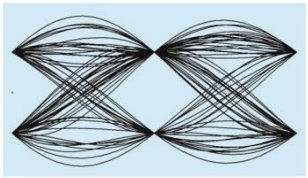


MaxEye Digital Audio and Video Signal Generation

ISDB-T Signal Generation Toolkit

Version 2.0.0

Getting Started Guide

MAXEYE TECHNOLOGIES

Contents

1 Introduction

MaxEye Technologies provides generation functions in LabVIEW and C for generating the standard complaint signals for various digital audio and video broadcasting standards. This guide explains how to use the ISDB-T signal generation toolkit using the Soft Front Panel (SFP) and programming examples by using NI Vector Signal Generator (NI VSG), Vector Signal Transceiver (NI VST), and Universal Software Radio Peripheral (NI USRP).

Integrated Services Digital Broadcasting - Terrestrial (ISDB-T) is a Japanese standard for digital terrestrial television and a derivative of ISDB. Developed by the Brazilian government.

2 Installed File Location

2.1 Soft Front Panel

The ISDB-T signal generation soft front panel is located in, C:\Program Files\MaxEye\Digital Video Toolkits\ISDB-T Generation\SFP

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

2.2 Programming Examples

The programming examples are installed in, <LabVIEW>examples\MaxEye\Digital Video Toolkits\ISDB-T Generation.

You can also find a shortcut to the above location from the windows start menu.
Start->All Programs->MaxEye->Digital Video Toolkits->ISDB-T->Generation
***Note**: - For Windows 10,* **Start-> MaxEye**.

2.3 Toolkit API VIs

The toolkit APIs are installed in, <LabVIEW>\vi.lib\addons\MaxEye\Digital Video Toolkits \ISDB-T Generation\Generation\API.

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

2.4 Documentation

The toolkit help file is installed in, <LabVIEW>\help\MaxEye\Digital Video Toolkits\ MaxEye ISDBT Signal Generation Help.chm

The toolkit documentation files are installed in, <LabVIEW>\vi.lib\addons\MaxEye\Digital Video Toolkits\ISDB-T Generation\Generation\Documentation.

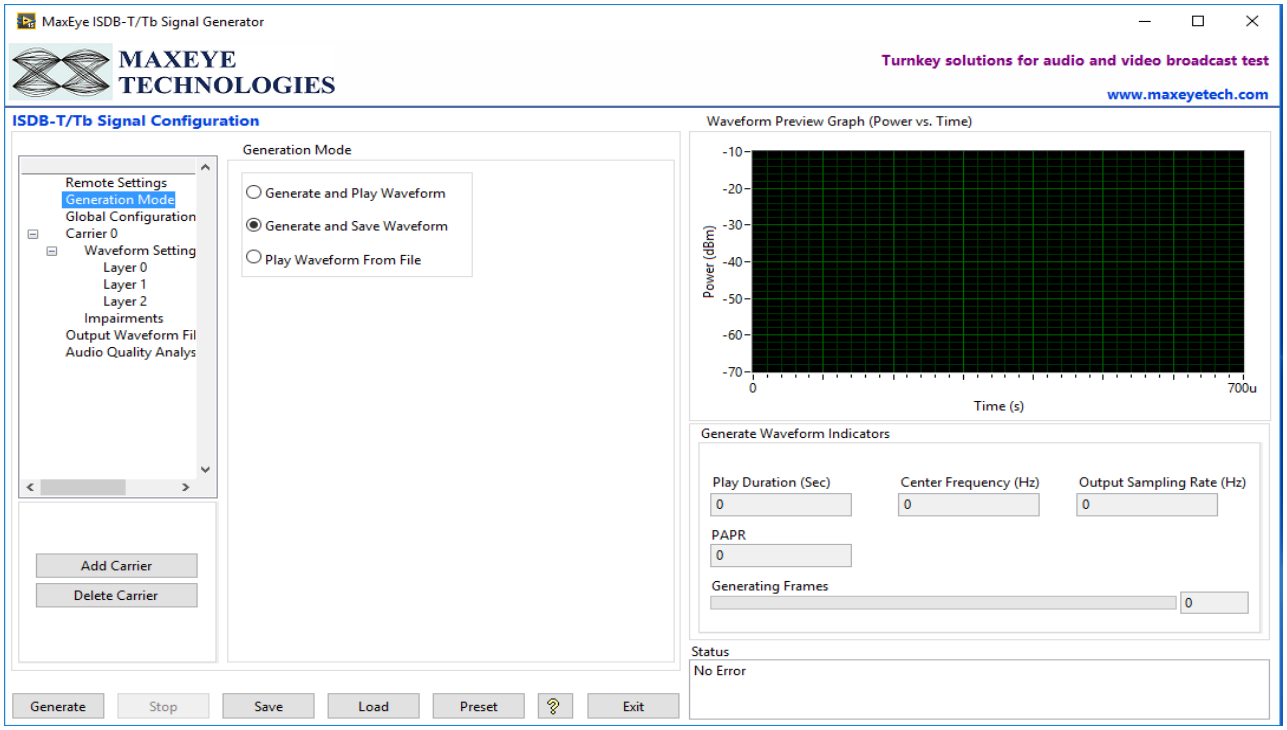
You can also find a shortcut to the above location from the windows start menu.
Start->All Programs->MaxEye->Digital Video Toolkits->ISDB-T->Documentation
***Note**: - For Windows 10,* **Start-> MaxEye**.

3 Soft Front Panel

The soft front panel (SFP) for ISDB-T Signal Generator allows engineer to quickly generate the signals by selecting appropriate generation mode and other configurations. The default signal generation mode of the SFP is Generate and Save Waveform in file and in this mode the generated waveform is stored in a file. Multiple carriers (stations) can also be generated using SFP.

3.1 MaxEye ISDB-T Signal Generation SFP

The figure below shows the ISDB-T Signal Generation SFP.



3.1.1 Generate and Save Waveform/Generate and Play Waveform

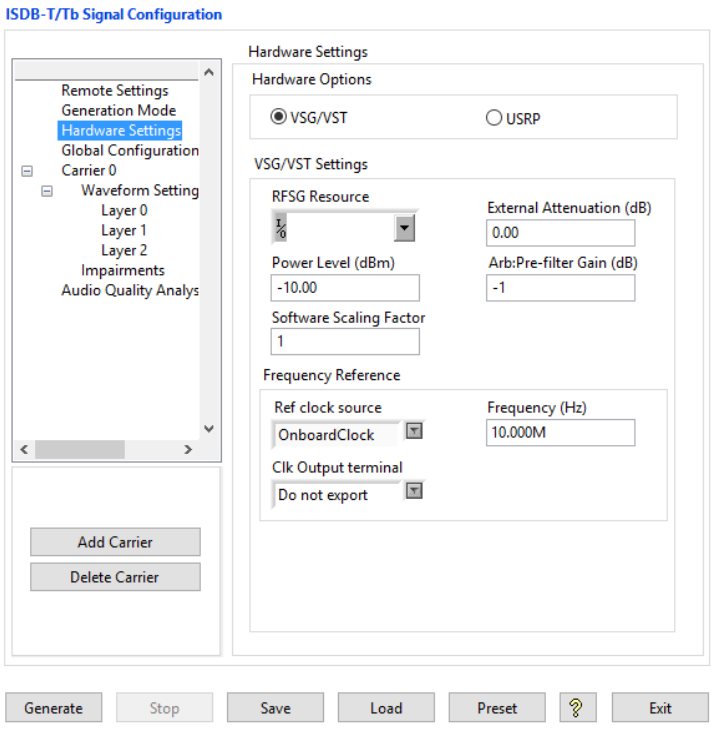
Generate and Play waveform is used to generate ISDB-T signal using hardware. Generate and Save waveform is used to generate the baseband IQ waveform and store in a file. For this mode hardware is not required. The Play Waveform from File mode reads the ISDB-T waveform from the file created using the Generate and Save Waveform and then downloads the waveform to NI RFSG Memory and then plays the waveform.

Use the Generate and Save Waveform mode

- 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.

Follow the procedure below to generate signals using these generation modes.

1. Select **Generation Mode** -> **Generate and Save Waveform** or **Generate and Play Waveform**
2. Select **Hardware Settings** to configure the following parameters.



***Note*: -** *These settings need not to be configured if the chosen Generation Mode is Generate and Save Waveform.*

- **Hardware Options –** Select hardware as **VSG/ VST** or **USRP**.

➢ VSG/ VST

- **RFSG Resource –** Select the Resource Name used in NI Measurement and Automation Explorer (NI MAX) for the NI PXIe-5672/5673/5673E or NI PXIe 5644R/45R/46R or NI 5840 device.
- **Power Level (dBm) –** Specifies the Average Power level of the signal in dBm.
- **External Attenuation (dB) –** Specifies the external amplification or attenuation, in dB, 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 Arbitrary Waveform Generator (AWG) Pre-filter Gain, in dB. The pre-filter 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 pre-filter gain.
- **Software Scaling Factor –** Specifies how much to scale the data before writing it with the NI RFSG. The resulting waveform must be smaller than 1.0 in complex magnitude.
- **Reference Source –** Specifies the source of the Reference Clock signal.
- **Frequency (Hz) –** Specifies the Reference Clock rate, in Hertz (Hz).
- **Clk Output Terminal –** Specifies the terminal where the signal will be exported.

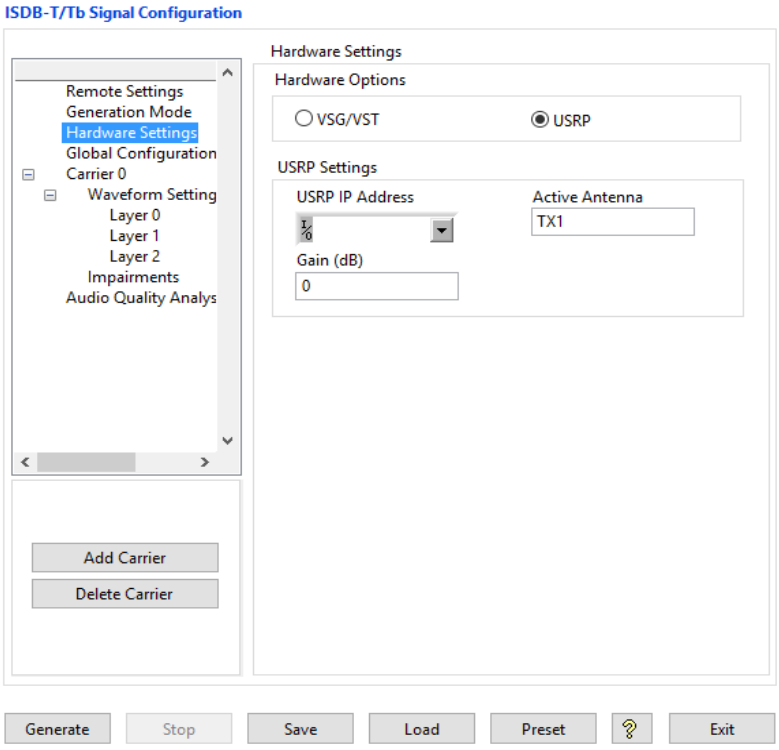
For more information on External Attenuation (dB), Arb: Pre-filter Gain (dB), Reference Source, Frequency (Hz), Clk Output Terminal, please refer NI RFSG Signal Generators help file.

➢ USRP

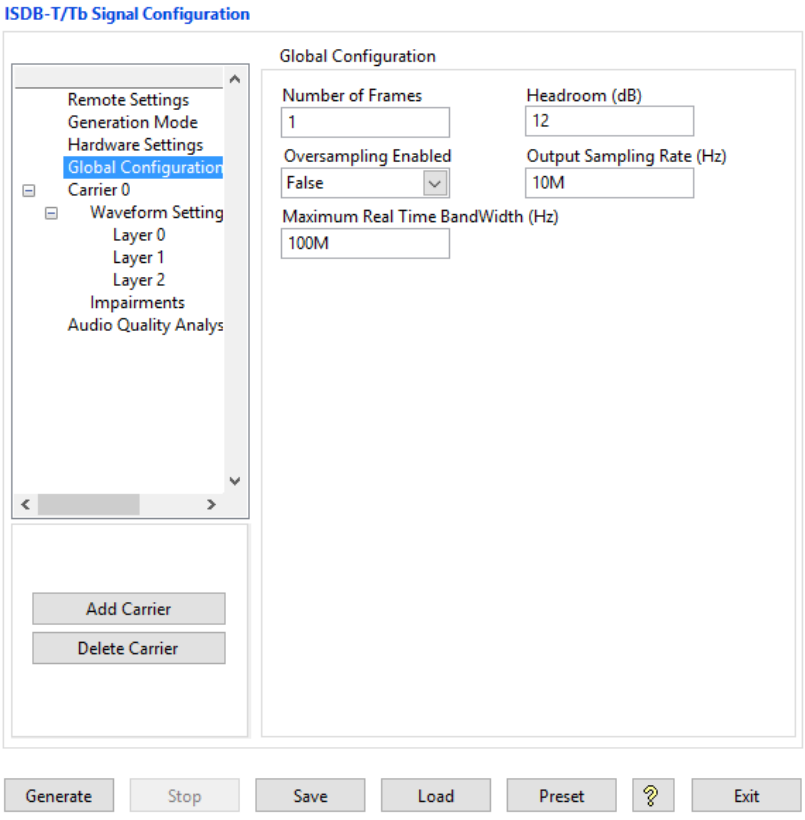
- **USRP IP Address** – Configure the IP address of the NI USRP
- **Gain (dB)** – Configure the aggregate gain, in dB, to be applied to the RF signal.
- **Active Antenna** – Configure the antenna port to be used for this channel.

For more information on Active Antenna, Gain (dB), Coerced IQ rate, Coerced Carrier Frequency and Coerced Gain, please refer NI USRP help file.

The figure below shows the hardware settings for USRP.



