V2.6.4.2

07/09/2026

# SGStudio User Guide

HAROGIC

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# 1. Version Management

Updated Description Sheet

| Version | Description | Date |
|---|---|---|
| **V2.6.4.2** | 1. Added: Default Software Storage Paths section<br>2. Added: Appendix describing the IQ recording file format | 07/09/2026 |
| **V2.6.4** | 1. Removed: Fan Control section<br>2. Added: Phase Modulation section<br>3. Added: Compact Mode (Minibar) section<br>4. Added: Frequency and Power Settings section<br>5. Added: Medium-Power Output (Option 10) section<br>6. Removed: Default update method in the Software and Firmware Update section | 16/07/2026 |
| **V2.6.2** | 1. Removed: Streaming Mode section<br>2. Refactored: Introduction to Operating Modes section<br>3. Added: Quick Waveform section<br>4. Added: Multitone section | 16/06/2026 |
| **V2.5.4** | 1. Added: Connect ETH Device section<br>2. Added: External Reference Clock Input section<br>3. Added: Reference Clock Output section<br>4. Added: Trigger Input section<br>5. Added: Trigger Output section<br>6. Added: RF Hardware section<br>7. Added: GNSS Usage section<br>8. Refactored: RF and Modulation Control section<br>9. Added: Software and Firmware Update section | 09/05/2026 |
| **V1.1.5** | 1. Initial Version | 19/03/2026 |

# 2. Preparation

## 2.1 Software Compatibility

SGStudio supports the full range of SG, PG, and T Series RF transmitters. For information on using T Series RF transmitters, please refer first to the *T1000 Series RF Transmitter User Guide*.

## 2.2 Operating Environment Requirements

The operating environment requirements for SGStudio are listed in the following table:

The table only lists the basic recommended configurations. For systems below the recommended specifications, please refer to the actual test results.

Table 1 System Operating Environment Requirements

| | |
|---|---|
| **Operating System** | Windows 11/10/8/7, dependent on VS2019 C++ redistributables |
| **Architecture** | Windows: x64<br>Linux: x64, AArch64 |
| **Processor** | Intel i3 or above |
| **Memory** | 8 GB. If generating digitally modulated waveforms with PN > 15, 16 GB RAM is recommended to improve performance and processing capability |
| **Storage** | If outputting 62.5 MHz sample rate signals in streaming mode, the hard drive must support a sustained read/write speed greater than 250 MB/s |
| **Data Interface** | USB 2.0 or USB 3.0 (USB 3.0 recommended)<br>Streaming mode is limited by the bandwidth of the data interface |
| **Display Resolution** | At least 1280 × 800 pixels |
| **Other** | Some antivirus software may prevent the system from operating normally |

## 2.3 Default Software Storage Paths

**PG Series instruments and the embedded host of T Series RF transmitters:** The software is installed in the "/software" directory on the instrument by default.

**SG Series instruments and the host PC for T Series RF transmitters:** The installation directory is specified by the user on the PC.

Under the software installation directory, the "data", "images", and "QuickWaveFormData" folders are used to store the following data:

- data folder: Baseband IQ data and configuration files
- images folder: Quick screenshots
- QuickWaveFormData folder: Preloaded waveform files in .wav format

Except for quick screenshots, the storage paths for other recorded files can be customized.

# 3. Introduction to Operating Modes

The system supports multiple signal generation modes, including CW, AM, FM, PM, pulse, digital ramp sweep, Gaussian white noise, digital modulation, DSSS, OFDM, playback, multitone, streaming mode, and quick waveform generation. This chapter describes in detail the configuration methods and underlying signal generation mechanisms of these operating modes.

## 3.1 Overview of Operating Modes

In actual hardware operation, the above modes are primarily based on three underlying operating methods: CW, onboard memory playback, and high-speed real-time streaming. Please select the appropriate operating mode according to your test requirements.

Table 2 Underlying Operating Methods

| Operating Method | Corresponding Software Button/Mode | Description |
|---|---|---|
| **CW Mode** | RF On Only | The hardware directly and continuously transmits a CW signal without occupying waveform memory. |
| **Playback Mode** | AM, FM, PM, Pulse, Digital Ramp Sweep, AWGN, DSSS, OFDM, Digital Modulation, Playback, Quick Wave, Multitone | **The core operating mode of the system.** It supports downloading software-generated waveforms or user-imported IQ data blocks to the instrument's onboard storage in a single operation. **The maximum supported IQ data size depends on the onboard storage capacity.** Once the data is loaded, playback is triggered and controlled by the hardware in either single or continuous loop mode. |
| **Streaming Mode** | Streaming Mode | Bypasses the onboard storage capacity limitation. Real-time generated IQ data streams are continuously and dynamically transferred to the transmission engine through a high-speed bus, making it suitable for ultra-long-duration signal simulation. |

## 3.2 CW Mode

When RF output is enabled and modulation is disabled in the software interface, the device enters CW mode. In this mode, a single-tone carrier signal can be generated without loading any baseband waveform file.

## 3.3 Playback Mode

This mode adopts an onboard memory preloaded playback mechanism. When the signal type or parameters are modified, the host software immediately calculates and generates the corresponding IQ data and downloads the complete waveform into the instrument's internal memory. Since the waveform data is preloaded and resides entirely within the hardware, transmission does not rely on real-time bus transfer, enabling stable output at the instrument's maximum supported analog bandwidth.

### 3.3.1 Amplitude Modulation

In AM mode, the instrument modulates the amplitude of a high-frequency carrier using a low-frequency baseband signal. This mode is commonly used for wireless communications, broadcast receiver testing, and modulation characteristic analysis. The AM mode provides the following functions:

- AM parameter configuration
- Baseband IQ data export

### 3.3.2 Frequency Modulation

In FM mode, the instrument modulates the instantaneous frequency of a high-frequency carrier using a low-frequency modulation waveform. Modulation types such as sine wave, square wave, triangle wave, and ramp wave are supported. This mode is widely used for testing walkie-talkies, vehicle-mounted radios, and wireless communication equipment. The FM mode provides the following functions:

- FM parameter configuration
- Baseband IQ data export

### 3.3.3 Phase Modulation

In Phase Modulation (PM) mode, the instrument modulates the instantaneous phase of the RF carrier according to the selected modulation waveform. It supports sine, square, triangle, and ramp modulation waveforms, with configurable modulation rate, phase deviation, and initial phase. This mode is suitable for testing communication systems, receivers, and phase modulation characteristics. The Phase Modulation mode provides the following functions:

- PM parameter configuration
- Baseband IQ data export

### 3.3.4 Pulse

In Pulse mode, the instrument generates pulse-modulated signals by applying gating control to the RF carrier. This mode is suitable for receiver transient response testing, pulsed characteristic testing of microwave devices, as well as radar and navigation system excitation applications. The Pulse mode provides the following functions:

- Pulse parameter configuration
- Baseband IQ data export

### 3.3.5 Digital Ramp Sweep

In Digital Ramp Sweep mode, the output frequency performs linear frequency sweeping according to the configured sweep span, sweep time, and sweep period. The instrument achieves high-precision frequency ramp generation through digital frequency control, making it suitable for applications such as radar linear frequency modulation (LFM) signal simulation, broadband excitation, and frequency response testing. This mode provides the following functions:

- Sweep parameter configuration
- Baseband IQ data export

### 3.3.6 AWGN

In AWGN mode, the instrument outputs broadband noise signals within a specified bandwidth range, with amplitude statistical characteristics following a Gaussian distribution. This mode is commonly used for receiver anti-interference testing, SNR testing, and system noise performance evaluation. The mode provides the following functions:

- Bandwidth and length configuration
- Baseband IQ data export

### 3.3.7 Digital Modulation

In Digital Modulation mode, the instrument maps baseband digital bit streams onto IQ constellation points and outputs the signals after pulse-shaping filtering. The Digital Modulation mode provides the following functions:

- Digital Mod Parameter configuration
- ASK/APSK/FSK/PSK/QAM modulation
- Data truncation and parameter adjustment
- Raw baseband IQ data export
- IQ/spectrum/constellation diagram preview

### 3.3.8 DSSS

In DSSS mode, the instrument performs spread-spectrum processing on baseband modulated data using pseudo-random spreading codes, thereby expanding the signal spectrum. This mode supports spreading code configuration, random seed settings, and pulse-shaping filter configuration, making it suitable for spread-spectrum communication systems and anti-interference testing. The DSSS mode provides the following functions:

- DSSS core parameter configuration
- Raw baseband IQ data export

### 3.3.9 OFDM

In OFDM mode, the instrument maps data streams onto multiple mutually orthogonal subcarriers for parallel modulation, thereby generating broadband multicarrier communication signals. This mode supports configuration of parameters such as FFT length, guard interval, subcarrier allocation, and modulation type, making it suitable for wireless communication systems, receiver performance evaluation, and spectrum characteristic testing. The OFDM mode provides the following functions:

- Basic OFDM parameter configuration
- OFDM time-frequency structure configuration
- Raw baseband IQ data export

### 3.3.10 Multitone

In Multitone mode, the instrument supports the generation of multiple discrete tones with equal frequency spacing to meet the requirements of receiver testing, intermodulation testing, linearity testing, and complex spectrum scenario simulation. The Multitone mode provides the following functions:

- Multitone signal generation
- Individual tone enable/disable control
- Fixed, random, and parabolic phase control
- In-band notch function

### 3.3.11 Playback

In Playback mode, the instrument supports downloading user-provided external waveform data in .wav format to the instrument's onboard memory for transmission. This enables complex non-standard protocols or custom signal generation. The waveform data size must not exceed the onboard memory capacity of the current instrument. Playback mode provides the following functions:

- Single external waveform file loading
- Real-time waveform parameter parsing
- Playback sample count and range control
- IQ amplitude control and automatic scaling

### 3.3.12 Quick Waveform

In Quick Waveform mode, the instrument allows users to directly replay built-in modulation waveform files, eliminating the need for complex parameter configuration and external file import procedures, and enabling one-click generation of standard signals. The Quick Waveform mode provides the following functions:

- Preset waveform files
- Real-time waveform parameter parsing
- Playback sample count and range control
- IQ amplitude control and automatic scaling

## 3.4 Streaming Mode

In this mode, the software transmits IQ waveform data to the instrument via the USB bus. The instrument receives the data and plays it in real time. When the user stops streaming data, the instrument continues playback until all received data has been played, and then stops. The sampling rate and transmission rate of real-time data are limited by the physical bandwidth of the data interface. The streaming mode in the software uses this transmission mechanism.

- Loading multiple waveform files
- File parameter parsing
- Playback progress display
- IQ amplitude control

## 3.5 Interface Layout

The SGStudio interface consists of the following components;

- Menu
- RF Parameter Settings Area
- Mode Selection Area
- Mode Parameter Settings Area
- Instrument State

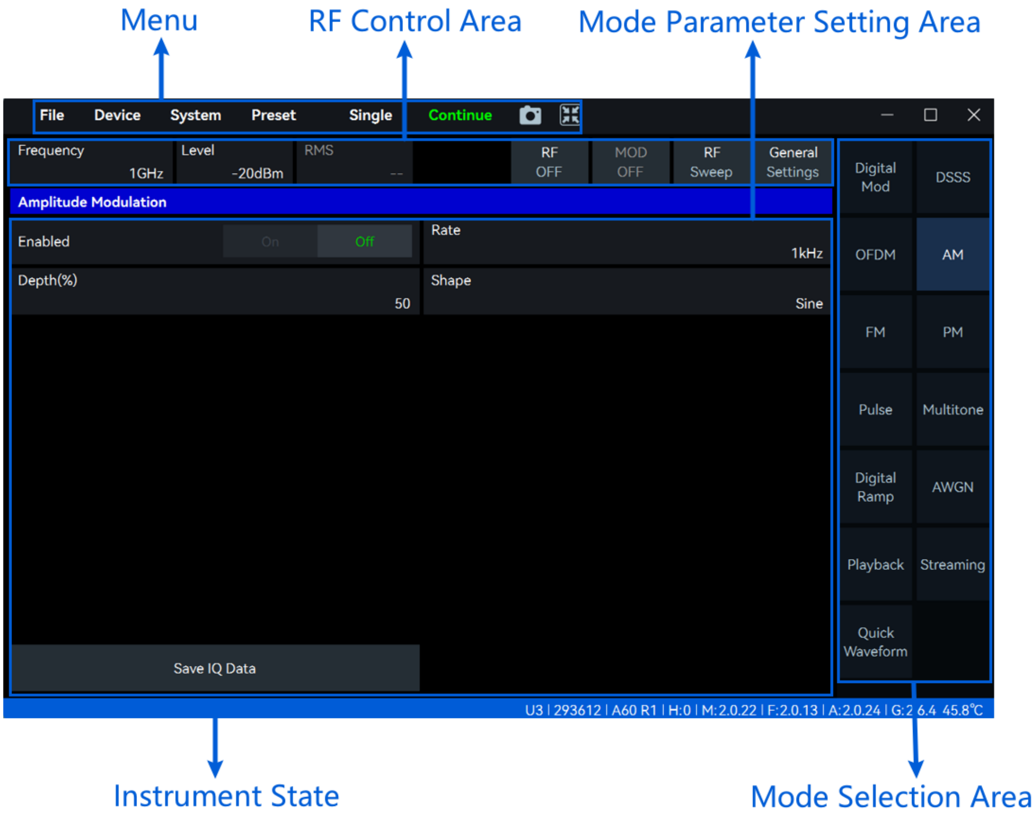


Figure 1 SGStudio Interface Layout

### 3.5.1 Menu

- Save and Open Configuration Files
- Set Power On State
- Connect USB/ETH devices
- Switch language/theme
- GPIO Settings (PGA Only)
- GNSS Information
- View instrument information
- Software and firmware update
- Preset
- Single and continuous transmission
- Quick Screenshot
- Minibar

### 3.5.2 RF Parameter Settings Area

- Frequency
- Level
- RF On/Off
- Modulation On/Off
- Frequency/Power Sweep
- General Settings

### 3.5.3 Mode Selection Area

- AM
- FM
- PM
- Multitone
- Pulse
- Digital Ramp
- AWGN
- Digital Mod
- DSSS
- OFDM
- Playback
- Streaming
- Quick Waveform

### 3.5.4 Instrument State

- Instrument Connection Status
- Bus Data Throughput
- Instrument Model and UID
- Software/Firmware Version
- Instrument Real-Time Temperature
- Instrument Battery Level (PG Series Only)

# 4. General Operations

## 4.1 Save and Open Configuration Files

1. Save Current Configuration

1). Click "File" -> "Save" in the menu bar;

2). In the "Save Settings" dialog, set the save path and file name, then click "Save". Instrument configuration files are saved in the "/data" folder by default.

