V1.0 2608

Applicable Series:

R1000 Series Embedded RF Receivers

R1000 Series User Guide

HAROGIC

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Contents

How to Use This Manual

This manual is organized in the order in which users typically perform tasks: first, verify safety, interfaces, and power supply; then establish network and software connections; next, view signals and acquire and manage IQ data; and finally, configure GNSS, the reference clock, the triggering, and troubleshoot issues.

First-Time Use: If your goal is to get the device up and running within 30 minutes, please start with the R1000 Series RF Receiver Quick Start Guide. This manual is intended as a comprehensive operational reference after the device has been successfully set up and is running.

1 Reading This Manual

1.1 Purpose and Intended Audience

This manual is intended for RF engineers, system integrators, algorithm developers, test engineers, and FAEs who use, integrate, or maintain HAROGIC R1000 Series RF receivers. It provides information on "how to connect interfaces, configure parameters, acquire data, and troubleshoot issues".

1.2 Scope and Version Baseline

Item	Description
Product Series	R1000 Series embedded RF receivers
Applicable Models	R1060、R1090、R1200、R1400
Receive/Transmit Channels	1 receive channel, 0 transmit channels
Target Hardware Platform	Compact integrated system incorporating an RF receiver, FPGA/ baseband processing, and Raspberry Pi 5

Item	Scope
Product	HAROGIC R1000 Series RF receivers
Desktop Software	SAStudio4 version should be 4.55.50 or above. The software can run independently on a host computer or on the Raspberry Pi 5 host.
Development Software	HTRA API, SDK, and example applications matched to the device and firmware version 0.55.89 or above.
Operating System	Refer to the delivered software package, installation instructions, and release notes. Chapter 6 lists the general host requirements for SAStudio4.

1.3 R1000 Documentation Set and Content

Task	Primary Document
Product selection, specifications, options, and application scenarios	R1000 Series Datasheet
First-time power-on, network connection, signal viewing, and first IQ/API operation within 30 minutes	R1000 Series RF Receiver Quick Start Guide
Interfaces, power supply, networking, SAStudio4 software, IQ data, GNSS, triggering, and troubleshooting	This User Manual

Complete SAStudio4 measurement modes, menus, and analysis functions	SAStudio4 User Guide
API sessions, parameters, data structures, error codes, timestamps, and s ynchronization	HTRA API Programming Guide
C/C++、Qt、Python、Matlab、LabVIEW	HTRA API Example Usage Guide
Creating applications with GNU Radio, obtaining the latest GNU Radio and SoapySDR examples	GNU Radio Example Usage Guide HAROGIC Git Repo. (regularly updated)

1.4 Terminology, Abbreviations, and UI Conventions

Term	Meaning
AUXIO	Multifunction auxiliary input/output interface
CMOS	Complementary metal-oxide-semiconductor logic level
GNSS	Global Navigation Satellite System, used for frequency calibration and time synchronization
OCXO	Oven-controlled crystal oscillator used as the internal reference clock
PPS / 1PPS	One-pulse-per-second timing reference signal
RI	Abbreviation for reference clock input (REF IN)
RO	Abbreviation for reference clock output (REF OUT)
REF IN / REF OUT	Functional names for the reference clock input/output
RF IN	RF input port
Trigger / TRG	Trigger input or output signal

Term	Meaning in This Manual
Receiver IQ Stream	SAStudio4 operating mode for configuring the receive path, acquiring time-domain IQ data, and performing preview analysis.
IQ Record & Play Back	Workflow for IQ data recording, file management, playback, and status monitoring.
Spectrum Preview	Used for quick signal observation using spectrum, probability density, or waterfall displays.

HTRA API	Primary programming interface for accessing R1000 Series device capabilities in custom applications.
Example Applications	Example applications provided with the SDK for demonstrating and verifying HTRA API call flows.
Device	Unless referring to an original UI label or document title, “device” in this manual refers to an R1000 Series RF receiver.

1.5 Recommended Reading Paths

User Goal	Recommended Reading
Initial deployment and RF verification	Chapters 2 to 8, followed by Chapters 9 to 12 as needed
IQ acquisition and offline processing only	Chapters 6 to 9, Appendix A, and Appendix B
GNSS/PPS, multi-device synchronization, or external triggering	Complete the basic verification in Chapters 4 to 8, then read Chapters 11 to 12
Developing unattended or automated applications	After verifying the parameters in Chapters 6 to 8, read Chapter 13, then refer to the HTRA API documentation
	Chapters 14 to 15, with reference to the relevant hardware or software chapters as needed

2 Safety and Compliance

Before applying power, making connections, or deploying the device in the field, always verify the power supply, RF input, ESD protection, thermal conditions, and mechanical conditions.

2.1 Safety Notice Levels

Level	Meaning
DANGER	If not avoided, will result in death or serious injury.
WARNING	If not avoided, may result in personal injury or serious equipment damage.
CAUTION	If not avoided, may result in damage to the equipment, interfaces, cables, or data.
NOTICE	Provides information helpful for proper connection, verification, or maintenance.

2.2 General Safety

- Only personnel familiar with RF, electrical, and ESD protection requirements are permitted to install, connect, and maintain the equipment.
- Before applying power, inspect the enclosure, connectors, and cables. Do not power on the equipment if there are signs of shipping damage, loose parts, unusual odors, liquid ingress, or obvious deformation.
- Do not disassemble, modify, bypass protective components, or replace internal modules without authorization from HAROGIC. There are no user-serviceable parts inside the device.
- Before connecting or disconnecting non-hot-swappable interfaces, AUXIO ribbon cables, trigger adapter boards, or external reference cables, stop acquisition and power off the equipment.
- Do not operate the equipment in environments with condensation, conductive dust, flammable or explosive gases, or conditions exceeding the specified environmental ratings.

2.3 ESD Protection

CAUTION
RF, GNSS, reference, trigger, and AUXIO interfaces may be susceptible to electrostatic discharge (ESD). Operate the equipment in an ESD-controlled area, wear a properly grounded antistatic wrist strap, and discharge any static electricity from your body, cables, and antennas before making connections.

Keep connector protective caps clean. When handling the equipment, hold it by the enclosure. Do not touch center conductors, AUXIO pins, or exposed pads on adapter boards.

2.4 Power Safety

WARNING

Use only the power adapter and cables supplied with the equipment, or those that fully comply with the specifications stated on the equipment nameplate. Power adapters may use different power delivery configurations; do not interchange them or assume compatibility based solely on connector appearance.

- Verify the device nameplate and power supply output specifications before powering on.
- Do not use USB-C cables that are loose, damaged, overheating, or have insufficient current-carrying capacity.
- Do not power the entire unit through the AUXIO power pins, and do not back-feed voltage into any output pin.
- If the equipment repeatedly restarts, becomes abnormally hot, emits a burning odor, or triggers power protection, disconnect power immediately and isolate the equipment.

2.5 RF Input Protection

WARNING

Exceeding the absolute maximum RF input power or DC voltage may immediately damage the RF front end.For signal frequencies from 50 MHz up to the maximum specified frequency, with the preamplifier disabled, the maximum damage-level CW input power is +23 dBm.

For signal frequencies from 10 MHz to 50 MHz, or when the preamplifier is enabled, the maximum damage-level input power is +10 dBm.

Ensure that the RF input power remains below the applicable maximum damage-level input power. It is recommended to connect an appropriate attenuator before connecting the signal to the RF input port.

2.6 Thermal and Mechanical Safety

Do not cover or obstruct ventilation openings, heat-sink fins, or airflow paths while the equipment is operating. When installing the equipment in a chassis, enclosure, backpack, or unattended node, evaluate worst-case ambient temperature, solar radiation, nearby heat sources, cable obstruction, and total system power consumption.

Do not directly touch metal surfaces that may become hot while the equipment is operating or immediately after power-off.

3 R1000 System Overview and Usage Paths

Understanding the respective roles of the RF chain, embedded host, SAStudio4 desktop software, and HTRA API is essential for selecting the appropriate connection and data path.

3.1 Product Positioning

The R1000 Series integrates a single-channel, high-performance superheterodyne RF receiver, ADC/FPGA baseband processing, and a Raspberry Pi 5 embedded host in a compact enclosure. It can be used as a remote receiving node, a standalone local node, or a distributed RF signal acquisition front end.

The device connects to a host computer through the unified HTRA API and 1GbE interface, while local applications can also run directly on the embedded host.

3.2 Functional Architecture

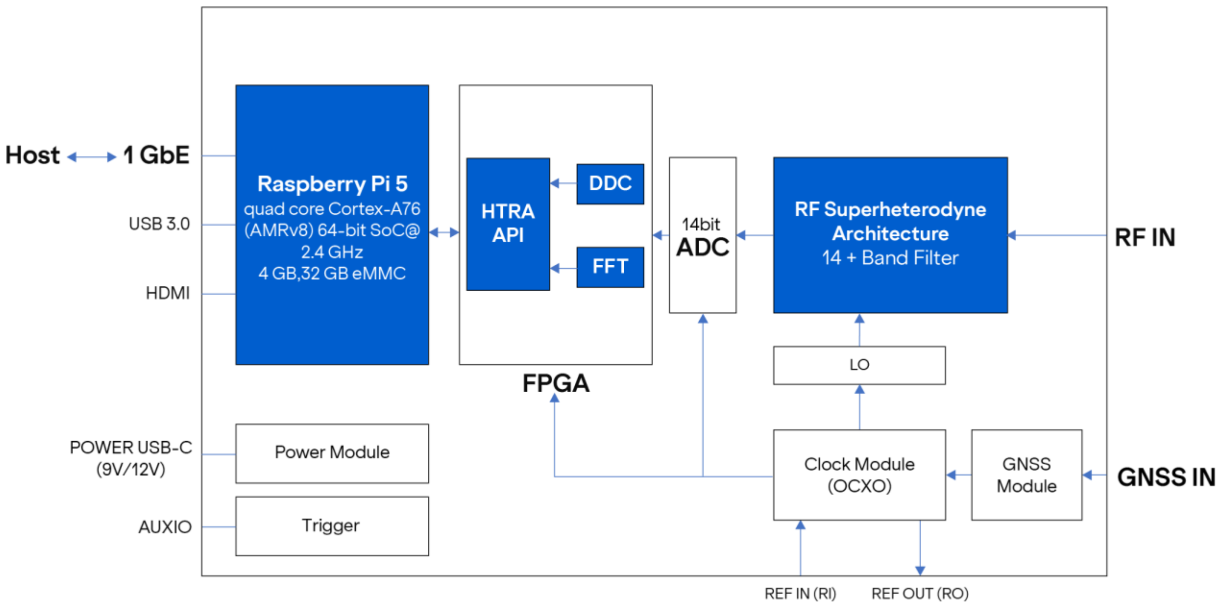


Figure 3-1 Functional Signal Flow of the R1000 Series

At the functional level, the data path consists of the RF input, preselection and superheterodyne receiver chain, ADC/FPGA, Raspberry Pi 5 embedded host, and local/network applications. GNSS, the internal OCXO, external reference, PPS/trigger, and other signals provide reference or control inputs for the receiver chain and timestamping.

This figure is intended only to illustrate the relationships among external interfaces. It does not represent implementation details of the circuitry, clock tree, or FPGA resources.

3.3 Typical Operating Modes

Operating Mode	Hardware Connections	Typical Applications
Remote host control	Connect RF, power, 1GbE, and optional synchronization interfaces only	Desktop verification, remote control, API access, and network data transfer
Standalone local operation	Connect RF, power, display/USB, or local storage	Embedded applications, unattended nodes, and field processing
Distributed nodes	Power and network multiple devices individually and use a verified GNSS/PPS/reference topology	Distributed spectrum monitoring, time-synchronized acquisition, and algorithm validation
Custom system integration	Mount the device, provide cutouts, and plan cable routing according to the mechanical drawings and interface control documents	OEM, enclosure, backpack, vehicle-mounted, or fixed-site integration

Desktop verification, example applications, and customer applications serve different purposes. The following sections describe their relationships and the recommended migration sequence.

R1000 software usage follows two primary paths: desktop verification and application development. SAStudio4 is used for initial verification, while the HTRA API is used for final system integration.

3.4 SAStudio4

SAStudio4 provides a graphical user interface suitable for initial device setup, parameter exploration, data-link verification, IQ recording and playback, and signal preview.
It reduces the operational effort required during the verification phase and provides a reusable configuration baseline for subsequent API development.

3.5 HTRA API and SDK

The HTRA API and SDK are the primary means for customer applications to control the R1000, acquire data, and implement automated processing.
Production systems can manage device lifecycle, parameter configuration, data streaming, recording, synchronization, and error handling according to application requirements without requiring SAStudio4 to be running.

3.6 Example Applications

The example applications help users quickly understand the HTRA API call sequence, data structures, and basic receive workflow.
It is recommended to first run the example applications provided with the current SDK version and then incrementally develop the customer application based on those examples.

3.7 Relationship Between SAStudio4 and Customer Applications

Figure 3-2 shows the recommended workflow: first use SAStudio4 to verify the device and RF environment, then use the example applications to verify the development environment and API workflow, and finally proceed to customer application integration.

