RIGOL

LoRaWAN Test

For RSA6000 Series Spectrum Analyzer

User Guide

Apr. 2026

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Section	Description	Page

1 Document Overview

This manual gives you a quick review about the operation methods for the functions of LoRa measurement in the VSA mode of RSA6000 series.

For the general functions of the VSA mode, its quick operation key operation, and system settings of the RSA6000 series spectrum analyzer, refer to *RSA6000 VSA User Guide*.

TIP

For the latest version of this manual, download it from the official website of RIGOL (*http://www.rigol.com*).

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Software upgrade might change or add product features. Please acquire the latest version of the manual from RIGOL website or contact RIGOL to upgrade the software.

Format Conventions in this Manual

1. **Key**

   The front panel key is denoted by the menu key icon. For example, 

   indicates the "System" key.

2. **Menu**

   The menu item is denoted by the format of "Menu Name (Bold) + Character Shading" in the manual. For example, **Setup** indicates clicking or tapping the "Setup" sub-menu under the system menu to view the basic setting configuration items.

3. **Operation Procedures**

   The next step of the operation is denoted by "**>**" in the manual. For example,  **>** **Save** indicates that first clicking or tapping the icon  , then clicking or tapping **Save**.

4. **Connector**

   The connectors on the front or rear panel are usually denoted by the format of "Connector Name (Bold) + Square Brackets (Bold)". For example **[TRIG IN]**.

Content Conventions in this Manual

The RSA6000 series spectrum analyzer includes the following models. Unless otherwise specified, this manual takes RSA6265 as an example to illustrate the functions and operation methods of the RSA6000 series.

Model	Frequency Range
RSA6265	5 kHz to 26.5 GHz
RSA6140	5 kHz to 14 GHz
RSA6085	5 kHz to 8.5 GHz

2 LoRa Measurement Introduction

LoRa (Long Range) is a core physical layer modulation technology for Low Power Wide Area Networks (LPWAN), specifically designed for the Internet of Things (IoT). Based on Chirp Spread Spectrum (CSS) technology, LoRa is recognized as one of the fundamental radio frequency core technologies for IoT wide-area wireless communication.

LoRa Technology

- **Modulation Scheme:**

  Uses CSS to improve signal anti-interference.

- **Key Parameters:**

  SFactor, bandwidth (125 kHz/250 kHz/500 kHz), channel coding rate, etc.

- **Spread Spectrum Characteristics:**

  Supports variable spreading factors from SF7 to SF12, enabling multi-SF coexistence on the same frequency to improve spectral efficiency.

- **Frame Structure:**

  Composed of Preamble, Sync Word, Header, Payload, and CRC. The header can be configured as explicit or implicit, and CRC can be disabled, minimizing frame overhead and adapting to burst transmission.

- **Bandwidth and Rate:**

  The transmission rate is determined by spread spectrum factor (SF), bandwidth, and coding rate (CR4/5~CR4/8), and the low rate adapts to the scenarios where IoT that requires small data volume transmission.

LoRa Measurement Introduction

The LoRa measurement function is a dedicated software application embedded in RIGOL's RSA6000 spectrum analyzer in the VSA mode. It enables you to perform R&D validation and troubleshooting analysis of LoRa signals.

- **Spectrum Analysis:**

  RF/AF spectrum display, channel power, occupied bandwidth, spurious emission measurements

- **Modulation Demodulation:**

  Chirp signal demodulation, frequency deviation (peak/RMS), carrier frequency error, burst length/payload length statistics

- **Protocol Decode:**

Demodulated bitstream output, valid data decode, CRC status check, sync byte identification

- **Stability Analysis:**

  Frequency drift (RMS/peak), symbol level frequency offset tracking

3 User Interface of LoRa Measurement

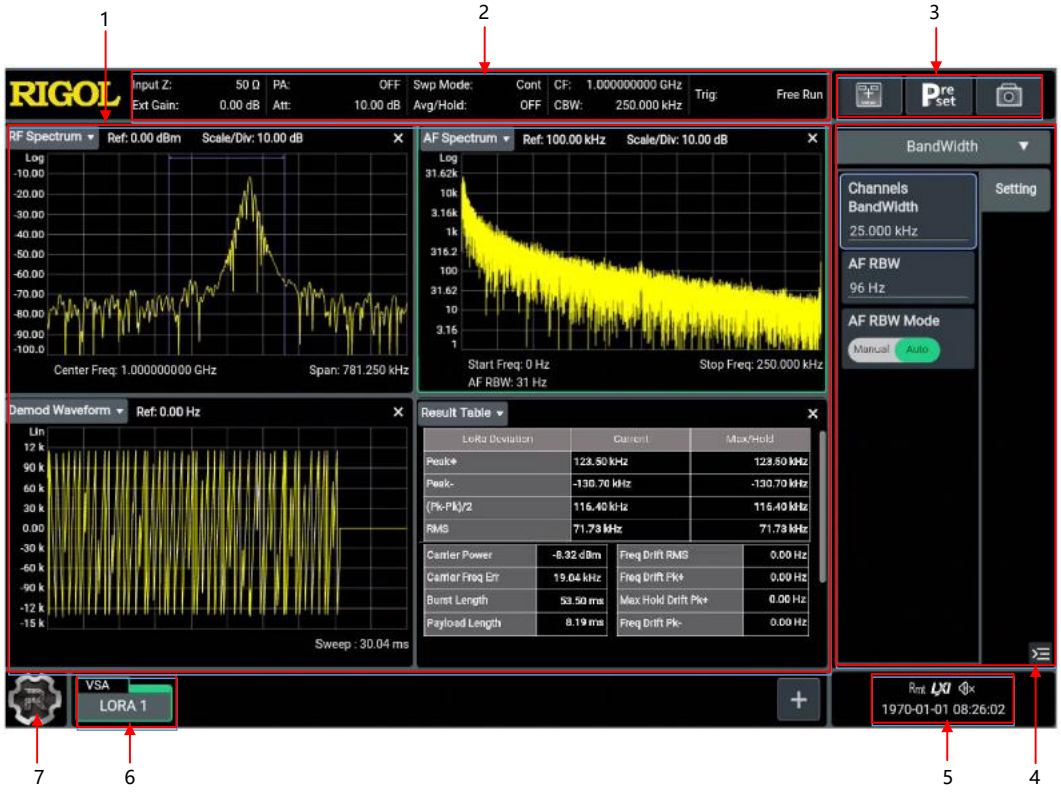


Figure 3.1 User Interface

1. Multi-pane Display Area

Displays different display views for LoRa measurement. The signal can be analyzed and tested in various views.

2. Status Display Bar

- Input Z: input impedance. By default, it is 50 Ω. It can be set to 50 Ω or 75 Ω.
- Ext Gain: external gain. It can be set in the **Input/Output** menu.
- PA: Preamplifier (PA). It can be set to ON or OFF, available to be set in the **Amplitude** menu.
- Att: Attenuation value. It can be set in the **Amplitude** menu. In this menu, you can also set the attenuation mode to **Manual** or **Auto**.
- Swp Mode: sweep mode. It can be set to **Cont** or **Single**. Cont indicates continuous sweep; Single indicates single sweep.