3. Select **Global Configuration** to configure the following parameters.



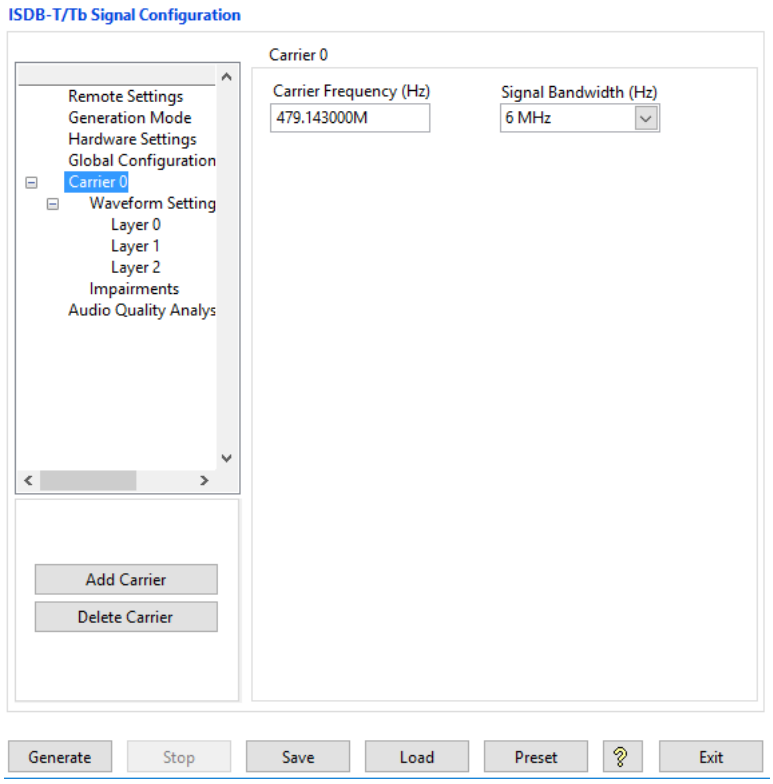
- **Number of Frames** – Configure the required number of Transmission Frames. The Number of Frames property decides the length of waveform to be generated.
- **Headroom (dB) –** Specifies the Headroom value higher than PAPR of the signal to be generated. For more information, please refer MaxEye ISDB-T Signal Generation Help.chm.
- **Oversampling Enabled & Output Sampling Rate (Hz) –** Use this configuration only when you want to resample the signal to different sampling rate. The toolkit resamples the generated signal to a sampling rate equal to the **Output Sampling Rate** only if the **Over Sampling Enabled property** is set to True.
- **Maximum Real-Time Bandwidth (Hz) –** The available bandwidth to combine the multi carrier waveform based on the selected hardware.

4. Select **Carrier** to configure the following parameters.

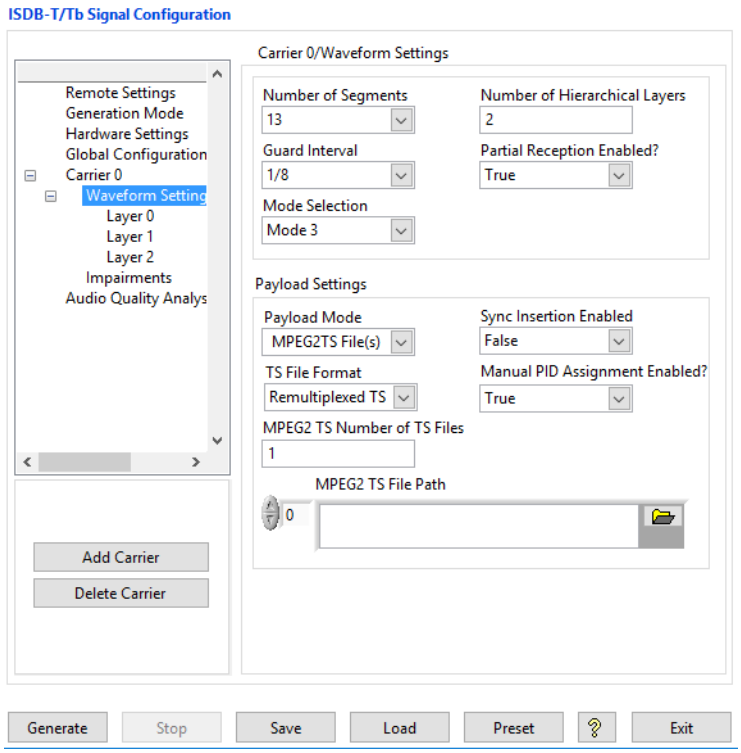
- **Carrier Frequency (Hz)** – Configure the Carrier Frequency for the selected carrier in Hz.
- **Bandwidth (Hz) –** Configure the Bandwidth of the signal for the selected carrier. The toolkit internally uses the Carrier Frequency and Bandwidth property values internally to compute the overall bandwidth and sampling rate of the signal when more than one carrier is used.

***Note*: -** *By default, the tree control shows Carrier 0. To configure more carriers, click the Add Carrier button and* configure *the following parameters for each carrier.*

The figure below shows the carrier configuration for each carrier.



4.1 Select **Waveform Settings** to configure the following parameters for the selected carrier.

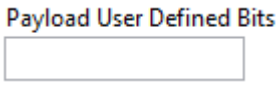


- **Number of Segments –** Configure the Number of Segments to be used for generating the signal.
- **Guard Interval –** Configure the Guard Interval for the selected carrier. The Guard Interval is used to specify the length of cyclic prefix as a fraction of the total FFT size. The FFT size in Mode 1, Mode 2 and Mode 3 are 2048, 4096 and 8192 respectively.
- **Mode Selection –** Configure the Mode Selection for the selected carrier. The valid enum values are Mode 1, Mode 2 and Mode 3. The mode selection determines the number of subcarriers used for data, pilot and other control information. The total number of used subcarriers in Mode 1, Mode 2 and Mode 3 are 1405, 2809 and 5617 respectively.
- **Partial Reception Enabled?** – Configure the Partial Reception Enabled for the selected carrier. The valid enum values are True and False. When this property is set to True, the first hierarchical layer is assigned for partial data reception and the number of segments in the first hierarchical layer should be 1. The toolkit returns an error if the number of segments in the first hierarchical layer is not 1 when this property is set to True.
- **Number of Hierarchical Layers** – Configure the Number of Hierarchical Layers for the selected carrier. The valid values are 1, 2 and 3.
- **Manual PID Assignment Enabled? –** Configure the Manual PID Assignment Enabled for the selected carrier. The valid values are True and False. When this property is set to True, the user

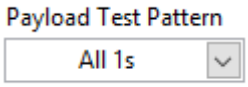
needs to assign the PIDs for each Hierarchical layer. The toolkit ignores this property if the value for Payload Mode property is set to other than MPEG2TS File(s) mode.

- **TS File Format –** Configure the TS File Format for the selected carrier. The valid values for this property are TS File and Remultiplexed TS File. The toolkit internally uses this property only if the Manual PID Assignment Enabled property is set to True.
- **Payload Mode –** Configure various payload settings. The possible payload options are
  - **PN Sequence** – Configure the **Sync Insertion Enabled, Payload PN Order, PN Seed** properties. 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. When the number of super frames is more than 1 then the toolkit maintains payload continuity across the super frames. The below parameters need to be configured in layer configuration.

  - **User defined bits** – Configure **Sync Insertion Enabled and Payload User Defined Bits** properties. Specifies a bit pattern as an array of ones and zeros. If the array length is greater than the required payload length, the toolkit uses a subset of the required length from the beginning of the array for waveform generation. If the array length is less than the required payload length, the toolkit repeats the bit pattern until the required length is achieved.



  - **Test Pattern** – Configure **Sync Insertion Enabled and Payload Test Pattern** properties. 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. The below parameters need to be configured in layer configuration.



  - **Test File –** Configure the Sync Insertion Enabled and Payload File Path properties. This mode is used for generating signal with the binary data from the file. The below parameters need to be configured in layer configuration.

  - **MPEG2TS File(s) –** In this mode configure the MPEG2 TS Number of TS Files and MPEG2 TS File Path property.

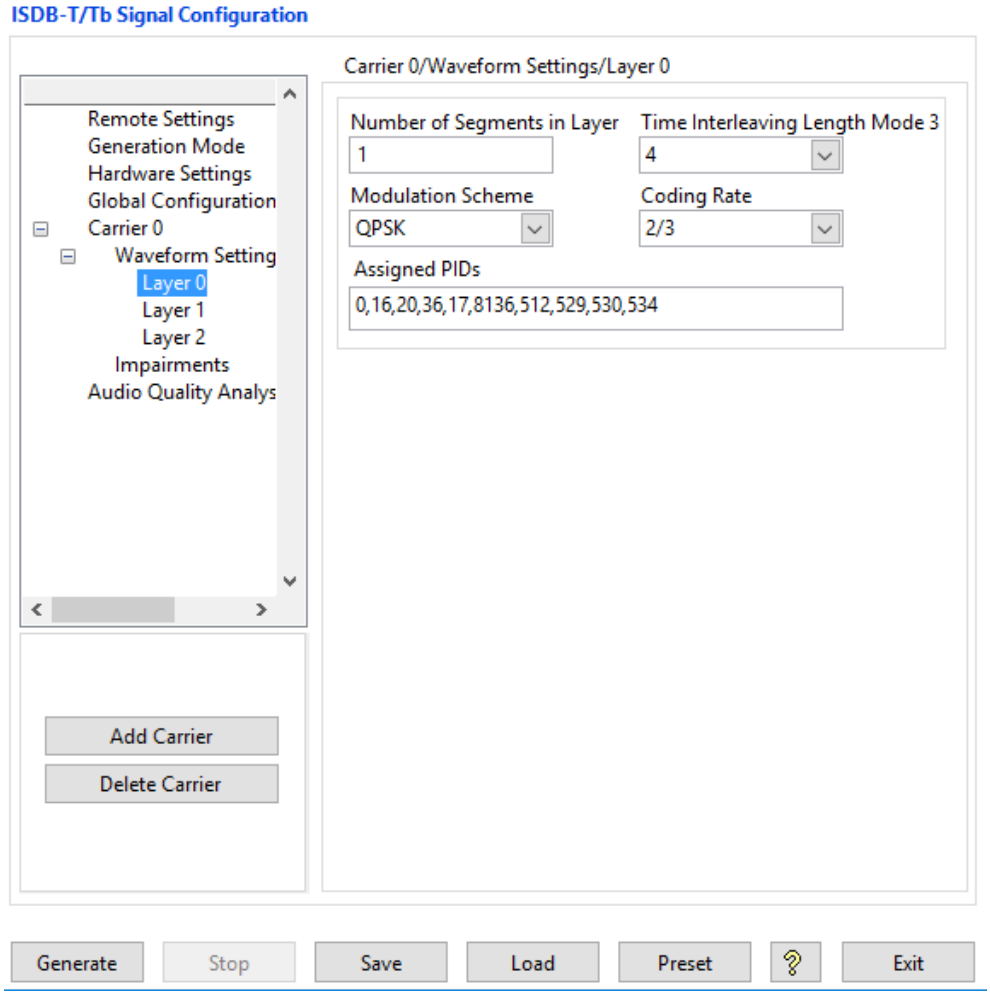
If the Sync Insertion Enabled property is set to True, the toolkit inserts MPEG2 TS packet sync byte (0x47) after every 187 bytes. The length of the TS packet is 188 bytes and the first byte is

a sync byte (0x47).

Note: *- Except for MPEG2TS File(s) mode the other payload properties should be configured for each layer separately.*

- **MPEG2 TS Number of TS Files –** Configure the Number of MPEG2 TS Number of Files for the selected carrier.
- **MPEG2 TS File Path –** Select the MPEG2 TS File based on the number of TS files configured for the selected carrier.

4.2 Select **Layer Configuration** to configure the following parameters for the selected carrier.



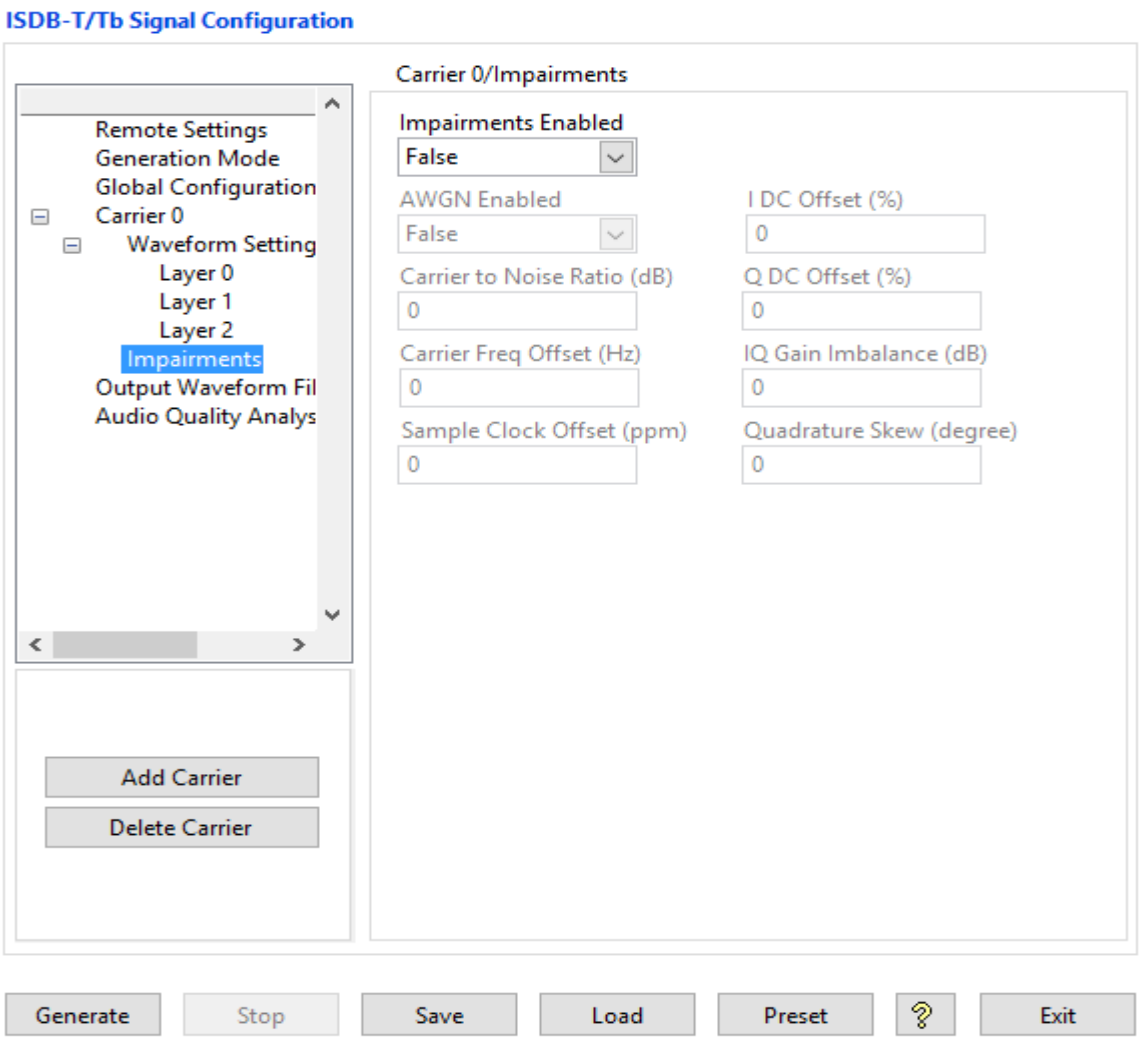
Note: *- Based on the Payload Mode selection in Waveform Settings corresponding Payload settings are visible in Layer Configuration.*