2. Load Preset Configuration

1). Click "File" -> "Open" in the menu bar;

2). In the "Open Settings" dialog, select the configuration file and click "Open" to apply the preset configuration.

## 4.2 Set Power On State

The instrument supports user-defined startup states. Detailed description of the available power on state is provided in the table below.

**Table 3 SGStudio Software Power On State**

| No. | Power On State Name | Description |
|---|---|---|
| 1 | Default | Instrument default configuration |
| 2 | User Preset | Use a user-saved configuration file as the initial power on configuration |
| 3 | Last State | Use the parameter configuration from the previous software session as the initial startup configuration |

To set the startup state, follow these steps:

1. Click "File" -> "Power On State" in the menu bar;
2. For "Default" or "Last State", just click the option. The software will use the selected option as the initial state on the next startup;
3. Select "User Preset" and choose a user-saved configuration file in the "Open Settings" dialog. The software will open with this specified configuration on the next startup.

## 4.3 Connect USB Device

When the instrument is directly connected to the computer via a USB cable, click "Device" -> "USB Connect" in the menu bar. The interface will display a list of all signal generators connected to the PC, click the first six digits of the corresponding UID to switch the currently connected instrument.

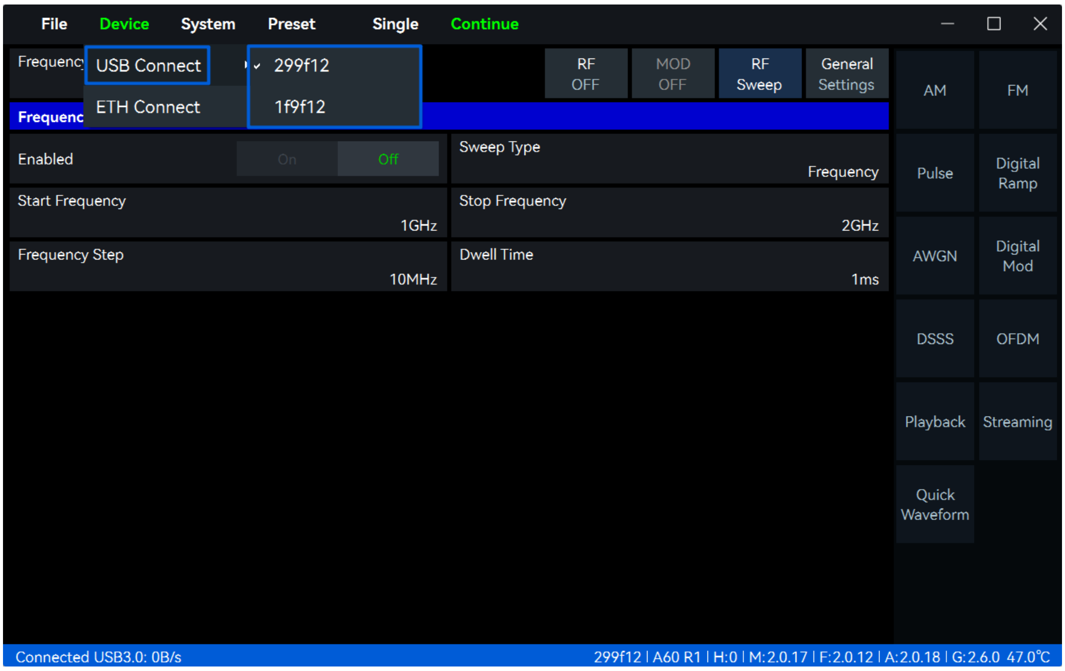


Figure 2 Connect the USB device

## 4.4 Connect ETH Device

1. When using an Ethernet-based instrument, navigate to the menu bar and select "Device" -> "ETH Connect". In the dialog box, enter the "IP Address" and "Port", then select the "Local Interface" (ensure the PC is configured to the same network segment as the instrument);
2. Click "Connect". The software will attempt to establish a connection with the device. Once successful, the status bar will display "Connected ETH XXX" (e.g., Connected ETH 192.168.1.100 0 B/s).

## 4.5 Theme Setting

Click "System" -> "Theme" in the menu bar to switch between the "Dark" and "Light" themes.

## 4.6 Preference Settings

Click "System" -> "Preference" in the menu bar to open the configuration window. The following functional settings can be configured.

Table 4 Preference Settings Description

| Parameter | Description |
| --- | --- |
| **Vibration Feedback (PG Series Only)** | When enabled, the instrument provides haptic feedback through vibration during touchscreen operation. |
| **Screen Lock** | On: A lock icon"" will appear on the right side of the screen. Click the icon"" to lock the screen and prevent accidental operations; click again to unlock. |
| **Auto Mod** | On: When "Enable" in the mode parameter settings area is selected, the "Modulation" control in the RF parameter settings area will be automatically enabled, with no manual operation required.<br>Off: The "MOD" control in the RF parameter settings area must be enabled manually. |
| **Idle Brightness Reduction (PG Series Only)** | When enabled, the instrument automatically reduces the screen brightness if there is no user operation for 1 minute. |
| **Brightness (PG Series Only)** | Adjusts the screen brightness of PGA Series instruments. |
| **Fan Control (PG Series Only)** | **Standard:** The temperature trigger threshold is lower, providing a more responsive fan response.<br>**Silent:** The trigger threshold is higher, and the fan speed increases more gradually. |

## 4.7 Viewing Instrument Information

Click "System" -> "About" in the menu bar. A dialog box will display information such as the current instrument's UID, software/firmware version, power port voltage and current, and USB port voltage and current.

## 4.8 Single and Continuous Transmission

Single: Click "Single" to transmit the signal once;
Continue: Click "Continue" to transmit the signal continuously.

## 4.9 Save Image

Click the shortcut button "" on the menu bar to capture a screenshot. The image is saved to the "/images" folder by default, and the storage path cannot be changed.

## 4.10 Preset

Click the "Preset" button in the menu bar to restore the current software configuration to the instrument's default initial state.

## 4.11 Minibar

Minibar switches the software main interface to a simplified quick control panel while retaining commonly used functions such as RF output, output frequency, output power, modulation, and frequency/power sweep. It enables users to quickly configure key parameters when working with multiple application windows.

1. Click the "" icon on the menu bar to switch the software to the Compact Control Panel;
2. Set the output frequency and output power, then enable RF Output to quickly generate a CW signal;
3. To output a modulated signal or perform a frequency/power sweep, click the "Mod" or "Frequency/Power Sweep" button to expand the corresponding parameter configuration panel. After completing the configuration, click anywhere outside the panel to collapse it;
4. Click "Restore" to exit Compact Mode and return to the main software interface. Click the " ^/v" toggle button at the bottom of the panel to collapse or expand the Compact Control Panel.

**Note:** The parameter settings, valid ranges, and application methods in Compact Mode are identical to those in the main software interface. For detailed descriptions, refer to the corresponding functional sections.

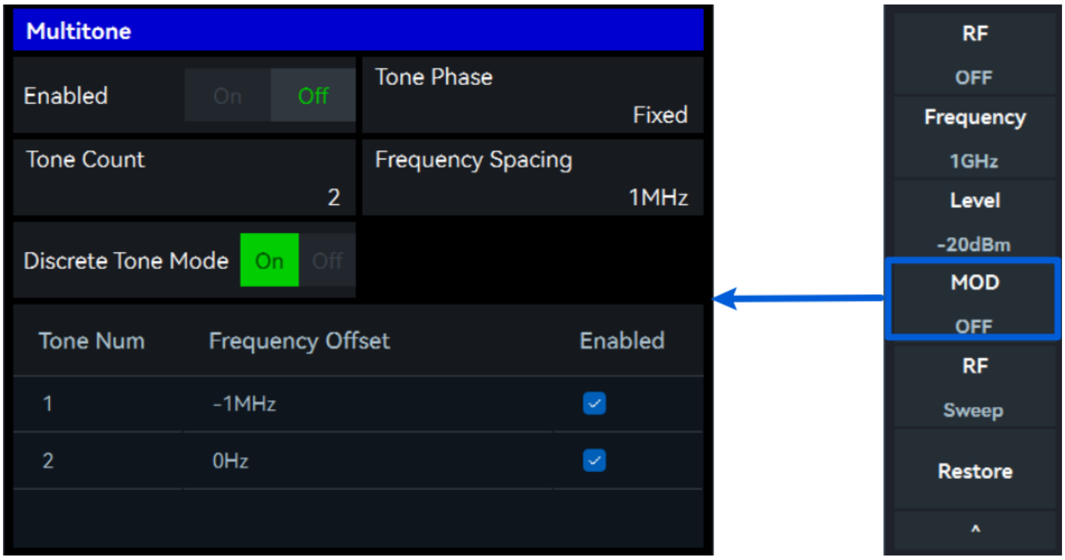


figure 3 Launch Minibar and configure the parameters

## 4.12 Frequency and Power Settings

The output frequency and peak power can be configured at the top of the software main interface. Based on the current configuration, the instrument returns the corresponding RMS power value. The parameters are described in the table below.

**Table 5 Frequency and Power Settings**

| Frequency and Power | |
|---|---|
| Frequency | Sets the output frequency of the RF signal. Range: 9 kHz to 6 GHz. For output frequencies below 500 MHz, the frequency resolution is 1 Hz. For output frequencies from 500 MHz to 6 GHz, the frequency resolution is 0.1 Hz. |
| Power | Sets the peak output power of the signal. The standard configuration provides a maximum output power of 7 dBm to 14 dBm, with an optional 25 dBm high-power output. |
| RMS | Displays the actual average power of the current output signal. This is a read-only value and cannot be configured. |

## 4.13 Medium-Power Output (Option 10)

The instrument supports an optional Medium-Power Output (Option 10). When this option is installed, the maximum output power is increased to 25 dBm, and signals are output through the dedicated medium-power RF output port. To output a medium-power RF signal:

1. Click "General Settings" in the RF Control section, and set "Output Port" to "HP Port" under the RF Hardware settings;
2. Connect the RF cable to the instrument's medium-power RF output port;
3. Configure the desired output frequency, output power, and signal type, then enable "RF-HP" to output the configured signal.

