

SigIQPro

User Manual

EN01A

Guaranty and Declaration

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SIGLENT guarantees this product conforms to the national and industrial standards in China as well as the ISO9001: 2008 standard and the ISO14001: 2004 standard. Other international standard conformance certification is in progress.

SigIQPro Overview

The SigIQPro is a PC software for IQ waveform generation produced by SIGLENT, which can create rich IQ protocol signals with optimized performance. It supports Bluetooth, IOT, Custom OFDM, Custom IQ, 5G NR, LTE, WLAN and DFS Radar, meeting the requirements of the Internet of Things, short-range communications, wireless cellular communications, satellite communications and radar.

Supported protocols:

- ◆ Bluetooth BR/EDR (version: 5.0)
- ◆ Bluetooth Low Energy (version: 5.2)
- ◆ IEEE 802.15.4 O-QPSK BPSK (ZigBee) (version: IEEE Std 802.15.4 -2020)
- ◆ IEEE 802.15.4 SUN FSK (version: IEEE Std 802.15.4 -2020)
- ◆ IEEE 802.15.4 SUN OFDM (version: IEEE Std 802.15.4 -2020)
- ◆ ITU-T G.9959 (Z-WAVE) (version: IEEE Std 802.15.4 -2020)
- ◆ Custom OFDM
- ◆ Custom IQ

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1 Installation

To install the SigIQPro software, please do the following:

1. System Requirements;
2. Download and Install SigIQPro Software;
3. Equipment Setup and Connection;
4. Testing Connections.

1.1 System Requirements

To generate signals using SigIQPro software, you must have a properly configured PC and a properly configured instrument, as described below.

1.1.1 PC Requirements

- 200 GB HDD with 1 GB free disk space at runtime (2 GB or higher recommended)
- 1280 x 768 screen resolution
- Windows 7 or Windows 10
- 1 GHz or faster 32-bit or 64-bit processor
- 2 GB of memory minimum
- This software requires the installation of NI-VISA, which can be downloaded from <http://www.ni.com/visa>.

1.1.2 Hardware Requirements

You can download and play IQ waveforms generated by SigIQPro software through the following SIGLENT instruments.

- SSG5000X-V
- SDG7000A

Proper firmware and options will be required on above instruments.

Instruments	Requirements	
SSG5000X-V	Firmware:	Version V2.1.2.4.1 or later
	Required options:	SigIQPro-BT (support Bluetooth) SigIQPro-IOT (support IOT) SigIQPro-OFDM (support Custom OFDM)
SDG7000A	Firmware:	Version V1.1.1.32 or later
	Required options:	SigIQPro-BT (support Bluetooth) SigIQPro-IOT (support IOT) SigIQPro-OFDM (support Custom OFDM)

1.2 Download and Install SigIQPro Software

Please visit <https://www.siglent.com/download/software/> to download and install.

1.3 Equipment Setup and Connection

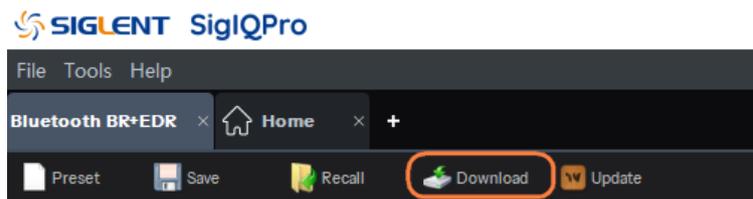
To connect to a Signal Generator, you should do the following:

1. Ensure the signal generator is turned on.
2. Connect the signal generator to the computer using one of the following methods for instrument control:
 - LAN Network -- connect both the signal generator and the computer to an external LAN network using standard LAN cables.
 - Crossover LAN -- connect the signal generator directly to the computer using a crossover LAN cable (You will need to configure your PC).
 - GPIB -- connect the signal generator directly to the computer using a GPIB cable.
 - USB -- connect the signal generator directly to the computer using a USB cable.

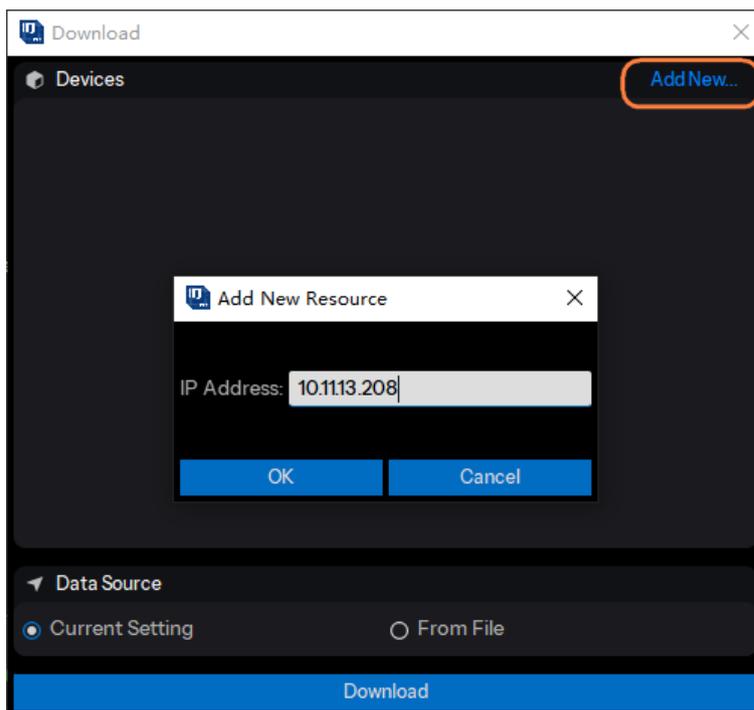
1.4 Testing Connections

Please follow below steps to test connections between the signal generator and the SigIQPro software.

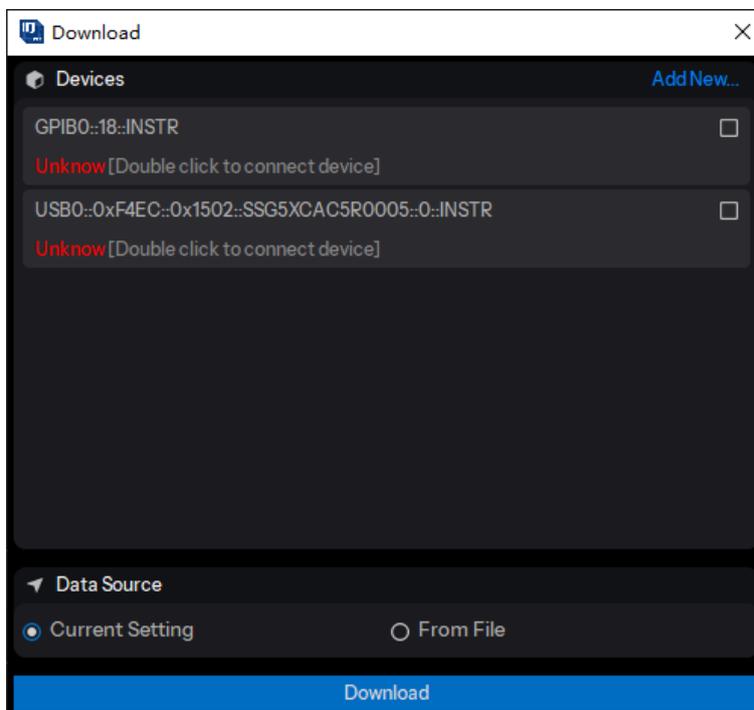
1. Turn on the signal generator and the computer.
2. Start the SigIQPro software.
3. Establish communications between the software and the instrument.
 - 1) Firstly, click the download button of the SigIQPro software, and then a download dialog will pop up.



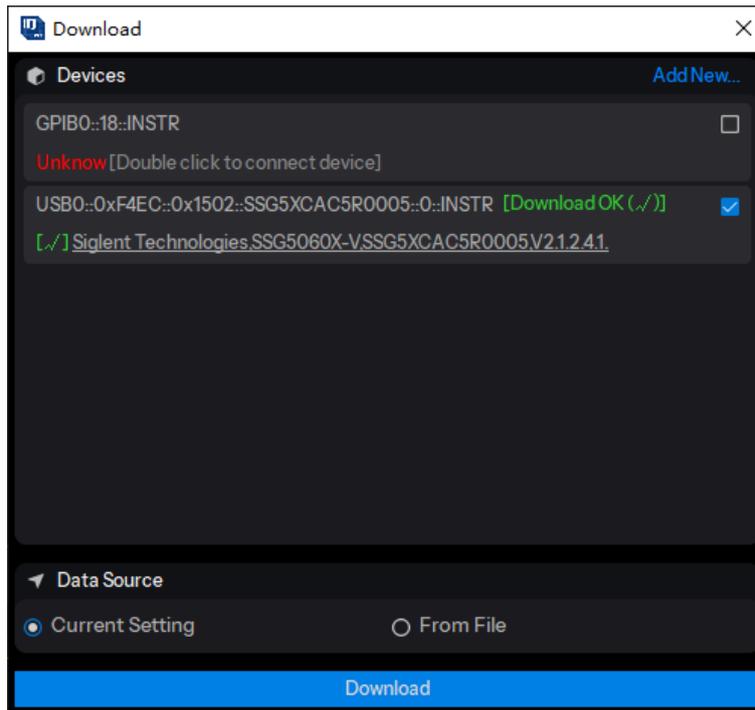
- 2) If the signal generator is connected to the PC through LAN, click "Add New..." and enter the IP address of the signal generator to add new resource.



- 3) If the signal generator is connected to the PC through USB or GPIB, the resource name will be in the device list when the download dialog is opened. You can double-click the resource name to connect to the device.



- 4. Download a waveform to the signal generator. When the download is successful, it will prompt "Download OK".



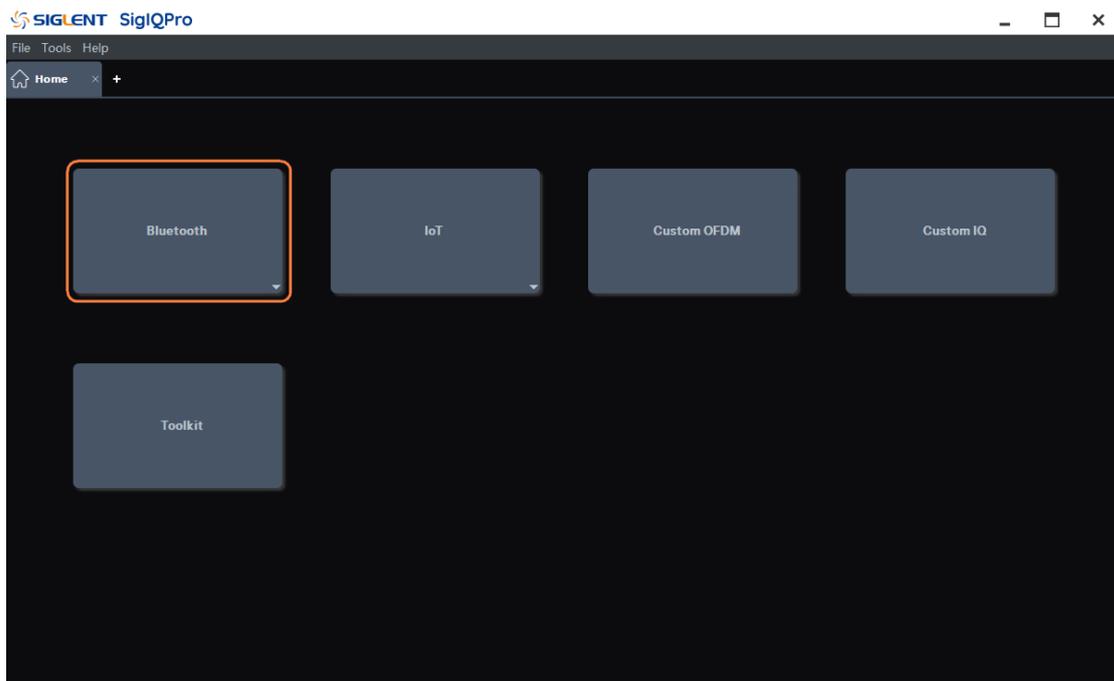
2 Application Examples

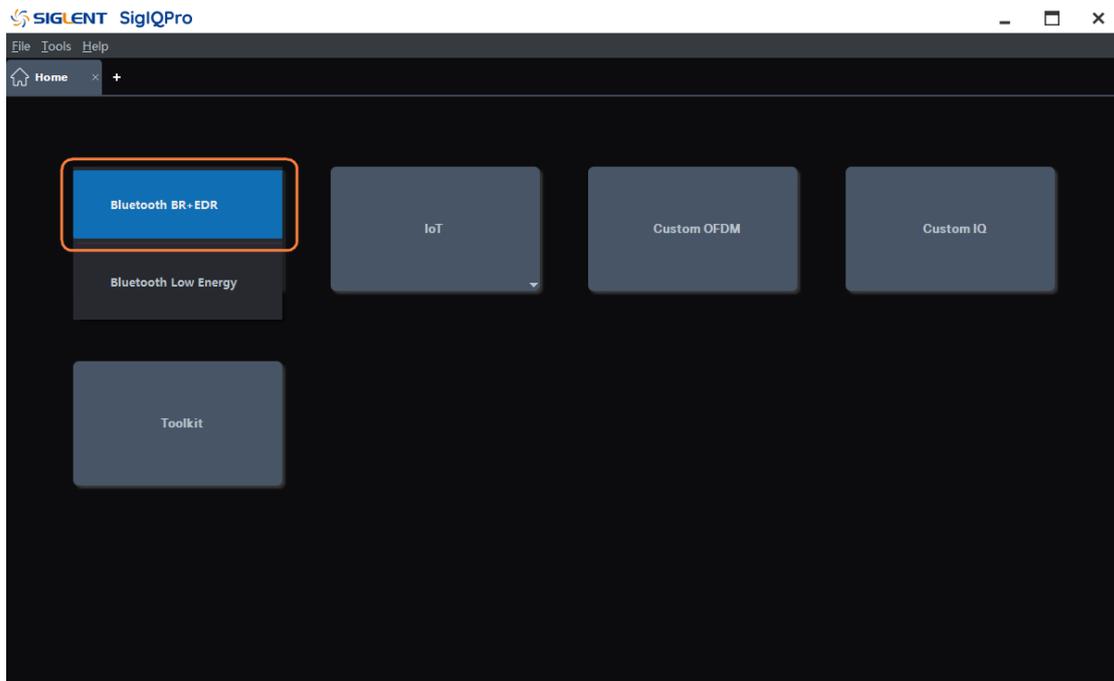
2.1 Create and Play Bluetooth EDR Waveforms

An example of how to create and play Bluetooth EDR waveforms with package type DM1 is given below. First configure the waveform parameters on SigIQPro, then download the waveform to SSG5000X-V, and finally play the waveform on SSG5000X-V.

2.1.1 Configure waveform parameters

1. Click **Bluetooth** -> **Bluetooth BR+EDR** on the homepage to enter the Bluetooth BR/EDR setting interface.

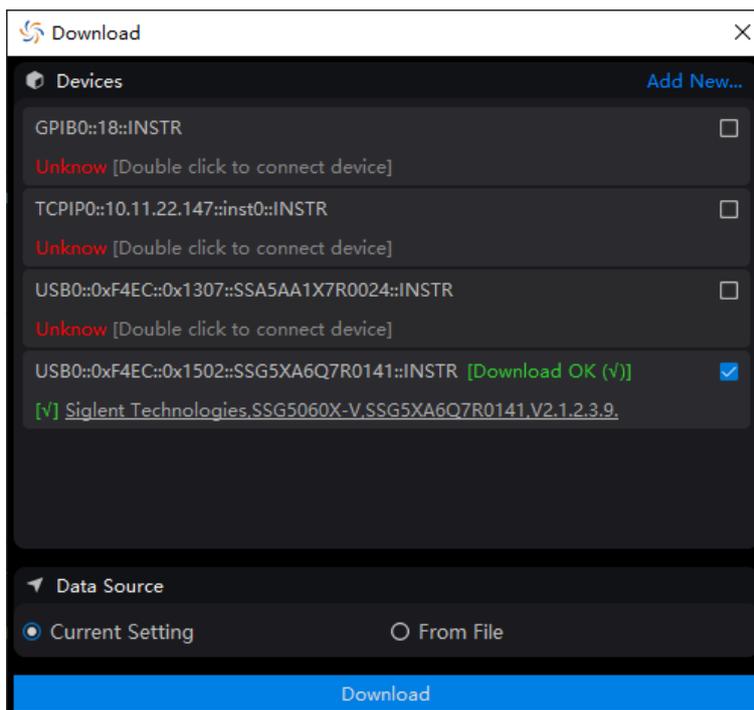




2. Click the **Packet** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Bluetooth Mode** as "Enhanced Data Rate".
 - 2) Set **Transport Mode** as "ACL".
 - 3) Set **Packet Type** as "DM1".
 - 4) Keep other parameters at their default settings.
3. Click the **Parameters Setup** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Waveform Name** as "EDR_DM1".
 - 2) Keep other parameters at their default settings.

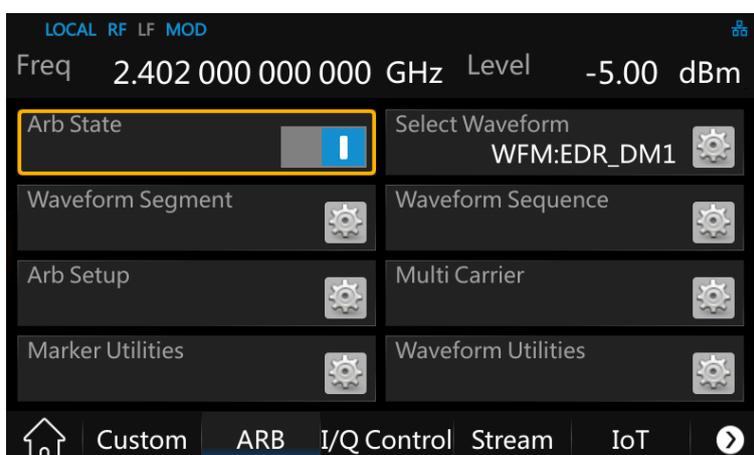
2.1.2 Download the Waveform to Signal Source

1. Click the Update button on the toolbar to update the I/Q waveform and spectrum display at the bottom of the software UI.
2. Click the Download button on the toolbar to download the waveform to SSG5000X-V.
 - 1) After clicking the Download button, select the instrument to play the waveform in the pop-up Download sub-window.
 - 2) When the instrument is not connected, please double-click the resource name of the instrument to connect to the instrument as prompted.
 - 3) Then click the Download button in the Download sub-window.
 - 4) After the download is successful, a "Download OK" prompt will appear after the name of the downloaded instrument.



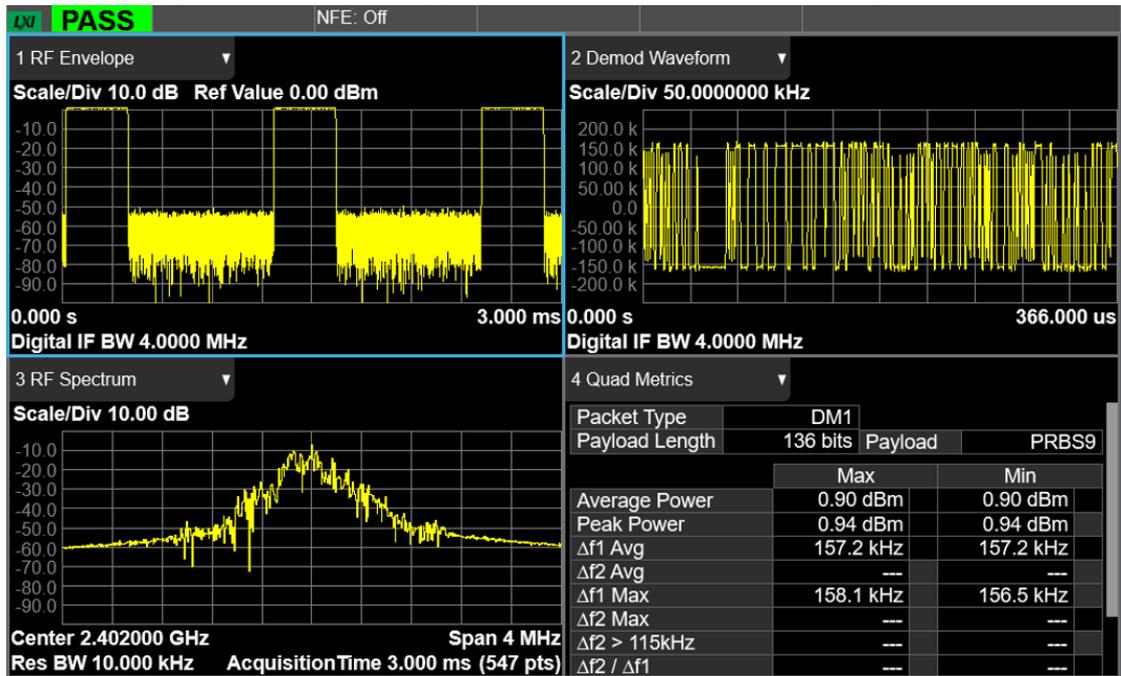
2.1.3 Play the Waveform in Signal Source

1. After successfully downloading the waveform, check whether there is a waveform in SSG5000X-V IQ MOD -> ARB:
 You can see that ARB mode is playing EDR_DM1.
2. Set the RF carrier to 2.402 GHz, -4 dBm.
3. Turn on modulation and RF output.
 - 1) Press the **RF ON/OFF** front panel button to turn on the RF output.
 - 2) Press the **MOD ON/OFF** front panel button to turn on the IQ Mod modulation main switch.



2.1.4 Demodulation Result

View the demodulation results in the spectrum analyzer:

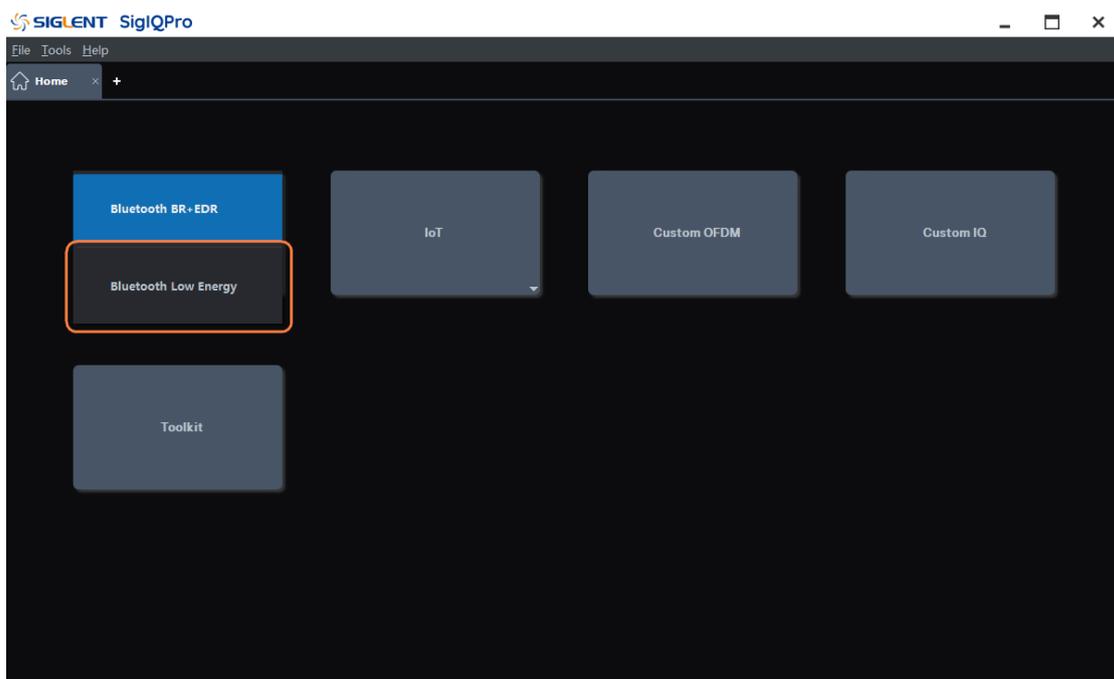
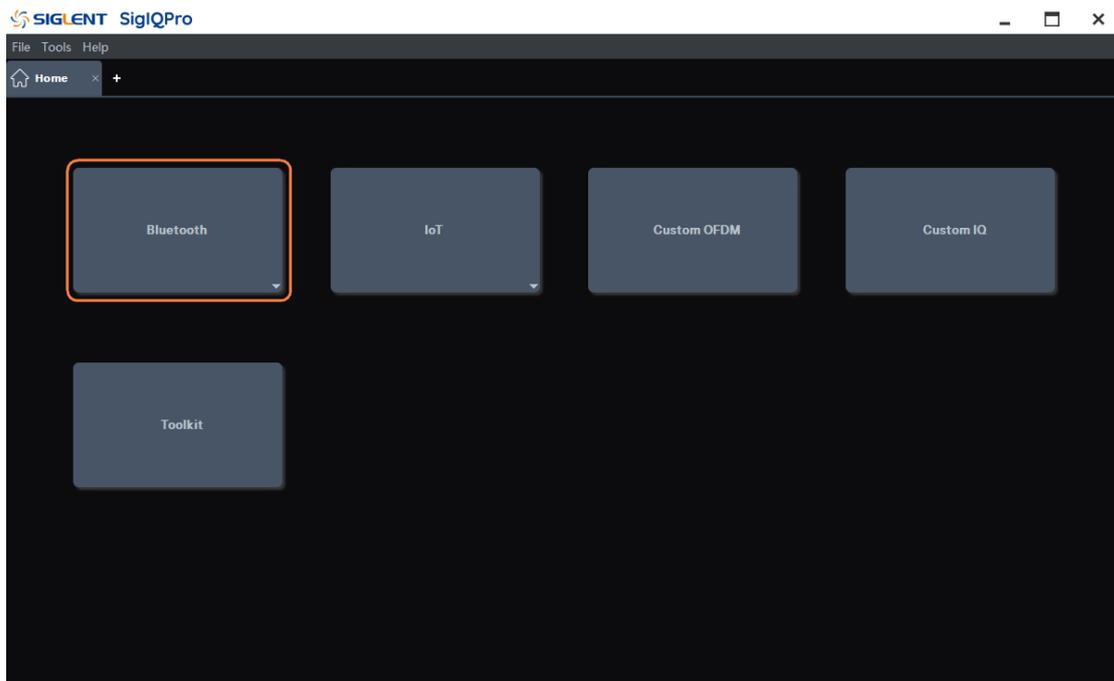


2.2 Create and Play Bluetooth LE Waveforms

An example of how to create and play Bluetooth Low Energy LE 1M test packet waveforms is given below. First configure the waveform parameters on SigIQPro, then download the waveform to SSG5000X-V, and finally play the waveform on SSG5000X-V.

2.2.1 Configure waveform parameters

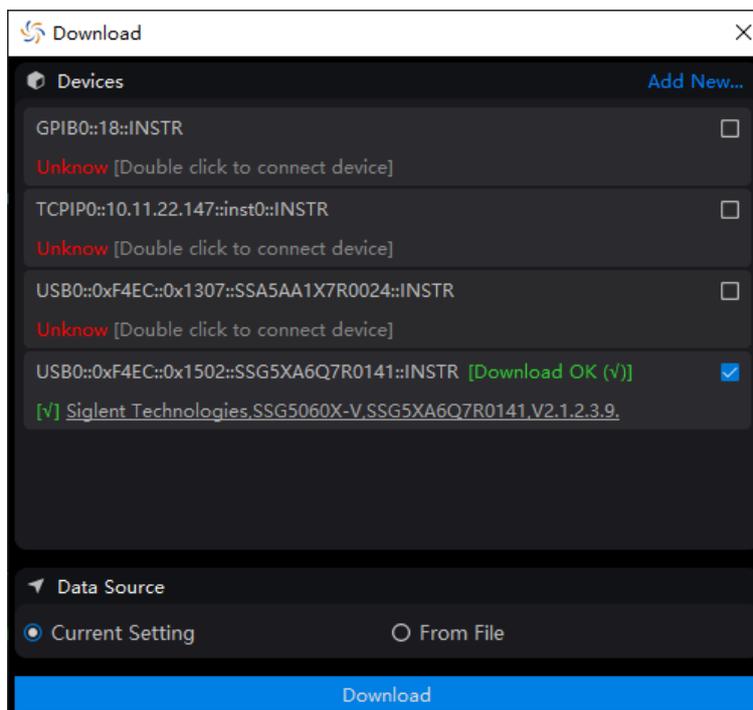
1. Click **Bluetooth** -> **Bluetooth Low Energy** on the homepage to enter the Bluetooth LE setting interface.



2. Click the **Packet** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Channel Type** as "Test".
 - 2) Set **Packet Format** as "LE 1M".
 - 3) Keep other parameters at their default settings.
3. Click the **Parameters Setup** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Waveform Name** as "LE_test".
 - 2) Keep other parameters at their default settings.

2.2.2 Download the Waveform to Signal Source

1. Click the Update button on the toolbar to update the I/Q waveform and spectrum display at the bottom of the software UI.
2. Click the Download button on the toolbar to download the waveform to SSG5000X-V.
 - 1) After clicking the Download button, select the instrument to play the waveform in the pop-up Download sub-window.
 - 2) When the instrument is not connected, please double-click the resource name of the instrument to connect to the instrument as prompted.
 - 3) Then click the Download button in the Download sub-window.
 - 4) After the download is successful, a "Download OK" prompt will appear after the name of the downloaded instrument.

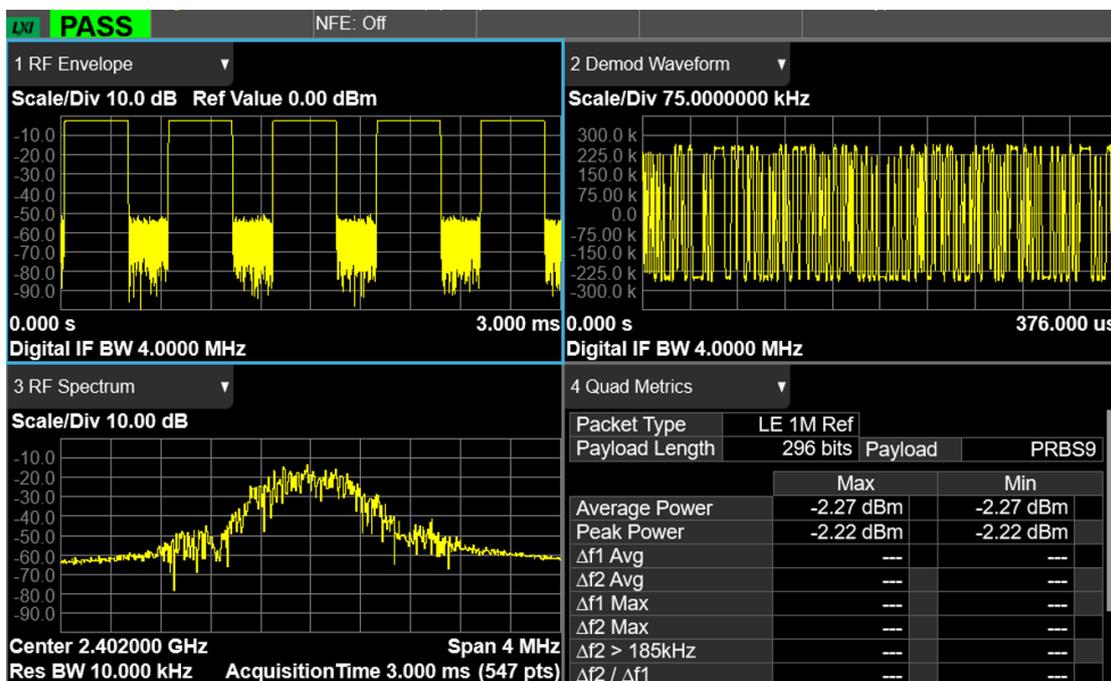


2.2.3 Play the Waveform in Signal Source

1. After successfully downloading the waveform, check whether there is a waveform in SSG5000X-V IQ MOD -> ARB:
 You can see that ARB mode is playing LE_test.
2. Set the RF carrier to 2.402 GHz, -4 dBm.
3. Turn on modulation and RF output.
 - 1) Press the **RF ON/OFF** front panel button to turn on the RF output.
 - 2) Press the **MOD ON/OFF** front panel button to turn on the IQ Mod modulation main switch.

2.2.4 Demodulation Result

View the demodulation results in the spectrum analyzer:

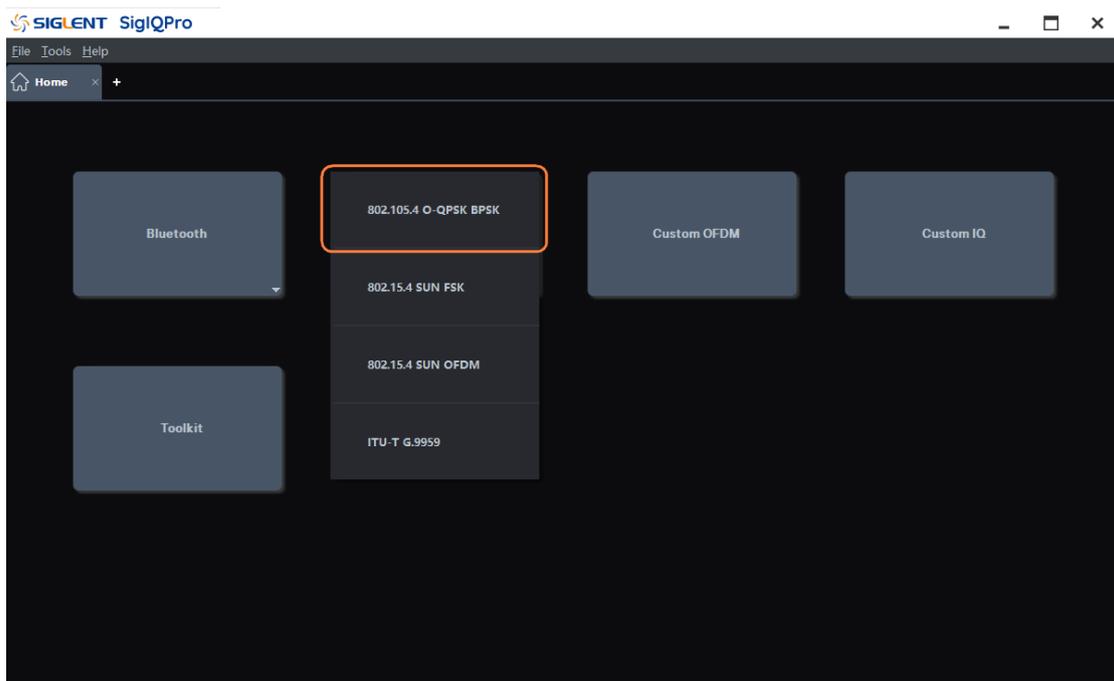
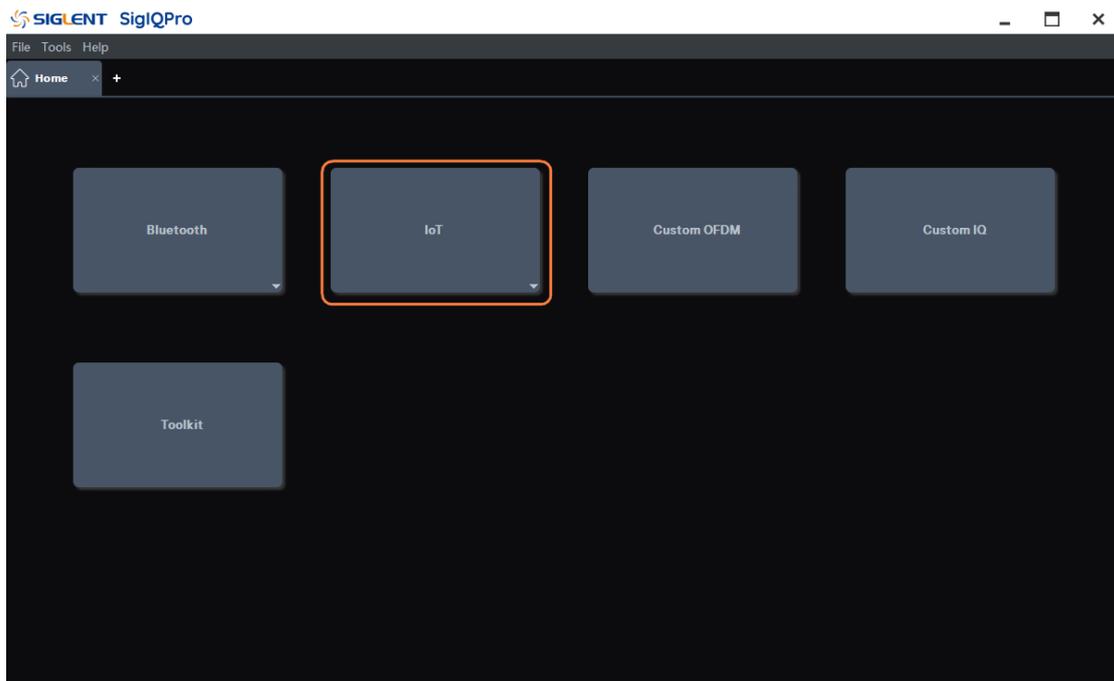


2.3 Create and Play ZigBee Waveforms

An example of how to create and play ZigBee OQPSK 868 MHz band waveforms is given below. First configure the waveform parameters on SigIQPro, then download the waveform to SSG5000X-V, and finally play the waveform on SSG5000X-V.

2.3.1 Configure waveform parameters

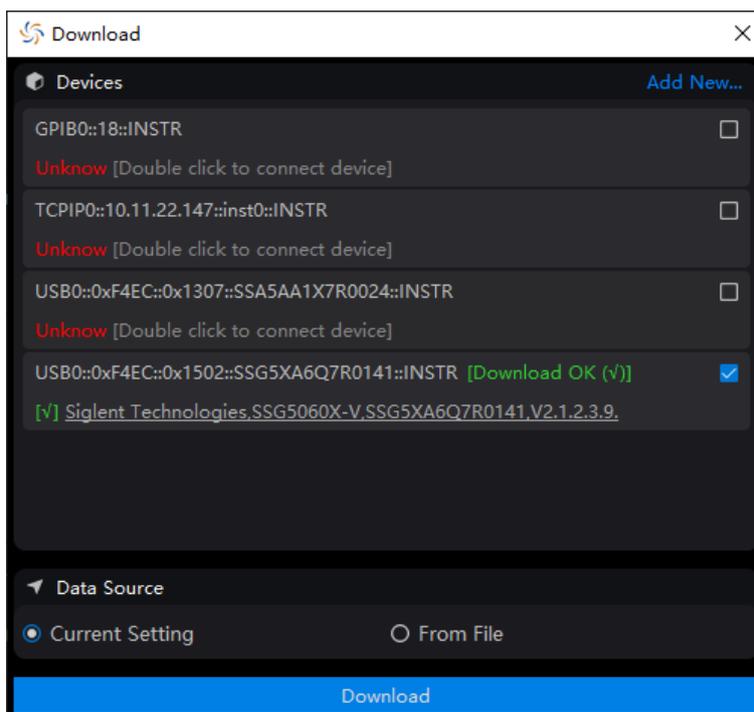
1. Click **IoT** -> **802.15.4 O-QPSK BPSK** on the homepage to enter the ZigBee setting interface.