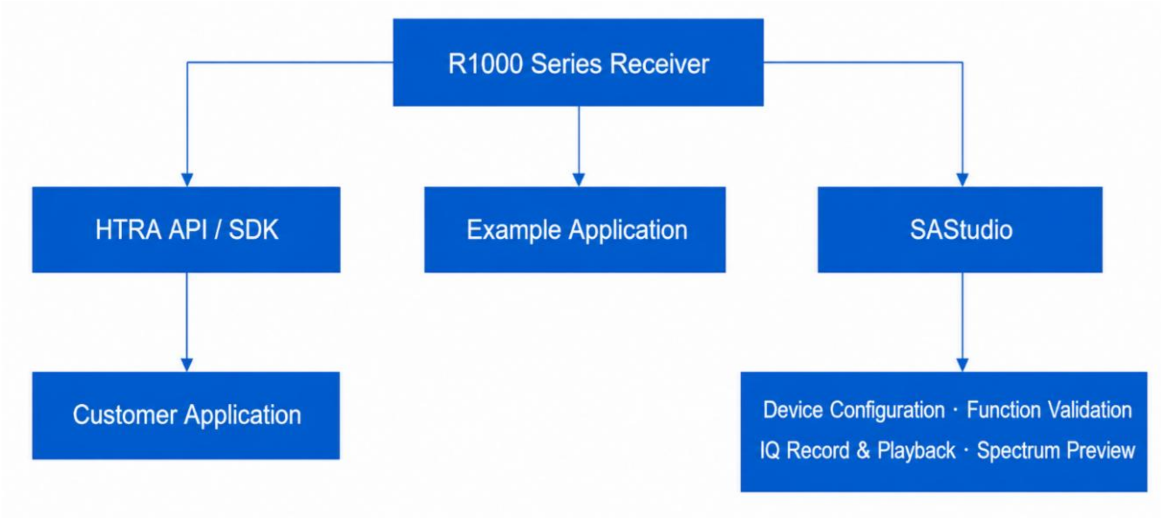


Figure 3-2 R1000 Series Software Architecture and Typical Usage Path

- HTRA API/SDK is the primary path for customer application development.
- Example applications help customers quickly understand and verify the API.
- SAStudio4 is used for device configuration, functional verification, IQ recording and playback, and spectrum preview.

4 Appearance, Panels, and Interface Index

Before connecting any cables, identify the interface locations, orientations, and electrical functions for the specific model.

4.1 R1090 Interface Layout

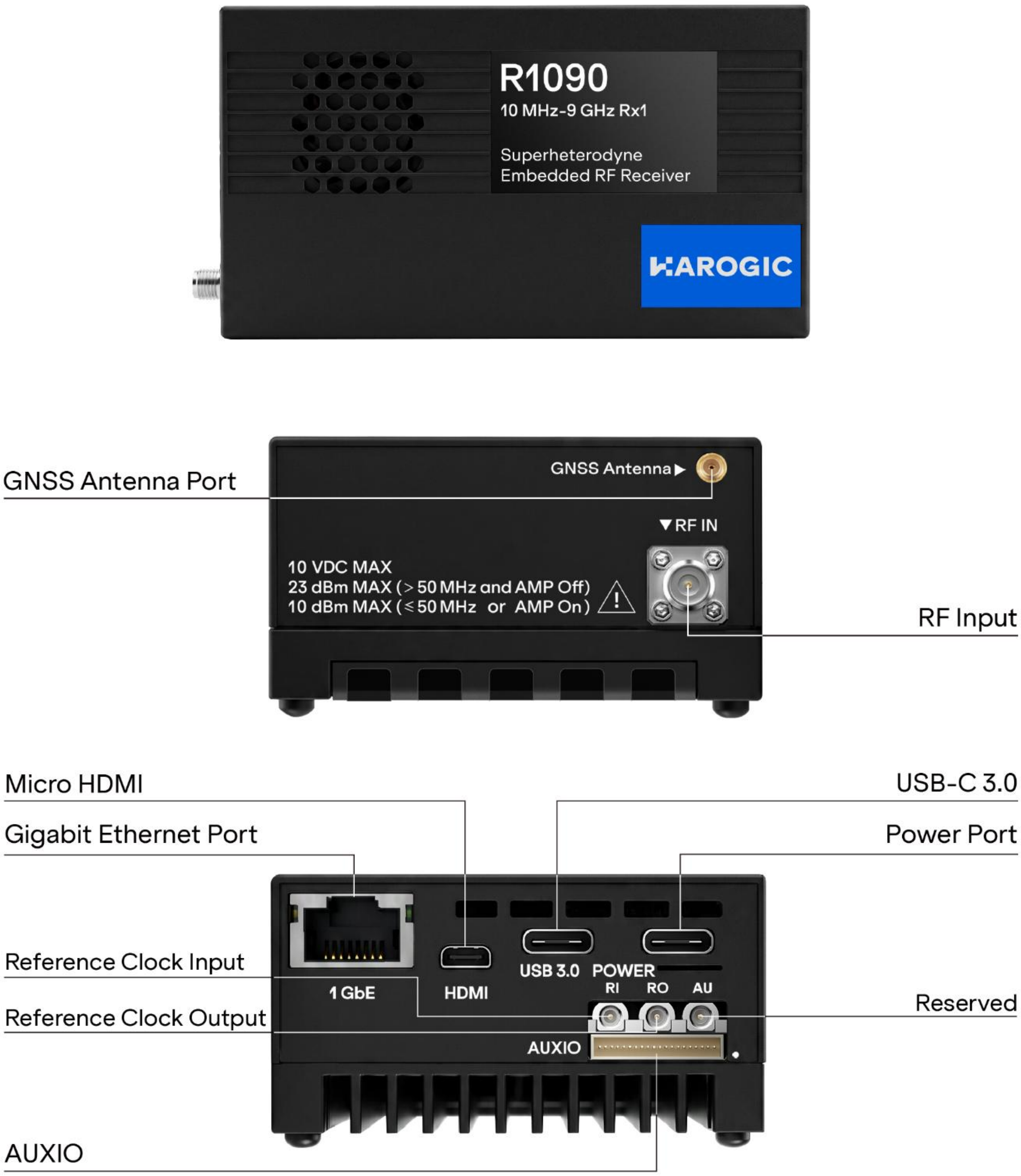


Figure 4-1 R1090 Appearance and Interface Layout

Figure 4-1 shows the following R1090 interfaces: GNSS Antenna, RF IN, 1 GbE, HDMI, USB 3.0, POWER, RI, RO, AU, and the 14-pin AUXIO connector.

4.2 R1090 Panel Interface Index

No.	Interface	Purpose	Details
1 / GNSS Antenna	GNSS antenna input	Receives GNSS signals for frequency calibration and time synchronization	See "GNSS,Reference, Clock,PPS,and Synchronization"
2 / RF IN	SMA (F)，50 Ω	Single-channel RF input; before connection, verify the maximum safe input level, allowable DC voltage, and external protection requirements for the specific model	See "RF Input and Protection"
3 / 1 GbE	Gigabit Ethernet	Control, API access, and data transfer	See "1GbE Ethernet Port"
4 / HDMI	Micro HDMI	Local display and debugging	See "HDMI and USB"
5 / USB 3.0	USB-C form factor	Peripheral expansion, such as keyboard, mouse, and storage devices	See " HDMI and USB"
6 / POWER	USB-C form factor	Main power input for the unit	See "Power Supply and Power-On"
7 / RI	MMCX（F），	10 MHz reference clock input	Amplitude >=1.5 Vpp, 330 Ω
8 / RO	MMCX（F），	100 MHz reference clock output	Amplitude >=0.3 Vpp, programmable on/off
9 / AU	Reserved port	Reserved	Reserved; leave unconnected
10 / AUXIO	14-pin multi-function connector	Multifunction I/O interface, including GPIO, Trigger, and others as listed in the table below.	External trigger input: 3.3 V CMOS, high impedance; trigger output: 3.3 V CMOS

Table 4-1 Description of Multi-function AUXIO PIN Interface（Illustration direction from right to left in Figure 4-1)

Pin	Name	Direction	Level Standard	Meaning
1	TRG IN	I	3.3 V	Trigger input, maximum trigger rate: 500 events/s
2	TRG OUT	O	3.3 V	Trigger output
3	Reserved	/	/	Reserved
4	GND	/	/	Ground
5	PPS OUT	O	3.3 V	XPPS output
6	3.3 V	O	3.3 V	3.3 V power output
7	USART RX	/	3.3 V	/
8	GND	/	/	Ground
9	USART TX	O	3.3 V	/
10	Reserved	/	/	Reserved
11	Reserved	/	/	Reserved
12	Reserved	/	/	Reserved
13	GND	/	/	Ground
14	Reserved	/	/	Reserved

5 Power Supply, RF Input, Installation, and Environmental Requirements

This chapter describes the hardware requirements that must be satisfied before the instrument is powered on and connected to an RF system.

5.1 Power Supply and Power-On

Confirm the power-supply configuration first, then check the power source, cables, cooling conditions, and startup status.

5.2 Power Supply Version

WARNING

Use only the original power adapter and cable supplied with the instrument and matching the specifications on the instrument nameplate. Using a power supply with incompatible specifications may prevent the instrument from powering on or operating properly, and may result in equipment damage.

Item	Specification	Description
Interface	USB-C POWER	USB Type-C connector Optional PoE (Power over Ethernet)
Input	9V 3A/ 12V 2.5A	Wide input-voltage range
Power Consumption	≤22 W	Operating conditions/peripherals: mouse, keyboard, and HDMI; CPU at full load, fan at full speed, SAStudio4 running, with no signal input.

5.3 Power Integration Requirements

- Use only the power cable supplied with the instrument or a cable that fully meets the specified requirements. Do not substitute an ordinary USB-C cable, USB hub, or monitor USB port as the power source.
- Optional PoE (Power over Ethernet) is available, allowing both data and power to be carried over a single Ethernet cable. This function requires Option 24.

5.4 RF Input and Protection

The absolute maximum ratings of the RF input port are not recommended operating levels.

For unknown signals, measure the signal externally before connection and use appropriate attenuation, DC blocking, or limiting protection as required.

5.5 Interfaces and Operating Range

Condition	Maximum Allowable Value
Frequency >50 MHz with preamplifier disabled	Maximum damage-level input power: 23 dBm CW

Frequency <50 MHz, or preamplifier enabled	Maximum damage-level input power: 10 dBm CW
DC voltage at RF input	±10 VDC

5.6 Recommended RF Protection Methods

- For unknown signals or operation in high-field-strength environments, connect an external attenuator with a sufficient power rating before connecting the signal to the instrument.
- If the signal path may contain DC voltage, use a DC block with an appropriate frequency range, and verify its breakdown voltage and insertion loss.
- Where transmitter leakage, shared-antenna operation, or strong transients may occur, use a limiter, filter, isolator, or external RF protection switch as appropriate.
- Do not overtighten SMA connectors with a standard wrench. Use of a suitable torque wrench is recommended.

5.7 Dimensions Overview

Model	Dimensions	Weight
R1060	119.75 × 62.8 × 32.9 mm	357g
R1090	119.75 × 62.8 × 32.9 mm	357g
R1200	127.2 × 62.8 × 33.3 mm	375g
R1400	127.2 × 62.8 × 33.3 mm	375g

HAROGIC also offers core modules without an enclosure, with optional fan-based cooling solutions. For detailed information about core modules, contact your HAROGIC sales representative.

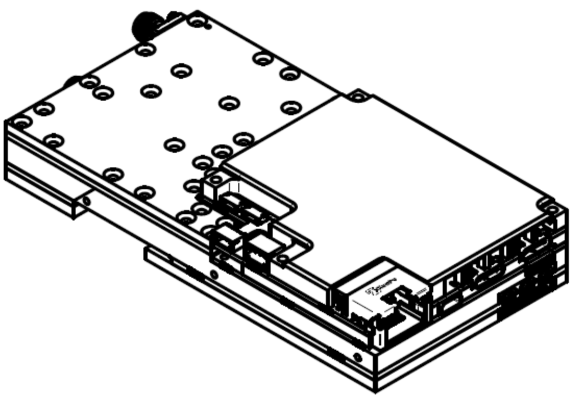


Figure 5-1 Typical Core Module

5.8 Cooling and Airflow

The maximum power consumption of the R1060 and R1090 is approximately 22 W, while the R1200 and R1400 consume up to approximately 25 W. The products incorporate ventilation openings or heat-dissipation fins. At a minimum, the system integration design shall meet the following requirements:

- Do not block air inlets, air outlets, or heat-dissipation surfaces, and do not stack multiple units together without adequate clearance.
- Evaluate the maximum ambient temperature, mounting orientation, enclosure sealing, and other conditions.
- Ensure that cables, foam, labels, and fasteners do not obstruct ventilation openings, heat-dissipation surfaces, or any identified moving components.

NOTICE

The standard product is rated T0, with an operating temperature range of 0 to 50 °C. For applications requiring an extended operating temperature range, the HAROGIC T1 option is available.

The temperature rating does not replace proper system-level thermal design. For questions regarding system integration, installation, or thermal management, contact HAROGIC for professional technical guidance.

5.9 Operating Environment Rating

Operating Temp.	Storage Temp.	Rating
0–50 °C	-20–70 °C	T0
-20–65 °C	-40–85 °C	T1 (opt. 40)
-40–65 °C	-40–85 °C	Non-standard order option; contact HAROGIC Sales for details

Ambient Temp.	Operating Relative Humidity
0–40 °C	5%–75%
>40 °C	5%–45%

Avoid condensation. After moving the instrument from a low-temperature environment into a warm and humid environment, keep the instrument powered off until it has fully reached ambient temperature. Confirm that no condensation is present before applying power.

6 Network, Embedded Host, and Software Preparation

Establish and verify a 1GbE connection, confirm host access, and then prepare the system environment for running SAStudio4.

6.1 Host-Side Physical Interfaces

The 1GbE interface is the primary interface for remote control and data transfer on the R1000 Series. The HDMI and USB interfaces are used for local display, keyboard/mouse peripherals, and debugging.

6.1.1 1 GbE Ethernet Port

The R1000 Series provides a single 1GbE RJ45 port for device control, API access, and data transfer. Sustained IQ data throughput is jointly limited by the sampling rate, data format, host network interface, CPU performance, and disk write performance.

For the default network address, user credentials, system paths, and service commands, refer to the Quick Start Guide. For batch deployment, plan for unique IP addresses, access control, initial credential changes, network isolation, and version management.

6.1.2 HDMI and USB

The R1000 Series provides a Micro HDMI (HDMI 2.0) interface for display output. Peripherals can be connected via the USB 3.0 Type-C port next to the HDMI port. A standard USB-C hub can be used to connect a keyboard, mouse, USB storage devices, and other peripherals.

6.2 Wi-Fi and Bluetooth

The integrated Raspberry Pi 5 host supports 2.4/5 GHz Wi-Fi and Bluetooth 5.0 (BT). Wi-Fi and Bluetooth are disabled by default at shipment and must be manually enabled by the user when required.