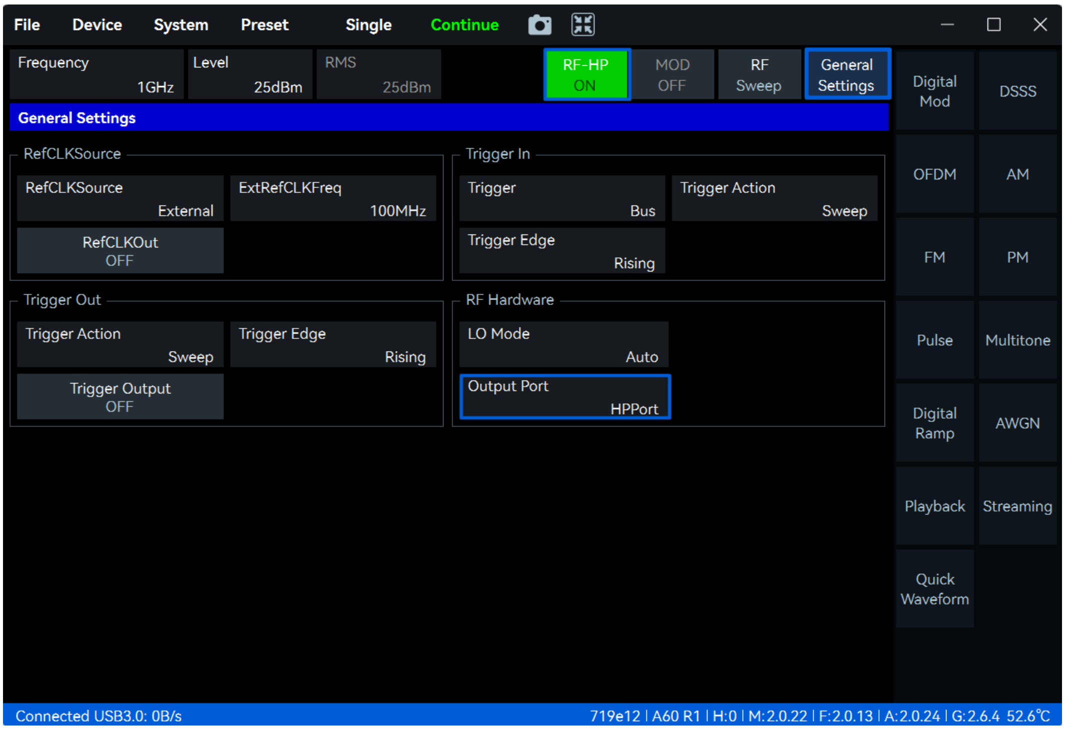


figure 4 25 dBm CW Signal Output via the Medium-Power Port

## 4.14 RF and Modulation Control

When only RF output is enabled, the instrument outputs a continuous-wave (CW) signal. When modulation is also enabled, the instrument outputs the currently selected modulation signal.

**Table 6 RF and Modulation**

| RF and Mod Control | |
|---|---|
| RF ON/OFF | Controls the RF output state. When set to "OFF", the RF output is forcibly disabled regardless of other settings. |
| MOD ON/OFF | Switches the current modulation state.<br>When MOD is set to "OFF" and RF is set to "ON", the instrument outputs a CW signal.<br>When both states are "ON", the instrument outputs the signal using the currently selected modulation type. |

## 4.15 Frequency and Power Sweep

When only RF and Frequency/Power Sweep are enabled, the instrument outputs a CW sweep signal. By additionally enabling the MOD function, the instrument provides a modulated sweep signal output.

### 4.15.1 Parameter Description

**Table 7 Frequency and Power Sweep Parameter Description**

| Frequency and Power Sweep (Analog) | |
|---|---|
| Sweep Type | Frequency Sweep: Sweeps the frequency across the specified range at a fixed level;<br>Power Sweep: Sweeps the level across the specified range at a fixed frequency. |
| Start/Stop Frequency | Sets the sweep range for frequency sweep. |
| Start/Stop Level | Sets the sweep range for power sweep. |
| Frequency Step | Sets the frequency step size between adjacent sweep points in frequency sweep. |
| Level Step | Sets the level increment between adjacent sweep points in level sweep. |
| Dwell Time | Sets the update interval between adjacent sweep points. The actual interval is the sum of the instrument reconfiguration time and the dwell time at each frequency/level point. Range: 1 ms to 1000 s. |

### 4.15.2 Operating Procedure

Using an analog frequency sweep signal with a start frequency of 1 GHz, stop frequency of 2 GHz, power level of -20 dBm, frequency step of 100 MHz, and dwell time of 10 ms as an example, the operation procedure is as follows:

1. Click "RF Sweep" in the RF parameter settings area;
2. In the parameter settings area, set "Sweep Type" as "Frequency", "Start Frequency" as 1 GHz, "Stop Frequency" as 2 GHz, "Frequency Step" as 100 MHz, and "Dwell Time" as 10 ms, then enable the RF Sweep mode;
3. Set the Level to -20 dBm, and set the RF On;
4. The signal generator outputs an analog frequency sweep signal with a start frequency of 1 GHz, stop frequency of 2 GHz, level of -20 dBm, frequency step of 100 MHz, and dwell time of 10 ms.

## 4.16 External Reference Clock Input

1. Refer to the Vector Signal Generator Quick Start Guide to input an external reference clock.
2. Click "General Settings" -> "RefCLKSource", and select "External". Set the Reference Clock Frequency as 10 MHz. If the status bar at the bottom displays the warning message "Warning: External reference clock not locked", the switch to the external reference clock has failed. If no such warning is displayed, the switch has been completed successfully.

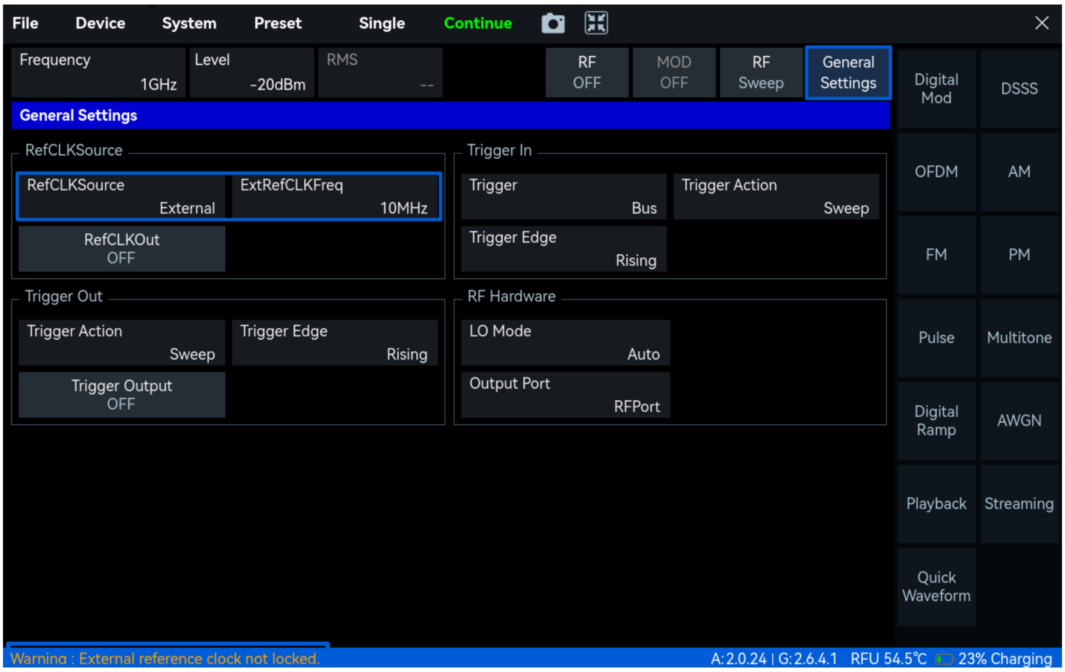


figure 5 Reference Clock Switching Failure

## 4.17 Reference Clock Output

1. Refer to the Vector Signal Generator Quick Start Guide and connect the instrument's reference clock output port.
2. Click "General Settings" in the RF parameter settings area and enable "RefCLKOut" to output a 100 MHz clock signal.

## 4.18 Trigger Input

### 4.18.1 Parameter Description

Table 8 Trigger Input Parameter Description

| Trigger Input | |
|---|---|
| **Trigger Source** | Supports bus trigger, external trigger, and XPPS trigger. |
| **Trigger Action** | The trigger action takes effect only when RF sweep is enabled.<br>Sweep: Upon receiving a trigger signal, the instrument starts the preset RF sweep. During the sweep process, the switching interval between adjacent RF sweep points is determined by the dwell time.<br>Hop: Upon receiving a trigger signal, the system performs only a single-step transition and switches to the next RF state in the preset sweep sequence. In this mode, the dwell time is ignored, and the hopping rate depends on the arrival rate of the trigger pulses. |
| **Trigger Edge** | Supports both rising edge and falling edge triggering. In Bus trigger mode, the trigger edge setting is ignored. |

### 4.18.2 Operating Procedure

Using an AM signal with frequency hopping as an example, the operation procedure is as follows:

1. Refer to the *Vector Signal Generator Quick Start Guide* to configure the external trigger input;
2. Click "AM" in the mode selection area. In the mode parameter configuration area, set "Rate" to 200 kHz, keep the remaining parameters at their default values, and enable AM mode;
3. In the RF parameter settings area, click "RF Sweep". In the mode parameter configuration area, set "Frequency Step" to 100 MHz, keep the remaining parameters at their default values, and enable the RF Sweep mode;
4. Click "General Settings" in the RF parameter configuration area, set "Trigger Source" to "External", and set "Trigger Action" to "Hop";

5. Enable the RF output. The instrument then enters the trigger-wait state. Each time a valid external trigger is received, the system hops to the next frequency point with a 100 MHz step size and simultaneously outputs an AM signal with a modulation rate of 200 kHz.

## 4.19 Trigger Output

Table 9 Trigger Output Parameter Description

| Trigger Output | |
|---|---|
| **Trigger Output** | Enable or disable the trigger output function. |
| **Trigger Action** | Sweep: Outputs one trigger signal after completing one RF sweep;<br>Hop: Outputs one trigger signal after completing one frequency hop. |
| **Trigger Edge** | The output trigger can be configured as either a rising edge or falling edge. |

## 4.20 RF Hardware

Table 10 LO Mode Parameter Description

| LO Mode | |
|---|---|
| **Auto** | In this mode, the instrument automatically selects the optimal operating parameters based on the current output frequency, frequency step size, and operating state. |
| **Low Phase Noise** | This mode improves signal phase stability and optimizes close-in phase noise by adjusting the PLL control strategy. |
| **Low Spurious** | This mode optimizes the LO output spectrum, effectively suppressing fractional spurs and related spurious components to improve spectral purity. |

## 4.21 Saving Baseband IQ Data

Click the "Save IQ Data" button in the mode parameter configuration area. In the "Save IQ Data" dialog box, set the save path and file name, then click "OK" to save the baseband IQ data file.

## 4.22 GNSS Usage

Correctly connect the external antenna to the instrument's GA port. Click "System" -> "GNSS Information" on the menu bar. Wait for 1 to 3 minutes for the GNSS to acquire a lock. The parameters in the "GNSS Information" window are described in the following table.

Table 11 GNSS Parameter Description

| GNSS | |
|---|---|
| **XPPS Output** | On: Outputs the XPPS pulse signal.<br>Off: Disables the XPPS output of the GNSS module. |
| **XPPS** | Adjusts the frequency of the pulse signal output by the GNSS module, in Hz.<br>Default: 1 Hz, corresponding to a 1PPS signal. When set to 0.5 Hz, one pulse is output every 2 seconds. |
| **Delay** | Sets the PPS delay, in seconds. The maximum delay must not exceed one period. |
| **Format** | Supports "Local Time" and "UTC Time" formats |
| **Date** | Date information of the current positioning |
| **Time** | Time information of the current positioning |
| **Longitude** | Longitude coordinate of the current positioning |
| **Latitude** | Latitude coordinate of the current positioning |
| **Altitude** | Altitude of the current positioning |
| **Satellite Number** | Number of positioned satellites |
| **SNR (Max)** | Maximum SNR of positioned satellites |
| **SNR (Min)** | Minimum SNR of positioned satellites |
| **SNR (Avg)** | Average SNR of positioned satellites |

# 5. Signal Waveform Overview

## 5.1 Amplitude Modulation

Using an AM signal with a carrier frequency of 1 GHz, power level of -10 dBm, modulation rate of 30 kHz, and modulation depth of 50% as an example.

### 5.1.1 Parameter Description

Only the key parameters related to amplitude modulation are described here. The main AM parameters are listed in the table below.

**Table 12 Amplitude Modulation Parameter Description**

| Amplitude Modulation | |
|---|---|
| **Rate** | Specifies the AM modulation frequency, range: 1 Hz to 10 MHz |
| **Depth(%)** | Sets the relative depth by which the carrier amplitude varies with the modulation signal, range: 1% to 100%. |
| **Shape** | Sine/Square/Triangle/Ramp |

### 5.1.2 Operating Procedure

1. Click "AM" in the mode selection area;
2. In the AM control area, set "Rate" to 30 kHz, "Depth" to 50%, "Shape" to Sine, and enable the AM mode;
3. Set the "Frequency" to 1 GHz, "Level" to -10 dBm, and turn on the RF output.