2. Click the **Packet** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **PHY Scheme** as "O-QPSK".
 - 2) Set **Frequency Band** as "868 MHz".
 - 3) Keep other parameters at their default settings.
3. Click the **Parameters Setup** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Waveform Name** as "zigbee_868".
 - 2) Set **OverSampling Ratio** as "8".
 - 3) Keep other parameters at their default settings.

2.3.2 Download the Waveform to Signal Source

1. Click the Update button on the toolbar to update the I/Q waveform and spectrum display at the bottom of the software UI.
2. Click the Download button on the toolbar to download the waveform to SSG5000X-V.
 - 1) After clicking the Download button, select the instrument to play the waveform in the pop-up Download sub-window.
 - 2) When the instrument is not connected, please double-click the resource name of the instrument to connect to the instrument as prompted.
 - 3) Then click the Download button in the Download sub-window.
 - 4) After the download is successful, a "Download OK" prompt will appear after the name of the downloaded instrument.

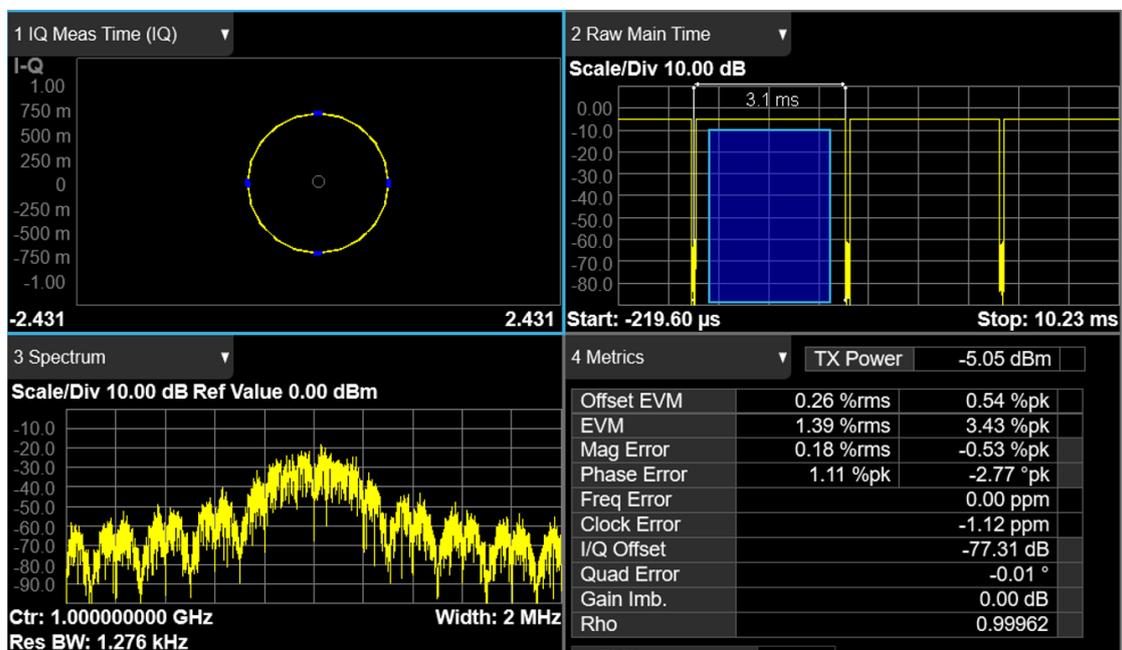


2.3.3 Play the Waveform in Signal Source

1. After successfully downloading the waveform, check whether there is a waveform in SSG5000X-V IQ MOD -> ARB:
You can see that ARB mode is playing zigbee_868.
2. Set the RF carrier to 1 GHz, -5 dBm.
3. Turn on modulation and RF output.
 - 1) Press the **RF ON/OFF** front panel button to turn on the RF output.
 - 2) Press the **MOD ON/OFF** front panel button to turn on the IQ Mod modulation main switch.

2.3.4 Demodulation Result

View the demodulation results in the spectrum analyzer:

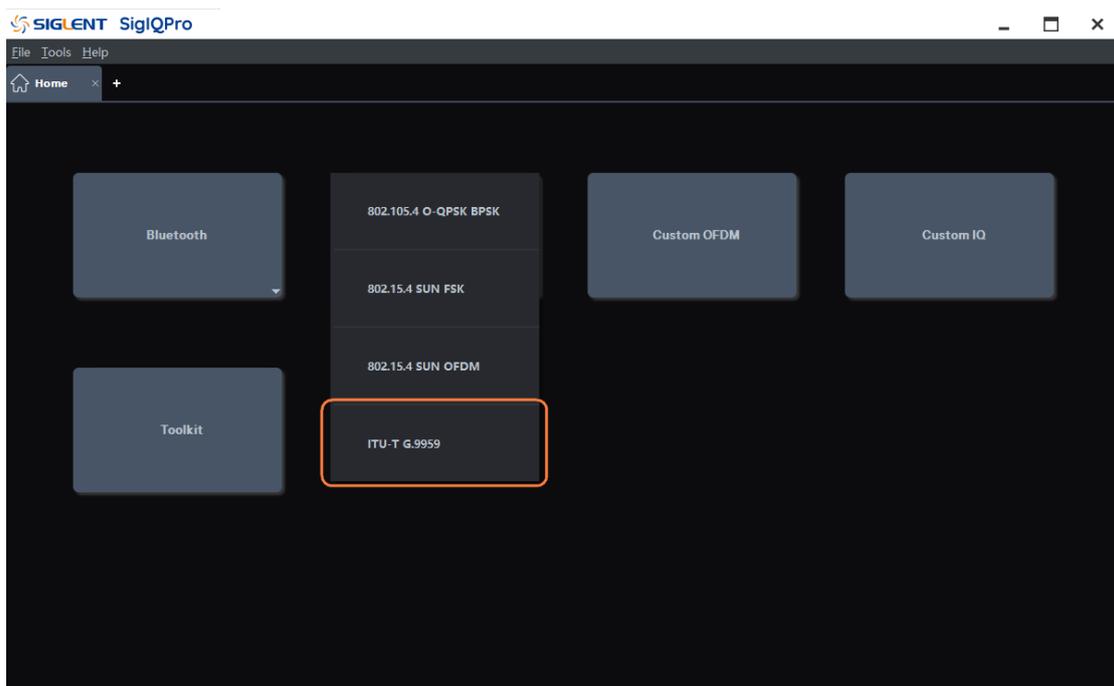
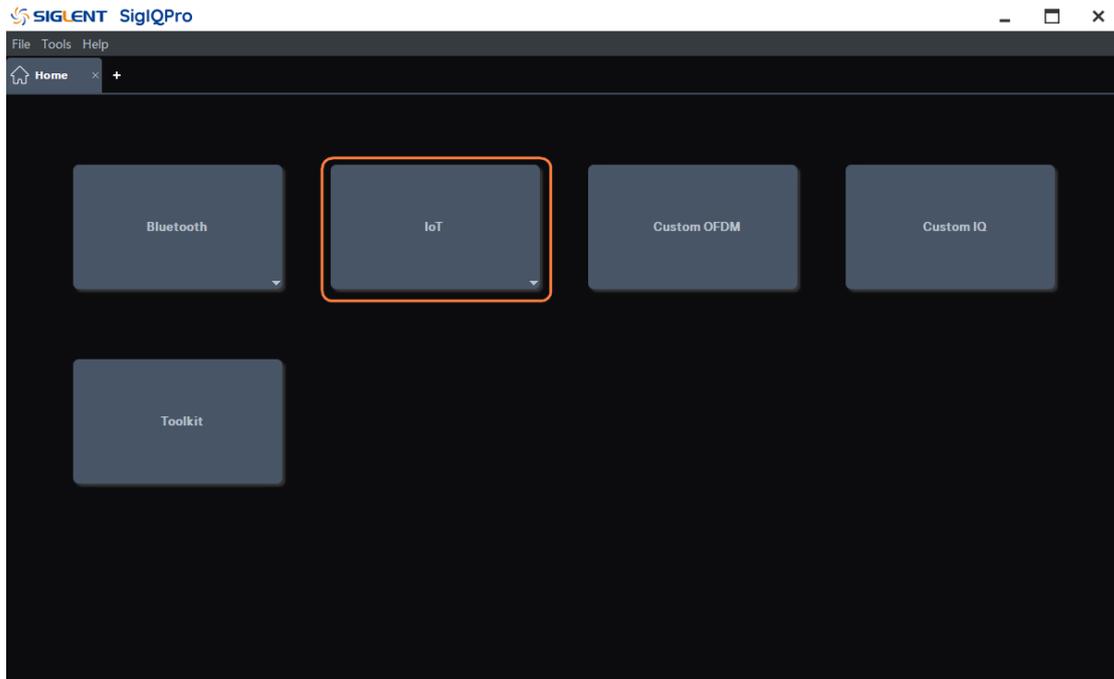


2.4 Create and Play Z-WAVE Waveforms

An example of how to create and play a Z-WAVE waveform with data rate R2 is given below. First configure the waveform parameters on SigIQPro, then download the waveform to SSG5000X-V, and finally play the waveform on SSG5000X-V.

2.4.1 Configure waveform parameters

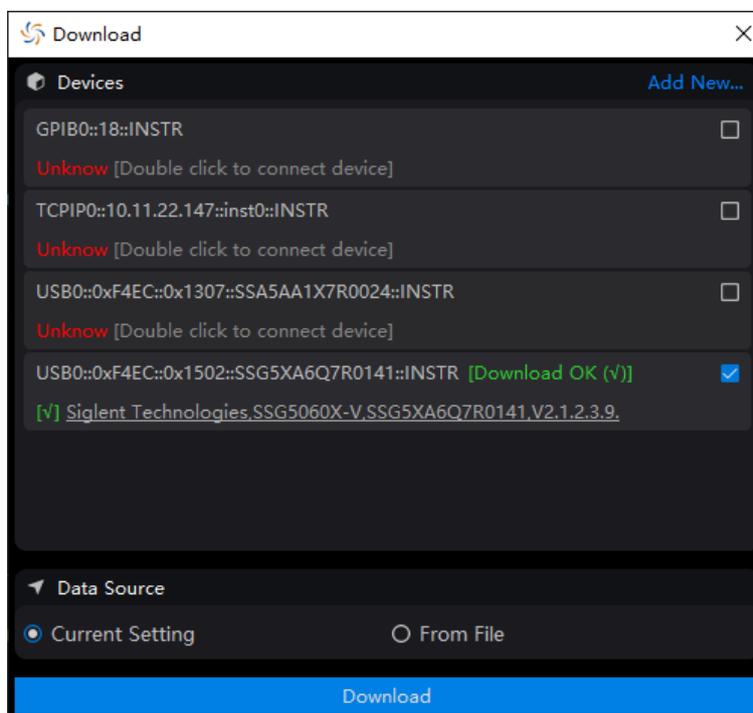
1. Click **IoT** -> **ITU-T G.9959** on the homepage to enter the Z-WAVE setting interface.



2. Click the **Packet** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Data Rate as** "R2-40kbps".
 - 2) Keep other parameters at their default settings.
3. Click the **Waveform Setup** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Waveform Name** as "zwave_r2".
 - 2) Keep other parameters at their default settings.

2.4.2 Download the Waveform to Signal Source

1. Click the Update button on the toolbar to update the I/Q waveform and spectrum display at the bottom of the software UI.
2. Click the Download button on the toolbar to download the waveform to SSG5000X-V.
 - 1) After clicking the Download button, select the instrument to play the waveform in the pop-up Download sub-window.
 - 2) When the instrument is not connected, please double-click the resource name of the instrument to connect to the instrument as prompted.
 - 3) Then click the Download button in the Download sub-window.
 - 4) After the download is successful, a "Download OK" prompt will appear after the name of the downloaded instrument.

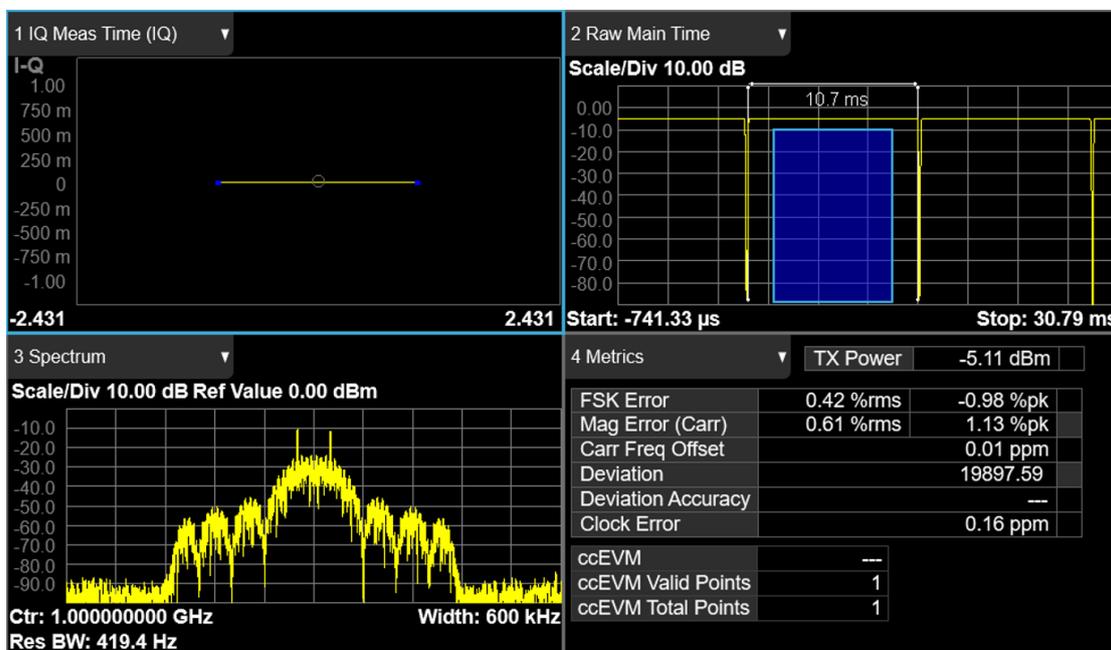


2.4.3 Play the Waveform in Signal Source

1. After successfully downloading the waveform, check whether there is a waveform in SSG5000X-V IQ MOD -> ARB:
 You can see that ARB mode is playing zwave_r2.
2. Set the RF carrier to 1 GHz, -5 dBm.
3. Turn on modulation and RF output.
 - 1) Press the **RF ON/OFF** front panel button to turn on the RF output.
 - 2) Press the **MOD ON/OFF** front panel button to turn on the IQ Mod modulation main switch.

2.4.4 Demodulation Result

View the demodulation results in the spectrum analyzer:

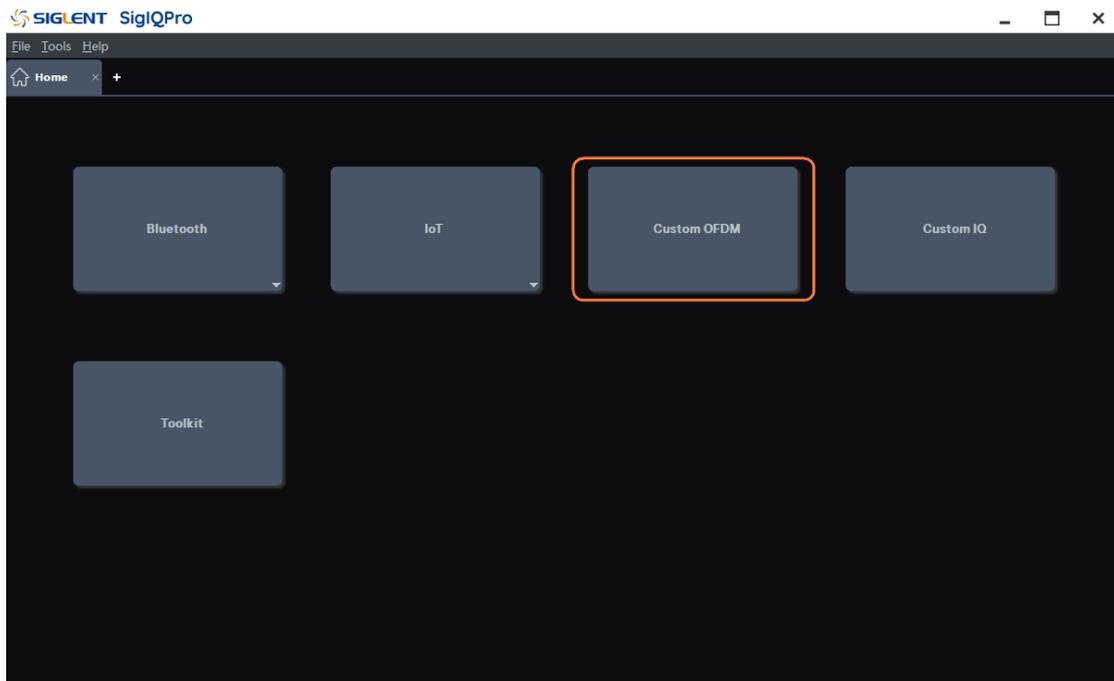


2.5 Create and Play WLAN Custom OFDM Waveforms

An example of how to create and play a WLAN Custom OFDM waveform is given below. First configure the waveform parameters on SigIQPro, then download the waveform to SSG5000X-V, and finally play the waveform on SSG5000X-V.

2.5.1 Configure waveform parameters

1. Click **Custom OFDM** on the homepage to enter the Custom OFDM setting interface.



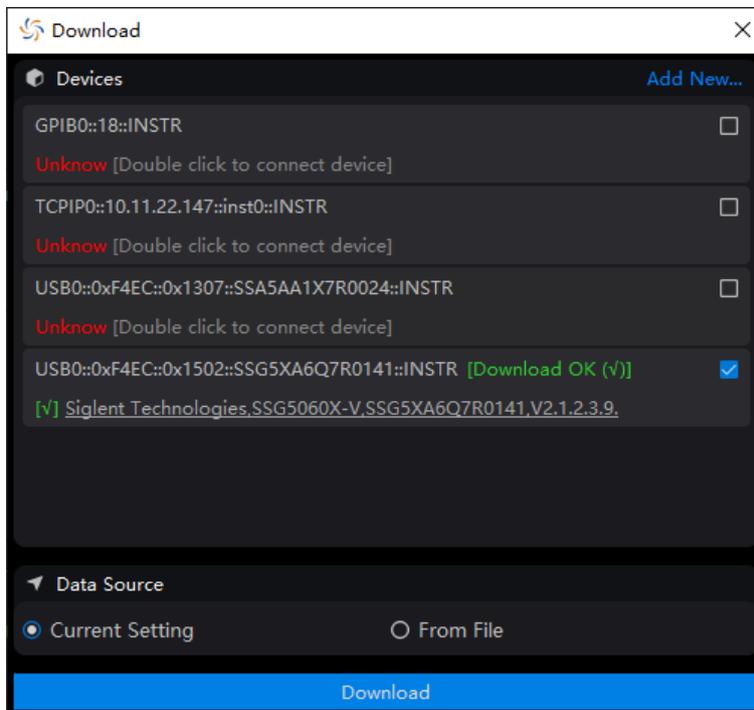
2. Click Quick Setups on the toolbar and select WLAN: IEEE 802.11a.
3. Click the **Waveform Setup** node in the tree view on the left side of the window to enter parameter settings.
 - 1) Set **Waveform Name** as "WLAN_Custom_OFDM".
 - 2) Set **OverSampling Ratio** as "8".
 - 3) Keep other parameters at their default settings.

2.5.2 Download the Waveform to Signal Source

1. Click the Update button on the toolbar to update the I/Q waveform and spectrum display at the bottom of the software UI.
2. Click the Download button on the toolbar to download the waveform to SSG5000X-V.
 - 1) After clicking the Download button, select the instrument to play the waveform in the pop-up Download sub-window.
 - 2) When the instrument is not connected, please double-click the resource name of the

instrument to connect to the instrument as prompted.

- 3) Then click the Download button in the Download sub-window.
- 4) After the download is successful, a "Download OK" prompt will appear after the name of the downloaded instrument.

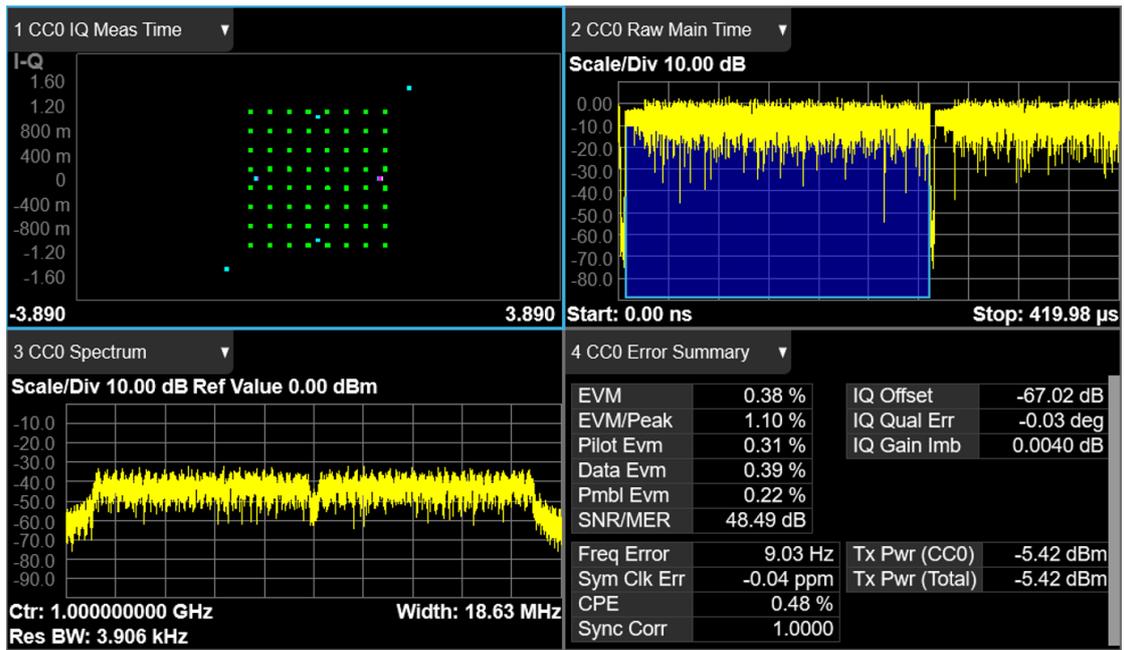


2.5.3 Play the Waveform in Signal Source

1. After successfully downloading the waveform, check whether there is a waveform in SSG5000X-V IQ MOD -> ARB:
You can see that ARB mode is playing WLAN_Custom_OFDM.
2. Set the RF carrier to 1 GHz, -5 dBm.
3. Turn on modulation and RF output.
 - 1) Press the **RF ON/OFF** front panel button to turn on the RF output.
 - 2) Press the **MOD ON/OFF** front panel button to turn on the IQ Mod modulation main switch.

2.5.4 Demodulation Result

View the demodulation results in the spectrum analyzer:

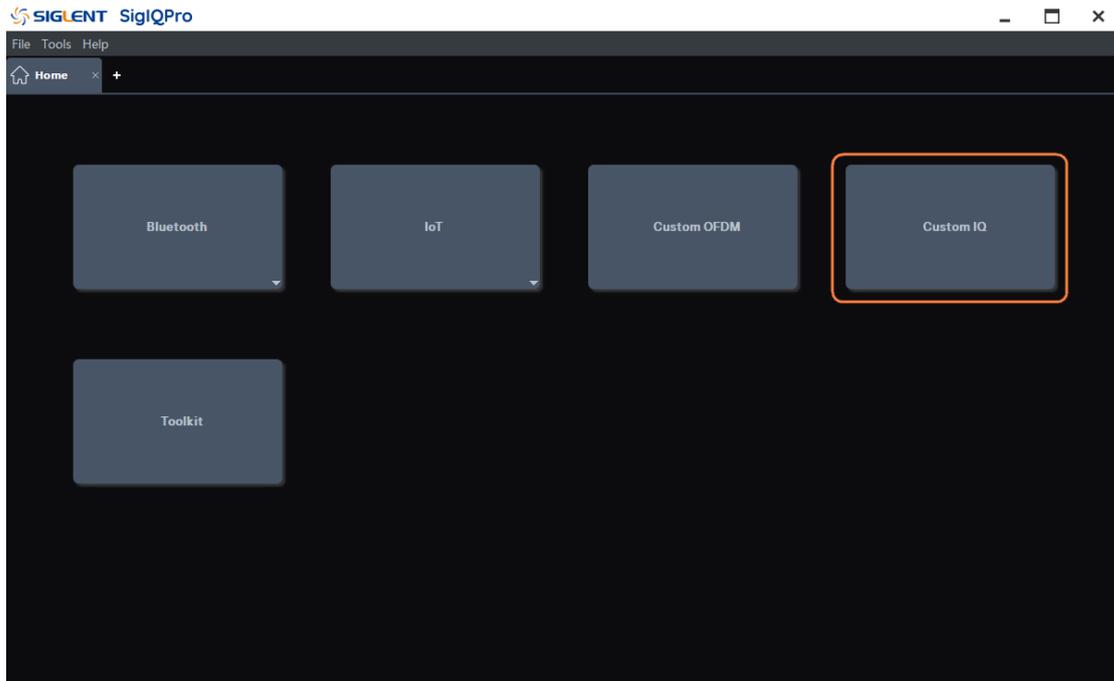


2.6 Create and Play Custom IQ Waveforms

An example of how to create and play a Custom IQ 16QAM waveform is given below. First configure the waveform parameters on SigIQPro, then download the waveform to SSG5000X-V, and finally play the waveform on SSG5000X-V.

2.6.1 Configure waveform parameters

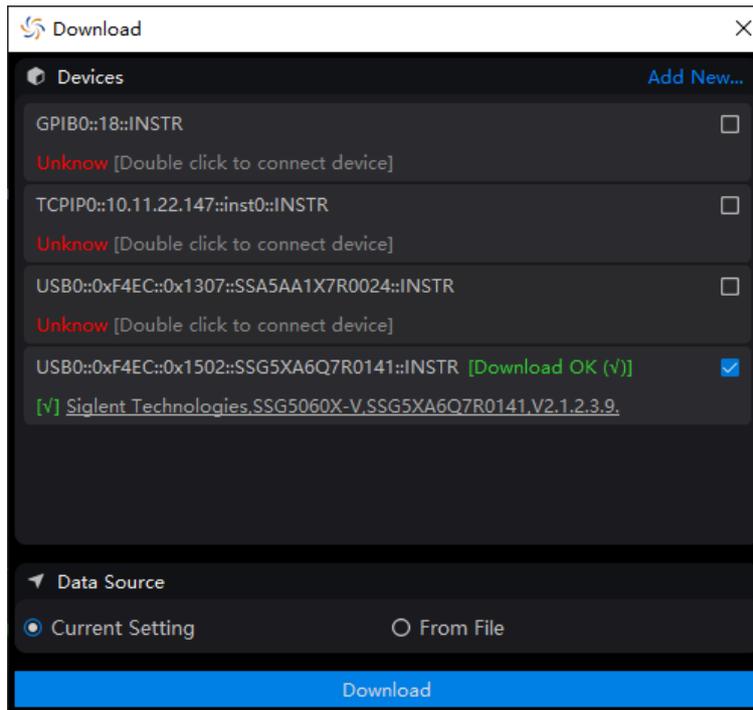
1. Click **Custom IQ** on the homepage to enter the Custom IQ setting interface.



2. Keep the parameters at their default settings.

2.6.2 Download the Waveform to Signal Source

1. Click the Update button on the toolbar to update the I/Q waveform and spectrum display at the bottom of the software UI.
2. Click the Download button on the toolbar to download the waveform to SSG5000X-V.
 - 1) After clicking the Download button, select the instrument to play the waveform in the pop-up Download sub-window.
 - 2) When the instrument is not connected, please double-click the resource name of the instrument to connect to the instrument as prompted.
 - 3) Then click the Download button in the Download sub-window.
 - 4) After the download is successful, a "Download OK" prompt will appear after the name of the downloaded instrument.

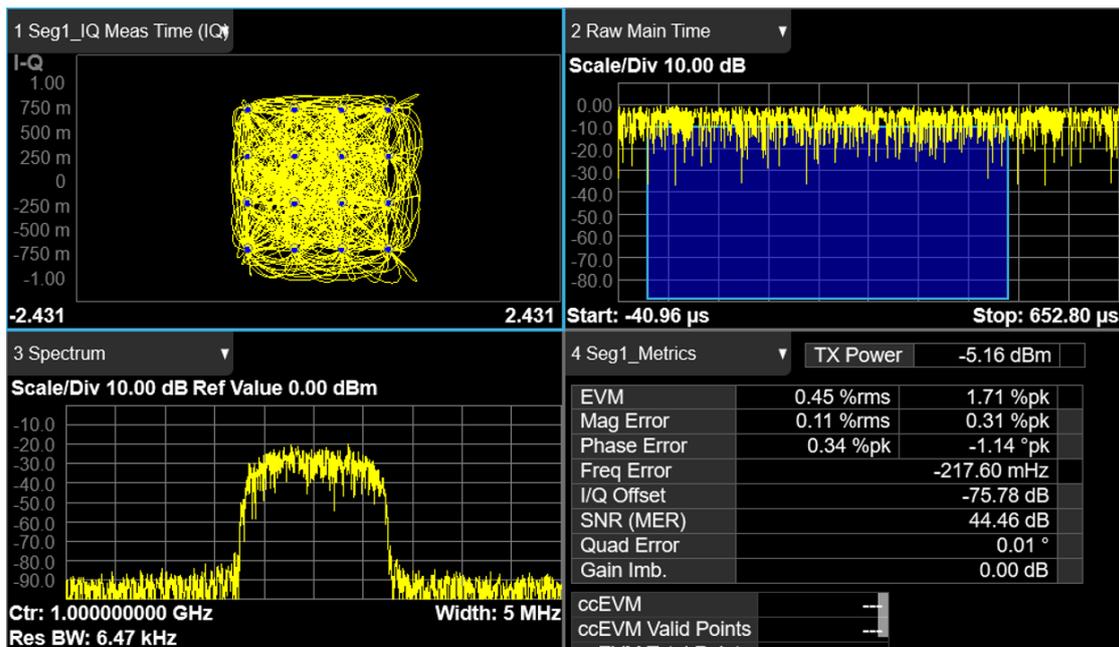


2.6.3 Play the Waveform in Signal Source

- After successfully downloading the waveform, check whether there is a waveform in SSG5000X-V IQ MOD -> ARB:
You can see that ARB mode is playing UserIQ_1 (When Waveform Name is not set, SSG5000X-V automatically names the waveform).
- Set the RF carrier to 1 GHz, -5 dBm.
- Turn on modulation and RF output.
 - Press the **RF ON/OFF** front panel button to turn on the RF output.
 - Press the **MOD ON/OFF** front panel button to turn on the IQ Mod modulation main switch.

2.6.4 Demodulation Result

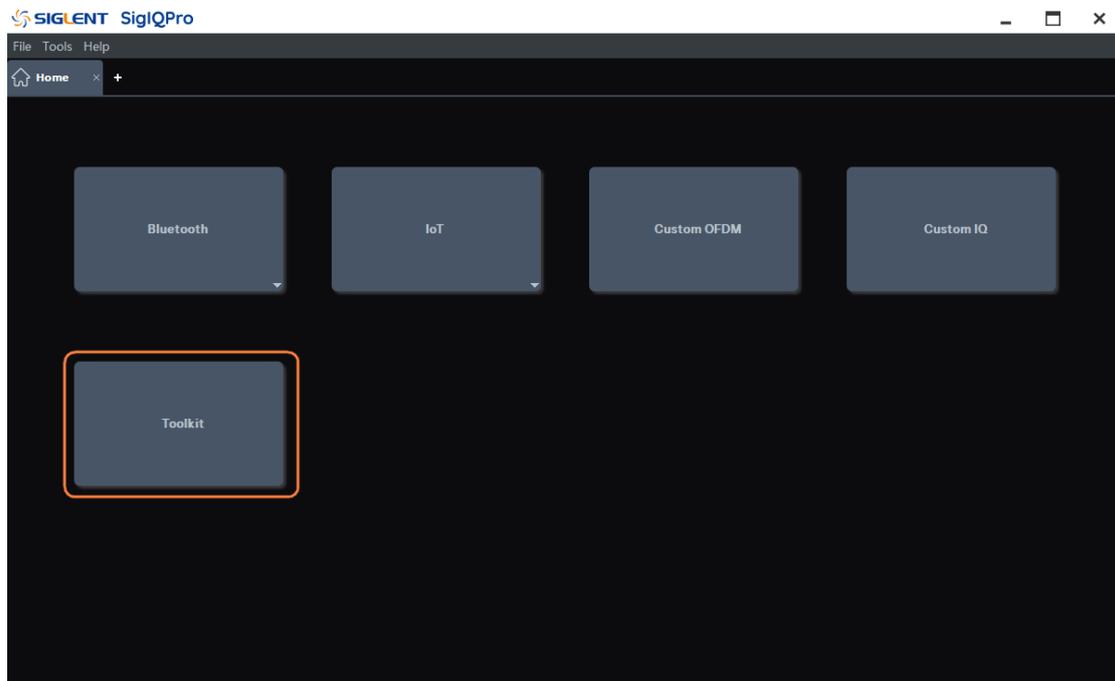
View the demodulation results in the spectrum analyzer:



2.7 Use Toolkit to Convert the File Format to ARB

The Toolkit can convert waveform files in specific formats, such as MAT files, TXT files, DAT files and CSV files, into ARB files that can be played by SIGLENT signal generators.

Click **Toolkit** on the homepage, or select **Tools** -> **Toolkit** in the menu bar, to enter the Toolkit setting interface.



2.7.1 Convert MAT Files

Step1. Selecting a waveform

1. In the Waveform Import area, select the file type as Mat-File 5 in the **Source File Type** field.
2. In the **Source File** field, click and select the original MAT file.
3. Select the correct **I Data** and **Q Data**.
4. Check if the number of waveform points is correct in the **Number of Points** field.
5. Set the **Sample Rate** of the waveform.

Step2. Set the parameters of the target file

1. In the Waveform Download area, set the name of the target file in the **Waveform Name** field.
2. Set the **Mirror Spectrum** state.
3. Set the **Oversampling Ratio**.

Step3. Update and download the target file

1. Click **Update** in the toolbar to generate the target file.
2. Click **Download** in the toolbar to download the target file to SIGLENT signal generator.

2.7.2 Convert ASCII Files

Step1. Selecting a waveform

1. In the Waveform Import area, select the file type as ASCII/CSV/DAT in the **Source File Type** field.
2. In the **Source File** field, click and select the original file. You can select TXT, CSV or DAT files.
3. If you want to use a separate file for Q data, you should set **Use Separate Q File** as "Yes", and then click and select the Q source file you want to import in the **Q Source File** field.
4. In the **Data Type** field, select the data type of the source file.
5. If the data type of the source file is Hexadecimal, you should select big or little endian for HEX data in the **Big / Little Endian** field.
6. If the data type of the source file is Hexadecimal, you select signed or unsigned type for HEX data in the **Signed / Unsigned Number** field.
7. Set swap IQ flag in the **Swap IQ** field.
8. Check if the number of waveform points is correct in the **Number of Points** field.
9. Set the **Sample Rate** of the waveform.

Step2. Set the parameters of the target file

1. In the Waveform Download area, set the name of the target file in the **Waveform Name** field.
2. Set the **Mirror Spectrum** state.
3. Set the **Oversampling Ratio**.

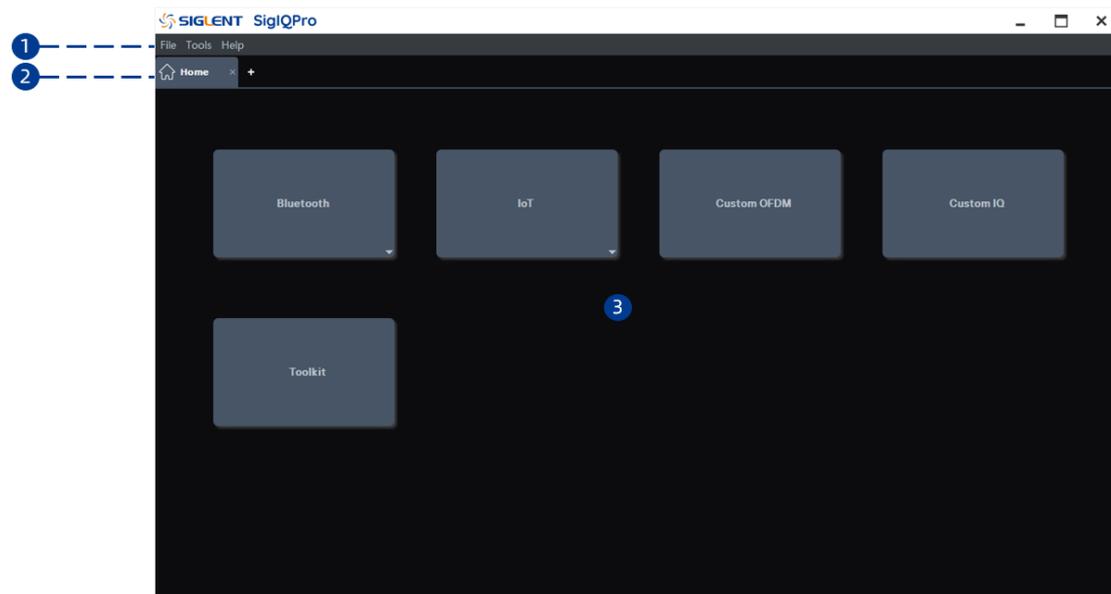
Step3. Update and download the target file

1. Click **Update** in the toolbar to generate the target file.
2. Click **Download** in the toolbar to download the target file to SIGLENT signal generator.

3 User Interface Overview

This topic describes the common features of the SigIQPro user interface.

3.1 Home Page



3.1.1 Menu Bar

File

- Recall: Opens a file management window where you can open a previously saved SigIQPro configuration file (*.project) to recall settings.
- Save As: Opens a file management window where you can save your current SigIQPro configuration as a file (*.project) for future use.
- Exit: Exits the SigIQPro software.

Tools

- Toolkit: Launches the Toolkit application.

Help

- Content: Shows the help file.
- Website: Opens company website.
- About: Shows software information.