- Avg/Hold: enables or disables the average hold function. It is presented in (current averaging times/total averaging count) form. It can be set in the **Meas Setup** > **Setting** menu.
- CF: center frequency. It can be set in the **Frequency** menu.
- CBW: channel bandwidth. It can be set in the **BandWidth** menu.
- Trig: trigger source. It can be set in the **Trigger** menu. The available choices include Free Run, External, and IF Power. When you select External or IF Power as the trigger source, Trig Delay will also be displayed in the status display bar.

3. Quick Operation Key

Adds a view; restores to its default settings; captures the screenshot

4. Menu Operation Area

Selects the specified menu to configure the relevant parameters. For example, Frequency, Amplitude, BandWidth, Meas Setup, Marker, etc.

5. Notification Area

Displays the USB storage device icon, LAN connection icon, sound icon, remote control icon, and system time. Click or tap this area, then the **System** menu is displayed. You can set the system-related parameters.

6. Working Mode

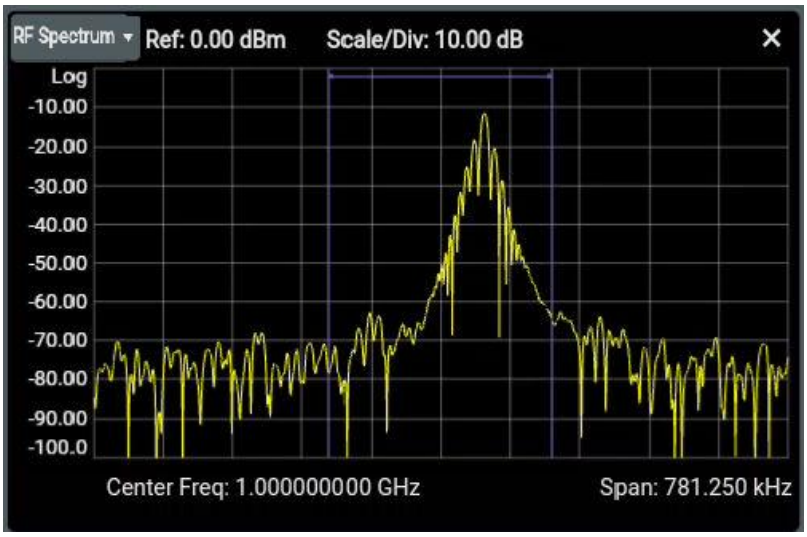
Displays the currently selected working mode.

7. Function Navigation Icon

Click or tap the icon  to open the function navigation menu. Click or tap the specified menu icon to enter the specified function setting menu.

3.1 RF Spectrum

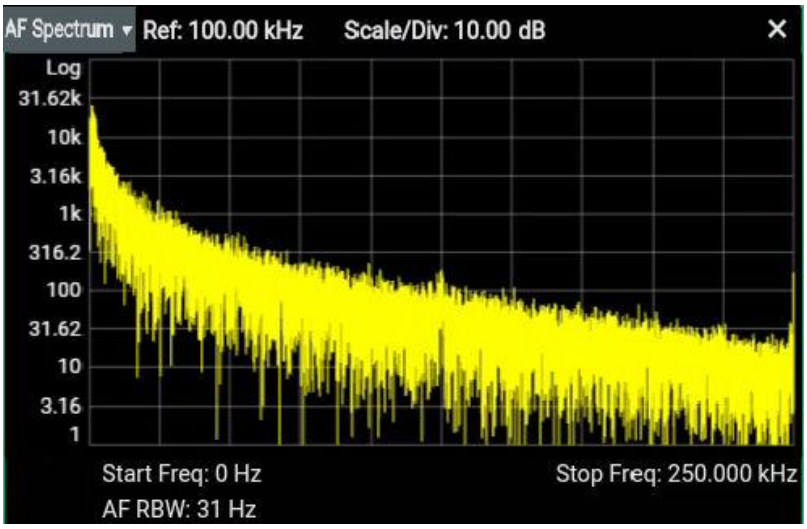
The RF Spectrum view displays the spectrum of the LoRa signal. In this view, its vertical represents logarithmic amplitude in dBm and its horizontal axis represents frequency.



- Center Freq: indicates the center frequency. By default, it is 1 GHz.
- Span: indicates the frequency span. By default, it is 75.000 kHz.
- Ref: indicates the reference power level. By default, it is 0.00 dBm.
- Scale/Div: indicates the Y-axis scale per division. Its unit is dB.
- There is a vertical line at the left and right side of the center frequency, and the spacing between the two vertical lines is equal to the channel bandwidth (Channel BW).

3.2 AF Spectrum

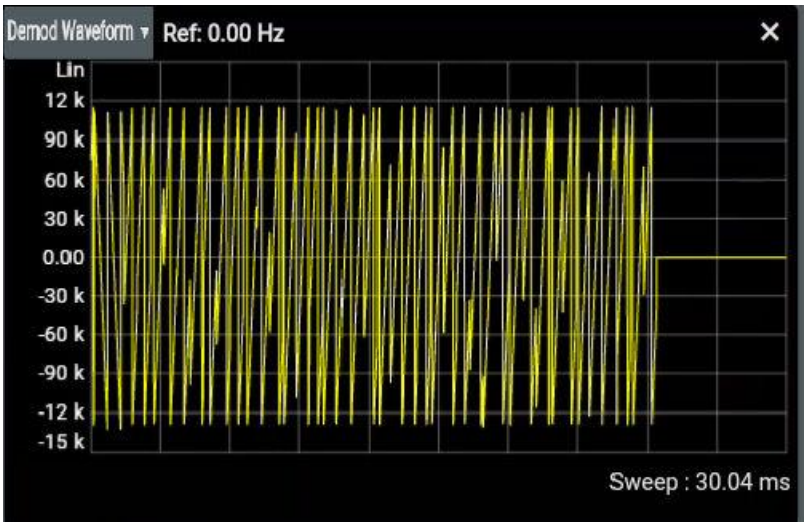
The AF Spectrum view displays the spectrum of the demodulated LoRa signal. Both the horizontal axis and vertical axis represent frequency, with the vertical axis displayed on a dB scale in units of dBm.



- Start Freq: indicates the AF start frequency.
- Stop Freq: indicates the AF stop frequency.
- Ref: indicates the reference frequency of the spectrum.
- Scale/Div: indicates the Y-axis scale per division.
- AF RBW: indicates the AF resolution bandwidth.

3.3 Demod Waveform

The Demod Waveform view displays the demodulated time-domain waveforms. The horizontal axis represents time, and the vertical axis, on a linear scale, expressed in Hz, represents frequency offset of the chirp signal.