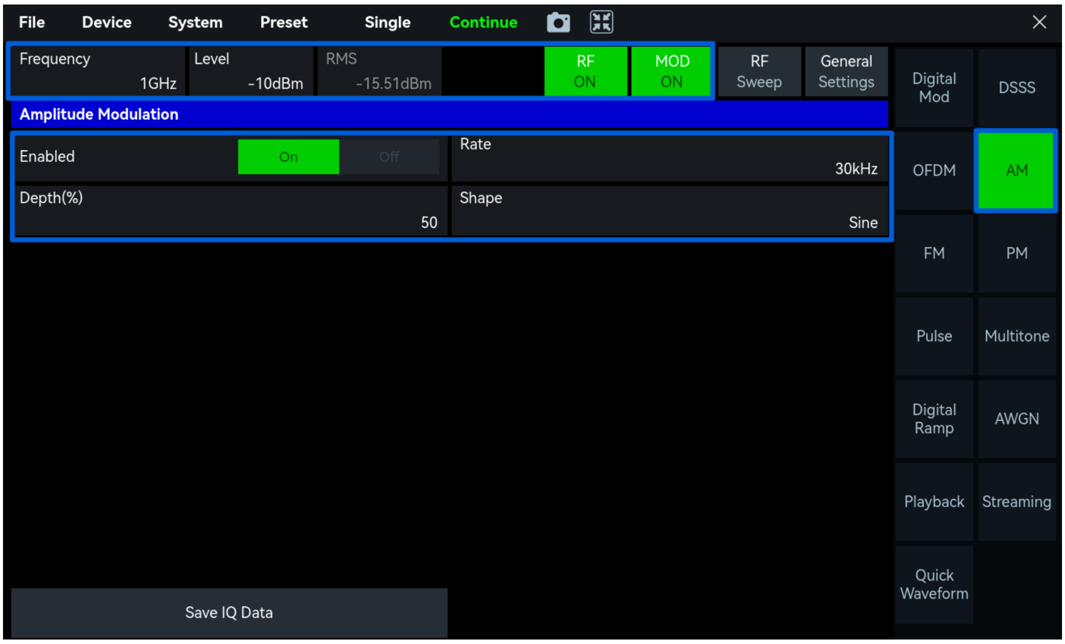


figure 6 AM Modulation

4. The signal generator outputs an AM signal with a carrier frequency of 1 GHz, RMS power level of -15.51 dBm, modulation rate of 30 kHz, modulation depth of 50%, and a sine-wave baseband modulation waveform.


figure 7 AM Demodulation

## 5.2 Frequency Modulation

Using an FM signal with a carrier frequency of 1 GHz, power level of -20 dBm, modulation rate of 15 kHz, frequency deviation of 75 kHz, and a sine-wave modulation waveform as an example.

### 5.2.1 Parameter Description

Only the key parameters related to frequency modulation are described here. The main FM parameters are listed in the table below:

**Table 13 Frequency Modulation Parameter Description**

| Frequency Modulation | |
|---|---|
| **Rate** | Specifies the FM modulation frequency |
| **Deviation** | Sets the maximum instantaneous frequency deviation of the RF carrier from the center frequency during modulation |
| **Shape** | Sine/Square/Triangle/Ramp |

### 5.2.2 Operating Procedure

1. Click "FM" in the mode selection area;
2. In the frequency modulation control area, set the "Rate" to 15 kHz, the "Deviation" to 75 kHz, select "Sine" for the shape, and enable frequency modulation;
3. Set the carrier "Frequency" to 1 GHz, "Level" to -20 dBm, and turn on RF output;

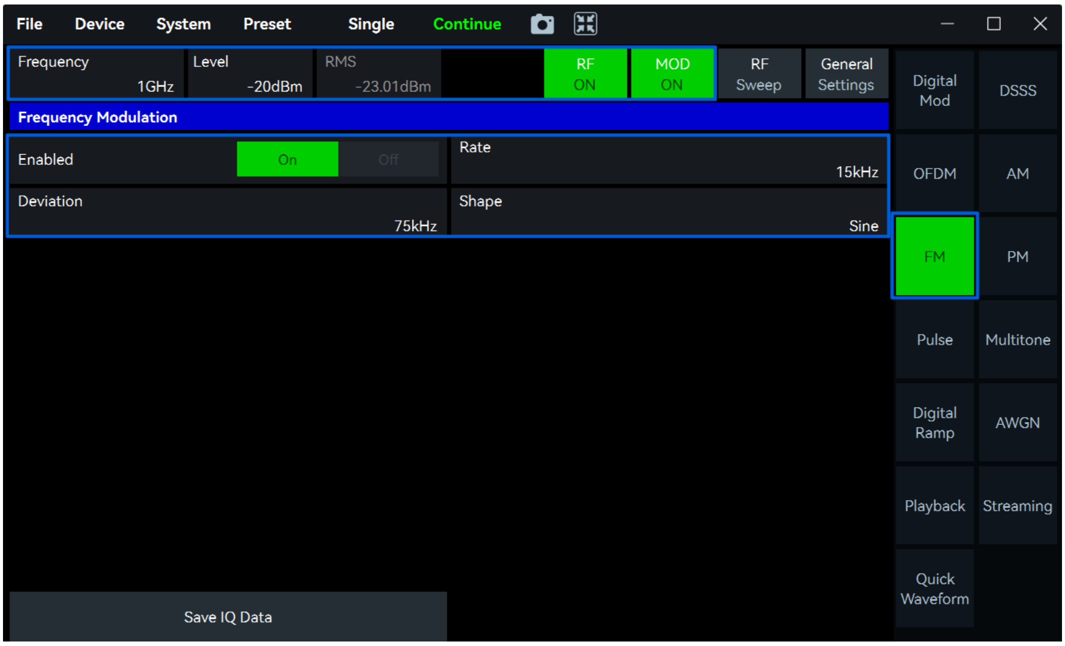


figure 8 FM Modulation

4. The signal generator outputs an FM signal with a carrier frequency of 1 GHz, RMS power of -23.01 dBm, modulation rate of 15 kHz, frequency deviation of 75 kHz, and a sinusoidal modulation waveform.

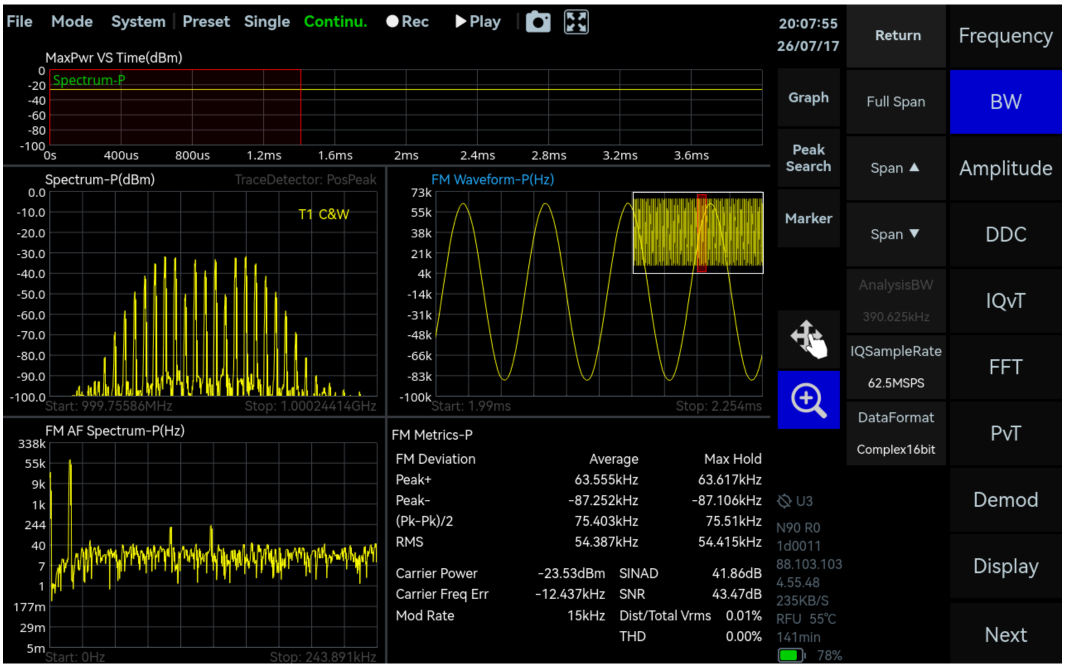


figure 9 FM Demodulation

## 5.3 Phase Modulation

Phase modulation (PM) varies the instantaneous phase of the RF carrier according to the modulation signal. This section uses a PM signal with a 1 GHz carrier frequency, −20 dBm peak power, 1 kHz modulation rate, 45° phase deviation, 0° initial phase, and a sine modulation waveform as an example.

### 5.3.1 Parameter Description

This section describes the key parameters for phase modulation. The parameters are listed in the table below.

**Table 14 Phase Modulation Parameters**

| **Phase Modulation** | |
|---|---|
| **Modulation Rate** | Sets the PM modulation frequency. Range: 1 Hz to 10 MHz. |
| **Phase Deviation (deg)** | Sets the maximum phase deviation of the RF carrier caused by the modulation signal. Range: 0° to 360°. |
| **Initial Phase (deg)** | Sets the initial phase of the modulation signal. Range: 0° to 180°. |
| **Signal Type** | Selects the modulation waveform. Supported waveforms: Sine, Square, Triangle, and Ramp. |

### 5.3.2 Operating Procedure

1. Click "PM" in the mode selection area;
2. In the Phase Modulation control panel, set "Rate" to 1 kHz, "Phase Deviation (deg)" to 45°, "Init Phase (deg)" to 0°, select Sine as the "Shape", and enable Phase Modulation;
3. Set the carrier "Frequency" to 1 GHz, the "Level" to −20 dBm, and enable the RF Output;

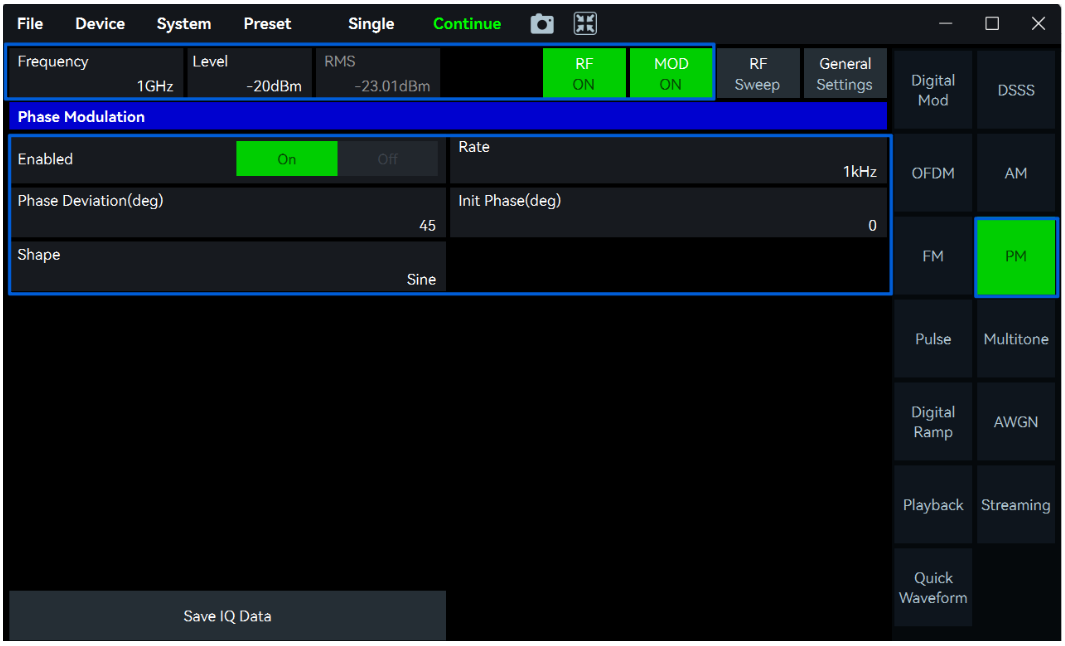


figure 10 PM Modulation

4. The signal generator outputs a PM signal with a 1 GHz carrier frequency, −20 dBm peak power, 1 kHz modulation rate, 45° phase deviation, 0° initial phase, and a sine modulation waveform.

## 5.4 Pulse

Using a pulse signal with a carrier frequency of 1 GHz, power level of -17 dBm, pulse width of 100 ns, and period of 400 ns as an example.

### 5.4.1 Parameter Description

Only the key parameters are described here. The main pulse modulation parameters are listed in the table below.

