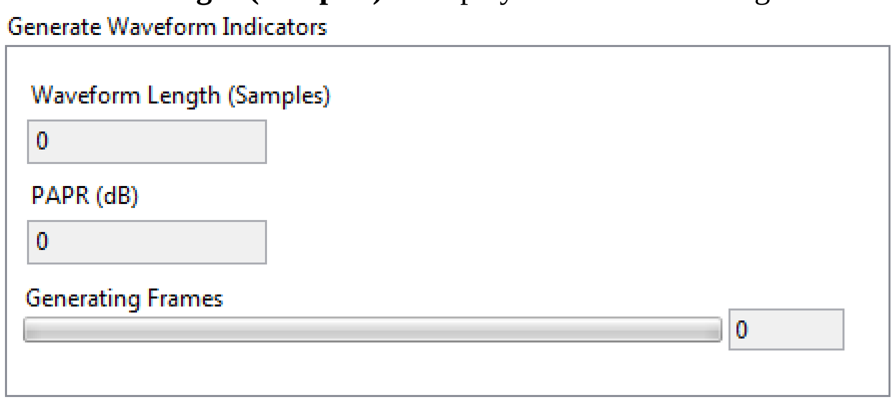
3.2 General SFP Controls and Indicators Details

- **Generate -** Click to generate signal as per the parameters configured.
  Note*:* - Parameters won't be changed at run time ones **Generate** button has been pressed.
- **Stop** – Click to stop the signal generation.
- **Save** – Saves the entire configuration in the Configuration file(.cfg).
- **Load** – Load the entire configuration back to the application which has been saved previously by Clicking **Save button.**

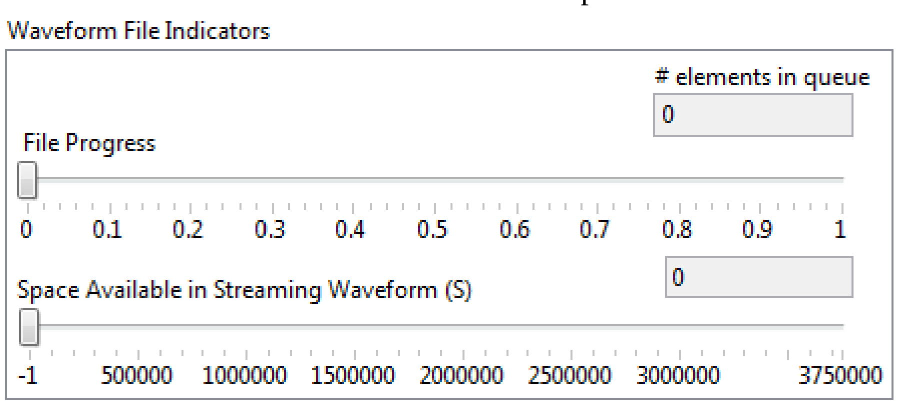
- **Preset** – Click to reinitialize all parameters to their defaults values.
-  - Context help.
- **Exit** – Click to exit the application.

Generate Waveform Indicators – Display of progress of generating frames.

- **Generating Frames –** Visualizes the progress of generating Frames.
- **PAPR –** Indicates Peak to Average Power Ratio, which is calculated by dividing the peak power by the Root Mean Square (RMS) value of the waveform. This value is used to set the Headroom (dB) value.
- **Waveform Length (Samples) –** Display the Waveform length.



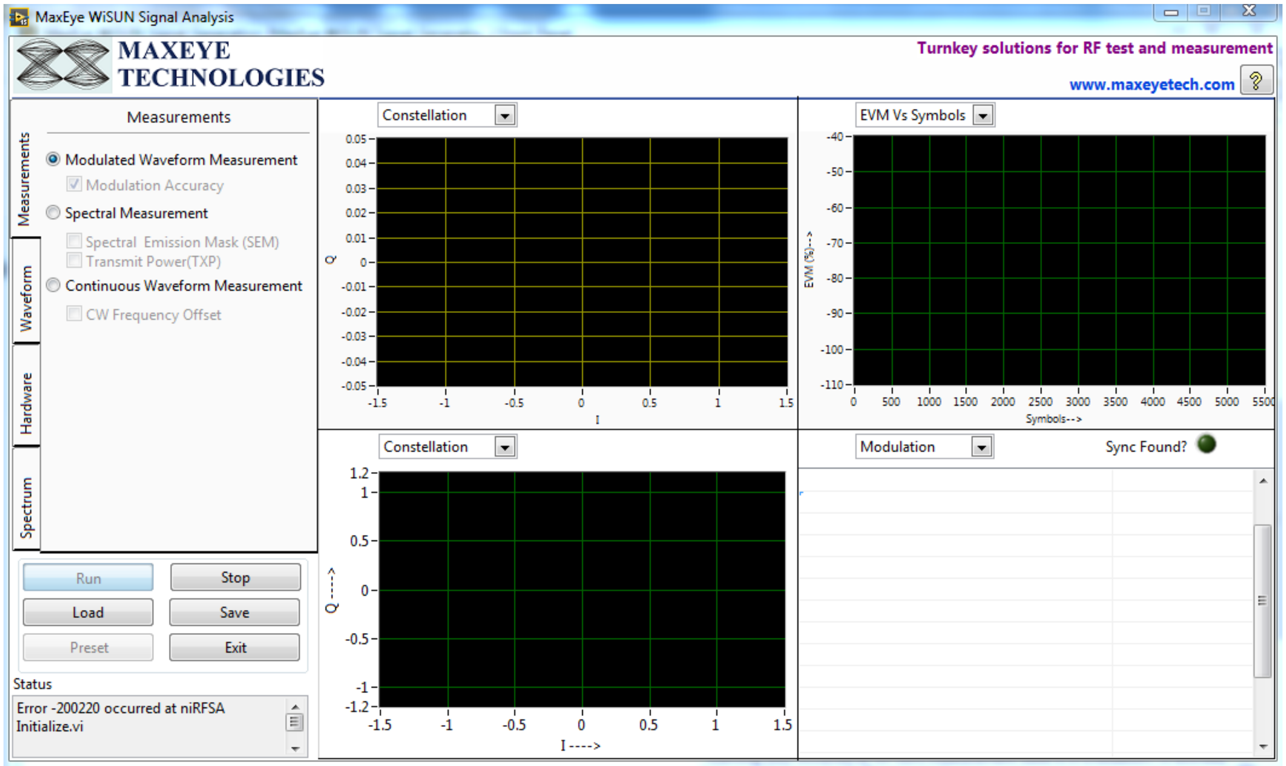
- **File Progress –** Indicates the progress of waveform generation.
- **Streaming Waveform Size in Samples -** Specifies the total number of samples used to write the waveform to NI RFSG device or output DMA Stream.



- **Status** – Displays warning or error.

3.3 MaxEye Wi-SUN Signal Analysis SFP

The figure given below is the Wi-SUN Signal Analysis SFP.



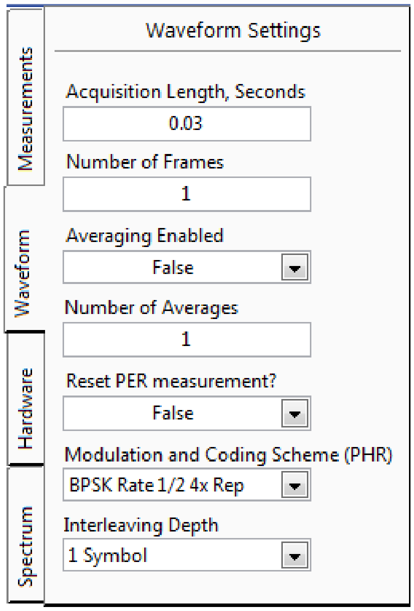
The following are the measurements available in Wi-SUN Analysis SFP.

- **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.
  - 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 time-domain 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.

3.3.1 Modulated Waveform Measurement

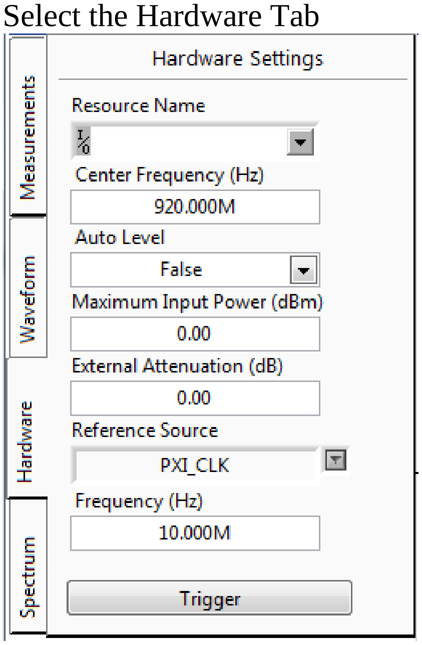
Follow the procedure for modulation accuracy measurements.

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

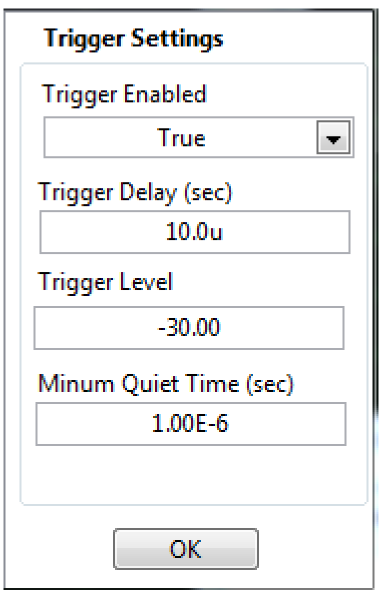


- **Acquisition Length, Seconds -** Needs to be configured for OQPSK modulation. Number of Samples to Acquire= IQ Rate* Acquisition Length
- **Number of frames -** Configure the number of frames to be acquired.
- **Averaging Enabled** - Enables averaging for digital demodulation measurement.
- **Number of Averages** - Specifies the Number of Averages. The measurement results are averaged over the number specified by Number of Averages.
- **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.
- **Modulation and Coding Scheme (PHR)** - Configure this field as same as the transmitted modulation and coding scheme for header.
- **Interleaving Depth** - Configure this field as same as transmitted Interleaving Depth.

3. Select the Hardware Tab



- **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.
- **Carrier Frequency -** Select Center Frequency of the Wi-SUN signal in 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.
- Click Trigger button. Configure the trigger settings 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.

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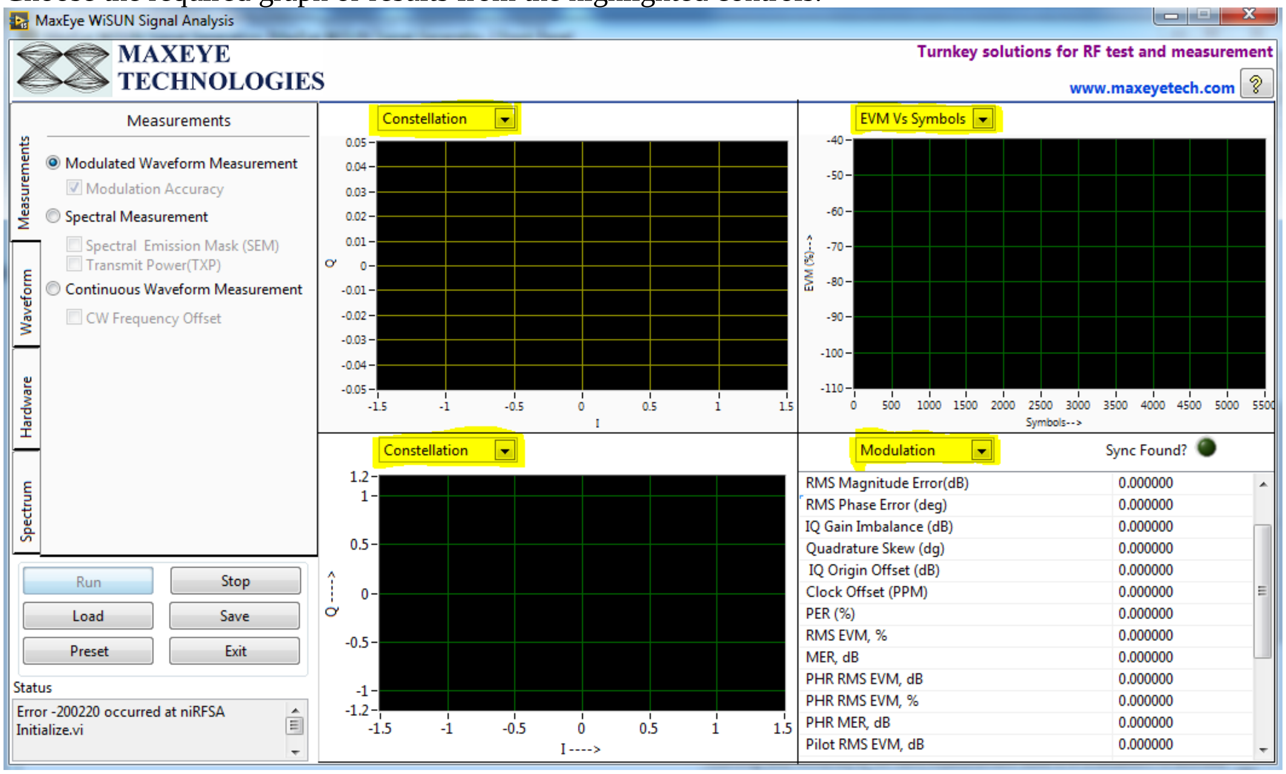
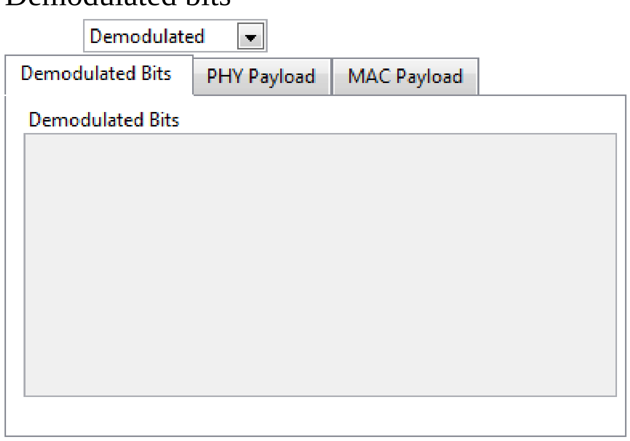
After configuring, click OK.