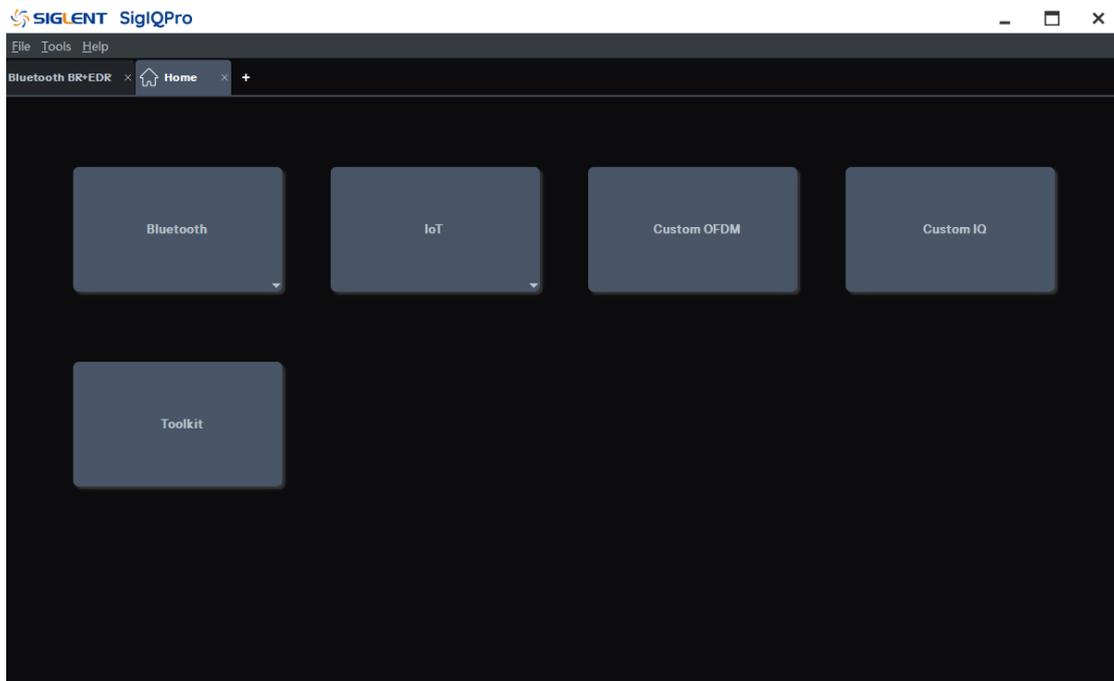
3.1.2 Tab Bar

Displays the Home page and currently running applications. Supports the following operations:

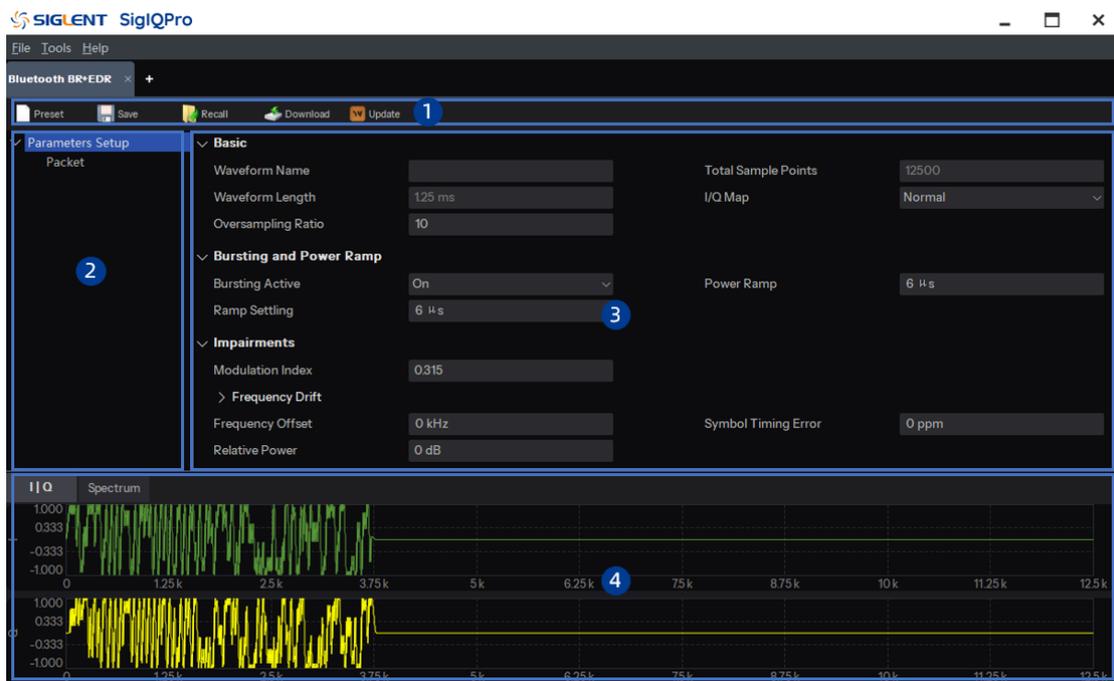
- Clicks the tab to switch to the settings page of the application;
- Clicks “x” on the tab to exit the application;
- Clicks “+” to add a home page.

3.1.3 Protocol Menu

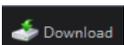
Select the protocol you want and click to open the protocol settings, such as Custom OFDM.



3.2 Parameters Setting Page



3.2.1 Toolbar

-  **Preset** : Resets your current application configuration to default settings.
-  **Save** : Opens a file management window where you can save your current application configuration as a file (*.state) or generated waveform file (*.ARB) for future use.
-  **Recall** : Opens a file management window where you can recall a previously saved application configuration file (*.state).
-  **Download** : Opens an instrument connection window where you can download a waveform, based on your application's current configuration or previously saved, to the connected instrument.
-  **Update** : Update the graph view based on your application's current configuration.

3.2.2 Tree View

The left pane of the main window is called the tree view. It is useful for navigating between the waveform setup nodes and packet setup nodes.

3.2.3 Parameter View

The right pane of the main window is called the parameter view. This area enables you to set the

waveform parameters. Selecting an item in the tree view enables the related elements in the parameter view.

3.2.4 Graph View

The graph view displays different representations of the generated waveform. Click the tab at the top of the graph view to switch to different waveform graphs. Changes to the waveform configuration will not update the graph until you update the waveform.

3.3 Export or Import Files

SigIQPro supports importing or exporting three types of files.

3.3.1 Project File (*.project)

This file is used to save software configuration, includes the currently launched applications and the current parameter settings of the applications.

Export: Click “File” -> “Save as...” in the menu bar to open a file management window, then click “Save” button to save the project file.

Import: Click “File” -> “Recall...” in the menu bar to open a file management window, then open a previously saved project file (*.project) to recall settings. The software will update the interface display based on the saved configurations in the file.

3.3.2 State File (*.state)

This file is used to save the settings for the current application and can only be imported or exported by current application.

Export: Click “Save” icon in the toolbar of the application to open a file management window, then select save type as “App State Files (*.state)” and click “Save’ to save the state file.

Import: Click “Recall” icon in the toolbar of the application to open a file management window, then open a previously saved state file (*.state) to recall settings for current application.

3.3.3 Waveform File (*.ARB)

This file is used to save an encrypted waveform file (with ARB extension) to your PC. The file contains waveform information of the current application and can then be downloaded and played in licensed instruments.

Export: Click “Save” icon in the toolbar of the application to open a file management window, then select save type as “Waveform File (*.ARB)” and click “Save’ to save the waveform file.

4 Waveform Setup

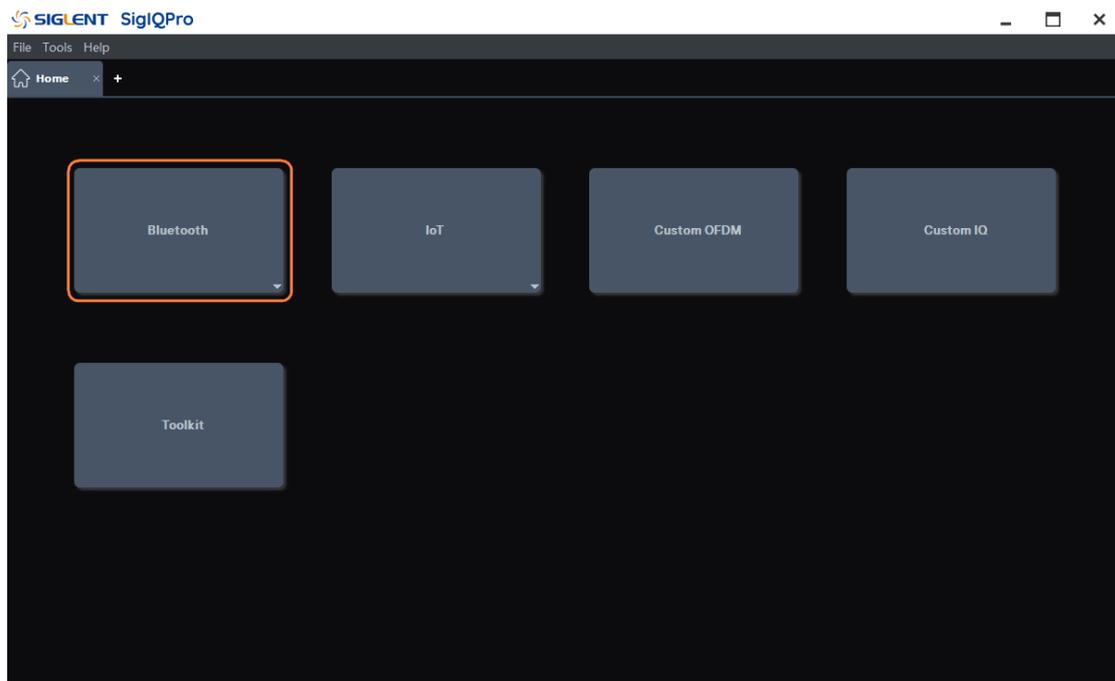
4.1 Bluetooth BR+EDR

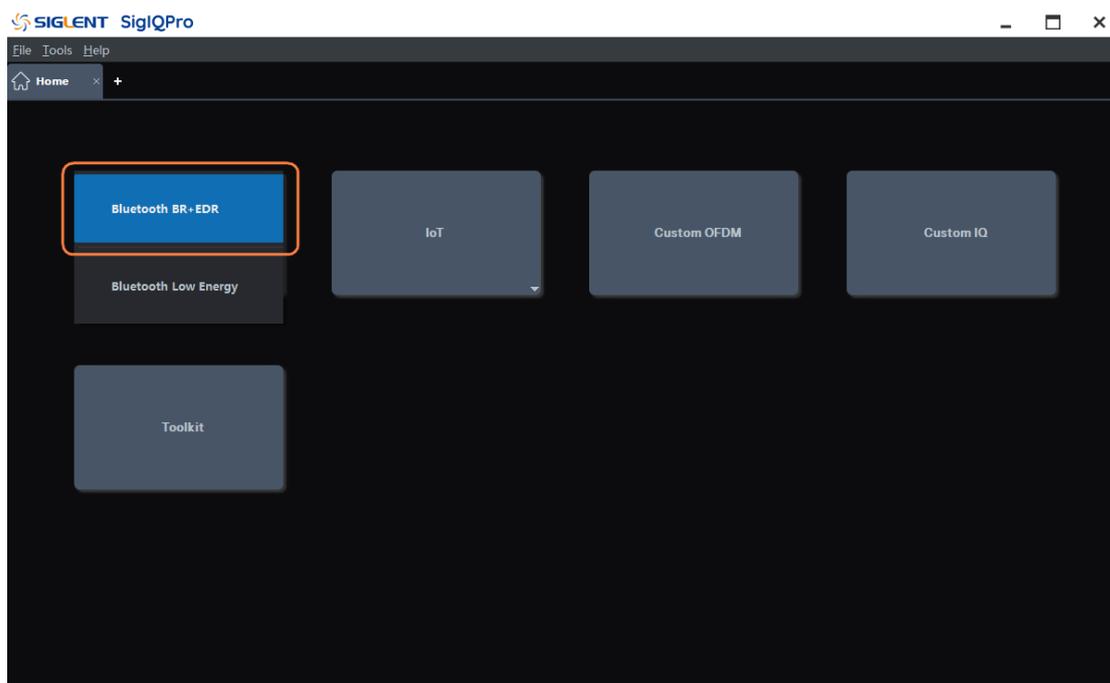
Bluetooth devices operate in the unlicensed 2.4 GHz ISM (Industrial Scientific Medical) band. A frequency hop transceiver is applied to combat interference and fading.

Two modulation modes are defined. A mandatory mode, called Basic Rate, uses a shaped, binary FM modulation to minimize transceiver complexity. An optional mode, called Enhanced Data Rate, uses PSK modulation and has two variants: $\pi/4$ -DQPSK and 8DPSK. The symbol rate for all modulation modes is 1 Msym/s. The gross air data rate is 1 Mb/s for Basic Rate, 2 Mb/s for Enhanced Data Rate using $\pi/4$ -DQPSK and 3 Mb/s for Enhanced Data Rate using 8DPSK.

Protocol version: 5.0

You can click **Bluetooth** -> **Bluetooth BR+EDR** on the homepage to enter the BR/EDR Bluetooth setting interface.





4.1.1 Parameters Setup

Press **Parameters Setup** in the left window to enter parameter settings.

4.1.1.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

3. Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4. I/Q Map

Choice: Normal | Inverted ; Default: Normal.

Use the drop-down menu to select a normal or inverted I/Q signal. If invert is selected, the I signal is unchanged and the Q is reversed.

5. Oversampling Ratio

Range: 2 to 100 ; Default: 10.

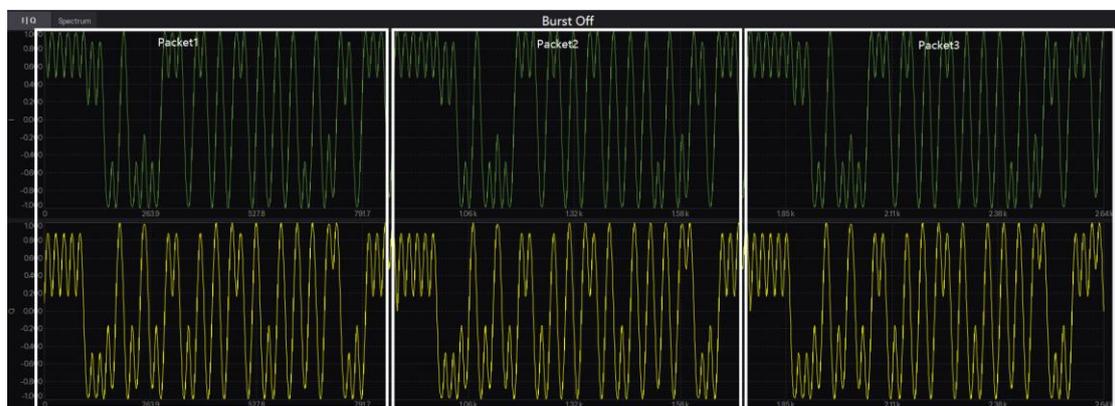
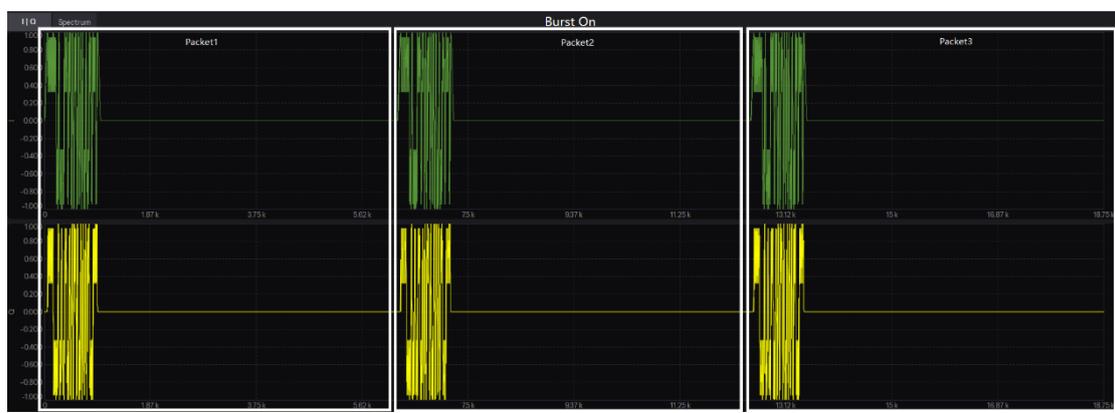
Set the number of samples calculated per I/Q symbol.

4.1.1.2 Bursting and Power Ramp

1. Bursting Active

Choice: On | Off ; Default: On.

Use the drop-down menu to enable or disable the bursting in the waveform. When enabled, the packet transmission timing of the test signal adheres to the Bluetooth TDD slot structure for the selected packet type.



2. Power Ramp

Range: 1 to 10 us ; Default: 6 us.

Set the power ramp up and power ramp down length of the burst.

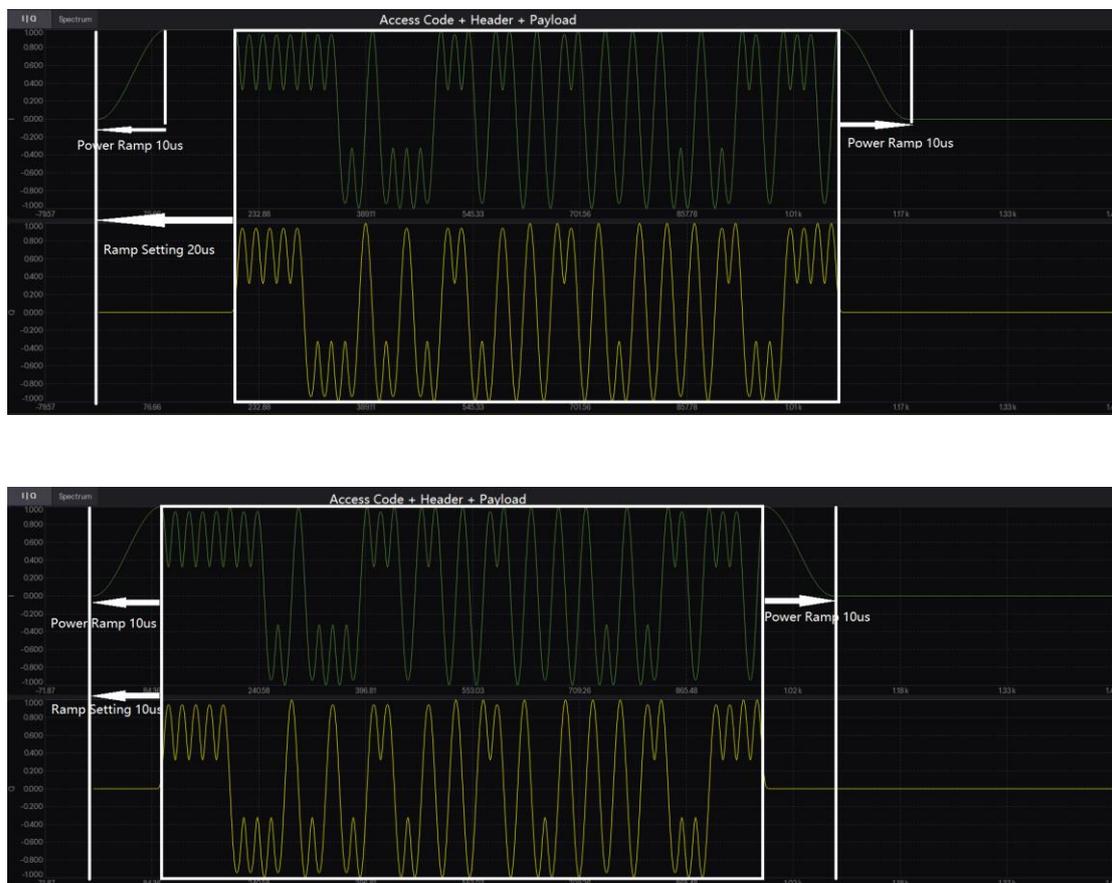
The power ramp up refers to the time when the carrier frequency ramped from idle power to transmitted power. The power ramp is shaped with a cosine function.

3. Ramp Settling

Range: 1 to 20 us ; Default: 6 us.

Set the Ramp Settling length of the burst.

The Ramp Settling refers to the time when the carrier frequency ramped from idle power to transmitted power and remains stable until it begins to transmit the first symbol.



4.1.1.3 Impairments

1. Modulation Index

Range: 0.05 to 0.95 ; Default: 0.315.

Set the modulation index of GFSK.

Specifies the modulation index used by GFSK, which is the ratio of peak-to-peak frequency deviation to the bit rate.

2. Frequency Drift

1) State

Choice: On | Off ; Default: Off.

Use the drop-down menu to enable or disable the frequency drift impairment applied to the packet. This impairment adds a dynamic error to the transmission frequency. It is used to simulate the frequency drift impairment repeats at the beginning of each timeslot and occurs over a time period equal to the packet duration.

2) Type

Choice: Linear | Sine ; Default: Linear.

Use the drop-down menu to select the type of frequency drift applied to the Bluetooth packet.

3) Deviation

Range: -100 to 100 kHz ; Default: 0 kHz.

Set the maximum deviation of frequency drift impairment.

4) Rate

Choice: 300 Hz | 500 Hz | 1.6 kHz | 10 kHz;

Default: 1.6 kHz.

Use the drop-down menu to select the frequency drift rate.

3. Frequency Offset

Range: -200 to 200 kHz ; Default: 0 kHz.

Sets the static offset of the carrier frequency. This static offset is used to simulate a Bluetooth device transmitting at a frequency slightly offset from the specified carrier.

4. Symbol Timing Error

Range: -50 to 50 ppm ; Default: 0 ppm.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the Bluetooth signal.

It is used to simulate a Bluetooth device transmitting at a slight deviation in the sampling clock.

5. Relative Power

Range: -10 to 10 dB ; Default: 0.00 dB.

Set the average power level of the synchronization sequence and payload relative to the access code and header portion during transmission.

4.1.1.4 Dirty Transmitter

1. State

Choice: On | Off ; Default: Off.

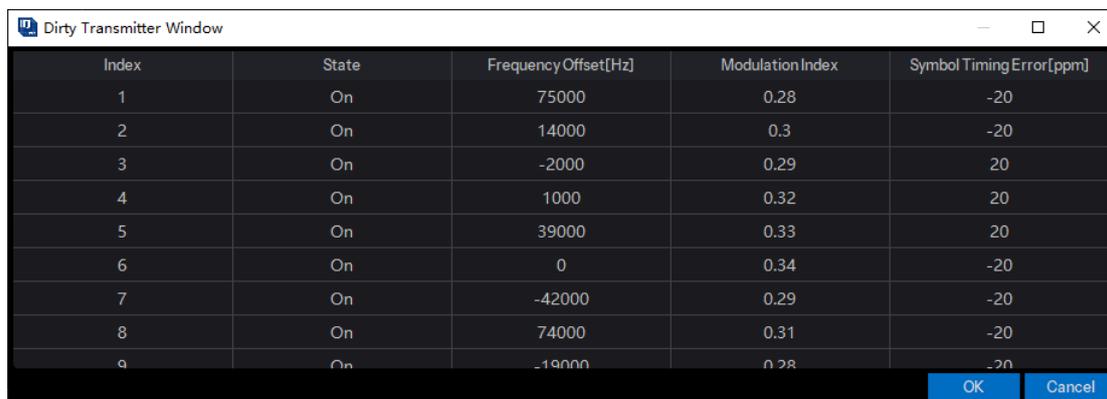
Use the drop-down menu to enable or disable the dirty transmitter test. When this setting is set to On, the Dirty Transmitter Impairments Setup window appears.

2. Number of Packet per Set

Range: 1 to 50 ; Default: 1.

Set the number of packets for each set of parameters displayed in the Dirty Transmitter Window.

3. Dirty Transmitter Window



Index	State	Frequency Offset [Hz]	Modulation Index	Symbol Timing Error [ppm]
1	On	75000	0.28	-20
2	On	14000	0.3	-20
3	On	-2000	0.29	20
4	On	1000	0.32	20
5	On	39000	0.33	20
6	On	0	0.34	-20
7	On	-42000	0.29	-20
8	On	74000	0.31	-20
9	On	-19000	0.28	-20

1) Index

This cell displays the impairment set index number.

2) State

Use this cell to enable or disable a specified impairment set in dirty transmitter test.

3) Frequency Offset [Hz]

Range: -200 to 200 kHz.

Set the static offset of the carrier frequency. This static offset is used to simulate a Bluetooth device transmitting at a frequency slightly offset from the specified carrier.

4) Modulation Index

Range: 0.05 to 0.95.

Specify the modulation index used by GFSK, which is the ratio of peak-to-peak frequency deviation to the bit rate.

5) Symbol Timing Error [ppm]

Range: -50 to 50.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the Bluetooth signal. It is used to simulate a Bluetooth device transmitting at a slight deviation in the sampling clock.

4.1.1.5 Frequency Hopping

1. State

Choice: On | Off ; Default: Off.

Use the drop-down menu to enable or disable frequency hopping.

2. Hop Selection

Choice: Selection Kernel | User Defined;

Default: Selection Kernel.

Use the drop-down menu to set the hop selection type.

Note: This setting can be edited only when the Hopping State is turned On. "Selection Kernel" means that the hopping sequence will be calculated using basic hop selection kernel, which uses 'CLK Start' and 'UAP/LAP' as input parameters.

"User Defined" means that the user input sequence will be used as hopping sequence.

3. CLK Start

Range: 0x00000000 to 0xFFFFFFFF;

Default: 0x00000000.

Set the starting value of CLK as an input of kernel hop selection.

Note: This setting can be edited only when the Hopping State is turned On and Hop Selection is Selection Kernel.

4. User Sequence

Set the user defined hopping sequence using comma as separator.

Note: This setting can be edited only when the Hopping State is turned On and Hop Selection is User Defined.

5. Hop Channel

Range: 0 to 78 ; Default: 0.

Set the fixed frequency channel index used for packet transmission.

Note: This setting can be edited only when the Hopping State is turned Off.

4.1.2 Packet

Press **Packet** in the left window to enter parameter settings.

4.1.2.1 General Setting

1. Bluetooth Mode

Choice: Basic Rate | Enhanced Data Rate;

Default: Basic Rate.

Use the drop-down menu to select the Bluetooth mode of the packet.

2. Transport Mode

Choice: ACL | eSCO | SCO (Basic Rate Only);

Default: ACL.

Use the drop-down menu to select the Transport Mode of the packet.

3. Packet Type

Use the drop-down menu to select the packet type.

Type code	Slot occupied	SCO (1Mbps)	eSCO (1Mbps)	eSCO (2-3Mbps)	ACL (1Mbps)	ACL (2-3Mbps)
0000	1	NULL	NULL	NULL	NULL	NULL
0001	1	POLL	POLL	POLL	POLL	POLL
0010	1	FHS	—	—	FHS	FHS
0011	1	DM1	—	—	DM1	DM1
0100	1	—	—	—	DH1	2-DH1
0101	1	HV1	—	—	—	—
0110	1	HV2	—	2-EV3	—	—
0111	1	HV3	EV3	3-EV3	—	—
1000	1	DV	—	—	—	3-DH1
1001	1	—	—	—	AUX1	AUX1
1010	3	—	—	—	DM3	2-DH3
1011	3	—	—	—	DH3	3-DH3
1100	3	—	EV4	2-EV5	—	—
1101	3	—	EV5	3-EV5	—	—
1110	5	—	—	—	DM5	2-DH5
1111	5	—	—	—	DH5	3-DH5
n/a	1	ID	ID	ID	ID	ID

4. Occupied Slots

Display the number of time slots occupied by the specified packet.

5. Modulation Type

Display the modulation type applied to the specified packet.

- GFSK: Basic Rate
- GFSK+ DQPSK: Enhanced Data Rate (2Mbps)
- GFSK+ D8PSK: Enhanced Data Rate (3Mbps)

4.1.2.2 Packet Setting

1. Packet Data Type

Choice: Standard | All Data ;

Default: Standard.

Use the drop-down menu to select the packet data type.

- Standard: Uses packet type information to generate packet data.
- All Data: The package structure is filled with raw data without regard to package type information.

2. Data Whitening

Choice: On | Off;

Default: Off.

Use the drop-down menu to set the data whitening state of the packet payload.

Before transmission of all packets both the header and the payload shall be scrambled with a data whitening word in order to randomize the data from highly redundant patterns and to minimize DC bias in the packet. The scrambling shall be performed prior to the FEC encoding.

3. BD_ADDR

Range: 0x000000000000 to 0xFFFFFFFFFFFF;

Default: 0x000000000008.

Display the Bluetooth Device Address in hexadecimal form. Each Bluetooth device shall be allocated a unique 48-bit Bluetooth device address (BD_ADDR). This address shall be obtained from the IEEE Registration Authority. The address is divided into three fields: LAP, UAP and NAP. The structure of BD_ADDR is as follows:

LSB → MSB

LAP						UAP		NAP			
0000	0001	0000	0000	0000	0000	0001	0100	0111	1011	0011	0101

4. LAP

Range: 1x000000 to 0xFFFFFFFF;

Default: 0x000008.

This 24-bit field shall contain the lower address part of the device.

5. UAP

Range: 0x00 to 0xFF;

Default: 0x00.

This 8-bit field should contain the upper address part of the device.

6. NAP

Range: 0x0000 to 0xFFFF;

Default: 0x0000.

This 16-bit field should contain the non-significant address part of the device.

7. LT_ADDR

Range: 0 to 7;

Default: 1.

Set the logical transport address in the packet header.

The 3-bit LT_ADDR field contains the logical transport address for the packet. This field indicates the destination slave (or slaves in the case of a broadcast) for a packet in a master-to-slave transmission slot and indicates the source slave for a slave-to-master transmission slot.

8. FLOW

Range: 0 to 1 ; Default: 1.

Set the flow control bit in the packet header.

The FLOW bit is used for flow control of packets over the ACL logical transport. When the RX buffer for the ACL logical transport in the recipient is full, a STOP indication (FLOW=0) shall be returned to stop the other device from transmitting data temporarily. The STOP signal only affects ACL packets. Packets including only link control information (ID, POLL, and NULL packets), SCO packets or eSCO packets can still be received. When the RX buffer can accept data, a GO indication (FLOW=1) shall be returned. When no packet is received, or the received header is in error, a GO shall be assumed implicitly. In this case, the slave can receive a new packet with CRC although its RX buffer is still not emptied. The slave shall then return a NAK in response to this packet even if the packet passed the CRC check.

The FLOW bit is not used on the eSCO logical transport and shall be set to one on transmission and ignored upon receipt. The FLOW bit is reserved for future use on the CSB logical transport.

9. ARQN

Range: 0 to 1 ; Default: 0.

Set the ARQ control bit in the packet header.

The 1-bit acknowledgment indication ARQN is used to inform the source of a successful transfer of payload data with CRC, and can be positive acknowledge ACK or negative acknowledge NAK.

10. SEQN

Range: 0 to 1 ; Default: 0.

Set the sequential number index in the packet header.

In Multiple Packet distribution case, the SEQN bit will be set automatically. In the first CRC data

packet at the start of the connection, SEQN shall be set to 1. If a new packet is sent, the value of SEQN will be toggled. If the number of total packets is not even, a padding packet will be added to keep the SEQN toggling rule.

4.1.2.3 Payload Setting

1. Payload Length

Set the number of bytes for the payload of the Bluetooth packet. If the packet has a payload header, it indicates the length field of the header.

2. Payload Data

Choice: PN9 | PN15 | USER ; Default: PN9.

Use the drop-down menu to set the type of packet payload.

When Data Continuous is set to ON and PN9 or PN15 is selected, the software automatically configures the Length and Repetitions fields. The number of packets required to accommodate the selected continuous PN pattern is also automatically determined and updated the number of bits. If USER is selected as the data pattern, the number of bits displayed in the Data Length field is equal to the length of the user data multiplied by Data Repetition. The maximum number of bits allowed by the packet type. Any remaining bits in the user data file beyond the maximum amount will be truncated.

Note: This parameter is displayed only when the current packet contains the payload data field.

3. LLID

Range: 0 to 3 ; Default: 2.

Set the logical link indication in the packet payload header.

Note: This parameter is displayed only when the current packet contains the payload header field.

4. FLOW

Range: 0 to 1 ; Default: 1.

The flow indicator in the payload is used to control the flow at the L2CAP level.

It is used to control the flow per logical link. FLOW=1 means flow-on (GO) and FLOW=0 means flow-off (STOP). After a new connection has been established the flow indicator shall be set to GO.

When a device receives a payload header with the flow bit set to STOP, it shall stop the transmission of ACL packets before an additional amount of payload data is sent.

Note: This parameter is displayed only when the current packet contains the payload header field.

5. EIR

Range: 0 to 1 ; Default: 0.

Set the extended inquiry response packet following indication bit in the FHS packet.

This bit shall indicate that an extended inquiry response packet may follow.

Note: This parameter is displayed only when the current packet is the FHS packet.

6. SR

Choice: R0, R1, R2, Reserved;

Default: R0.

Set the scan repetition mode in the FHS packet.

This 2-bit field is the scan repetition field and indicates the interval between two consecutive page scan windows.

Note: This parameter is displayed only when the current packet is the FHS packet.

7. Class Of Device

Range: 0x000000 to 0xFFFFFFFF;

Default: 0x000000.

Set the class of Bluetooth device.

This 24-bit field shall contain the class of device of the device that sends the FHS packet. This field is defined in Bluetooth Assigned Number.

Note: This parameter is displayed only when the current packet is the FHS packet.

8. CLK

Range: 0x0000000 to 0x3FFFFFFF;

Default: 0x0000000.

Set the native clock of the Bluetooth device.

This 26-bit field shall contain the value of the native clock of the device that sends the FHS packet, sampled at the beginning of the transmission of the access code of this FHS packet. This clock value has a resolution of 1.25ms (two-slot interval). For each new transmission, this field is updated so that it accurately reflects the real-time clock value.

Note: This parameter is displayed only when the current packet is the FHS packet.

9. Page Scan Mode

Choice: Mandatory, Reserved;

Default: Mandatory.

Set the page scan mode in the FHS packet.

This 3-bit field shall indicate which scan mode is used by default by the sender of the FHS packet.

Note: This parameter is displayed only when the current packet is the FHS packet.

10. Payload Data (Voice)

Choice: PN9 | PN15 | USER;

Default: PN9.

Set the voice field data type of the DV packet. The DV packet payload is divided into a voice field of 80 bits and a data field containing up to 150 bits.

Note: This parameter is displayed only when the current packet is the DV packet.

11. Payload Distribution

Choice: Single Packet | Multiple Packet;

Default: Single Packet.

Use the drop-down menu to set the distribution type of packet payload.

When Single Packet is selected, the software creates a waveform that consists of one Bluetooth packet. When downloaded to the signal source, the waveform is repeatedly played back resulting in a packet sequence comprised of identical packets. When Multiple Packet is selected, the software creates a waveform that consists of a multiple packet sequence. A data pattern is distributed into the payload portion of each packet in the sequence. Once downloaded to the instrument, the signal generator plays back the entire package sequence repeatedly.

12. Data Continuous

Choice: On | Off ; Default: On.

Use the drop-down menu to set the continuous state of the packet payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet.

13. Data Repetition

Set the repetition number of the packet payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet and Data Continuous is set to Off.

14. Data Length

Set the number of total bits contained in the payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet and Data Continuous is set to Off.

15. Number Of Full Packets

Display the number of full packets occupied by the packet payload.

16. Number Of Partial Packets

Display the number of partial packets occupied by the packet payload.

Because the payload portion of each packet is filled to capacity, if possible, the number of partial

packets appended to the end of a packet sequence will always be 0 or 1.

17. Number Of Padding Packets

Choice: 0 | 1 ; Default: 0.

Sets the number of padding packets occupied by the packet payload.

When the software creates a multiple packet sequence, the sequence bit in the header field is toggled after each packet transmission in the sequence. This indicates to the Bluetooth device that the incoming packet is not a re-transmitted packet. To maintain an alternating sequence bit when the waveform is repeatedly played back, an even number of packets must be generated. If the data pattern length is set such that an odd number of packets are required to send the data, then a pad packet is appended to the end of the packet sequence. The pad packet has no payload and is only generated in this circumstance to accommodate the alternating sequence bit.

4.2 Bluetooth Low Energy

Bluetooth Low Energy (LE) devices operate in the unlicensed 2.4 GHz ISM (Industrial Scientific Medical) band. A frequency hopping transceiver is used to combat interference and fading. Two modulation schemes are defined. The mandatory modulation scheme (“1 Msym/s modulation”) uses a shaped, binary FM to minimize transceiver complexity. The symbol rate is 1 Msym/s. An optional modulation scheme (“2Msym/s modulation”) is similar but uses a symbol rate of 2 Msym/s. Protocol version: 5.2.

The 1 Msym/s modulation supports two PHYs:

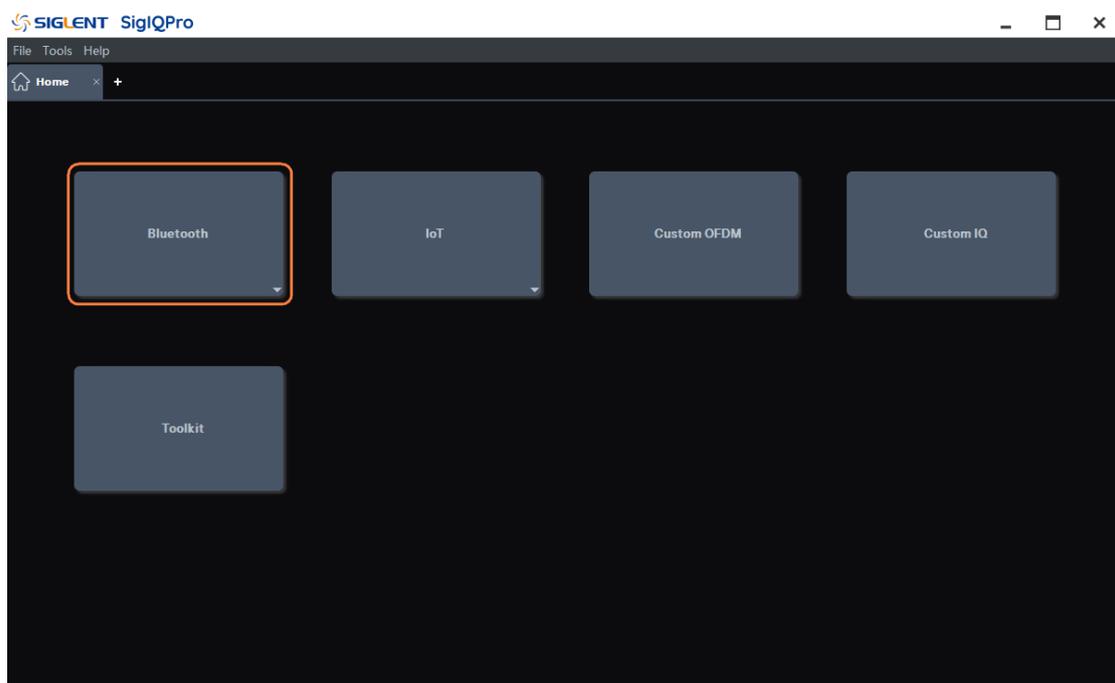
- LE 1M, with uncoded data at 1 Mb/s;
- LE Coded, with the Access Address, Coding Indicator, and TERM1 coded at 125 kb/s and the payload coded at either 125 kb/s or 500 kb/s.