Table 15 Description of Pulse Parameters

| Pulse | |
|---|---|
| **Width** | The duration of the high-level state within one pulse period. Range: 48 ns to 1 s. |
| **Period** | The time interval between the rising edges of two adjacent pulse signals. Range: 96 ns to 1 s. |
| **Duty Cycle (%)** | Return value. The ratio of pulse width to period, used to indicate the percentage of high-level duration within the entire period. |

### 5.4.2 Operating Procedure

1. Click "Pulse" in the mode selection area;
2. In the pulse modulation control area, set the "Width" to 2 us, the "Period" to 4 us, and enable pulse modulation;
3. Set the carrier "Frequency" to 1 GHz, "Level" to -17 dBm, and turn on the RF output;

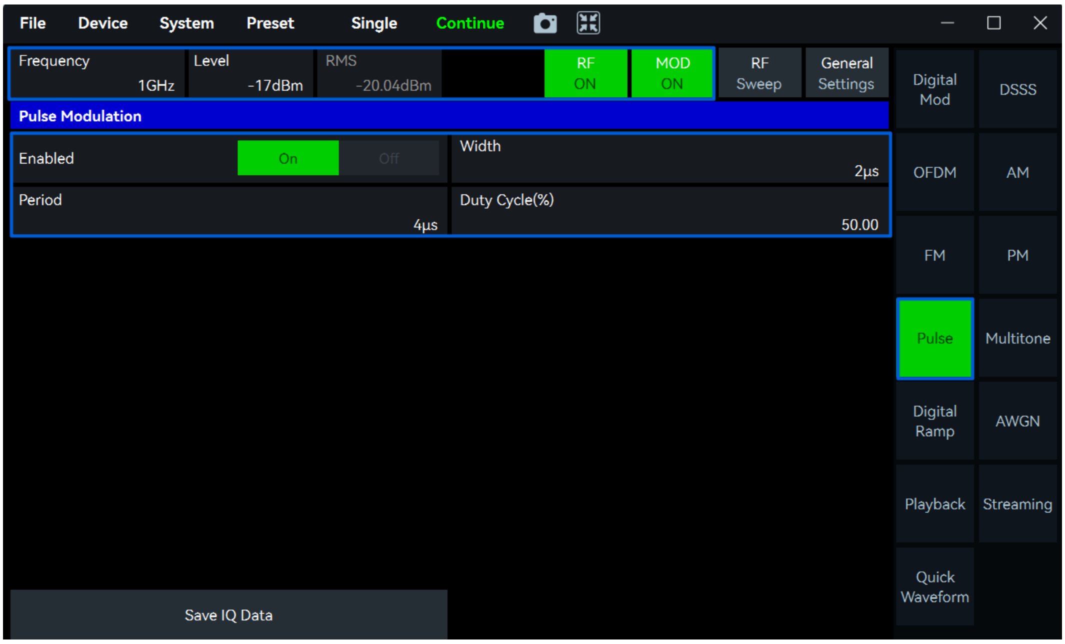


figure 11 Pulse Modulation

4. The signal generator will output a pulse signal with a frequency of 1 GHz, RMS power of -20.04 dBm, pulse width of 2 us, and period of 4 us.


figure 12 Pulse Demodulation

## 5.5 Digital Ramp Sweep

Ramp Sweep mode refers to CW sweeping across a specified frequency range at the desired output level. Since the frequency changes continuously, this mode is limited by the instantaneous bandwidth capability of the transmit channel.

### 5.5.1 Parameter Description

The parameter descriptions for Ramp Sweep mode are listed on the table below:

**Table 16 Digital Ramp Sweep Parameter Description**

| Digital Ramp Sweep | |
|---|---|
| **Span** | Specifies the frequency span of the ramp. The carrier frequency is the center frequency of the sweep. Range: 1 kHz to the maximum playback bandwidth supported by the current instrument. |
| **Sweep Time** | Specifies the time required to sweep across the defined frequency range. |
| **Period** | Specifies the time interval between two consecutive sweeps (must be greater than or equal to the sweep time), the configurable upper limit is inversely proportional to the sweep span. |

### 5.5.2 Operating Procedure

Using a ramp sweep signal with a center frequency 1 GHz, power level of -20 dBm, span of 40 MHz, sweep time of 200 ms, and sweep period of 200 ms as an example, the operation procedure is as follows:

1. Click "Digital Ramp" in the mode selection area;

2. In the ramp sweep control area, set the "Span" to 40 MHz, the "Sweep Time" to 200 ms, and the "Period" to 200 ms, then enable ramp sweep mode;
3. Set the "Frequency" to 1 GHz, the "Level" to -20 dBm, and turn on the RF output;

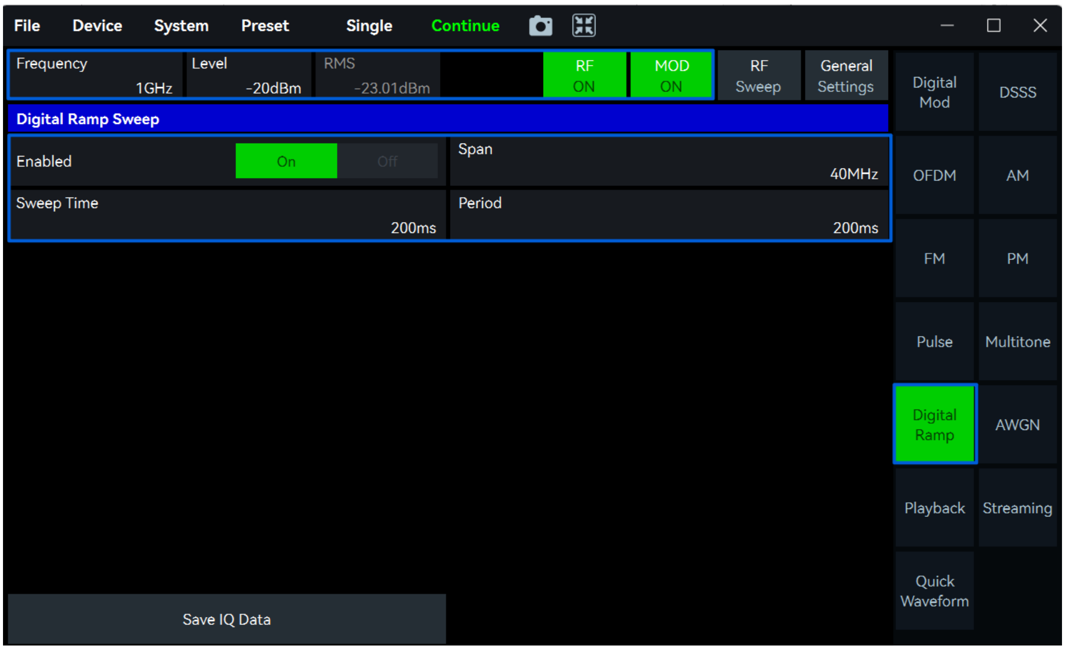


figure 13 Digital Ramp Sweep

4. The signal generator outputs a ramp sweep signal with a frequency of 1 GHz, RMS power of -23 dBm, sweep span of 40 MHz, sweep time of 200 ms, and sweep period of 200 ms.

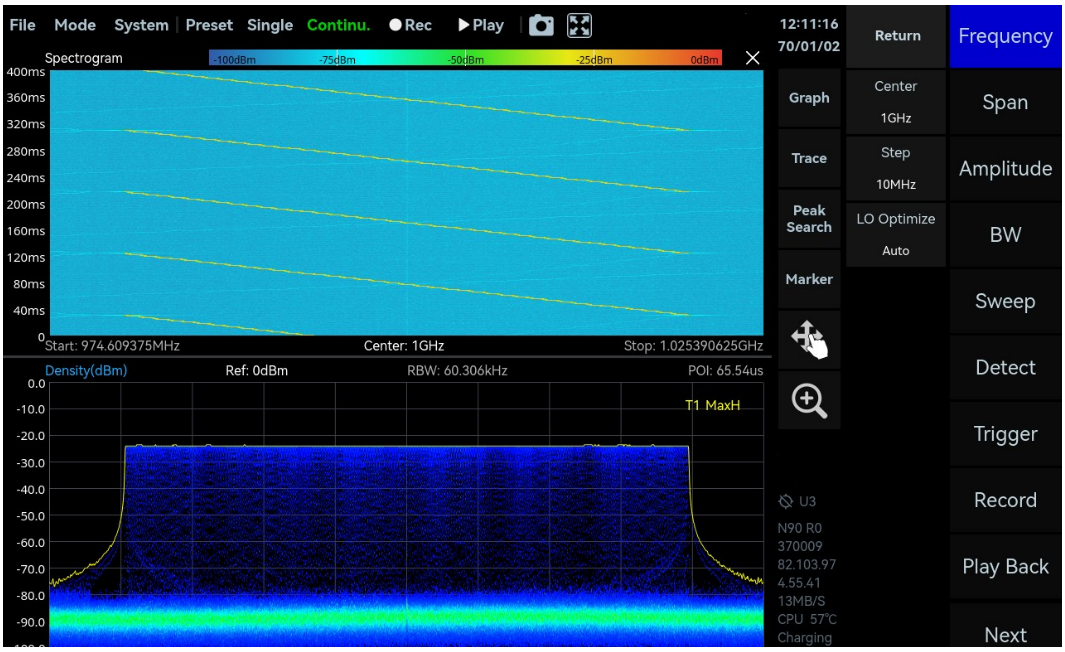


figure 14 Digital Ramp Sweep Diagram

## 5.6 AWGN

Using a Gaussian white noise signal with a center frequency of 1 GHz, output bandwidth of 100 MHz, duration of 10 ms, and power level of -20 dBm as an example.

### 5.6.1 Parameter Description

**Table 17 Gaussian White Noise Parameter Description**

| AWGN | |
|---|---|
| **Bandwidth** | The effective frequency range of the noise. |
| **Length** | The duration of a single noise signal. |

### 5.6.2 Operating Procedure

1. Click on "AWGN" in the mode selection area;
2. In the control area, set "Bandwidth" to 100 MHz, the "Length" to 10 ms, and enable the Gaussian white noise mode;
3. Set the carrier "Frequency" to 1 GHz, "Level" to -20 dBm, and turn on the RF output;

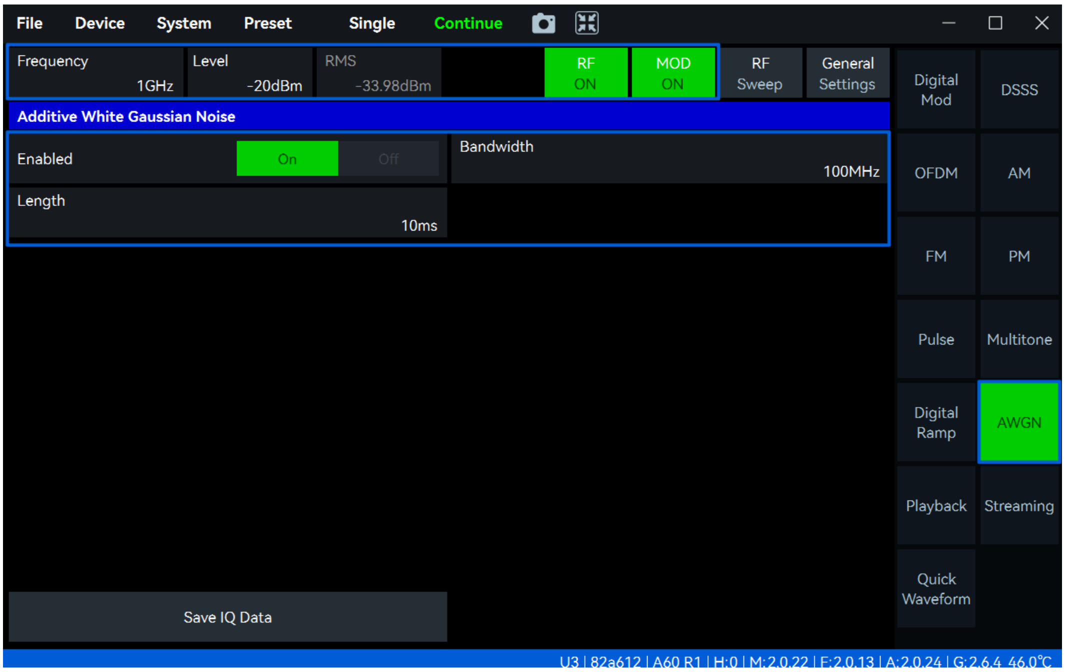


figure 15 AWGN

4. The signal generator will output a Gaussian white noise signal with a center frequency of 1 GHz, occupied bandwidth of 100 MHz, duration of 10 ms with a peak power of -20 dBm.

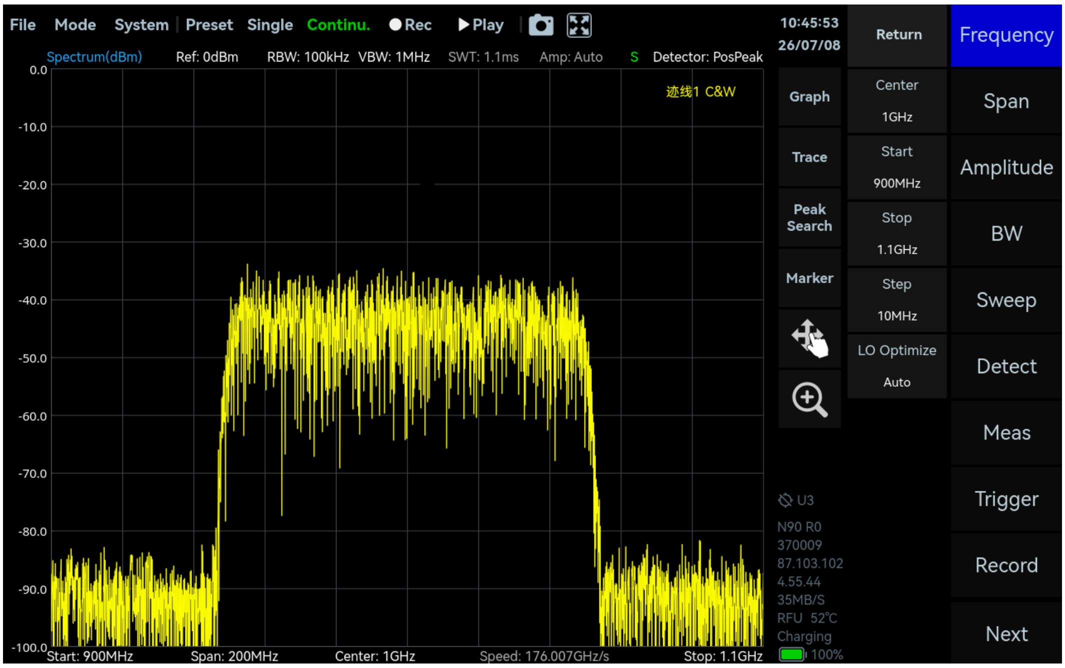


figure 16 AWGN Diagram

## 5.7 Digital Modulation

Using a 64QAM signal with a carrier frequency of 1 GHz, peak power of -20 dBm, and symbol rate of 1 MHz as an example.