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



- The following are measurement traces available,
  - Constellation
  - EVM Vs Symbols
  - Power Vs Time
  - Constellation Trace (PHR)
  - EVM Vs SubCarriers

- The following are the results available,
  - Demodulated bits



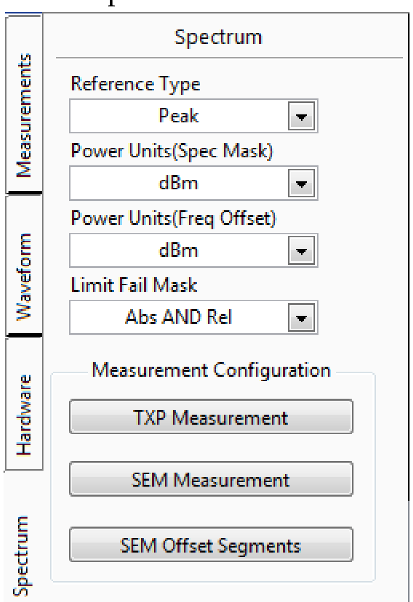
- MAC Frame - Displays the extracted MAC frame . Choose the required MAC frame by selecting the frame number.
- Modulation Accuracy Measurement Results - This include carrier measurements, EVM measurements, Magnitude Error measurements, Phase Error measurements, IQ Impairments measurements, etc.

5. 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 reinitialize all parameters to their defaults values Click Preset button. To exit the SFP click Exit button.

3.3.2 Spectral Measurement

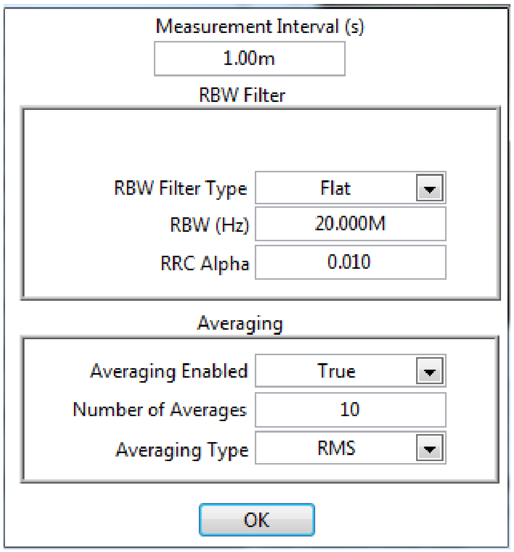
Follow the procedure for Spectral measurements.

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 3.3.1 to configure.
4. Select Spectrum Tab



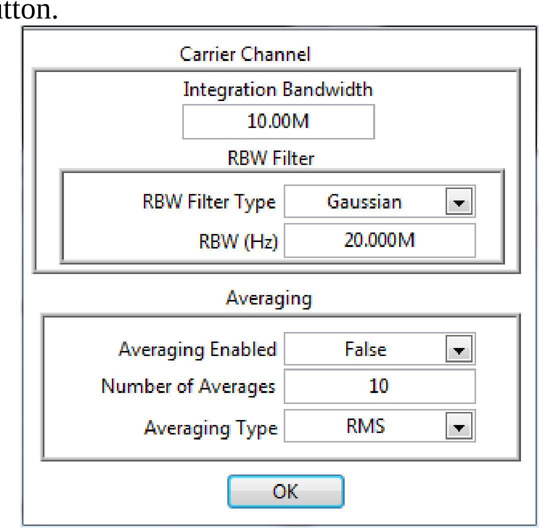
- **Reference Type-** Configures whether the power reference is the integrated power or the peak power in the closest carrier channel. Needs to be configured only foe SEM measurement.
- **Power Units(Spec Mask)-** Configures the units for the absolute power. Needs to be configured only foe SEM measurement.
- **Power Units(Freq Offset)** - Specifies the units for the absolute power for CW Frequency Offset. The default value is **dBm**.
- **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-** 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
- **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.

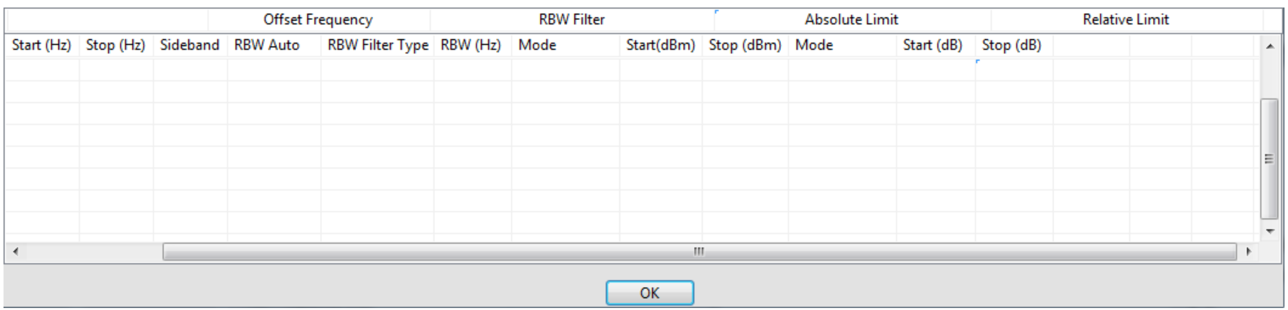
6. If the measurement Spectral Mask Emission is Selected ,Click on the SEM Measurement button.



- **Integration 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**.**
- **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.

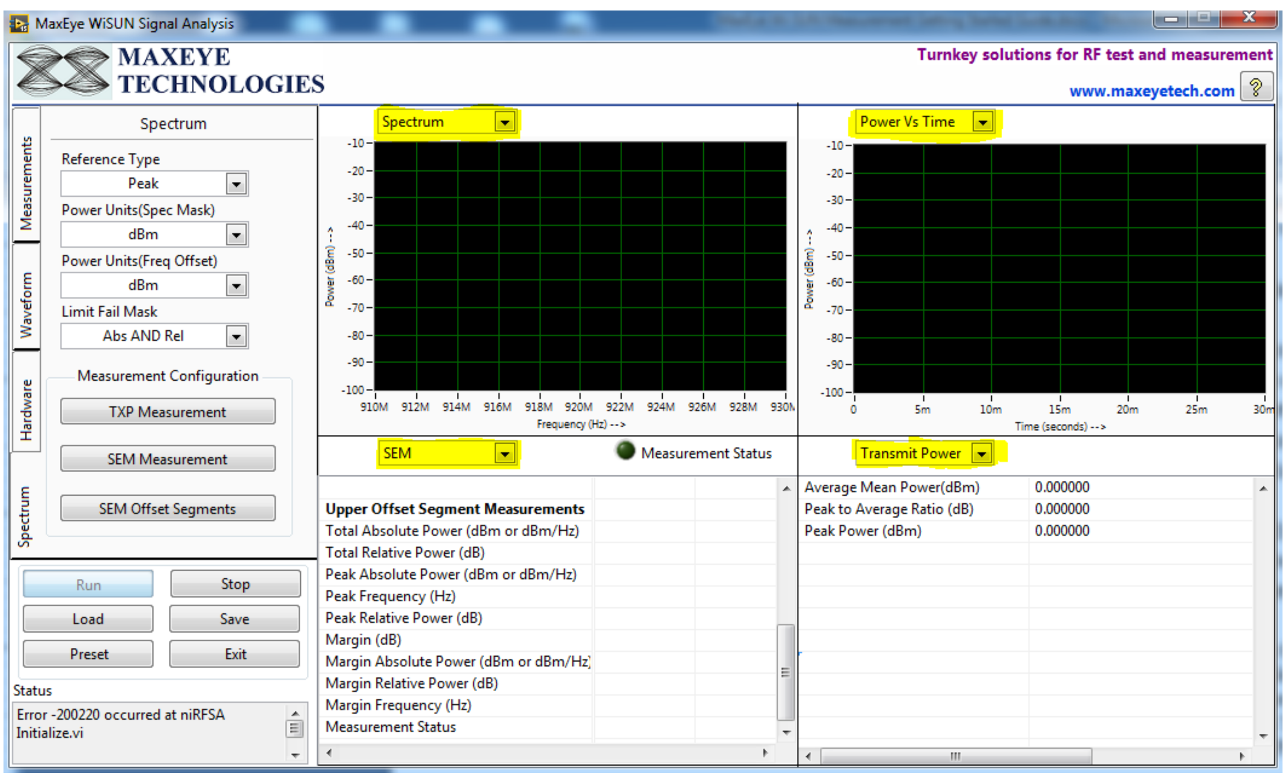
7. Click on the SEM offset Segments button and configure the SEM offset segment properties in the dialog box. Click OK button after configuring all the settings for the SEM offset segments.



- **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.

- **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.

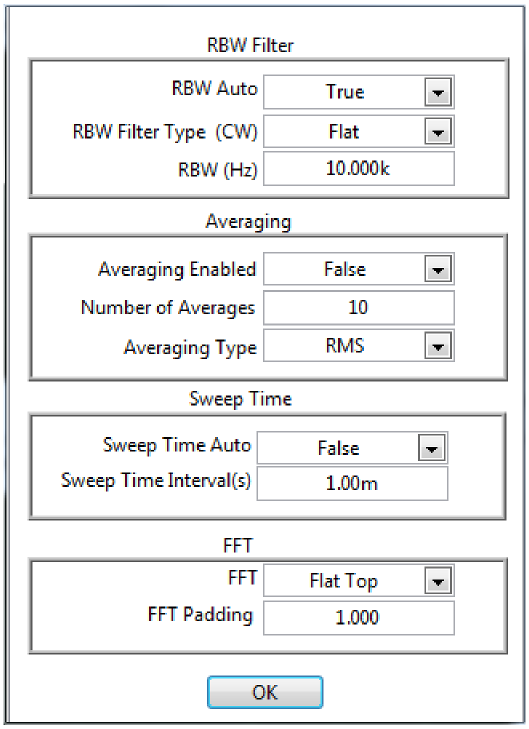
8. Choose the required graph or results from highlighted Controls shown below. In this SEM measurement the available graph is Spectrum(Power Vs Frequency) and available result is SEM measurement which includes carrier measurement , lower and upper offset segment measurements. In Transmit Power measurement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



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 reinitialize all parameters to their defaults values Click Preset button.To exit the SFP click on to the Exit button.

3.3.3 Continuous Waveform Measurement

1. Select Continuous Waveform Measurements from the Measurement Tab.
2. Select the Hardware Tab and Refer 3.3.1 to configure hardware settings.
3. Select Spectrum Tab and configure CW measurement settings by clicking CW measurement button.

