V1.0 2608

# T1000 Series Embedded RF Transmitter User Manual


HAROGIC

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# Contents

# How to Use This Manual

This manual is organized in the order of the typical T1000 user workflow. It begins with safety information, interfaces, and power supply, followed by Ethernet and embedded host connections. It then explains how to use SGStudio to generate continuous-wave (CW), modulated, and custom IQ signals. Finally, it covers reference clock, GNSS, and trigger configuration, as well as H2 API development, firmware/software updates, maintenance, and troubleshooting.

**First-Time Use**: If your goal is to get the device up and running within 30 minutes, please first read the T1000 Series RF Transmitter Quick Start Guide. This manual provides comprehensive operating instructions for reference after initial setup.

# 1. Reading This Manual

## 1.1 Purpose and Intended Audience

This manual is intended for test engineers, RF engineers, software developers, system integrators, and technical support personnel who use the T1060 for RF signal generation, field deployment, automated control, and system integration.

Readers should have basic knowledge of RF connections, Ethernet configuration, and Windows/Linux operation. When working with external references, AUXIO, triggering, or medium power RF output, appropriate knowledge of electrical safety and signal integrity is also required.

## 1.2 Applicable Scope and Version Baseline

| Item | Description |
|---|---|
| Product Series | T1000 Series Embedded RF Transmitter |
| Applicable Model | T1060 |
| Transmit/Receive Channels | 1 transmit channel, 0 receive channels |
| Target Hardware Platform | Compact integrated unit incorporating an RF transmitter, FPGA/baseband processing, and Raspberry Pi 5 |

| Item | Applicable Scope |
|---|---|
| Product | HAROGIC T1000 Series RF Transmitter |
| Desktop Software | SGStudio V2.6.4 or later. The software can run independently on either a host computer or the Raspberry Pi. |
| Development Software | H2 API V2.0.24 or later, SDK, and Example Applications compatible with the device and firmware versions. |
| Operating System | Refer to the delivered software package, installation instructions, and release notes. General host requirements for SGStudio are provided in Chapter 6. |

## 1.3 T1000 Documentation Set and Content

| Task | Primary Document |
|---|---|
| Product selection, specifications, options, and application scenarios | T1000 Series Datasheet |
| Initial power-on, network connection, and generation of RF signals and modulated waveforms within 30 minutes | T1000 Series Getting Started Guide |
| Interfaces, power supply, networking, SGStudio desk-top software, synchronization, GNSS, triggering, and troubleshooting | This User Manual |
| Complete SGStudio functionality, including all waveform generation and playback functions | SGStudio User Guide |
| API sessions, parameters, data structures, error codes, timestamps, and synchronization | H2 API Programming Guide |
| C/C++, Qt, Python, Matlab | H2 API Example Usage Guide |
| Creating applications with GNU Radio and obtaining the latest GNU Radio and SoapySDR examples via Git | HAROGIC Git Repo. (continuously maintained online) |

## 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 OUT | RF output port |
| Trigger / TRG | Trigger input or output signal |
| RF ON / MOD ON | RF output and modulation switches in the user interface |
| CW | Continuous Wave |
| IQ | In-phase/quadrature complex baseband sample data |

| | |
|---|---|
| H2 API | Primary programming interface for accessing T1000 Series device capabilities when developing custom applications. |
| Example Applications | Example applications supplied with the SDK for demonstrating and verifying H2 API call flows. |
| Device | Unless referring to an original UI label or document title, “device” in this manual refers to a T1000 Series RF transmitter. |

# 2. Safety and Compliance

Treat the T1060 as test equipment capable of actively generating RF energy. Connections, power-on, and RF output enablement must be verified step by step.

## 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 Output Protection

**▲WARNING**

RF OUT and HP OUT are both output ports. Do not connect an external signal source, antenna feed, DC power supply, or any port of unknown characteristics to RF OUT or HP OUT. Before connecting a receiver, spectrum analyzer, or other load, turn off the RF output and verify the maximum safe input level of the connected device.

1. Keep RF OFF in SGStudio.
2. Ensure that the load impedance is 50 Ω. Use an attenuator, DC block, limiter, or circulator if necessary.
3. Enable the output initially at a low power level (recommended no higher than −40 dBm). After verifying the frequency, output port, and signal path, gradually increase the output power.
4. Before switching between RF OUT and HP OUT, turn off all RF outputs.

**Medium Power Option**: With Option 10, the typical maximum output power can reach 25 dBm, approximately 316 mW. This power level is sufficient to damage many receiver front ends, probes, and unattenuated measurement inputs.

## 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. T1000 System Overview and Usage Paths

Understand the relationship among the embedded host, internal USB RF core, 1 GbE control link, and the three software access methods.