### 5.7.1 Parameter Description

The parameter descriptions for Digital Modulation mode are listed in the table below:

**Table 18 Digital Modulation Mode Parameter Description**

| Digital Mod | |
|---|---|
| **Symbol Rate** | The number of symbols transmitted per second. The symbol rate is limited by the instrument's maximum sampling rate and oversampling rate<br>Symbol Rate ≤ Maximum sample rate supported by the instrument / oversample. |
| **Filter Type** | Rectangular, Raised Cosine, Root Raised Cosine, Gaussian, Half-Sine |
| **Modulation Type** | APSK: 16APSK<br>ASK: 2ASK, 4ASK, 8ASK<br>FSK: 2FSK, 4FSK, 8FSK, 16FSK<br>PSK: BPSK, QPSK, OQPSK,8PSK, 16PSK, DBPSK, DQPSK, D8PSK, Pi/4 DQPSK<br>QAM: 16QAM, 64QAM, 256QAM, 1024QAM |

| | |
|---|---|
| **Filter Alpha** | Specifies the roll-off factor of the filter. Raised Cosine / Root Raised Cosine: 0.025 to 1, Gaussian Filter: 0.15 to 2.5. The roll-off factor is only valid for Raised Cosine, Root Raised Cosine, and Gaussian filters. |
| **Filter Length** | Specifies the length of the filter. The longer the filter, the better the filtering effect, but it increases the computational load and delay.<br>Range: [2, 400/oversample], must be an even number. |
| **PN** | Sets the order of the pseudo-random noise sequence (default is 15). A larger order generates a sequence with a longer period.<br>Range: [4, 24].<br>Note: If the PN order is set too high, the generated waveform may become too large to be fully downloaded into the instrument internal memory. In this case, the following options are available in the confirmation dialog:<br>1. Cancel waveform generation and adjust the parameters;<br>2. Continue waveform generation. The complete original IQ data can still be saved using "Save IQ Data", but the data downloaded to the instrument will be truncated;<br>3. Generate the complete waveform in the software background and automatically switch to Streaming mode. |
| **Sequence Seed** | Sets the initial value of the PN sequence generator (default: 23). By using the same seed value, the generated sequence can remain identical each time, which is convenient for repeatable testing and debugging. |
| **Oversample** | Specifies the number of samples per symbol. A higher oversampling factor results in a smoother waveform and reduced spectral aliasing, but also increases the data size.<br>Range: [2, 32], must be an even number |
| **FSK Deviation** | Sets the frequency deviation of the signal in FSK modulation mode.<br>Range: 1 Hz to 15 * symbol rate. |
| **Default Trim Download** | For certain configurations (such as a large PN length), when the generated baseband IQ data exceeds 125 MB, the data will be truncated before being downloaded to the instrument's internal memory. |
| **Save IQ Data** | Supports exporting the complete digitally modulated baseband raw IQ data generated under the current parameter configuration as a WAV file. |
| **Show WaveForm** | Displays the I/Q time-domain waveform, frequency-domain spectrum, and the constellation diagram specific to digital modulation for the currently configured signal. |

### 5.7.2 Operating Procedure

1. In the mode selection area, click "Digital Modulation" and set "Modulation Type" to 64QAM;
2. Set the data source to PN15, set "Oversampling" to 4, and set "Symbol Rate" to 1 MHz;
3. Set "Filter Type" to Root Raised Cosine, set "Filter Roll-Off Factor" to 0.35, set "Filter Length" to 16, and enable the digital modulation function;
4. Click "Show WaveForm" to view the I/Q time-domain waveform, frequency-domain spectrum, and constellation diagram.


Figure 17 Display waveform previews in digital modulation mode

5. Set the carrier "Frequency" to 1 GHz and "Power" to -20 dBm, then enable the RF output switch;
6. The instrument outputs a 64QAM digitally modulated signal with a center frequency of 1 GHz, a peak power of -20 dBm, and a symbol rate of 1 MHz.


figure 18 64QAM Demodulation

## 5.8 DSSS

Using a DSSS (Direct Sequence Spread Spectrum) signal with a carrier frequency of 1 GHz, power level of -20 dBm, symbol rate of 300 kHz, BPSK modulation, and spreading code order of 6 as an example:

### 5.8.1 Parameter Description

**Table 19 DSSS Parameter Description**

| DSSS | |
|---|---|
| **Symbol Rate** | Number of symbols transmitted per second in the raw data<br>Constraint: Symbol rate ≤ Sampling rate / (Oversampling * (2^PN – 1)) |
| **Filter Type** | Rectangular, Raised Cosine, Root Raised Cosine, Gaussian, Half-Sine |
| **Filter Alpha** | Specify the roll-off factor for the filter.<br>Raised Cosine / Root Raised Cosine: [0.025,1]; Gaussian: [0.15,2.5] |
| **Filter Length** | Number of taps (order) for the filter. A greater length results in a filtering effect closer to the ideal, but at the cost of higher computational complexity. Range: Even integers in [2, 400/OverSample]. |
| **Oversample** | Number of sample points per chip period. A higher oversampling rate results in a larger data volume and better signal quality.<br>Range: [4,32], must be an even number. |
| **Sequence Seed** | Initial value used to generate the pseudo-random sequence, ensuring that the generated sequence can be reproduced each time. |

| | |
|---|---|
| **Modulation Type** | Currently, only BPSK modulation is supported. |
| **Code** | Order of the spreading code, range [4,16]<br>The higher the order, the longer the generated spreading code sequence (length = 2^ n-1), resulting in higher spreading gain and stronger anti-jamming and anti-interception capabilities. However, a higher order also increases system computational complexity and implementation difficulty. |

### 5.8.2 Operating Procedure

1. In the mode selection area, click "DSSS";
2. In the control area, set the "Code" to 6, set "Oversample" to 4, "Symbol Rate" to 300 kHz, and enable the DSSS function;
3. Set "Frequency" to 1 GHz, "Level" to -20 dBm, and enable the RF output;

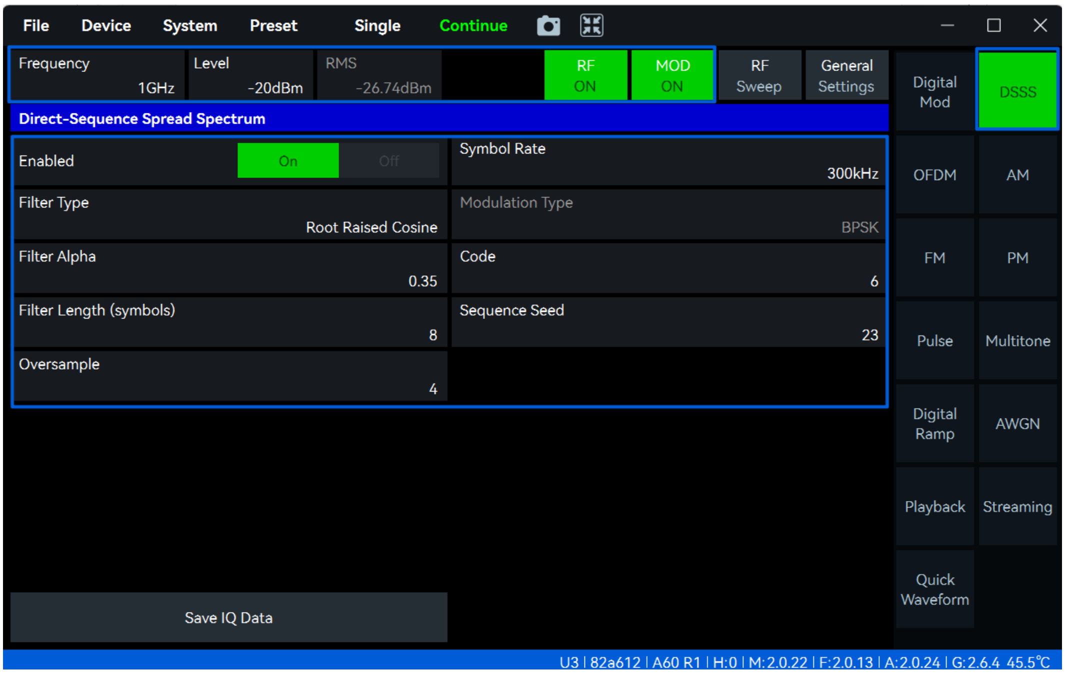


figure 19 DSSS

4. The instrument outputs a DSSS signal with a carrier frequency of 1 GHz, a peak power of -20 dBm, a symbol rate of 300 kHz, BPSK modulation, and a spreading code order of 6.

## 5.9 OFDM

### 5.9.1 Parameter Description

**Table 20 OFDM Parameter Description**

| **OFDM** | |
|---|---|
| **Modulation Type** | Set the modulation scheme used on each sub-carrier<br>Available options: BPSK, QPSK, 8PSK, 16PSK, QAM16, QAM64, QAM256 |
| **FFT Size** | Configure the total number of subcarriers for OFDM modulation<br>Range: 2 ^ n, where n ∈ {4, 5, 6, 7, 8, 9, 10, 11} |
| **Sample Rate** | Waveform Sampling Rate |
| **Carrier Spacing** | Displays the frequency interval between two adjacent sub-carriers under the current configuration.<br>Frequency Interval = Sample Rate / FFT Size. |
| **Symbol Count** | Set the number of OFDM symbols per burst.<br>Range: [2,16384]. |
| **Guard Band Carriers (Left)** | Set the number of low-frequency edge guard sub-carriers. These are not used for data transmission and serve as guard bands. |
| **Guard Band Carriers (Right)** | Set the number of high-frequency edge guard sub-carriers. These are not used for data transmission and serve as guard bands. |
| **Guard Interval (%)** | Set the Cyclic Prefix length as a percentage of the entire OFDM symbol. This provides protection against multipath interference. |
| **Null DC** | Enable: Disable the DC subcarrier (DC nulling is recommended)<br>Disable: Enable the DC subcarrier. |
| **Windowed** | Whether a window function should be applied to the time-domain waveform of the OFDM symbols to mitigate spectral leakage. |
| **Window Length (%)** | Set the percentage of the windowing function applied to both ends (bilateral) of the OFDM symbol. This value represents the total length of the window function as a percentage of one OFDM symbol's duration. The window function applies symmetrically to the leading and trailing edges of the symbol.<br>Setting range: 0% to 100%, default: 50% (25% on each side). |

### 5.9.2 Operating Procedure

Using the output of an OFDM signal closely matching the IEEE 802.11a standard as an example, the configuration steps are as follows:

1. In the mode selection area, choose "OFDM", set "Modulation Type" to BPSK, "FFT Size" to 64, "Sample Rate" to 20 MHz, "Guard Band Carriers (Left)" to 6, "Guard Band Carriers (Right)" to 5, and "Guard Interval (%)" to 25%. Leave the remaining parameters at their default values, then enable the OFDM signal mode to activate the current configuration;
2. Click "Save IQ Data" to save the current OFDM baseband signal in .wav format to the default

folder "SGStudio/data";

3. Set the carrier "Frequency" to 5.18 GHz and "Level" to -10 dBm. Enable the RF output;

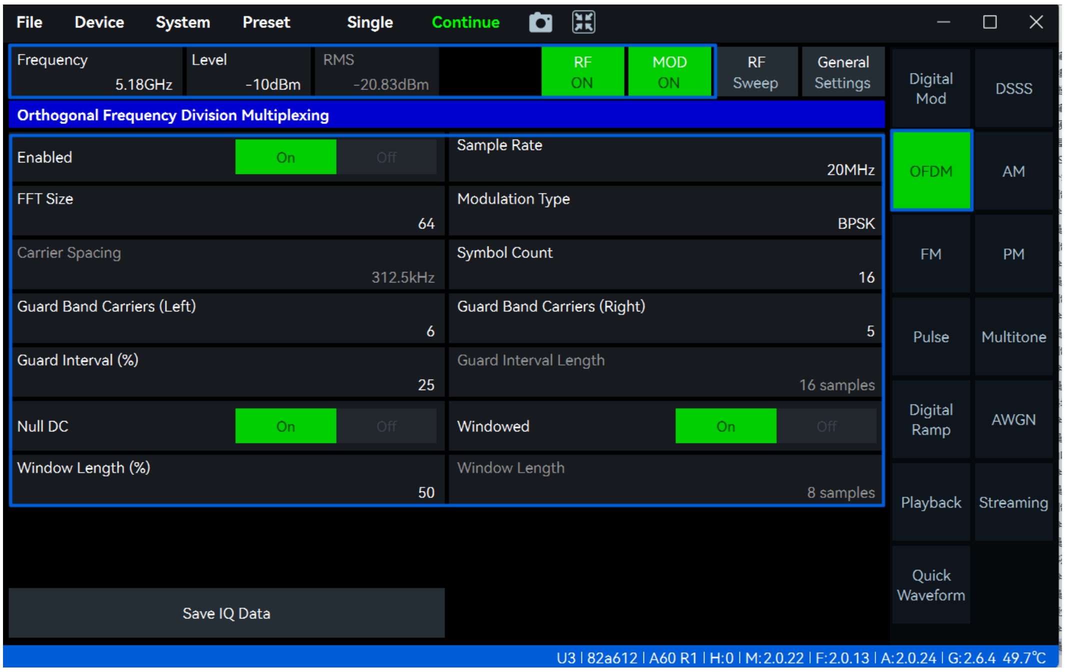


figure 20 OFDM Modulation

4. After completing the above settings, the instrument will output an OFDM signal with characteristics approximating those of the IEEE 802.11a standard.