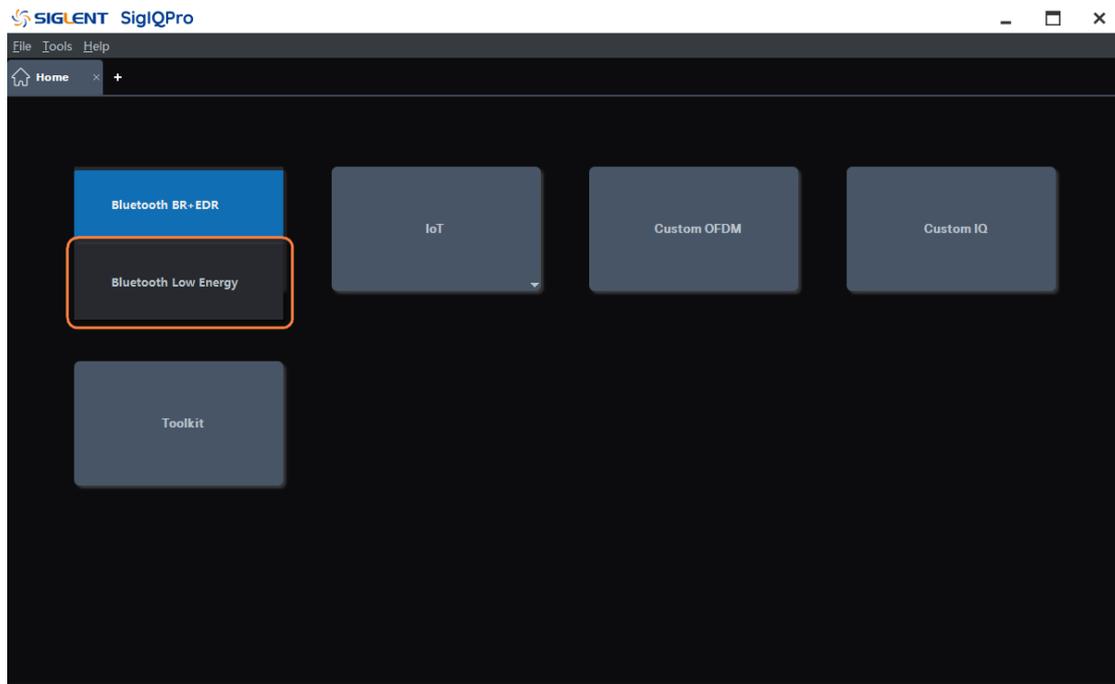
A device shall support the LE 1M PHY. Support for the LE Coded PHY is optional.

The 2 Msym/s modulation supports a single PHY:

- LE 2M, with uncoded data at 2 Mb/s

You can click **Bluetooth** -> **Bluetooth Low Energy** on the homepage to enter the Bluetooth LE setting interface.





4.2.1 Parameters Setup

Press **Parameters Setup** in the left window to enter parameter settings.

4.2.1.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

3. Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4. I/Q Map

Choice: Normal | Inverted ; Default: Normal.

Use the drop-down menu to select a normal or inverted I/Q signal. If invert is selected, the I signal is unchanged and the Q is reversed.

5. Oversampling Ratio

Range: 2 to 100 ; Default: 10.

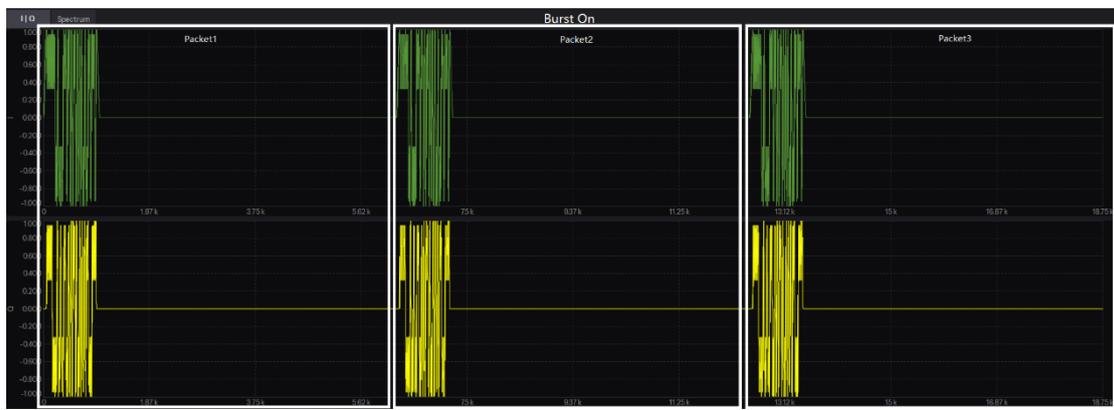
Set the number of samples calculated per I/Q symbol.

4.2.1.2 Bursting and Power Ramp

1. Bursting Active

Choice: On | Off ; Default: On.

Use the drop-down menu to enable or disable the bursting in the waveform. When enabled, the packet transmission timing of the test signal adheres to the Bluetooth TDD slot structure for the selected packet type.



2. Power Ramp

Range: 1 to 10 us ; Default: 6 us.

Set the power ramp up and power ramp down length of the burst.

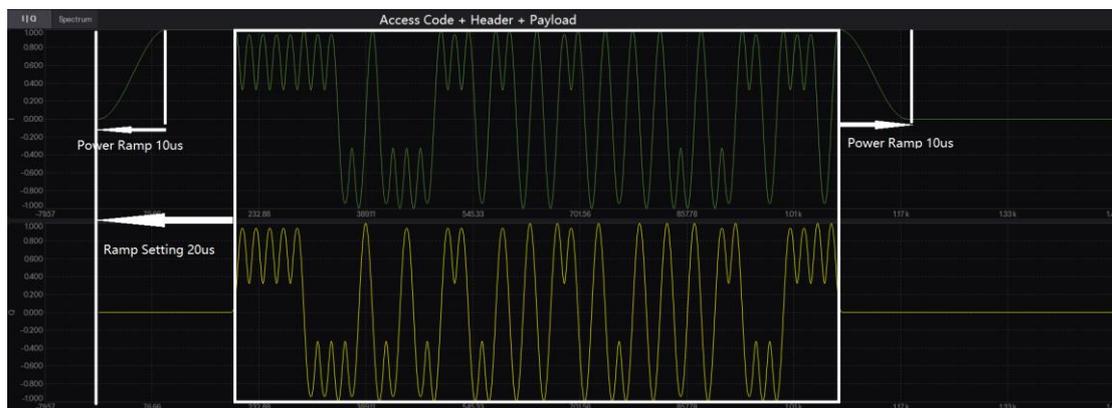
The power ramp up refers to the time when the carrier frequency ramped from idle power to transmitted power. The power ramp is shaped with a cosine function.

3. Ramp Settling

Range: 1 to 20 us ; Default: 6 us.

Set the Ramp Settling length of the burst.

The Ramp Settling refers to the time when the carrier frequency ramped from idle power to transmitted power and remains stable until it begins to transmit the first symbol.



4.2.1.3 Impairment

1. Modulation Index

Range: 0.45 to 0.55 ; Default: 0.5.

Set the modulation index of GFSK.

Specifies the modulation index used by GFSK, which is the ratio of peak-to-peak frequency deviation to the bit rate.

2. Frequency Drift

1) State

Choice: On | Off ; Default: Off.

Use the drop-down menu to enable or disable the frequency drift impairment applied to the packet.

This impairment adds a dynamic error to the transmission frequency. It is used to simulate the frequency drift impairment repeats at the beginning of each timeslot and occurs over a time period equal to the packet duration.

2) Type

Choice: Linear | Sine ; Default: Linear.

Use the drop-down menu to select the type of frequency drift applied to the Bluetooth packet.

3) Deviation

Range: -100 to 100kHz ; Default: 0 kHz.

Set the maximum deviation of frequency drift impairment.

4) Rate

Choice: 625Hz | 750Hz | 1250Hz ; Default: 1250Hz.

Use the drop-down menu to select the frequency drift rate.

3. Frequency Offset

Range: -200 to 200kHz ; Default: 0kHz.

Sets the static offset of the carrier frequency. This static offset is used to simulate a Bluetooth device transmitting at a frequency slightly offset from the specified carrier.

4. Symbol Timing Error

Range: -50 to 50ppm ; Default: 0ppm.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the Bluetooth signal.

It is used to simulate a Bluetooth device transmitting at a slight deviation in the sampling clock.

4.2.1.4 Dirty Transmitter

1. State

Choice: On | Off ; Default: Off.

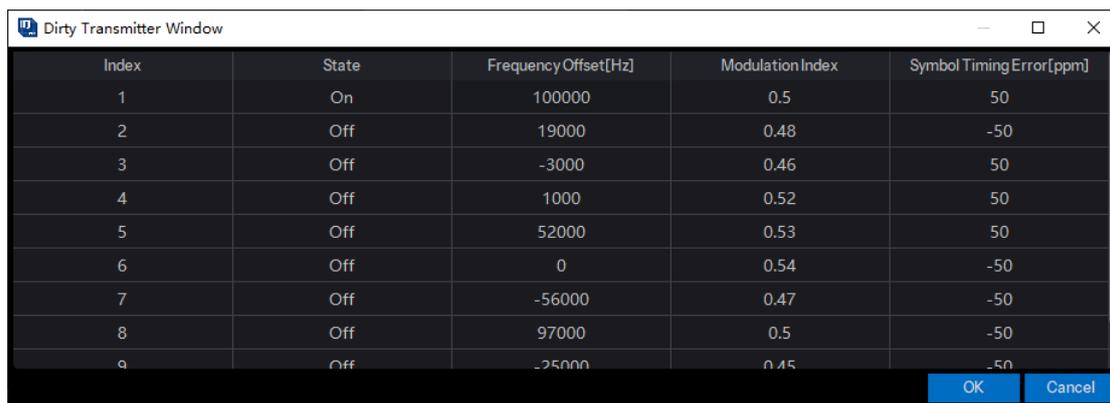
Use the drop-down menu to enable or disable the dirty transmitter test. When this setting is set to On, the Dirty Transmitter Impairments Setup window appears.

2. Number of Packet per Set

Choice: 1 | 2 | 50 ; Default: 1.

Use the drop-down menu to select the number of packets for each set of parameters displayed in the Dirty Transmitter Window.

3. Dirty Transmitter Window



Index	State	Frequency Offset [Hz]	Modulation Index	Symbol Timing Error [ppm]
1	On	100000	0.5	50
2	Off	19000	0.48	-50
3	Off	-3000	0.46	50
4	Off	1000	0.52	50
5	Off	52000	0.53	50
6	Off	0	0.54	-50
7	Off	-56000	0.47	-50
8	Off	97000	0.5	-50
9	Off	-25000	0.45	-50

1) Index

This cell displays the impairment set index number.

2) State

Use this cell to enable or disable a specified impairment set in dirty transmitter test.

3) Frequency Offset [Hz]

Range: -200 to 200kHz.

Sets the static offset of the carrier frequency. This static offset is used to simulate a Bluetooth device transmitting at a frequency slightly offset from the specified carrier.

4) Modulation Index

Range: 0.45 to 0.55.

Set the modulation index of GFSK.

Specifies the modulation index used by GFSK, which is the ratio of peak-to-peak frequency deviation to the bit rate.

5) Symbol Timing Error [ppm]

Range: -50 to 50.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the Bluetooth signal. It is used to simulate a Bluetooth device transmitting at a slight deviation in the sampling clock.

4.2.2 Packet

Press **Packet** in the left window to enter parameter settings.

4.2.2.1 General Setting

1. Channel Type

Choice: Advertising | Data | Test ;

Default: Test.

Display the channel type of Bluetooth low energy wireless technology packet. Use the drop-down menu to select the channel type of Bluetooth low energy packet.

2. Packet Type

Choice: Test_Packet | ADV_IND | ADV_DIRECT_IND | ADV_NONCONN_IND | ADV_SCAN_IND | ADV_EXT_IND | AUX_ADV_IND | AUX_SYNC_IND | AUX_CHAIN_IND | SCAN_REQ | SCAN_RSP | AUX_SCAN_REQ | AUX_SCAN_RSP | CONNECT_IND | AUX_CONNECT_REQ | AUX_CONNECT_RSP | LL_Data | LL_CONNECTION_UPDATE_IND | LL_CHANNEL_MAP_IND | LL_TERMINATE_IND | LL_ENC_REQ | LL_ENC_RSP | LL_START_ENC_REQ | LL_START_ENC_RSP | LL_UNKNOWN_RSP | LL_FEATURE_REQ | LL_FEATURE_RSP | LL_PAUSE_ENC_REQ | LL_PAUSE_ENC_RSP | LL_VERSION_IND | LL_REJECT_IND | LL_SLAVE_FEATURE_REQ | LL_CONNECTION_PARAM_REQ | LL_CONNECTION_PARAM_RSP | LL_REJECT_EXT_IND | LL_PING_REQ | LL_PING_RSP | LL_LENGTH_REQ | LL_LENGTH_RSP | LL_PHY_REQ | LL_PHY_RSP | LL_PHY_UPDATE_IND | LL_MIN_USED_CHANNELS_IND | LL_CTE_REQ | LL_CTE_RSP | LL_PERIODIC_SYNC_IND | LL_CLOCK_ACCURACY_REQ | LL_CLOCK_ACCURACY_RSP;

Default: Test_Packet.

Set the packet type of Bluetooth low energy wireless technology.

- Advertising Channel Type: ADV_IND | ADV_DIRECT_IND | ADV_NONCONN_IND | ADV_SCAN_IND | ADV_EXT_IND | AUX_ADV_IND | AUX_SYNC_IND | AUX_CHAIN_IND | SCAN_REQ | SCAN_RSP | AUX_SCAN_REQ | AUX_SCAN_RSP | CONNECT_IND | AUX_CONNECT_REQ | AUX_CONNECT_RSP;
- Data Channel Type: LL_Data | LL_CONNECTION_UPDATE_IND | LL_CHANNEL_MAP_IND | LL_TERMINATE_IND | LL_ENC_REQ | LL_ENC_RSP | LL_START_ENC_REQ | LL_START_ENC_RSP | LL_UNKNOWN_RSP | LL_FEATURE_REQ | LL_FEATURE_RSP | LL_PAUSE_ENC_REQ | LL_PAUSE_ENC_RSP | LL_VERSION_IND | LL_REJECT_IND | LL_SLAVE_FEATURE_REQ | LL_CONNECTION_PARAM_REQ | LL_CONNECTION_PARAM_RSP | LL_REJECT_EXT_IND | LL_PING_REQ | LL_PING_RSP | LL_LENGTH_REQ | LL_LENGTH_RSP | LL_PHY_REQ | LL_PHY_RSP | LL_PHY_UPDATE_IND | LL_MIN_USED_CHANNELS_IND | LL_CTE_REQ | LL_CTE_RSP | LL_PERIODIC_SYNC_IND | LL_CLOCK_ACCURACY_REQ | LL_CLOCK_ACCURACY_RSP;

Use the drop-down menu to select the packet type of Bluetooth low energy.

3. Packet Format

Set the PHY type. LE supports LE 1M PHY, LE 2M PHY, and LE Coded PHY.

4. Coding Indicator

Coding Indicator (CI) is a field of encoded Packet that determines the encoding mode of FEC Block 2. If 0 is set, S=8 is selected; if 1 is set, S=2 is selected. The default value is 0.

5. Channel Index

Range: 0 to 39 ; Default: 0.

Set the current RF channel index of Bluetooth low energy packet.

The LE system operates in the 2.4 GHz ISM band at 2400-2483.5 MHz. The LE system uses 40 RF channels. These RF channels are divided into 3 RF channels known as the "primary advertising channels", used for initial advertising and all legacy advertising activities, and 37 RF channels known as the "general-purpose channels", used for the majority of communications. Please refer to Table 1.3 of Vol 6 Part B of Core v5.2 for more information.

6. Access Address

Range: 0x00000000 to 0xffffffff ;

Default: 0x8e89bed6.

Set the logical link specify address of Bluetooth low energy packet. Please refer to section 2.1.2 of Vol 6 Part B of Core v5.2 for more information.

Note: The Access Address for all other advertising physical channel packets shall be 0b10001110-10001001-10111110-11010110 (0x8E89BED6).

7. CRC Preload

Range: 0x000000 to 0xfffff ;

Default: 0x555555.

Set the CRC preload state of Bluetooth low energy packet.

The PDU is followed by a 24-bit CRC. It shall be calculated over the PDU. Please refer to section 3.1.1 of Vol 6 Part B of Core v5.2 for more information.

Note: The CRC Preload for all other advertising physical channel packets shall be 0x555555.

8. Data Whitening

Choice: On | Off ;

Default: Off.

Use the drop-down menu to enable or disable data whitening for the PDU and CRC data of Bluetooth low energy packet.

Data whitening is used to avoid long sequences of zeros or ones, e.g., 0b0000000 or 0b1111111, in the data bit stream. Whitening shall be applied on the PDU and CRC of all Link Layer packets and is

performed after the CRC generation in the transmitter. The whitener and de-whitener are defined the same way, using a 7-bit linear feedback shift register with the polynomial $x^7 + x^4 + 1$. Please refer to section 3.2 of Vol 6 Part B of Core v5.2 for more information.

9. Idle Interval

Range: 150 – 150000 us ;

Default: 249 us.

Set the idle interval time in-between frames in microseconds.

Note: This parameter is visible and configurable only when the Bursting Active is on.

10. Packet Length

Display the packet length in microseconds.

Note: This value is read-only and automatically updated with Channel Type, Packet Type, Packet Format and Length.

4.2.2.2 Test PDU Header Setting

Set **General Setting** -> **Channel Type** as Test.

1. Payload Type

Display the payload type field of Test PDU header. Please refer to Table 4.1 of Vol 6 Part B of Core v5.2 for more information.

Note: This value is read-only and automatically updated when Payload Data is changed.

2. CP

Range: 0 – 1 ; Default: 0.

Set the CTEInfo Present (CP) field of the Test PDU header. This value indicates whether the CTEInfo field is present and therefore whether the test packet has a Constant Tone Extension.

If the CP field is 0, then no CTEInfo field is present and there is no Constant Tone Extension in the test packet. If the CP field is 1, then the CTEInfo field is present and the test packet includes a Constant Tone Extension.

Please refer to section 4.1.4 of Vol 6 Part B of Core v5.2 for more information.

3. Length

Range: 0 – 255 ; Default: 37.

Set the Test PDU payload length in bytes. It will be included in PDU Length field of the Test PDU header.

4. CTE Time

Range: 2 – 20 ; Default: 20.

Set the CTE Time field of CTE Info Header to indicate the length of the Constant Tone Extension in 8 μ s units. Please refer to section 2.5.2 of Vol 6 Part B of Core v5.2 for more information.

Note: This parameter is visible and configurable only when the CP is 1.

5. CTE Type

Choice: AOA | AOD(1us) | AOD(2us) ;

Default: AOA.

Set the CTE Type field of CTE Info Header to indicate the type of the Constant Tone Extension and the duration of the switching slots. Please refer to section 2.5.2 of Vol 6 Part B of Core v5.2 for more information.

Note: This parameter is visible and configurable only when the CP is 1.

4.2.2.3 Test PDU Payload Setting

Set **General Setting** -> **Channel Type** as Test.

1. Payload Distribution

Choice: Single Packet | Multiple Packet ;

Default: Single Packet.

Use the drop-down menu to set the distribution type of packet payload.

When Single Packet is selected, the software creates a waveform that consists of one Bluetooth low energy packet. When downloaded to the signal source, the waveform is repeatedly played back resulting in a packet sequence comprised of identical packets. When Multiple Packet is selected, the software creates a waveform that consists of a multiple packet sequence. A data pattern is distributed into the payload portion of each packet in the sequence. Once downloaded to the instrument, the signal generator plays back the entire package sequence repeatedly.

2. Payload Data

Choice: PRBS9 | 11110000 | 10101010 | PRBS 15 | 11111111 | 00000000 | 00001111 | 01010101 | ;

Default: PRBS9.

Use the drop-down menu to select the type of Test PDU payload. Please refer to section 4.1.4 and 4.1.5 of Vol 6 Part B of Core v5.2 for more information.

When Data Continuous is set to ON and PN9 or PN15 is selected, the software automatically configures the Length and Repetitions fields. The number of packets required to accommodate the selected continuous PN pattern is also automatically determined and updated the number of bits.

3. Data Continuous

Choice: On | Off ; Default: On.

Use the drop-down menu to set the continuous state of the packet payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet.

4. Data Repetition

Set the repetition number of the packet payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet and Data Continuous is set to Off.

5. Data Length

Set the number of total bits contained in the payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet and Data Continuous is set to Off.

6. Number Of Full Packets

Display the number of full packets occupied by the packet payload.

7. Number Of Partial Packets

Display the number of partial packets occupied by the packet payload.

Because the payload portion of each packet is filled to capacity, if possible, the number of partial packets appended to the end of a packet sequence will always be 0 or 1.

4.2.2.4 Advertising PDU Header Setting

Set **General Setting** -> **Channel Type** as Advertising.

1. PDU Type

Display the value of PDU Type field in the advertising PDU header. Please refer to section 2.3 of Vol 6 Part B of Core v5.2 for more information.

Note: This value is read-only and automatically updated when Packet Type is changed.

2. ChSel

Choice: 0 | 1 ; Default: 0.

Set the ChSel (Channel Selection) field of the advertising PDU header.

1: The device supports the LE Channel Selection Algorithm #2 feature.

0: The device does not support the LE Channel Selection Algorithm #2 feature.

Note: If the ChSel, TxAdd or RxAdd fields are not defined as used in a given PDU then they shall be

considered reserved for future use.

3. TxAdd

Choice: 0 | 1 ; Default: 0.

Set the TxAdd field of the advertising PDU header. The TxAdd in the advertising physical channel PDU header indicates whether the transmit address is public (TxAdd = 0) or random (TxAdd =1).

Note: If the ChSel, TxAdd or RxAdd fields are not defined as used in a given PDU then they shall be considered reserved for future use.

4. RxAdd

Choice: 0 | 1 ; Default: 0.

Set the RxAdd field of the advertising PDU header. The RxAdd in the advertising physical channel PDU header indicates whether the receiver address is public (RxAdd = 0) or random (RxAdd = 1).

Note: If the ChSel, TxAdd or RxAdd fields are not defined as used in a given PDU then they shall be considered reserved for future use.

5. Length

Display the value of Length field in in the Advertising PDU header. The Length field indicates the length of the Advertising PDU payload in octets.

Note: This value is read-only and automatically updated when with advertising PDU payload setting.

4.2.2.5 Advertising PDU Payload Setting (ADV_IND, ADV_NONCONN_IND, SCAN_RSP, ADV_SCAN_IND)

Set **General Setting** -> **Channel Type** as Advertising, and set Packet Type as ADV_IND, ADV_NONCONN_IND, SCAN_RSP or ADV_SCAN_IND.

1. AdvA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

Set the advertiser address of Bluetooth low energy device. It will be included in AdvA field of the advertising PDU Payload.

2. Payload Data

Choice: PN9 | PN15 | USER ;

Default: PN9.

Use the drop-down menu to set the type of packet payload.

When Data Continuous is set to ON and PN9 or PN15 is selected, the software automatically configures the Length and Repetitions fields. The number of packets required to accommodate the

selected continuous PN pattern is also automatically determined and updated the number of bits. If USER is selected as the data pattern, the number of bits displayed in the Data Length field is equal to the length of the user data multiplied by Data Repetition. The maximum number of bits allowed by the packet type. Any remaining bits in the user data file beyond the maximum amount will be truncated.

3. Payload Length

Range: 0 to 31 ; Default: 31.

Set the number of bytes for the payload of the Bluetooth low energy packet.

4.2.2.6 Advertising PDU Payload Setting (ADV_DIRECT_IND)

Set **General Setting** -> **Channel Type** as Advertising, and set Packet Type as ADV_DIRECT_IND.

1. AdvA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008

Set the advertiser's public or random device address as indicated by TxAdd. It will be included in AdvA field of the advertising PDU Payload.

2. TargetA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008

Set the target's public or random device address as indicated by RxAdd. It will be included in TargetA field of the advertising PDU Payload. The TargetA field is the address of the device to which this PDU is addressed.

4.2.2.7 Advertising PDU Payload Setting (SCAN_REQ, AUX_SCAN_REQ)

Set **General Setting** -> **Channel Type** as Advertising, and set Packet Type as SCAN_REQ or AUX_SCAN_REQ.

1. ScanA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008

Set the scanner's public or random device address as indicated by TxAdd. It will be included in ScanA field of the advertising PDU Payload.

2. AdvA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

Set the target's public or random device address as indicated by RxAdd. It will be included in AdvA field of the advertising PDU Payload. The AdvA field is the address of the device to which this PDU is addressed.

4.2.2.8 Advertising PDU Payload Setting (CONNECT_IND, AUX_CONNECT_REQ)

Set **General Setting** -> **Channel Type** as Advertising, and set Packet Type as ADV_EXT_IND, AUX_ADV_IND.

1. InitA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

Set the initiator's public or random device address as indicated by TxAdd. It will be included in InitA field of the advertising PDU Payload.

2. AdvA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

Set the advertiser's public or random device address as indicated by RxAdd. It will be included in AdvA field of the advertising PDU Payload. The AdvA field is the address of the device to which this PDU is addressed.

3. Access Address

Range: Range: 0x00000000 to 0xffffffff ;

Default: 0x00000000.

Set the ACL connection's Access Address determined by the Link Layer. It will be included in AA field of the advertising PDU Payload. Please refer to section 2.1.2 of Vol 6 Part B of Core v5.2 for more information.

4. CRCInit

Range: 0x000000 to 0xffff ;

Default: 555555.

Set the initialization value for the CRC calculation for the ACL connection. It will be included in CRCInit field of the advertising PDU Payload.

5. WinSize

Range: 1 to Lesser of 8 and (Interval - 1) ;

Default: 1.

Set the WinSize field of the advertising PDU Payload. The WinSize field is set to indicate the *transmitWindowSize* value, in the following manner: $transmitWindowSize = WinSize * 1.25ms$.

6. WinOffset

Range: 0 to Interval ; Default: 0.

Set the WinOffset field of the advertising PDU Payload. The WinOffset field is set to indicate the *transmitWindowOffset* value, in the following manner: $transmitWindowOffset = WinOffset * 1.25ms$.

7. Interval

Range: 6 to 3200 ; Default: 6.

Set the Interval field of the advertising PDU Payload. The Interval field is set to indicate the *connInterval*, in the following manner: $connInterval = Interval * 1.25 ms$.

8. Latency

Range: 0 to 500 ; Default: 6.

Set the Latency field of the advertising PDU Payload. The Latency field is set to indicate the *connSlaveLatency* value, in the following manner: $connSlaveLatency = Latency$.

9. Timeout

Range: 10 to 3200 ;

Default: 10.

Set the Timeout field of the advertising PDU Payload. The Timeout field is set to indicate the *connSupervisionTimeout* value, in the following manner: $connSupervisionTimeout = Timeout * 10 ms$.

10. ChM

Range: 0x0000000000 to 0x1fffffff ;

Default: 0x0000000001.

Set the ChM (channel map) field of the advertising PDU Payload.

The ChM field contains channel map indicating used and unused data channels. Every channel is represented with bit positioned as per the data channel index. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of 0 indicates that the channel is Unused. A bit value of 1 indicates that the channel is Used. The bits in positions 37, 38 and 39 are reserved for future use.

11. Hop

Range: 5 to 16 ;

Default: 5.

Set the Hop field of the advertising PDU Payload. The Hop field is set to indicate the *hopIncrement* used in the data channel selection algorithm.

12. SCA

Choice: 251-500 ppm | 151-250 ppm | 101-150 ppm | 76-100 ppm | 51-75 ppm | 31-50 ppm | 21-30 ppm | 0-20 ppm ;

Default: 251-500 ppm.

Use the drop-down menu to select the SCA (Sleep Clock Accuracy) type. It will be included in SCA field of the PDU Payload. The SCA field is set to indicate the *masterSCAused* to determine the worst-case Master's sleep clock accuracy.

4.2.2.9 Advertising PDU Payload Setting (ADV_EXT_IND, AUX_ADV_IND, AUX_ADV_IND, AUX_CHAIN_IND, AUX_SCAN_RSP, AUX_CONNECT_RSP)

Set **General Setting** -> **Channel Type** as Advertising, and set Packet Type as ADV_EXT_IND, AUX_ADV_IND, AUX_ADV_IND, AUX_CHAIN_IND, AUX_SCAN_RSP or AUX_CONNECT_RSP.

1. Extended Header Length

Display the Extended Header Length field of the Common Extended Advertising Payload.

The Extended Header Length is a value between 0 and 63 and indicates the size of the variable length Extended Header field.

2. AdvMode

Choice: Non-conn&Non-scan | Conn&Non-scan | Non-conn&Scan ;

Default: Non-conn&Non-scan.

Use the drop-down menu to select the mode of the advertisement. It will be included in AdvMode field of the Common Extended Advertising Payload.

3. Payload Data

Use the drop-down menu to select the data type of the AdvData field.

4. Data Length

Range: 0 – 254.

Set the AdvData field length in bytes.

5. Extended Header

1) AdvA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

Set the advertiser's public or random device address as indicated by TxAdd.

2) TargetA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

Set public or random device address for the scanner or initiator, as indicated by RxAdd. The TargetA field is the address of the device to which this PDU is addressed.

3) CTEInfo

● CTE Time

Range: 2 – 20 ;

Default: 20.

Set the CTE Time field of CTE Info Header to indicate the length of the Constant Tone Extension in 8 μ s units. Please refer to section 2.5.2 of Vol 6 Part B of Core v5.2 for more information.

● CTE Type

Choice: AOA | AOD(1us) | AOD(2us) ;

Default: AOA.

Set the CTE Type field of CTE Info Header to indicate the type of the Constant Tone Extension and the duration of the switching slots. Please refer to section 2.5.2 of Vol 6 Part B of Core v5.2 for more information.

4) AdvDataInfo

● Advertising Data ID

Range: 0x0 – 0xff ;

Default: 0x0.

Set the Advertising Data ID field of AdvDataInfo to distinguish between different advertising sets transmitted by this device.

● Advertising Set ID

Range: 0x0 – 0xf ;

Default: 0x0.

Set the Advertising Set ID field of AdvDataInfo to indicate to the scanner whether it can assume that the data contents in the AdvData are a duplicate of the previous AdvData sent in an earlier packet.

5) AuxPtr

The presence of the AuxPtr field indicates that some or all of the advertisement data is in a subsequent auxiliary packet. The contents of the AuxPtr field describe this packet.

- **Channel Index**

Range: 0 – 39 ; Default: 0.

Set the Channel Index field of AuxPtr. The Channel Index field contains the general-purpose channel index used to transmit the auxiliary packet.

- **CA**

Choice: 51 - 500 ppm | 0 - 50 ppm;

Default: 51 - 500 ppm.

Use the drop-down menu to select clock accuracy of the advertiser that will be used between the packet containing this data and the auxiliary packet.

- **Offset Units**

Choice: 30 us | 300 us;

Default: 30 us.

Use the drop-down menu to select the units used by the AUX Offset Field.

- **AUX Offset**

Range: 0 – 8191 ;

Default: 8191.

Set the value of Aux Offset field. The Aux Offset field contains the time from the start of the packet containing the AuxPtr field to the approximate start of the auxiliary packet. The value of the AUX Offset field is in the unit of time indicated by the Offset Units field; the offset is determined by multiplying the value by the unit.

- **AUX PHY**

Choice: LE 1M | LE 2M | LE Code ;

Default: LE 1M.

Use the drop-down menu to select the PHY used to transmit the auxiliary packet.

6) SyncInfo

- **Sync Packet Offset**

Range: 0 – 8191 ;

Default: 8191.

Set the value of Sync Packet Offset field. The Sync Packet Offset field contains the time from a reference point to the start of the AUX_SYNC_IND packet that this SyncInfo field describes. The

value of the Sync Packet Offset field is in the unit of time indicated by the Offset Units field; the offset is determined by multiplying the value by the unit.

- **Offset Units**

Choice: 30 us | 300 us;

Default: 30 us.

Use the drop-down menu to select the units used by the Sync Packet Offset Field.

- **Offset Adjust**

Choice: 0 | 1 ; Default: 0.

Set the value of Offset Adjust field. If the Offset Adjust field is set to 1, the actual sync packet offset adding 2.4576 seconds.

- **Interval**

Range: 6 – 65535 ; Default: 6.

Set the value of Interval field. The Interval field contains the time in 1.25 ms units from the start of one packet of the periodic advertising train to the start of the next packet.

- **ChM**

Range: 0x0000000000 to 0x1fffffff ;

Default: 0x0000000001.

Set the value of ChM (channel map) field.

The ChM field contains channel map indicating used and unused data channels. Every channel is represented with bit positioned as per the data channel index. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of 0 indicates that the channel is Unused. A bit value of 1 indicates that the channel is Used. The bits in positions 37, 38 and 39 are reserved for future use.

- **SCA**

Choice: 251-500 ppm | 151-250 ppm | 101-150 ppm | 76-100 ppm | 51-75 ppm | 31-50 ppm | 21-30 ppm | 0-20 ppm ;

Default: 251-500 ppm.

Use the drop-down menu to select the SCA (Sleep Clock Accuracy) type. The SCA field is set to indicate the masterSCAused to determine the worst-case Master's sleep clock accuracy.

- **Access Address**

Range: Range: 0x00000000 to 0xffffffff ;

Default: 0x00000000.

Set the ACL connection's Access Address determined by the Link Layer. Please refer to section 2.1.2 of Vol 6 Part B of Core v5.2 for more information.

- **CRCInit**

Range: 0x000000 to 0xfffff ;

Default: 0x555555.

Set the initialization value for the CRC calculation for the ACL connection.

- **Event Counter**

Range: 0– 65535 ; Default: 0.

Set the value of Event Counter field.

The Event Counter field contains the value of paEventCounter that applies to the AUX_SYNC_IND packet that this SyncInfo field describes. Please refer to section 2.3.4.6 of Vol 6 Part B of Core v5.2 for more information.

7) TxPower

Range: -127 – 126 ; Default: 0.

Set the value of TxPower field. The TxPower field indicates the transmitted power level of the packet containing the data type. It may be used to calculate path loss on a received packet.

8) ACAD

Use the drop-down menu to select the data type of the ACDC (Additional Controller Advertising Data) field. Please refer to section 2.3.4.8 of Vol 6 Part B of Core v5.2 for more information.

9) Length

Range: 0 – 62 ; Default: 0.

Set the ACAD field length in bytes.

The ACAD field length is the Extended Header length minus the sum of the size of the extended header flags (1 octet) and those fields indicated by the flags as present.

4.2.2.10 Data PDU Header Setting

Set **General Setting** -> **Channel Type** as Data.

1. LLID

Display the LLID field of the Data PDU Header. The LLID field determines the format of the payload.

- 1 = LL Data PDU: Continuation fragment of an L2CAP message, or an empty PDU
- 2 = LL Data PDU: Start of an L2CAP message, or a complete L2CAP message with no

fragmentation

- 3 = LL Control PDU

Note: This parameter can be edited only when Packet Type is LL_Data.

2. NESN

Range: 0 to 1 ; Default: 0.

Set the NESN (next expected sequence number) field of the Data PDU Header.

3. SN

Range: 0 to 1 ; Default: 0.

Set the SN (sequence number) field of the Data PDU Header.

4. MD

Range: 0 to 1 ; Default: 0.

Set the MD (more data) field of the Data PDU Header.

5. CP

Range: 0 – 1 ; Default: 0.

Set the CTEInfo Present (CP) field of the Data PDU header. This value indicates whether the CTEInfo field is present and therefore whether the packet has a Constant Tone Extension.

If the CP field is 0, then no CTEInfo field is present and there is no Constant Tone Extension in the test packet. If the CP field is 1, then the CTEInfo field is present and the test packet includes a Constant Tone Extension.

Please refer to section 4.1.4 of Part B of volume 6 in Bluetooth Core Specification Version 5.2 for more information

6. Length

Range: 0 – 255 ; Default: 31.

Set the Data PDU payload length in bytes. It will be included in Length field of the Data PDU header.

4.2.2.11 Data PDU Payload Setting (LL_Data)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_Data.

1. Payload Distribution

Choice: Single Packet | Multiple Packet; Default: Single Packet.

Use the drop-down menu to set the distribution type of packet payload.

When Single Packet is selected, the software creates a waveform that consists of one Bluetooth low

energy packet. When downloaded to the signal source, the waveform is repeatedly played back resulting in a packet sequence comprised of identical packets. When Multiple Packet is selected, the software creates a waveform that consists of a multiple packet sequence. A data pattern is distributed into the payload portion of each packet in the sequence. Once downloaded to the instrument, the signal generator plays back the entire package sequence repeatedly.

2. Payload Data

Choice: PN9 | PN15 | USER ;

Default: PN9.

Use the drop-down menu to select the type of PDU payload.

When Data Continuous is set to ON and PN9 or PN15 is selected, the software automatically configures the Length and Repetitions fields. The number of packets required to accommodate the selected continuous PN pattern is also automatically determined and updated the number of bits.

3. Data Continuous

Choice: On | Off ; Default: On.

Use the drop-down menu to set the continuous state of the packet payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet.

4. Data Repetition

Set the repetition number of the packet payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet and Data Continuous is set to Off.

5. Data Length

Set the number of total bits contained in the payload data.

Note: This parameter is only available when Payload Distribution is set to Multiple Packet and Data Continuous is set to Off.

6. Number Of Full Packets

Display the number of full packets occupied by the packet payload.

7. Number Of Partial Packets

Display the number of partial packets occupied by the packet payload.

Because the payload portion of each packet is filled to capacity, if possible, the number of partial packets appended to the end of a packet sequence will always be 0 or 1.

8. Number Of Padding Packets

Choice: 0 | 1 ; Default: 0.

Sets the number of padding packets occupied by the packet payload.

Note: This parameter is can be edited only when Payload Distribution is Multiple Packet.

When the software creates a multiple packet sequence, the sequence bit in the header field is toggled after each packet transmission in the sequence. This indicates to the Bluetooth device that the incoming packet is not a re-transmitted packet. To maintain an alternating sequence bit when the waveform is repeatedly played back, an even number of packets must be generated. If the data pattern length is set such that an odd number of packets are required to send the data, then a pad packet is appended to the end of the packet sequence. The pad packet has no payload and is only generated in this circumstance to accommodate the alternating sequence bit.

4.2.2.12 Data PDU Payload Setting (LL_CONNECTION_UPDATE_REQ)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_CONNECTION_UPDATE_REQ.

1. Opcode

Display the Opcode field of the PDU Payload. The Opcode field identifies different types of LL Control PDU, as defined in following table.