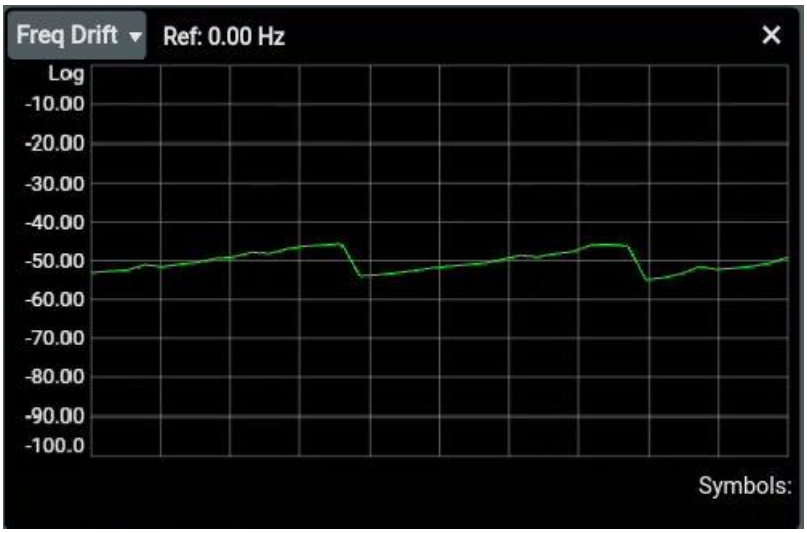
- Ref: indicates the reference frequency of the waveform.
- Sweep: sweep time for the demodulation waveforms. It has a coupling relationship with the sweep points. You can set the sweep points in **Sweep** > **Sweep Points**. The number of sweep points determines the number of waveform points to be demodulated.

3.4 Freq Drift

LoRa is modulated by CSS (chirp spread spectrum) technology, and each of its transmission symbol (symbol, as the basic transmission unit for LoRa) is intentionally applied a frequency offset.

The Frequency Drift view displays the offset of the carrier frequency of the LoRa signal over time.

- The horizontal axis represents the number counted from the first preamble symbol, which is used to locate the time order of each symbol.
- The vertical axis represents the offset of each symbol in Hz from the center frequency, reflecting the actual frequency position of the symbol.
- The curve displayed in the Freq Drift view is the transient frequency drift.



3.5 Result Table

Displays the quantitative metrics of the physical layer of signals.

- Frequency offset metrics display the current and max/hold values (Max/Hold).
  - **Peak+** (frequency offset positive peak): indicates the maximum frequency offset during acquisition.

- **Peak-** (frequency offset negative peak): indicates the minimum frequency offset during acquisition.
- **(Pk – Pk)/2** (frequency offset): indicates half of the peak-peak frequency offset.
- **RMS**: indicates the root-mean-square value of the frequency offset during acquisition.

• Carrier waveform metrics

- **Carrier Freq Err** (carrier frequency error): indicates the difference between the center frequency of the instrument and the detected carrier frequency.
- **Carrier Power**: indicates the average power detected at the carrier frequency.

• Demodulation metrics (signal processing related metrics)

- **Burst Length**: indicates the duration of the burst being analyzed.
- **Payload Length**: indicates the duration of the payload for the burst being analyzed.

  It is calculated according to the formula: Burst Length − Preamble Length.

  Since the preamble length is calculated according to the measurement settings (not the measurement results), in some cases the calculated payload length may be less than 0 and is displayed as "---".
- **Preamble Length**: indicates the duration of the preamble of the burst being analyzed.

  It is calculated based on the settings in **Meas Setup** > **Demod** (e.g.SFactor, Signal Bandwidth, PPLength).

• Frequency drift metrics (signal stability related)

- **Freq Drift RMS**: indicates the root-mean-square value calculated based on all points on the frequency drift trace.
- **Freq Drift Pk+** (frequency drift positive peak): indicates the maximum value on the frequency drift trace.

- **Max Hold Drift Pk+** (Max. Hold value of the frequency drift positive peak): When "Average State" is enabled, it indicates the Max Hold value on the frequency drift trace; when "Average State" is disabled, it displays "---".
- **Freq Drift Pk-** (frequency drift negative peak): indicates the minimum value on the frequency drift trace.
- **Min Hold Drift Pk-** (Min. Hold value of the frequency drift negative peak): When "Average State" is enabled, it indicates the Min Hold value on the frequency drift trace; when "Average State" is disabled, it displays "---".

• Protocol metrics (LoRa Protocol Layer related)

- **Sync Byte #1** (synchronization byte #1): indicates the first 8 bits of the sync word. If the measurement time does not cover the sync byte, then "---" is displayed.
- **Sync Byte #2** (synchronization byte #2): indicates the last 8 bits of the sync word. If the measurement time does not cover the sync byte, then "---" is displayed.

3.6 Demod Bits

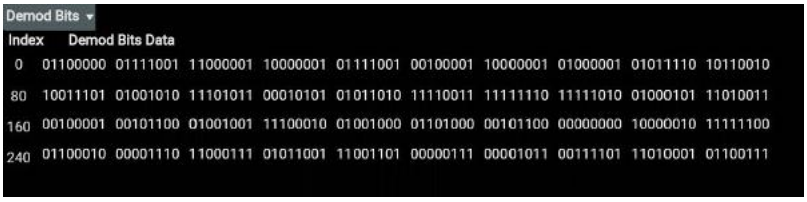
The demod bits view displays the demodulated digital bit stream (0/1 sequence).

In this view, it displays the demodulated bits (de-chirping bits) of each symbol starting from the first preamble symbol in the analyzed burst.

The number of symbols displayed is the one whichever is smaller: the specified number of symbols for the "measurement range" or the total number of actual symbols for that burst.

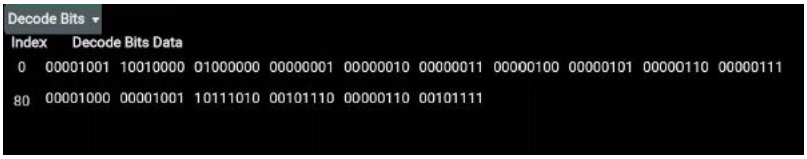
In LoRa (CSS modulation), each symbol corresponds to an integer index k, and its range is from 0 to 2^SF−1 (SF = spread spectrum factor).

The receiver first performs de-chirping on each symbol, then determines the index k of the symbol, and represents k in SF-bit binary format. This sequence of binary bits is called "demodulated bits/dechirps".



3.7 Decode Bits

Displays the payload bits parsed from the bitstream.

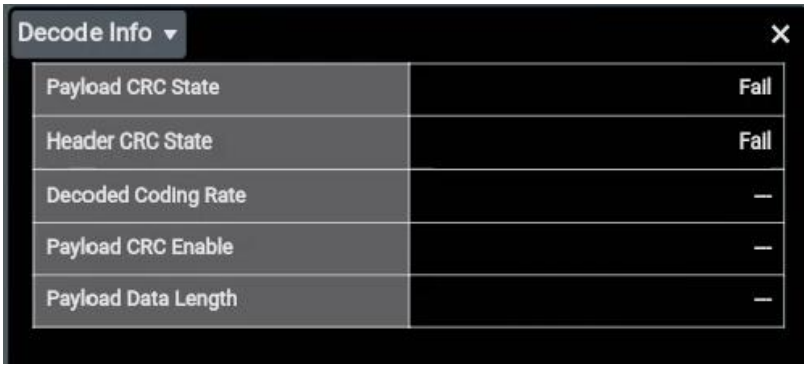


This view displays the decoded bits of the payload symbol being analyzed (CRC included if the payload is carried with CRC).

Ideally, the number of bytes displayed in the view should be equal to the payload length specified in **Meas Setup** > **Decode** > **Payload Length**. 2 additional bytes shall be added to the existing value if CRC is included.

3.8 Decode Info.

The Decode Info view displays the protocol layer status and parameters of the packet.