## 5.10 Multitone

### 5.10.1 Parameter Description

**Table 21 Multitone Parameter Description**

| **Multitone** | |
|---|---|
| **Tone Phase** | Sets the initial phase generation method for each tone. Options include Fixed, Random, or Parabolic. Different phase modes affect the crest factor and dynamic range of the multitone signal. |
| **Phase Random Seed** | Provides the initial seed value for the pseudo-random number generator used in "Random" phase mode. |
| **Tone Count** | Sets the number of discrete tones to be generated. |
| **Frequency Spacing** | Sets the frequency spacing between adjacent discrete tones.<br>(Tone Count - 1) * Frequency Spacing ≤ Playback Bandwidth Supported by the Instrument. |
| **Discrete Tone Mode** | On: Configures the discrete tones in the multitone signal to be evenly spaced.<br>Off: Allows in-band notch filtering (notching) of the multitone signal by configuring the notch bandwidth. |
| **Notch Width** | Sets the bandwidth of the notch filter.<br>Discrete tones within the notch range will be disabled. |

| | |
|---|---|
| **Frequency Offset** | Displays the frequency offset of each discrete tone relative to the RF center frequency. |
| **Enabled** | Independently enables or disables a specific indexed tone. |

### 5.10.2 Operating Procedure

The following example demonstrates how to generate a multitone signal containing 5 discrete tones, with a spacing of 2 MHz between each tone and a center frequency of 2.44 GHz.

1. Select "Multitone" in the mode selection area;
2. Set "Tone Count " to 5, set "Frequency Spacing" to 2 MHz, and enable Multitone mode;
3. Set the carrier "Frequency" to 2.44 GHz and "Level" to -10 dBm, then enable the RF output switch;
4. After completing the above settings, the instrument will output the corresponding multitone signal. The discrete tones will be distributed around the center frequency with a spacing of 2 MHz.

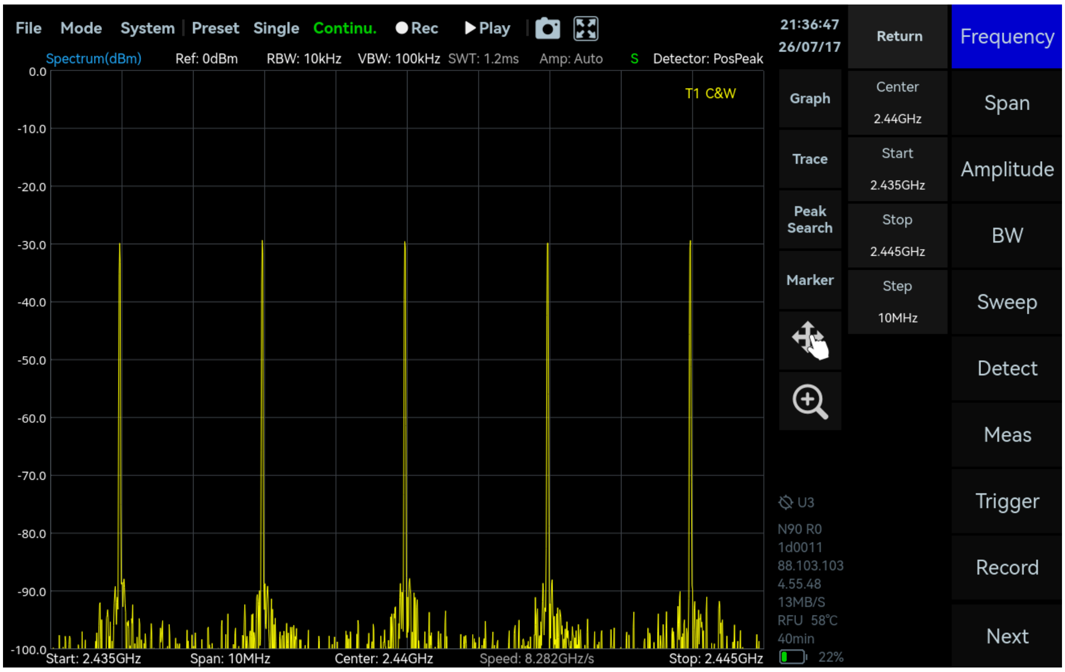


figure 21 Multitone

## 5.11 Playback

The Playback mode, also known as the arbitrary file output function, supports the playback of .wav waveform files, providing users with a highly flexible test signal generation solution. This function adopts a preloaded storage mechanism to achieve high-performance signal output. The software first loads the IQ waveform data into the instrument's internal memory, and the instrument directly plays back the preloaded data during operation. By avoiding real-time transmission bandwidth limitations, the system ensures stable output of various complex waveforms at the maximum analog bandwidth.

### 5.11.1 Parameter Description

**Table 22 Playback Parameter Description**

| **Playback** | |
|---|---|
| **Sample Rate** | Sets the sampling rate of the arbitrary waveform. It is recommended to match the original waveform's sampling rate to avoid distortion. |
| **Auto Scale** | Enabled: The system automatically adjusts the amplitude of I/Q waveform data so that the maximum sample value maps to full-scale output.<br>Disabled: The waveform is output according to the set I/Q scaling ratio. |
| **I/Q Ratio (%)** | When auto scaling is disabled, this ratio scales the amplitude of I and Q data. 100% means no scaling. Adjustable range: 1% to 100%. |
| **Period** | Displays the total number of samples in the loaded waveform file.<br>If the user sets a number of points greater than the original, zeros are automatically appended at the waveform tail. |
| **Sample Offset** | Sets the starting playback point within the arbitrary waveform file |
| **Samples To Use** | Number of samples actually used for output, starting from the point offset. |
| **Load** | Loads a file in WAV format. The maximum file size depends on the storage depth of the current instrument. |
| **Unload File** | Clears the currently loaded file, resetting related file parameters to "N/A" or 0. |
| **File Name** | Displays the name of the loaded file. "N/A" indicates no file is loaded. |
| **Samples In File** | Total I/Q sample pairs contained in the file. Determined by file size and format; automatically updated after loading. |
| **Signal Length** | Actual playback duration based on Used Points and Sampling Rate:<br>Signal Length = Samples To Use / Sample Rate. |
| **Period Length** | Original duration of the file's data:<br>Period Length = Samples In File / Sample Rate. |

### 5.11.2 Operating Procedure

Using the output of an externally generated .wav IQ waveform file as an example, the operating procedure is as follows:

1. Use signal editing software or other tools to generate a complex baseband signal with a sample rate of 10 MHz, save it in .wav format with a file size not exceeding the instrument's built-in memory depth (for example, QPSK_signal.wav), and store the file in the ../data folder;

2. Click "Playback" in the mode selection area to enter the arbitrary file playback interface, then click "Load";
3. In the pop-up file selection window, select the QPSK_signal.wav file in the data folder and click "Open" to complete the loading process;
4. After the file is successfully loaded, the interface will display the total number of samples and the corresponding playback duration. Set the "Sample Rate" to 10 MHz, while the remaining parameters can be adjusted according to actual requirements (in this example, all other parameters remain at their default settings), then enable the playback function;
5. Set the carrier "Frequency" to 1 GHz and the "Level" to -20 dBm, then enable the RF output switch;
6. The signal generator will modulate the baseband IQ data from the loaded .wav file onto a 1 GHz carrier and output the RF signal from the RF port with a peak power of -20 dBm.

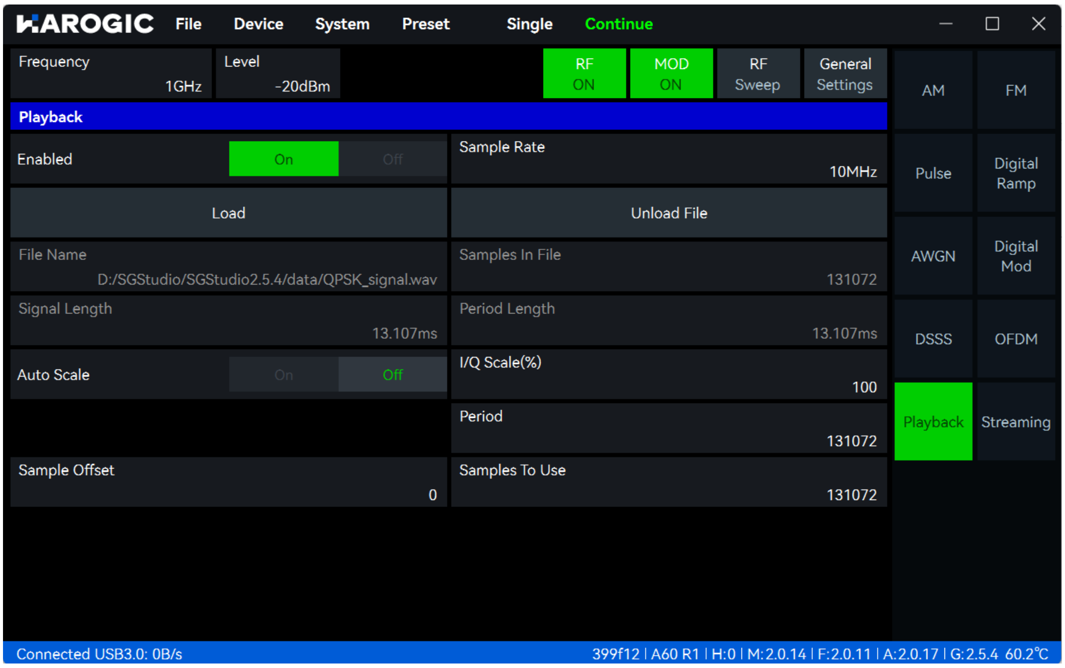


Figure 22 Playback mode

## 5.12 Streaming

Streaming mode is a mode that continuously outputs one or more WAV-format complex baseband waveform files as RF signals. Data is loaded and transmitted in real time from an external file system, enabling large-capacity and highly continuous signal output.

### 5.12.1 Parameter Description

**Table 23 Streaming Mode Parameter Description**

| Streaming | |
|---|---|
| **Sample Rate** | Set the sampling rate of the waveforms in the file list. It is recommended to match the original sampling rate of the signal to avoid distortion. No resampling is performed when the sampling rates are inconsistent. |
| **Load Files** | Add waveform files to the file list for playback. Currently, only WAV format is supported. |
| **Unload Files** | Remove all waveform files from the file list. |
| **Remove File** | Remove the selected waveform file from the file list. |

### 5.12.2 Operating Procedure

1. Use signal editing software to generate multiple .wav format complex baseband waveforms (such as signal1.wav, signal2.wav, etc.) with a sampling rate of 10 MHz, and save these files to the /data folder under the software directory;
2. Click "Streaming" in the mode selection area to enter the stream mode interface. Click "Load Files", select the signal1.wav file in the pop-up file selection window, and click "Open" to complete the loading process. To add multiple files, repeatedly click "Load Files" and select additional .wav files in sequence (such as signal2.wav, signal3.wav, etc.);
3. After the files are successfully loaded, the interface will display the number of files, total sample points, and total duration in the file list. Set the "Sample Rate" to 10 MHz. Other parameters can be adjusted according to actual requirements (in this example, all other parameters remain at their default settings), then enable the stream mode function;
4. Set the carrier "Frequency" to 1 GHz and the "Level" to -20 dBm, then enable the "RF" switch;
5. The instrument will then modulate and output the loaded waveform files, continuously playing them in a loop. The playback progress will be displayed in real time in the stream mode interface.