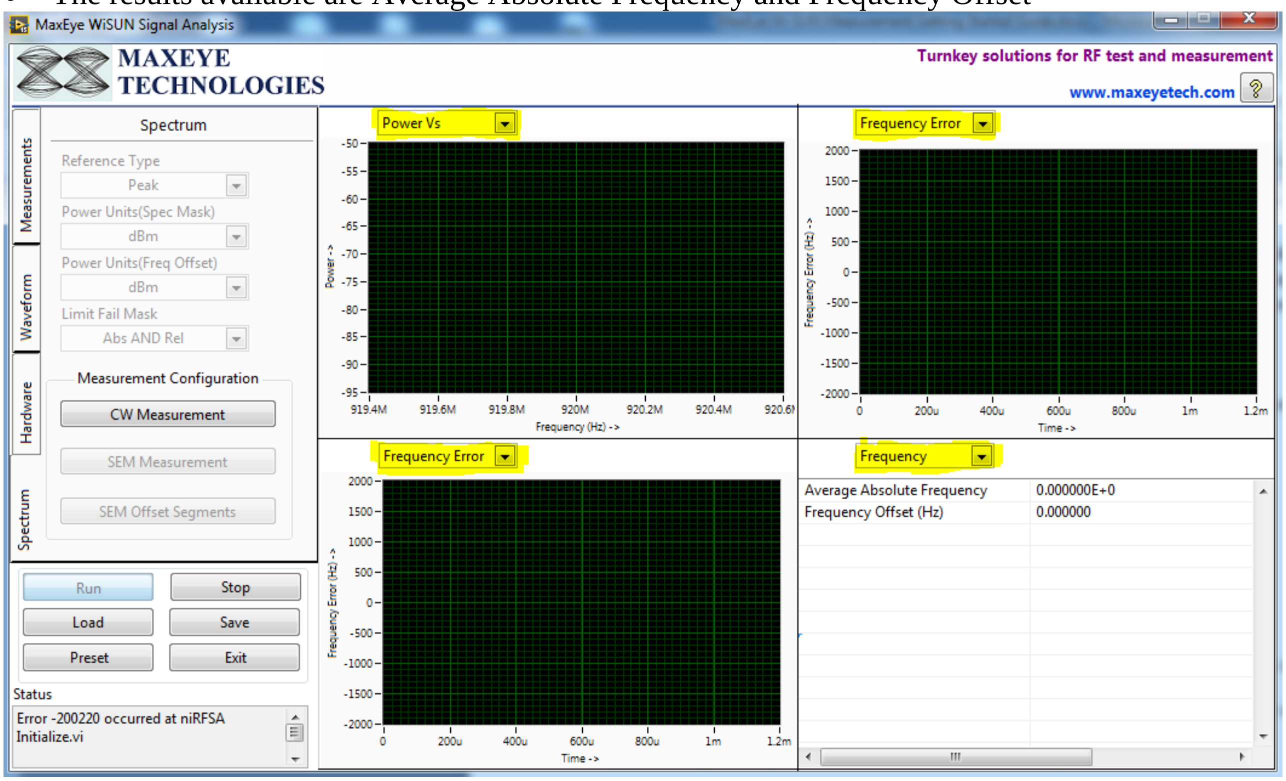


- **RBW Auto-** specifies whether the measurement computes the resolution bandwidth (RBW) of the carrier.
- **RBW Filter Type-** specifies the response of the digital RBW filter.
- **RBW-** specifies the bandwidth, in Hz, of the resolution bandwidth (RBW) filter used to sweep the acquired carrier signal, 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.
- **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



5. 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 reinitialize all parameters to their defaults values Click Preset button.To load the configuration, click load button. To exit the SFP, click Exit button.

4. LabVIEW Programming Examples

The Wi-SUN 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 Wi-SUN 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

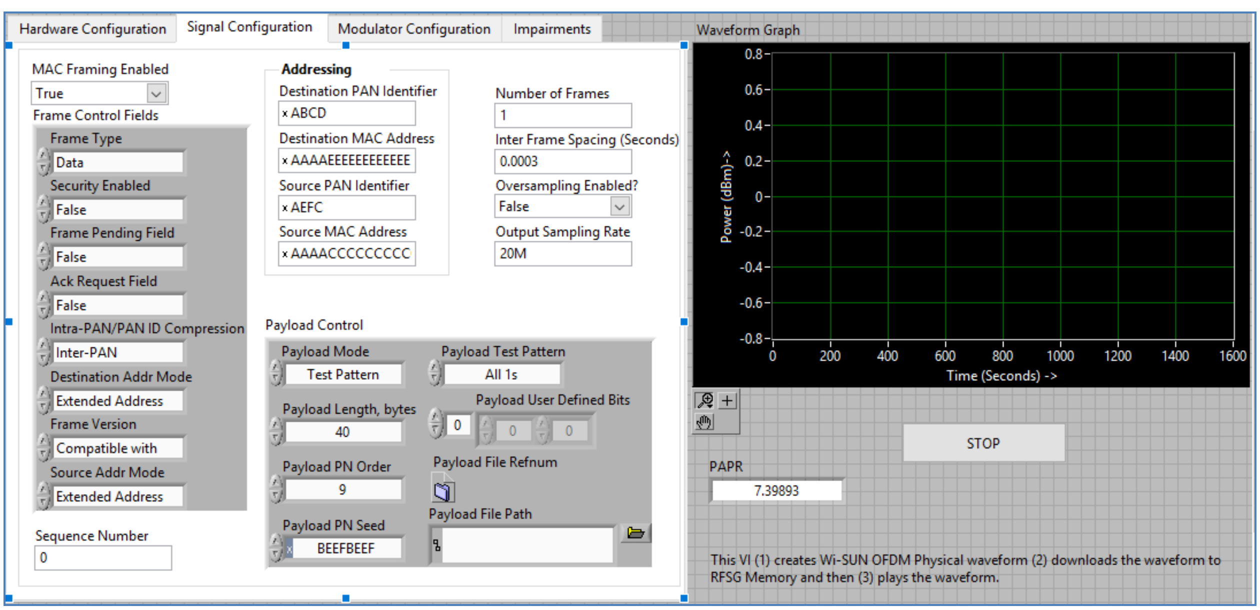
The programming examples are created using the LabVIEW API VIs. For more information about the API VI used in the example VIs refer to the MaxEye Wi-SUN Measurement Suite Help.chm document, accessible at Start->All Programs->MaxEye->Wi-SUN->Documentation.

3.1 Wi-SUN MR OFDM Signal Generation

Wi-SUN is an IEEE 802.15.4g-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 Wi-SUN 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. Examples are provided for MR OFDM scheme only.

3.1.1 MaxEye Wi-SUN OFDM Signal Generation (Data Frame)

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

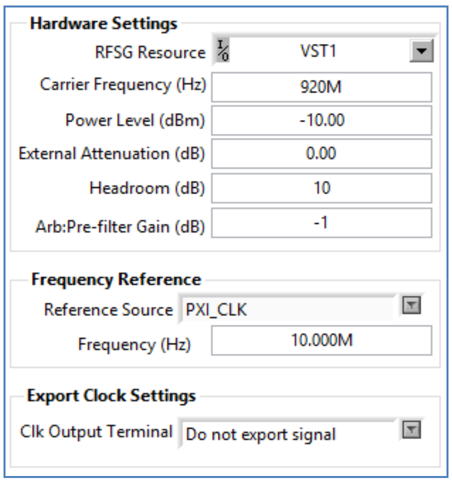


The user configurations are divided into three categories

i. Hardware Settings
ii. Signal Configuration
iii. Modulator Configuration
iv. Impairments

Follow the below procedure to run the example.

1. Select Hardware Configuration Tab and configure the following 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 Wi-SUN signal in Hz. .

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 Wi-SUN 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.

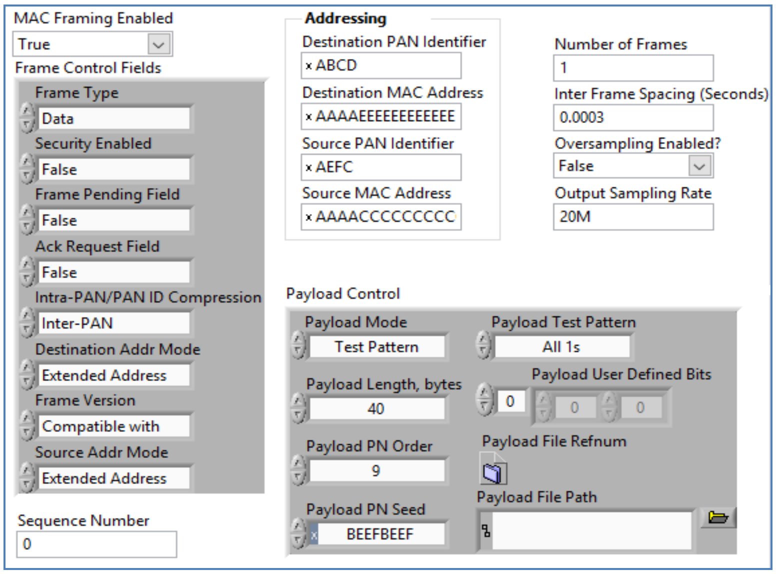
Reference Source- Specifies the source of the Reference Clock signal

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

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

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

The figure below shows the signal configuration for Wi-SUN MR OFDM Signal Generation Data frame example.



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.

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 frame control fields can be configured as follows

Frame Type- Select the frame type as Data.

Security Enabled- shall be set to True if the frame is protected bythe 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 Wi-SUN Measurement Suite Toolkit allows you to configure various payload settings. The 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 Wi-SUN 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 Wi-SUN 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 Wi-SUN 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 Wi-SUN 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.

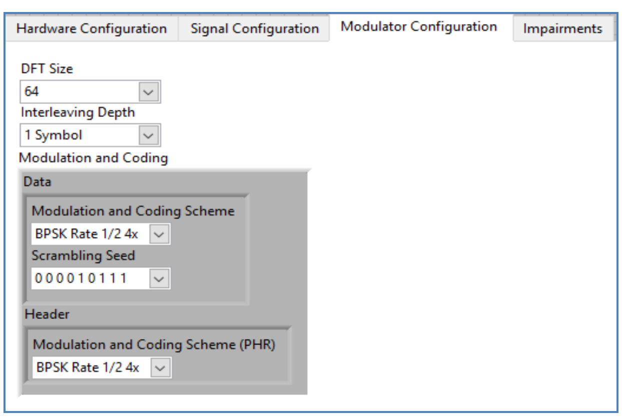
Payload PN Seed- specifies the initial state of the PN generator shift register. Configure this field when the Payload mode is PN Sequence

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.

3. Modulator Configuration can be configured as follows.



DFT Size – Select the required DFT Size. The possible DFT sizes are 128, 64, 32, 16.

Interleaving Depth - A value of one indicates an interleaving depth of one symbol. A value of SF Symbols indicates an interleaving depth of the number of symbols equal to the frequency domain spreading factor (SF).

Modulation and Coding can be configured as follows

Modulation and Coding Scheme(Data)- This VI configures the Modulation and Coding Scheme for Data Symbols.The possible Modulation and Coding Schemes are

BPSK 1/2 Rate 4x (4x frequency spreading)

BPSK 1/2 Rate 2x (2x frequency spreading)

QPSK 1/2 Rate 2x (2x frequency spreading)

QPSK 1/2 Rate (No frequency spreading)

QPSK 3/4 Rate (No frequency spreading)

16 QAM 1/2 Rate (No frequency spreading)

16 QAM 3/4 Rate (No frequency spreading)

Scrambling Seed - The scrambler uses PN sequence and the PN9 scrambleris initialized by one of the four seeds.

Modulation and Coding Scheme(Header)- Configures the Modulation and Coding Scheme for PHY Header. Please check the modulation and coding scheme(Header) description for the possible values.

4. 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.

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 in-phase (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.

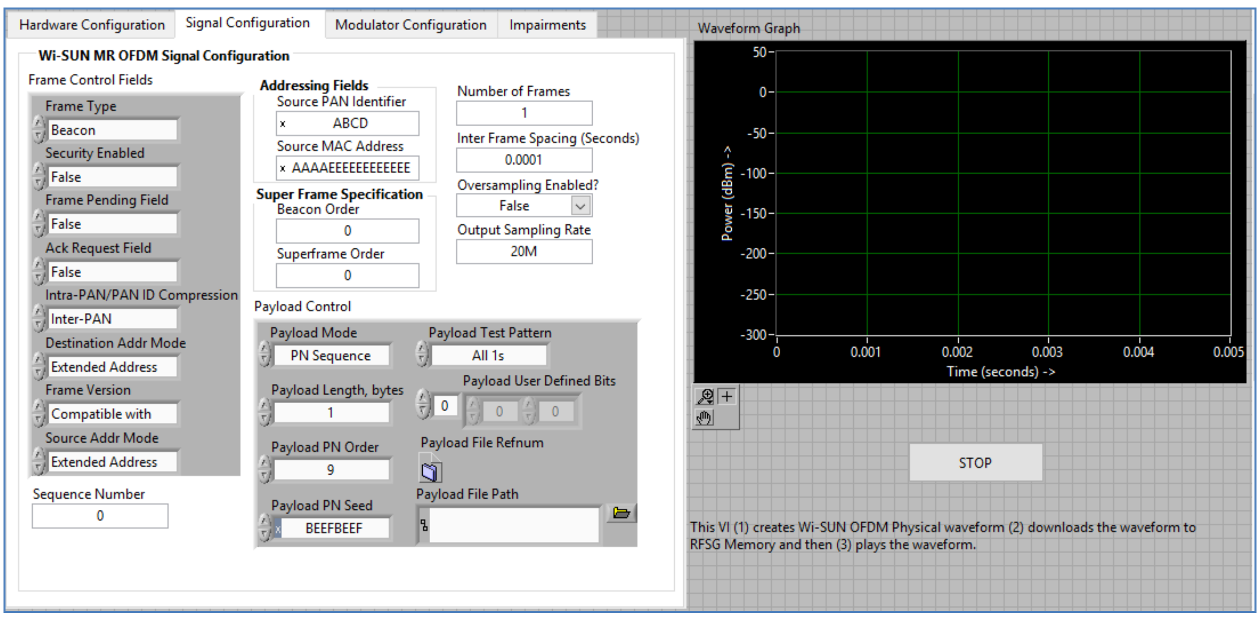
Q DC Offset, %- The toolkit adds the DC offset to the quadrature-phase signal component (Q) of the complex waveform as a percentage of the root mean square magnitude of the unaltered Q signal.