- Payload CRC State: Pass/Fail
- Header CRC State: Pass/Fail
- Decoded Coding Rate: CR1 to CR4. If the decode fails, -- is displayed.
- Payload CRC Enable: ON/OFF. If the decode fails, -- is displayed.
- Payload Length: ON/OFF. The unit is byte. If the decode fails, -- is displayed.

4 LoRa Measurement

Click or tap the working mode label 

at the lower-left corner of the screen to enter the measurement setting interface.

Figure 4.1 Measurement Setting Interface

Click or tap **LORA** > **Apply** to enter the LoRa measurement interface.

4.1 Frequency

Sets the frequency parameters. You can press 

on the front panel to switch to the frequency setting menu. The analyzer sweeps within a specified frequency range and restarts sweeping every time the frequency parameters are modified.

In this menu, **Center Freq** is, by default, selected.

4.1.1 Center Freq

Sets the center frequency of the current channel. You can view the Center Freq value in the RF Spectrum view.

Key Points:

- When you modify the center frequency, the start and stop frequency will be modified automatically if the span remains to be unchanged.

- Modifying the center frequency indicates that the frequency is changed with the current channel horizontally, and the adjustable range should be within the frequency range specified in the technical specifications of the analyzer.
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.1 Center Frequency

Parameter	Description
Default	1 GHz
Range	2.5 kHz to (F_{max}[1]-2.5 kHz)
Unit	GHz, MHz, kHz, Hz, mHz
Knob Step	span/200
Left/Right Arrow Key Step	CF step

NOTE

[1]: Maximum measurement frequency. It is determined by the instrument model.

4.1.2 Span

Sets the frequency range of the current channel. You can view the span value in the RF Spectrum view.

Key Points:

- Changing this parameter will change the frequency parameters, and after the span is changed, the sweep restarts.
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.2 Span

Parameter	Description
Default	200 kHz

Parameter	Description
Range	5 kHz to 80 MHz
Unit	GHz, MHz, kHz, Hz
Knob Step	span/200
Left/Right Arrow Key Step	at 1-1.5 step

4.1.3 AF Start Freq

Sets the AF start frequency in the AF Spectrum view.

Key Points:

- If the set start frequency is greater than the current stop frequency, then the stop frequency will be modified to (set start frequency + 10 Hz).
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.3 AF Start Freq

Parameter	Description
Default	0 Hz
Range	0 to (40 MHz - 10 Hz)
Unit	GHz, MHz, kHz, Hz
Knob Step	(AF Stop Frequency - AF Start Frequency)/200
Left/Right Arrow Key Step	at 1-1.5-2-3-5-7.5 step

4.1.4 AF Stop Freq

Sets the AF stop frequency in the AF Spectrum view.

Key Points:

- AF stop frequency is only available for the AF Spectrum view.
- If the set stop frequency is smaller than the current start frequency, then the start frequency will be modified to (set stop frequency - 10 Hz).

- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.4 AF Stop Freq

Parameter	Description
Default	10 kHz
Range	10 Hz to 40 MHz
Unit	GHz, MHz, kHz, Hz
Knob Step	(AF Stop Frequency - AF Start Frequency)/200
Left/Right Arrow Key Step	at 1-1.5-2-3-5-7.5 step

4.1.5 CF Step

Used to change the step size for the center frequency. Changing the center frequency by a constant step-size value switches the channel to be measured continuously.

Remarks:

- Set a proper CF step value, and then select the center frequency. Use the Left/Right arrow key to switch the measurement channel at a fixed step size. Thus, the instrument can sweep the adjacent channels manually.
- You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

Parameter	Description
Default	Fmax/10
Range	-Fmax to Fmax
Unit	GHz, MHz, kHz, Hz
Knob Step	span/200
Left/Right Arrow Key Step	at 1-2-5 step

4.1.6 CF Step Mode

The CF step mode consists of "Manual" and "Auto".

Remarks:

- In Auto mode, the CF step is 1/10 of the span.
- In Manual mode, you can use the numeric keys to set the step size.

4.2 Amplitude

Sets the amplitude parameters of the analyzer. You can modify these parameters to make the signals under test be displayed with minimal errors in the current window, easy for you to observe.

4.2.1 Auto Scale

Sets the Y-axis reference value and the Y-axis scale value in the RF Spectrum view, AF Spectrum view, and Demod Waveform view automatically to ensure that the signal can be fully displayed for better observation.

4.2.2 Ref Value

Sets the Y-axis reference value in the RF Spectrum view, AF Spectrum view, Demod Waveform view, and Freq Drift view.

Key Points:

- The default reference value of the Y-axis and its unit are different for the different selected views and demodulation types.
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.6 Ref Value in the RF Spectrum View

Parameter	Description
Default	0 dBm
Range	-170 dBm to 25 dBm
Unit	dBm
Knob Step	(Scale/Div)/10
Left/Right Arrow Key Step	Scale/Div

Table 4.7 Ref Value in the AF Spectrum View

Parameter	Description
Default	100 kHz
Range	1 Hz to 100 MHz
Unit	Hz, kHz, MHz, GHz
Knob Step	1
Left/Right Arrow Key Step	10

Table 4.8 Ref Value in the Demod Waveform View

Parameter	Description
Default	0 Hz
Range	-1 MHz to 1 MHz
Unit	Hz, kHz, MHz, GHz
Knob Step	0.1
Left/Right Arrow Key Step	1

Table 4.9 Ref Value in the Freq Drift View

Parameter	Description
Default	0 Hz
Range	-1 MHz to 1 MHz
Unit	kHz, MHz, GHz
Knob Step	1
Left/Right Arrow Key Step	10

4.2.3 Attenuation Mode

Selects "Manual" or "Auto" to be the current attenuation mode.

Remarks:

- If you select "Manual" to be the attenuation mode, set the attenuation value under the "Attenuation" menu, and the attenuation mode will be automatically switched to "Manual".
- When you select "Auto" to be the attenuation mode, the attenuator will automatically adjust the attenuation value to meet the current amplitude setting.

4.2.4 Attenuation

Sets the RF front-end attenuator to allow high-level signals to pass through the mixer with low distortion, and low-level signals to pass through the mixer with low noise.

Remarks:

- The attenuator consists of fixed attenuator and variable attenuator. The attenuation of the fixed attenuator is 10 dB, and the attenuation range of the variable attenuator is from 0 dB to 30 dB. Therefore, the input attenuation ranges from 0 dB to 40 dB.
- When the set attenuation amount is greater than 10 dB, fixed attenuator is preferred to be used by default.
- When the maximum mixer level and reference level are confirmed, the minimum of the input attenuation should meet the following equation:

$$ATT_{min} = L_{Ref} + a_{PA} + a_{Ext} - L_{mix}$$

Wherein, ATT_{min}, L_{Ref}, a_{PA}, a_{Ext}, and L_{mix} indicate the minimum input attenuation, reference level, PA, external gain, and maximum mixer level, respectively.

- You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

Parameter	Remarks
Default	10 dB
Range	0 dB to 40 dB
Unit	dB

Parameter	Remarks
Knob Step	Preamp off, step = 2 dB
Left/Right Arrow Key Step	4 dB

4.2.5 Scale/Div

Sets the Y-axis scale per division of the selected trace.