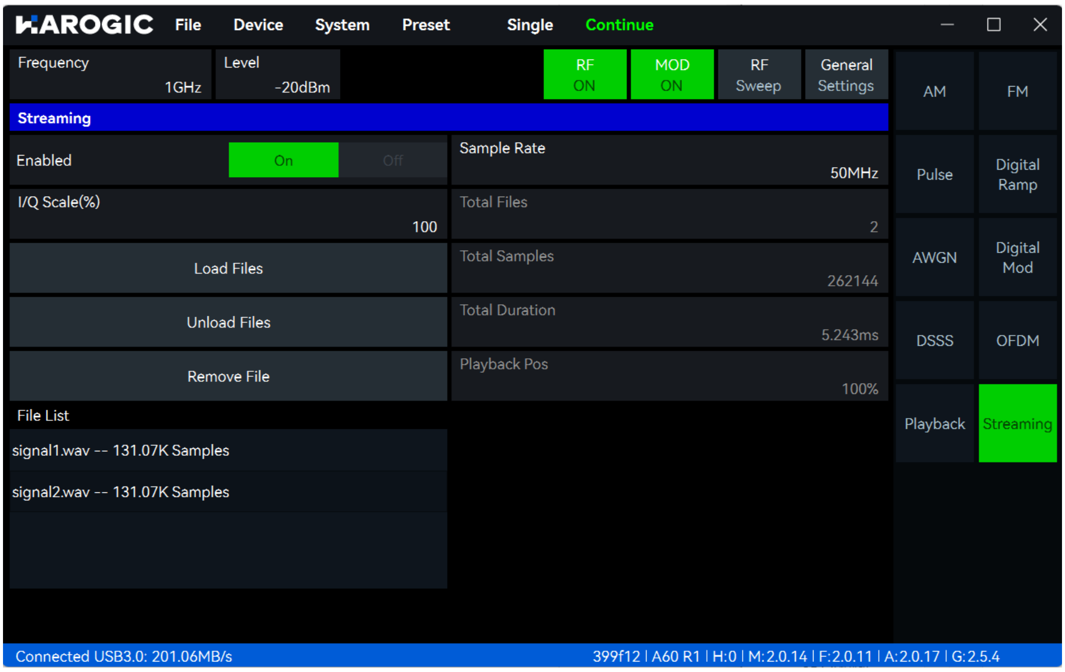


Figure 23 Streaming mode

## 5.13 Quick Waveform

In quick waveform mode, some preloaded waveform files in .wav format are available. You can directly select the desired waveform and output it quickly.

### 5.13.1 Parameter Description

**Table 24 Quick Waveform Parameter Description**

| Quick Waveform | |
|---|---|
| **Sample Rate** | Once the file is loaded successfully, the native sample rate of the current file is displayed automatically. The user can further modify this value as needed. |
| **Load File** | Click to select the WAV file from the file list and load it into the instrument's internal memory. Only after successful loading can the Quick Waveform Mode be enabled. |
| **Auto Scale** | Enabled: The system automatically adjusts the amplitude of I/Q waveform data so that the maximum sample value maps to full-scale output.<br>Disabled: The waveform is output according to the set I/Q scaling ratio. |
| **I/Q Ratio (%)** | When auto scaling is disabled, this ratio scales the amplitude of I and Q data. 100% means no scaling. Adjustable range: 1% to 100%. |
| **Period** | Displays the total number of samples in the loaded waveform file.<br>If the user sets a number of points greater than the original, zeros are automatically appended at the waveform tail. |
| **Samples To Use** | Number of samples actually used for output, starting from the sample offset. |
| **Sample Offset** | Set the starting sample point position for waveform output.<br>The system will start reading waveform data from this offset position for output. |
| **File Name** | Display the name of the currently pre-loaded waveform file. |
| **Samples In File** | Total I/Q sample pairs contained in the file. Determined by file size and format; automatically updated after loading. |
| **Signal Length** | Actual playback duration based on Used Points and Sampling Rate: Signal Length = Samples To Use / Sample Rate. |

### 5.13.2 Operating Procedure

The following steps use the instrument's preset 16QAM signal as an example to introduce the basic operation of Quick Waveform mode.

1. Select "Quick Waveform" in the mode selection area.
2. Select "QAM" -> "16QAM.wav" from the file list and click "Load Files" to load the selected waveform into the instrument's internal memory.
3. Once the file is loaded successfully, the software will automatically parse and display the Sample Rate, total sample points, and signal length of the current file. Adjust the

corresponding parameters according to the test requirements, and then enable Quick Waveform mode.

4. Set the Carrier Frequency to 1 GHz and the Level to -20 dBm, then enable the RF switch.
5. After completing the above settings, the instrument will output the 16QAM Quick Waveform signal at a carrier frequency of 1 GHz and a peak power of -20 dBm.

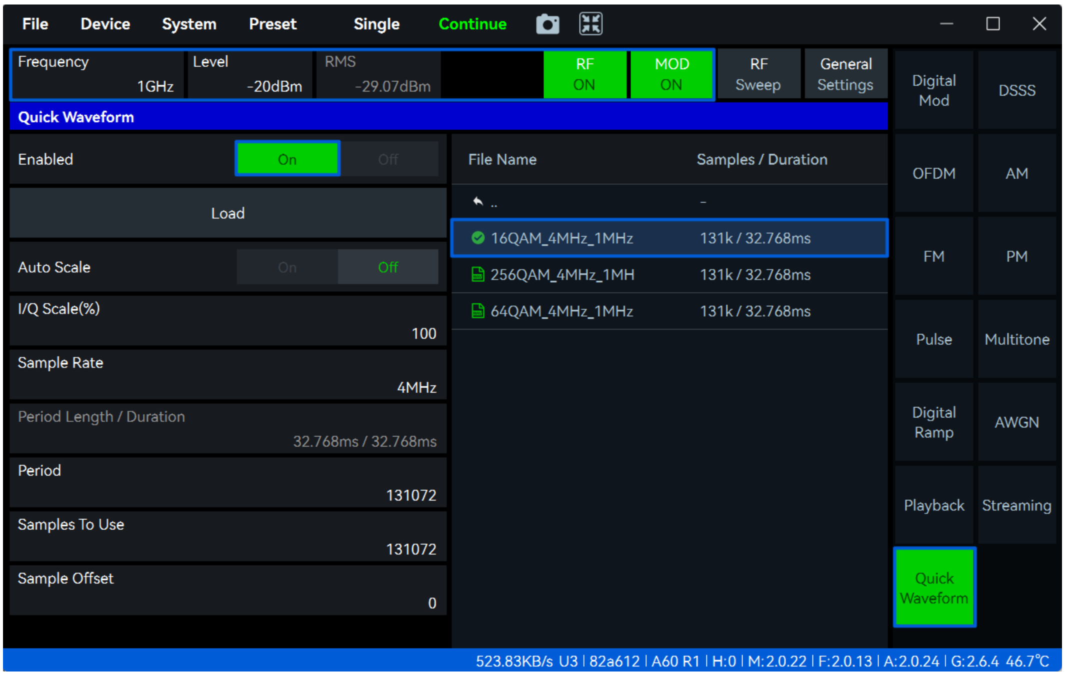


Figure 24 Play the 16QAM Quick Waveform signal.

# 6. Software and Firmware Update

This section describes how to update the instrument's software, FPGA, MCU, and Bus versions.

## 6.1 Version Requirements

1. Refer to the viewing instrument information section to check the software and firmware versions;
2. For all instruments, ensure that the GUI version is 2.5.4 or above;
3. If the software indicates that the update cannot be performed, please contact official technical support.

## 6.2 Parameter Description

**Note**: Displays the current and target versions of the software, FPGA, MCU, and Bus;

**Update Content**: Provides detailed information about the changes in the target version;

**Update Notification**: Sets whether to automatically pop up an update notification window when a new version is detected;

**Update Method**: The update methods are described in the table below.

**Table 25 Update Method Description**

| Update Method | Description |
|---|---|
| **Online** | Automatically connects to the remote server to download and install the latest software and firmware versions. |
| **Default** | Restores the firmware to the version corresponding to the current software version. |
| **Local** | Manually loads an update package from a USB drive or local storage for installation. |

## 6.3 Online Update

1. Click "System" -> "Update" to enter the update interface;
2. Check the "Update Notification" checkbox. When the device is connected to the Internet, the software automatically displays the Update window if a new version is detected during startup or operation;
3. Set the "Update Method" to Online. The system will then start downloading the update package, and the "Update" button will be temporarily disabled. After the package is successfully downloaded and parsed, detailed release notes will be displayed in the window, and the "Update" button will become enabled;

4. Carefully compare the information between the current version and the target version, and review the new features and fix list. Once confirmed, click the "Update" button in the lower-right corner;
5. After clicking, the software will automatically exit and enter the upgrade process. Please keep the update window open until the progress bar completes and the software automatically restarts and returns to the main interface.

# Appendix

## Appendix 1: Record File Format Description

The saved baseband IQ data uses the standard WAV format. The file is encapsulated using the standard RIFF/WAVE structure, with an extended custom prof chunk for storing waveform generation parameters and a data chunk for storing PCM16 IQ baseband data.

**Table 1 WAV Format Description**

| Byte Offset | Description |
|---|---|
| 0 ~35 | WAV file header information, including the RIFF identifier, file length, WAVE type, and fmt format chunk information. |
| 36 ~ 43+A | Custom prof parameter chunk used to store waveform generation parameters of the signal generator. |
| 44+A ~ End of File | data chunk, including the data identifier, data length, and PCM16 IQ waveform data. |

Definitions:

- A = P + Pad: The actual length occupied by the prof data area;
- P indicates the actual UTF-8 byte length occupied by the JSON parameters in prof;
- Pad = P & 1: The byte-alignment padding length.

**Table 2 Detailed Description of the .wav Format**

| | Chunk | Byte Index | Byte Count | Data Type | Field Name | Field Description | Endianness |
|---|---|---|---|---|---|---|---|
| **RIFF File Header Information** | RIFF | 0 | 4 | | Document Identifier | "RIFF" | |
| | | 4 | 4 | uint32_t | Data Length | Chunk Length | Little Endian |
| | | 8 | 4 | | File Format Type | "WAVE" | |
| **fmt Chunk Description** | fmt | 12 | 4 | | Format Chunk Identifier | "fmt " | |
| | | 16 | 4 | uint32_t | Chunk Length | 16 | Little Endian |
| | | 20 | 2 | uint16_t | Audio Format Code | PCM | Little Endian |
| | | 22 | 2 | uint16_t | Number of Channels | I/Q dual-channel | Little Endian |
| | | 24 | 4 | uint32_t | Sampling Frequency | IQ SampleRate, Hz | Little Endian |
| | | 28 | 4 | uint32_t | Byte Rate | SampleRate*4 | Little Endian |
| | | 32 | 2 | uint16_t | Block Alignment | 4 | Little Endian |
| | | 34 | 2 | uint16_t | Bits per Sample | 16 | Little Endian |
| **Prof Stores waveform generation parameters in UTF-8 JSON format** | prof | 36 | 4 | char | Format Chunk Identifier | “prof” | |
| | | 40 | 4 | uint32_t | Chunk Length | JSON data length | Little Endian |
| | | 44 | P | | Profile JSON | Waveform parameter information | Little Endian |
| | | 44+P | Pad | uint8_t | Padding | Byte-alignment padding length. When P is odd, Pad = 1; when P is even, Pad = 0. | Little Endian |
| **Data** | | 44+A | 4 | Char | Format Chunk Identifier | “data” | |
| | | 48+A | 4 | uint32_t | Chunk Length | IQ data length | Little Endian |
| | | 52+A | 2 | Int16 | I0 | I component of the 0th complex sample | Little Endian |
| | | 54+A | 2 | Int16 | Q0 | Q component of the 0th complex sample | Little Endian |
| | | 56+A | 2 | Int16 | I1 | I component of the 1st complex sample | Little Endian |
| | | 58+A | 2 | Int16 | Q1 | Q component of the 1st complex sample | Little Endian |
| | | | | | ………….. | | |

The prof chunk is used to store the configuration parameters of the waveform generated by the signal generator. It is stored in a compact UTF-8 encoded JSON format. Different waveform types correspond to different JSON fields.

**Table 3 JSON Field Description for Each Waveform Type**

| Waveform Type | JSON Parameter Fields |
| --- | --- |
| **Digital** | SymbolRate, PN, FSKDeviation, Oversample, FilterAlpha, FilterLength, SequenceSeed, ModulationType, FilterType |
| **DSSS** | SymbolRate, Code, Oversample, FilterAlpha, FilterLength, SequenceSeed, ModulationType, FilterType |
| **OFDM** | ModulationType, FFTSize, SymbolCount, GuardBandCarriersLeft, GuardBandCarriersRight, GuardInterval, WindowLength, NullDC, Windowed, SampleRate |
| **AM** | Rate, Depth, Shape |
| **FM** | Rate, Deviation, Shape |
| **PM** | Rate, PhaseDeviation, InitPhase, Shape |
| **Pulse** | Width, Period |
| **AWGN** | Bandwith, Length |
| **Ramp** | Span, SweepTime, Period |
| **Multitone** | PhaseMode, FixedPhaseOffset, Seed, NotchWidth, Count, FreqSpacing, DiscreteKeepToneMode, EvenCountCenterToneMask, EnabledToneIndices |

Notes:

- The capitalization of JSON field names is part of the file format definition and shall be preserved exactly.
- Enumeration parameters such as ModulationType are stored as strings.
- The Shape parameter is stored as the string representation of the enumeration name.
- In OFDM, NullDC and Windowed are stored as JSON number types.
- The prof chunk is used to restore waveform generation parameters. Actual IQ waveform reconstruction depends on the SampleRate in the file header and the data contained in the data chunk.

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