HAROGIC can also supply product variants with the Wi-Fi and Bluetooth wireless functionality removed before shipment. This configuration must be specified when placing the order. Contact HAROGIC Sales for details.

6.3 Network Configuration

The R1000 can connect to a network through its 1GbE Ethernet (LAN) interface.
When an R1000 Series device is connected to a network, its built-in network logic first attempts to obtain an IP address through DHCP. If an active DHCP server is available, an IP address is assigned automatically. If no DHCP server is detected, the device retains its default IP address, 192.168.1.100.

For the initial connection, it is recommended to configure the host computer on the same subnet as the R1000 using the following settings:

Item	Default / Description
Default IPv4 address	192.168.1.100
Subnet mask	255.255.255.0
Example host IP address	192.168.1.102, subnet mask 255.255.255.0

6.4 Verify a Direct PC Connection

In Windows, open Settings -> Network & Internet -> Ethernet;

- Enter the Ethernet, locate the IP settings section, and click Edit;
- Select Manual, enable IPv4, set the IP address to 192.168.1.102, and set the subnet mask to 255.255.255.0;
- Open Command Prompt and run ping 192.168.1.100. If replies are received, the network connection has been successfully established.

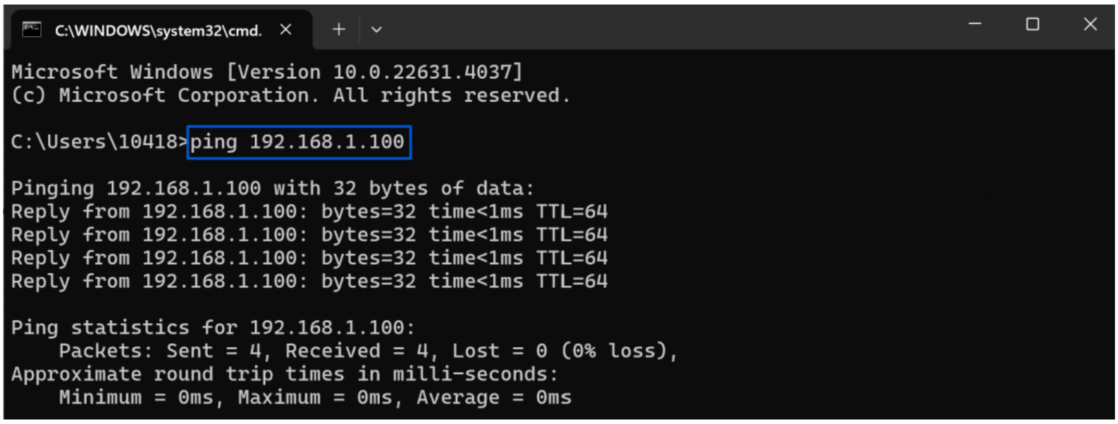


Figure 6-1 Verifying the Device Network Connection Using the ping Command

6.5 Accessing the R1000 Embedded Host

The R1000 integrates a Raspberry Pi 5 host, which can be accessed either through SSH or through a locally connected display.

Default SSH username: htra; Default SSH password: htra

ssh htra@192.168.1.100

6.5.1 Network Settings

R1000 series network configuration description:

- **IPv4 address:** "192.168.1.100"
- **Subnet mask:** "255.255.255.0"

Other support noted: DHCP hostname and mDNS hostname can be modified.

6.5.2 Changing the Static IP Address

To change the default static IP address of an R1000 Series device, follow the steps below. The following example sets the IP address to 192.168.1.100:

- Log in using the username root and the default password htra.
- Access the Raspberry Pi host via SSH and enter the following command:
- hlc --set-static-ip 192.168.1.100/24

The static IP address is now configured. The device must be restarted for the change to take effect.

- Enter reboot and wait for the device to restart. Note that you must be logged in as the root user to restart the Raspberry Pi host.

```
root@raspberrypi:~# hlc --set-static-ip 192.168.1.100/24
root@raspberrypi:~# reboot
root@raspberrypi:~#
```

Figure 6-2 Command for Changing the Static IP Address After Logging In via SSH

6.6 System Requirements

The following table lists the basic recommended system configuration. For systems below the recommended specifications, actual performance should be verified through testing.

Table 6-1 Host System Requirements

Operating System	Windows 11/10, (requires VS2019 C++ redistributables) Ubuntu 22.04/20.04/18.04
Architecture	Windows: x64 Linux: x64, AArch64
Processor	Windows: Intel i3 or higher Linux: Compatibility testing has been completed on Raspberry Pi 4B, Raspberry Pi 5, RK3399, and RK3588
Memory	4 GB or more
Storage	IQ signal recording requires the storage system to support a sustained write bandwidth greater than 400 MBytes/s.
Data Interface	1GbE Ethernet. IQ recording bandwidth and maximum recording duration are limited by the available data-interface bandwidth
Display Resolution	Minimum resolution: 1280 × 768 pixels
Other	Some antivirus software may cause system instability

Table 6-2 Raspberry Pi System Specifications

Model	Raspberry Pi Compute Module 5
Processor	Broadcom BCM2712, quad core Cortex-A76 (ARMv8) 64-bit SoC @ 2.4GHz
Memory	4GB LPDDR4-4267 SDRAM with ECC
Storage	32GB eMMC Flash Memory
Preinstalled Operating System	Debian 12 Bookworm 64-bit
Wireless Connectivity	2.4 GHz, 5GHz Wi-Fi, Bluetooth 5.0, disabled by default and must be manually enabled

6.7 Obtaining and Installing the Desktop Software

- Obtain the SAStudio4 installation package that matches the R1000 hardware and software/firmware versions from the media supplied with the product, an official HAROGIC distribution channel, or HAROGIC Technical Support.
- **Note:** Windows x64, Linux x86_64, and Linux AArch64 versions are provided by default. If a Windows x86 version is required, contact HAROGIC Technical Support for assistance.
- Review the release notes and verify the supported operating system, CPU architecture, required runtime libraries, and device compatibility.
- Follow the instructions provided with the installation package to complete the installation. If the software is provided as a portable package that does not require installation, keep the entire directory structure intact and do not copy only the executable file.
- Before the first launch, verify that the current user has read and write permissions for both the software directory and the intended data-storage directory.

6.8 Default Data Storage Paths

The root directory may vary depending on the installation method. Relative to the current SAStudio4 software directory, the commonly used subdirectories are as follows:

Relative Directory	Primary Contents
data	Recorded data, configuration files, and waterfall-exported data in formats such as CSV and WAV
images	PNG images generated by quick screenshots and chart exports
reports	CSV data exported from charts and the corresponding configuration files

Chapter Completion Criteria: The host computer can successfully ping **192.168.1.100**; the embedded host can be accessed through SSH or a local display when required; the SAStudio4 version is compatible with the device; and the target storage drive has sufficient free space and sustained write performance.

7 Connecting to SAStudio4 and Verifying Device Status

Begin with the minimum required operations to verify that SAStudio4 recognizes the device and that the data link remains stable, before adjusting any RF parameters.

7.1 Starting SAStudio4

- Confirm that the power supply, data connection, and storage preparation described in Chapter 6 have been completed;
- Launch the SAStudio4 version that matches the current R1000 delivery version. The executable is located at the following relative path: \SAStudio4\SAStudio4\bin\SAStudio4.exe;
- Wait for the main interface to complete initialization. Do not launch multiple instances while initialization is in progress. By default, R1000 Series instruments start in the Receiver IQ Streaming mode interface;
- Check the Instrument State area and verify that information such as the model, last six digits of the UID, API/FPGA/MCU versions, GUI version, bus data throughput, and real-time temperature is displayed.

7.2 Interface Layout

The standard SAStudio4 interface consists of six main areas.

Area	Primary Function
Menu	Save/open configurations, switch modes, select single/continuous operation, quick recording and playback, and system settings.
Graph Set Area	Select graphs and configure Graph, Trace, Marker, zoom, and data export settings.
Graph Display Area	Display the maximum power-over-time thumbnail, spectrum, IQvT, PvT, spectrogram, and other plots.
Main Setting Area	Configure Frequency、BW、Amplitude、Trigger、Record、Play Back、DDC、FFT、IQvT and PvT.
Instrument State	Display status information such as the model, UID, software/firmware versions, throughput, and temperature.
Parameter Quick Set	Quickly view or modify frequently used parameters such as center frequency.

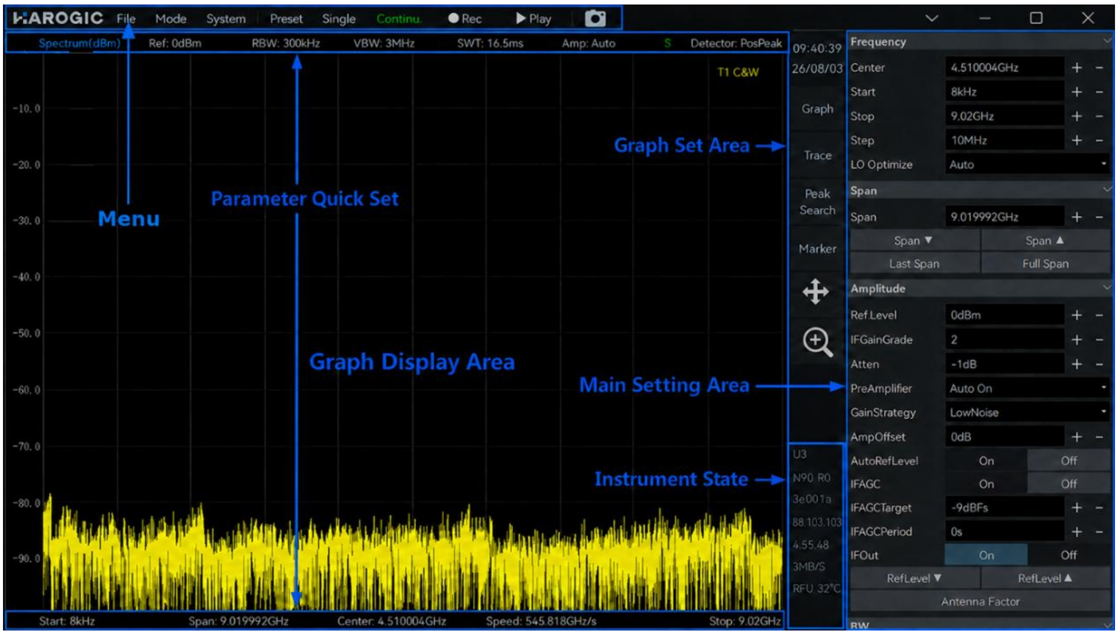


Figure 7-1 Software Interface Layout

7.3 Establishing the Device Connection

The primary indication of a successful desktop connection is whether SAStudio4 can display the device status information. If the status information remains blank after startup, errors persist, or data does not refresh, exit the software first, then check the hardware connections and verify that the software and device versions are compatible.

Quick Verification Task

Without changing any critical receiver parameters, click “Continuous” and verify that the status information and graphs continue to refresh. Then click “Single” and confirm that the software can complete a single acquisition.

7.4 Viewing the Model, UID, and Software/Firmware Versions

Click “System” -> “About” on the menu bar to view the current device UID and software/firmware versions:

- Device model and UID;
- SAStudio4 GUI version;
- API, FPGA, MCU, and other firmware versions displayed in the interface;

7.5 Viewing Temperature, Bus Throughput, and Operating Status

The Device Status Area displays the bus data throughput and real-time device temperature. Pay particular attention to the following:

Item	Normal Behavior
Status Refresh	Information such as the model, version, and temperature remains visible and updates normally.
Bus Throughput	Changes with the data stream after acquisition or recording starts, and decreases after acquisition or recording stops.

Temperature	Changes gradually within the specified operating range of the product.
Graph Refresh	Stable continuous updates with no prolonged UI freezes.

7.6 Restoring the Default Configuration

Click “Preset” on the menu bar to restore the current software configuration to the device's default settings. In the following situations, it is recommended to save the current configuration before applying the preset:

- After multiple parameter changes, when it is difficult to determine which setting is causing the absence of data;
- When external clock configuration fails and the device needs to be returned to the internal clock;
- After changing devices or switching the primary operating mode, when the interface status does not match the expected state.

7.7 Checklist for Verifying Normal Device Operation

No.	Check Item	Pass Criteria
1	Power supply, cooling, and data connection	Comply with the hardware manual and remain stable.
2	Temperature and status	Remain within the allowable range for the corresponding model, with no persistent alarms.
3	Continuous and single acquisition	Acquisition can be completed normally in both modes.
4	Receiver IQ Streaming mode	The Spectrum, IQvT, or PvT view refreshes normally.
5	Short-duration IQ recording and playback	Files can be created, recording can be stopped, and recorded files can be opened and played back.

8 Viewing and Configuring RF Signals: Receiver IQ Streaming Mode

Configure the center frequency, bandwidth/sample rate, and display settings in sequence to establish a reproducible workflow for receiver signal monitoring and recording.

Receiver IQ Streaming mode is the primary mode for desktop verification of the R1000 Series. It brings together receiver configuration, time-domain IQ data, power-vs.-time analysis, spectrum preview, DDC, and recording controls within a single workflow.

8.1 Entering Receiver IQ Streaming Mode

- Complete the connection and device-status verification in the checklist provided in Chapter 7.
- SAStudio4 enters Receiver IQ Streaming mode by default at startup. Alternatively, click “Mode” -> “Receiver/IQ Streaming” on the menu bar.

Figure 8-1 Receiver IQ Streaming Mode Interface

8.2 Setting the Center Frequency

- In the Main Setting Area, select “Frequency.”
- Set the Center Frequency so that the target signal falls within the current analysis bandwidth.
- Click “Continuous” and observe the spectrum or time-domain display to determine whether the target signal is present.
- If the target signal is not observed, first check the signal source, RF connection, and center frequency before adjusting the gain. Do not rely solely on continuously increasing the gain to determine whether the signal path is connected properly.