Key Points:

- The default scale/div value and unit are different when you select a different view.
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Scale/Div in the RF Spectrum View

Parameter	Description
Default	10 dB
Range	0.1 dB to 20 dB
Unit	dB
Knob Step	Scale/Div ≥ 1: step = 1 dB Scale/Div < 1: step = 0.1 dB
Left/Right Arrow Key Step	at 1-2-5 step

Scale/Div in the AF Spectrum View

Parameter	Description
Default	10 dB
Range	0.1 dB to 20 dB
Unit	dB
Knob Step	Scale/Div ≥ 1: step = 1 dB Scale/Div < 1: step = 0.1 dB
Left/Right Arrow Key Step	at 1-2-5 step

Scale/Div in the Demod Waveform View

Parameter	Description
Default	30 kHz
Range	1 Hz to 100 kHz
Unit	Hz, kHz, MHz, GHz
Knob Step	1 Hz
Left/Right Arrow Key Step	at 1-2-5 step

Scale/Div in the Freq Drift View

Parameter	Description
Default	100 Hz
Range	1 Hz to 100 kHz
Unit	Hz, kHz, MHz, GHz
Knob Step	1 Hz
Left/Right Arrow Key Step	at 1-2-5 step

4.2.6 Preamplifier

Sets the RF front-end preamplifier to be on or off. When the signal under test is a low-level signal, turning on the preamplifier can reduce the displayed average noise level, so that you can distinguish low-level signals from the noise. By default, the preamp gain is 20 dB.

4.2.7 Max Mixer Level

Sets the maximum input level of the mixer according to the amplitude of the signal.

Remarks:

- For the high-level input signal, select a smaller maximum mixer level to increase the input attenuation and reduce the distortion of the signal; for the low-level input signal, select a larger maximum mixer level to reduce the input attenuation and noise.
- You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

Parameter	Description
Default	-10 dBm
Range	-40 dBm to -10 dBm
Unit	dBm
Knob Step	1 dBm
Left/Right Arrow Key Step	5 dBm

4.3 Sweep

Sets the sweep-related parameters.

4.3.1 Sweep Points

Sets the number of points acquired in each sweep, i.e. the number of the trace points.

Remarks:

- With the increase of the sweep points, the frequency resolution of the marker will increase with it, but the sweep speed will decrease with it.
- Due to the limitation of the minimum interval of sweep points, when the number of sweep points is increased, the sweep time will be prolonged.
- Changing the number of the sweep points will affect multiple parameters of the system. Therefore, the system will make a new sweep and measurement again.
- You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

Parameter	Description
Default	2001
Range	101 to 400001
Unit	N/A
Knob Step	1
Left/Right Arrow Key Step	5

4.3.2 Sweep Mode

RSA6000 series spectrum analyzer supports two sweep modes: Single sweep and Continuous sweep.

Continuous Sweep

- If the current system is in single sweep mode and no measurement is performed, click or tap Sweep > **Sweep Mode** > **Cont** to enter continuous sweep mode. In this case, if the trigger conditions are met, the system will sweep continuously.
- If the current system is in single sweep mode and is performing the specified measurement, click or tap Sweep > **Sweep Mode** > **Cont** to enter continuous sweep mode. In this case, if the trigger conditions are met, the system will perform measurements continuously.
- In continuous sweep mode, the system will send a trigger initialization signal automatically and enter the trigger condition judgment directly after each sweep is completed.

Single Sweep

- If the current system is in continuous sweep mode and no measurement is performed, selecting this menu to enter the single sweep mode. In this case, if the trigger conditions are met, the system performs one sweep.
- If the current system is in continuous sweep mode and is performing the specified measurement, selecting this menu to set the measurement mode to "Single". In this case, if the trigger conditions are met, the system will execute the specified number of measurements.
- If the system is already in single sweep mode, press this key and then the system will execute the specified number of sweeps (or measurements) once the trigger conditions are met.
- In single sweep mode, trigger initialization (click or tap **Sweep** > **Sweep Mode** > **Cont** or send the SCPI command through the remote interface) should be executed before judging the trigger conditions.

NOTE

Switching between Single and Continuous sweep mode will result in restarting the sweep.

4.3.3 Restart

Click or tap **Restart**, the current sweep will be suspended. All the previously measured data will be remeasured, and the trigger restores to the not-triggered state.

4.4 Bandwidth

Sets the bandwidth of the analyzer. Press BW on the front panel to enter the bandwidth setting menu.

4.4.1 Channel Bandwidth

Sets the bandwidth of the demodulation.

Key Points:

- The channel bandwidth shall be smaller than or equal to the span. If the set channel bandwidth is greater than the current span, the span will be modified to the channel bandwidth.
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.17 Channel Bandwidth

Parameter	Remarks
Default	25 kHz
Range	40 Hz to 80 MHz
Unit	GHz, MHz, kHz, Hz
Knob Step	Channel Bandwidth/200
Left/Right Arrow Key Step	at 1-1.5-3-5-7.5 step

4.4.2 AF RBW

Sets the resolution bandwidth of the demodulated waveforms in the AF Spectrum view. It is used to adjust the display accuracy of the signal spectrum.

You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.18 AF Resolution Bandwidth

Parameter	Description
Default	96 Hz
Range	Range is related to *Span*
Unit	GHz, MHz, kHz, Hz
Knob Step	at 1-3-10 step
Left/Right Arrow Key Step	at 1-3-10 step

4.4.3 AF RBW Mode

Sets the AF RBW mode in the AF Spectrum view.

- **Manual:** use the numeric keypad or use the touch screen to modify AF RBW value. When you modify the AF RBW value, the AF RBW Mode will be automatically switched to Manual.
- **Auto:** automatically sets the AF RBW value according to the current configuration.

4.5 Trigger

Selects the trigger source and sets trigger-related parameters.

4.5.1 Trigger Source

Sets "Free Run", "External", or "IF Power" to be the trigger source.

4.5.2 Free Run

The trigger conditions are met at any time, that is, the analyzer generates trigger signals continuously.

4.5.3 External Trigger

Click or tap **Trigger** > **Source** > **External**, then an external signal is input via the **[TRIG IN]** connector on the rear panel. When the signal meets the set trigger conditions, trigger signals are generated.

NOTE

The input signal frequency on the external trigger interface should not be greater than 1 MHz.

1. Slope

Sets the trigger polarity for External Trigger. It is set positive to trigger on a rising edge and negative to trigger on a falling edge.

2. Delay State

Enables or disables the trigger delay function. After the trigger delay function is enabled, you can set the trigger delay time.

3. Delay Time

Sets the time interval during which the instrument waits to start the sweep operation after the trigger signal that meets the trigger conditions is generated. You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

Parameter	Remarks
Default	1 µs
Range	-500 ms[1] to 500 ms
Unit	s, ms, us, ns, ps
Knob Step	trigger delay/100, Min = 1 µs
Left/Right Arrow Key Step	at 1-1.5-2-3-5-7.5 step

NOTE

[1]: When the trigger delay is set to a negative value, it indicates a pre-trigger.

4.5.4 IF Power

A trigger signal will be generated when the system detects a IF signal whose power level exceeds the specified trigger level.