- **Number of Segments in Layer–** Configure the Number of Segments in layer for the selected layer. The total number of used segments in all the layers should be less than or equal to the value configured in the Number of Segments property. The toolkit returns an error if the total number of segments in all the layer exceeds the Number of Segments.
- **Coding Rate –** Select one of the coding rate as per the requirement. Supporting coding rates are 1/2, 2/3, 3/4, 5/6 and 7/8.
- **Modulation Scheme –** Select one of the Modulation Scheme as per the requirement. Supporting schemes are DQPSK, QPSK, 16 - QAM and 64 QAM.
- **Time Interleaving Length Mode 1 –** Select one of the Time Interleaving Length Mode values as per the requirement. Supporting values are 0, 4, 8 and 16.
- **Time Interleaving Length Mode 2 –** Select one of the Time Interleaving Length Mode values as per the requirement. Supporting values are 0, 2, 4 and 8.
- **Time Interleaving Length Mode 3 –** Select one of the Time Interleaving Length Mode values as per the requirement. Supporting values are 0, 1, 2 and 4.
  Note: *- Based on the Mode selection in Waveform Settings, Time Interleaving Length Modes are visible in Layer Configuration.*
- **Assigned PIDs –** Configure Assigned PIDs of the selected TS File for each layer. This Control is visible only if the Payload Mode selected as a MPEG2 TS File format.
- **Payload Test Pattern –** Select the required Test Pattern. Configure this field when the Payload mode is Test Pattern.
- **Payload User Defined Bits –** Configure Payload User Defined Bits for each layer. This Control is visible only if the Payload Mode selected as a User Defined Bits format.
- **Payload File Path –** Configure the Payload File Path properties and the toolkit ignores other properties available in the Payload settings/ Digital Video Payload Control. This mode is used for generating signal with the data from the file. This Control is visible only if the Payload Mode selected as a Test File format.
- **Payload PN Order –** Specifies the order of the PN bit sequence to be generated. The valid values are 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.

4.3 Select **Impairments** to configure the following parameters for the selected carrier.

- **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.

Note: *- If Impairments Enabled is True, then the following parameters are enabled in the SFP otherwise the controls are disabled and grayed out.*

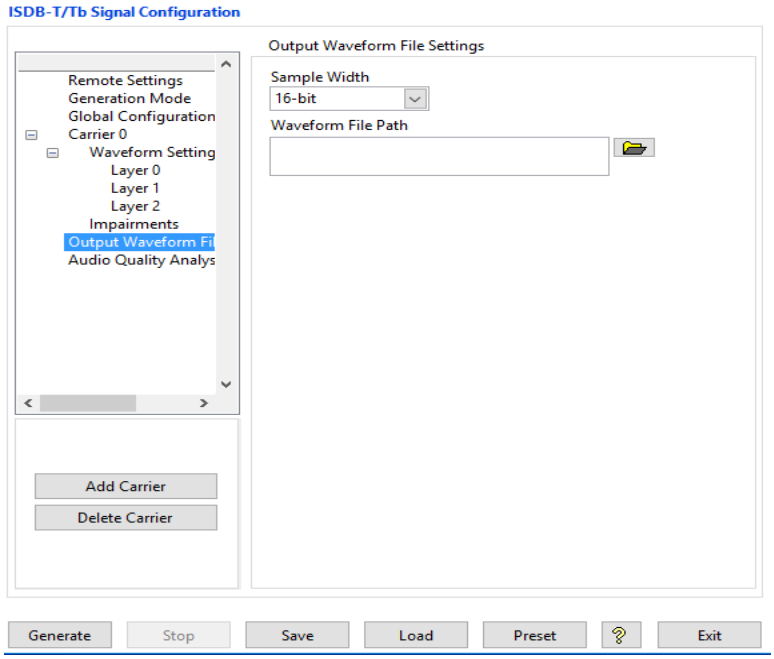


- **Clock Offset (PPM) -** The toolkit applies the clock offset to the generated waveform based on this value. The applied clock offset is relative to the clock frequency of the signal generator. The default value is 0.
- **Frequency Offset, Hz-** The toolkit applies frequency offset to the created waveform 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 40dB.

4.4 Select **Output Waveform Settings** to configure the following parameters to save output waveform in a file.

- **Sample Width –** The default sample width of the output waveform is 16-bits. The available options are 8-bits and 16-bits. We recommend using 16-bits sample width for better signal quality of the generated waveform.
- **Waveform File Path-** Select a path to save the waveform.
  Note: **-** Needs to be configured only when the generation mode is Generate and Save waveform.



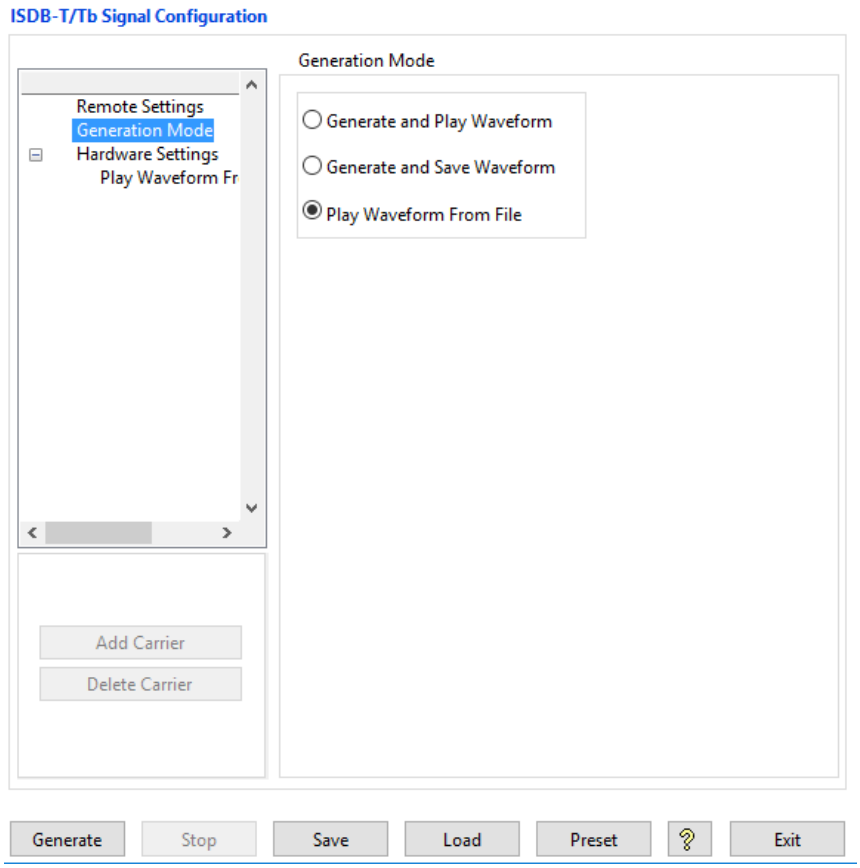
3.1.2 Play Waveform from File

In this generation mode ISDB-T Signal Generator reads the waveform from the file created using the Generate and Save waveform generation mode, explained in the section 3.1.1 of this section, 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 the CPU and available RAM memory.

Follow the procedure below to generate waveform using this generation mode

1. Select **Generation Mode** -> **Play Waveform from File**

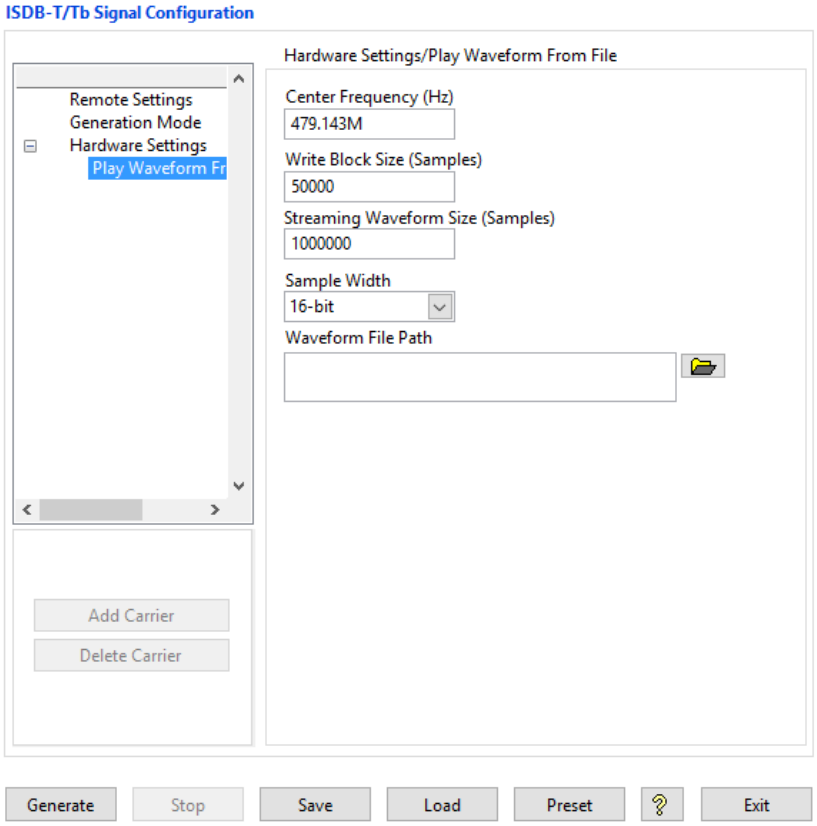


2. Select **Hardware Settings** to configure the following parameters.

- **Hardware Options –** Select hardware as **VSG/ VST** or **USRP**.

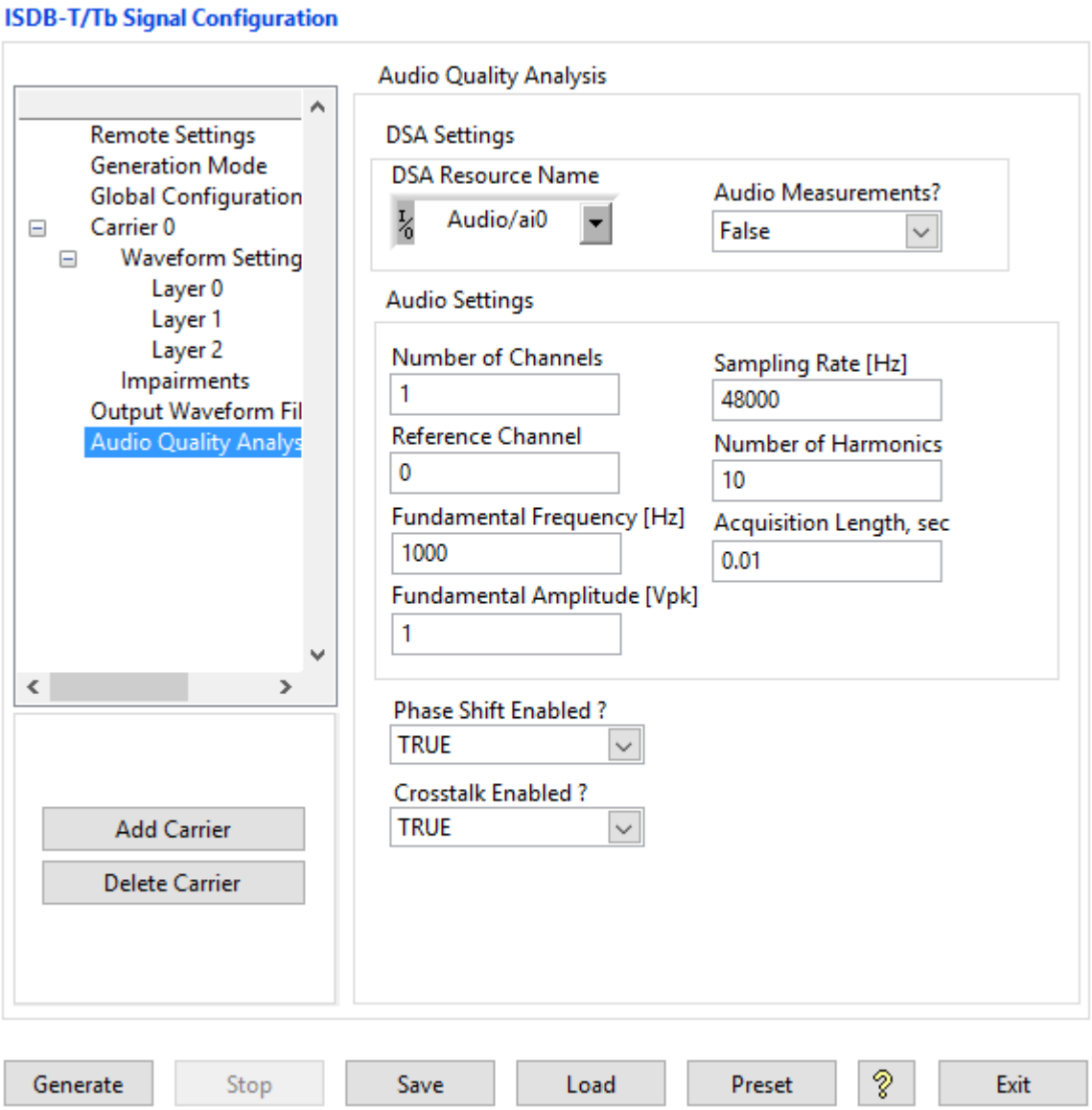
Refer section 3.1.1 of this document to configure the desired hardware.