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.

3.1.2 MaxEye Wi-SUN MR OFDM Signal Generation (Beacon Frame)

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



The user configurations are divided into three categories

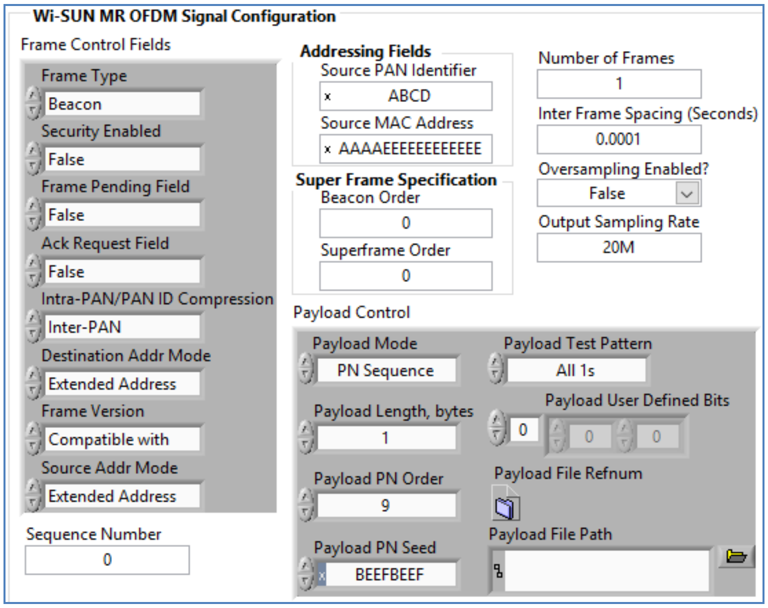
i. Hardware Settings
ii. Signal Configuration
iii. Modulator Configuration
iv. Impairments

1. Select Hardware Configuration and Refer 3.1.1 for configuration.

2. Select Signal Configuration Tab

Frame Type- Select the frame type as Beacon.

The superframe specifications can be configured as follows.



Beacon Order- specify the transmission interval of the beacon.

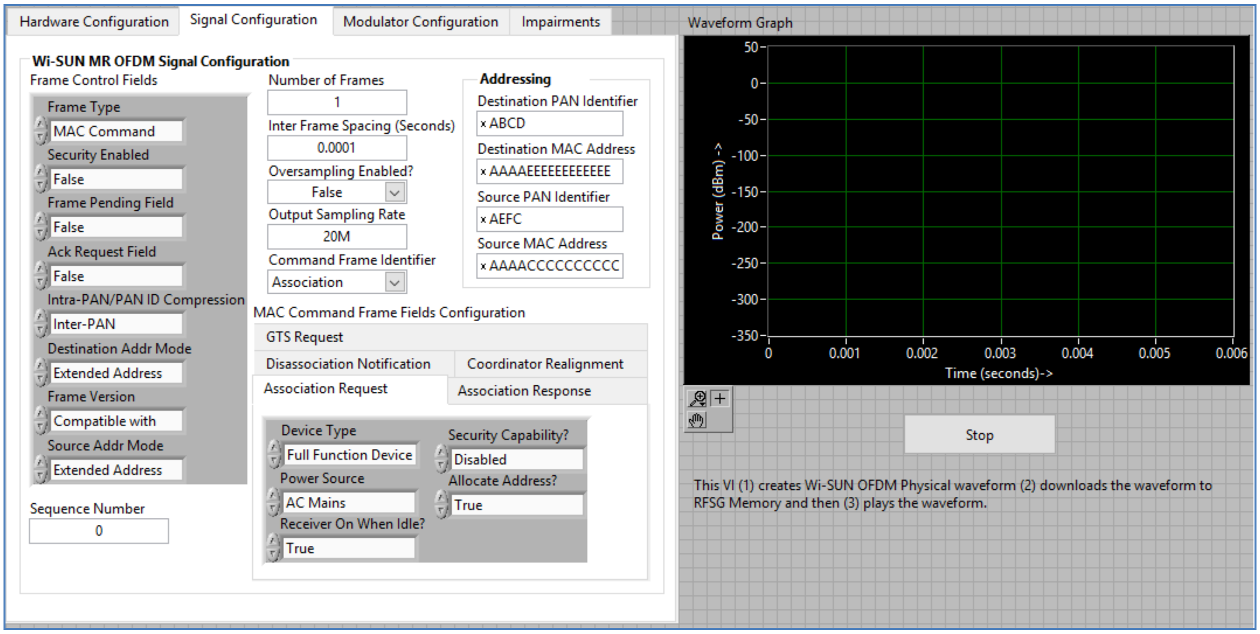
Superframe Order- specify the length of time during which the superframe is active (i.e., receiver enabled), including the beacon frame transmission time.

For rest of the configuration , Refer 4.1.1.1.

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

3.1.3 MaxEye Wi-SUN MR OFDM Signal Generation (MAC Command)

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



The user configurations are divided into three categories

i. Hardware Settings
ii. Signal Configuration
iii. Modulator Configuration
iv. Impairments

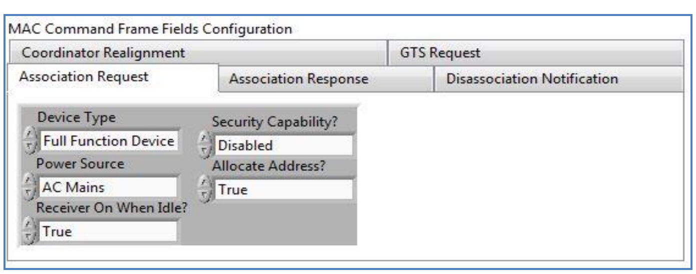
1. Select Hardware Configuration and Refer 4.1.1.1 for configuration.
2. Select Signal Configuration Tab

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.



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

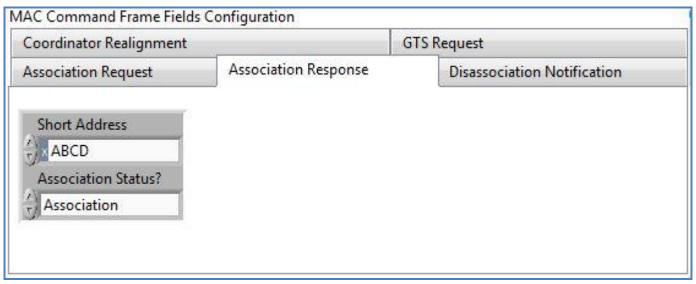
Power Source- Select AC Mains, if the device is receiving power from the alternating current mains. Otherwise, the Power Source field shall be set to Not From AC Mains.

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.

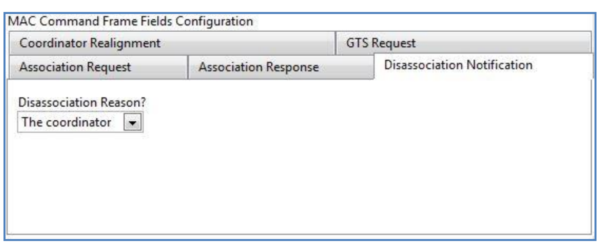
2. If Command frame Identifier is Association Response, then user has to configure the following



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.

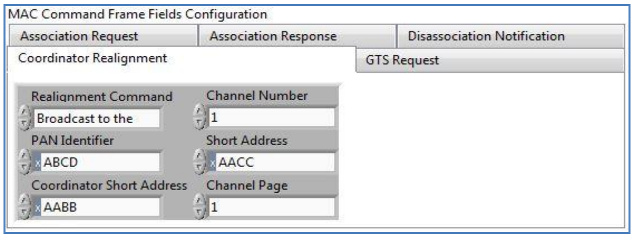
Association status?- Select the Valid values of the Association Status field.

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



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.



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.

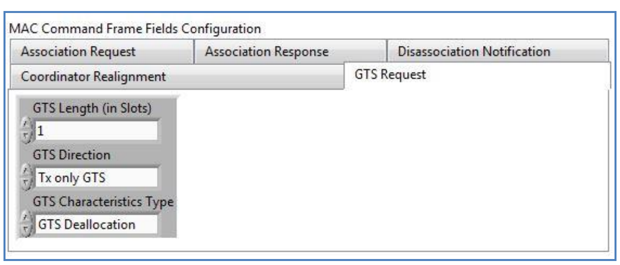
Coordinator Short Address- shall contain the value of *macShortAddress*. Valid values from 0000 to FFFF.

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



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.

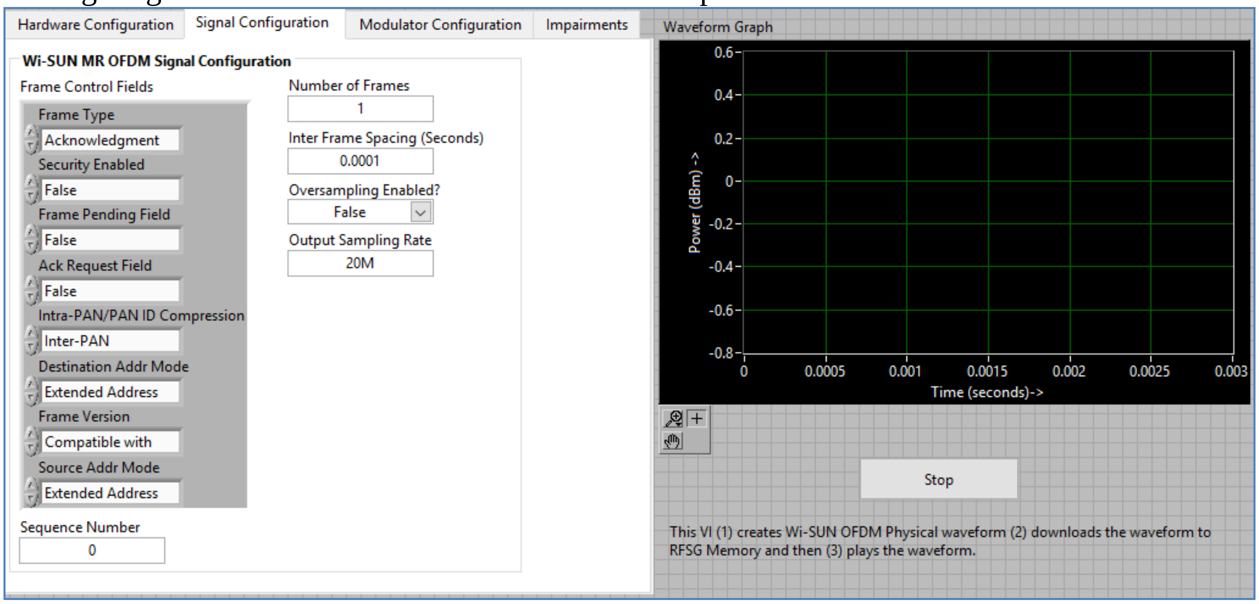
GTS Characteristics Type- Select GTS Characterstics type as GTS allocation or GTS deallocation.

For rest of the configuration , Refer 4.1.1.1.