Opcode	LL Control PDU Name
0x00	LL_CONNECTION_UPDATE_IND
0x01	LL_CHANNEL_MAP_IND
0x02	LL_TERMINATE_IND
0x03	LL_ENC_REQ
0x04	LL_ENC_RSP
0x05	LL_START_ENC_REQ
0x06	LL_START_ENC_RSP
0x07	LL_UNKNOWN_RSP
0x08	LL_FEATURE_REQ
0x09	LL_FEATURE_RSP
0x0A	LL_PAUSE_ENC_REQ
0x0B	LL_PAUSE_ENC_RSP
0x0C	LL_VERSION_IND
0x0D	LL_REJECT_IND
0x0E	LL_SLAVE_FEATURE_REQ
0x0F	LL_CONNECTION_PARAM_REQ
0x10	LL_CONNECTION_PARAM_RSP

0x11	LL_REJECT_EXT_IND
0x12	LL_PING_REQ
0x13	LL_PING_RSP
0x14	LL_LENGTH_REQ
0x15	LL_LENGTH_RSP
0x16	LL_PHY_REQ
0x17	LL_PHY_RSP
0x18	LL_PHY_UPDATE_IND
0x19	LL_MIN_USED_CHANNELS_IND
0x1A	LL_CTE_REQ
0x1B	LL_CTE_RSP
0x1C	LL_PERIODIC_SYNC_IND
0x1D	LL_CLOCK_ACCURACY_REQ
0x1E	LL_CLOCK_ACCURACY_RSP
0x1F	LL_CIS_REQ
0x20	LL_CIS_RSP
0x21	LL_CIS_IND
0x22	LL_CIS_TERMINATE_IND
0x23	LL_POWER_CONTROL_REQ
0x24	LL_POWER_CONTROL_RSP
0x25	LL_POWER_CHANGE_IND
All other values	Reserved for future use

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. WinSize

Range: 1 to Lesser of 8 and (Interval - 1) ;

Default: 1.

Set the WinSize field of the data PDU Payload. The WinSize field is set to indicate the *transmitWindowSize* value, in the following manner: $transmitWindowSize = WinSize * 1.25ms$.

3. WinOffset

Range: 0 to Interval ; Default: 0.

Set the WinOffset field of the advertising PDU Payload. The WinOffset field is set to indicate the *transmitWindowOffset* value, in the following manner: $transmitWindowOffset = WinOffset * 1.25ms$.

4. Interval

Range: 6 to 3200 ; Default: 6.

Set the Interval field of the advertising PDU Payload. The Interval field is set to indicate the *connInterval*, in the following manner: $connInterval = Interval * 1.25 \text{ ms}$.

5. Latency

Range: 0 to 500 ; Default: 6.

Set the Latency field of the advertising PDU Payload. The Latency field is set to indicate the *connSlaveLatency* value, in the following manner: $connSlaveLatency = Latency$.

6. Timeout

Range: 10 to 3200 ; Default: 10.

Set the Timeout field of the advertising PDU Payload. The Timeout field is set to indicate the *connSupervisionTimeout* value, in the following manner: $connSupervisionTimeout = Timeout * 10 \text{ ms}$.

7. Instant

Range: 1 to 32767 ; Default: 1.

Set the count of LL connection event before the new LL connection event of the Bluetooth low energy packet.

4.2.2.13 Data PDU Payload Setting (LL_CHANNEL_MAP_REQ)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_CHANNEL_MAP_REQ.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. ChM

Range: 0x0000000000 to 0x1fffffff ;

Default: 0x0000000001.

Set the ChM (channel map) field of the PDU Payload.

The ChM field contains channel map indicating used and unused data channels. Every channel is represented with bit positioned as per the data channel index. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of 0 indicates that the channel is Unused. A bit value of 1 indicates that the channel is Used. The bits in positions 37, 38 and 39 are reserved for future use.

3. Instant

Range: 1 to 32767 ; Default: 1.

Set the count of LL connection event before the new LL connection event of the Bluetooth low energy packet.

4.2.2.14 Data PDU Payload Setting (LL_TERMINATE_IND, LL_REJECT_IND)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_TERMINATE_IND or LL_REJECT_IND.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. Error Code

Range: 0x00 to 0xff ;

Default: 0x00.

Set the ErrorCode field of the PDU Payload. The ErrorCode field shall be set to inform the remote device why the connection is about to be terminated.

4.2.2.15 Data PDU Payload Setting (LL_ENC_REQ)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_ENC_REQ.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. Rand

Range: 0x0000000000000000 to 0xffffffffffffff;

Default: 0x0000000000000000.

Set the random number that is provided by the Host and used with EDIV.

3. EDIV

Range: 0x0000 to 0xffff ;

Default: 0000.

Set the encrypted diversifier.

4. SKDm

Range: 0x0000000000000000 to 0xffffffffffffff ;

Default: 0x0000000000000000.

Set the master's portion of the session key identifier.

5. IVm

Range: 0x00000000 to 0xffffffff ;

Default: 00000000.

Set the master's portion of the initialization vector.

4.2.2.16 Data PDU Payload Setting (LL_ENC_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_ENC_RSP.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. SKDm

Range: 0x0000000000000000 to 0xffffffffffffff ;

Default: 0x0000000000000000.

Set the master's portion of the session key identifier.

3. IVm

Range: 0x00000000 to 0xffffffff ;

Default: 00000000.

Set the master's portion of the initialization vector.

4.2.2.17 Data PDU Payload Setting (LL_START_ENC_REQ, LL_START_ENC_RSP, LL_PAUSE_ENC_REQ, LL_PAUSE_ENC_RSP, LL_PING_REQ, LL_PING_RSP, LL_CTE_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_START_ENC_REQ, LL_START_ENC_RSP, LL_PAUSE_ENC_REQ, LL_PAUSE_ENC_RSP, LL_PING_REQ, LL_PING_RSP or LL_CTE_RSP.

Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

4.2.2.18 Data PDU Payload Setting (LL_UNKNOWN_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_UNKNOWN_RSP.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. Unknown Type

Range: 0x00 to 0xff ; Default: 0x00.

Set the Opcode field value of received LL Control PDU of the Bluetooth low energy packet.

4.2.2.19 Data PDU Payload Setting (LL_FEATURE_REQ, LL_FEATURE_RSP, LL_SLAVE_FEATURE_REQ)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_FEATURE_REQ, LL_FEATURE_RSP or LL_SLAVE_FEATURE_REQ.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. Feature Set

Range: 0x0000000000000000 to 0xffffffffffffff;

Default: 0x0000000000000000.

Set the set of features supported by the master's Link Layer of the Bluetooth low energy packet.

4.2.2.20 Data PDU Payload Setting (LL_VERSION_IND)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_VERSION_IND.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. VersNr (Version Number)

Range: 0x00 to 0xff ; Default: 00.

Set the version of the Bluetooth Controller specification.

3. **Compld (Company Identifier)**

Range: 0x0000 to 0xffff ;

Default: 0000.

Set the company identifier of the manufacturer of the Bluetooth Controller.

4. **SubVersNr (Sub-version Number)**

Range: 0x0000 to 0xffff ;

Default: 0000.

Set the unique value for each implementation or revision of an implementation of the Bluetooth Controller.

4.2.2.21 Data PDU Payload Setting (LL_CONNECTION_PARAM_REQ, LL_CONNECTION_PARAM_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_CONNECTION_PARAM_REQ or LL_CONNECTION_PARAM_RSP.

1. **Opcode**

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. **Interval_Min**

Range: 6 to 3200 ; Default: 6.

Set the Interval_Min field of the PDU Payload. The Interval_Min field is set to indicate the minimum value of *connInterval*, in the following manner: $connInterval = Interval_Min * 1.25 \text{ ms}$.

3. **Interval_Max**

Range: 6 to 3200 ; Default: 3200.

Set the Interval_Max field of the PDU Payload. The Interval_Max field is set to indicate the maximum value of *connInterval*, in the following manner: $connInterval = Interval_Max * 1.25 \text{ ms}$.

4. **Latency**

Range: 0 to 500 ; Default: 0.

Set the Latency field of the PDU Payload. The Latency field is set to indicate the *connSlaveLatency* value, in the following manner: $connSlaveLatency = Latency$. Latency is in units of number of connection events.

5. **Timeout**

Range: 10 to 3200 ; Default: 10.

Set the Timeout field of the PDU Payload. The Timeout field is set to indicate the *connSupervisionTimeout* value, in the following manner: *connSupervisionTimeout* = Timeout *10 ms.

6. Preferred Periodicity

Range: 0 to 255 ; Default: 0.

Set the PreferredPeriodicity field of the PDU Payload. The PreferredPeriodicityfield is set to indicate a value the connInterval is preferred to be a multiple of. PreferredPeriodicity is in units of 1.25 ms. A value of zero means no preference.

7. Reference Connection Event Counter

Range: 0 to 65535 ; Default: 1.

Set the ReferenceConnEventCount field of the PDU Payload. The ReferenceConnEventCount is set to indicate the value of the connEventCounter relative to which all the valid Offset0 to Offset5 fields have been calculated.

8. Offset 0-5

Range: 0 to 3200, 65535;

Set the Offset 0-5 field of the PDU Payload.

The Offset 0-5 field is set to indicate the possible values of the position of the anchor points of the LE connection with the updated connection parameters relative to the ReferenceConnEventCount.

Offset0 to Offset5 fields are in units of 1.25 ms and are in decreasing order of preference, that is, Offset0 is the most preferred value followed by Offset1 and so on. Offset0 to Offset5 shall be less than Interval_Max. A value of 0xFFFF (65535) means not valid. Valid Offset0 to Offset5 fields shall contain unique values. Valid fields shall always be before invalid fields.

4.2.2.22 Data PDU Payload Setting (LL_REJECT_EXT_IND)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_REJECT_EXT_IND.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. Reject Opcode

Range: 0x00 to 0xff ; Default: 00.

Set the Opcode field value of the LL Control PDU being rejected.

3. Error Code

Range: 0x00 to 0xff ; Default: 00.

Set the reason the LL Control PDU was being rejected.

4.2.2.23 Data PDU Payload Setting (LL_LENGTH_REQ, LL_LENGTH_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_LENGTH_REQ or LL_LENGTH_RSP.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. MaxRxOctets

Range: 27 to 251 ; Default: 27.

Set the sender's connMaxRxOctets value. Please refer to section 4.5.10 of Vol 6 Part B of Core v5.2 for more information.

3. MaxRxTime

Range: 328 to 17040 ; Default: 328.

Set the sender's connMaxRxTime value. Please refer to section 4.5.10 of Vol 6 Part B of Core v5.2 for more information.

4. MaxTxOctets

Range: 27 to 251 ; Default: 27.

Set the sender's connMaxTxOctets value. Please refer to section 4.5.10 of Vol 6 Part B of Core v5.2 for more information.

5. MaxTxTime

Range: 328 to 17040 ; Default: 328.

Set the sender's connMaxTxTime value. Please refer to section 4.5.10 of Vol 6 Part B of Core v5.2 for more information.

4.2.2.24 Data PDU Payload Setting (LL_PHY_REQ, LL_PHY_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_PHY_REQ or LL_PHY_RSP.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. RX PHYS

Range: 0 to 7 ; Default: 1.

Set to indicate the receiver PHYs that the sender prefers to use.

3. TX PHYS

Range: 0 to 7 , Default: 1.

Set to indicate the transmitter PHYs that the sender prefers to use.

4.2.2.25 Data PDU Payload Setting (LL_PHY_UPDATE_REQ)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_PHY_UPDATE_REQ.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. M_TO_S_PHY

Range: 0 to 7 ; Default: 1.

Set to indicate the PHY that shall be used for packets sent from the master to the slave.

3. S_TO_M_PHY

Range: 0 to 7 ; Default: 1.

Set to indicate the PHY that shall be used for packets sent from the slave to the master.

4. Instant

Range: 1 to 32767 ; Default: 1.

Set the count of LL connection event before the new LL connection event of the Bluetooth low energy packet.

4.2.2.26 Data PDU Payload Setting (LL_MIN_USED_CHANNELS_IND)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_MIN_USED_CHANNELS_IND.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. PHYS

Range: 0 to 7 ; Default: 1.

Set to indicate the PHY(s) for which the slave has a minimum number of used channels requirement.

3. MinUsedChannels

Range: 2 to 37 ; Default: 2.

Set the minimum number of channels to be used on the specified PHY.

4.2.2.27 Data PDU Payload Setting (LL_CTE_REQ)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_CTE_REQ.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. MinCTELenReq

Range: 2–20 ; Default: 20.

Set the minimum length of the Constant Tone Extension requested from the remote device, in 8 μ s units. Please refer to section 2.5.1 of Vol 6 Part B of Core v5.2 for more information.

3. CTETypeReq

Choice: AOA | AOD(1us) | AOD(2us) ; Default: AOA.

Set the type of the Constant Tone Extension requested from the remote device.

4.2.2.28 Data PDU Payload Setting (LL_PERIODIC_SYNC_IND)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_PERIODIC_SYNC_IND.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. ID

Range: 0 to 65535 ; Default: 65535.

Set the identifier provided by the Host.

3. SyncInfo

1) Sync Packet Offset

Range: 0 – 8191 ; Default: 8191.

Set the value of Sync Packet Offset field. The Sync Packet Offset field contains the time from a reference point to the start of the AUX_SYNC_IND packet that this SyncInfo field describes. The value of the Sync Packet Offset field is in the unit of time indicated by the Offset Units field; the offset is determined by multiplying the value by the unit.

2) Offset Units

Choice: 30 us | 300 us ; Default: 30 us.

Use the drop-down menu to select the units used by the Sync Packet Offset Field.

3) Offset Adjust

Choice: 0 | 1 ; Default: 0.

Set the value of Offset Adjust field. If the Offset Adjust field is set to 1, the actual sync packet offset adding 2.4576 seconds.

4) Interval

Range: 6 – 65535 ; Default: 6.

Set the value of Interval field. The Interval field contains the time in 1.25 ms units from the start of one packet of the periodic advertising train to the start of the next packet.

5) ChM

Range: 0x0000000000 to 0x1fffffff ;

Default: 0x0000000001.

Set the value of ChM (channel map) field.

The ChM field contains channel map indicating used and unused data channels. Every channel is represented with bit positioned as per the data channel index. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of 0 indicates that the channel is Unused. A bit value of 1 indicates that the channel is Used. The bits in positions 37, 38 and 39 are reserved for future use.

6) SCA

Choice: 251-500 ppm | 151-250 ppm | 101-150 ppm | 76-100 ppm | 51-75 ppm | 31-50 ppm |

21-30 ppm | 0-20 ppm ;

Default: 251-500 ppm.

Use the drop-down menu to select the SCA (Sleep Clock Accuracy) type. The SCA field is set to indicate the *masterSCA* used to determine the worst-case Master's sleep clock accuracy

7) Access Address

Range: Range: 0x00000000 to 0xffffffff ;

Default: 0x00000000.

Set the ACL connection's Access Address determined by the Link Layer. Please refer to section 2.1.2 of Vol 6 Part B of Core v5.2 for more information.

8) CRCInit

Range: 0x000000 to 0xfffff ;

Default: 0x555555.

Set the initialization value for the CRC calculation for the ACL connection.

9) Event Counter

Range: 0 – 65535 ; Default: 0.

Set the value of Event Counter field.

The Event Counter field contains the value of *paEventCounter* that applies to the AUX_SYNC_IND packet that this *SyncInfo* field describes. Please refer to section 2.3.4.6 of Vol 6 Part B of Core v5.2 for more information.

4. connEventCount

Range: 0 – 65535 ; Default: 0.

Set the connection event counter value that meets the requirement $\text{currEvent} - 2^{14} < \text{connEventCount} < \text{currEvent} + 2^{14}(\text{modulo } 65536)$, where *currEvent* is the counter value for the connection event when the LL_PERIODIC_SYNC_IND PDU is being transmitted (or retransmitted).

5. lastPaEventCounter

Range: 0 – 65535 ; Default: 0.

Set the *paEventCounter* applying to the AUX_SYNC_IND PDU used to determine the contents of the *SyncInfo*.

6. SID

Range: 0 – 15 ; Default: 0.

Set the Advertising SID subfield of the advertising set pointing to the periodic advertising.

7. AType

Range: 0 – 1 ; Default: 0.

Set the AType field to indicate whether the AdvA field is public (AType = 0) or random (AType = 1).

8. SCA

Choice: 251-500 ppm | 151-250 ppm | 101-150 ppm | 76-100 ppm | 51-75 ppm | 31-50 ppm | 21-30 ppm | 0-20 ppm ;

Default: 251 - 500 ppm.

Use the drop-down menu to select the SCA (Sleep Clock Accuracy) type. It will be included in SCA field of the PDU Payload. The SCA field is set to indicate the sleep clock accuracy of the device sending this PDU.

9. PHY

Range: 0 to 7 ; Default: 1.

Set to indicate the PHY used by the periodic advertising.

10. AdvA

Range: 0x000000000000 to 0xffffffff ;

Default: 0x000000000008.

set the advertiser's address in the advertising set pointing to the periodic advertising.

11. syncConnEventCount

Range: 0 – 65535 ; Default: 0.

Set the connection event counter for the connection event that the sending device used in determining the contents of this PDU.

4.2.2.29 Data PDU Payload Setting (LL_CLOCK_ACCURACY_REQ, LL_CLOCK_ACCURACY_RSP)

Set **General Setting** -> **Channel Type** as Data, and set Packet Type as LL_CLOCK_ACCURACY_REQ or LL_CLOCK_ACCURACY_RSP.

1. Opcode

Display the Opcode field of the PDU Payload.

Note: This parameter is read-only and automatically updated when Packet Type is changed.

2. SCA

Choice: 251-500 ppm | 151-250 ppm | 101-150 ppm | 76-100 ppm | 51-75 ppm | 31-50 ppm | 21-30 ppm | 0-20 ppm ;

Default: 251 - 500 ppm.

Use the drop-down menu to select the SCA (Sleep Clock Accuracy) type. It will be included in SCA

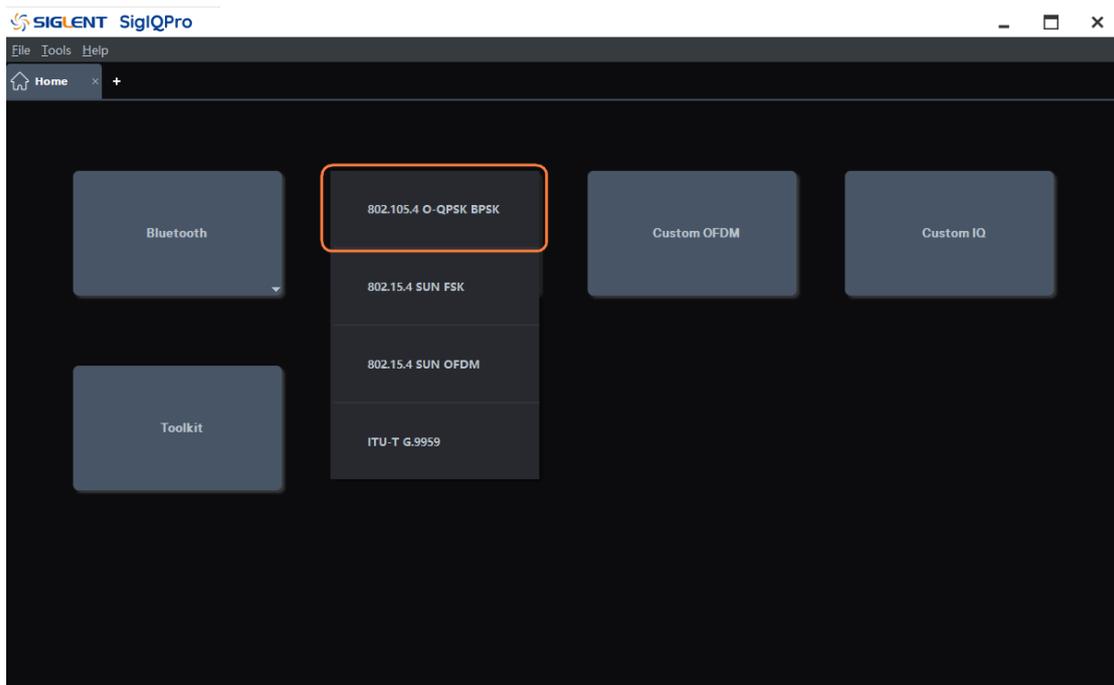
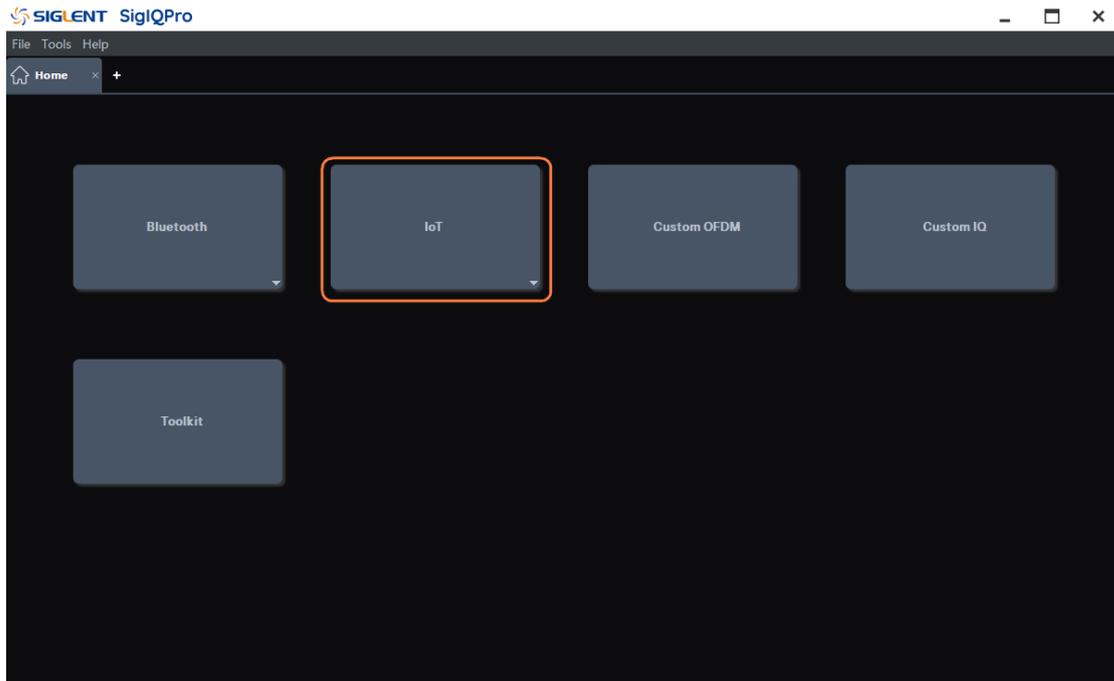
field of the PDU Payload. The SCA field is set to indicate the current masterSCA (if the PDU is sent by the master) or slaveSCA (if the PDU is sent by the slave) used to determine the worst-case sleep clock accuracy of the sending device.

4.3 IEEE 802.15.4 O-QPSK BPSK

O-QPSK PHY and BPSK PHY are physical layer specifications defined in IEEE standard 802.15.4 for low data rate wireless connections.

Protocol version: IEEE Std 802.15.4 -2020

You can click **IoT** -> **802.15.4 O-QPSK BPSK** on the homepage to enter the ZigBee setting interface.



4.3.1 Waveform Setup

Press **Waveform Setup** in the left window to enter parameter settings.

4.3.1.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Number of Frames

Range: 1 to 2000 ; Default: 1.

Set the number of frames included in the generated waveform.

3. OverSampling Ratio

Range: 2 to 100 ; Default: 10.

Set the number of samples calculated per I/Q symbol.

4. Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

5. Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4.3.1.2 Marker

1. Marker 1 Source

Choice: Waveform Start | Frame Start ;

Default: Waveform Start.

Use the drop-down menu to select the type of Mark 1 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

2. Marker 2 Source

Choice: Waveform Start | Frame Start ;

Default: Frame Start.

Use the drop-down menu to select the type of Mark 2 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

4.3.2 Packet

Press **Packet** in the left window to enter parameter settings.

4.3.2.1 General Setting

1. PHY Scheme

Choices: O-QPSK | BPSK ;

Default: O-QPSK.

Use the drop-down menu to select the 802.15.4 PHY scheme.

2. Idle Interval (us)

Range: 0 – 200000 ; Default: 100.

Set the idle interval in-between frames in microseconds. When idle interval is set to zero, a continuous waveform will be generated.

3. Data Rate

Displays the data rate for current 802.15.4 PHY scheme.

4. Frequency Band

Choices: 780 MHz | 868 MHz | 915 MHz | 2450 MHz ;

Default: 2450 MHz .

Use the drop-down menu to select the frequency band of 802.15.4 PHY scheme.

Note 1: If PHY Scheme is set to BPSK, 780 MHz and 2450 MHz cannot be selected.

Note 2: The selected frequency band does not actually change the center frequency of the signal source.

4.3.2.2 Packet Setting

The screenshot shows the 'Packet Setting' interface with the following settings:

- PPDU Settings**
 - Preamble(Hex): 00 00 00 00
 - PHR(Hex): 21
 - SFD(Hex): A7
- PSDU**
 - MHR(MAC Header): On
 - Seed (Hex): 1FF
 - Data Mode: Continuous
 - Data Type: PN9
 - Data Length(Octets): 20
 - MAC FCS: On

1. Preamble (Hex)

Displays the Preamble field of PPDU in hexadecimal format.

Note: This parameter is displayed only and cannot be edited.

2. SFD (Hex)

Displays the SFD (Start of Frame Delimiter) field of PPDU in hexadecimal format.

Note: This parameter is displayed only and cannot be edited.

3. PHR (Hex)

Displays the PHR (Payload Header) field of PPDU in hexadecimal format. The value is automatically updated when the PSDU settings are changed.

Note: This parameter is displayed only and cannot be edited.

4. PSDU

These are the Settings for the Physical Service Data Unit (PSDU) portion of the frame that contains the payload data.

1) MHR (MAC Header)

Use the drop-down menu to enable or disable the MAC Header field.

The screenshot shows the 'MHR (MAC Header)-Hexadecimal Input' dialog box with the following settings:

Header Field	Settings (Hex)
MAC Header	On
Frame Control (Octets: 1/2)	8821
Sequence Number (Octets: 0/1)	01
Destination PAN Identifier (Octets: 0/2)	1234
Destination Address (Octets: 0/2/8)	5678
Source PAN Identifier (Octets: 0/2)	4321
Source Address (Octets: 0/2/8)	8765
Auxiliary Security Header (Octets: 0/5/6/10/14)	
Header IEs	
Payload IEs	

Buttons: OK, Cancel

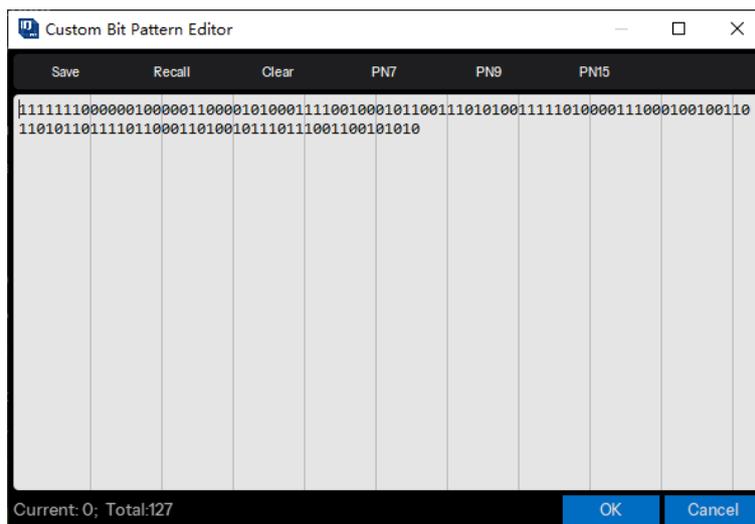
For more information on the MAC header, refer to the IEEE standards 802.15.4.

2) Data Type

Choices: PN9 | PN15 | USER ; Default: PN9.

Use the drop-down menu to set the type of packet payload.

- PN9: A pseudo-random binary sequence of order 9 is used to fill the packet payload
- PN15: A pseudo-random binary sequence of order 15 is used to fill the packet payload
- USER: A user-defined binary sequence is used to fill the packet payload



3) Seed

Set the seed value used to generate the pseudo-random binary sequence.

When Data Type PN9 is selected: Range: 0x0 – 0x1FF ; Default: 0x1FF.

When Data Type PN15 is selected: Range: 0x0 – 0x7FFF ; Default: 0x7FFF.

Note: This parameter can be edited only when the Data Type is PN9 or PN15.

4) Data Length (Octets)

Range: 0 – 127 ; Default: 20.

Set the length of packet payload in octets.

5) Data Mode

Choices: Continuous | Truncated ; Default: Continuous.

For multi-frame signals, select the mode applied to the packet payload. If there is only one frame in the signal, then there is no difference in selection.

- Continuous: packet payload data bits are distributed consecutively across multiple frames
- Truncated: packet payload data bits are the same for all frames, with the data size truncated for one frame

6) MAC FCS

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable the MAC FCS (frame check sequence). For more information on the MAC FCS, refer to the IEEE standards 802.15.4.

4.3.2.3 Impairments

1. Symbol Timing Error

Range: -300 to 300ppm ; Default: 0ppm.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the signal. It is used to simulate transmission when the device's sampling clock is slightly off.

2. Frequency Offset

Range: -200 to 200kHz ; Default: 0kHz.

Set the static offset of the carrier frequency. This static offset is used to simulate the device transmitting at a frequency slightly offset from the specified carrier.

4.4 IEEE 802.15.4 SUN FSK

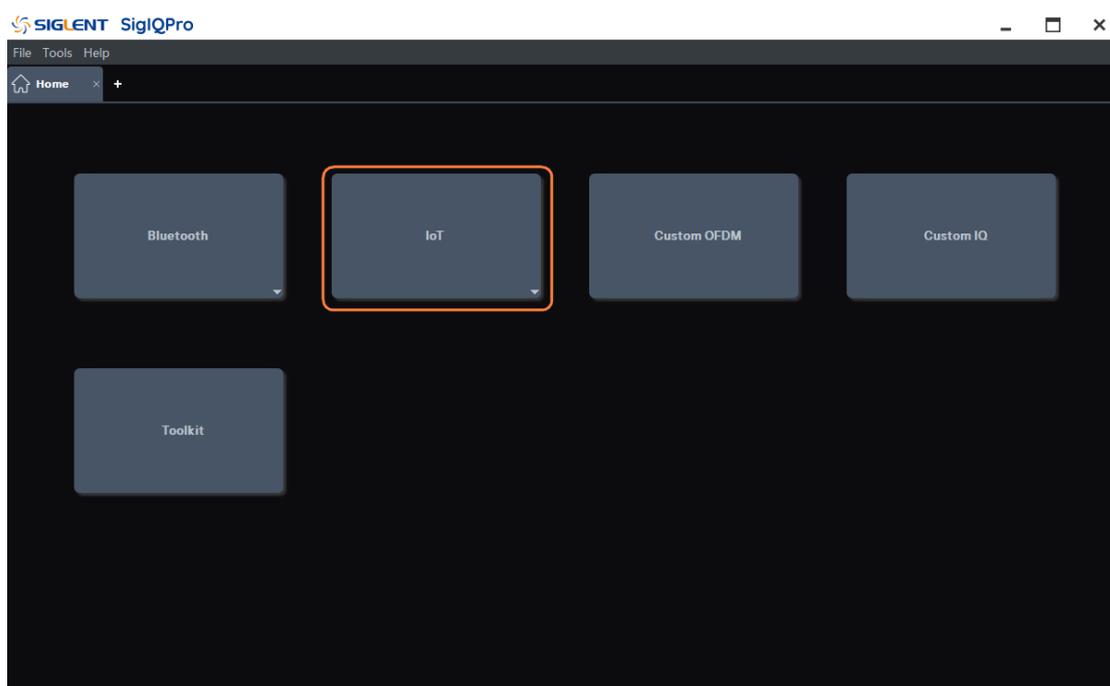
SUNs PHY defined in IEEE standard 802.15.4. The smart utility network is a principally outdoor, low data rate wireless network that supports two-way communications among sensing, measurement, and control devices in the smart grid.

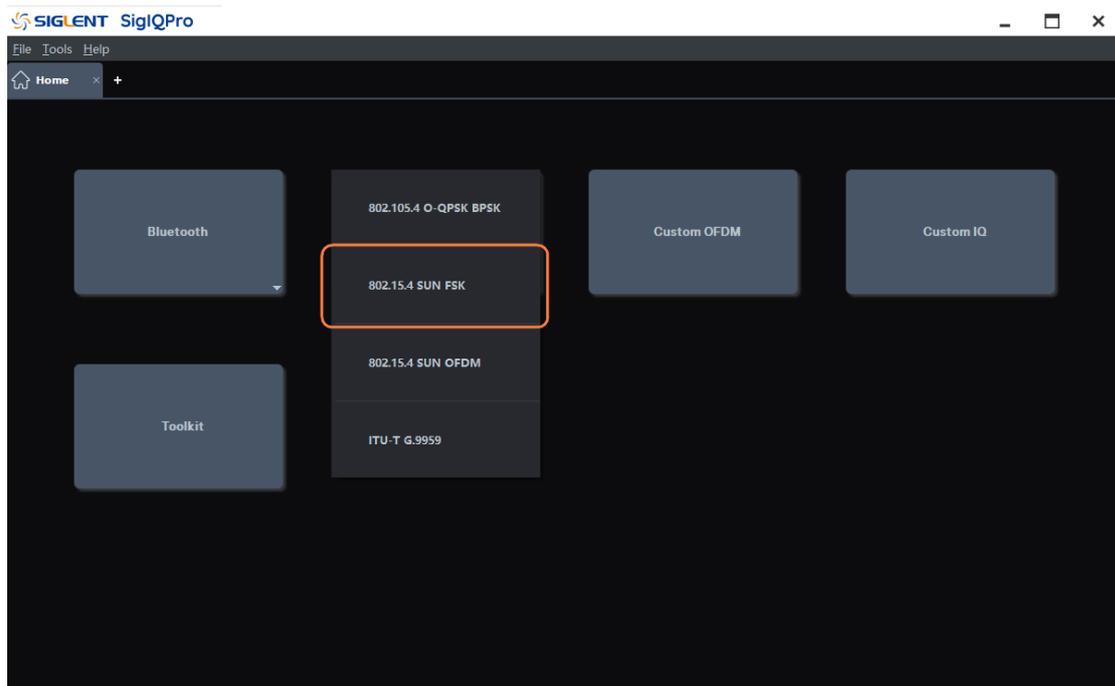
SUNs enable multiple applications to operate over shared network resources, providing monitoring and control of a utility system. SUN devices are designed to operate in very large-scale, low-power wireless applications and often require using the maximum transmit power available under applicable regulations, in order to provide long-range, point-to-point connections. Frequently, SUNs are required to cover geographically widespread areas containing a large number of outdoor devices. In these cases, SUN devices typically employ mesh or peer-to-peer multihop techniques to communicate with an access point.

SUN FSK is one of the physical layers defined in the standard.

Protocol version: IEEE Std 802.15.4 -2020

You can click **IoT** -> **802.15.4 SUN FSK** on the homepage to enter the 802.15.4 SUN FSK setting interface.





4.4.1 Waveform Setup

Press **Waveform Setup** in the left window to enter parameter settings.

4.4.1.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Number of Frames

Range: 1 to 2000 ; Default: 1.

Set the number of frames included in the generated waveform.

3. Oversampling Ratio

Range: 2 to 100 ; Default: 10.

Set the number of samples calculated per I/Q symbol.

4. Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

5. Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4.4.1.2 Marker

1. Marker 1 Source

Choice: Waveform Start| Frame Start ;

Default: Waveform Start.

Use the drop-down menu to select the type of Mark 1 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start ; Set the first point of the waveform to an active marker point.
- Frame Start ; Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

2. Marker 2 Source

Choice: Waveform Start| Frame Start ;

Default: Frame Start.

Use the drop-down menu to select the type of Mark 2 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

4.4.2 Packet

Press **Packet** in the left window to enter parameter settings.

4.4.2.1 General Setting

1. Data Rate

Range: 2.4 kb/s – 400 kb/s ; Default: 100 kb/s.

Set the data rate of FSK modulation in kb/s.

For more information on Data Rates, please refer to "Modulation and Coding for SUN FSK" in Section 19.3 of the IEEE Std 802.15.4-2020.

2. Modulation

Choice: 2FSK | 4FSK ; Default: 2FSK.

Use the drop-down menu to select the FSK modulation level.

For more information on the Modulation, please refer to " Modulation and Coding for SUN FSK " in Section 19.3 of the IEEE Std 802.15.4-2020.

3. Modulation Index

Range: 0.33 – 2 ; Default: 1.

Set the modulation index for FSK.

For more information on the Modulation Index, please refer to " Modulation and Coding for SUN FSK " in Section 19.3 of the IEEE Std 802.15.4-2020.

4. Idle Interval

Range: 0 – 200000 us ; Default: 1000 us.

Set the idle interval time in-between frames in microseconds. When idle interval is set to zero, a continuous waveform will be generated.

5. Ramp Symbols

Range: 1 – 10 ; Default: 4.

Set the symbol duration for waveform ramp up and down.

Note: This parameter is visible and configurable only when the idle interval is not zero.

6. Ramp Up/Down Symbol

Choice: First/Last | Center | One | Zero ; Default: First/Last.

Use the drop-down menu to select the symbol for the period of waveform ramp up and down.

- First/Last: Use the first data symbol value as the ramp up symbol value and the last data symbol value as the ramp down symbol value.
- Center: Set the ramp up/down symbol when frequency deviation is zero.
- One: Set the ramp up/down symbol when frequency deviation is negative.
- Zero: Set the ramp up/down symbol when frequency deviation is positive.

Note: This parameter is visible and configurable only when the idle interval is not zero.

4.4.2.2 SHR (Synchronization Header)

1. Preamble Sequence

Default: 0101 0101.

Set the preamble sequence used by the Synchronization Header. The sequence length should be a multiple of 8 for 2FSK and a multiple of 16 for 4FSK.

Note: The final preamble field will contain several multiples of the preamble sequence.

2. Preamble Length

Range: 32 – 8000 for 2FSK , 64 – 16000 for 4FSK ;

Default: 32.

Set the preamble length in bits in Synchronization Header.

The Preamble Length should be the integer multiple of the length of preamble sequence.

For more information on the preamble, please refer to "PPDU format for SUN FSK" in Section 19.2 of the IEEE Std 802.15.4-2020.

3. SFD Index

Choices: 0 | 1 ; Default: 0.

Set the index of SFD (Start of Frame Delimiter) sequence in Synchronization Header. It corresponds to the PIB attribute *phySunFskSfd* defined in IEEE Std 802.15.4-2020. See section 19.2.3.2 for details.

4. SFD Customized

Choices: On | Off ; Default: Off.

Use the drop-down menu to enable or disable customized SFD.

If SFD Customized is off, the standard SFD sequence is used, and the SFD Sequence is read-only.

For more information on the standard SFD sequence, see Section 19.2.3.2 of the IEEE Std 802.15.4-2020.

If SFD Customized is on, the SFD Sequence can be edited, and the custom SFD sequence is used.

The SFD Sequence length should be 16 for 2FSK and 32 for 4FSK, otherwise it will be truncated or padded with zeros.