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



- **Center Frequency (Hz) –** Specifies the center frequency of the signal to be generated in Hz
- **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 (Samples) –** Specifies the total memory allocated in the hardware for streaming the waveform in samples.
  ***Note**: - This parameter needs to be configured only if the chosen hardware is VSG/ VST.*
- **Sample Width –** Use the same sample width value used for saving the waveform in the file.
- **Waveform File Path –** Give the absolute path of the saved waveform intended to play in this generation mode.

4. Select **Audio Quality Analysis** to configure the following parameters.



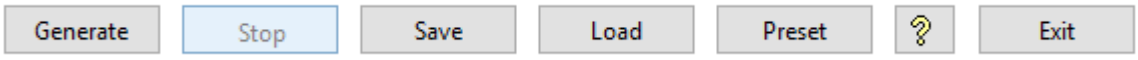
- **DSA Resource Name** – Configure the resource name used in NI Measurement and Automation explorer for the DAQmx.
- **Audio Measurements? –** Configure the audio measurements as a true to measure the audio quality analysis.
- **Channel Index –** Corresponds to audio channel, based on this measurement traces desired audio channels are displayed.
- **Audio Settings –** The Audio Settings for Audio Analyzer contains Configures the Audio Settings property of the Audio Signal Analysis handle. This Configuration gives the information about Audio tone and channels to analyze.
- **Number of Channels –** Number of Audio Channels to Analyze.

- **Reference Channel –** The Audio Channel to be analyzed.
- **Fundamental Frequency [Hz] –** The Input Single tone signal that was generated in the all of the audio channel.
- **Sampling Rate [Hz] –** Audio Signal sampling rate.
- **Number Harmonics –** Number Harmonic tones to be considered for Analysis.
- **Acquisition Length –** Configure the Acquisition Length in seconds, length in sec for which Audio Analysis measurements are carried out.
- **Phase Shift Enabled –** If Phase shift Enabled is true then Phase Shift Measurements are performed on the audio Channels or else Phase Shift Measurements are disabled.
- **Crosstalk Enabled –** If Crosstalk Enabled is true then Crosstalk Measurements are performed on the audio Channels or else Crosstalk Measurements are disabled.

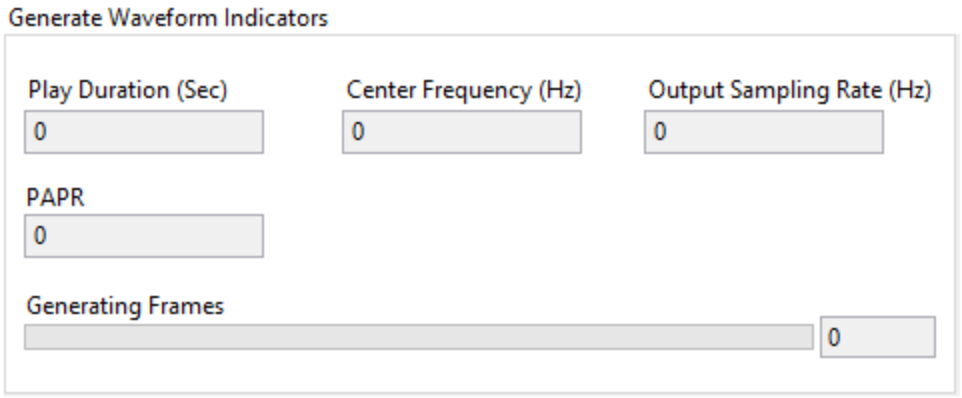
3.2 General SFP Controls and Indicators

- **Add carrier –** Click to add new carrier configuration with default values.
- **Delete Carrier –** Click to delete the selected carrier. Click on the appropriate **carrier tag** in a tree control or on any **child tag** like waveform settings, impairments, service configuration under specific **parent carrier tag** (carrier 0, carrier 1 etc.) to select which **carrier** is going be deleted.
  Note*: - One carrier configuration is default which can't be deleted.*
  All the items under the **parent carrier tag** specify configuration that need to be configured for each and every unique carrier.

- **Generate -** Click to generate signal as per the parameters configured.
- ***Note****: -* Parameters can 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 binary file.
- **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.
- **Exit** – Click to exit the application.

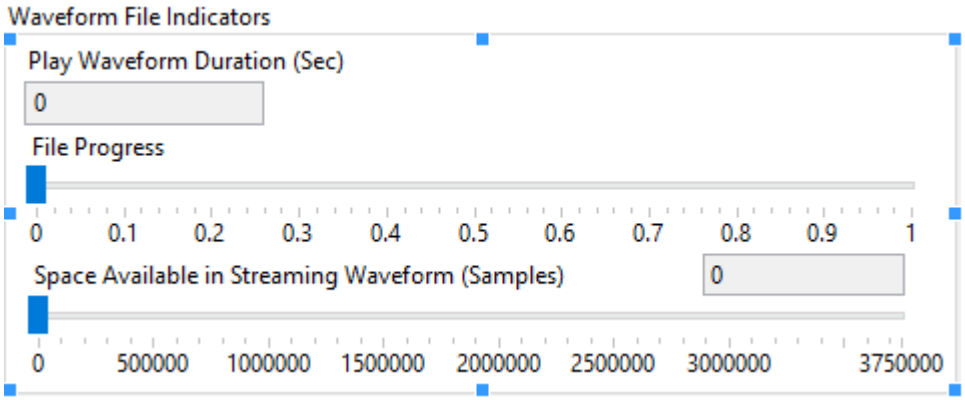


Generate Waveform Indicators



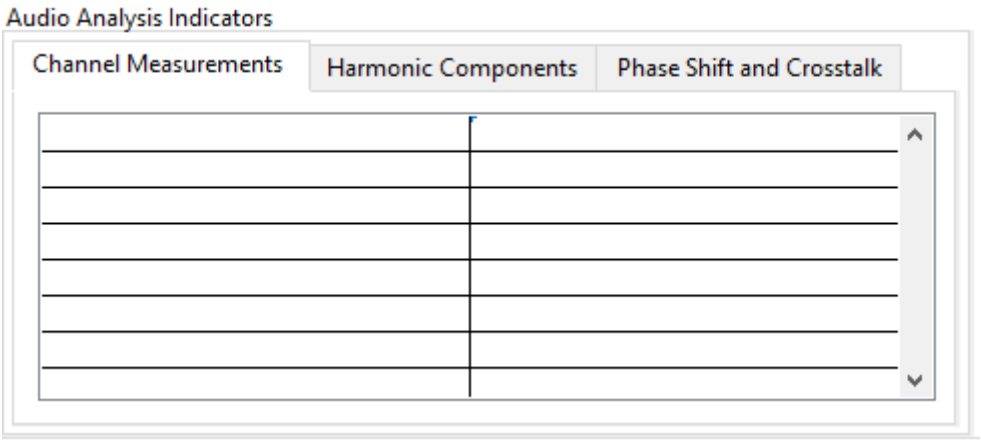
- **Play Duration (sec)** – Indicates the total duration, in seconds, of waveform generated. To generate longer duration of the waveform increase the Number of Frames value.
- **Center Frequency (Hz) –** Indicates the center frequency of the multiple carrier waveform. The same frequency must be used when using **Play Waveform from File** examples.
- **Output Sampling Rate (Hz) –** Indicates the sampling frequency of the generated IQ baseband waveform. **S**ame sampling rate/IQ rate must be used when using **Play Waveform from File** examples.
- **PAPR –** Peak to average power ratio, the peak divided by the Root Mean Square (RMS) of the waveform. Based on this value, the Headroom (dB) can be set.
- **Generating Frames –** To visualize the progress of generating signal.

Waveform File Indicators



- **Play Waveform Duration (sec) –** Indicates the total duration, in seconds, of waveform generated. To generate longer duration of the waveform increase the Number of Frames value.
- **File Progress –** Indicates the file progress of a generating waveform.
- **Space Available in Streaming Waveform –** Returns the space available in streaming waveform in VSG hardware. This control is enabled only for VSG Playback from file.

Audio Analysis Indicators



Returns the audio analysis output parameters Channel Measurements, Harmonic Components, Crosstalk and Phase shift.

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

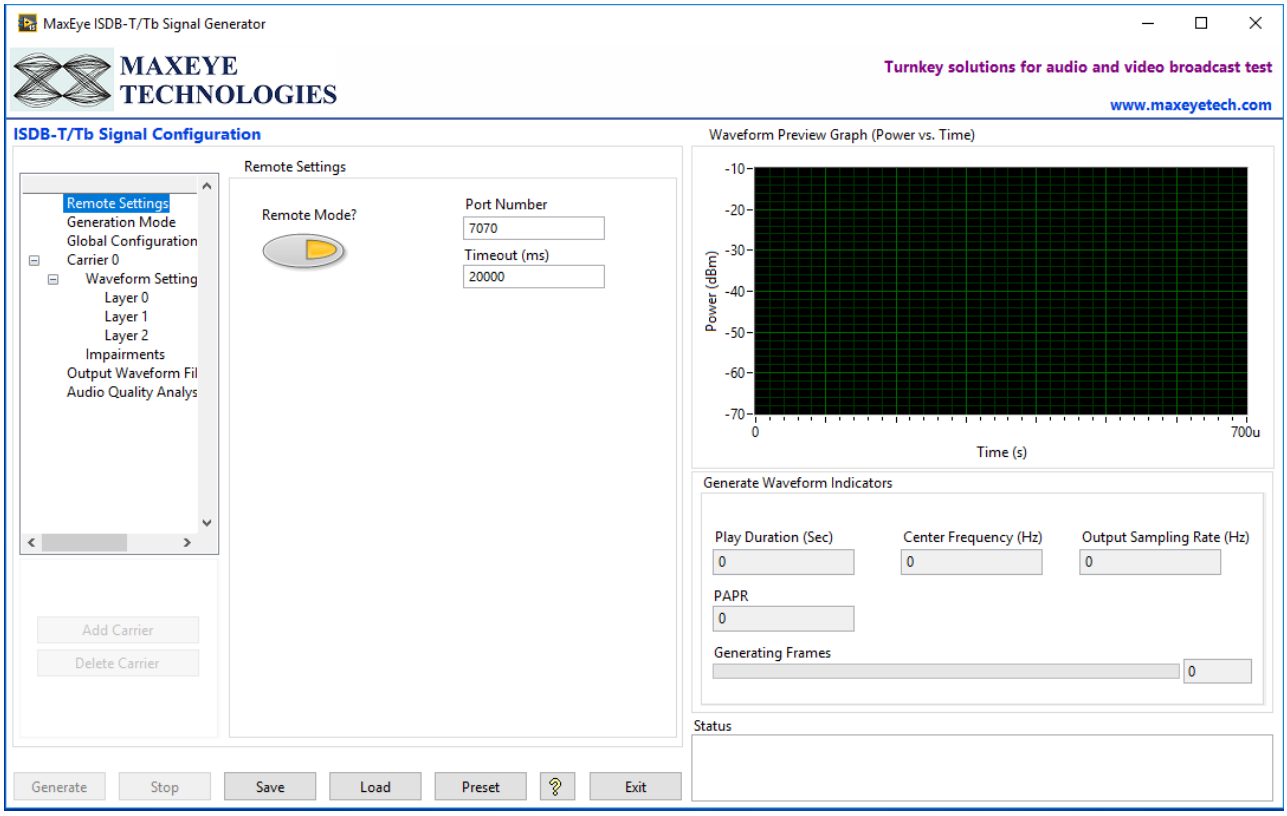
3.3 Remote Mode

Remote mode allows user to control the MaxEye ISDB-T/Tb Signal Generator remotely using programming examples (LabVIEW or C) to generate signals. The programming examples and APIs are provided with the ISDB-T/Tb signal generation toolkit.

Follow the below procedure in SFP to run the ISDB-T/Tb Signal Generator in Remote Mode

1. Select **Remote Settings** to configure the following parameters

- **Remote Mode?** – Turn **Remote Mode?** switch **ON** (Remote) or **OFF** (Local) as required. The glowing yellow LED indicates ON state of the switch. By default, the Remote Mode? switch is in **OFF** state.
- **Port Number** – Configure this control if **Remote Mode is ON**. Both client (MaxEye DRM Radio Generator) and server application must have same port number. The default Port Number is **7070**.
- **Timeout (ms)** – Configure this control if **Remote Mode is ON.** Timeout specifies the time in milliseconds that the client waits for a connection to be established with the server application. If a connection is not established in the specified time, the MaxEye Universal Radio Generator returns an error. The default Timeout is **20 seconds**.



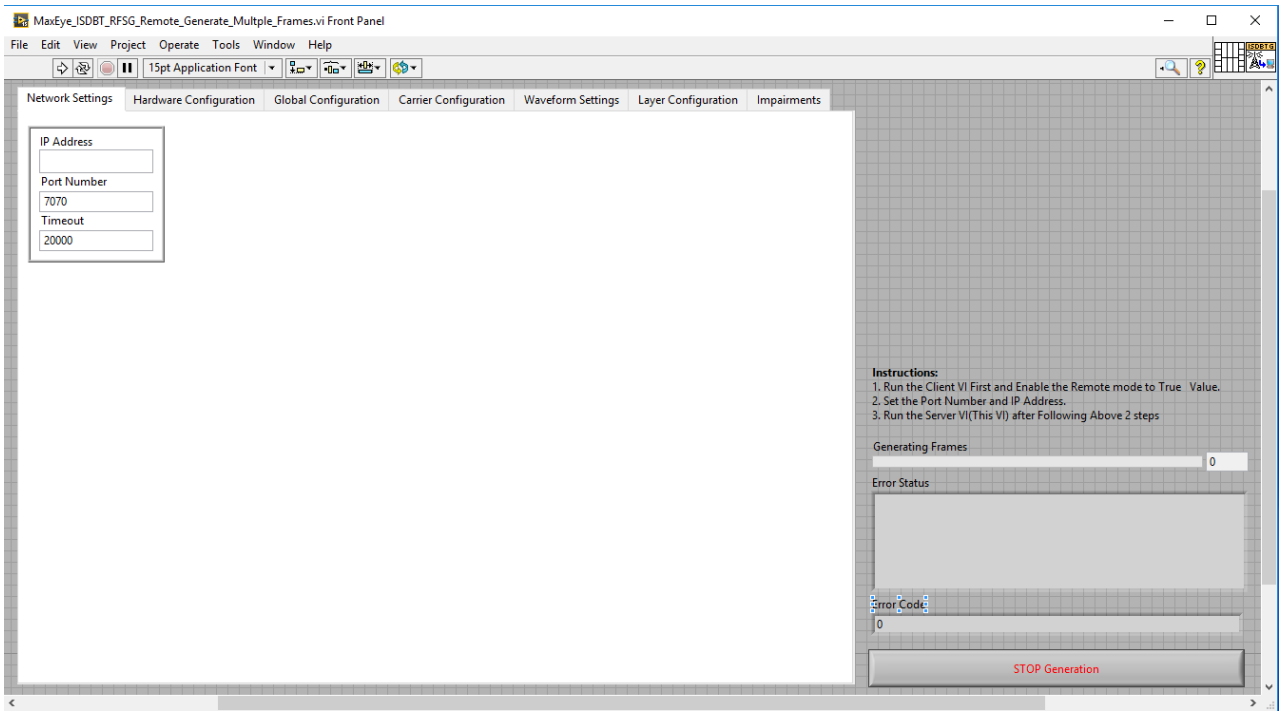
3.3.1 ISDB-T Signal Generator Remote Mode LabVIEW Examples Procedure

3.3.1.1 ISDB-T Generate Multiple Frames

Follow the below procedure to configure the example

1. Find the ISDB-T LabVIEW Remote example in, <LabVIEW>examples\MaxEye\Digital Video Toolkits\ISDB-T Generation\Remote
2. Open **MaxEye ISDBT RFSG Remote Generate Multiple Frames.vi**
3. The user configurations are organized into the following categories displayed in multiple Tabs
   - Network Settings
   - Hardware Configuration
   - Global Configuration
   - Carrier Configuration
   - ISDB-T Configuration
   - Layer Configuration
   - Impairments

Navigate to the **Network Settings** tab to configure the following parameters



- **IP Address –** Configure the IP address of the client system in which the MaxEye ISDB-T Signal Generator is intended to run.
- **Port Number –** Both client (MaxEye ISDB-T Signal Generator) and server application must have same port number. The default Port Number is **7070**.
- **Timeout (ms)** – Timeout specifies the time in milliseconds that the client waits for a connection to be established with the server application. If a connection is not established in the specified time, the MaxEye ISDB-T Signal Generator returns an error. The default Timeout is **20 seconds**.