8.3 Setting Bandwidth, Sample Rate, and Gain

Parameter	SAStudio4 Setting	Usage Guidelines
Native Sample Rate	“BW” -> “Native Sample Rate”	Sets the ADC sample rate. The native sample rate can be used together with the span setting to achieve flexible sample-rate adjustment.
Analysis Bandwidth / Span	“BW” -> “Span”	Defines the frequency range for preview and analysis. “Span ▲/▼” adjusts the span in powers of two.
Data Format	“BW” -> “Data Format”	The software provides single-channel 16-bit and 32-bit options, with 16-bit as the default. A higher bit width generally provides greater precision but also results in a larger amount of data.
Preamplifier	“Amplitude” -> “Preamplifier”	The preamplifier can be set to Auto, forced Off, or one of the gain modes provided by the interface. In strong-signal environments, priority should be given to preventing RF front-end overload.
Gain	“Amplitude” -> “Gain”	“Low Noise” prioritizes a lower noise floor, while “High Linearity” prioritizes linearity performance. Select the appropriate strategy for the application.
IF Automatic Gain Control	“Amplitude” -> “IF Automatic Gain Control”	When enabled, the software can reduce the IF gain if IF saturation occurs. When disabled, the manually configured gain is maintained.
Attenuation	“Amplitude” -> “Atten”	Used to increase headroom in strong-signal environments. After making changes, recheck the noise floor, peak level, and overload status.

8.4 Spectrum and Waterfall Preview

The spectrum preview in Receiver IQ Streaming mode is used to verify the signal location and its basic frequency-domain characteristics. In the Main Setting Area, click “FFT” and enable “Analysis.” Drag the “Spectrum-P” selection box in the maxpower-vs-time overview, or set the Start Time and Time Length, to select the IQ time interval to be used for FFT analysis.

Use “FFTsize” to set the number of FFT points, “Window” to select the window function, “TraceDetector” to select the trace detection method, and “Intercept” to exclude the transition band from the displayed spectrum. To observe frequency activity over time, select “Graph” -> “Spectrogram”.

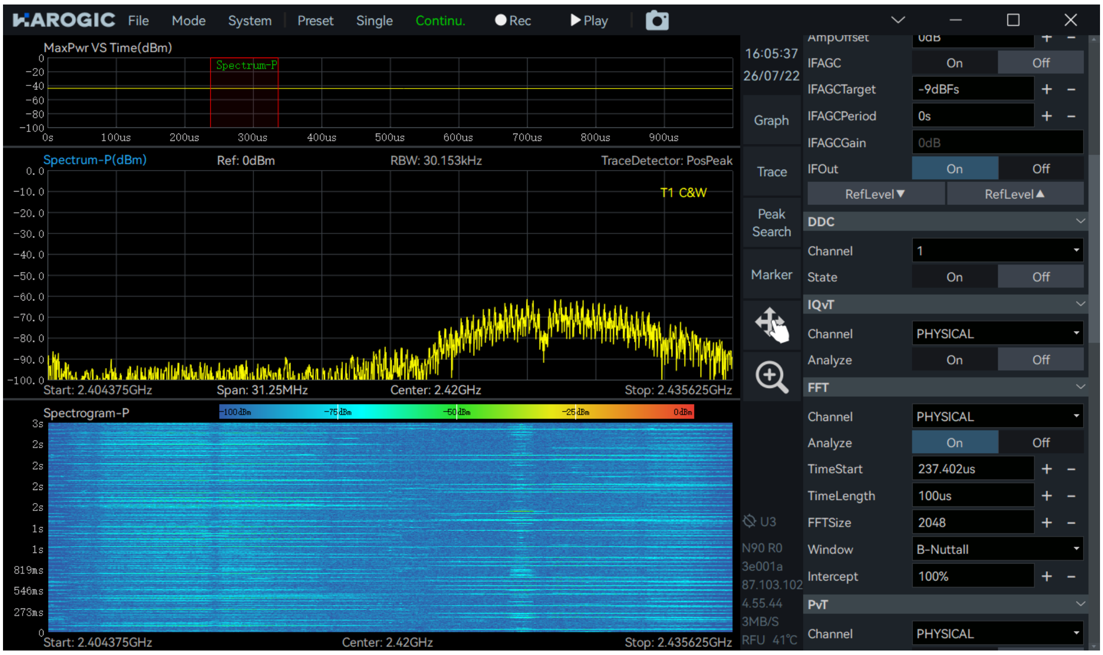


Figure 8- 2 Spectrum and Waterfall Displays in Receiver IQ Streaming Mode

8.5 Time-Domain Waveform

- In the Main Setting Area, click “IQvT” and enable “Analyze”;
- Drag the “IQvT-P” selection box in the maxpower-vs-time overview, or set “TimeStart” and “Time-Length”;
- From the “Graph” menu of the target IQ graph, select “Auto Scale” to adjust the I/Q waveforms to an appropriate display range;
- To examine waveform details, enable Zoom or use the Magnifier function.

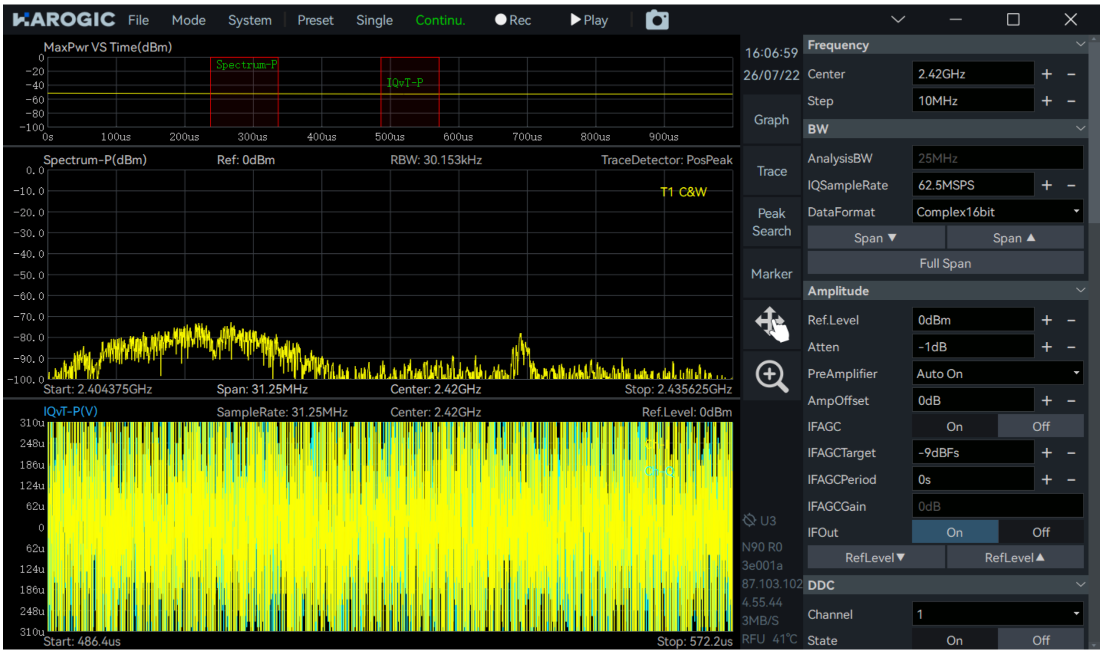


Figure 8-3 Spectrum and IQ Time-Domain Waveform in Receiver IQ Streaming Mode

8.6 MaxPwr vs Time Waveform

In the Main Setting Area, click “PvT” and enable “Analyze.” Drag the “PvT-P” selection box in the maximum-power-vs.-time overview, or set “TimeStart” and “TimeLength,” to view the power-vs-time characteristics of the selected IQ time interval.

This view is useful for evaluating signal duty cycle, burst timing, and whether the selected recording interval captures the target event.

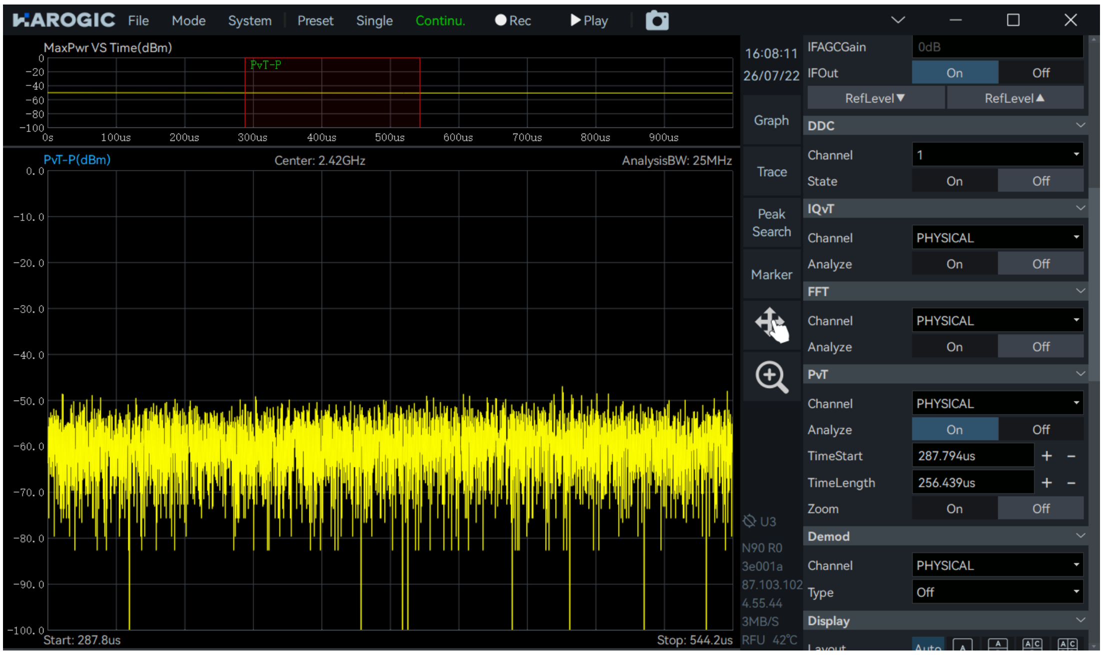


Figure 8-4 PvT Waveform in Receiver IQ Streaming Mode

8.7 DDC and Other Receiver Functions Applicable to the R1000

DDC performs digital downconversion and resampling of the IQ data stream to generate a sub-band IQ stream, enabling further spectrum, IQvT, or PvT analysis of the target sub-band within the available bandwidth.

Parameter	**Description**
OffsetFreq	Complex-mixer frequency offset. A value greater than 0 shifts the spectrum to the right, while a value less than 0 shifts it to the left.
Decimate	DDC decimation factor, used to configure the resampling rate.

- Click “DDC” and enable the desired channel from the channels available in the interface;
- Set the sub-channel center frequency, frequency offset, and decimation factor;
- In the channel selection of “FFT”, “IQvT”, or “PvT”, select the corresponding DDC channel;
- Enable “Analyze”, then use the corresponding red time-selection box or time parameters to select the analysis interval.

Figure 8-5 DDC Multi-Channel Target Sub-Band Analysis in Receiver IQ Streaming Mode

8.8 Trigger Settings

Click “Trigger” in the Main Setting Area to open the trigger settings. Common controls include trigger source, trigger edge, trigger delay, pre-trigger, retrigger, level threshold, and timing period.

Configuration Workflow: First use continuous preview to verify the target signal, noise floor, and overload status, and then save the configuration. Subsequent IQ recording, trigger configuration, and API examples should, whenever possible, use the same configuration as their baseline.

9 IQ Recording, Playback, Export, and Data Management

Complete a short recording workflow first, then proceed to long-duration or high-data-rate acquisition while maintaining traceability of configurations, software/firmware versions, and recorded data.

IQ Record & Playback is a key focus of this manual. It is recommended to first complete a short record–stop–open–playback workflow before performing long-duration or high-data-rate acquisitions.

9.1 Overview of IQ Recording

In Receiver IQ Streaming mode, SAStudio4 can write the received IQ data to recording files for subsequent opening and playback. Recorded IQ data can be used for offline analysis, issue reproduction, algorithm validation, and comparison with results from custom applications.

Recording Mode	Behavior
Fixed Duration	The number of samples, recording duration, and file size limit can be preset. The actual recording will not exceed the configured file size limit.
Manual	Recording is controlled by clicking "Record" and "Stop". When the file size limit is reached, software automatically stops recording.

9.2 Configuring Recording Parameters and Storage Path

- In Receiver IQ Streaming mode, verify through the preview that the center frequency, sample rate, bandwidth, data format, gain, and trigger settings are correct;
- In the Main Setting Area, click "Record" -> "Recording Mode", and select "Fixed Duration" or "Manual";
- In Fixed Duration mode, set the recording duration. In both recording modes, check the "Single File Size Limit";
- Click "File Path" and select the destination directory. The default relative directory is data; another writable directory may also be selected;
- Check "Remaining Capacity" and make sure that the target drive has sufficient free space.

9.3 Starting and Stopping IQ Recording

9.3.1 Fixed-Duration Recording

- Verify the recording duration, file size limit, and trigger conditions;
- Click "Record", software acquires data using the current configuration and stops recording when the specified duration or file size limit is reached;
- After recording stops, wait until the file has been completely written before closing SAStudio4 or disconnecting the device.

9.3.2 Manual Recording

- Click "Record" to start recording.
- During recording, monitor the bus throughput, recording status, and remaining disk capacity.

- Click “Stop” to end the recording. If the file size limit is reached, SAStudio4 stops recording automatically.

  Data Integrity: Do not force-quit SAStudio4, disconnect the storage drive, or interrupt power to the device while recording is in progress. An abnormal termination may result in the final recording file being incompletely written.

9.4 Check Recording Status and Data Throughput

During recording, monitor at least the following information simultaneously:

Item	What to Check
Bus throughput	It should correspond to the current data stream and remain continuous.
Available disk space	Sufficient free space should be maintained as a safety margin.
Recording status	Start, stop, and automatic termination should correspond to the actual operation.
Temperature and system load	They should remain stable, with no persistent alarms or UI freezes.