5. SFD Sequence

Displays the value of the SFD fields in the Synchronization Header. For more information on the SFD sequence, see Section 19.2.3.2 of the IEEE Std 802.15.4-2020.

Note: This parameter can be edited only when SFD Customized is on.

4.4.2.3 PHR (PHY Header)

1. Mode Switch

Choices: Off | On ; Default: Off.

Use the drop-down menu to enable or disable the Mode Switch PHR.

- On: A mode switch packet is generated. The Mode Switch field of the packet shall be set to one, indicating that a mode switch shall occur.

- Off: A normal packet is generated. The Mode Switch field of the packet shall be set to zero, indicating that the entire packet shall be transmitted at a single data rate and using a single modulation scheme.

It will be included in Mode Switch field of PHR. For more information on the Mode Switch, see Section 19.2.4 and 19.2.5 of the IEEE Std 802.15.4-2020.

2. FCS Type

Choices: 0 = 4-octets | 1 = 2-octets;

Default: 0 = 4-octets.

Use the drop-down menu to select the FCS type. The FCS Type field of PHR indicates the length of the FCS field contained in the MPDU.

It will be included in FCS Type field of PHR. The FCS Type field of PHR shall be set to zero for a 4-octet FCS and shall be set to one for a 2-octet FCS. For more information on the FCS Type, see Section 19.2.4 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible and configurable only when the Mode Switch is off.

3. Data Whitening

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable the data whitening of PSDU upon transmission. It will be included in Data Whitening field of PHR. For more information on the Data Whitening, see Section 19.2.4 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible and configurable only when the Mode Switch is off.

4. Frame Length

Display the total number of octets contained in the PSDU (prior to FEC encoding, if enabled). It will be included in Frame Length field of PHR. For more information on the Frame Length, see Section 19.2.4 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible and configurable only when the Mode Switch is off.

5. Mode Switch Parameter

Range: 0 – 3 ; Default: 0.

Set the parameter group used for mode switch. It will be included in Mode Switch Parameter field of PHR. For more information on the Mode Switch Parameter, see Section 19.2.5 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible and configurable only when the Mode Switch is on.

6. New Mode FEC

Choices: On | Off ; Default: Off.

Use the drop-down menu to specify whether the packet following the mode switch PPDU is transmitted using FEC. It will be included in New Mode FEC field of PHR. For more information on the New Mode FEC, see Section 19.2.5 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible and configurable only when the Mode Switch is on.

7. New Mode

1) Page

Range: 0 – 1 ; Default: 0.

Set the Page in New Mode Field of mode switch PHR. The Page field shall be set to zero to indicate channel page nine or set to one to indicate channel page ten.

Note: This parameter is visible and configurable only when the Mode Switch is on.

2) Modulation Scheme

Range: 0 – 3 ; Default: 0.

Set the Modulation Scheme in New Mode Field of mode switch PHR. The Modulation Scheme field indicates the modulation scheme.

Modulation Scheme Field value	Description
0	SUN FSK
1	SUN OFDM
2	SUN O-QPSK
3	Additional modes

Note: This parameter is visible and configurable only when the Mode Switch is on.

3) Mode

Range: 0 – 15 ; Default: 0.

Set the Mode in New Mode field of mode switch PHR. The Mode field specifies the new mode of operation. For more information on the Mode, see Section 19.2.5 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible and configurable only when the Mode Switch is on.

8. Checksum

Display the checksum field in mode switch PHR. This value is read-only and automatically updated with PHR value. For more information on the Checksum, see Section 19.2.5 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible only when the Mode Switch is on.

9. Parity Check

Display the parity check field in mode switch PHR. This value is read-only and automatically updated with PHR value. For more information on the Parity Check, see Section 19.2.5 of the IEEE Std 802.15.4-2020.

Note: This parameter is visible only when the Mode Switch is on.

4.4.2.4 PSDU

These are the settings for the physical service data unit (PSDU) part of the frame when Mode Switch is off.

1. FEC

Choices: None | RSC | NRNSC ; Default: None.

Use the drop-down menu to select whether FEC is enabled and what type of FEC is used. For more information on the FEC, see Section 19.3.5 of the IEEE Std 802.15.4-2020.

2. Interleaving

Choices: On | Off ; Default: Off.

Use the drop-down menu to select whether interleaving is enabled after FEC. Interleaving is always enabled for NRNSC coding and disabled when FEC is not used. For more information on the interleaving, see Section 19.3.6 of the IEEE Std 802.15.4-2020.

3. Padding Bits

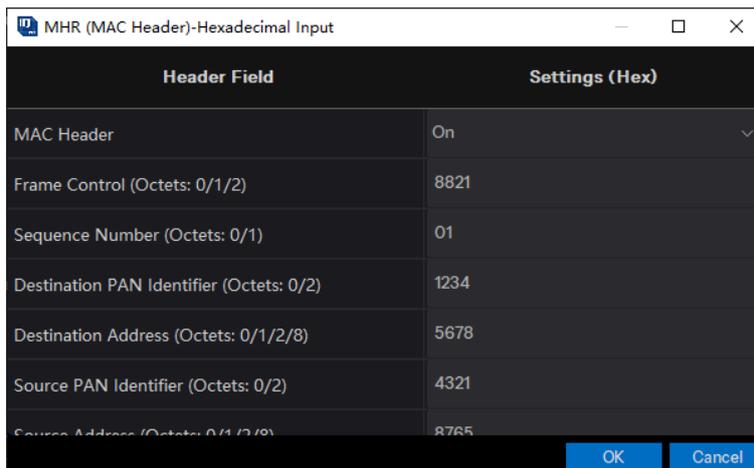
Display the number of padding bits appended to the tail bits, when interleaving is used in conjunction with convolutional coding.

The padding bits are required to fill up the last interleaver buffer completely, and the padding bits length is usually 5 or 13. This value is read-only and automatically updated with PHR and PSDU length. For more information on the padding bits, see Section 19.3.6 of the IEEE Std 802.15.4-2020.

4. PHY Payload

1) MHR (MAC Header)

Use the drop-down menu to enable or disable the MAC Header field.



For more information on the MAC header, refer to the IEEE standards 802.15.4.

2) Data Type

Choices: PN9 | PN15 | USER ;

Default: PN9.

Use the drop-down menu to set the type of packet payload.

PN9: A pseudo-random binary sequence of order 9 is used to fill the packet payload

PN15: A pseudo-random binary sequence of order 15 is used to fill the packet payload

USER: A user-defined binary sequence is used to fill the packet payload



3) Seed

Set the seed value used to generate the pseudo-random binary sequence.

When Data Type PN9 is selected: Range: 0x0 – 0x1FF ; Default: 0x1FF.

When Data Type PN15 is selected: Range: 0x0 – 0x7FFF ; Default:0x7FFF.

Note: This parameter can be edited only when the Data Type is PN9 or PN15.

4) Data Length (Octets)

Range: 0 – 2047 ; Default: 1024.

Set the length of MAC payload in octets.

5) Data Mode

Choices: Continuous | Truncated ;

Default: Continuous.

For multi-frame signals, select the mode applied to the packet payload. If there is only one frame in the signal, then there is no difference in selection.

- Continuous: packet payload data bits are distributed consecutively across multiple frames
- Truncated: packet payload data bits are the same for all frames, with the data size truncated for one frame

6) MAC FCS

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable the MAC FCS (frame check sequence). For more information on the MAC FCS, refer to the IEEE standards 802.15.4.

4.4.2.5 Encoding

These are the encoding settings when Mode Switch is on.

1. FEC

Choices: None | RSC | NRNSC ;

Default: None.

Use the drop-down menu to select whether FEC is enabled and what type of FEC is used. For more information on the FEC, see Section 19.3.5 of the IEEE Std 802.15.4-2020.

2. Interleaving

Choices: On | Off ; Default: Off.

Use the drop-down menu to select whether interleaving is enabled after FEC. Interleaving is always enabled for NRNSC coding and disabled when FEC is not used. For more information on the interleaving, see Section 19.3.6 of the IEEE Std 802.15.4-2020.

3. Padding Bits

Display the number of padding bits appended to the tail bits, when interleaving is used in conjunction with convolutional coding.

The padding bits are required to fill up the last interleave buffer completely, and the padding bits length is usually 5 or 13. This value is read-only and automatically updated with PHR and PSDU

length. For more information on the interleaving, see Section 19.3.6 of the IEEE Std 802.15.4-2020.

4.4.2.6 Impairments

1. Symbol Timing Error

Range: -300 to 300ppm ;

Default: 0ppm.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the signal. It is used to simulate transmission when the device's sampling clock is slightly off.

2. Frequency Offset

Range: -200 to 200kHz ;

Default: 0kHz.

Set the static offset of the carrier frequency. This static offset is used to simulate the device transmitting at a frequency slightly offset from the specified carrier.

3. Frequency Deviation Scaling

Range: 50 – 150% ;

Default: 100%.

Set the additional scaling to the nominal FSK frequency deviation. This is equivalent to apply scaling to FSK modulation index.

4. Gaussian BT

Range: 0.1 – 1.0 ;

Default: 0.5.

Set the BT product of the Gaussian filter applied to FSK modulation.

4.5 IEEE 802.15.4 SUN OFDM

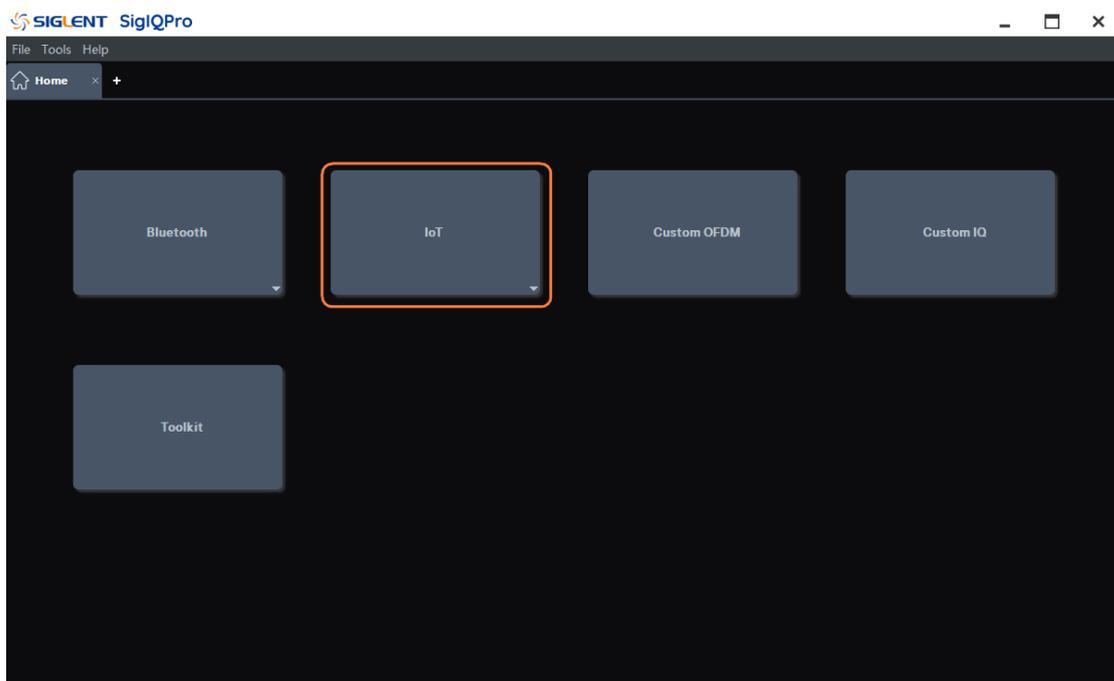
SUNs PHY defined in IEEE standard 802.15.4. The smart utility network is a principally outdoor, low data rate wireless network that supports two-way communications among sensing, measurement, and control devices in the smart grid.

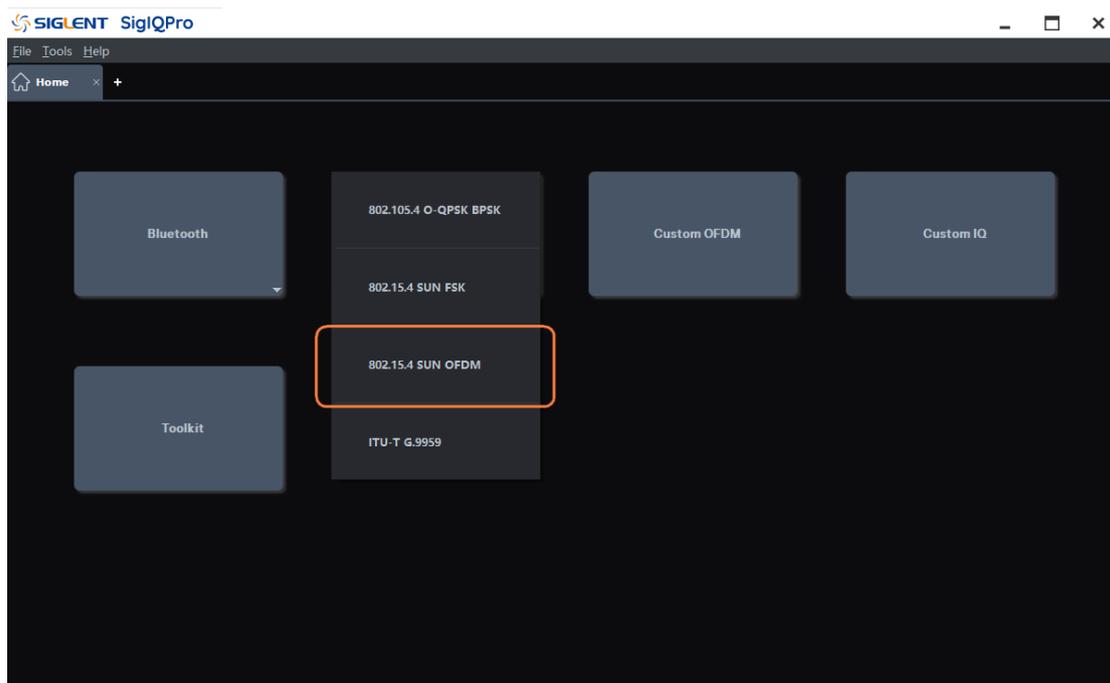
SUNs enable multiple applications to operate over shared network resources, providing monitoring and control of a utility system. SUN devices are designed to operate in very large-scale, low-power wireless applications and often require using the maximum transmit power available under applicable regulations, in order to provide long-range, point-to-point connections. Frequently, SUNs are required to cover geographically widespread areas containing a large number of outdoor devices. In these cases, SUN devices typically employ mesh or peer-to-peer multihop techniques to communicate with an access point.

SUN OFDM is one of the physical layers defined in the standard, which supports data rates ranging from 12.5 kb/s to 2400 kb/s. The subcarrier spacing is constant and is equal to $10416\frac{2}{3}$ Hz. The symbol rate is $8\frac{1}{3}$ kSymbol/s, which corresponds to 120 us per symbol.

Protocol version: IEEE Std 802.15.4 -2020

You can click **IoT** -> **802.15.4 SUN OFDM** on the homepage to enter the 802.15.4 SUN OFDM setting interface.





4.5.1 Waveform Setup

Press **Waveform Setup** in the left window to enter parameter settings.

4.5.1.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Number of Frames

Range: 1 to 2000 ; Default: 1.

Set the number of frames included in the generated waveform.

3. Oversampling Ratio

Range: 2 to 100 ; Default: 10.

Set the number of samples calculated per I/Q symbol.

4. Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

5. Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4.5.1.2 Marker

1. Marker 1 Source

Choice: Waveform Start | Frame Start;

Default: Waveform Start.

Use the drop-down menu to select the type of Mark 1 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

2. Marker 2 Source

Choice: Waveform Start | Frame Start;

Default: Frame Start.

Use the drop-down menu to select the type of Mark 2 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

4.5.2 Packet

Press **Packet** in the left window to enter parameter settings.

4.5.2.1 OFDM Setting

1. Option

Choices: Option 1 | Option 2 | Option 3 | Option 4 ; Default: Option 2.

Use the drop-down menu to select PHY option. This PHY includes four options, each one being characterized by the number of active tones during the PHR or PSDU. Please refer to Table 20-10 in IEEE Std 802.15.4-2020 for more information.

2. FFT Size

Display the FFT size of selected OFDM option. This value is read-only and automatically updated when Option is changed. Please refer to Table 20-10 in IEEE Std 802.15.4-2020 for more information.

3. Idle Interval

Range: 0 – 200000 us ;

Default: 1000 us.

Set the idle interval time in-between frames in microseconds. When idle interval is set to zero, a continuous waveform will be generated.

4. Windowing Length

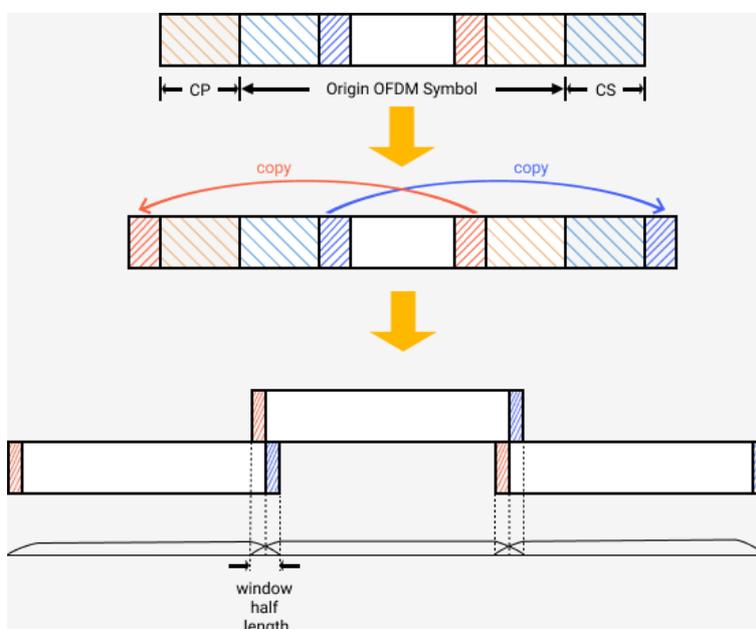
Range: 0 – FFT Size * Oversampling Ratio * 0.5;

Default: 16.

Set the raised cosine window length used to smooth the OFDM symbol transition. The maximum windowing length is limited to avoid exceeding the cyclic prefix (CP) part based on the option of OFDM signal.

To achieve a balance between ACP and EVM test results, it is necessary to set an appropriate windowing length. If you increase the windowing length to enhance the ACP result, the EVM result may deteriorate.

Note: Window length must be even.



5. Filter for STF Symbols

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable an ideal low pass filter that is applied to STF symbols.

This filter will help eliminate the out-of-band spurs that are caused by the negated half of the 4th STF symbol.

6. Filter

Choices: None | Gaussian | Root Nyquist | Nyquist ;

Default: None.

Use the drop-down menu to select the pulse shape filter type to be applied to the waveform.

4.5.2.2 PSDU

These are the settings for the physical service data unit (PSDU) part of the frame that includes the payload data.

1. MCS

Range:0 – 6 ; Default: 3.

Set the MCS level for PSDU. The MCS level affects the modulation and coding for PSDU. Please refer to Table 20-10 in IEEE Std 802.15.4-2020 for more information.

2. Modulation and Coding

Display the modulation and coding scheme under selected MCS level. This value is read-only and automatically updated when MCS is changed. Please refer to Table 20-10 in IEEE Std 802.15.4-2020 for more information.

3. Scrambler

Choices: 00 (Seed 000010111) | 01 (Seed 101110111) | 10 (Seed 000011100) | 11 (Seed 101111100);

Default: 00 (Seed 000010111).

Use the drop-down menu to select the seed for scrambling PN sequence generation. It will be included in Scrambler field of PHR. Please refer to section 20.2.4 in IEEE Std 802.15.4-2020 for more information.

4. OFDM Interleaving

Choices: 0 | 1 ; Default: 0.

Set the SUN OFDM interleaving attribute. This value affects the depth of interweaving. It corresponds to the PIB attribute *phyOfdmInterleaving* defined in IEEE Std 802.15.4-2020.

0: The interleaving depth of one symbol

1: The interleaving depth of the number of symbols equal to the frequency domain spreading factor.

For more information on the interleaving, see Section 20.4.5 of the IEEE Std 802.15.4-2020.

5. FCS Type

Choices: 0 = 4-octets | 1 = 2-octets;

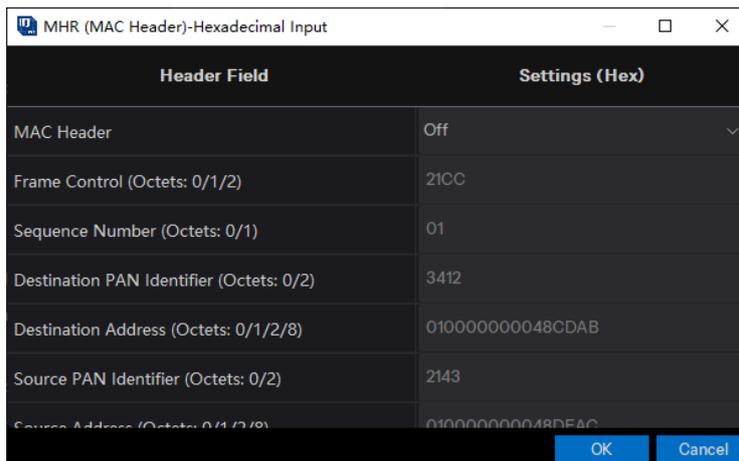
Default: 0 = 4-octets.

Use the drop-down menu to select the FCS type. The FCS Type indicates the length of the FCS field contained in the MPDU.

6. PHY Payload

1) MHR (MAC Header)

Use the drop-down menu to enable or disable the MAC Header filed.



For more information on the MAC header, refer to the IEEE standards 802.15.4.

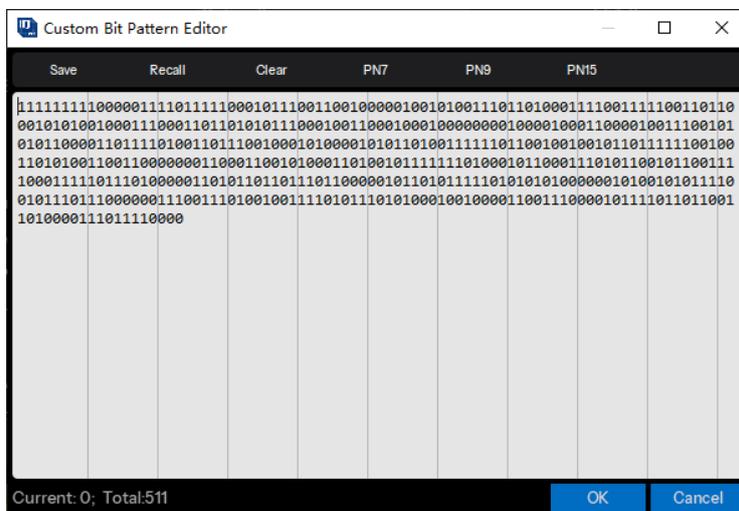
2) Data Type

Choices: PN9 | PN15 | USER ;

Default: PN9.

Use the drop-down menu to set the type of packet payload.

- PN9: A pseudo-random binary sequence of order 9 is used to fill the packet payload.
- PN15: A pseudo-random binary sequence of order 15 is used to fill the packet payload.
- USER: A user-defined binary sequence is used to fill the packet payload.



3) Seed

Set the seed value used to generate the pseudo-random binary sequence.

When Data Type PN9 is selected: Range: 0x0 – 0x1FF ; Default: 0x1FF.

When Data Type PN15 is selected: Range: 0x0 – 0x7FFF ; Default: 0x7FFF.

Note: This parameter can be edited only when the Data Type is PN9 or PN15.

4) Data Length (Octets)

Range: 0 – 2047 ; Default: 1024.

Set the length of MAC payload in octets.

5) Data Mode

Choices: Continuous | Truncated ;

Default: Continuous

For multi-frame signals, select the mode applied to the packet payload. If there is only one frame in the signal, then there is no difference in selection.

- Continuous: packet payload data bits are distributed consecutively across multiple frames
- Truncated: packet payload data bits are the same for all frames, with the data size truncated for one frame

6) MAC FCS

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable the MAC FCS (frame check sequence). For more information on the MAC FCS, refer to the IEEE standards 802.15.4.

7. Padding Bits

Display the number of padding bits appended to the tail bits in PSDU. The appended bits in PSDU are set to zeros, and to ensure that the number of bits in the PHY Payload field are multiple of Ncbps.

For more information on the padding bits, see Section 20.4.10 of the IEEE Std 802.15.4-2020.

This value is read-only and automatically updated with Option, MCS, Frame Length and OFDM Interleaving.

8. Number of OFDM Symbols

Display the number of OFDM symbols of PSDU. This value is read-only and automatically updated with Option, MCS, OFDM Interleaving and PSDU settings.

4.5.2.3 PHR (PHY Header) Info

These are the settings for PHY Header. All configuration items are read-only and automatically

updated with OFDM setting and PSDU settings.

1. MCS

Display the MCS level for PHR. The MCS level affects the modulation and coding for PHR. The PHR shall be transmitted using the lowest supported MCS level for Option 1 and Option 2. For OFDM option 3 and OFDM Option 4, the PHR shall be transmitted using MCS1 and MCS2 respectively. This value is read-only and automatically updated when Option is changed. Please refer to Section 20.2.4 in IEEE Std 802.15.4-2020 for more information.

2. Modulation and Coding

Display the modulation and coding scheme under selected MCS level. This value is read-only and automatically updated when MCS is changed. Please refer to Table 20-10 in IEEE Std 802.15.4-2020 for more information.

3. Frame Length

Display the total number of octets contained in the PSDU (prior to FEC encoding). It will be included in Frame Length field of PHR. This value is read-only and automatically updated with PSDU settings. Please refer to Section 20.2.4 in IEEE Std 802.15.4-2020 for more information.

4. HCS

Display the HCS (header check sequence) field of PHR in HEX. The HCS shall be computed using the first 22 bits of the PHR. This value is read-only and automatically updated when any of the PHR filed settings is changed. Please refer to Section 20.2.4 in IEEE Std 802.15.4-2020 for more information.

5. Padding Bits

Display the number of padding bits appended to the tail bits in PHR. The appended bits in PHR are set to zeros, and to ensure that the number of bits in the PHR field are multiple of Ncbps. For more information on the padding bits, see Section 20.4.10 of the IEEE Std 802.15.4-2020.

This value is read-only and automatically updated with Option, MCS, Frame Length and OFDM Interleaving.

6. Number of OFDM Symbols

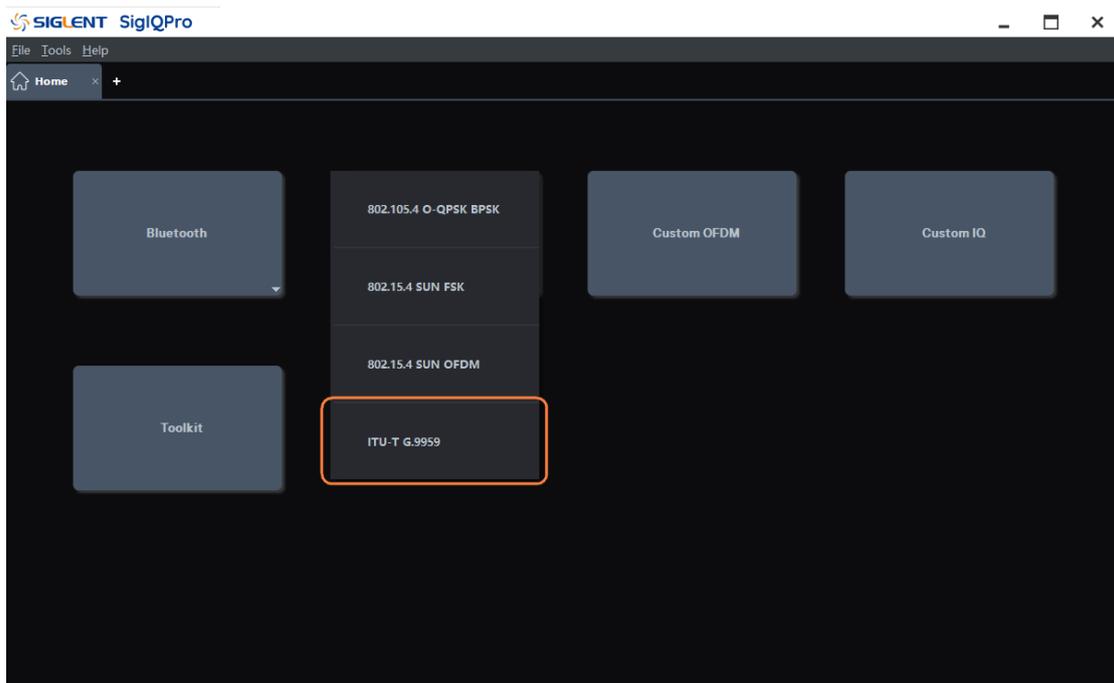
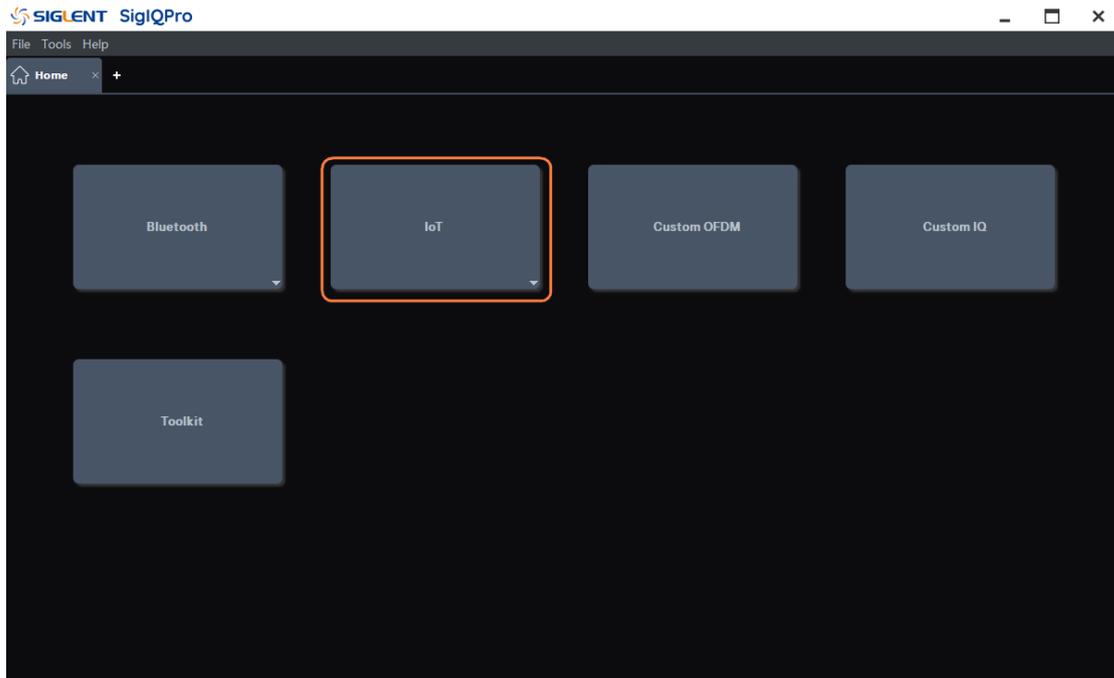
Display the number of OFDM symbols of PHR. This value is read-only and automatically updated with Option, MCS, and OFDM Interleaving.

4.6 ITU-T G.9959

ITU-T G.9959 PHY is defined in short range narrow-band digital radiocommunication transceivers -- PHY, MAC, SAR and LLC layer specifications.

Protocol version: IEEE Std 802.15.4 -2020.

You can click **IoT** -> **ITU-T G.9959** on the homepage to enter the ITU-T G.9959 setting interface.



4.6.1 Waveform Setup

Press **Waveform Setup** in the left window to enter parameter settings.

4.6.1.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Number of Frames

Range: 1 to 2000 ; Default: 1.

Set the number of frames included in the generated waveform.

3. Oversampling Ratio

Range: 2 to 100 ; Default: 10.

Set the number of samples calculated per I/Q symbol.

4. Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

5. Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4.6.1.2 Marker

1. Marker 1 Source

Choice: Waveform Start | Frame Start;

Default: Waveform Start.

Use the drop-down menu to select the type of Mark 1 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

2. Marker 2 Source

Choice: Waveform Start | Frame Start;

Default: Frame Start.

Use the drop-down menu to select the type of Mark 2 Source to set the active mark points within the waveform. When the signal generator encounters an active mark point, a pulse signal is output via the IQ_EVENT connector on the rear panel. For more information, see the Signal Generator's User guide.

- Waveform Start : Set the first point of the waveform to an active marker point.
- Frame Start : Set the first point of the frame to an active marker point.

Note: A waveform may contain multiple frames.

4.6.2 Packet

Press **Packet** in the left window to enter parameter settings.

4.6.2.1 General Setting

1. Data Rate

Choices: R1 – 9.6 kbps | R2 – 40 kbps | R3 – 100 kbps;

Default: R1 – 9.6 kbps.

Use the drop-down menu to select the data rate type of PHY.

- R1: Data Rate Type 1 (9.6 kbit/s).
- R2: Data Rate Type 2 (40 kbit/s).
- R3: Data Rate Type 3 (100 kbit/s).

For more information on Data Rate, please refer to "Data rates" in Section 7.1.2.2 of the ITU-T G.9959 -2015.

2. Modulation

Choices: FSK | GFSK;

Default: FSK for R1/R2, GFSK for R3.

Use the drop-down menu to select the modulation type for PHY. For more information on Modulation, please refer to "Modulation and encoding" in Section 7.1.2.4 of the ITU-T G.9959 -2015.

3. Coding

Displays the coding type. This value is read-only and automatically updated when Data Rate is changed.

Manchester code shall be used for data symbol encoding at data rate R1 and non-return-to-zero (NRZ) shall be used for data symbol encoding at data rates R2 and R3. Please refer to Section 7.1.2.4 in ITU-T G.9959 -2015 for more information.

4. Separation

Displays the separation of FSK. This value is read-only and automatically updated when Data Rate is changed. Please refer to Table 7-4 in ITU-T G.9959 -2015 for more information.

5. Idle Interval

Range: 0 – 200000 us ; Default: 1000 us.

Set the idle interval time in-between frames in microseconds. When idle interval is set to zero, a continuous waveform will be generated.

6. Ramp Symbols

Range: 1 – 10 ; Default: 4.

Set the symbol duration for waveform ramp up and down.

Note: This parameter is visible and configurable only when the idle interval is not zero.

7. Ramp Up/Down Symbol

Choice: First/Last | Center | One | Zero;

Default: First/Last.

Use the drop-down menu to select the symbol for the period of waveform ramp up and down.

- First/Last : Use the first data symbol value as the ramp up symbol value and the last data symbol value as the ramp down symbol value.
- Center : Set the ramp up/down symbol when frequency deviation is zero.
- One : Set the ramp up/down symbol when frequency deviation is negative.
- Zero : Set the ramp up/down symbol when frequency deviation is positive.

Note: This parameter is visible and configurable only when the idle interval is not zero.

4.6.2.2 PPDU Settings

These are the settings to configure the physical protocol data unit (PPDU) which is the frame.

1. PPDU Length (Octets)

Display the total PPDU length in bytes. This value is read-only and automatically updated with PPDU Settings.

2. Preamble Length (Octets)

Range: 10 – 100 ; Default: 10.

Set the preamble length in bytes in SHR (Synchronization Header). For more information on preamble, please refer to " Preamble field" in Section 7.1.3.2 of the ITU-T G.9959 -2015.

3. Start of Frame Delimiter (Hex)

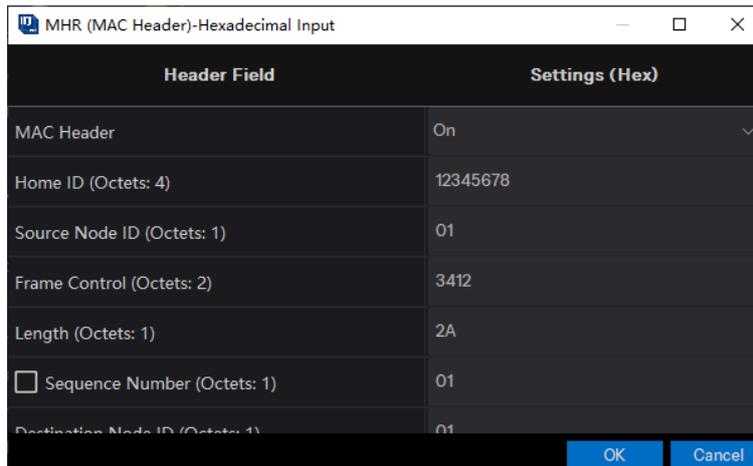
Range: 00 to FF ; Default: F0.

Set the SOF field in hex in SHR (Synchronization Header). The SOF is an 8-bit field terminating the preamble field and the start of the PSDU. For more information on SOF, please refer to "Start of frame (SOF) field " in Section 7.1.3.3 of the ITU-T G.9959 -2015.

4. PSDU

1) MHR (MAC Header)

Use the drop-down menu to enable or disable the MAC Header filed.



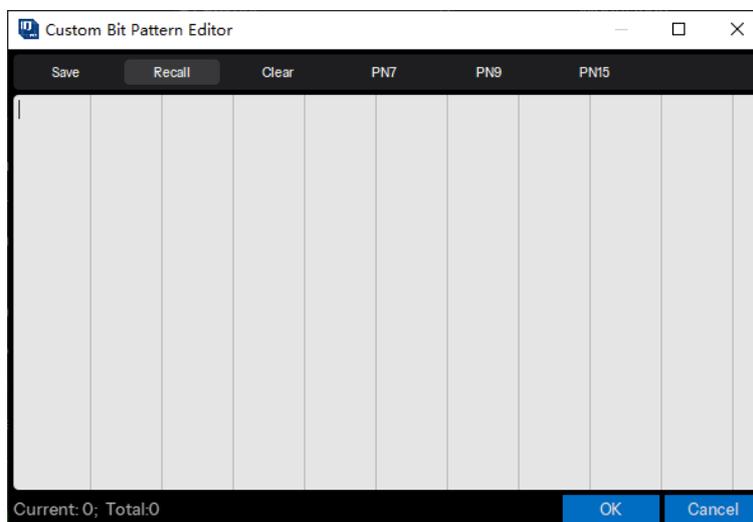
For more information on the MAC header, please refer to " MPDU format " in Section 8.1.3 of the ITU-T G.9959 -2015.

2) Data Type

Choices: PN9 | PN15 | USER ; Default: PN9.

Use the drop-down menu to set the type of packet payload.

- PN9: A pseudo-random binary sequence of order 9 is used to fill the packet payload
- PN15: A pseudo-random binary sequence of order 15 is used to fill the packet payload
- USER: A user-defined binary sequence is used to fill the packet payload



3) Seed

Set the seed value used to generate the pseudo-random binary sequence.