For configuring other parameters, please refer section 3.1.1 of this document.

4. Run the example. Now the MaxEye ISDB-T Signal Generator 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 remote system starts generating the waveform.

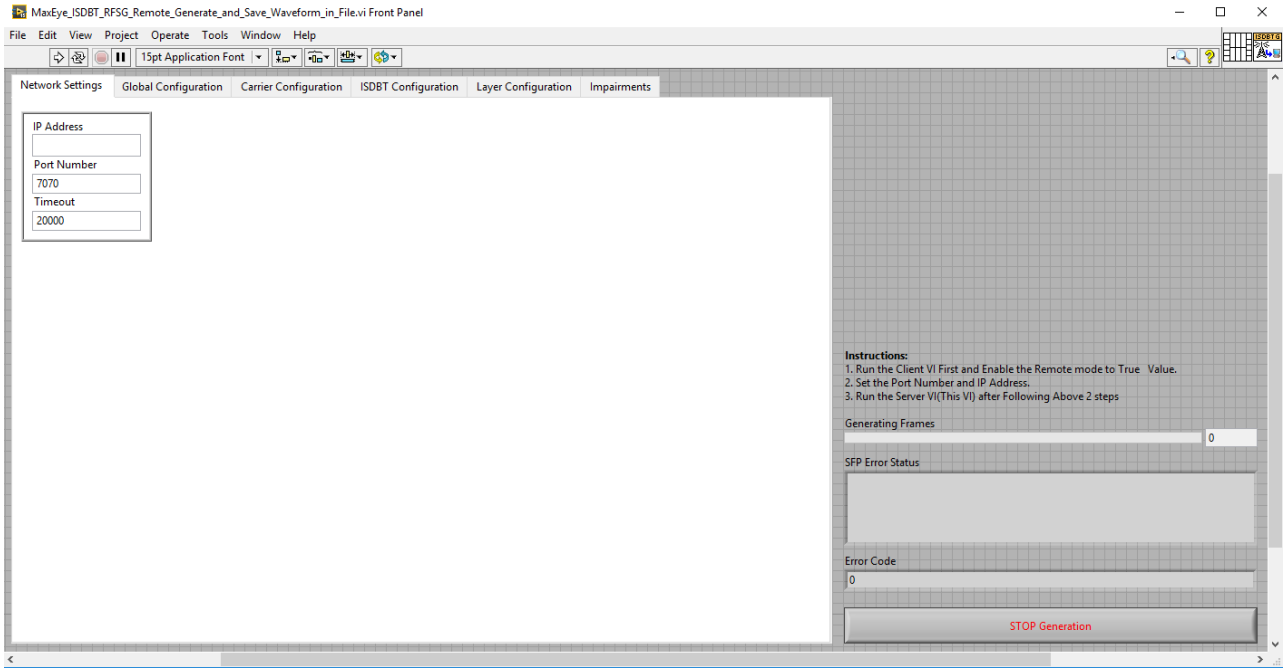
3.3.1.2 ISDB-T Generate and Save Waveform in file

Follow the below procedure to configure the example

1. Find the ISDB-T LabVIEW Remote example in, <LabVIEW>examples\MaxEye\Digital Video Toolkits\ISDB-T Generation\Remote
2. Open **MaxEye ISDBT SG Remote Generate and Save Waveform in File.vi**

3. The user configurations are Organized into the following categories displayed in multiple Tabs
   - Network Settings
   - Global Configuration
   - Carrier Configuration
   - ISDB-T Configuration
   - Layer Configuration
   - Impairments

Navigate to the **Network Settings** tab to configure the following parameters



- **IP Address –** Configure the IP address of the client system in which the MaxEye ISDB-T Signal Generator is intended to run.
- **Port Number –** Both client (MaxEye ISDB-T Signal Generator) and server application must have same port number. The default Port Number is **7070**.
- **Timeout (ms)** – Timeout specifies the time in milliseconds that the client waits for a connection to be established with the server application. If a connection is not established in the specified time, the MaxEye ISDB-T Signal Generator returns an error. The default Timeout is **20 seconds**.

For configuring other parameters, please refer section 3.1.1 of this document.

4. Run the example. Now the MaxEye ISDB-T Signal Generator validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by

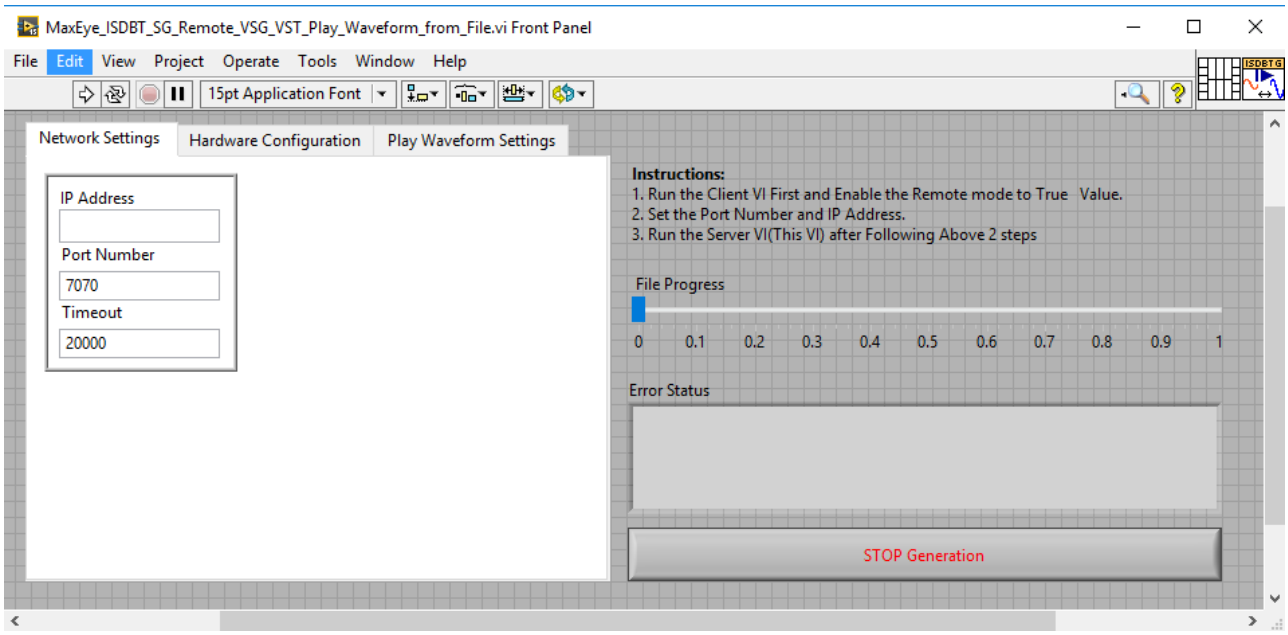
the toolkit. If the configuration is successfully validated the remote system starts generating the waveform.

3.3.1.3 ISDBT VSG VST Play Waveform from File

Follow the below procedure to configure the example

1. Find the ISDB-T LabVIEW Remote example in, <LabVIEW>examples\MaxEye\Digital Video Toolkits\ISDB-T Generation\Remote
2. Open **MaxEye ISDBT SG Remote VSG VST Play Waveform from File.vi**
3. The user configurations are Organized into the following categories displayed in multiple Tabs
   - Network Settings
   - Hardware Configuration
   - Play Waveform Settings

Navigate to the **Network Settings** tab to configure the following parameters



- **IP Address –** Configure the IP address of the client system in which the MaxEye ISDB-T Signal Generator is intended to run.
- **Port Number –** Both client (MaxEye ISDB-T Signal Generator) and server application must have same port number. The default Port Number is **7070**.
- **Timeout (ms)** – Timeout specifies the time in milliseconds that the client waits for a connection to be established with the server application. If a connection is not established in the specified time, the MaxEye ISDB-T Signal Generator returns an error. The default Timeout is **20 seconds**.

For configuring other parameters, please refer section 3.1.1 of this document.

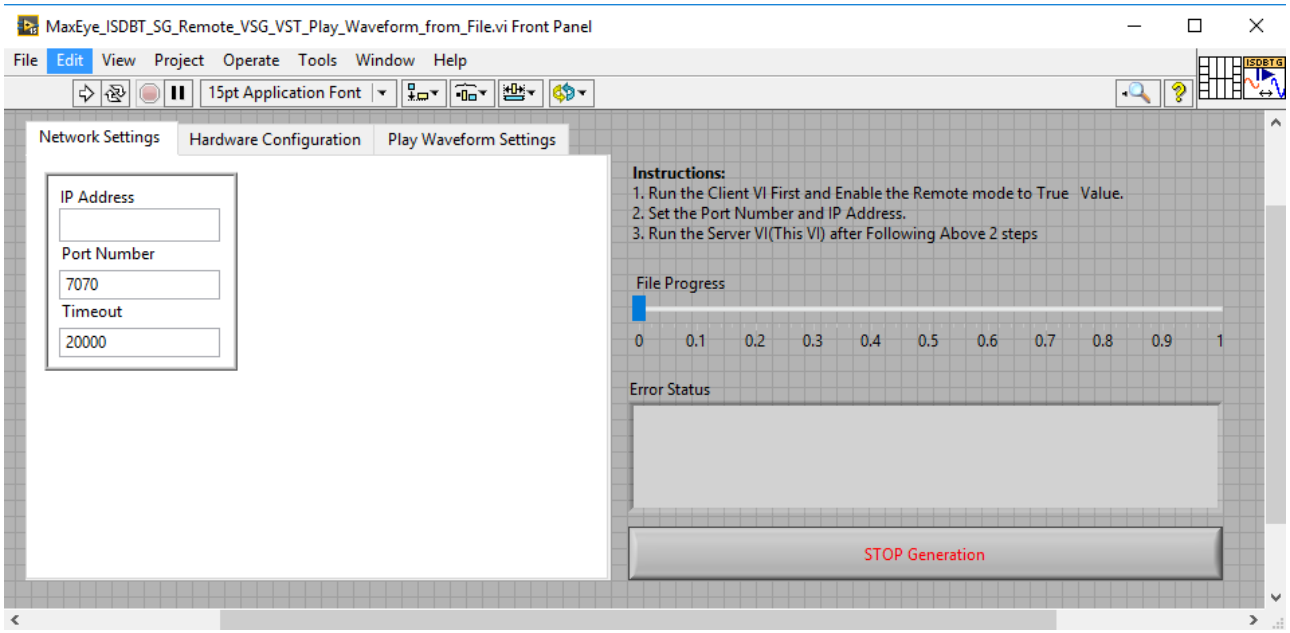
4. Run the example. Now the MaxEye ISDB-T Signal Generator validates the user configuration and reports error to the user if the configuration is not as per the standard or not supported by the toolkit. If the configuration is successfully validated the remote system starts generating the waveform.

3.3.1.4 ISDBT USRP Play Waveform from File

Follow the below procedure to configure the example

1. Find the ISDB-T LabVIEW Remote example in, <LabVIEW>examples\MaxEye\Digital Video Toolkits\ISDB-T Generation\Remote
2. Open **MaxEye ISDBT SG Remote USRP Play Waveform from File.vi**
3. The user configurations are Organized into the following categories displayed in multiple Tabs
   - Network Settings
   - Hardware Configuration
   - Play Waveform Settings

Navigate to the **Network Settings** tab to configure the following parameters



- **IP Address –** Configure the IP address of the client system in which the MaxEye ISDB-T Signal Generator is intended to run.
- **Port Number –** Both client (MaxEye ISDB-T Signal Generator) and server application must have same port number. The default Port Number is **7070**.

- **Timeout (ms)** – Timeout specifies the time in milliseconds that the client waits for a connection to be established with the server application. If a connection is not established in the specified time, the MaxEye ISDB-T Signal Generator returns an error. The default Timeout is **20 seconds**.

For configuring other parameters, please refer section 3.1.1 of this document.

4. Run the example. Now the MaxEye ISDB-T Signal Generator 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 remote system starts generating the waveform.