3. Select Impairments Tab. Refer 4.1.1.1 for configuration.

3.1.4 MaxEye Wi-SUN MR OFDM Signal Generation (Acknowledgement)

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



The user configurations are divided into three categories

i. Hardware Settings
ii. Signal Configuration
iii. Modulator Configuration
iv. 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

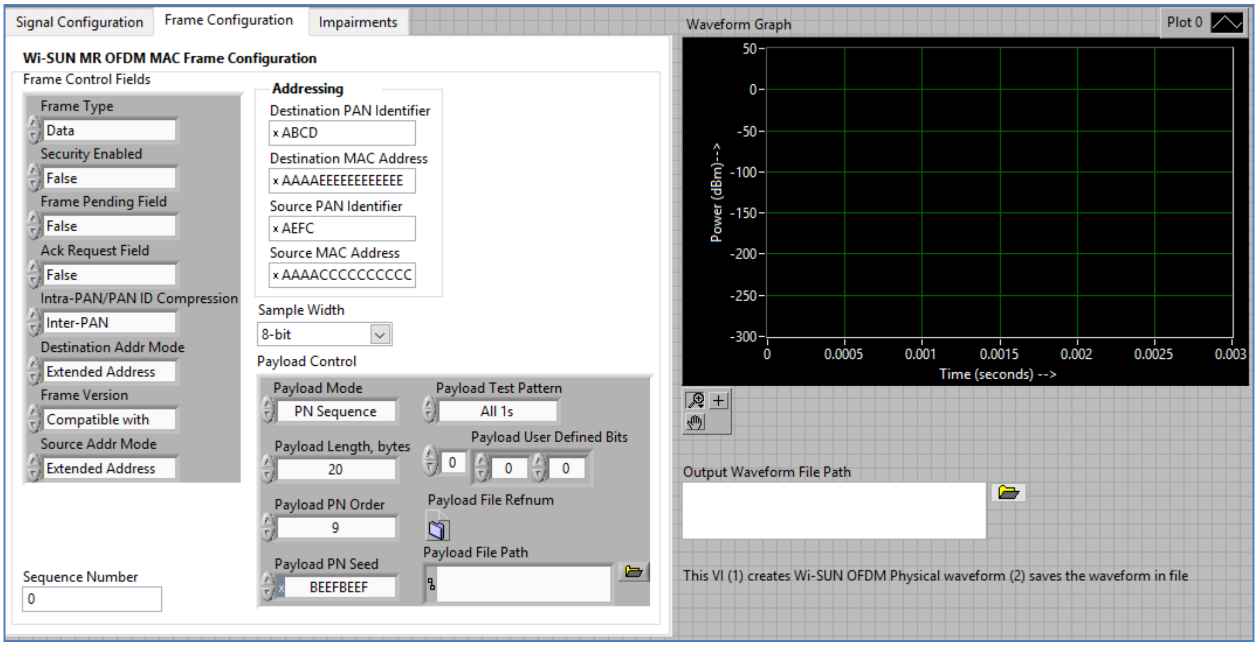
3. Select Impairments Tab and Refer 4.1.1.1 for configuration.

3.1.5 MaxEye Wi-SUN MR OFDM Signal Generation (Data) Save Waveform in file

This Example is used to generate multiple Wi-SUN 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.

The figure below shows the front panel.



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.

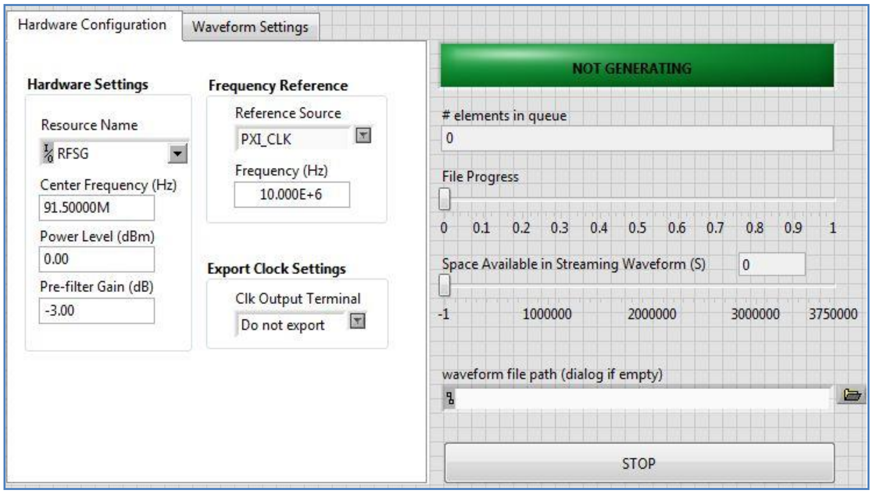
3.1.6 MaxEye Wi-SUN MR OFDM RFSG Play Waveform From File

This example reads the Wi-SUN 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.

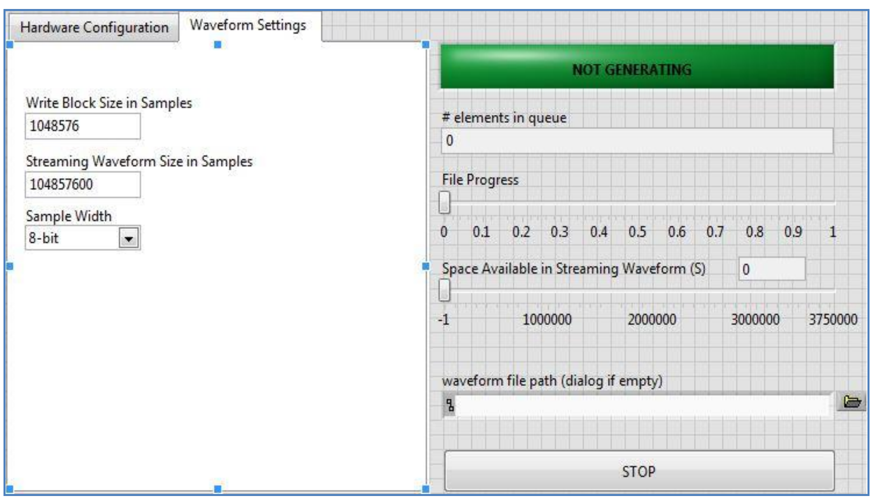
This example uses NI RFSG in streaming mode for playing the waveform in real-time. The performance of this example is related to the performance of your CPU and available RAM memory.

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/



This example requires the following additional input parameters.



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.

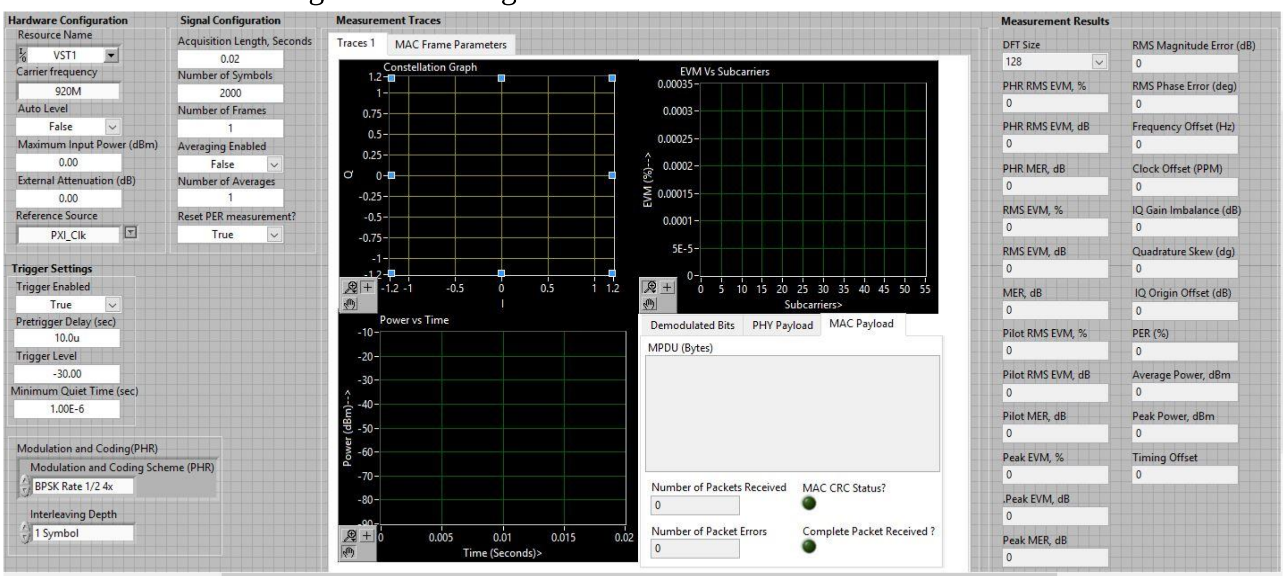
3.2 Wi-SUN MR OFDM Signal Analysis

3.2.1 MaxEye Wi-SUN MR OFDM 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

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..

Carrier Frequency- Configure the center frequency of the Wi-SUN OFDM Signal **.**

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.

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.

Minimum 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. Modulation and Coding(PHR) can be configured as follows

Modulation and Coding Scheme(PHR) – configure this field as same as the transmitted modulation and coding scheme for header.

Interleaving Depth – configure this field as same as transmitted Interleaving Depth.

5. Signal Configuration can be configured as follows.

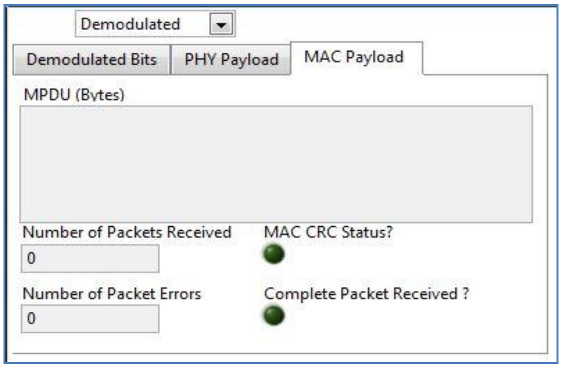
Acquisition Length, Seconds- Needs to be configured for OFDM modulation. Number of Samples to Acquire= IQ Rate* Acquisition Length

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.



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

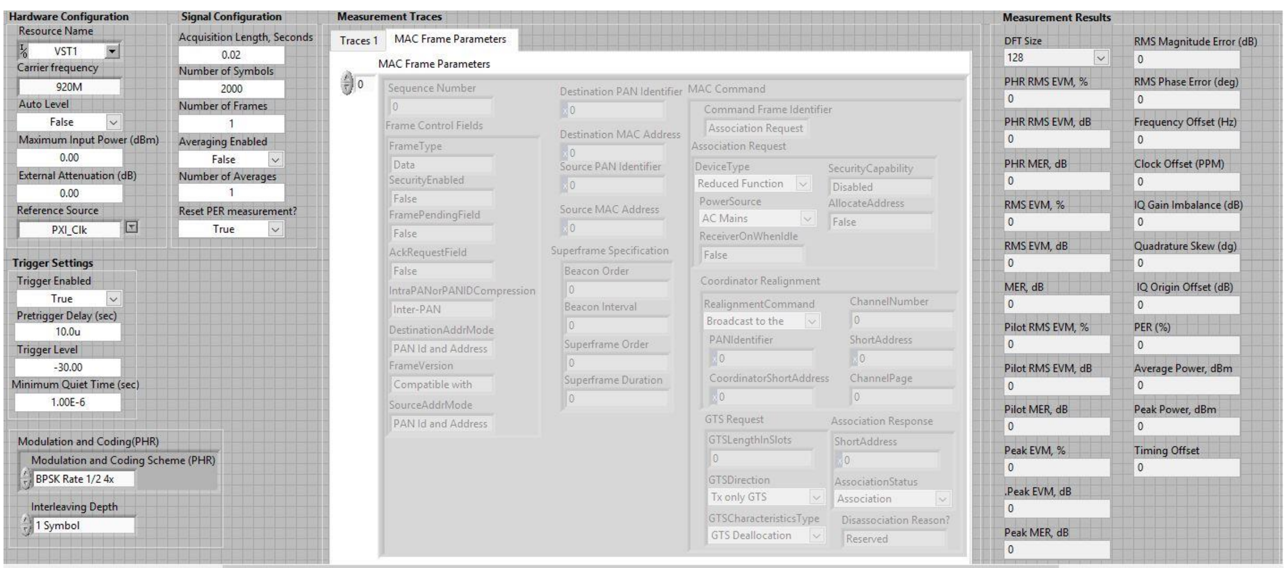
Number of Packets Received- This shows the total number of Packets received

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 complete

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.