9.5 Open and Play Back an IQ Recording

- In the main settings area, click “Play Back” -> “Open File”;
- In the file selection window, open the recording file to be played back;
- Click “Play” to start playback, and click “Pause” to temporarily pause it;
- Use “Previous Frame”, “Next Frame”, “Back”, or “Forward” to navigate through the data. Enable “Auto Loop” when repeated playback is required;
- Click “Stop” to exit playback and resume data acquisition. If necessary, click “Continuous” on the menu bar to return to live acquisition.

9.6 Export Data

Chart data and raw IQ recordings are two different types of output:

- From the target chart, select “Graph” -> “Export Data”, or right-click in the chart display area and select “Export Data”;
- Select “Image” to export the current chart as a PNG file. By default, it is saved to the images folder;
- Select “Data” to export the current chart data as a CSV file. By default, it is saved to the reports folder;
- Raw IQ data should be retained in the original SAStudio4 recording file. Do not use chart CSV files as a substitute for raw IQ data.

9.7 Recording File Format

SAStudio4 IQ recordings use a WAVE-compatible container that includes a RIFF/WAVE file header and data chunks such as fmt, prof, trig, and data. Configuration information, stream information, device information, and per-packet trigger/status information are stored together with the IQ data. See Appendix A for a complete overview.

9.8 Storage Bandwidth, File Capacity, and Usage Considerations

- Data volume increases with the sampling rate, data format, channel configuration, and recording duration. Perform a short recording first and verify the actual file growth rate.
- "File Size Limit" limits the size of each individual recording file. A single long recording session may therefore generate multiple subfiles.
- Use a high-performance local data drive. Avoid writing real-time recordings directly to synchronized folders or unstable remote storage.
- Before recording, disable unnecessary disk-scanning, backup, and large-file copy tasks.
- After recording, immediately perform a brief playback check, and archive the device UID, software version, and configuration file together with the recorded data.

10 Real-Time Spectrum Mode

Use the spectrum, probability density plot, Spectrogram, traces, and markers to quickly observe continuous, transient, and burst signals.

Real-Time Spectrum Mode is designed for rapid observation of transient and burst signal activity. It serves as a preview and auxiliary analysis tool for RF signals.

10.1 Overview of Real-Time Spectrum Mode

Click “Mode” -> “Real-Time Spectrum Analysis” to enter Real-Time Spectrum Mode. In this mode, real-time spectral processing is performed on time-domain signals within the analysis bandwidth. Spectrum, probability density, and Spectrogram help users observe continuous, transient, and burst signals.

10.2 Setting the Center Frequency, Analysis Bandwidth, and Reference Level

- Set the center frequency under “Frequency” so that the target signal falls within the displayed frequency range;
- Set an appropriate analysis bandwidth under “BW” for the current task;
- Under “Amplitude”, configure the reference level, preamplifier, gain strategy, and attenuation so that the signal is neither overloaded nor too weak;
- First click “Continuous” to confirm continuous updating, and then adjust the graph display parameters.

10.3 Probability Density

Graph Parameter	Function
BitMap	On enables the probability density display; Off disables it.
Color	Available color scales include Sky, Deep Sea, Jet, Cool, Hot, and Grayscale. Deep Sea is the default option in the original software.
Afterglow	Increasing the value extends trace persistence, making burst signals easier to capture. Decreasing the value speeds up visual refresh, making continuous signals easier to track.

10.4 Spectrogram

Click “Graph” -> “Spectrogram” to create a waterfall display. After selecting the waterfall display, open “Graph” again to configure the scan depth, time density, and color scale.

The source software supports a maximum buffer depth of 8,000 pixel rows. When the time density is set to 100, the spectrogram display scrolls at 100 pixel rows per second.

“Export Image” exports the current Spectrogram as a PNG file. “DataExport” exports the data within the current buffered range as a CSV file, with the data arranged in reverse chronological order.

10.5 Wi-Fi Signal Measurement

Connect the antenna to the “RFIN” RF input port;

Set “Center” to 2.44 GHz，Increase the “Afterglow” value under the “Graph” submenu in the graph settings area to make Wi-Fi signals more clearly visible.

Figure 10- 1 Spectrogram and Afterglow Displays in Real-Time Spectrum Mode

10.6 Real-Time Spectrum Data Recording and Playback

Real-Time Spectrum Mode also supports recording and playback through SAStudio4's standard "Record" and "Play Back" functions. In this mode, scroll down the right-hand toolbar to access the recording and playback settings.

Before starting a recording, verify the file path, file size limit, and available storage capacity. For playback controls, refer to Section 9.5.

When algorithmic processing or precise signal reproduction is required, the raw IQ data recorded in Receiver IQ Streaming Mode should be retained whenever possible.

11 Extended Analysis Functions

The extended analysis functions are intended for signal observation and auxiliary analysis. This chapter provides only an overview of the available capabilities. For detailed information, refer to the SAStudio4 User Guide.

The extended analysis functions provided by SAStudio4 can be used for signal observation and auxiliary analysis. The guaranteed specifications of R1000 Series products are subject to the corresponding product datasheets.

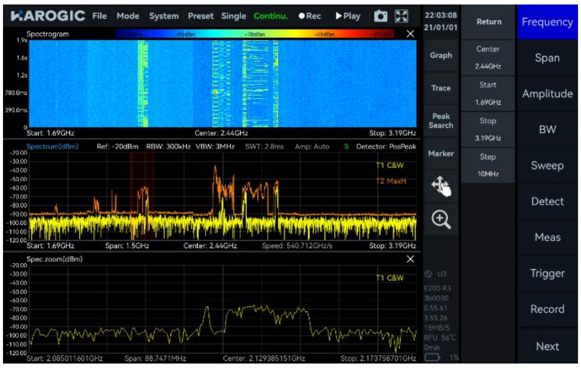
Introduction to Extended Analysis Operating Modes

In addition to Receiver/IQ Streaming Mode and Real-Time Spectrum Analysis Mode, the R1000 Series provides a variety of operating modes, including Standard Spectrum Analysis Mode, Detector Analysis Mode, Phase Noise Measurement Mode, Basic Vector Modulation Analysis (Option 71), Pulse Analysis (Option 72), Harmonic Analysis, and Mapping Mode.

SAStudio4 Main Operating Modes Description

- Standard Spectrum Analysis Mode

This mode provides a wide range of measurement functions, including full-span spectrum sweep, channel power, OBW, ACPR, IM3 and SEM. It also supports spectrum recording and playback. Combined with auxiliary tools such as signal tracking, peak table, and amplitude correction, it delivers a one-stop platform for comprehensive spectrum check.



- IQ Streaming Mode

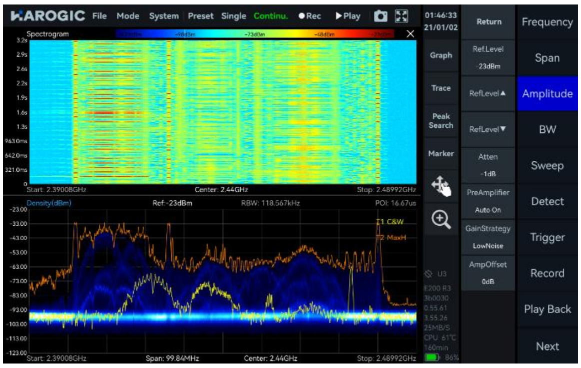
This mode supports up to 100 MHz analysis bandwidth and allows IQ data acquisition through multiple trigger methods. It provides IQ time-domain waveform display, spectrum and spectrogram views, AM/FM demodulation, and digital down conversion (DDC).

■ Power Detection Analysis Mode

This mode enables detection and analysis of time-domain signals within the analysis bandwidth, making it suitable for applications focused on in-band power-versus-time relationships, such as pulse signal measurements.

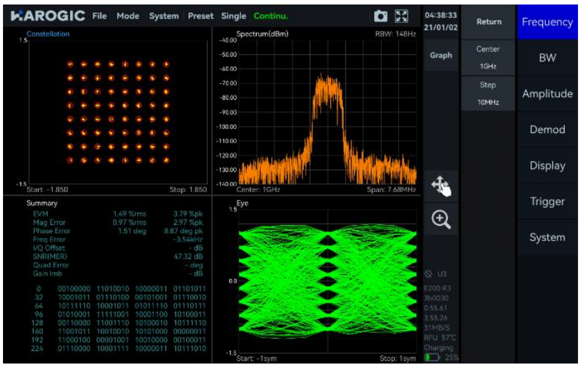
■ Real-time Spectrum Analysis Mode

This mode is powered by a high-speed FPGA-based FFT engine, featuring with strictly gapless and overlap-free FFT, achieving true real-time monitoring across the full bandwidth.



■ Basic Vector Modulation Analysis Mode (opt.71)

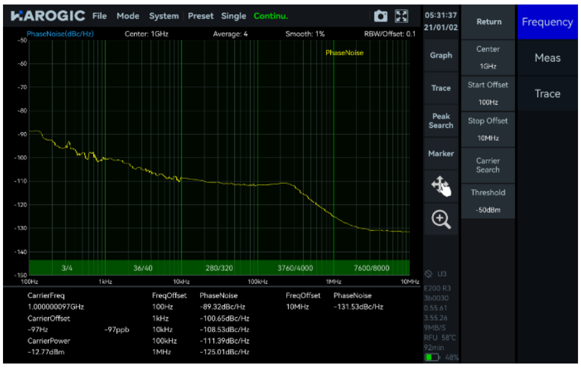
This mode supports 2ASK, 2FSK, 4FSK, GMSK, BPSK, QPSK, 8PSK, 16QAM, 32QAM 64QAM, 128QAM, and 256QAM signals.



■ Harmonic Analysis Mode

This mode supports detection and measurement of up to 10 harmonic components, including harmonic peaks, harmonic channel power, and total harmonic distortion.

Phase Noise Measurement Mode

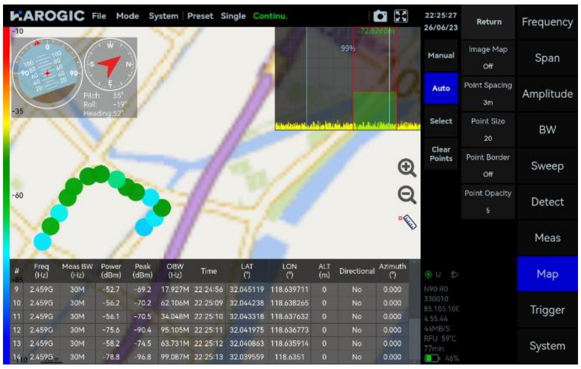


This mode supports offset ranges from 1 Hz to 10 MHz for evaluating carrier phase stability. With the built-in automatic carrier search function, the software can quickly locate the target carrier without manual adjustment.

Pulse Analysis (opt.72)

This mode supports the measurement of pulse signals with a pulse width of 32ns or more, displaying key parameters such as Top level (dBm), Base level (dBm), Top/Base, Droop, Over Shoot, Ripple, Rise/Fall Time, Rise/Fall Edge, Width, PRI, and Duty Cycle.

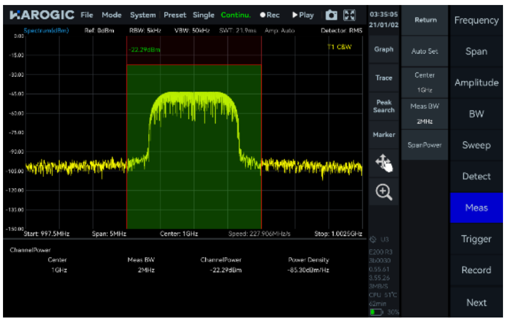
Mapping Mode



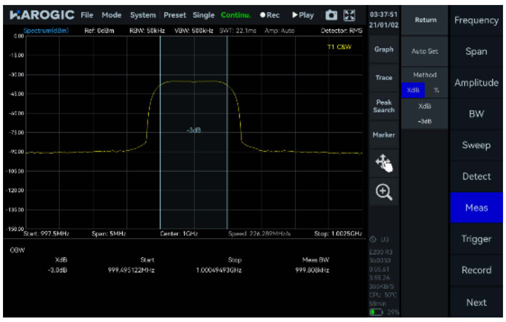
This mode integrates GPS positioning function to generate heat maps and other visual charts, displaying key information such as Channel Power, Occupied BW, Time, Coordinates (latitude/longitude), Altitude, Pixel Position, and Azimuth within a specific area. It is ideally suited for fields such as radio monitoring and interference analysis.