3.3.2 ISDB-T Signal Generator Remote Mode C Examples Procedure

3.3.2.1 ISDB-T Generate Multiple Frames

MaxEye ISDBT Generate and Play Init.c

(Global Scope)

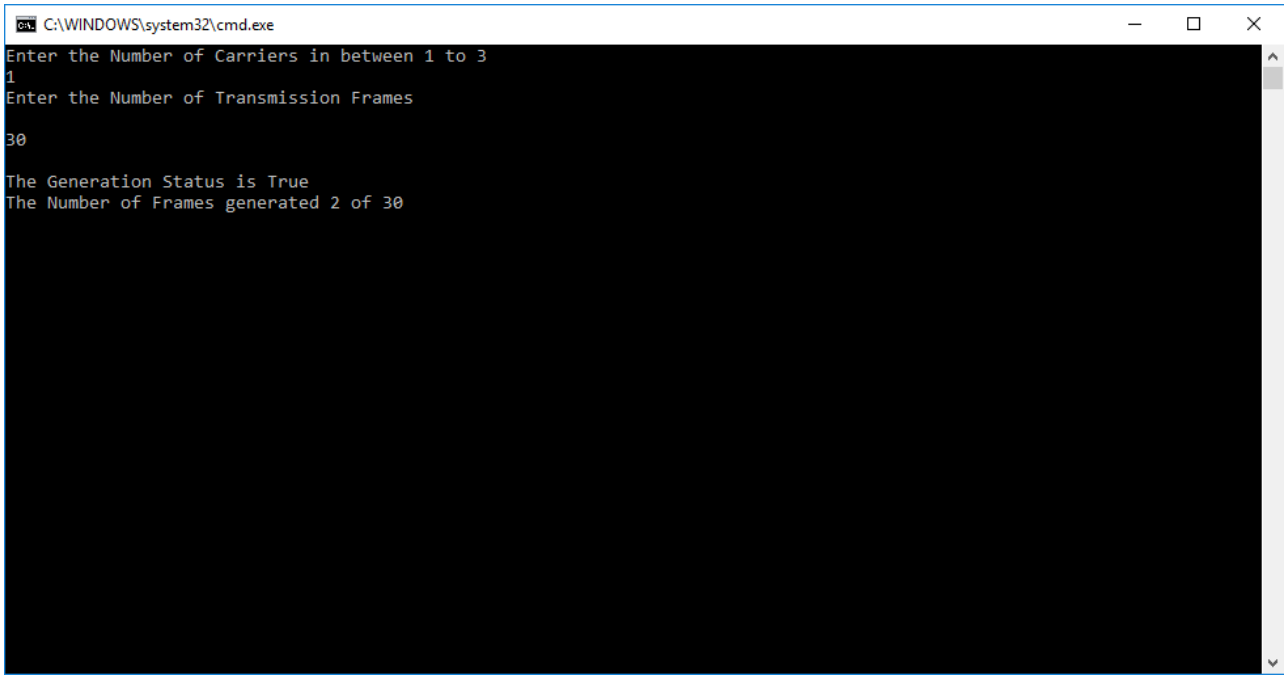
```
/*****************************************************************************************************************
Function Name: MaxEye ISDB-T Generate and Play Init

Description:

The Main aim of this function is to define all the User Configurable ISDB-T parameters.
*****************************************************************************************************************/
#include <stdio.h>
#include "..\Includes\MaxEye Utilities Typedefs.h"
#include "..\Includes\MaxEye ISDBT Generate and Play Defines.h"
#include "..\Includes\MaxEye ISDBT Generate and Play Externs.h"

char IP_Address[]="localhost";                                          //IP Address of the client system
char RFSG_Resource[]="PXI1Slot2";
UINT16 Command_Type=0;                                                  //0- StartGeneration, 1- StopGeneration
UINT32 Hardware_Type=0;                                                 //Select Hardware Type 0 - VSG/VST, 1-USRP
double Carrier_Frequency[MAX_NUM_CARRIERS] = {479143000, 485143000, 491143000};    //Multi Carrier Frequency
UINT16 Carrier_Bandwidth[MAX_NUM_CARRIERS] = {0, 0, 0};                 //0- 6MHz, 1- 7MHz, 2- 8MHz
char *TSFilePath[MAX_NUM_CARRIERS][1] =
{
    {"C:\\MAXEYE\\TS Files\\ISDBT\\18ch_GloboHD.ts"},                   //MPEG2TS_File_Path  Specify appropriate TS File path
    {"C:\\MAXEYE\\TS Files\\ISDBT\\22ch_canal HD.ts"},
    {"C:\\MAXEYE\\TS Files\\ISDBT\\29ch_RedeTVHD.ts"}
};
int NumberofSegments[MAX_NUM_CARRIERS][3] =
{
    {1, 12, 0},
    {1, 12, 0},
    {1, 12, 0}
};                                                                      //Number of segments in each layer
UINT16 Modulation_Scheme[MAX_NUM_CARRIERS][3] =
{
    {1, 3, 0},
    {1, 3, 0},
    {1, 3, 0}
};                                                                      //Modulation Shceme in each layer 0- DQPSK, 1- QPSK, 2- 16QAM, 3- 64QAM
```

100 %

Follow the below procedure to configure the example

1. Find the Remote C examples in, C:\Program Files (x86)\MaxEye\Digital Video Toolkits\ ISDB-T Generation\Generation\C\Generate Multiple Frames
2. Open the desired example directory and open the solution file **Generate Multiple Frames.jsln** in **Microsoft visual C++**.
3. Navigate to **MaxEye ISDB-T Generate and Play Init.c** from the solution explorer.

4. Configure the parameters listed as required. For help, please follow the comments given against each configuration parameter.
5. Navigate to **MaxEye ISDB-T Generate and Play Main.c** 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. Enter the required **Number of Carriers**.
7. Enter the desired **Number of Frames**.

Now the MaxEye ISDB-T/Tb Signal Generator validates the user configuration and reports error to the user if the configuration is not as per standard or not supported by the toolkit. If the configuration is successfully validated the remote system starts generating the waveform.

8. Press any key, to stop the generation.

3.3.2.2 ISDB-T Generate and Save Waveform

MaxEye ISDBT Generate and Save Init.c

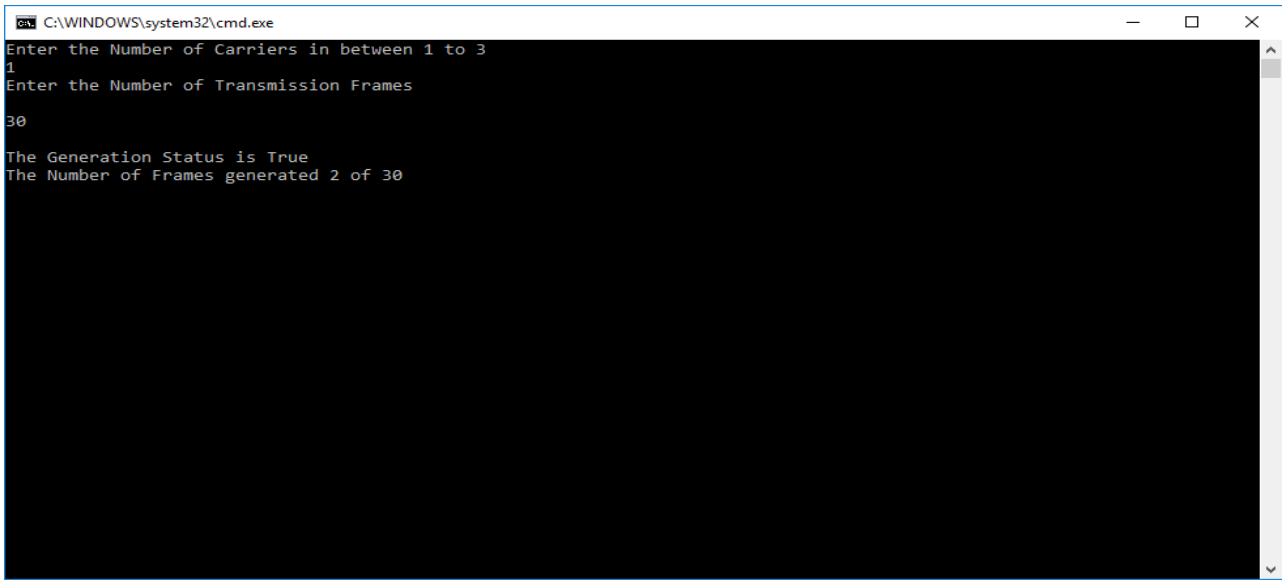
(Global Scope)

```
/*****************************************************************************************************************************
Function Name: MaxEye ISDB-T Generate and Save Init

Description:

The Main aim of this function is to define all the User Configurable ISDB-T parameters.
*****************************************************************************************************************************/

#include <string.h>
#include "..\Includes\MaxEye Utilities Typedefs.h"
#include "..\Includes\MaxEye ISDBT Generate and Save Defines.h"
#include "..\Includes\MaxEye ISDBT Generate and Save Externs.h"

char IP_Address[]="localhost";                                          //IP Address of the client system
char Waveform_File_Path[]="C:\MAXEYE\\TS Files\\ISDBT\\ISDBT_C_1Carr.bin";  //Specify appropriate file path to save waveform
UINT16 Command_Type=0;                                                  //0- StartGeneration, 1- StopGeneration
double Carrier_Frequency[MAX_NUM_CARRIERS] = {479143000, 485143000, 491143000};  //Multi Carrier Frequency
UINT16 Carrier_Bandwidth[MAX_NUM_CARRIERS] = {0, 0, 0};                 //0- 6MHz, 1- 7MHz, 2- 8MHz
char *TSFilePath[MAX_NUM_CARRIERS][1] =
{
    {"C:\MAXEYE\\TS Files\\ISDBT\\18ch_GloboHD.ts"},                    //MPEG2TS_File_Path  Specify appropriate TS File path
    {"C:\MAXEYE\\TS Files\\ISDBT\\22ch_canal HD.ts"},
    {"C:\MAXEYE\\TS Files\\ISDBT\\29ch_RedeTVHD.ts"}
};
int NumberofSegments[MAX_NUM_CARRIERS][3] =
{
    {1, 12, 0},
    {1, 12, 0},
    {1, 12, 0}
};                                                                      //Number of segments in each layer
UINT16 Modulation_Scheme[MAX_NUM_CARRIERS][3] =
{
    {1, 3, 0},
    {1, 3, 0},
    {1, 3, 0}
};                                                                      //Modulation Shceme in each layer 0- DQPSK, 1- QPSK, 2- 16QAM, 3- 64QAM
```

100 %

Follow the below procedure to configure the example

1. Find the C example in, C:\Program Files (x86)\MaxEye\Digital Video Toolkits\ ISDB-T Generation\Generation\C\Generate and Save Waveform
2. Open the desired example directory and open the solution file **Generate and Save.jsln** in **Microsoft visual C++.**
3. Navigate to **MaxEye ISDB-T Generate and Save Init.c** from the solution explorer.
4. Configure the parameters listed as required. For help, please follow the comments given against each configuration parameter.
5. Navigate to **MaxEye ISDB-T Generate and Save Main.c** 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.



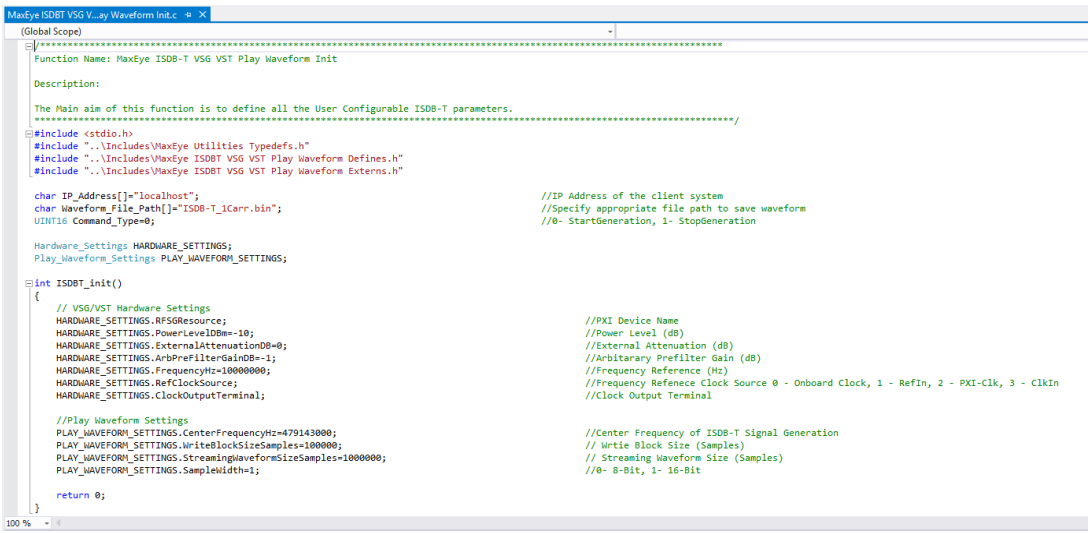
6. Enter the required **Number of Carriers**.
7. Enter the desired **Number of Frames**.

Now the MaxEye ISDB-T/Tb Signal Generator validates the user configuration and reports error to the user if the configuration is not as per standard or not supported by the toolkit. If the configuration is successfully validated the remote system starts generating the waveform.

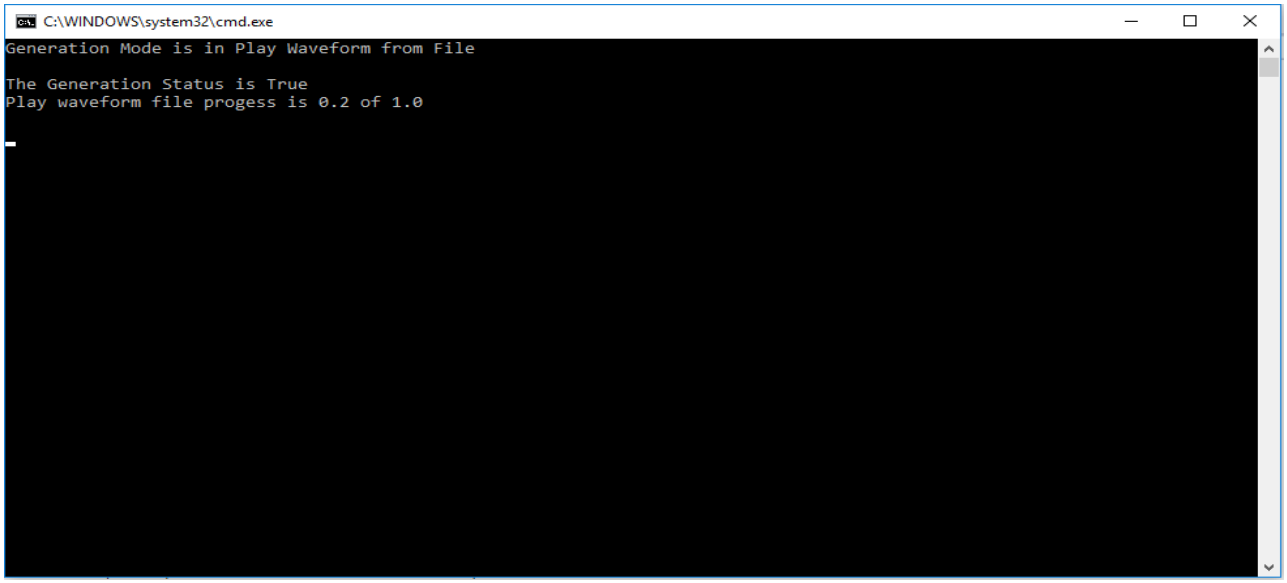
8. Press any key, to stop the generation.