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

3.2.2 MaxEye Wi-SUN MR OFDM RFSA Measure Spectral Emission Mask

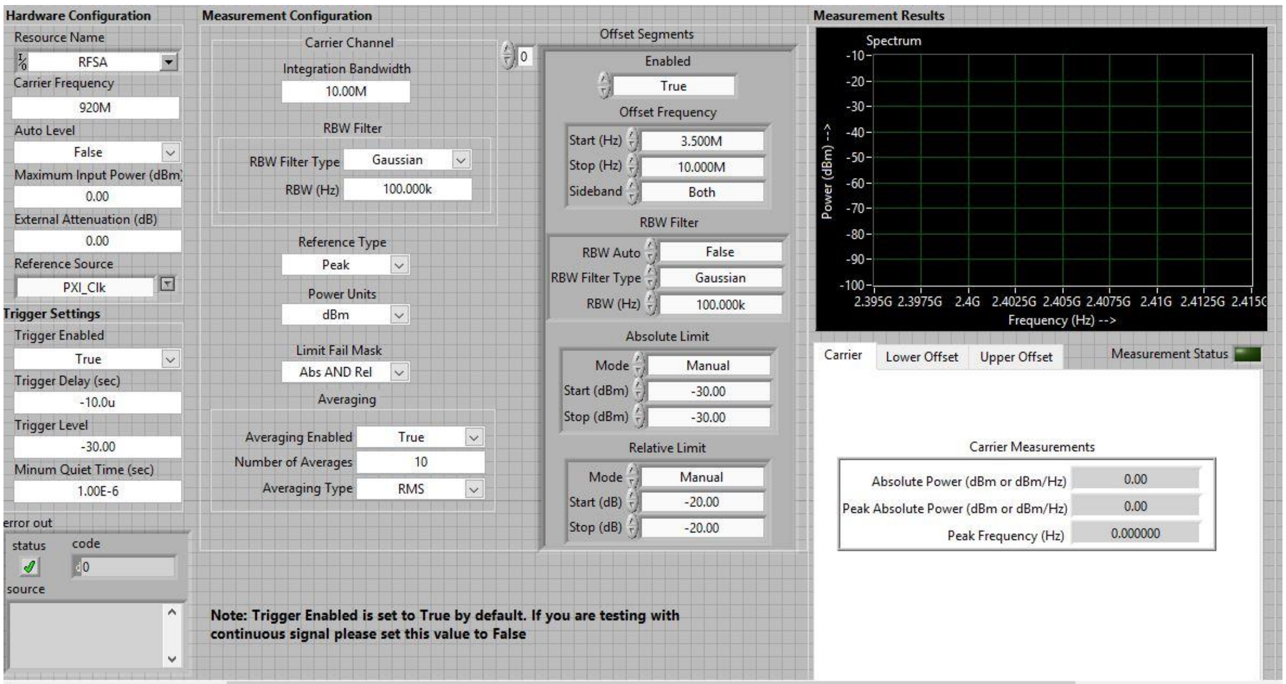
In this example SEM measurement which includes carrier measurement , lower and upper offset segment measurements are calculated.

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.



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

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.

3.2.3 MaxEye Wi-SUN MR OFDM RFSA Measure Transmit Power

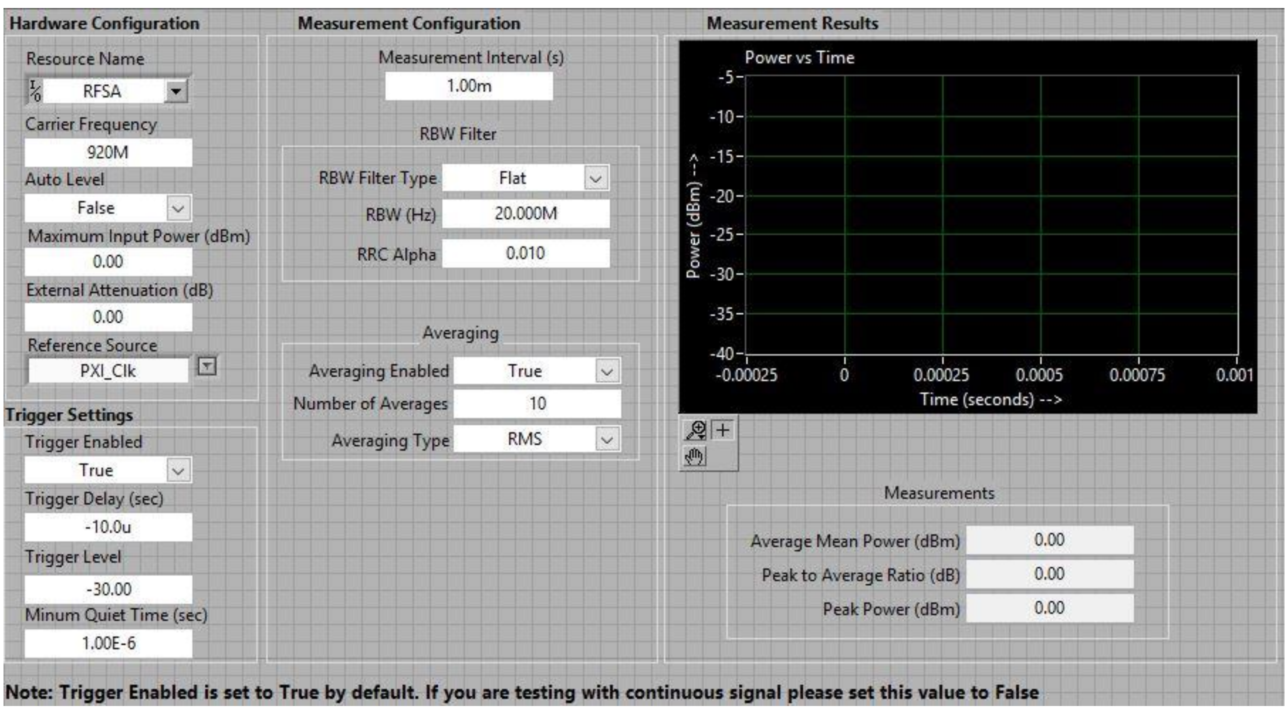
Transmit Power is a zero span measurement of transmitted power using the time-domain signal as seen through a resolution bandwidth (RBW) filter for the specified measurement interval.

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.



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.

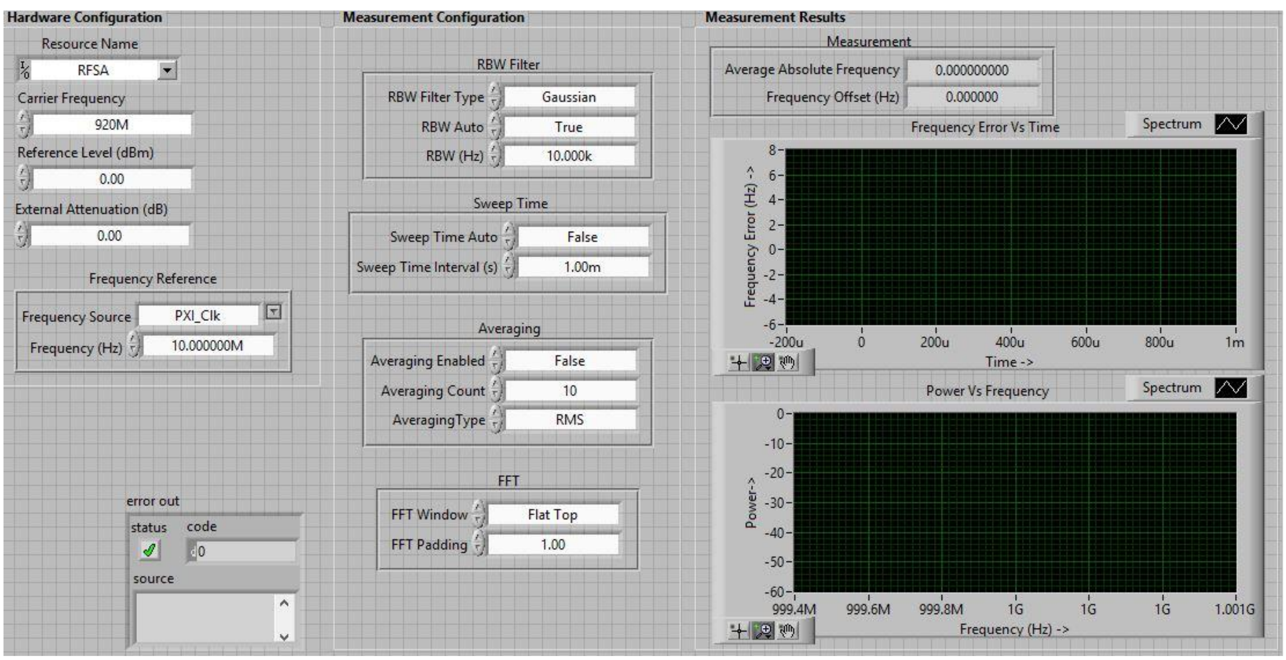
3.2.4 MaxEye Wi-SUN MR OFDM RFSA Measure CW Frequency Offset

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

1. Refer 4.2.1.1 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**.**

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.

4. C# .NET Programming Examples

The Wi-SUN 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 Wi-SUN 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

The programming examples are created using C# .NET functions. For more information about the API used in the C# .NET Examples refer to the MaxEye WiSUN Measurement Suite DotNet API

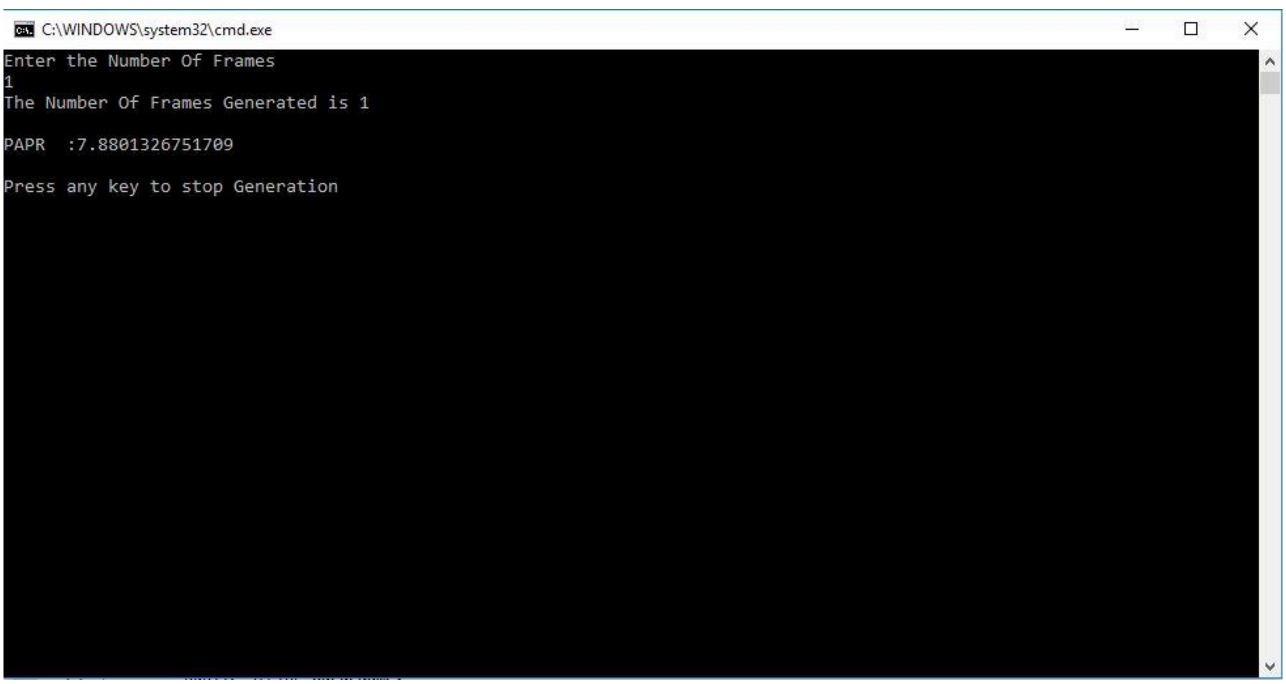
User Manual.pdf document, accessible at Start->All Programs->MaxEye->Wi-SUN>Documentation.