Main Functions Overview

Channel Power



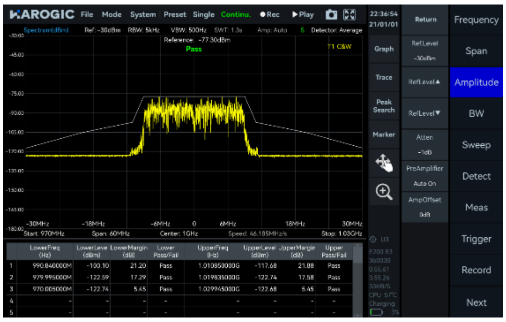
OBW



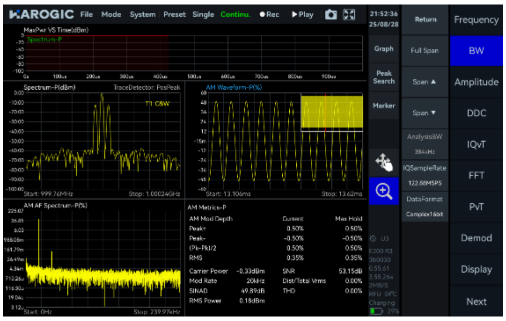
ACPR

IM3

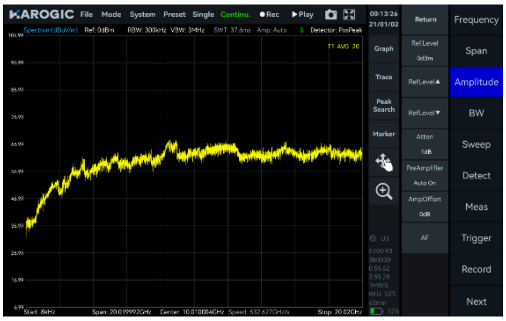
SEM



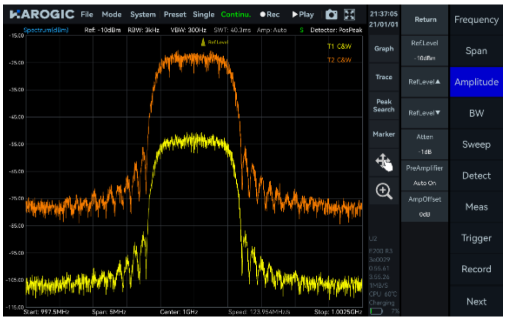
AM/FM Demodulation



Antenna Factor



Amplitude Offset



Signal Track

Peak Table

■ Data Record and Playback

■ Multiple Unit Display

In addition to the technical specifications listed in the product manual, the specifications for the corresponding operating modes are as follows:

STANDARD SPECTRUM ANALYSIS

Detector	PosPeak, NegPeak, Sample, Average, RMS, RawFrames, MaxPower			
RBW	0.1 Hz-10 MHz			
VBW	0.1 Hz-10 MHz			
Data chart	SAStudio4 software provides spectrum, spectrogram, historical trace			
Measurements	Channel power, OBW, X dB bandwidth, Adjacent channel power ratio, IM3			
Sweep Speed (Spur Rejection = Bypass)	RBW = 250 kHz	FPGA processing	B-Nuttall	≥ 1 THz/s
	RBW = 25kHz	FPGA processing	Kaiser	≥ 300 GHz/s
	RBW = 1kHz	CPU processing	B-Nuttall	≥ 4 GHz/s

DETECTION ANALYSIS

Min. time resolution	16 ns / 8 ns (opt.50)
Max. analysis bandwidth	50 MHz / 100 MHz (opt.50)
Detector	PosPeak, NegPeak, Sample, Average, RMS, MaxPower

REAL TIME SPECTRUM ANALYSIS

FFT analysis	FFT engine is implemented in FPGA. Frame compression and trace detection are supported. No missing samples between FFT frames
	FFT frame update rate=10 ^ 9 ns/(N × D × Minimum time resolution) POI = 2 × N × D × Minimum time resolution N is FFT size (4096, 2048, 1024, 512, 256, 128, 64, 32) D is the decimation factor (1, 2, 4, 8, ...).

	Typical settings	FFT refresh rate (times/s)		100% POI	
		std.	opt.50	std.	opt.50
	N = 4096, D = 1	15,258	30,517	131.072 us	65.536 us
	N = 32, D = 1	1,953,125	3,906,250	1.024 us	0.512 us

Max. analysis bandwidth	50 MHz / 100 MHz (opt.50)
Window function	B-Nuttall, Flat-top, LowSideLobe, Rectangle, Kaiser
RBW steps	≥ 12 grades
Amplitude resolution	0.5 dB

Phase Noise Measurement

Min. frequency offset	1 Hz			
Max. measurement frequency offset	10 MHz			
Trace smooth	Support			
SSB phase noise (dBc/Hz) Guaranteed/Typical				
Carrier frequency	1 GHz	4.5 GHz	6 GHz	9 GHz
100 Hz	-90 / -94	-80 / -83	-80 / -83	-78 / -81
1 kHz	-113 / -117	-102 / -105	-100 /-103	-95 / -98
10 kHz	-120 / -125	-112 / -115	-109 / -112	-106 / -109
100 kHz	-126 / -129	-114 / -117	-111 / -114	-108 / -111
1 MHz	-136 / -139	-125 / -128	-123 / -126	-119 / -122
10 MHz	-140 / -143	-137 / -140	-137 /-140	-136 / -139

PULSE DETECTION

Min. pulse width	64 ns / 32 ns (opt.50)
Measurement parameters	Top Level, Base Level, Top/Base, Droop, OverShoot, Ripple, Rise Time, Rise Edge, Fall Time, Fall Edge, Width, PRI, Duty Cycle

AM DEMODULATION

Measurement parameters	Modulation depth, carrier power, modulation rate, SINAD signal-to-noise ratio, RMS power, total harmonic distortion, etc.

Modulation rate test range	20 Hz - 10 MHz	
Modulation rate test accuracy	< 1 Hz when modulation rate < 1 kHz	< 0.1% when modulation rate ≥ 1 kHz
Modulation depth test range and accuracy	5% - 95%, ± 5% (Nominal)	

FM DEMODULATION

Measurement parameters	Modulation frequency offset, carrier power, modulation rate, SINAD signal-to-noise ratio, RMS power, total harmonic distortion, etc.	
Modulation rate test range	20 Hz - 2 MHz	
Modulation rate test accuracy	< 1 Hz when modulation rate < 1 kHz	< 0.1% when modulation rate ≥ 1 kHz
Frequency offset test range and accuracy	1 kHz - 10 MHz， ± 6% (Nominal)	

BASIC VECTOR MODULATION ANALYSIS

Modulation type	ASK： 2ASK FSK： 2FSK, 4FSK MSK： GMSK PSK： BPSK, QPSK, 8PSK QAM： 16QAM, 32QAM, 64QAM, 128QAM, 256QAM
Symbol length	128QAM, 256QAM： 4000 Others: 2000
Symbol rate	(1/64 to 1/4) * sample rate, ≤ 32.5 MSPS
Filter	Root raised cosine
Filter roll-off factor	0.01 - 0.99
Display	Spectrum, constellation, eye diagrams, measurement results
Measurement	EVM, amplitude error, phase error, frequency error, signal-to-noise ratio, part of the bitstream

*Specification applies under the following conditions:
(1) Start up and warm up for 10 minutes
(2) Ambient temperature 25 °C
(3) Specifications may vary with hardware and software versions without prior notice

For complete operating instructions for the extended analysis functions, refer to the HAROGIC SAStudio4 User Guide.

12 GNSS, Reference Clock, PPS, and Synchronization

First, ensure that the hardware requirements for the antenna and reference inputs are met. Then select the clock source and verify the lock status.

12.1 Hardware Interfaces and Electrical Requirements

This section first describes the connectors and electrical requirements for GNSS, the external reference input, and the reference output, followed by the corresponding SAStudio4 settings.

12.2 Internal Reference and GNSS

The reference clock and GNSS input connectors are both MMCX (F). The GNSS input port can supply power to a GNSS antenna. Contact HAROGIC Sales if a compatible GNSS antenna is required.

The standard built-in GNSS provides 1PPS timing accuracy of ±100 ns. With Option 05, a higher-accuracy built-in GNSS is provided. When GNSS is locked and operating under clear-sky conditions (with the receiving surface facing an unobstructed view of the sky), the 1PPS timing accuracy is ≤20 ns.

12.3 External 10 MHz Reference Input

The external clock input requirements are: 10 MHz, amplitude ≥1.5 Vpp, and input impedance 330 Ω. Sine waves, square waves, and clipped sine waves are accepted. Users can select the external reference and set the reference frequency to 10 MHz in SAStudio4, or control it through the corresponding API function.

Figure 12-1 Selecting an External 10 MHz Reference Source in SAStudio4

12.4 Reference Output

The reference clock output is 100 MHz, with an amplitude of ≥0.3 Vpp, and can be programmatically enabled or disabled. Users can enable the reference clock output in SAStudio4 or control it through the corresponding API function.

Figure 12-2 Enabling the Reference Clock Output in SAStudio4

12.5 Selecting an External Reference in SAStudio4

- Connect an external reference clock that meets the requirements specified in Section 12.3;
- Click “System” in the main settings area;
- Set “RefCLKFreq” to 10 MHz and “RefCLKSource” to “External”;
- Confirm that the reference clock source remains displayed as “External”. If the setting reverts to “Internal” and an error occurs, click “Preset” to restore the internal clock. Check the external clock and try again.

12.6 GNSS Lock and 1PPS

The device is equipped with GNSS as standard. The positioning and lock status can be viewed by selecting “System” -> “GNSS Information” from the menu bar. When GNSS 1PPS triggering is required:

- Connect the GNSS antenna as described in Section 12.2 and wait until the interface indicates that GNSS is locked;
- Set “XPPS” to 1 Hz;
- Enter Receiver IQ Streaming mode and click “Next” -> “Trigger”;
- If this option is available on the current device, set “TriggerSource” to “GNSS-1PPS.”

For antenna type, lock time, timing accuracy, and timestamp semantics, refer to the datasheet for the corresponding model and the HTRA API documentation.

Table 12-1 GNSS Description of GNSS parameters

No.	Parameter	Description
1	GNSS Source	Default: Uses the device's built-in GNSS module. EIO: Uses the dedicated external GNSS expansion module supplied by the manufacturer. External: Uses a third-party GNSS module that supports standard serial communication.
2	Baud Rate	Serial baud rate of the external GNSS module. This setting is required only when the External GNSS source is used.
3	Antenna	Select "Internal Antenna" or "External Antenna" (currently, only the external antenna is supported). This setting is required only when the Default GNSS source/EIO is used.
4	XPPS Out	On: Outputs the XPPS pulse signal Off: Forces the GNSS module's XPPS output function to be disabled
5	XPPS	Adjust the output pulse frequency of the GNSS module, in Hz. Default value: 1Hz, which outputs a 1PPS signal. If set to 0.5Hz, a pulse is output every 2 seconds, i.e., a 0.5PPS signal.
6	Format	Provides two formats: Local Time and UTC Time.
7	SatNum	Number of satellites currently positioned.
8	SNR (Max)	Maximum signal-to-noise ratio of positioned satellites.
9	SNR (Min)	Minimum signal-to-noise ratio of positioned satellites.
10	SNR (Avg)	Average signal-to-noise ratio of positioned satellites.
11	Reference Frequency Offset	Displays the frequency offset between the internal GNSS clock and the device.

12.6.1 Use the Default GNSS Source

- Connect the GNSS antenna to the GNSS antenna port of the device;
- Click "System" -> "GNSS Info", and set "GNSS Source" to "Internal GNSS";
- Wait 1 to 3 minutes for the GNSS to lock, you can judge whether the GNSS is locked or not. According to the GNSS lock logo in the status bar information, after locking the GNSS lock logo is green, if it is grey, then it is not locked. see Table 12-1 for the explanation of the parameters in the GNSS information pop-up window.

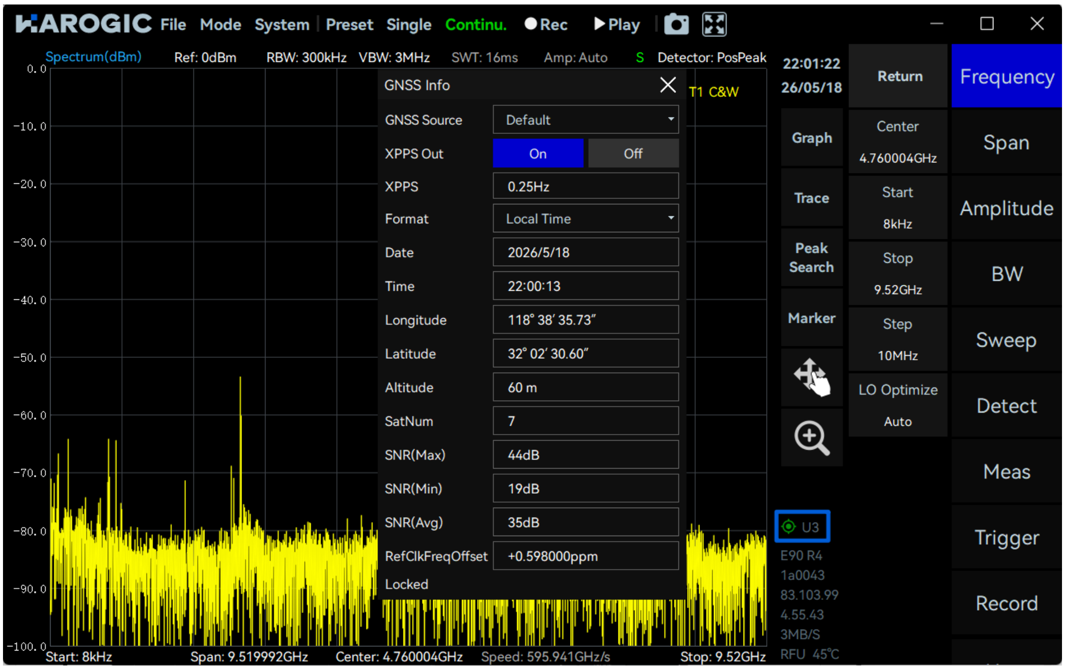


Figure 12- 3 Lock the GNSS External Antenna

12.6.2 1PPS Trigger Using Default GNSS Source

Only IQS mode, DET mode and RTA mode can use 1PPS trigger of GNSS module. This section will take IQS mode as an example and explain in detail how to configure the 1PPS trigger function of the GNSS module.

Refer to the Use the Default GNSS Source section on to ensure that the GNSS is locked;

- Set "XPPS" to 1 Hz in the "GNSS Info";
- Click "Mode" -> "IQStreaming" to switch to IQS mode;
- Click "Next" -> "Trigger" in the main setup area, and set "TriggerSource" to "GNSS 1PPS" in the "Trigger" submenu to use the GNSS module 1PPS trigger.

Figure 12- 4 Triggered using GNSS 1 PPS

13 AUXIO for Trigger and GPIO

First, verify the 3.3 V CMOS electrical limits and connection orientation, and then select the trigger source, edge, delay, and pre-trigger settings. For GPIO operation, use the GPIO interface board. Note that the trigger board and the GPIO interface board are two separate hardware modules.

13.1 Trigger Capabilities

The R1000 Series supports bus triggering, digital edge triggering, and power event triggering. The external trigger input uses 3.3 V CMOS, features a high-impedance input, and supports a maximum trigger response rate of 500 triggers per second. The trigger output also uses 3.3 V CMOS.