1. Trigger Level

Sets the trigger level of the IF power trigger. When the signal meets the set trigger level value, a trigger occurs.

Parameter	Description
Default	-25 dBm

Parameter	Description
Range	(-140+Level Offset) to (30+Level Offset)
Unit	dBm
Knob Step	1 dBm
Left/Right Arrow Key Step	5 dBm

2. Delay State

Enables or disables the trigger delay function. After the trigger delay function is enabled, you can set the trigger delay time.

3. Delay Time

Sets the time interval during which the instrument waits to start the sweep operation after the trigger signal that meets the trigger conditions is generated. You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

Parameter	Description
Default	1 μs
Range	-500 ms[1] to 500 ms
Unit	s, ms, μs, ns, ps
Knob Step	Trigger Delay/100, Min. 1 μs
Left/Right Arrow Key Step	at 1-1.5-2-3-5-7.5 step

NOTE

[1]: When the trigger delay is set to a negative value, it indicates a pre-trigger.

4.5.5 Trigger Holdoff State

Click or tap the ON/OFF tab for "Holdoff State" to enable or disable the trigger hold-off state.

4.5.6 Trigger Holdoff

Sets the holdoff time between trigger signals. You can use the numeric keys, the knob, or arrow keys to modify this parameter; you can also use the touch screen to modify the parameter.

When the trigger conditions are met, the trigger occurs. Then, the delay begins, and the holdoff time begins. During the holdoff time, new trigger signals will be ignored.

For a free-running trigger, the holdoff value is the minimum time between two trigger signals.

Parameter	Remarks
Default	100 ms
Range	0 us to 500 ms
Unit	s, ms, us, ns, ps
Knob Step	trigger holdoff time/100, Min = 1 us
Left/Right Arrow Key Step	at 1-1.5-2-3-5-7.5 step

4.5.7 Auto Trig State

Enables or disables the auto trigger function.

4.5.8 Auto Trig

Sets the time that the instrument will wait for the trigger conditions to be met. When the set waiting time times out, the instrument will not wait and start to initiate the sweep measurement.

Parameter	Remarks
Default	100 ms
Range	1 ms to 100 s
Unit	s, ms, us, ns, ps
Knob Step	auto trigger time/100, Min = 1 us
Left/Right Arrow Key Step	at 1-1.5-2-3-5-7.5 step

The relationship of the trigger parameters is shown in the following figure.

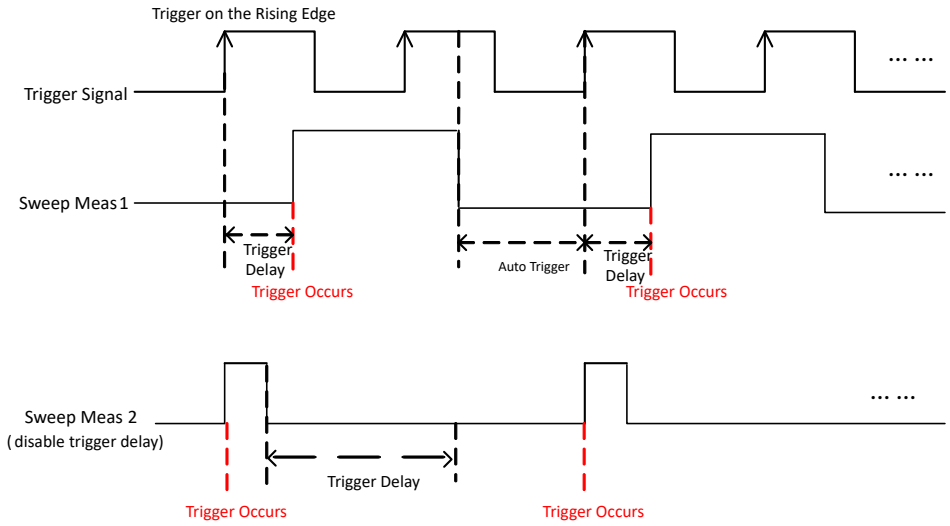


Figure 4.2 Relationship of Trigger Parameters

4.6 Meas Setup

Press Meas Setup to enter the measurement setup menu.

4.6.1 Setting

4.6.1.1 Avg Number

Sets the count of the average/hold measurement.

Table 4.24 Avg Number

Parameter	Remarks
Default	10
Range	1 to 10,000
Unit	N/A
Knob Step	1
Left/Right Arrow Key Step	1

4.6.1.2 Avg State

Enables or disables the average/hold state. By default, it is disabled. When enabled, the instrument performs the averaging operation on the measurement values based on the currently set average count (*Avg Number*).

Key Points:

- When the average state is disabled:
  - The RF Spectrum view and AF Spectrum view traces show real-time measurement data.
  - The Demod Waveform view only displays the current demodulation signal.
  - The Result Table view only displays the Current measurement column.
- When the average state is enabled:
  - The RF Spectrum view and AF Spectrum view traces show average measurement results.
  - The Demod Waveform view displays four traces, namely, Demod, Demod Average, Demod Max, and Demod Min.
  - The Result Table view displays the Average column and Max Hold column results.

4.6.2 Demod

The LoRa technology is based on the Chirp Spread Spectrum (CSS) modulation. The core function of the demodulation module is to process the RF receiver signal and revert it back to the original baseband bitstream, providing effective input for subsequent channel decode and error correction.

4.6.2.1 SFactor

The Spreading Factor (SF) is a core parameter of the LoRa physical layer. It defines how each information bit is spread into 2^SF radio frequency chips.

- SF value directly determines GSF. GSF = $10\log_2(SF)$.
- A higher SF value results in higher receiver sensitivity, better anti-interference, and longer transmission range. However, this will also cause lower data transmission rate and longer symbol transmission time.

- The SF parameter settings must be consistent with that of the DUT, otherwise, demodulation fails.

Table 4.25 SFactor

Parameter	Description
Default	8
Range	7 to 12
Unit	N/A
Knob Step	1
Left/Right Arrow Key Step	1

4.6.2.2 Signal Bandwidth

The signal bandwidth is the core demodulation configuration parameter. In the test, the bandwidth at the RSA side needs to configured as the same for the transmitter of the LoRa device under test, otherwise the signal demodulation will fail.

The signal bandwidth defines the spectrum width occupied by the LoRa RF signal. The instrument supports standard LoRa bandwidth configurations, with BW125K, BW250K, and BW500K available to choose.

- The higher the bandwidth, the higher the data rate and the shorter the transmission time, suitable for short to medium range and high-rate application scenarios.
- The narrower the bandwidth, the higher the receiving sensitivity, the stronger anti-interference for narrow band, suitable for long-range, complex electromagnetic environment application scenarios.
- The signal bandwidth is the key parameter for the demodulation. In the test, the bandwidth needs to configured as the same for the DUT transmitter, otherwise the demodulation will fail.

4.6.2.3 PPLength

The Preamble is the synchronization signal at the beginning of a LoRa packet. It consists of a series of linear frequency modulated pulses (Chirp), which help the

receiver identify valid signals from noise and complete time-frequency synchronization.

- Short Preamble: Suitable for low-power, short-range, and periodic transmission scenarios.
- Long Preamble: Significantly improves synchronization success rate in high-interference environments or long-distance communications.