4.1 Wi-SUN MR OFDM Signal Generation

4.1.1 MaxEye Wi-SUN OFDM Signal Generation (Data Frame)

Follow the procedure below to configure the example

1. Find the C# .NET example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame) (***Note***: - *For 32-bit Operating System*, C examples are installed in, C:\Program Files\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame)).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame).sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the parameters listed as required. For help, please follow the comments given against each configuration parameter.
5. Configure the Resource Name under Hardware Settings and also configure the other parameters listed, if required.
   public string ResourceName = "RFSG"; // Enter the Resource or Hardware Name
6. Navigate to **WiSUN_OFDM_SignalGenerationData.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



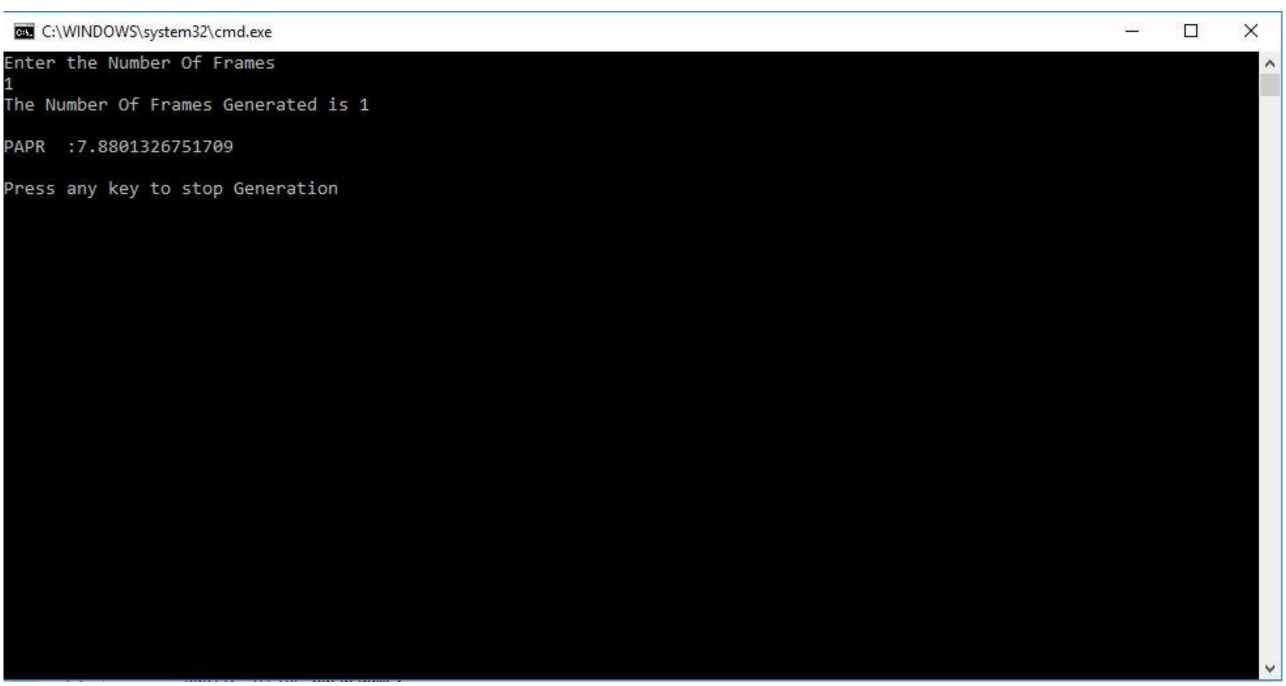
Now the application validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by the toolkit. If the configuration is successfully validated, the toolkit generates the waveform.

7. Press any key, to stop the generation.

4.1.2 MaxEye Wi-SUN OFDM Signal Generation (Beacon Frame)

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Beacon Frame).
   (***Note***: - *For 32-bit Operating System*, C examples are installed in, C:\Program Files\ MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Beacon Frame)).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM Signal Generation (Beacon Frame).sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings and also configure the other parameters listed, if required.
   public string ResourceName = "RFSG"; // Enter the Resource or Hardware Name
5. Navigate to **WiSUN_OFDM_SignalGenerationBeacon.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.

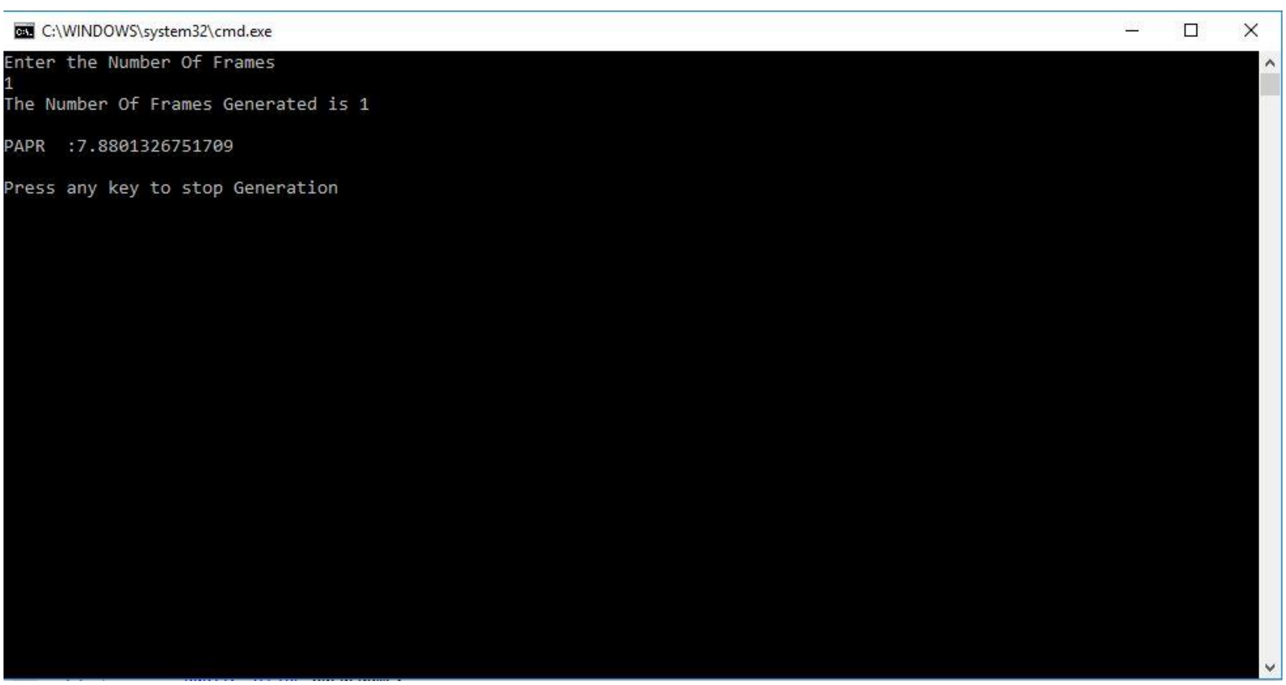


6. Now the application validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by the toolkit. If the configuration is successfully validated, the toolkit generates the waveform.
7. Press any key, to stop the generation.

4.1.3 MaxEye Wi-SUN OFDM Signal Generation (MAC Command Frame)

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (MAC Command Frame).
   (***Note***: *- For 32-bit Operating System*, C examples are installed in, C:\Program Files\ MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (MAC Command Frame)).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM Signal Generation (MAC Command Frame).sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings and also configure the other parameters listed, if required.
   public string ResourceName = "RFSG"; // Enter the Resource or Hardware Name
5. Navigate to **WiSUN_OFDM_SignalGenerationMACCommand.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



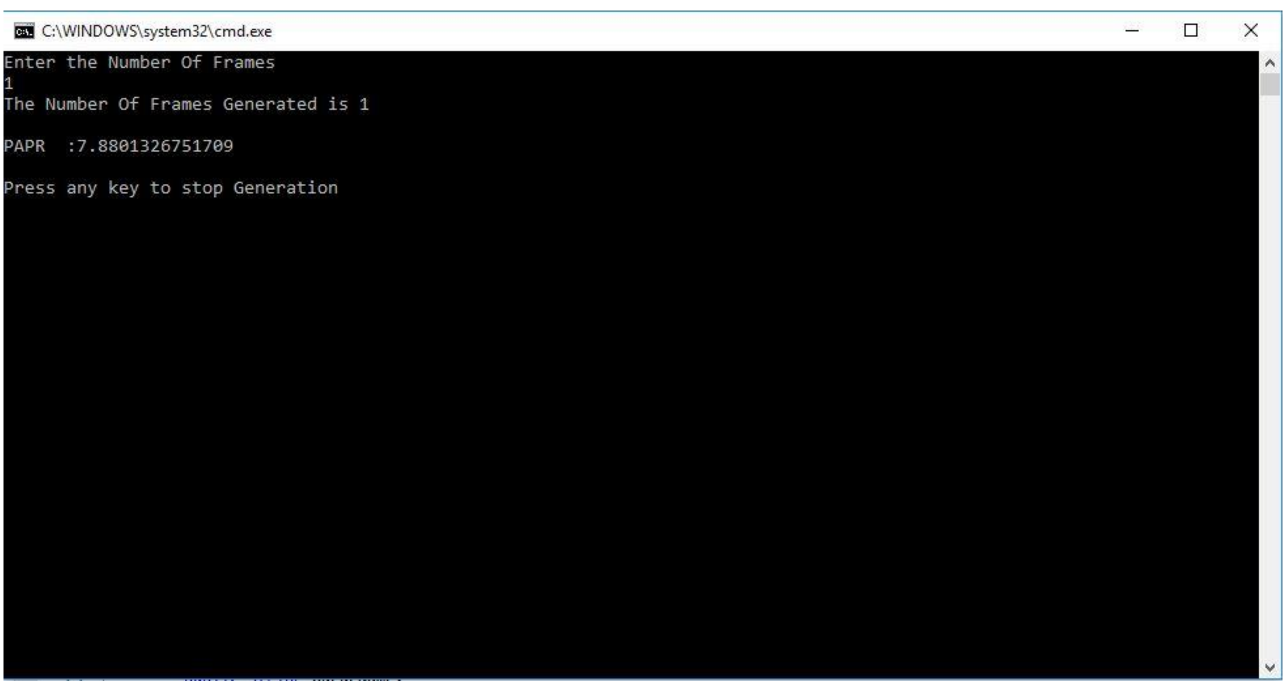
Now the application validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by the toolkit. If the configuration is successfully validated, the toolkit generates the waveform.

6. Press any key, to stop the generation.

4.2.4 MaxEye Wi-SUN OFDM Signal Generation (Acknowledgement Frame)

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Acknowledgement Frame).
   (***Note***: - *For 32-bit Operating System*, C examples are installed in, C:\Program Files\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Acknowledgement Frame)).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM Signal Generation (Acknowledgement Frame).sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings and also configure the other parameters listed, if required.
   public string ResourceName = "RFSG"; // Enter the Resource or Hardware Name
5. Navigate to **WiSUN_OFDM_SignalGenerationAck.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



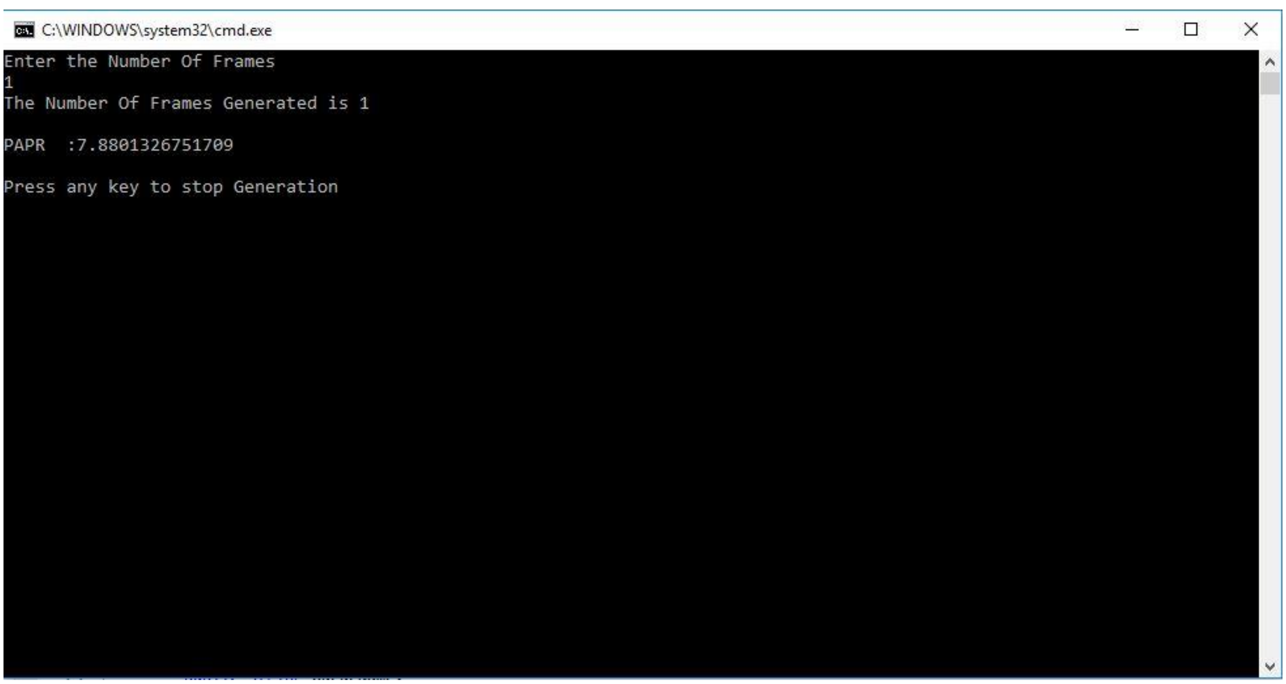
Now the application validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by the toolkit. If the configuration is successfully validated, the toolkit generates the waveform.