When Data Type PN9 is selected: Range: 0x0 – 0x1FF ; Default:0x1FF.

When Data Type PN15 is selected: Range: 0x0 – 0x7FFF ; Default:0x7FFF.

Note: This parameter can be edited only when the Data Type is PN9 or PN15.

4) Data Length (Octets)

Range: 0 – 64 for R1 or R2; 0 – 170 for R3 ;

Default: 32.

Set the length of MAC payload in octets.

5) Data Mode

Choices: Continuous | Truncated;

Default: Continuous.

For multi-frame signals, select the mode applied to the packet payload. If there is only one frame in the signal, then there is no difference in selection.

- Continuous: packet payload data bits are distributed consecutively across multiple frames .
- Truncated: packet payload data bits are the same for all frames, with the data size truncated for one frame.

6) MAC FCS

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable the MAC FCS (frame check sequence). For more information on the MAC FCS, refer to Section 8.1.3.8 and Section 8.1.3.9 of the ITU-T G.9959 -2015.

5. End of Frame Delimiter

Choices: On | Off ; Default: On.

Use the drop-down menu to enable or disable EOF in the PPDU. The EOF delimiter field shall be sent only when transmitting at data rate R1. For more information on the EOF, refer to Section 7.1.3.5 of the ITU-T G.9959 -2015.

4.6.2.3 Impairments

1. Symbol Timing Error

Range: -300 to 300ppm ; Default: 0ppm.

Set the shift of standard symbol rate for transmission. This shift varies the symbol rate of the signal. It is used to simulate transmission when the device's sampling clock is slightly off.

2. Frequency Offset

Range: -200 to 200kHz ; Default: 0kHz.

Set the static offset of the carrier frequency. This static offset is used to simulate the device transmitting at a frequency slightly offset from the specified carrier.

3. Frequency Deviation Scaling

Range: 50 – 150% ; Default: 100%.

Set the additional scaling to the nominal FSK frequency deviation. This is equivalent to apply scaling to FSK modulation index.

4. Gaussian BT

Range: 0.1 – 1.0 ; Default: 0.6.

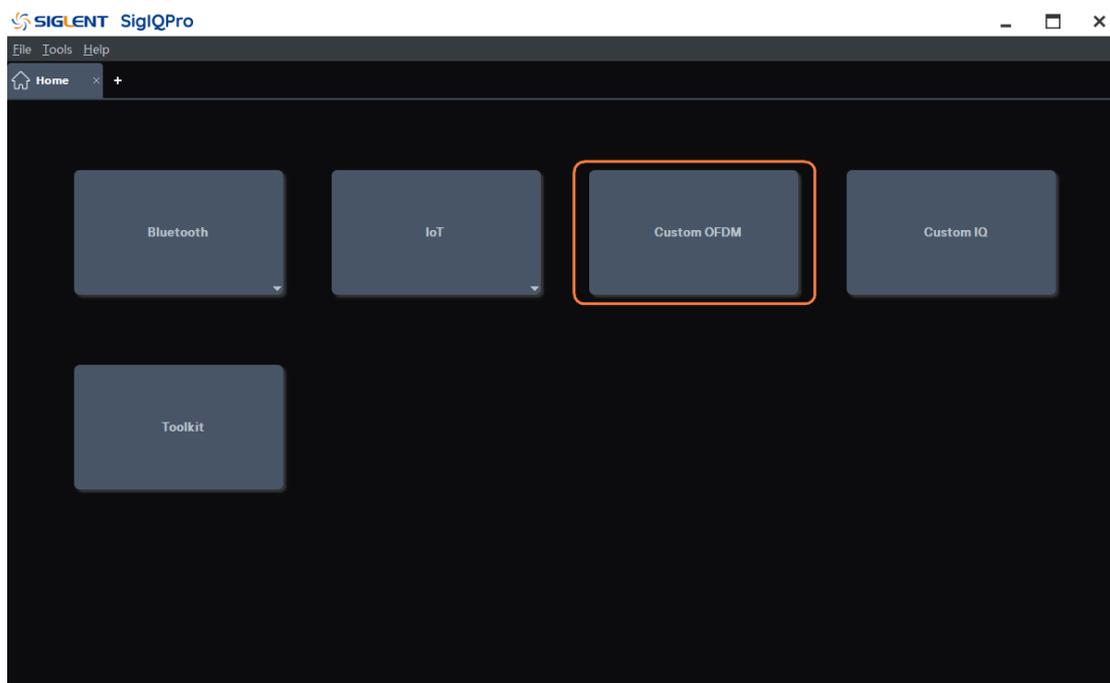
Set the BT product of the Gaussian filter applied to FSK modulation.

Note: This parameter is visible only when the Modulation selection is GFSK.

4.7 Custom OFDM

Custom OFDM software module supports highly customizable settings based on Orthogonal Frequency Division Multiplexing (OFDM), and generates baseband data for Siglent signal generators to output modulated signals.

You can click **Custom OFDM** on the homepage to enter the Custom OFDM setting interface.



4.7.1 Term Definition

For the purposes of the present document, some terms are applied. IEEE Std 802.11a-1999 provides references for term definitions.

The definitions of these terms are as follow.

4.7.1.1 Frame

In Custom OFDM software module, OFDM baseband signal is divided as frames in the time domain, which is made up of a certain number of OFDM symbols. There is the same number of subcarriers in the frequency domain for every OFDM symbol, each of them can carry a symbol generated by means of linear digital modulation, such as PSK and QAM.

OFDM symbols in frame are numbered, starting from 0.

Subcarriers are also numbered, and the index of center subcarrier is set to 0. Compared to the center subcarrier, the indices of subcarriers at lower frequencies are negative, the other subcarrier indices are positive integers.

4.7.1.2 Resource Unit

Physical Resources in a frame is generally described as two-dimensional grids, whose dimensions are OFDM symbols and subcarriers.

Resource Unit is the smallest unit of physical resources in a frame, referring to the physical resource made up of single subcarrier on a single OFDM symbol.

4.7.1.3 Resource Block

To transmit data effectively by means of OFDM, some known signals is usually transmitted in a frame, which is used to analyze the physical channel parameters in the receiving side. The other signals carry data encoding based on valid transmission information.

Resource Blocks are transmission units of independent signals for different proposes, which is called as Channel in some communication protocols.

Resource Blocks occupy certain resource units to transmission data, which is assigned by resource mapping in OFDM. Transmitted data in resource blocks is encoded into IQ value arrays by linear digital modulation, which is called as Payload.

Payload can be directly given as IQ value arrays, or modulated according to the bit patterns and the linear digital modulation type. The bit pattern can be automatically generated PN codes, or directly given.

Resource Blocks is classified into three types in accordance with the function of transmitted signals: Preamble, Pilot and Data.

Preamble is used to transmit known signals for frame synchronization. The signals might be also used to frequency/phase offset estimation or channel model estimation. It's usually assigned fixed IQ sequences for these resource blocks in the communication protocols.

Pilot is used to transmit known signals for channel model estimation, which is usually widely distributes in OFDM symbols to track time-varying channel parameters. Pilot might be also used to synchronization. It's usually assigned fixed bit sequences for these resource blocks in the communication protocols, and payloads are generated by linear digital modulation.

Data is used to transmit signals carrying the valid transmission information. The information is encoded into binary bit sequences, then modulated into IQ value sequences for resource block payloads.

Resource mapping priority of the resource blocks relates to the resource block type. Preamble has the highest priority, Pilot is the second, Data is the lowest.

Resource Blocks are numbered, the indices start from 1. For resource blocks of the same type, the resource blocks with larger indices have higher priority to resource mapping.

4.7.1.4 Resource Group

To assign resource units occupied by resource blocks clearly, resource groups is introduced to divide occupied resource units into several groups.

Resource units occupied by resource groups are given as OFDM symbol index lists and subcarrier index lists, which respectively assign certain OFDM symbols and subcarriers. For every OFDM symbol assigned, resource unit made up of every subcarrier assigned on the symbol is indicated to be occupied.

Every resource group has a unique group ID, that a non-negative integer to indicate the group. Resource group ID 0 is reserved, and indicates the group is global. The resource group is assigned as 0 by default if not given, its symbol index lists and subcarriers don't assign resource units for itself, but are appended the lists to those of other resource groups to expand physical resource ranges occupied by those groups.

4.7.2 Techniques Explanation

For the purposes of the present document, some techniques used in the software are explained as follow.

4.7.2.1 Cyclic Prefix / Cyclic Suffix

To reduce the effect of multipath transmission on the communication quality, Cyclic Prefix and Cyclic Suffix are frequently applied in the communication protocols based on OFDM.

Cyclic Prefix (CP) means adding certain number of sample points before the origin OFDM symbol sample data. Extra sample points are copied from the same number of sample points at the end of the origin symbol sample data.

Cyclic Suffix works similarly to CP, copying the sample points at the beginning of the origin and adding them into the end of the origin.

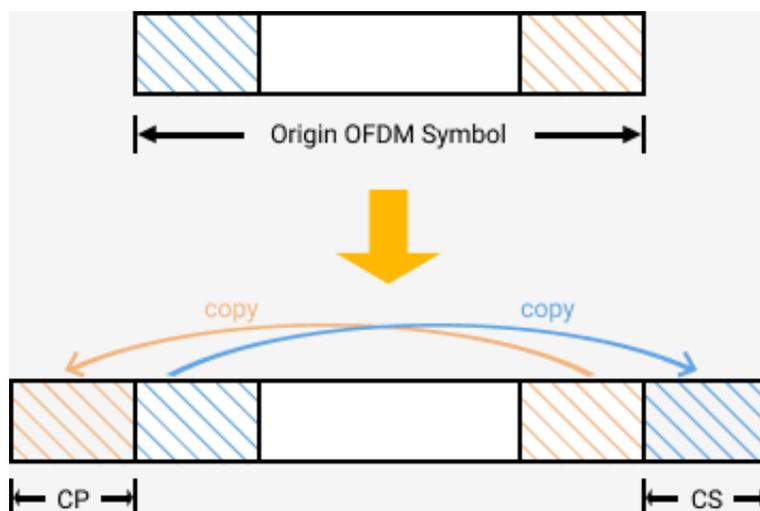


Figure 4-1 Cyclic Prefix and Cyclic Suffix

4.7.2.2 DFT Spread

DFT Spread is a technique to mapping the DFT calculation output sequences of the payload IQ values to physical resources, instead of origin payload sequences. It's introduced to suppress the Inter-Symbol Interference (ISI) and reduce the Peak to Average Power Ratio (PAPR) the spectrum in some communication protocols, like Uplink of LTE and NR.

If DFT spread is enabled for a resource block, the software will execute DFT calculation for payload values of it on every OFDM symbols respectively, and replace the origin data by the calculation results.

4.7.2.3 Windowing

Windowing is a technique to smoothing the transitions between OFDM symbols, in order to reduce the spectrum leakage of OFDM. There are two windowing method supported in the software:

Window centered at symbol boundary, or window starting at symbol boundary.

For window centered at symbol boundary, origin OFDM symbol sample data are expanded at the beginning and the end, expanded sample points are copied from the end and the beginning of the origin respectively. For symbol with CP and /or CS, the copy source is before the source of CP and /or after the source of CS respectively. The expand data length is the quarter of the length of window rising / falling edge respectively.

Then, raise cosine window is applied to the expanded symbol data, the center of the rising / falling edge of the window function is aligned with the origin symbol boundary. The process flow is shown in Figure 4–2.

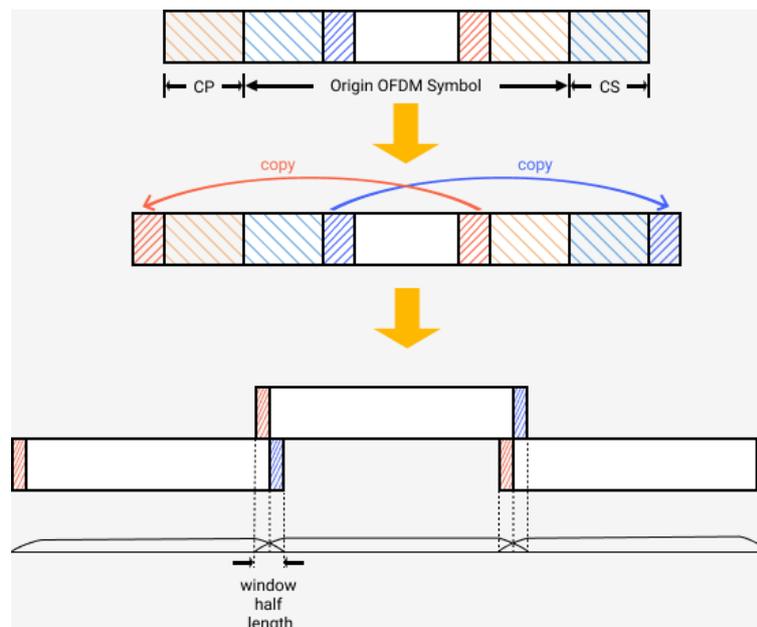


Figure 4–2 Window center aligning with symbol boundary

For window starting at symbol boundary, origin OFDM symbol sample data are expanded at the end

only. The expand method is similar to the former method, but the expand length is the half of the window edge length.

Then, raise cosine window is applied, and the starting of window edge is aligned with the origin symbol boundary. The process flow is shown in Figure 4–3.

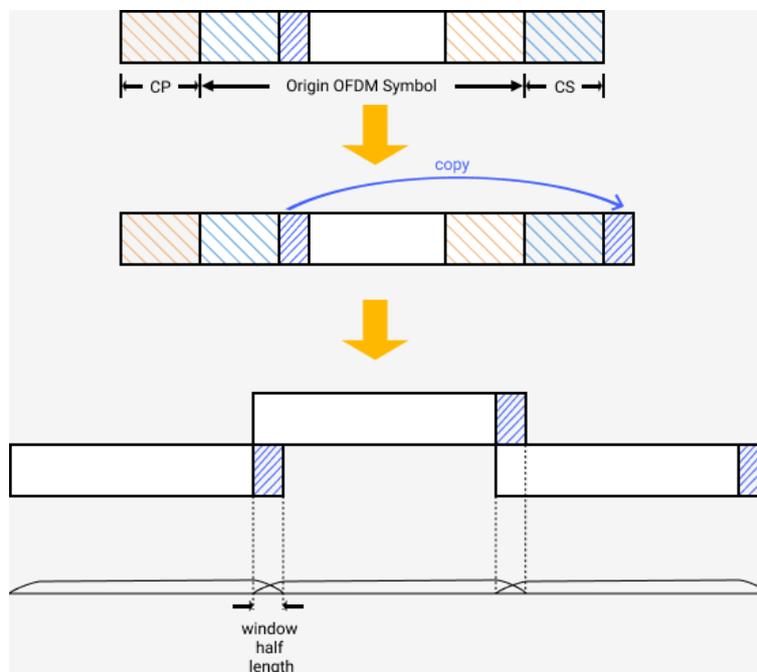


Figure 4–3 Window starting aligning with symbol boundary

4.7.2.4 Crest Factor Reduction

If Peak to Average Power Ratio (PAPR) of the OFDM baseband signal is relatively high, the power amplifier used in the transmission circuit must have wide dynamic range, which usually results in a lower power efficiency. To avoid the problem, it's necessary to reduce the PAPR of the baseband signals, which is called as Crest Factor Reduction (CFR).

There are some mature techniques to implement CFR, such as Clipping and filtering, Peak Windowing and Peak Cancellation. Peak Cancellation is adopted in the software.

If CFR is enabled, the software divides the baseband signal into blocks according to the block size assigned, and execute Peak Cancellation for every block:

For the sample point whose amplitude is highest, if the amplitude is over CFR target PAPR limit, generate the cancellation signal to cut down the over-limited amplitude according to the cancelling percent assigned.

Combine the cancellation signal of all blocks, and filter the combined signal to suppress the spectrum leak, then add the filtered signal to the baseband signal.

Check if the target PAPR value has been achieved, if not achieved and not meeting the max iteration limit, execute above steps iteratively.

4.7.3 Waveform Setup

The section explains the settings in the Waveform Setup Menu. Press **Waveform Setup** in the left window to enter parameter settings.

4.7.3.1 Basic

1. Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

2. Number of Frames

Range: 1 to 300 ; Default: 1.

Set the number of frames in the baseband signal data to download to the devices or export to the files.

3. Oversampling Ratio

Range: 1 to 128 ; Default: 4.

Set oversampling ratio of the baseband signal.

The parameter will increase the actual FFT length during the signal generation, too large parameter value will slow down the processing procedure, even result in out-of-memory failure.

4. Total Sample Points

Display the total number of sample points for the baseband signal according to the current settings.

5. Waveform Length

Display the time length of the baseband signal according to the current settings.

6. Mirror Spectrum

Choice: On | Off ; Default: Off.

Select setting the spectrum of the baseband signal into mirror symmetry or not.

The mirror spectrum is implemented by inverting the Q path of the baseband IQ signal.

4.7.3.2 Crest Factor Reduction

The section introduces the settings of CFR applied to the baseband signal.

1. Crest Factor Reduction

Choice: On | Off ; Default: Off.

Select applying CFR to the baseband signal or not.

If the parameter is set to Off, other settings of Crest Factor Reduction will be hidden.

2. Target PAPR

Range: 3 dB to 100 dB ; Default: 8 dB.

Set the target PAPR value of CFR applied to the baseband signal.

The software tries to reduce the PAPR value to the target assigned by executing CFR iteratively, but the target is NOT guaranteed to be achieved. If Max Iteration or Cancelling Percent is too little, it will be little possible to reduce the PAPR value to the low target value.

3. Max Iteration

Range: 1 to 20 ; Default: 10.

Set the maximum iterations of CFR process for the baseband signal.

The software executes CFR iteratively, and terminate the iteration if the target PAPR value has been achieved or the maximum iterations limit has been met.

4. Cancelling Percent

Range: 0 % to 100 % ; Default: 100 %.

Set the cancelling percent of the generated cancellation signal in the CFR process.

To reduce the PAPR of the blocked signals, cancellation signal amplitude equals to the cancelling percent assigned multiplies the over-limited amplitude of the origin signal. If the cancelling percent is too little, the effect of CFR will become too weak to achieve the target PAPR value.

5. Block Size

Range: 20 to Total Sample Points ; Default: 1000.

Set the block size of the signal segmentation in the CFR process.

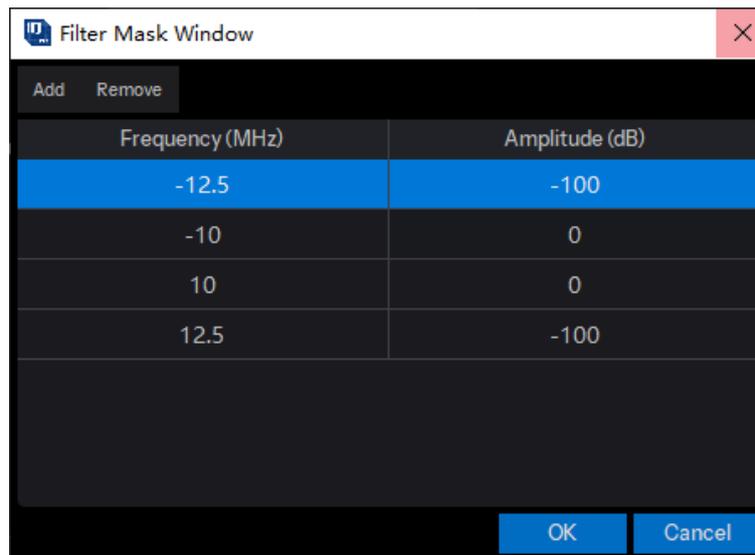
In the CFR process, the baseband signal is divided into blocks to execute Peak cancellation. For every signal block, only one peak will be cancellation in a single iteration. If the block size is too large, it's little possible to cancel all over-limited sample points in the baseband signal, resulting in failing to achieve the target PAPR value.

6. Filter Mask

Set the amplitude-frequency response data of the filter used to suppress the spectrum leak in the CFR process.

The cancellation signal generated in the CFR process will be filtered before add to the baseband signal, the software generates lowpass or bandpass FIR filter according the filter mask data assigned automatically.

If the passband of filter is too broad, the spectrum leak can't be suppressed effectively. If the passband is too narrow, the peak cancellation will be too weak to reduce PAPR value to the target.



4.7.3.3 Multicarrier

The section introduces the settings of multicarrier applied to the baseband signal.

Multicarrier is implemented by mixing the baseband signal to the carrier frequency assigned, and combine all signals on multi-carriers into the final baseband signal data to output to the devices or files.

1. Multicarrier Enabled

Choice: On | Off ; Default: Off.

Select applying multicarrier to the baseband signal or not.

If the parameter is set to Off, other settings of Multicarrier will be hidden.

2. Number of Carriers

Display the number of carriers in the multicarrier process.

3. Carrier Phases

Choice: Fixed | Random ;

Default: Random.

Select the initial phases of the carriers to be aligned or random in the multicarrier process.

If the parameter is set to Fixed, the initial phases of all the carriers is set to the Initial Phase assigned in the Section 5. If the parameter is set to Random, the initial phases will be given by random numbers.

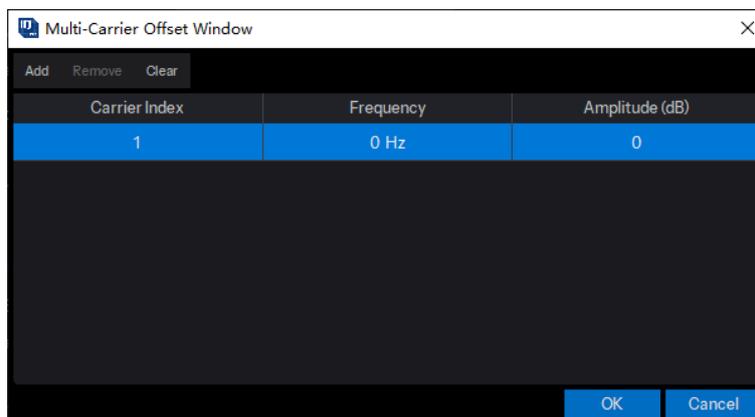
4. Frequency Offsets & Power Offsets

Click the "Frequency Offsets" or "Power Offsets" box to open the Multi-Carrier Offset Window, set the frequency or Power Offsets of carriers.

The Frequency Offset values larger than the baseband signal bandwidth or the device output

bandwidth will result in undefined behaviors.

The Power Offset is limited to be non-positive values, indicating the power attenuation factors of the signal on the carriers.



4.7.4 Custom OFDM

The section explains the settings in the Waveform Setup Menu. Press **Custom OFDM** in the left window to enter parameter settings.

4.7.4.1 General Settings

1. Idle Interval

Range: 0 to 200ms;

Default: 4us (IEEE STD 802.11a-1999).

Set the idle interval length between frames in the baseband signal.

The idle interval is added to the end of the frames, and filled with zero sample data.

2. System Sample Frequency

Range: 1kHz to 250MHz;

Default: 20MHz (IEEE STD 802.11a-1999).

Set the basic sample frequency of the baseband signal.

The actual sample frequency of the baseband signal equals to the System Sample Frequency multiplies the Oversampling Ratio in Section 3. The actual sample frequency over the device bandwidth limit will result in undefined behaviors.

3. Half Subcarrier Offset

Choice: On | Off ; Default: Off.

Select half subcarrier offset applying to the baseband signal or not.

The transmission quality of signal on the DC subcarrier might be low because of the LO leakage in the transmitting and receiving end. Some communication protocol, like LTE Uplink, apply the

technique to avoid DC subcarriers working, which shifts the frequency spectrum of the modulated signals from the bandwidth center, usually integer multiplies of the half of subcarrier spacing.

If the parameter is set to Off, the parameter "Number of Shifted Half Subcarriers" will be disabled and hidden.

If the parameter is set to On, the parameter "Initial Phase" will be disabled and hidden.

4. Number of Shifted Half Subcarriers

Range: 1 to 16 ; Default: 1.

Set the half subcarrier number of frequency spectrum shifting of the baseband signal.

The parameter will be disabled and hidden, if the parameter "Half Subcarrier Offset" is set to Off.

5. Initial Phase

Range: 0 to 360 degrees ; Default: 0.

Set initial phase of the carrier for the modulated signal.

The parameter will be disabled and hidden, if the parameter "Half Subcarrier Offset" is set to Off.

If the Multicarrier Enabled is set to On, and the parameter "Carrier Phases" is set Random, the parameter will be actually invalid.

4.7.4.2 OFDM Settings

1. FFT Length

Range: 4 to 16384, must be an even number.

Default: 64 (IEEE STD 802.11a-1999).

Set the total subcarrier number of OFDM symbols.

The parameter decides the total subcarrier number of OFDM symbols, but the actual FFT length of the modulation equals to the parameter multiplies the Oversampling Ratio assigned in the Section 3.

The parameter will increase the actual FFT length during the signal generation, too large parameter value will slow down the processing procedure, even result in out-of-memory failure.

The parameter is usually set to the power of 2, or the FFT calculation will be slower.

2. Number of OFDM Symbols

Range: 1 to 2000 ; Default: 64.

Set the total OFDM symbol number in a frame.

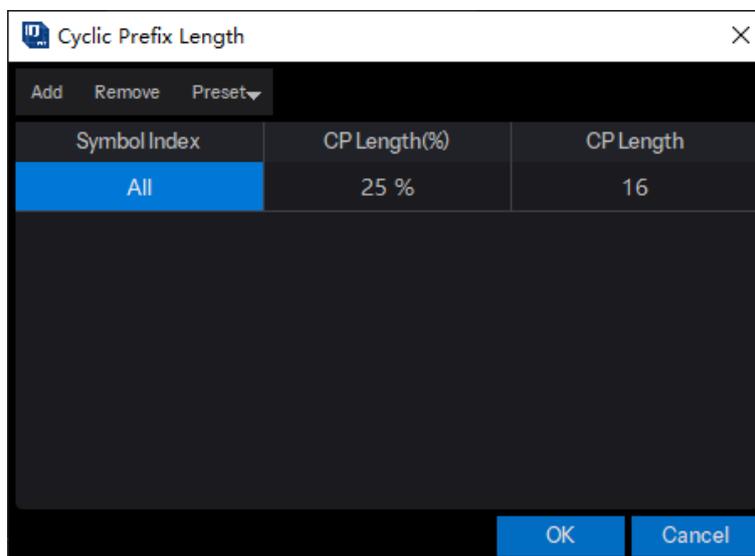
The parameter decides the total symbol number in a frame, and determines the size of the physical resources together with the parameter "FFT Length".

3. Cyclic Prefix Length

Click the "Cyclic Prefix Length" box to open the Cyclic Prefix Length Window, set the cyclic prefix

length according to OFDM symbol grouping.

To express which symbols in a group, the symbol index lists is given according to the method presented in the Section 4.7.6.1. The Cyclic Prefix length is given as the length ratio of the sample point number of CP and origin OFDM symbol, whose range is 0 to 1.



4. Cyclic Suffix Length

Set the cyclic suffix applied to the modulated signal, the way to configure is similar to Cyclic Prefix Length in the Section 3.

5. Guard Lower Subcarriers

Range: 0 to the half of the FFT Length assigned in the Section 1 (included).

Default: 6 (IEEE STD 802.11a-1999).

Set the guard subcarrier number at the lower edge of the bandwidth.

To suppress the effect of the spectrum leakage, the subcarriers close to the edge of the bandwidth might be set to reserved or unused. The parameter indicates the number of the unused subcarriers at the lower edge.

6. Guard Upper Subcarriers

Range: 0 to the half of the FFT Length assigned in the Section 1 (not included).

Default: 5 (IEEE STD 802.11a-1999).

To suppress the effect of the spectrum leakage, the subcarriers close to the edge of the bandwidth might be set to reserved or unused. The parameter indicates the number of the unused subcarriers at the upper edge.

To ensure at least one subcarrier to transmit data, the maximum of the guard upper subcarrier is set to the half of the total subcarrier number minus 1.

7. Subcarrier Spacing

Display the spacing frequency between adjacent subcarriers according to the current settings.

8. Actual Signal Bandwidth

Display the actual bandwidth of data transmission according to the current settings, which equals to System Sample Frequency (in the Section 2) minus the bandwidth of guard subcarriers (in the Section 5 and 6).

9. Power Reference Type

Choice: First Symbol | Preamble Symbol(s) | All Symbol(s) | All Burst Symbol(s);

Default: First Symbol.

Select OFDM symbols to participate the RMS power calculation, the RMS power will be downloaded to the device to adjust the actual output power.

The option "Preamble Symbol(s)" indicates that the RMS power of all symbols used by Preamble resource blocks is set to the reference power.

The option "All Symbol(s)" indicates that frame idle intervals participate the power calculation, and the option "All Burst Symbol(s)" excludes the idle intervals.

4.7.4.3 Spectrum Control

1. Baseband Filter

To suppress the adjacent channel interference, the communication protocol usually regulates the spectrum masks to limit the spectrum leakage. It's a widely used solution to design a filter to achieve the requirement, and apply it to the modulated signals.

The software uses window function method to design lowpass FIR filters automatically, according to assigned filter length, cut-off frequency and window function type, and supports apply the FIR filter to the baseband signals generated.

1) Filter Enabled

Choice: On | Off ; Default: Off.

Set the baseband filter applied to the baseband signals or not.

If the parameter is set to Off, other settings of the baseband filter will be hidden.

2) Filter Type

Choice: Rectangle | Hanning | Flat Top | Blackman;

Default: Blackman.

Set the window function type applied to design the baseband filters.

3) Filter Length

Range: 1 to 2048 ; Default: 32.

Set the length of the baseband filter without account of oversampling.

The actual filter length equals to the parameter multiplies the Oversampling Ratio assigned in the Section 3, which determines the order of the filter and the process speed of the baseband filtering.

4) Filter Cutoff Frequency

Range: 0 to the half of the product of the System Sample Frequency times the Oversampling Ratio.

Default: 10MHz (IEEE STD 802.11a-1999).

Set the cut-off frequency of the baseband lowpass filter.

The cut-off frequency is counts from center frequency (DC) and the filter passband width is twice the cut-off frequency because of spectral symmetry.

The cut-off frequency is usually set larger than the half of the System Sample Frequency, or the valid spectrum data will be filtered and lost.

2. Windowing

The section explains the settings about windowing applied to OFDM baseband signals.

1) Window Beta

Range: 0 to 0.5 ; Default: 0.005.

Set the window function length applied in the signal windowing process.

The length of the single edge of the window function equals to the Window Beta multiplies the actual FFT Length.

2) Windowing Method

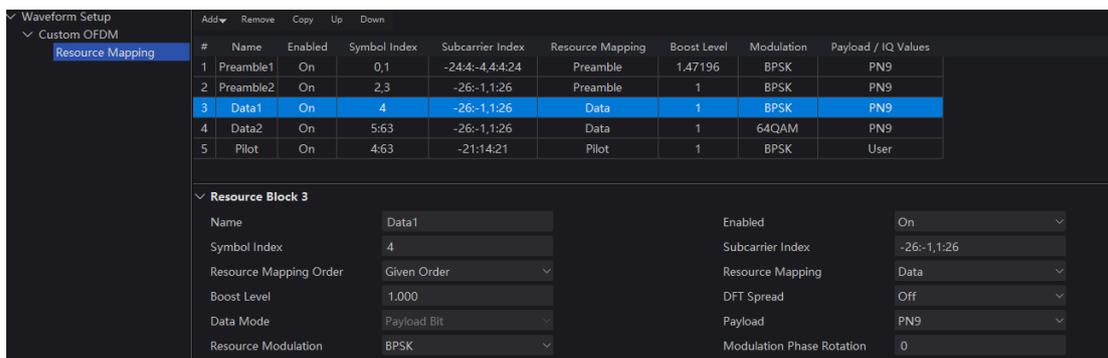
Choice: Centered at Symbol Boundary | Starting at Symbol Boundary

Default: Centered at Symbol Boundary

Set the windowing method applied in the windowing process.

4.7.5 Resource Mapping

The Section explains the settings in the Resource Mapping menu. Press **Resource Mapping** in the left window to enter parameter settings.



4.7.5.1 Resource Block List

To configure the list of resource blocks, use the buttons above the list respectively to:

- Add a new resource block of assigned type at the end of the list.
- Remove the selected resource block.
- Copy the selected resource block and add it at the end of the list.
- Move the selected resource block up one line.
- Move the selected resource block down one line.

The list displays the settings of all resource blocks, and click one to select it and modify the its settings with the edit boxes and buttons below.

4.7.5.2 Name

Set the name of the selected resource block.

4.7.5.3 Enabled

Choice: On | Off ;

Default: Off.

Set the resource block is used in the resource mapping and signal modulation or not.

If a resource block is set to disabled, the resource mapping and signal modulation will skip the resource block, other settings in the resource block will be invalid but reserved.

4.7.5.4 Symbol Index

Set the symbols which the payload of selected resource block should be mapped to.

The Symbol Index should be given as resource groups introduced in the Section 4.7.1.4, and in the format given in the Section 4.7.6.2.

The parameter "Symbol Index" together with the parameter "Subcarrier Index" determines the resource units occupied by selected resource block.

4.7.5.5 Subcarrier Index

Set the subcarriers which the payload of selected resource block should be mapped to.

The Subcarrier Index should be given as resource groups introduced in the Section 4.7.1.4, and in the format given in the Section 4.7.6.2.

The parameter "Symbol Index" together with the parameter "Subcarrier Index" determines the resource units occupied by selected resource block.

4.7.5.6 Resource Mapping Order

Choice: Given Order | Resource Order ;

Default: Given Order.

Set the payload mapping order of selected resource block.

The option "Given Order" indicates that the payload IQ value sequence of the resource block is mapping to physical resources according to the order of resource units given in the parameter "Symbol Index " and "Subcarrier Index".

The option "Resource Order" indicates that the mapping is according to the small-to-large order of the symbol and subcarrier indices of resource units.

Both mapping order is subcarrier-major mapping, meaning filling the subcarriers given in a single symbol first, then fill the subcarriers for next symbols.

4.7.5.7 Resource Mapping

Choice: Preamble | Pilot | Data ;

Set the type of selected resource block.

4.7.5.8 Boost Level

Range: 0.1 to 10 ; Default: 1.0 .

Set the boost level of the payload in selected resource block.

The payload IQ values will be multiplying the Boost Level before mapping to physical resources.

4.7.5.9 DFT Spread

Choice: On | Off ; Default: Off.

Set DFT Spread is enabled or not in selected resource block.

4.7.5.10 Data Mode

Choice: Payload Bit | IQ Values.

Set the payload data mode of selected resource block.

The option "Payload Bit" indicates that the payload IQ values are generated by modulating the payload bit patterns with certain linear digital modulation mode.

The option "IQ Values" indicates that the payload IQ values is directly given in the resource block setting.

4.7.5.11 Payload

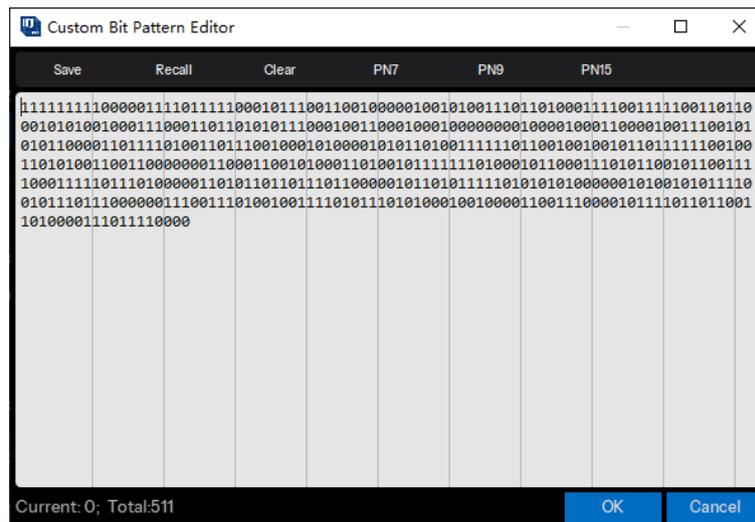
Choice: PN9 | PN15 | PN23 | User ;

Default: PN9.

Set the payload bit pattern type of selected resource block.

PN codes will be generated automatically for following modulation and payload generation, if PN code type is selected. Otherwise, a user-defined bit patterns should be inputted in the Custom Bit Pattern Editor. The Editor will pop up when the option "User" is clicked.

If the parameter "Data Mode" is set to "IQ Values", the parameter will be disabled and hidden.



4.7.5.12 Resource Modulation

Choice: BPSK | QPSK | 8PSK | 16QAM | 32QAM | 64QAM | 128QAM | 256QAM | 512QAM | 1024QAM | 2048QAM | 4096QAM ;

Default: BPSK.

Set the linear digital modulation type is applied to generate payload IQ values from given bit patterns.

If the parameter "Data Mode" is set to "IQ Values", the parameter will be disabled and hidden.

4.7.5.13 Modulation Phase Rotation

Range: 0 to 360 degrees

Default: 0.

Set rotation phase of the modulated IQ values.

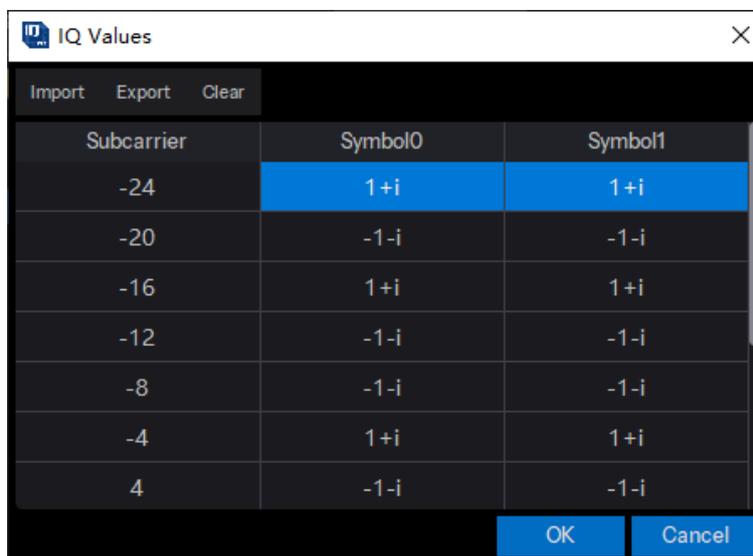
The software will rotate the modulated IQ values before payload mapping to physical resources, if the parameter "Data Mode" is set to "Payload Bit".

If the parameter "Data Mode" is set to "IQ Values", the parameter will be disabled and hidden.

4.7.5.14 IQ Values

Click the "IQ Values" box to open the IQ Values Window, set payload IQ value sequence of selected resource block directly.

If the parameter "Data Mode" is set to "Payload Bit", the parameter will be disabled and hidden.



4.7.6 Appendix

4.7.6.1 Integer Array Expressions

Integer arrays are given as formatted expressions, which is used for assigning symbol index lists and subcarrier index lists of resource groups, or symbols which cyclic prefix / suffix is applied.