## 3.1 Product Positioning

The T1060 integrates a high-performance single-channel RF transmitter core and a Raspberry Pi 5 within a single device. It can be controlled remotely from a host computer or operated independently on the embedded host. Typical applications include portable waveform playback, wireless signal and scenario simulation, remotely operated unattended signal generation, and distributed synchronized excitation nodes.

## 3.2 Functional Architecture

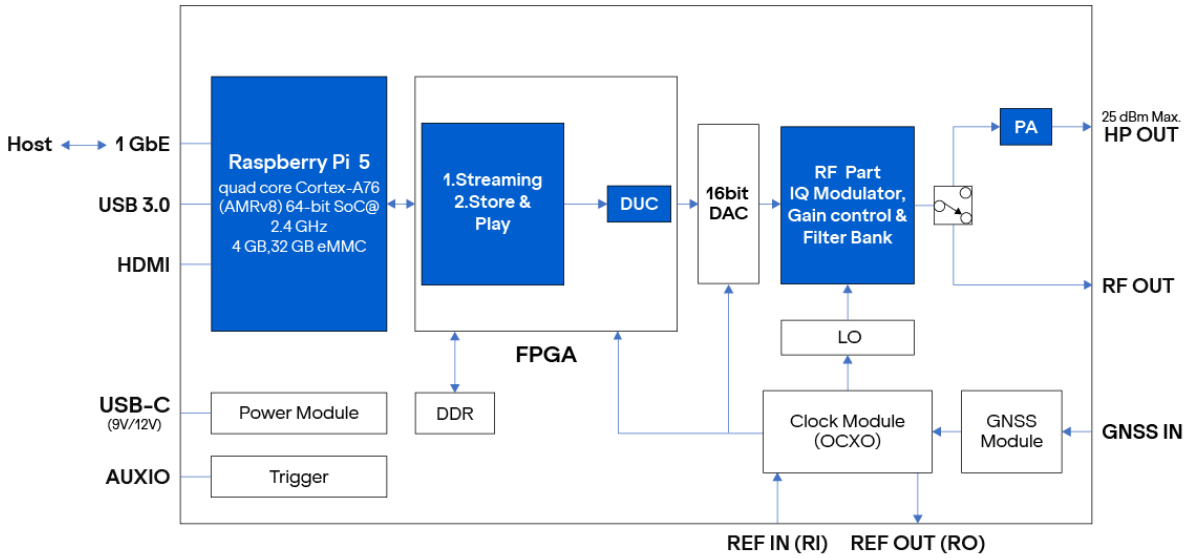


Figure 3-1 T1000 Series Functional Signal Flow

At the functional level, the signal path runs from the host computer or embedded host through the FPGA, DAC, RF IQ modulator, and RF chain to the RF output. GNSS, the internal OCXO, external reference, PPS, and trigger signals provide reference or control signals for the transmit chain and timing functions. This figure is intended only to illustrate the relationships among the external interfaces and does not represent implementation details of the circuitry, clock tree, or FPGA resources.

The T1060 therefore uses its integrated Raspberry Pi 5 to manage the internal USB RF transmitter core while providing external Ethernet connectivity and standalone operation. Accordingly, when

connecting to the T1060 from a host computer, select the ETH device; when operating from the embedded host, select the USB device.

## 3.3 Typical Operating Modes

| Operating Mode | Hardware Connections | Typical Applications |
|---|---|---|
| Remote host control | Connect only RF, power, 1 GbE, and optional synchronization interfaces | Desktop verification, remote control, API access, and network data transfer |
| Standalone local operation | Connect RF, power, diplay/USB peripherals, or local storage | On-site processing of high-data-rate streams, portable deployment, unmanned platforms, and low-latency control |
| Remote Unattended Operation | Connect RF, Ethernet | Tasks issued from a host computer, with waveforms stored locally and services/applications running on the embedded host |
| 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.

T1000 software usage follows two primary paths: desktop verification and application development. SGStudio is used for initial verification, while the H2 API is used for final system integration.

## 3.4 SGStudio

SGStudio provides a graphical user interface for initial device connection, device configuration, functional verification, modulation generation, custom waveform playback, synchronization, and updates.

## 3.5 H2 API and SDK

The H2 API and SDK provide the primary means of controlling the T1000 from customer applications and implementing automated workflows. Once parameters have been verified, they can be incorporated into customer applications, services, or unattended workflows without requiring SGStudio to be running.

## 3.6 Example Applications

The Example Applications help users quickly understand the H2 API call sequence by demonstrating the minimum code flow for device discovery, connection, configuration, transmission, and waveform operations. It is recommended to first run the examples provided with the current SDK version and then incrementally develop customer applications based on these examples.