The set PPLength shall be consistent with that of the TX of the DUT.

Table 4.26 PPLength

Parameter	Description
Default	8
Range	6 to 65512
Unit	N/A
Knob Step	1
Left/Right Arrow Key Step	at 1-2-5 step

4.6.3 Decode

The decoding module interprets frame structure of the output demodulated original bitstream. The main processes are: Frame Sync, Header Parsing, CRC Checksum, De-interweaving, and Forward Error Correction (FEC), and Pure Payload Output.

4.6.3.1 Decode Enabled

When enabled, the instrument automatically performs the subsequent protocol-layer parsing processes.

4.6.3.2 Decode From Header

When LoRa receives data, if you enable this menu, it will be forced to parse from the start frame header.

This will prevent parsing errors caused by truncation from the middle of a packet or noise misinterpretation. It is recommended to keep this menu enabled to ensure the integrity and accuracy of the decoding.

4.6.3.3 Coding Rate

- Coding Rate: CR. LORA adopts Cyclic Error-Correcting Codes to improve transmission reliability. It is expressed as CR = 4/x, where x belongs to the set {5, 6, 7, 8}. For example, CR 4/5 indicates 1 redundant error correction bit appended to every 4 information bits. The more redundancy, the stronger anti-interference and the lower data rate.

Available Options	Coding Rate	Remarks
CR1	4/5	1 redundant error correction bit is appended to every 4 information bits, with a total transmission of 5 bits. It has the highest transmission efficiency, applicable in short range, low interference scenarios.
CR2	4/6	2 redundant error correction bits are appended to every 4 information bits, with a total transmission of 6 bits. It is applicable in medium-range and moderate interference scenarios.
CR3	4/7	3 redundant error correction bits are appended to every 4 information bits, with a total transmission of 7 bits. It is applicable in long-range and strong interference scenarios.
CR4	4/8	4 redundant error correction bits are appended to every 4 information bits, with a total transmission of 8 bits. It has the strongest error correction capability and lowest transmission efficiency.

4.6.3.4 Payload CRC Enabled

CRC (cyclic redundancy check) can improve data reliability. You can set whether to enable payload CRC.

- ON: By default, it is enabled. It will automatically verify that received packets are complete, with no transmission errors.
- OFF: If it is disabled, it indicates that no CRC is performed.

4.6.3.5 Payload Length

If Implicit Header is disabled, LoRa is presented in explicit mode, and the payload length information is auto carried. "0" may be data not auto-recognized (or required to be configured manually).

If Implicit Header is enabled, you need to configure the fixed payload length manually, as the implicit header does not include payload length information.

Table 4.28 Payload Length

Parameter	Description
Default	0
Range	0 to 255
Unit	N/A
Knob Step	1
Left/Right Arrow Key Step	1

4.6.3.6 Implicit Header

LoRa physical layer supports two header transmission modes. You can select the desired one according to the actual conditions of the DUT.

- **OFF:** By default, it is OFF. It is the explicit header.

  The transmitter sends the packet with header information included. The receiver does not need to pre-configure SF, CR or payload length, and can complete the parameter extraction and decoding automatically based on the header information.

- **ON:** Implicit header mode.

  The transmitter ignores the header transmission to reduce the air time. The receiver must be manually configured with the SF, BW, CR, and payload length parameters in advance as what the transmitter has been configured, otherwise it may fail in the CRC check and cannot be properly parsed. This mode usually does not include the header CRC, and only the payload CRC is available to choose.

4.6.4 Global CF Mode

1. Global CF Mode

Turns on or off the global center frequency. In any working mode, if you enable the global center frequency mode, then the global center frequency will be set to the center frequency of the current mode. When a different working mode is selected, the global center frequency will be set to the center frequency of the previous working mode, that is, the one that is before switching the working mode. If you

change the center frequency in any working mode, then the global center frequency will change with it.

2. Global CF

Sets the global center frequency. It is only available when you enable the global CF mode.

4.7 Marker

4.7.1 Marker Setting

Marker is used for marking the point on the trace. Through the marker, you can read the X-axis and Y-axis readouts of the point on the trace.

Key Points:

- RSA6000 offers 8 markers, and only a single marker or one pair of markers can be turned on each time.
- The marker readout will be displayed at the upper-right corner of the marker trace view.
- In the Marker menu, you can use the numeric keys, the knob, or the arrow keys to modify X-axis readout; to view the readout of different points on the trace. You can also use the touch screen to do the above things.

4.7.1.1 Selected Marker

RSA6000 provides 8 markers. By default, Marker1 is selected under "Selected Marker". After you select a marker, you can set parameters such as the marker mode, the marker trace, and marker readout. The currently enabled marker will be marked on the trace selected under **Marker Trace**. The readout of the marker will be displayed at the upper-right corner of the screen.

4.7.1.2 Next Marker

Click or tap **Next Marker** to select the next enabled marker.

4.7.1.3 Marker Mode

Sets the type of the marker. The available marker modes include Position, Delta, Fixed, and OFF.

1. Position

It is used to measure the X (Frequency or Time) and Y (Amplitude) values of a certain point on the trace. When "Position" is selected, a marker indicated by a number (e.g., "1") appears on the trace.

Key Points:

If no active marker exists currently, a marker will be enabled in the center of the current trace.

2. Delta

It is used to measure the difference between "reference point" and "certain point on the trace": X (frequency or time) and Y (amplitude) value. When "Delta" is selected, a pair of markers appears on the trace: Reference Marker (marked by "X") and the Delta Marker (marked by "△").

Key Points:

- If an active marker exists currently, then activate a reference marker at the current marker; otherwise activate both the reference marker and Delta marker at the same time in the center of the current trace.
- When you change the position of the Delta marker, the position of the reference marker remains unchanged, but the frequency (or time) difference between the two markers will change along with it.
- The frequency (or time) difference between the two markers and the amplitude difference between them are displayed in the measurement result bar at the upper-right corner of the marker trace view.

Application of the "Delta" Marker:

It is used to measure the S/N ratio of the single spectrum signal. Move the reference marker to the location where the signal resides, and move the Delta marker to the location where the noise resides. The amplitude displayed in the measurement results is S/N ratio.

3. Fixed

When you select "Fixed" marker, you can directly or indirectly set the X-axis and Y-axis values for the marker. Once specified, its position remains unchanged, and its Y-axis value does not change along with the trace. The fixed marker is generally used as the reference marker for the Delta marker. It is indicated by the sign "×".

4. OFF

Turns off the marker currently selected. Then, the marker information displayed on the screen and the functions concerning the marker will also be disabled.

4.7.1.4 Reference Marker

Sets the reference marker for the current marker. By default, the reference marker is the marker next to it.

Key Points:

- Each marker can have another marker to be its reference marker.
- If the current marker is a Delta marker, the measurement result of the marker will be determined by the reference marker.
- Any marker cannot take itself to be the reference marker.

4.7.1.5 Selected Trace

Selects the trace that the current marker marks. The available traces for the **Selected Trace** menu are as follows. One marker can only mark one trace.

- RF Spectrum: RF Spectrum trace
- AF Spectrum: AF Spectrum trace
- Demod: Demod Waveform trace
- Demod Max: Demod Waveform Max Hold trace
- Demod Min: Demod Waveform Min Hold trace
- Demod Average: Demod Waveform Average trace
- FreqDrift: frequency drift trace

TIP

The following traces are available to choose when you have enabled the average state (**Meas Setup** > **Setting** > **Avg State**).