3.3.2.3 ISDBT VSG VST Play Waveform from File

Follow the below procedure to configure the example



1. Find the C example in, C:\Program Files (x86)\MaxEye\Digital Video Toolkits\ ISDB-T Generation\Generation\C \VSG VST Play Waveform from File
2. Open the desired example directory and open the solution file MaxEye **VSG VST Play Waveform.jsln** in **Microsoft visual C++.**
3. Navigate to **MaxEye ISDB-T VSG VST Play Waveform Init.c** from the solution explorer.
4. Configure the parameters listed as required. For help, please follow the comments given against each configuration parameter.
5. Navigate to **MaxEye ISDB-T VSG VST Play Waveform Main.c** 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 MaxEye ISDB-T/Tb Signal Generator validates the user configuration and reports error to the user if the configuration is not as per standard or not supported by the toolkit. If the configuration is successfully validated the remote system starts generating the waveform.

6. Press any key, to stop the generation.

3.3.2.4 ISDBT USRP Play Waveform from File

MaxEye ISDBT USRP...lay Waveform Init.c

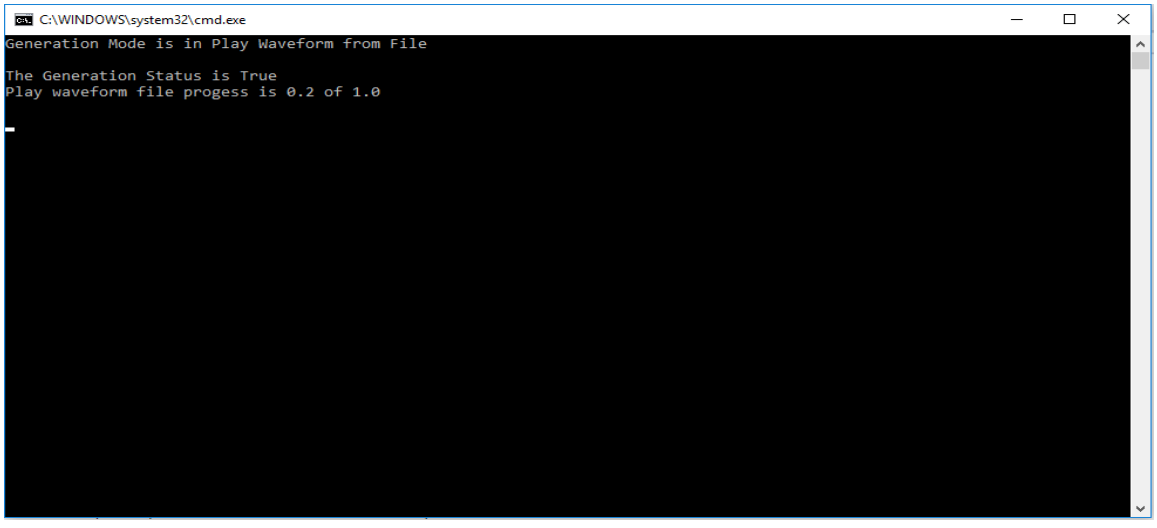
(Global Scope)

```
/*****************************************************************************************************************************
Function Name: MaxEye ISDB-T USRP Play Waveform Init

Description:

The Main aim of this function is to define all the User Configurable ISDB-T parameters.
*****************************************************************************************************************************/
#include <stdio.h>
#include <string.h>
#include "..\Includes\MaxEye Utilities Typedefs.h"
#include "..\Includes\MaxEye ISDBT USRP Play Waveform Defines.h"
#include "..\Includes\MaxEye ISDBT USRP Play Waveform Externs.h"

char IP_Address[]="localhost";                          //IP Address of the Client system
char USRP_IPAddress[]="192.168.10.2";                   //IP Address of the USRP system
char Waveform_File_Path[]="ISDBT_1Carr.bin";            //Specify appropriate file path to save waveform
double USRP_Carrier_Frequency=479143000;                //USRP Carrier Frequency (Hz)
double Gain=0;                                          //USRP Gain (dB)
UINT16 Sample_Width=1;                                  //0- 8-Bit, 1- 16-Bit   (Applicable for Generation_Mode -1 & 2)
int Write_Block_Size=50000;                             //Write Block Size in Samples
UINT16 Command_Type=0;                                  //0- StartGeneration, 1- StopGeneration
```

100 %

Follow the below procedure to configure the example

1. Find the C example in, C:\Program Files (x86)\MaxEye\Digital Video Toolkits\ ISDB-T Generation\Generation\C \USRP Play Waveform from File
2. Open the desired example directory and locate the project file **MaxEye ISDB-T USRP Play Waveform.jsln** in **Microsoft visual C++**.
3. Navigate to **MaxEye ISDB-T USRP Play Waveform Init.c** from the solution explorer.
4. Configure the parameters listed as required. For help, please follow the comments given against each configuration parameter.
5. Navigate to **MaxEye ISDB-T USRP Play Waveform Main.c** 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 MaxEye ISDB-T/Tb Signal Generator validates the user configuration and reports error to the user if the configuration is not as per standard or not supported by the toolkit. If the configuration is successfully validated the remote system starts generating the waveform.

6. Press any key, to stop the generation.

4 Programming Examples

The ISDB-T Signal generation toolkit 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.
iii. Playing the waveform using NI VSG, NI VST and NI USRP.

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 ISDB-T Signal Generation Help.chm** document, accessible at

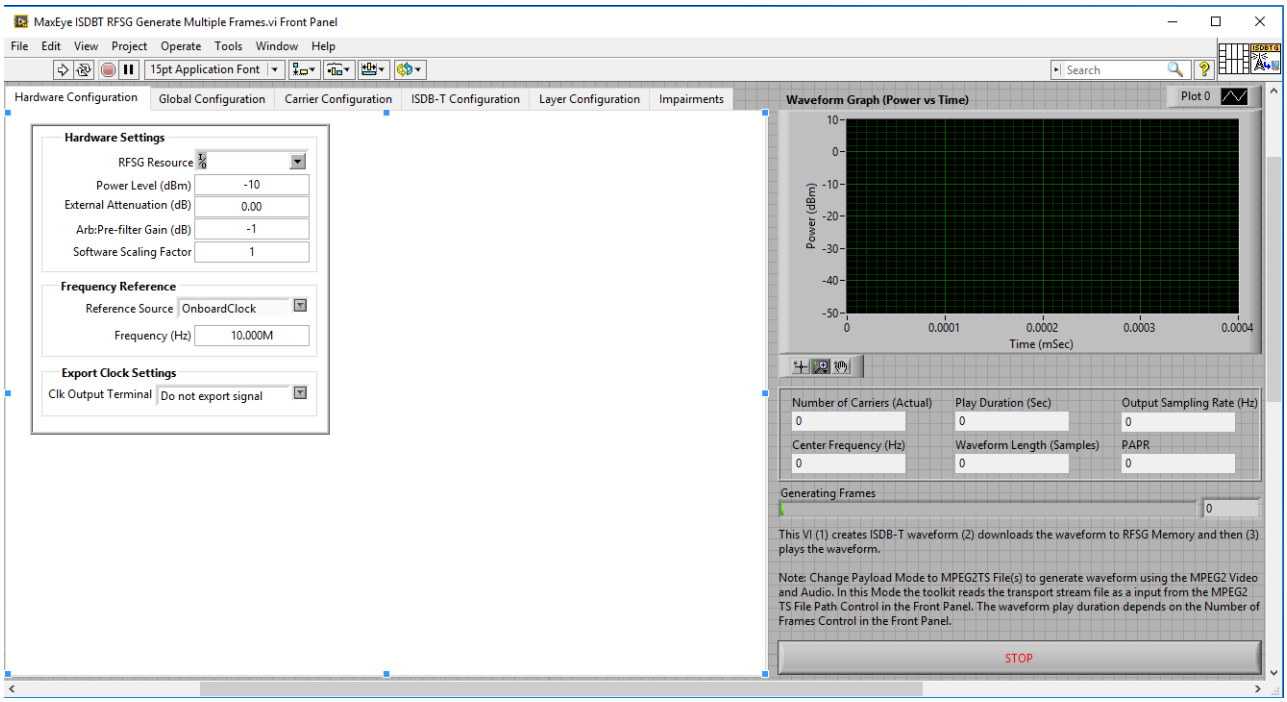
Start ->All Programs->MaxEye->Digital Video Toolkits-> ISDB-T ->Documentation.

4.1 ISDB-T Signal Generation

The ISDB-T is a Japanese standard for digital terrestrial television and a derivative of ISDB, ISDB-T is developed by the Brazilian government and is being widely adopted in South America. ISDB-T standard supports hierarchical transmission to support both partial reception, fixed and mobile reception. Each hierarchical layer consists of one or more OFDM segments and parameters such as the carrier modulation scheme, inner-code coding rate, and time interleaving length can be specified for each hierarchical layer. The standard supports up to 3 hierarchical layers including the partial reception hierarchical layer which is transmitted in one segment.

4.1.1 MaxEye ISDB-T RFSG Generate Multiple Frames

This Example is used to generate multiple Transmission Frames. TS stream is used for generating the signal for ISDB-T waveforms. The figure below shows the front panel of the Example VI.



The user configurations are divided into following categories displayed in multiple Tabs

- Hardware Configuration
- Global Configuration
- Carrier Configuration
- ISDB-T Configuration
- Layer Configuration
- Impairments Configuration

Please refer section 3.1.1 of this document for the configuration procedure and control details.

How to Configure for Single Carrier/ Multiple Carriers

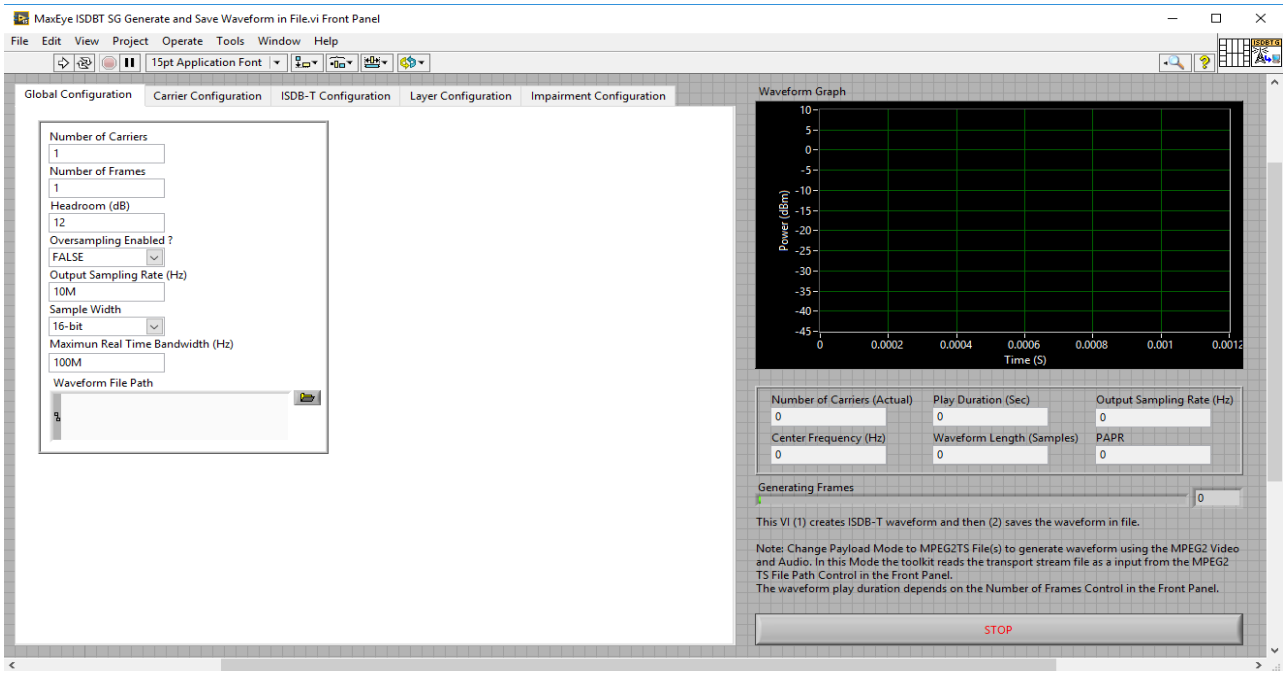
Please refer section 6 of this document for information on configuring for Single Carrier and Multiple Carriers.
After configuring all the parameters, run the example to start generating the waveform. Press **Stop** to stop generation at any time. Error dialog box pops up to the user if any error occurs. The user can click either **Continue** or **Stop** from the error dialog box to abort the generation.

Indicators

Please refer section 3.2 of this document for the indicator details.

4.1.2 MaxEye ISDBT SG Generate and Save Waveform in File

This Example is used to generate multiple ISDB-T transmission frames and the generated waveform is stored in a file for play back. The figure below shows the front panel of the Example VI.



The user configurations are divided into following categories displayed in multiple Tabs

- Global Configuration
- Carrier Configuration
- ISDB-T Configuration
- Layer Configuration
- Impairments Configuration

Please refer section 3.1.1 of this document for the configuration procedure and control details.

- **Maximum Real Time Bandwidth –** The available bandwidth to combine the multi carrier waveform based on the selected hardware.

Please refer section 5.1.1 of this document for the other indicator details in the example.

How to Configure for Single Carrier/ Multiple Carriers

Please refer section 6 of this document for information on configuring for Single Carrier and Multiple Carriers.