13.2 AUXIO Trigger Board

This section describes how to connect and use the compatible trigger board with the R1000 Series RF receiver platform, including the use of trigger input and output functions. The AUXIO interface on the R1000 is connected to Connector 10 on the compatible trigger board (shown below) using a 14-pin ribbon cable.

- Note: The ribbon-cable connector is designed to prevent reverse insertion. Pay attention to the connector orientation and do not use excessive force. When correctly aligned, the connector should insert easily.

Figure 13- 1 Connection Diagram of the AUXIO Trigger Board and R1000

13.2.1 Introduction to the AUXIO Expansion Board for the R1000 Series

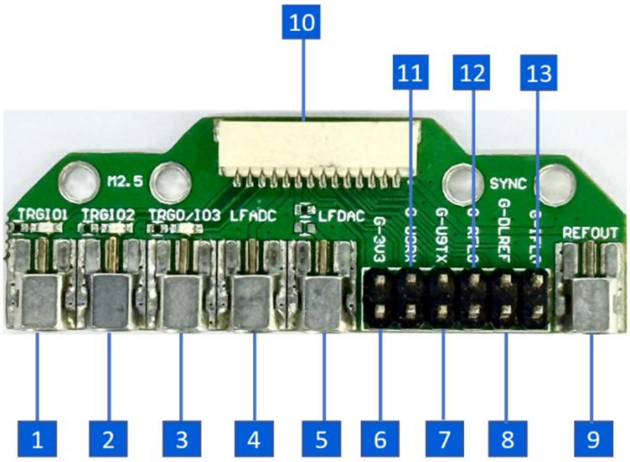


Figure 13-2 R1000 Series Trigger Board Interface Diagram

Table 13-1 R1000 Series AUXIO Trigger Board Interface Description

Pin	Name	Direction	Level Standard	Meaning
1	**TRGIO1**	I	3.3 V	External trigger input
2	**TRGIO2**	/	/	Reserved
3	**TRGO/IO3**	O	3.3 V	Trigger output
4	**LFADC**	/	/	Reserved
5	**LFADC**	/	/	Reserved
6	**G-3V3**	O	/	Power Output, 3.3 V
7	**G-U9TX**	/	/	Reserved
8	**G-DLREF**	/	/	Reserved
9	**NA**	O	/	Reserved
10	**AUXIO**	/	/	Multi-Function Port
11	**G-U9RX**	/	/	Reserved
12	**G-RFLO**	/	/	Reserved
13	**G-IFLO**	/	/	Reserved

13.3 Configuring Triggering in SAStudio4

Fixed-frequency modes, such as Receiver IQ Streaming, provide trigger options under "Trigger", including External, Bus, Level, Timer, Multi-Device Synchronization, and GNSS-1PPS triggering.

Parameter	Function
Trigger Edge	Rising edge, falling edge, or both edges.
Trigger Delay	The delay between trigger arrival and the start of acquisition.
Pre-Trigger	Retains a specified amount of data acquired before the trigger arrives.
Retrigger	Continues responding to subsequent triggers according to the configured settings; the number of triggers and trigger interval can be specified.
Level Threshold	The trigger condition is met when the signal level exceeds the threshold; a debounce/safety time can also be configured.
Timer Period	Defines the timer trigger period and its synchronization relationship.

Trigger Verification Sequence: First, use bus/software triggering to verify that the acquisition chain is functioning properly. Then connect the external trigger signal. Use an oscilloscope to verify the trigger source amplitude, polarity, pulse width, and edge characteristics. Finally, verify that the pre-trigger, trigger delay, and timestamps conform to the application requirements.

13.4 Using the GPIO Interface

The R1000 can be connected to the EIO expansion board through the AUXIO interface, as shown in the following figure. The output logic level of each GPIO pin can then be controlled independently.

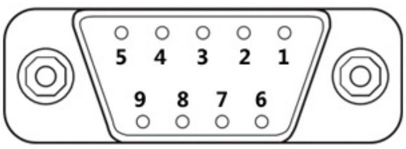


Figure 13-3 EIO Expansion Board Interface

Table 13-2 EIO Expansion Board Pin Assignments

Pin	Definition
1	GPIO0
2	GPIO2
3	GPIO4
4	GPIO6
5	GND
6	GPIO1
7	GPIO3
8	GPIO5
9	GPIO7

After connecting the EIO expansion board to the AUXIO interface, select **System > GPIO** from the SAStudio4 menu bar to control the output logic level of each GPIO pin.

14 Migrating from SAStudio4 to the HTRA API

SAStudio4 helps users verify that the device and parameter settings work correctly; the HTRA API helps users integrate the same capabilities into their custom applications.

14.1 Why Use the HTRA API

The HTRA API should be used when an application requires unattended operation, automated configuration, multi-device coordination, custom processing of continuous data streams, remote management, or integration with business systems.

SAStudio4 can still be retained as a debugging and reference tool, but it is not a required runtime environment for the Customer Application.

14.2 HTRA API, SDK and Example Applications

Component	Purpose
HTRA API	Defines programming interfaces for device discovery/connection, receiver configuration, data acquisition, status monitoring, error handling, and related operations.
SDK	Provides header files, libraries, runtime components, development documentation, and platform-specific build resources.
Example Applications	Demonstrate typical API call sequences and data-processing entry points, allowing users to validate the development environment before starting application development.

14.3 Basic Mapping Between SAStudio4 Parameters and HTRA API Parameters

The following table illustrates conceptual mappings only and does not specify function names or enumeration values. For the actual API names, refer to the HTRA API Reference documentation released with the current SDK.

SAStudio4 Concept	HTRA API Considerations
Center Frequency	Receiver tuning frequency configuration.
Native Sample Rate, Analysis Bandwidth	Sample rate, data bandwidth, and decimation relationships.
Data Format	Sample bit width, I/Q data organization, and data packet interpretation.
Preamplifier, Gain Strategy, Attenuation, IF AGC	Receiver-chain gain and dynamic range configuration.
Trigger Source, Edge, Delay, Pre-Trigger	Acquisition trigger configuration and timing semantics.

DDC Channel OffsetFreq、Decimate	Sub-band downconversion, decimation, and sub-band IQ streams.
Record	Data reception, buffering, file storage, and data integrity strategy implemented by the user application.
Status Area	Device information, version information, temperature, link status, and error diagnostics.

14.4 Running the First Receiver Example

- Obtain the HTRA API, SDK, and Example Applications release package that matches the R1000 software and firmware versions.
- Select the most basic receiver example and configure the device connection parameters according to the documentation provided with the release package.
- Start with center frequency, sample rate, bandwidth, gain, and other settings similar to those already verified in SAStudio4.
- Run the example and check the device information, returned status, number of data packets, and received data.
- Stop the example and release the device, then use SAStudio4 to verify that the device can still be connected and operated normally.

The specific example names, directory structure, build commands, and runtime parameters may vary between SDK releases and are therefore not fixed in this manual.

14.5 Obtaining Development Documentation and Technical Support

Obtain the HTRA API Reference, SDK documentation, and Example Applications that match the current release combination from the SDK package supplied with the device or through official HAROGIC channels. When requesting technical support, provide the information listed in Chapter 15.

Development Question	Documentation to Consult
Functions, enumerations, structures, error codes, timestamps, and synchronization semantics	HTRA API Programming Guide
Where to find examples, how to build and run them, and how to adapt them for the R1000	API Example User Guide
Whether a parameter in SAStudio4 can be configured through the API	First refer to the conceptual mapping in this chapter, then consult the API Reference for the current SDK for the definitive implementation.
GNU Radio and similar environments	Use GNU Radio to create applications. Obtain the latest GNU Radio and SoapySDR examples from the HAROGIC Git repositories, which are continuously maintained: HAROGIC Git Repo.

15 Software Updates, Maintenance, and Service

Before performing any update or maintenance operation, record the current version information and reproducible baseline, and prepare a recovery path in case the update or maintenance fails.

15.1 Software and Firmware Update

This chapter describes how to update the device software, FPGA, MCU, and BUS versions.

Automatic system updates are disabled by default on Raspberry Pi systems. It is recommended not to perform operating system updates or upgrades, in order to maintain compatibility with the product software and API. Contact HAROGIC Technical Support if assistance is required.

15.2 Version Requirements

- Refer to Section 7.4 to check the model, UID, and software/firmware versions;
- Use the GUI version that matches the software and firmware combination supplied with the device. Read the corresponding release notes before performing an update;
- If the software indicates that an update cannot be performed, contact HAROGIC Technical Support.

15.3 Parameter Description

Prompt: Displays the current and target version information for the software, FPGA, MCU, and BUS.

Update Content: Displays detailed information about the changes included in the target version.

Update Notification: Specifies whether the update notification window automatically appears when a new version is detected.;

Update Method: The available update methods are described in the following table.

Table 15-1 Update Methods

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 matching version associated with the currently installed software.
Local	Manually loads and installs an update package from a USB drive or local storage device.

15.4 Online Update

- Click "System" -> "Update" to enter the update interface;
- Check the "Update Notification" checkbox and ensure the device is connected to the internet. When the software starts or is running, if a new version is detected, the "Update" window will pop up automatically;
- Set the “Update Method” to Online Download. The system will then start downloading the update package. You can monitor the progress on the download progress bar; during this process, 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;

- 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.

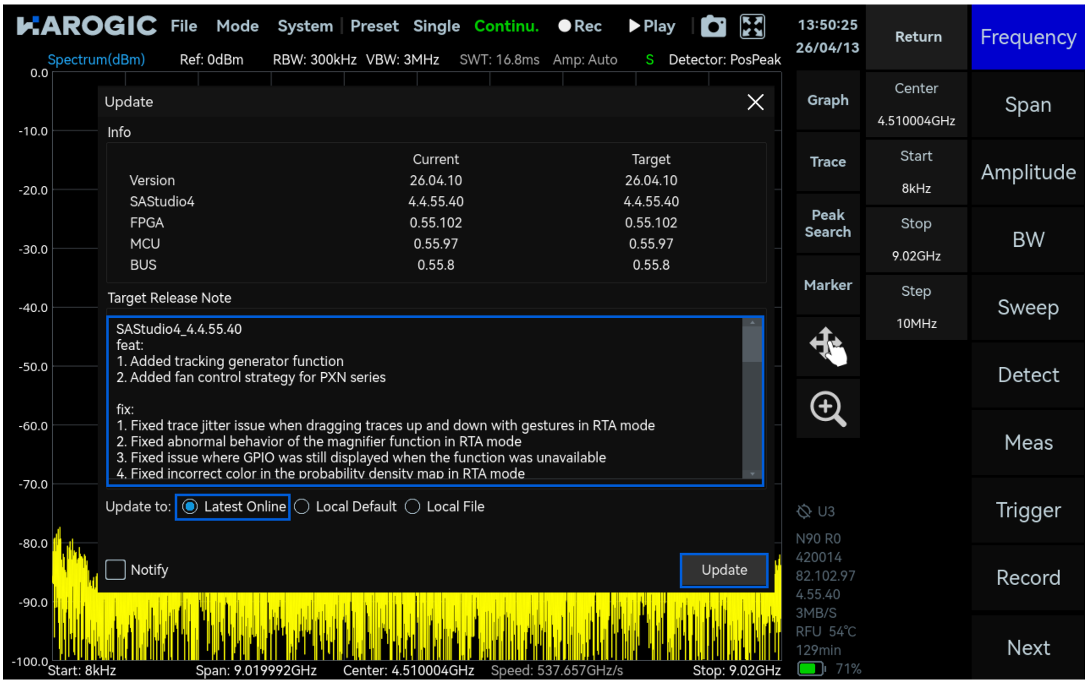


Figure 15-1 Online Software and Firmware Update

- After clicking the "Update", 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 re-starts and returns to the main interface;

- Close the update information window, then click "System" -> "About" in the menu bar to view the cur-rent firmware version of the instrument.

15.5 Local Update

Visit the company website using the link below to obtain the latest software version.

- Download the SAStudio4 version and release notes that match the R1000 delivery configuration from the official HAROGIC Download Center:

■ https://www.harogic.cn/support/download-center/

- The local update procedure is as follows:

- Click "System" -> "Update" on the software menu bar to open the update window;

- Select "Local", click "Open" to select the target software installation package, and wait for the corre-sponding version information to appear in the update information area. Then click the "Update" button in the lower-right corner;

- The software will automatically exit and enter the update process. Keep the update window open until the progress bar completes and the software automatically restarts and returns to the main interface;

During the update: Maintain stable device power, network connectivity, and the update window. Do not close the software, disconnect cables, or force-restart the device. Before performing batch or remote updates, first verify the update, rollback, and minimum required functionality on one representative device.

15.6 Accessories, Routine Inspection, Cleaning, and Repair Information

Accessories and Options

Category	Item	Remarks
Standard Accessories	Power adapter, USB-C power cable, 1GbE Ethernet cable, documentation USB drive	Standard items included with product shipment.
Optional Accessory	AUXIO IO Expansion Board	Contact HAROGIC Sales for purchase.
Option	T1 Temperature Grade (40)	-20-65℃
Option	100 MHz Analysis Bandwidth (50)	The default bandwidth is 50 MHz, with an optional 100 MHz analysis bandwidth.
Option	PoE (Power over Ethernet)	Provides a Power over Ethernet option, allowing a single Ethernet cable to carry both data and power.
Optional Accessories	GNSS antenna, RF cables, external attenuator/limiter/DC block	Contact HAROGIC Sales for purchase.

Routine Inspection

- Check the RF, GNSS, reference, network, power, and AUXIO connectors for looseness, contamination, or deformation.
- Inspect power cables and ribbon cables for damage, crushing, or excessive bending.
- Remove dust from around the ventilation openings and heat-dissipation surfaces, and check the fan status.
- For long-term deployments, record temperature, restarts, network packet loss, reference unlock events, and changes in GNSS status.
- After changing the hardware, system image, firmware, API, or software, repeat the minimum functionality and synchronization verification.

Cleaning and Storage

Power off the device and disconnect all cables before cleaning the enclosure with a soft, lint-free cloth. Do not allow liquids to enter ventilation openings or connectors, and do not use strong solvents that may damage coatings, plastics, or labels. Connectors should be cleaned using tools and procedures appropriate for the specific RF or electrical connector type.