- Demod Max
- Demod Min
- Demod Average

4.7.1.6 Marker Frequency/Time

You can set **Marker Freq** or **Marker Time** to adjust the position of the marker on the trace based on your selection for the selected trace.

- **Marker Freq**

  When the following traces are selected as the trace, you can modify the marker frequency.

  - RF Spectrum: RF Spectrum trace
  - AF Spectrum: AF Spectrum trace

Parameter	Description
Default	0 GHz
Range	-
Unit	GHz, MHz, kHz, Hz
Knob Step	RF Spectrum: span/(number of sweep points - 1) AF Spectrum: (stop freq - start freq)/(number of sweep points - 1)
Left/Right Arrow Key Step	RF Spectrum: span/10 AF Spectrum: (stop freq - start freq)/10

- **Marker Time**

  When the following traces are selected as the trace, you can modify the marker time.

  - Demod: Demod Waveform trace
  - Demod Max: Demod Waveform Max Hold trace
  - Demod Min: Demod Waveform Min Hold trace
  - Demod Average: Demod Waveform Average trace

Parameter	Description
Default	1 ms
Range	0 to Demod Time
Unit	s, ms, µs, ns
Knob Step	Demod Time/(sweep points - 1)
Left/Right Arrow Key Step	Demod Time/10

- **Marker Symbols**

  When you select FreqDrift as the trace, you can modify the marker symbols.

4.7.1.7 Marker Amplitude

When the marker mode is set to "Fixed", you can click or tap this menu to set the Y value of the current marker.

4.7.1.8 Line State

Enables or disables the marker line.

Key Points:

- When you enable the marker line, a cross line is displayed at the amplitude point where the marker resides. The width of the horizontal line and the height of the vertical line are consistent with the length and height of the graticule in the waveform display area.
- If the marker is not visible in the selected area, extend the marker line to the display area for better observation. This function is useful for the marker outside the display area. The marker extension line can better display the amplitude of the marker, making it easy for you to observe and compare.

4.7.1.9 All Markers Off

Turns off all the enabled markers and their related functions.

4.7.2 Marker To

Sets other system parameters based on the current marker value.

4.7.2.1 Mkr->CF

Sets the center frequency of the analyzer to the frequency of the current marker.

- If Position marker is selected, the center frequency will be set to the frequency of the current marker.
- If Delta marker is selected, the center frequency will be set to the frequency of the Delta marker.
- This function is valid in RF Spectrum view.

4.7.3 Peak Search

The peak search function enables the marker to move to the specific signal peak point.

Press Peak Search on the front panel to enter the peak search menu. You can also click or tap **Marker** > **Peak Search** to enter the peak search menu.

4.7.3.1 Peak Search

Performs the peak search function. Searches for the maximum value on the trace and marks it with a marker.

4.7.3.2 Next Peak

Searches for and marks the peak whose amplitude on the trace is next lower than that of the current peak.

4.7.3.3 Next Peak Right

Searches for and marks the peak closest to the right side of the current peak.

4.7.3.4 Next Peak Left

Searches for and marks the peak closest to the left side of the current peak.

4.7.3.5 Minimum Search

Searches for and marks the peak with the minimum amplitude on the trace.

4.7.3.6 Pk-Pk Search

Executes Peak Search and Minimum Peak functions at the same time, and marks the results with the Delta marker. Wherein, the result of Peak Search is marked with the reference marker and the result of Minimum Peak is marked with the Delta marker.

4.7.3.7 Continuous Peak

Enables or disables continuous peak search. By default, it is OFF. When it is enabled, after finishing each sweep, the analyzer will automatically execute one peak search operation to track the measurement signal.

4.7.3.8 Cont Peak Min

Enables or disables continuous Min search. By default, it is OFF. When it is enabled, after finishing each sweep, the analyzer will automatically execute one Min search operation to track the measurement signal.

NOTE

- When the marker is a fixed type, the Cont Peak Min and continuous peak menus are grayed out and disabled.
- When the Cont Peak Min function is enabled, if the current marker is off, set the marker to Position mode, and then execute the Minimum Search operation.

4.8 Input/Output

Sets the input/output interface.

4.8.1 Input Impedance

Sets the input impedance for voltage-to-power conversions. The default input impedance is 50 Ω. To measure a 75 Ω device, you should set the input impedance to 75 Ω.

4.8.2 Ext Gain

Compensates for gain or loss in the measurement system outside the instrument.

Remarks:

- The value does not affect the trace position, but will modify the parameters such as reference level readout and the marker amplitude readout.
- You can use the numeric keys to modify this parameter; you can also use the touch screen to modify the parameter.

Table 4.31 Ext Gain

Parameter	Remarks
Default	0 dB
Range	-120 dB to 120 dB
Unit	dB
Knob Step	1 dB
Left/Right Arrow Key Step	1 dB

4.8.3 Trig Out

Trig Out

Enables or disables the trigger output.

Trig Out Polarity

Click or tap to select "Positive" or "Negative" under **Trig Out Polarity**.

5 Preset

Press this key to recall the preset setting and restores the system settings of the analyzer to its factory defaults.

Parameter Name	LORA Parameter	
Freq		
Center Frequency	1 GHz	
AF Start Freq	0	
AF Stop Freq	10 kHz	
Span	200 kHz	
CF Step	7.5 kHz	
CF Step Mode	Auto	
BandWidth		
Channels BandWidth	25 kHz	
AF Resolution Bandwidth	96 Hz	
AF RBW Mode	Auto	
Amplitude		
Ref Value	RF Spectrum View	0 dBm
	AF Spectrum View	100 kHz
	Demod Waveform View	0 Hz
	Freq Drift View	
Scale/Div	RF Spectrum View	10 dB
	AF Spectrum View	
	Demod Waveform View	30 kHz
	Freq Drift View	100 Hz
Max Mixer Level	-10 dBm	

Parameter Name	LORA Parameter
Attenuation Mode	Auto
Preamplifier (PA)	OFF
Meas Setup	
Global CF Mode	OFF
Setting	
Avg State	OFF
Avg Number	10
Demod	
SFactor	8
Signal Bandwidth	BW250K
PPLength	8
Decode	
Decode Enabled	ON
Decode From Header	ON
Coding Rate	CR1
Payload CRC Enabled	ON
Payload Length	0
Implicit Header	OFF
Marker	
Selected Marker	Marker1
Marker Mode	OFF
Reference Marker	Marker2
Selected Trace	RF Spectrum
Marker Frequency	1 GHz
Line State	OFF
Peak	

Parameter Name	LORA Parameter
Continuous Peak	OFF
Cont Peak Min	OFF
Trigger	
Trigger Source	Free Run
Trigger Hold	OFF, 100 ms
Auto Trig	OFF, 100 ms
Slope	POS
Trigger Delay	OFF, 1 μs
Trigger Level	-25 dBm
System	
Power On	Preset
Power Switch	OFF
Beeper	OFF
Screen Brightness	80%
Fan Speed	49%
Display Time	ON
Calibrate Auto	OFF
Language	English

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