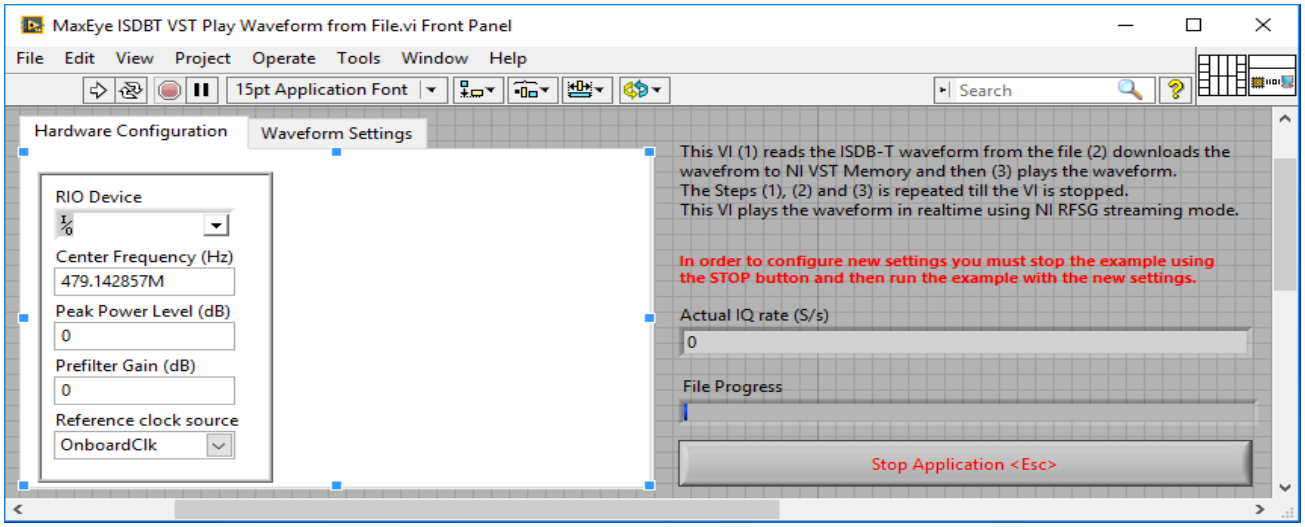
After configuring all the parameters, run the example to start generating the waveform. Press **Stop** to stop generation at any time. Error dialog box pops up to the user if any error occurs. The user can click either **Continue** or **Stop** from the error dialog box to abort the generation.

4.1.3 MaxEye ISDBT RFSG Play Waveform from File

This example reads the ISDB-T waveform from the file created using the previous example in section 3.2 and then real time downloads the waveform 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/

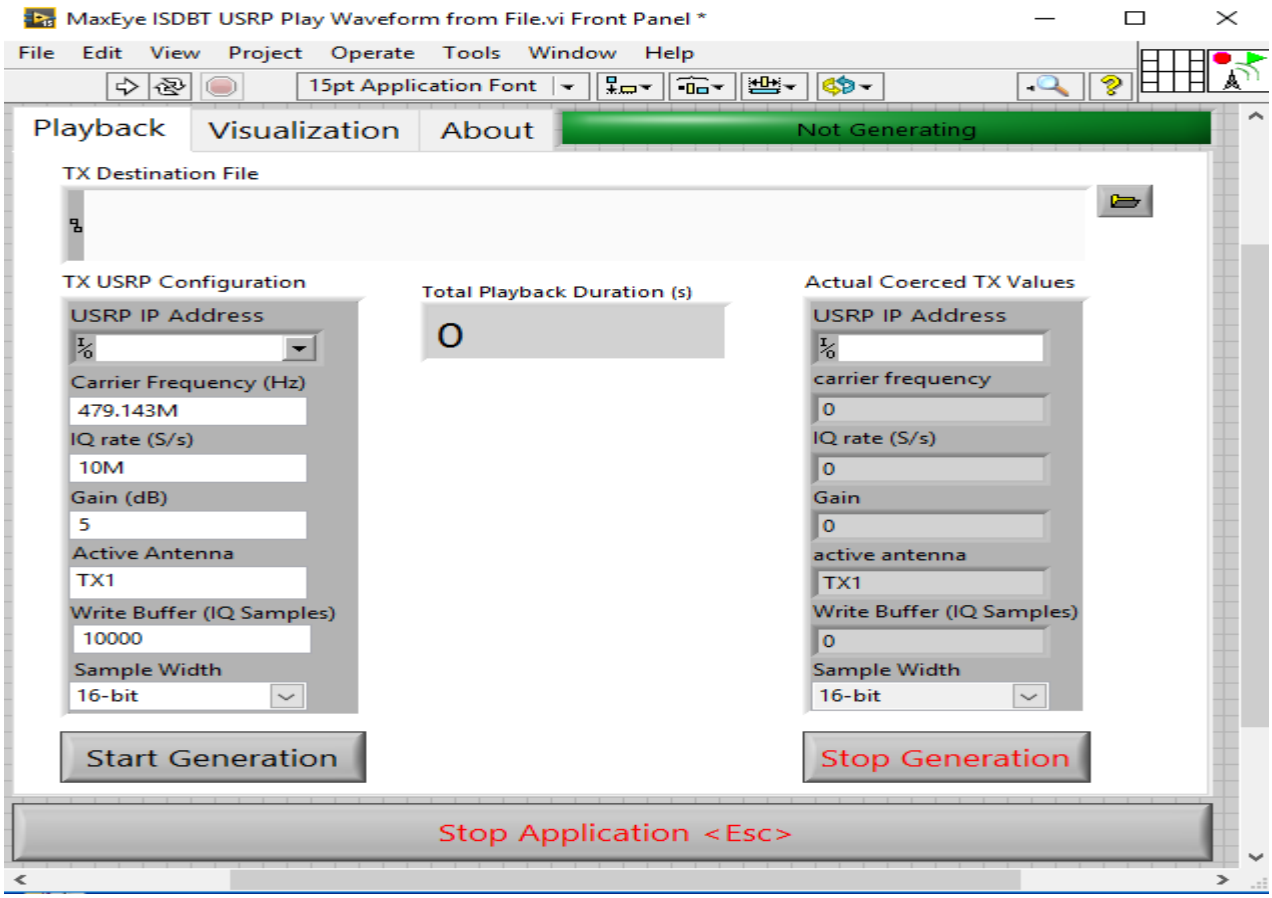
Please refer section 3.1.2 of this document for configuration procedure and control details.

After configuring all the parameters, run the example and click **Start Generation** to start generating the waveform. Press **Stop Generation** to stop generation at any time. Error dialog box pops up to the user if any error occurs. The user can click either **Continue** or **Stop** from the error dialog box to abort the generation.

4.1.4 MaxEye ISDBT USRP Play Waveform from File

This example reads the ISDB-T waveform from the file created using the example mentioned in the Section 5.1.2 and then downloads the waveform in real time to NI USRP memory and then plays the waveform. 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.

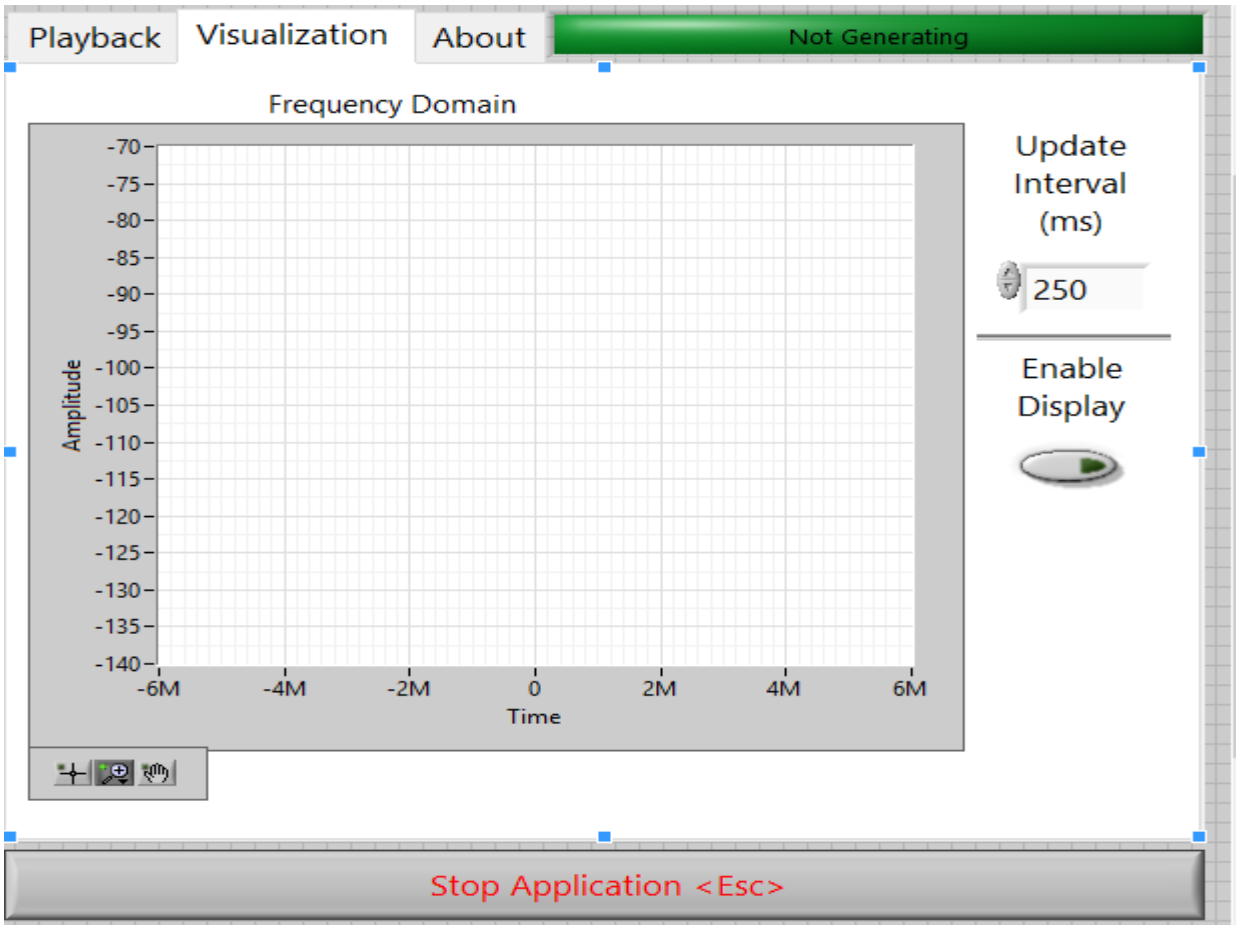


Please refer section 3.1.2 of this document for configuration procedure and control details.

- **IQ Rate (S/s) –** Rate of the baseband I/Q data in samples per second (S/s).

Visualization

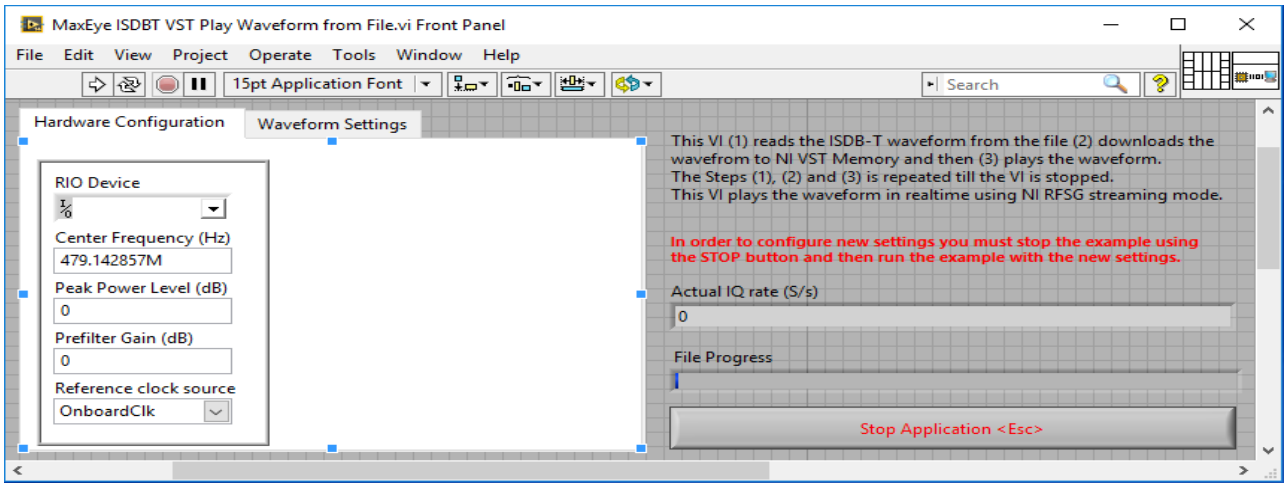
The spectrum of the generated waveform can be monitored in the Visualization Tab. **Enable Display** button needs to set to ON state in order to view the spectrum.



4.1.5 MaxEye ISDBT VST Play Waveform from File

This example reads the ISDB-T waveform from the file created using the example mentioned in the Section3.2. This example deploys the bit file dynamically to the respective target (FPGA) and configures a stream from the Host to the FPGA target and writes waveform data to the streaming DMA FIFO.

The figure below shows the front panel of the Example VI.



Please refer section 3.1.2 of this document for configuration procedure and control details.

After configuring all the parameters, run the example and click Start Generation to start generating the waveform. Press Stop Generation to stop generation at any time. Error dialog box pops up to the user if any error occurs. The user can click either Continue or Stop from the error dialog box to abort the generation.

Indicators

- **Actual IQ Rate (S/s) –** Rate of the baseband I/Q data in samples per second (S/s).
- **File Progress –** To visualize the progress of generating signal.

5 How to configure parameters for Single Carrier/ Multiple Carriers

The controls in the Carrier Configuration, ISDB-T Configuration, Layer Configuration and Impairments are configured for each carrier. Hence the controls are given in an array where each element corresponds to one carrier. Since the index value starts from 0, the index 0 corresponds to 1st carrier, index 1 corresponds to 2nd carrier and so on.

5.1 Single Carrier

For single carrier configuration, configure only index 0 of the above controls.

5.2 Multiple Carrier

For multiple carriers, use the index display to navigate through different elements and configure for the required number of carriers. For N carriers, configure upto index N-1.

The figure below shows the ISDB-T Configuration Control array with index display (highlighted in yellow).