## 3.7 Relationship Between SGStudio and Customer Applications

Figure 3-2 shows the recommended workflow: first use SGStudio to verify the device and RF environment, then use the Example Applications to verify the development environment and communication path, and finally proceed with customer application integration.

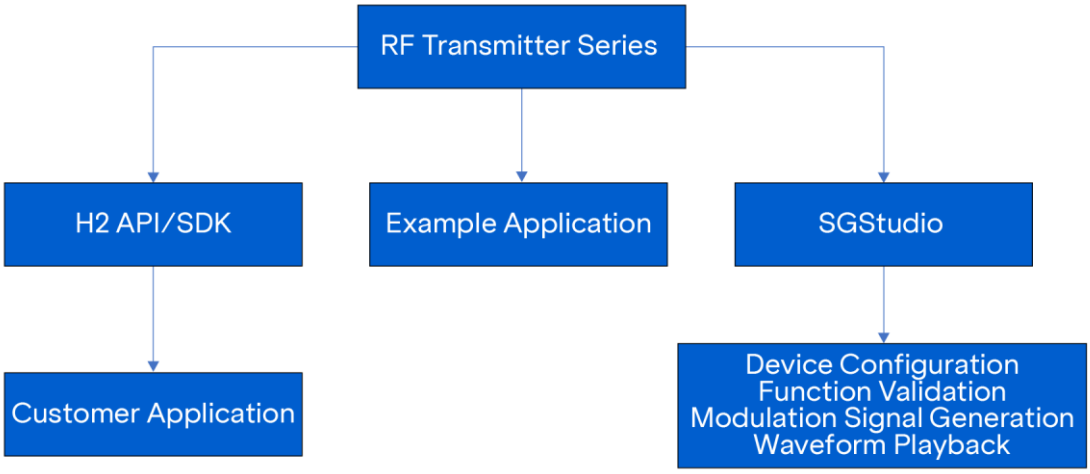


Figure 3-2 T1000 Series Software Architecture and Typical Usage Path

- **H2 API/SDK** is the primary path for customer application development.
- **Example applications** help customers quickly understand and verify the API.
- **SGStudio** is used for device configuration, functional verification, RF and modulated signal generation, and custom waveform playback.