The syntax format of formatted expressions supported are as follow:

1. A single integer value, e.g., 0, 1, 2.
2. Two integer values separated by a colon (:), indicating all integer values between the two numbers, including the numbers directly given in the expressions. e.g., -3:2 means -3, -2, -1, 0, 1, 2.
3. Three integer values separated by colons (:), like A:B:C (A, B, C are integer values), indicating the integer values at intervals of the value C from the value A to the value B. e.g., -4:3:8 means -4, -1, 2, 5, 8.

The value B should have the same sign as the difference between C and A (C-A), or the expressions is considered illegal.

The value A is guaranteed to be included in the integer array. The value C will NOT be included if the difference between C and A (C-A) is not divisible by the value B.

4. Five integer values separated by colons (:), like A:B:C:D:E (A, B, C, D are integer values, E is 0 or 1).

The expression means the combination of certain numbers of integer arrays, and the number of integer arrays is assigned to be the value D.

The initial integer array is the same as the one parsed from A:B:C, the following array are generated from every element in the former array increment by 1.

The value A must be larger than the value C. The value B and the value D must be positive. The expressions violate the rules will be considered as illegal.

The value E indicates the integer arrays to skip zero or not. It can be omitted, like A:B:C:D. The value E is considered as 0 by default in this case.

For example, to parse the formatted expression -6:3:6:2:1, generate the initial array -6,-3, 0, 3, 6; Then the number of arrays is assigned to be 2, the following array is generated as -5,-2, 1, 4, 7; The skip zero flag is assigned to be 1, so skip zero and get array -6, -3, 1, 4, 7 and array -5, -2, 2, 5, 8; At last, combine the arrays to get indicated integer array -6, -5, -3, -2, 1, 2, 4, 5, 7, 8.

Two or more formatted expressions separated by a comma (,) indicate a single integer array, which includes all elements of integer arrays parsed from expressions.

4.7.6.2 Resource Group Expressions

To show resource units occupied by resource blocks, resource group is introduced, and is given by symbol groups and subcarrier groups respectively. To get more information about resource groups, refer to Section 4.7.1.4.

Every resource group is assigned an ID, symbol / subcarrier groups with the same ID will combine into the resource group. The expressions of symbol / subcarrier groups should be separated by commas (,).

The syntax format of symbol / subcarrier groups is as follow:

{n|xxxxx}

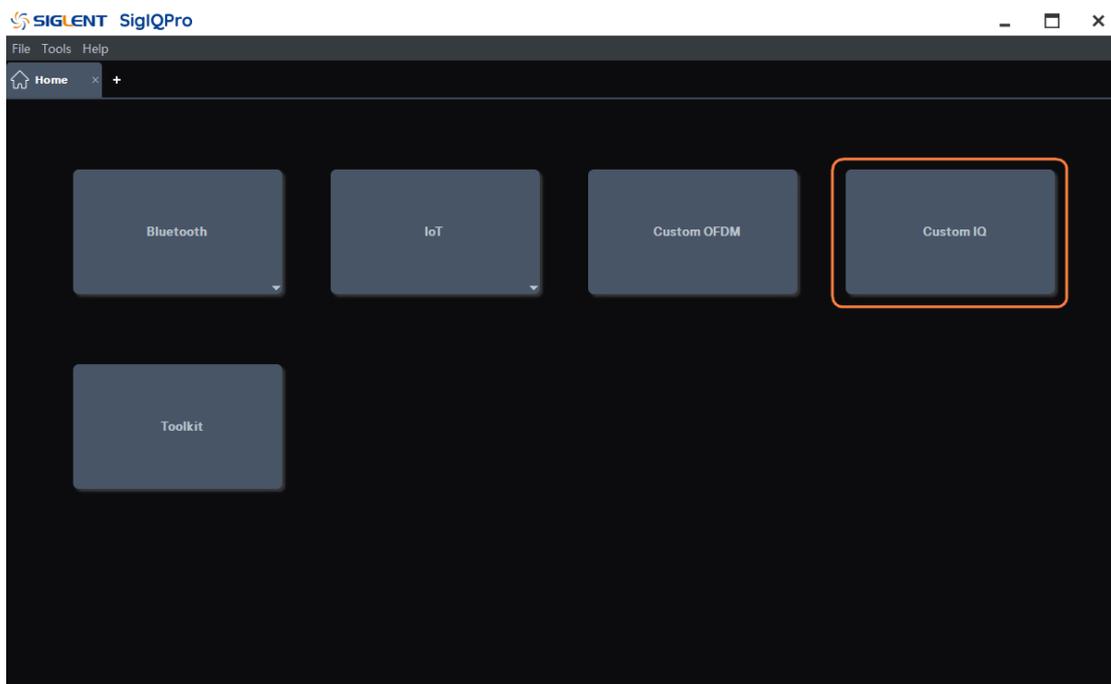
where non-negative integer value n is the group ID, xxxxx is the formatted expressions to indicate symbol / subcarrier index lists, whose syntax format is given in Section 4.7.6.1.

The group ID can be omitted, like {xxxxx} or xxxxx, which is considered as 0 in this case, and the resource group is considered as a global group.

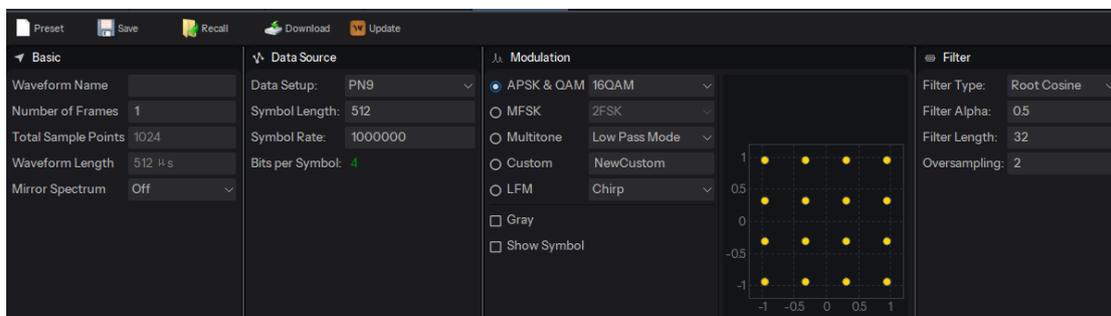
It's allowed to give a single symbol / subcarrier group in two or more expressions separated by commas (,) with the same group ID.

4.8 Custom IQ

Custom IQ includes Digital modulation, Custom modulation, Multitone and LFM sweep. You can click **Custom IQ** on the homepage to enter the Custom IQ setting interface.



Waveform setup panel is used for setting parameters of a waveform, such as Data Source, Modulation and Filter.



4.8.1 Basic

4.8.1.1 Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

4.8.1.2 Number of Frames

Range: 1 to 300 ; Default: 1.

Set the number of frames included in the generated waveform.

4.8.1.3 Total Sample Points

Display the generated waveform length (number of points).

Note: This parameter is displayed only and cannot be edited.

4.8.1.4 Waveform Length

Display the generated waveform length (in second).

Note: This parameter is displayed only and cannot be edited.

4.8.1.5 Mirror Spectrum

Choice: On | Off ; Default: Off.

Select setting the spectrum of the baseband signal into mirror symmetry or not.

The mirror spectrum is implemented by inverting the Q path of the baseband IQ signal.

4.8.2 Data Source

Data Source panel sets parameters for symbol data that to be modulated.

4.8.2.1 Data Setup

Select a data source type for modulation.

Choices: PN7 | PN9 | PN15 | PN23 | PN31 | User File | Custom Bit Pattern ;

Default: PN9.

- PN7 | PN9 | PN15 | PN23 | PN31:

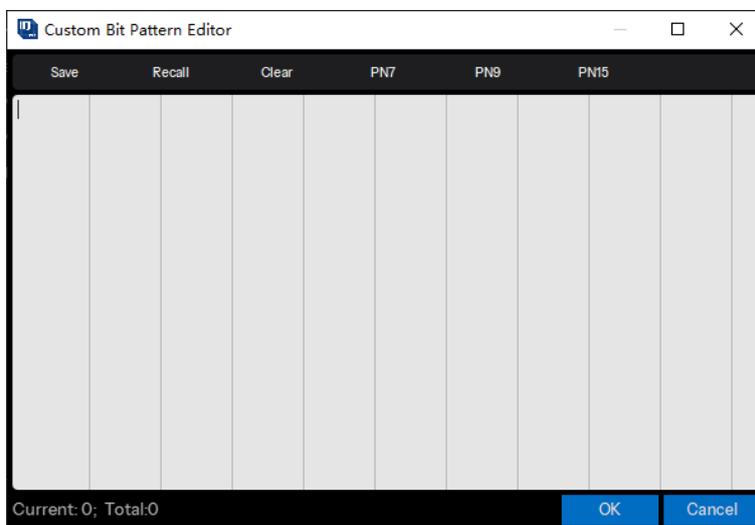
When selecting “PN7 | PN9 | PN15 | PN23 | PN31” as data source type, software generates data source bit automatically.

- User File:

When selecting “User File” as data source type, a file selection dialog box pops up for you to select a TXT (*.txt) file as input data bits. In the user data file, only 0 and 1 is acceptable. If there is any illegal value in it, an error message box will pop up.

- Custom Bit Pattern:

When selecting “Custom Bit Pattern” as data source type, a Pattern Editor window opens for data bits editing. You can input 0|1 in the input box manually or insert PN7|PN9|PN15 data bits by corresponding button, and you can also save the data to a new file and recall data from an existing file. Use “Clear” button to clear the data edit box.



4.8.2.2 Symbol Length

Set the length of modulated symbols.

Range: 100 to 100000;

Default: 512.

4.8.2.3 Symbol Rate

Set the symbol rate (symbols per second) of the waveform.

Range: 250 to (8e+09/Oversampling) Symbol/s;

Default: 1000000 Symbol/s.

4.8.2.4 Bits Per Symbol

Display the number of bits contained in one modulated symbol. It is read-only, not settable.

4.8.3 Modulation

Modulation panel sets parameters for user selected modulation type.

Choices: APSK & QAM | MFSK | Multitone | Custom | LFM;

Default: APSK & QAM.

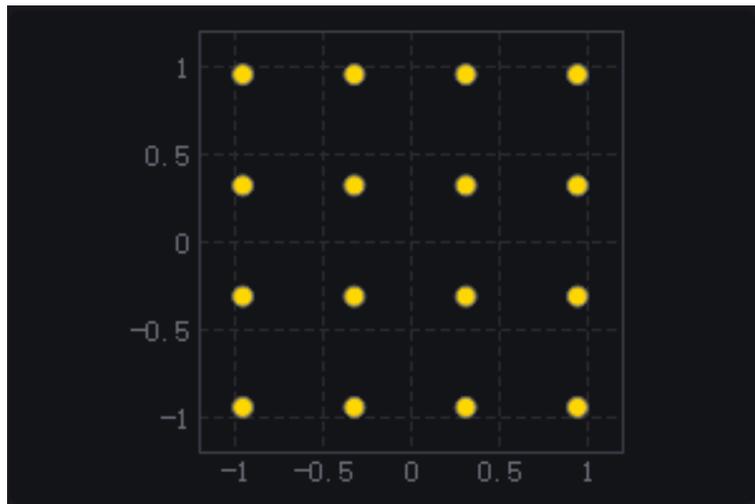
4.8.3.1 APSK & QAM

Select a type in APSK & QAM category for modulation.

Choices: 2ASK | PR-ASK | BPSK | OQPSK | QPSK | 8PSK | DBPSK | DQPSK | PI/4-DQPSK | D8PSK | PI/8-D8PSK | 16APSK | 32APSK | 8QAM | 16QAM | 32QAM | 64QAM | 128QAM | 256QAM | 512QAM | 1024QAM | 2048QAM | 4096QAM;

Default: 16QAM.

After a modulation type is selected, the constellation of current modulation is displayed on right side of the panel:



You can double click on the constellation display to show a zoomed in window of the constellation.

Gray

Turn ON or OFF the Gray code for the constellation data.

Default: OFF.

Show Symbol

Turn ON or OFF the Symbol display of the constellation diagram.

Default: OFF.

4.8.3.2 MFSK

Select a type in MFSK category for modulation.

Choices: 2FSK | 4FSK | 8FSK | 16FSK | MSK;

Default: 2FSK.

● 2FSK | 4FSK | 8FSK | 16FSK

When selecting 2FSK | 4FSK | 8FSK | 16FSK as current modulation type, FSK Deviation setting is displayed on the bottom of the panel.

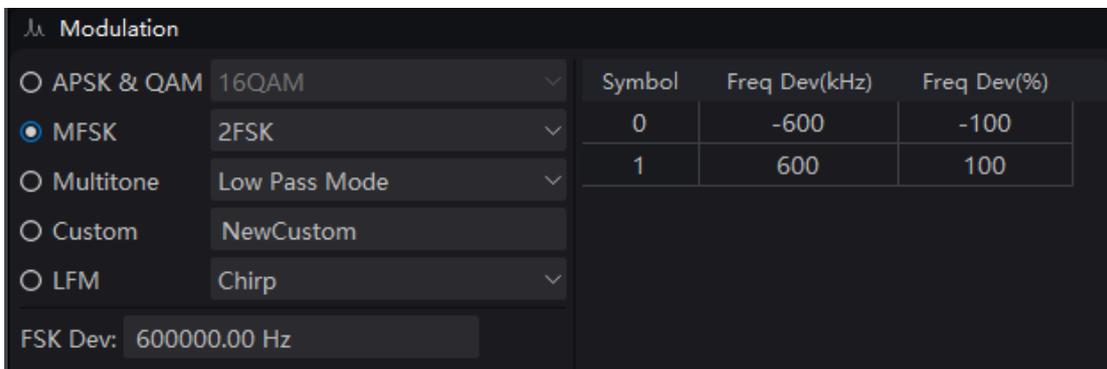
FSK Dev (Hz)

Set frequency deviation for FSK modulation in Hz.

Range: 0 to (0.8 * Symbol Rate * Oversampling) Hz;

Default: 600000 Hz.

The Symbol and FSK deviation table is displayed on the right side of the panel:

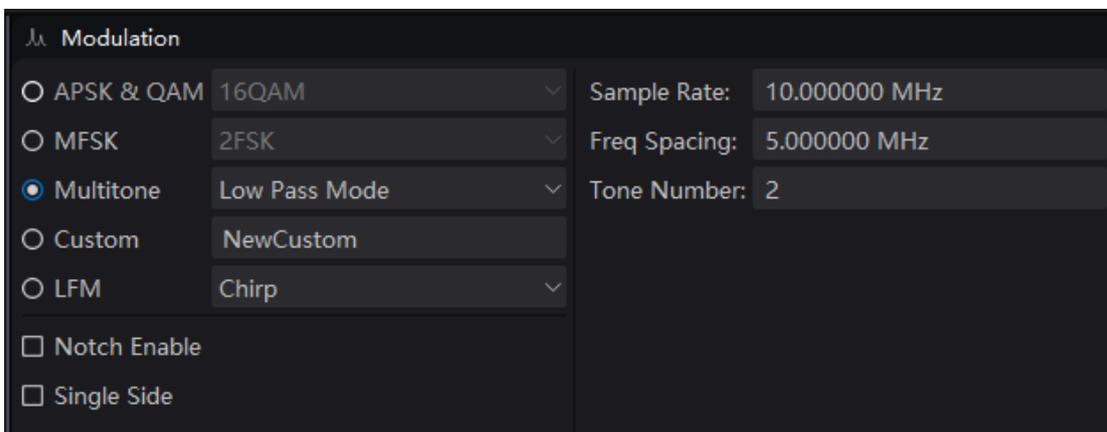


- **MSK**

When selecting MSK as current modulation type, Filter type can only be selected as Gaussian.

4.8.3.3 Multitone

Select Multitone as current modulation type. Filter setting panel is invisible under multitone modulation. The settings for Multitone modulation are displayed on the right side of the panel:



1) Low Pass Mode

- **Sample Rate**

Set sample rate of multitone modulation in MHz.

Range: 500 Hz to 4000 MHz;

Default: 10 MHz.

- **Freq Spacing**

Set frequency spacing of multitone modulation in MHz.

Range: 0 to (Sample Rate / 1.28) MHz;

Default: 5 MHz.

- **Tone Number**

Set tones number of multitone modulation.

Range: 1 to 10000;

Default: 2.

2) **Band Mode**

- **Sample Rate**

Set sample rate of multitone modulation in MHz.

Range: 500 Hz to 4000 MHz;

Default: 10 MHz.

- **Start Freq**

Set start frequency of multitone modulation in MHz.

Range: 0 to (Sample Rate / 2.56) MHz;

Default: 2 MHz.

- **Stop Freq**

Set frequency spacing of multitone modulation in MHz.

Range: (start freq) MHz to (Sample Rate / 2.56) MHz;

Default: 2 MHz.

- **Tone Number**

Set tones number of multitone modulation.

Range: 1 to 10000;

Default: 2.

3) **Notch Enable**

Turn ON or OFF the multitone notch.

Default: OFF.

- **Notch Start**

Set notch start of multitone modulation in MHz.

Range: 0 to (Sample Rate / 2) MHz; Default: 0 MHz.

● **Notch Stop**

Set notch stop of multitone modulation in MHz.

Range: (notch start) to (Sample Rate / 2) MHz; Default: 0 MHz.

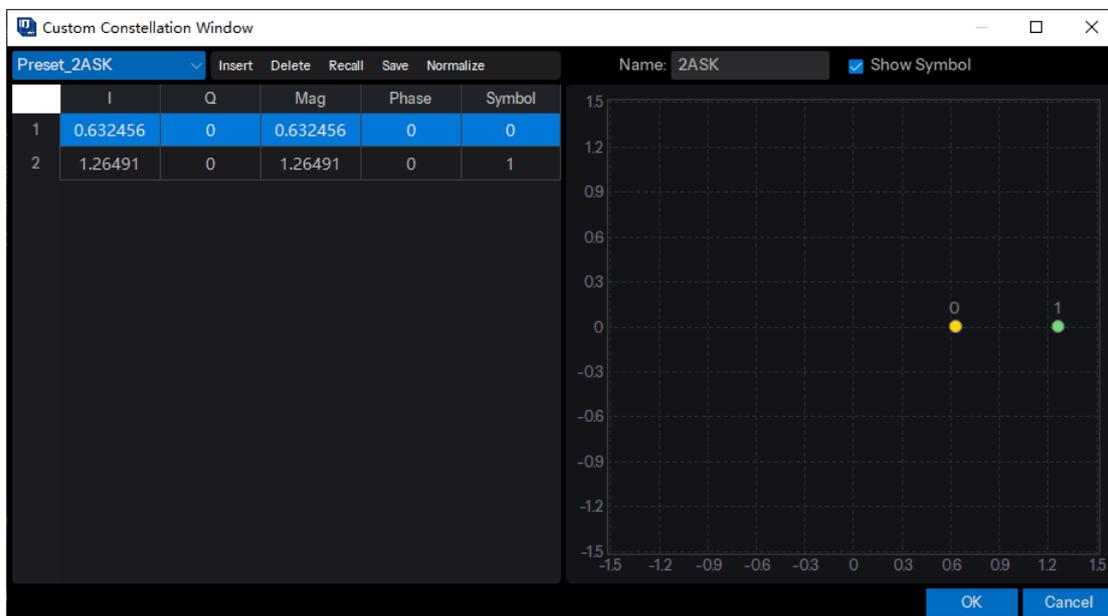
4) Single Side

Turn ON or OFF single side modulation for multitone.

Default: OFF.

4.8.3.4 Custom

Set a custom constellation for modulation. After selecting Custom modulation type, a custom constellation editing window is displayed:



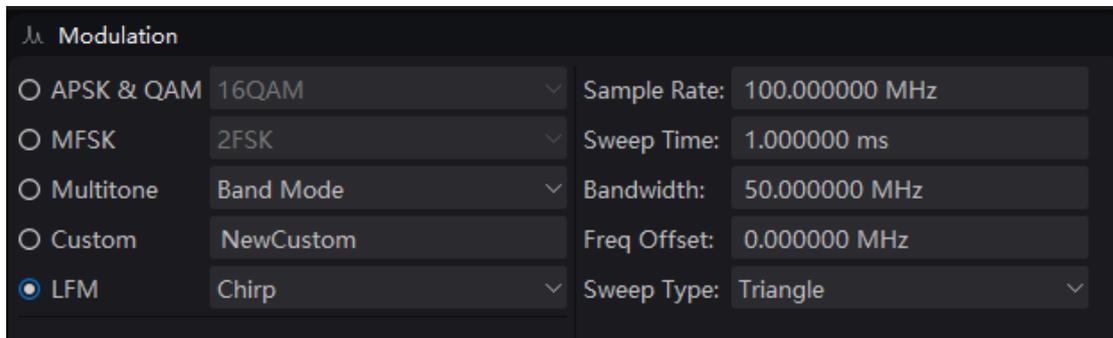
In the custom constellation editing window, you can preset the constellation data to a known modulation type first by pressing **Preset_2ASK** buttons, then you can insert or delete constellation points and edit the IQ data for each constellation point manually. You can also recall constellation data from an existing file and save the edited constellation data to a new file. "Normalize" button is used to normalize all constellation data for RMS value = 1.

On the right side of the window, it shows the constellation display of current editing. You can input a name for the constellation, this name will be displayed beside the "Custom" modulation item after you click "OK" button. You can also turn ON or OFF symbol display on the constellation display by clicking "Show Symbol" button.

Note: When editing the constellation points, the number of points must be a value of power of 2 and the Symbol values cannot be duplicated, otherwise there will be error message when you click "OK" button.

4.8.3.5 LFM

Select LFM as current modulation type. Filter setting panel is invisible under LFM modulation. The settings for LFM modulation are displayed on the right side of the panel:



1) Chirp

Single segment waveform.

- **Sample Rate**

Set sample rate in MHz.

Range: 500 Hz to 12000 MHz; Default: 100 MHz.

- **Sweep Time**

Set sweep time in ms.

Range: 10 ns to 1s; Default: 1 ms.

- **Bandwidth**

Set sweep bandwidth of LFM modulation in MHz.

Range: 100 Hz to (Sample Rate) MHz; Default: 50 MHz.

- **Freq Offset**

Set freq offset of LFM modulation in MHz.

Range: $(-\text{bandwidth} / 2)$ MHz to $(\text{bandwidth} / 2)$ MHz;

Default: 50 MHz.

- **Sweep Type**

Choices: Triangle | Up | Down;

Default: Triangle.

2) Customized Chirp

Multi-segment waveform.

- **Sample Rate**

Set sample rate of LFM modulation in MHz.

Range: 500 Hz to 12000 MHz;

Default: 100 MHz.

- **Segment**

Enter the number of chirp segments.

Range: 1 to 100; Default: 3.

- **Total Sweep Time**

Display the total sweep time for all the chirp segments.

- **Frequency Start**

Enter the start frequency for current chirp segment.

Range: $(-\text{Sample Rate} / 2)$ MHz to $(\text{Sample Rate} / 2)$ MHz.

- **Frequency End**

Enter the end frequency for current chirp segment.

Range: $(-\text{Sample Rate} / 2)$ MHz to $(\text{Sample Rate} / 2)$ MHz.

- **Duration**

Enter the duration for current chirp segment.

Range: 10 ns to 1 s

4.8.4 Filter

Set the filter parameters for current modulation.

4.8.4.1 Filter Type

Set filter type for current modulation.

Choices: None | Gaussian | RaisedCosine | RootCosine | HalfSine;

Default: Gaussian for MSK and RootCosine for all other modulation types.

Note: For MSK modulation, only Gaussian filter type is supported. For HalfSine filter, only OQPSK modulation type is supported.

4.8.4.2 Filter Alpha/BT

Set the Alpha factor of the filter (BT of Gaussian filter).

Alpha Range: 0.01 ~ 1;

BT Range: 0.1 ~ 5;

Default: 0.5 .

4.8.4.3 Filter Length

Set length of filter in symbols.

Range: 1 ~ min (Symbol Length, 512) ;

Default: 32.

4.8.4.4 Oversampling

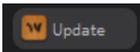
Set the oversampling ratio of the waveform. The waveform Sample Rate is determined based on Symbol Rate and Oversampling ratio.

Range: 2 - 32;

Default: 2.

Notes: For OQPSK modulation, the oversampling must be even. For HalfSine filter, the oversampling must be more than 8.

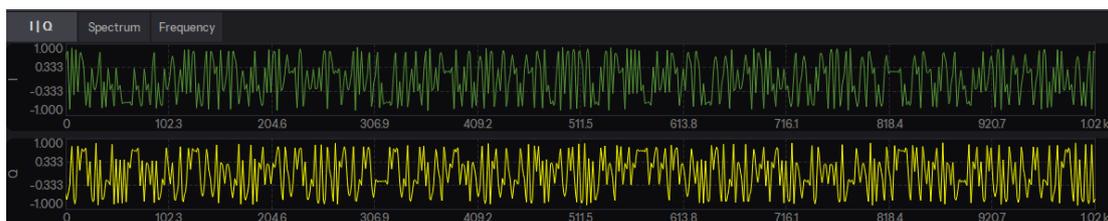
4.8.5 Waveform Display

After setting all parameters for modulation and click the  button on the top of the window, the modulated waveform is displayed on the lower half of the main window. You can click "Spectrum" tab to display the Frequency domain waveform, click "I | Q" tab to display the Time domain waveform alternatively, click "Frequency" tab to display the Frequency waveform.

When the Mouse is on waveform display, you can use the scroll button of your Mouse to zoom in or zoom out the waveform plots. You can also click "Update" button to restore the default display of the plots.

4.8.5.1 IQ Waveform Display

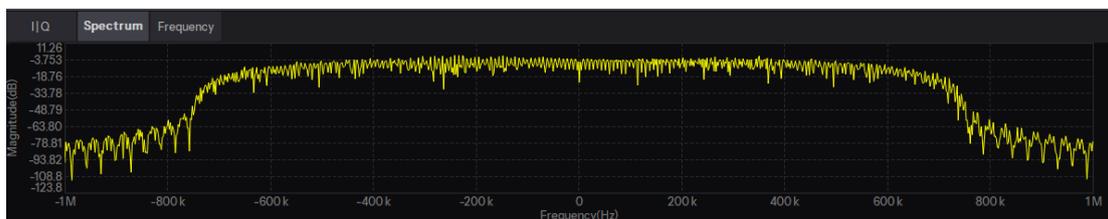
After clicking “I | Q” tab, the time domain plot of modulated IQ data is displayed.



The I/Q data plots are displayed separately in two graphs. The horizontal coordinate shows the symbol values and the vertical coordinate shows the amplitude values of I/Q data.

4.8.5.2 FFT Spectrum Display

After clicking “Spectrum” tab, the frequency domain plot of modulated IQ data by FFT is displayed.



The horizontal coordinate shows the frequency values in Hz and the vertical coordinate shows the Magnitude values in dB.

4.8.5.3 Frequency Diagram

After clicking “Frequency” tab, the frequency diagram is displayed.

This diagram is displayed only when the modulation mode is LFM.

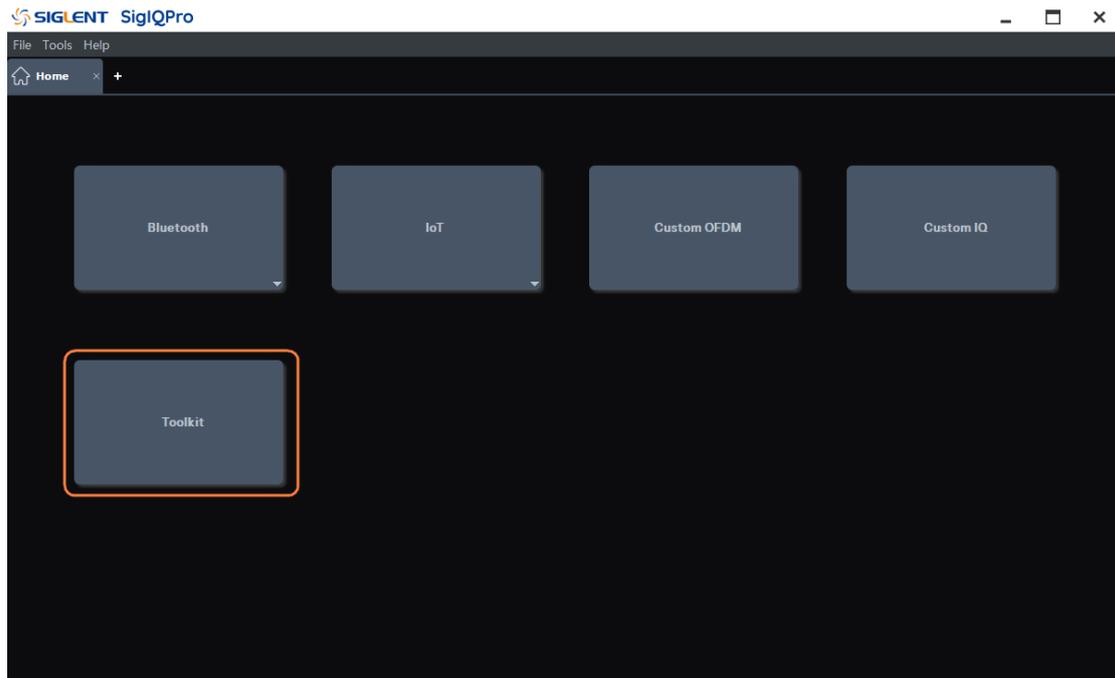


Information such as sweep time, sweep frequency and sweep bandwidth are clearly displayed in the frequency plot.

4.9 Toolkit

Toolkit is a file conversion tool, which can convert MAT files generated by MATLAB or ASCII files such as TXT files, DAT files or CSV files into files that can be played by SIGLENT instruments. To convert the file format, you need to import the file in "Waveform Import", fill in the information about the exported file in " Waveform Download", and click "Download" in the toolbar to download the target file.

You can click **Toolkit** on the homepage to enter the Toolkit setting interface.



4.9.1 Waveform Import

This function enables you to import a waveform file, with a specific file format, from the PC.

4.9.1.1 Source File Type

Use the drop-down menu to select the source file type.

Properties are displayed. Select one of the file types to navigate to that topic to view the associated waveform properties. MAT-File 5 and TXT/CSV/DAT are supported.

1. MAT-File 5

This format is currently used by MATLAB versions 5, 6, 6.5 and 7.

Mat-File 5 Details and Code Example

The MAT file can contain an I array of data, a Q array of data. The array variables are named by the person saving the data.

- I and Q are two separate arrays. The arrays must be the same size.

```
iData = 1:10;           % 10 I data points
qData = iData;         % 10 Q data points
save('mydata', 'iData', 'qData'); % default format is .mat
```

- I, Q data can be saved as any numeric type supported by MATLAB:

```
double precision floating point values -- 8 bytes per sample;
single precision floating point values -- 4 bytes per sample;
int32( ) -- 4 bytes per sample;
int16( ) -- 2 bytes per sample;
and so on.
```

- The application will only recognize numeric types and will discard any variable that is contained in a structure, cell or object.

For example, if the data is placed in a structure and then stored:

```
MyData = struct('I', iData, 'Q', qData);
save 'myfile' MyData
```

The application will not be able to discover I, Q under this structure.

2. ASCII /CSV/DAT

The ASCII / CSV / DAT file must contain I and Q data, and may also include marker data. The import function searches for markers, so it must know how many markers the file contains.

ASCII Code Example

This is an example of ASCII code from a single file.

```
I1 Q1
I2 Q2
I3 Q3
```

4.9.1.2 Source File

To select the source file:

Step1. Click the Source File box to open a dialog window.

Step2. Navigate to the desired file.

Waveform IQ data will finally be transformed into format of 4 bytes per sample to play on signal generator. Hence, Int16 format with 32767 scale is recommended for source file.

4.9.1.3 I Data

This parameter takes effect only when Source File Type is set to MAT-File 5.

The drop-down list enables you to select an I data array from the imported waveform file.

4.9.1.4 Q data

This parameter takes effect only when Source File Type is set to MAT-File 5.

The drop-down list enables you to select a Q data array from the imported waveform file.

4.9.1.5 Use Separate Q File

This parameter takes effect only when Source File Type is set to TXT/CSV/DAT.

Use the drop-down menu to enable or disable the ability to use a separate file for Q data.

If “Yes” is selected, then only I data from the Source file is read.

4.9.1.6 Q Source File

This parameter takes effect only when Source File Type is set to TXT/CSV/DAT.

To select the source file:

Step1. Click the Q Source File box to open a dialog window.

Step2. Navigate to the desired file.

4.9.1.7 Data Type

This parameter takes effect only when Source File Type is set to TXT/CSV/DAT.

Choices: Decimal | Hexadecimal;

Default: Decimal.

Use the drop-down menu to select data type.

4.9.1.8 Big / Little Endian

This parameter takes effect only when Source File Type is set to TXT/CSV/DAT and when the Data Type is set to hexadecimal.

Choices: Big Endian | Little Endian;

Default: Big Endian.

Use the drop-down menu to select big or little endian for HEX data.

Note: When Little Endian is selected, only 2-byte hexadecimal numbers can be parsed.

4.9.1.9 Signed / Unsigned Number

This parameter takes effect only when Source File Type is set to TXT/CSV/DAT and when the Data Type is set to hexadecimal.

Choices: Signed | Unsigned;

Default: Signed.

Use the drop-down menu to select signed or unsigned type for HEX data.

4.9.1.10 Swap IQ

This parameter takes effect only when Source File Type is set to TXT/CSV/DAT.

Choices: Yes | No;

Default: No.

Use the drop-down menu to set the swap IQ flag. If it is set to “Yes”, IQ data will be swapped for waveform generation.

4.9.1.11 Number of Points

Displays the number of points defined by the data files in the selected waveform. Read-only.

4.9.1.12 Sample Rate

Range: 100.0 Hz to 200.0 MHz;

Default: 100.00 MHz.

Enter the waveform sample rate. Instrument Sample Clock is coupled with waveform Sample Rate and Oversampling Ratio.

Sample Clock = Sample Rate * Oversampling Ratio.

4.9.2 Waveform Download

4.9.2.1 Waveform Name

When you download the waveform, the name you defined here will be displayed on the signal generator, if you do not define it, the signal generator will automatically generate a name for the waveform.

4.9.2.2 Mirror Spectrum

Use the drop-down menu to control the Mirror Spectrum state. This feature inverts the Q channel, resulting in a mirrored spectrum. In some systems, as a signal propagates normally through the

up-conversion process, the signal spectrum may be inverted. Use this feature to convert the signal back to a non-mirrored spectrum.

4.9.2.3 Oversampling Ratio

Range: 1 - 10 ; Default: 1.

When Oversampling Ratio is set to value other than 1, waveform is re-sampled. A larger Oversampling Ratio results in using more waveform memory. So, set it to 1 if re-sampling is not required.

Instrument Sample Clock is coupled with waveform Sample Rate and Oversampling Ratio.

Sample Clock = Sample Rate * Oversampling Ratio.

5 Troubleshooting

If there is an exception when SigIQPro downloads waveforms to SIGLENT signal source or when SIGLENT signal source plays the downloaded waveform, please first check whether there are the following problems.

1. SigIQPro prompts the download failed

If SigIQPro prompts that the download failed, please check whether the connection between SigIQPro and SIGLENT signal source is normal.

2. SigIQPro prompts the download is successful, but the SIGLENT signal source does not receive the waveform

- Check whether the software version is correct
If you have installed an old software version, please update to the correct version.
- Check if the correct options are installed
If the correct option has not been installed and the trial times of the option has been 0, the waveform will not be downloaded to the signal generator. Please install the correct option.
For more information, please refer to “Hardware Requirements”.

3. The waveform download is successful, but there is an exception when playing the waveform

- Check the waveform sample rate
If waveform sample rate * oversampling ratio exceeds the valid range of instrument sample clock, the downloaded waveform may not be played correctly.
- Check the waveform points
If the number of waveform points exceeds the valid range of the number of instrument sampling points, the downloaded waveform may not be played correctly.
In the above two situations, SigIQPro and SIGLENT signal sources will have prompt messages, please check carefully.

If the problem still remains, please contact **SIGLENT** and provide the details. Thank you!

6 Service and Support

6.1 Service Summary

SIGLENT warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of three years (accessories for a period of one year) from the date of shipment from an authorized Siglent distributor. If the product proves defective within the respective period, **SIGLENT** will provide repair or replacement as described in the complete warranty statement.

To arrange for service or obtain a copy of the complete warranty statement, please contact your nearest Siglent sales and service office. Except as provided in this summary or the applicable warranty statement, **SIGLENT** makes no warranty of any kind, express or implied, including without limitation the implied warranties of merchantability and fitness for a particular purpose. In no event shall **SIGLENT** be liable for indirect, special or consequential damages.

6.2 Contact Us

China:

SIGLENT TECHNOLOGIES CO., LTD.

Add: Bldg. No.4 & No.5, Antongda Industrial Zone, 3rd Liuxian Road, Bao'an District, Shenzhen, 518101, China.

Tel: + 86 755 3661 7876

Fax: + 86 755 3359 1582

Email: sales@siglent.com;

Website: <http://www.siglent.com/ens/>

USA:

SIGLENT Technologies America, Inc.

6557 Cochran Rd Solon, Ohio 44139

Tel: 440-398-5800

Toll Free: 877-515-5551

Fax: 440-399-1211

Email: info@siglent.com

Website: www.siglentamerica.com

Europe:

SIGLENT TECHNOLOGIES EUROPE GmbH

ADD: Liebigstrasse 2-20, Gebaeude 14, 22113 Hamburg Germany

Tel: +49(0)-819-95946

Fax: +49(0)-819-95947

Email: info-eu@siglent.com

Website: www.siglenteu.com



About SIGLENT

SIGLENT is an international high-tech company, concentrating on R&D, sales, production and services of electronic test & measurement instruments.

SIGLENT first began developing digital oscilloscopes independently in 2002. After more than a decade of continuous development, SIGLENT has extended its product line to include digital oscilloscopes, isolated handheld oscilloscopes, function/arbitrary waveform generators, RF/MW signal generators, spectrum analyzers, vector network analyzers, digital multimeters, DC power supplies, electronic loads and other general purpose test instrumentation. Since its first oscilloscope was launched in 2005, SIGLENT has become the fastest growing manufacturer of digital oscilloscopes. We firmly believe that today SIGLENT is the best value in electronic test & measurement.

Headquarters:

SIGLENT Technologies Co., Ltd
Add: Bldg No.4 & No.5, Antongda Industrial
Zone, 3rd Liuxian Road, Bao'an District,
Shenzhen, 518101, China
Tel: + 86 755 3688 7876
Fax: + 86 755 3359 1582
Email: sales@siglent.com
Website: int.siglent.com

North America:

SIGLENT Technologies America, Inc
6557 Cochran Rd Solon, Ohio 44139
Tel: 440-398-5800
Toll Free: 877-515-5551
Fax: 440-399-1211
Email: info@siglentna.com
Website: www.siglentna.com

Europe:

SIGLENT Technologies Germany GmbH
Add: Staetzlinger Str. 70
86165 Augsburg, Germany
Tel: +49(0)-821-666 0 111 0
Fax: +49(0)-821-666 0 111 22
Email: info-eu@siglent.com
Website: www.siglenteu.com

Follow us on
Facebook: SiglentTech