6. Press any key, to stop the generation.

4.2.5 MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame) Save Waveform

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame) Save Waveform).
   (***Note***: - *For 32-bit Operating System*, C examples are installed in, C:\Program Files\ MaxEye\Wi-SUN\Examples\Generation\cs\MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame) Save Waveform).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM Signal Generation (Data Frame) Save Waveform.sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the toolkit configurations parameters.
5. Navigate to **MaxEyeWISUN_GenerateAndSave.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



Now the application validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by the toolkit. If the configuration is successfully validated, the toolkit generates the waveform.

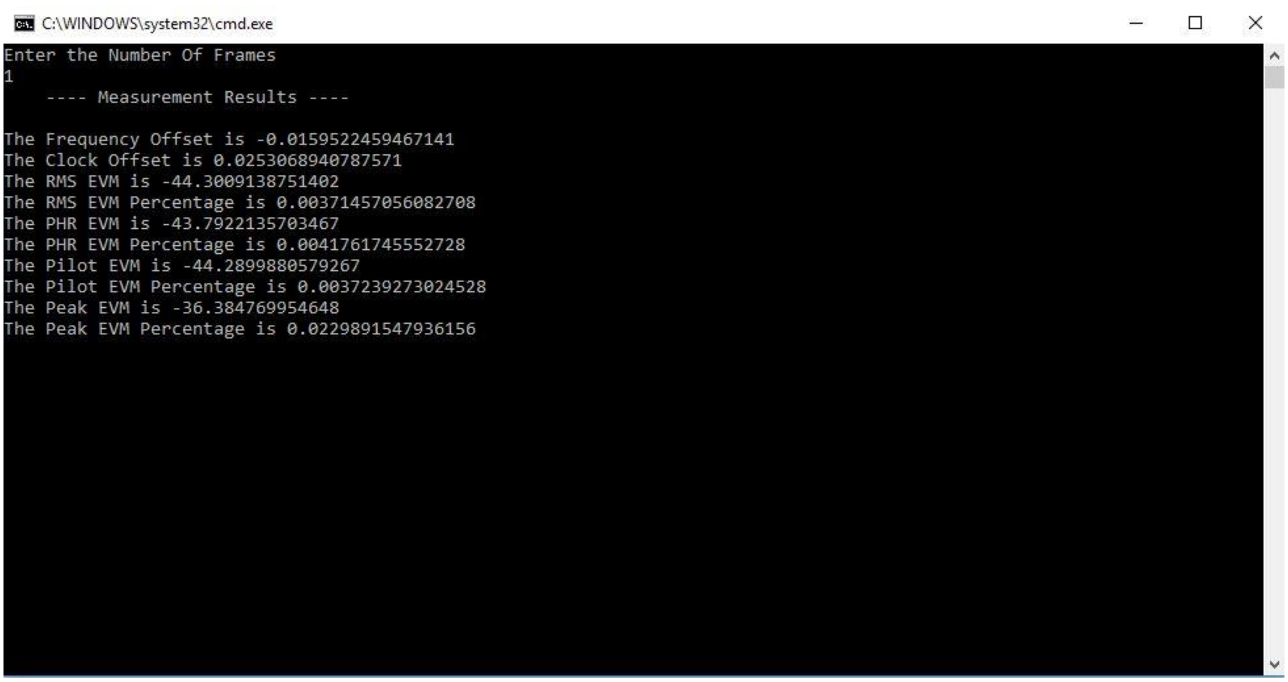
6. Press any key, to stop the generation.

4.2 Wi-SUN MR OFDM Signal Analysis

3.1.34.2.1 MaxEye Wi-SUN MR OFDM RFSA Modulation Accuracy

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Modulation Accuracy.
   (***Note****: - For 32-bit Operating System*, C examples are installed in, C:\Program Files\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Modulation Accuracy).
2. Open the desired example directory and open the solution file **MaxEye WiSUN OFDM Analaysis Modulation Accuracy.sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings. Configure the Modulation and Coding(PHR), Interleaving Depth as same as transmitted signal and also configure the other parameters listed, if required.
   `public string ResourceName = ""; // Enter the Resource or Hardware Name`
5. Navigate to **WiSUN_OFDM_SignalAnalysis.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



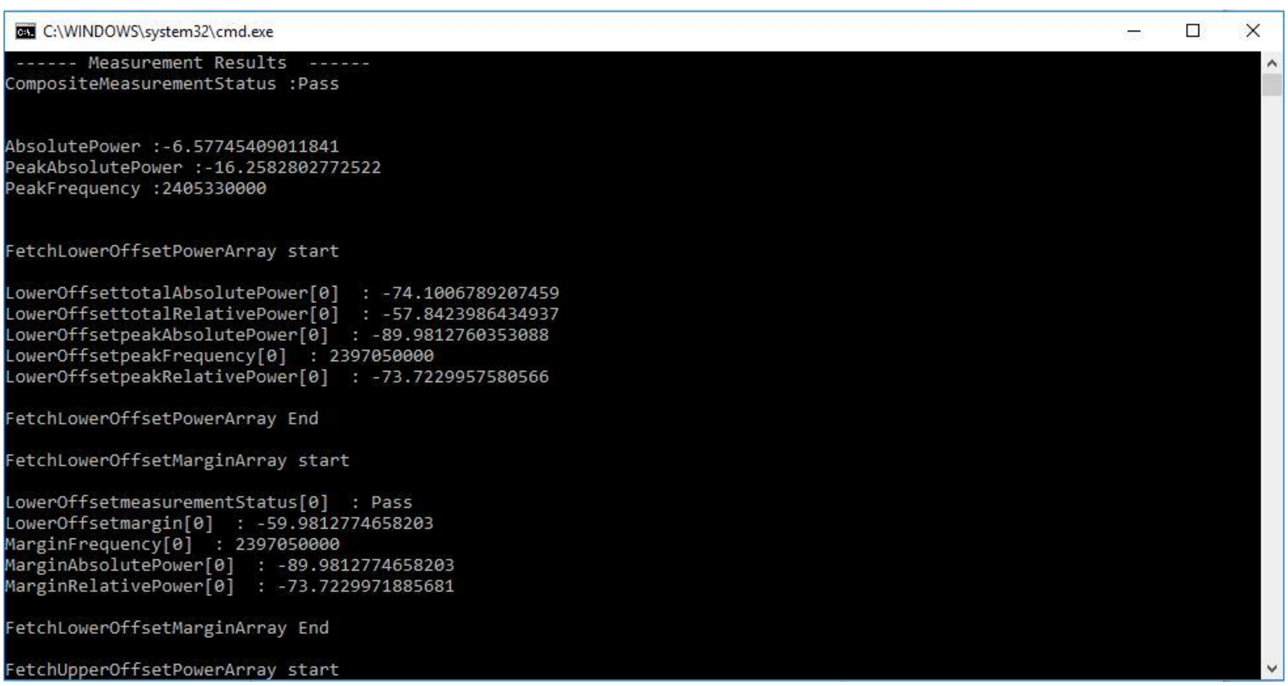
Now the application validates the user configuration and reports error to the user if the configuration. If the configuration is successfully validated, the toolkit acquires the waveform and outputs the measurements.

6. Press any key, to stop the exit.

4.2.2 MaxEye Wi-SUN MR OFDM RFSA Measure Spectral Emission Mask

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Measure Spectral Emission Mask.
   (***<u>Note</u>**: - For 32-bit Operating System*, C examples are installed in, C:\Program Files\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Measure Spectral Emission Mask).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM RFSA Measure Spectral Emission Mask.sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings. Configure the Modulation and Coding(PHR), Interleaving Depth as same as transmitted signal and also configure the other parameters listed, if required.
   `public string ResourceName = ""; // Enter the Resource or Hardware Name`
5. Navigate to **WiSUN_OFDM_SignalAnalysisSEM.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



Now the application validates the user configuration and reports error to the user if the configuration. If the configuration is successfully validated, the toolkit acquires the waveform and outputs the measurements.

6. Press any key, to exit.

4.2.3 MaxEye Wi-SUN MR OFDM RFSA Measure Transmit Power

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Measure Transmit Power. (***Note****: - For 32-bit Operating System*, C examples are installed in, C:\Program Files\ MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Measure Transmit Power).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM RFSA Measure Transmit Power.sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings. Configure the Modulation and Coding(PHR), Interleaving Depth as same as transmitted signal and also configure the other parameters listed, if required.
   public string ResourceName = ""; // Enter the Resource or Hardware Name
5. Navigate to **WiSUN_OFDM_SignalGenerationTxp.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.

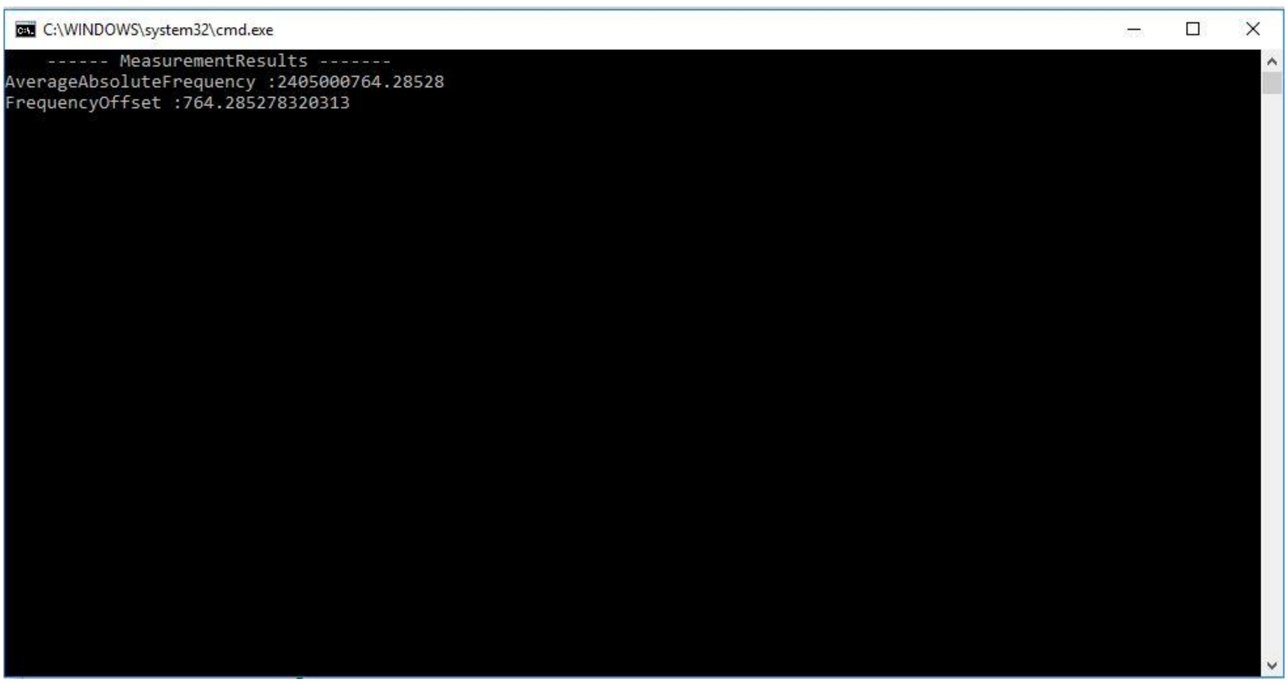
Now the application validates the user configuration and reports error to the user if the configuration. If the configuration is successfully validated, the toolkit acquires the waveform and outputs the measurements.

6. Press any key, to exit.

4.2.4 MaxEye Wi-SUN MR OFDM RFSA Measure CW Frequency Offset

Follow the procedure below to configure the example

1. Find the C example in C:\Program Files (x86)\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Measure CW Frequency Offset.
   (**<u>Note</u>**: - *For 32-bit Operating System*, C examples are installed in, C:\Program Files\MaxEye\Wi-SUN\Examples\Analysis\cs\MaxEye Wi-SUN MR OFDM RFSA Measure CW Frequency Offset).
2. Open the desired example directory and open the solution file **MaxEye Wi-SUN MR OFDM RFSA Measure CW Frequency Offset.sln** in **Microsoft Visual C++.**
3. Navigate to **MaxEyeWiSUN_SetConfiguration.cs** from the solution explorer.
4. Configure the Resource Name under Hardware Settings and also configure the other parameters listed, if required.
   public string ResourceName = "VST1"; // Enter the Resource or Hardware Name
5. Navigate to **WiSUN_OFDM_SignalGenerationCWOffset.cs** and press Run button or (Ctrl + F5) for running the example. Enter the values in the console application window that appears after running the example.



Now the application validates the user configuration and reports error to the user if the configuration. If the configuration is successfully validated, the toolkit acquires the waveform and outputs the measurements.

6. Press any key, to exit.