For long-term storage, use suitable ESD-protective packaging and connector caps. Keep the device dry and avoid placing heavy loads on it.

Information to Record Before Repair or Service

Before contacting technical support or returning the device for repair, record at least the following information: device model, serial number, installed options, system image/firmware/API/software versions, connection topology, power supply model, RF input conditions, reference/trigger configuration, reproducible steps, and relevant logs or screenshots.

16 Troubleshooting

Narrow down the problem in the following order: power, connectivity, software, RF, storage, synchronization, and triggering, and retain reproducible evidence for troubleshooting.

16.1 Hardware Troubleshooting Table

Symptom	Safety Checks and Possible Causes	Recommended Actions
Unable to power on	Check whether the power cable is loose, verify the power supply specifications, and check for poor connections.	Disconnect peripheral devices and verify the device nameplate, supplied power adapter, and cables.
1GbE connection unavailable	Cable issues, IP address conflicts, subnet configuration, or firewall settings.	Confirm that a Gigabit Ethernet cable is being used. Refer to the Quick Start Guide and test the connection using SAStudio4. If necessary, restart the computer and the R1000 device.

For other issues, contact HAROGIC Technical Support.

16.2 Quick Troubleshooting for Network, Software, GNSS, and IQ

The following items are intended to help quickly narrow down the source of a problem. If the issue remains reproducible, collect the version information, connection topology, logs, and operating conditions as described in Section 7.4.

Device Does Not Power On

Check whether the green power indicator is illuminated. A brief fan sound can normally be heard after the device is powered on.

Verify that the power adapter is a HAROGIC-recommended model, the power cable is securely connected, and the power input specifications match the current hardware version. Also check the device for any abnormal overheating or unusual odors. If the problem persists, contact HAROGIC Technical Support.

Unable to Access the R1000 over the Network

Check that a 1GbE Ethernet cable is being used and that the computer is connected through a corresponding 1GbE LAN port. Confirm that the host computer and the R1000 have been configured on the same subnet as described in this document, and verify that the firewall is not blocking the software connection.

Device Not Detected in SAStudio4

Confirm that the SAStudio4 version matches the software/firmware combination delivered with the device. If the version is outdated, upgrade to the latest version and confirm that Ethernet has been selected as the connection method. Check whether the device can be reached using ping. If the ping test is successful, select **System > Device Connection > ETH** from the SAStudio 4 menu bar. This switches the SAStudio connection from USB to Ethernet. If the device still cannot be detected, restart the computer or the R1000 device.

GNSS Does Not Lock

Confirm that the GNSS antenna is properly connected and positioned under clear-sky conditions. Allow sufficient time for GNSS lock, and verify whether the antenna requires active power.

IQ Acquisition Packet Loss or Lower-Than-Expected Data Rate

Check whether the current sample rate exceeds the sustained throughput capability of the network or storage system. Confirm that the computer or host system uses a Gigabit Ethernet or faster network interface, and avoid running background tasks that consume significant CPU or disk resources.

Confirm whether the IQ acquisition mode is configured for continuous recording or burst recording. The recording duration in burst mode is limited by the onboard memory capacity. For continuous recording, the IQ sample rate must not exceed the specifications stated in the product manual.

Appendix A
IQ Record File Format Description

A.1 File Naming Format

The file name consists of the last four digits of the device ID, the date and time (year, month, day, hour, minute, and second) at the start of recording, the part index, and the file suffix.

For example: 0028_yyyymmdd_hhmmss_partx.suffix

When a single recording session generates multiple subfiles, all subfiles use the same start time field and are distinguished by partx.

A.2 IQ Recording Container

Chunk	Content
RIFF/WAVE	Standard RIFF file identifier, file length, and WAVE format type.
fmt	Encoding format, number of I/Q channels, sample rate, data transfer rate, block alignment, and bits per sample.
prof	IQ configuration, stream information, and device information, including center frequency, reference level, sample rate, bandwidth, trigger settings, gain, reference clock, device UID, version information, and other parameters.
trig	Trigger information, device status, IQ scaling factor, maximum power, and maximum-value index corresponding to each IQ data packet.
data	IQ data packets stored sequentially.

Some structures in the configuration and stream information are converted into byte arrays using MessagePack. When reading these structures, use the structure definitions and parsing rules that match the current release version.

The RIFF and Chunk length fields use little-endian byte order. Some structure fields may use big-endian byte order or platform-dependent representations. Therefore, the entire file should not be interpreted solely using a standard audio WAV parser.

For detailed format information, see the table below:

Table A-1 Description of the WAV Format

Chunk	Description
RIFF chunk	
RIFF chunk size	
File Format Type: "WAVE"	
fmt chunk	

fmt chunk size	
fmt chunk data	
prof chunk	Format Chunk Identifier: "prof"
prof chunk size	Chunk Length
prof chunk data	This chunk stores the IQS_Profile_TypeDef, IQS_StreamInfo_TypeDef, DeviceInfo_TypeDef, and other related information.
trig chunk	Format Chunk Identifier: "trig"
trig chunk size	Chunk Length
trig chunk data	This chunk stores the IQS_TriggerInfo_TypeDef, DeviceState_TypeDef, IQS_ScaleToV, MaxPower_dBm, and MaxIndex for each IQ data packet, sequentially arranged. Each entry corresponds one-to-one with the packets in the data chunk.
data chunk	Format Chunk Identifier: "data"
data chunk size	Chunk Length
data chunk data	This chunk stores the IQ data packets in sequential order.

Table A-2 Detailed Description of the iq.wav Format

	Chunk	Byte Index	Byte Index within Chunk	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	1	Little Endian
		22		2	uint16_t	Channel Count	2	Little Endian
		24		4	uint32_t	Sampling Frequency		Little Endian
		28		4	uint32_t	Byte Rate		Little Endian
		32		2	uint16_t	Block Align		Little Endian
		34		2	uint16_t	Bits per Sample		Little Endian
File Header Information	prof	36		4		Format Chunk Identifier	"prof"	
		40		4	uint32_t	Chunk Length		Little Endian
		44	0	2	uint16_t	File ID		Big Endian
		46	2	1	uint8_t	0x8c		Big Endian
		47	3	1	uint8_t	0x22		Big Endian
		48	4	1	uint8_t	0x52		Big Endian
		49	5	1	uint8_t	0x9b		Big Endian
		50	6	1	uint8_t	0x00 Protocol Version		Big Endian
		51	7	1	uint8_t	0x02 Protocol Version		Big Endian
		52	8	4	uint32_t	api Version Information		Big Endian
		53-107	56			Reserved		
IQS_Profile Information msgpack Byte Array		108	64	2	uint16_t	IQS_Profile + IQS_StreamInfo Structure Byte Length		Big Endian
		110	66		double	CenterFreq_Hz		
					double	RefLevel_dBm		
					uint32_t	DecimateFactor		
					int	RxPort		
					uint32_t	BusTimeout_ms		

	Chunk	Byte Index	Byte Index within Chunk	Byte Count	Data Type	Field Name	Filed Description	Endianness
					int	TriggerSource		
					int	TriggerEdge		
					int	TriggerMode		
					uint64_t	TriggerLength		
					int	TriggerOutMode		
					int	TriggerOutPulsePolarity		
					double	TriggerLevel_dBm		
					double	TriggerLevel_SafeTime		
					double	TriggerDelay		
					double	PreTriggerTime		
					int	TriggerTimerSync		
					double	TriggerTimer_Period		
					uint8_t	EnableReTrigger		
					double	ReTrigger_Period		
					uint16_t	ReTrigger_Count		
					int	DataFormat		
					int	GainStrategy		
					int	Preamplifier		
					uint8_t	AnalogIFBWGrade		
					uint8_t	IFGainGrade		
					uint8_t	EnableDebugMode		
					int	ReferenceClockSource		
					double	ReferenceClockFrequency		
					uint8_t	EnableReferenceClockOut		
					int	SystemClockSource		
					double	ExternalSystemClockFrequency		
					double	NativeIQSampleRate_SPS		
					uint8_t	EnableIFAGC		
					int8_t	Atten		
					int	DCCancelerMode		

	Chunk	Byte Index	Byte Index within Chunk	Byte Count	Data Type	Field Name	Filed Description	Endianness
					int	QDCMode		
					float	QDCIGain		
					float	QDCQGain		
					float	QDCPhaseComp		
					int8_t	DCCIOffset		
					int8_t	DCCQOffset		
					int	LOOptimization		
IQS_ StreamInfo Struct Information msgpack Byte array					double	Bandwidth		
					double	IQSampleRate		
					uint64_t	PacketCount		
					uint64_t	StreamSamples		
					uint64_t	StreamDataSize		
					uint32_t	PacketSamples		
					uint32_t	PacketDataSize		
					uint32_t	GainParameter		
DeviceInfo Structure Information				2	uint16_t	DeviceInfo Structure Byte Length		Big Endian
				8	uint64_t	DeviceUID		Big Endian
				2	uint16_t	Model		Big Endian
				2	uint16_t	HardwareVersion		Big Endian
				4	uint32_t	MFWVersion		Big Endian
				4	uint32_t	FFWVersion		Big Endian
Reserved								
IQS_ TriggerInfo Structure Information	trig	400		4		Chunk Identifier	"trig"	
		404		4	uint32_t	Chunk Length		Little Endian
		408		2	uint16_t	IQS_TriggerInfo Structure Byte Length		Big Endian
				8	uint64_t	SysTimerCountOfFirstDataPoint		Big Endian
				2	uint16_t	InPacketTriggeredDataSize		Big Endian
				2	uint16_t	InPacketTriggerEdges		Big Endian
				4*25	uint32_t	StartDataIndexOfTriggerEdges[25]		Platform Dependent
				8*25	uint64_t	SysTimerCountOfEdges[25]		Platform Dependent

	Chunk	Byte Index	Byte Index within Chunk	Byte Count	Data Type	Field Name	Filed Description	Endianness
				25	int8_t	EdgeType[25]		Platform Dependent
DeviceState Structure Information				2	uint16_t	DeviceState Structure Byte Length		Big Endian
				2	int16_t	Temperature		Big Endian
				2	uint16_t	RFState		Big Endian
				2	uint16_t	BBState		Big Endian
				8	double	AbsoluteTimeStamp		Big Endian
				4	float	Latitude		Big Endian
				4	float	Longitude		Big Endian
				2	uint16_t	GainPattern		Big Endian
				8	int64_t	RFCFreq		Big Endian
				4	uint32_t	ConvertPattern		Big Endian
				4	uint32_t	NCOFTW		Big Endian
				4	uint32_t	SampleRate		Big Endian
				2	uint16_t	CPU_BCFlag		Big Endian
				2	uint16_t	IFOverflow		Big Endian
				2	uint16_t	DecimateFactor		Big Endian
				2	uint16_t	OptionState		Big Endian
Return Information				4	float	IQS_ScaleToV		Big Endian
				4	float	MaxPower_dBm		Big Endian
				4	uint32_t	MaxIndex		Big Endian
Reserved								
Data Packet	Data	25*1024*1024+400		4		Chunk Identifier	"data"	
		25*1024*1024+404		4	uint32_t	Chunk Length		Little Endian
		25*1024*1024+408		64968		IQ Data Packet		Platform Dependent
				64968		IQ Data Packet		Platform Dependent
						...		Platform Dependent
						The Nth IQ Data Packet, where N = (Chunk Length / 64968)		Platform Dependent

Appendix B
Receiver IQ Streaming Parameter Description

Parameter visibility and allowed values depend on the device model, installed options, and software/firmware combination.

Group	Parameters	Description
Frequency	Center Frequency, LO Optimization	Sets the receiver center frequency and LO optimization strategy. Actual options depend on the device.
BW	Native Sample Rate, Analysis Bandwidth, Span, Data Format	Controls the data size and settings for sampling and preview.
Amplitude	Preamplifier, Gain Strategy, IF Gain, Attenuation, IF AGC	Controls the receiver-chain dynamic range and the trade-off between noise performance and linearity.
Trigger	Trigger Source, Edge, Delay, Pre-Trigger, Retrigger	Determines when acquisition starts and the time window of data to be retained.
Record	Mode, Duration, File Size Limit, Path, Available Capacity	Controls IQ file generation and storage limits.
Play Back	Open, Play, Pause, Stop, Previous/Next Frame, Loop	Controls offline playback of recorded files.
FFT	Analyze, TimeStart, TimeLength, FFTsize, Window, Intercept	Generates a spectrum preview from the selected IQ time interval.
IQvT/PvT	Analyze, TimeStart, TimeLength, Zoom	Displays I/Q time-domain data or the power-versus-time relationship.
DDC	Channel, OffsetFreq, Decimate	Generates and analyzes the target sub-band IQ stream.

Appendix C
Related Documentation

Document	Description
HAROGIC R1000 Series RF Receiver Product Manual	Product datasheet covering core features, application scenarios, specification overview, and detailed technical specifications.
HAROGIC R1000 Series RF Receiver Quick Start Guide	Guides users through powering on the device, establishing a network connection, accessing the embedded host, connecting the control software, viewing RF signals, and running the first IQ software application within 30 minutes.
HAROGIC R1000 Series RF Receiver User Manual	Covers the complete R1000 user workflow, including interfaces, power supply, networking, desktop software, IQ acquisition, GNSS, triggering, and troubleshooting across hardware and software.
HAROGIC SAStudio4 User Guide	Comprehensive user guide for SAStudio4, covering general measurement modes, menus, and advanced analysis functions.
HAROGIC HTRA API Programming Guide	API concepts, sessions, modes, parameters, data structures, error codes, timestamps, synchronization, and triggering.
HAROGIC HTRA API Example Usage Guide	Example directories, development environments, build and run procedures, and language-specific adaptation for C/C++, Qt, Python, MATLAB, C#, and LabVIEW.
GNU Radio Example Usage Guide HAROGIC Git Repo.	Create applications using GNU Radio. Obtain the latest GNU Radio and SoapySDR examples from Git (continuously maintained online).

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