# 4. Appearance, Panels, and Interface Index

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

## 4.1 T1060 Interface Layout

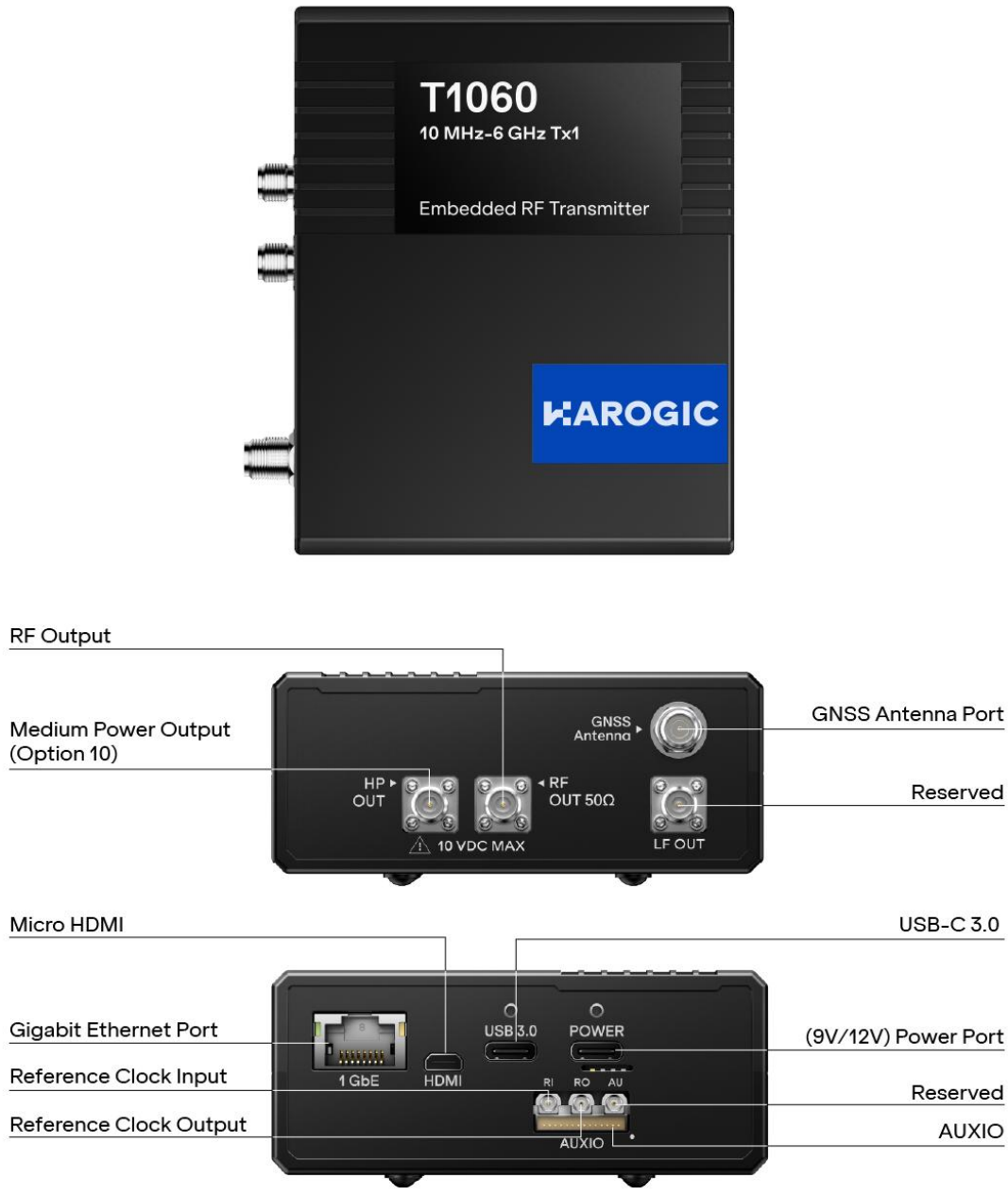


Figure 4-1 T1060 Appearance and Interface Layout

Figure 4-1 shows the following T1060 interfaces: GNSS Antenna, RF OUT, HP OUT, 1 GbE, HDMI, USB 3.0, POWER, RI, RO, and the 14-pin AUXIO connector.

## 4.2 T1060 Panel Interface Index

| Figure Label | Interface | Function | Details |
|---|---|---|---|
| 1 / GNSS Antenna | GNSS antenna input | Receives GNSS signals for frequency calibration and time synchronization | See the “GNSS and Synchronization” section |
| 2 / RF OUT | SMA (F), 50 Ω | Main RF output, SMA (F), 50 Ω | See the “RF Output and Protection” section |
| 3 / HP OUT | SMA (F), 50 Ω | Medium-power RF output, SMA (F), typical maximum output of 25 dBm (Option 10) | See the “RF Output and Protection” section |
| 4 / LF OUT | SMA (F), 50 Ω | Reserved | Reserved interface; do not connect |
| 5 / 1 GbE | Gigabit Ethernet | Control, API access, and data transfer | See the “Network and Embedded Host Interfaces” section |
| 6 / HDMI | Micro HDMI | Local display and debugging | See the “Network and Embedded Host Interfaces” section |
| 7 / USB 3.0 | USB-C form factor | Peripheral expansion, such as keyboard, mouse, and storage devices | See the “Network and Embedded Host Interfaces” section |
| 8 / POWER | USB-C form factor | System power input | See the “Power Supply and Power-On” section |
| 9 / RI | MMCX (F) | 10 MHz reference clock input | Amplitude ≥1.5 Vpp, 330 Ω |
| 10 / RO | MMCX (F) | 100 MHz reference clock output | Amplitude ≥0.3 Vpp, programmable on/off |
| 11 / AU | Reserved port | Reserved | Reserved port; leave unconnected |
| 12 / AUXIO | 14-pin multifunction connector | Multifunction I/O interface, including GPIO, Trigger, and others as listed in the table below. | External trigger: 3.3 V CMOS, high impedance;<br>trigger output: 3.3 V CMOS |

**Table 4-1 Description of 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 |

## 4.3 Status Indicator

| Color | Meaning | Recommended Action |
|---|---|---|
| Green | Device status normal | Continue checking the network and software status |
| Red | Device status abnormal | Turn off the RF output, record the device status, and troubleshoot according to Chapter 14 |
| Yellow | Remote update failed | Keep the device powered on, re-establish the network connection, and contact technical support for recovery instructions |

# 5. Power Supply, RF Output, Installation, and Environmental

Connect the signal and network interfaces first and the power supply last, while allowing sufficient safety margin for the load and heat dissipation.

## 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 device that match the specifications on the device nameplate. Using an incompatible adapter or cable may prevent the device from powering on or operating properly and may even cause damage.

| Item | Specification | Description |
|---|---|---|
| Interface | USB-C POWER | USB Type-C connector |
| Input | 9 V / 3 A or 12 V / 2.5 A | Wide input-voltage range |
| Power Consumption | ≤ 25 W | Maximum Operating Condition: CPU at full load, fan at full speed, SGStudio running, RF output enabled with a 1 GHz, 20 dBm modulated signal, and a sample rate of 62.5 MHz. |

## 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.

## 5.4 RF Output and Protection

| Item | Requirement |
|---|---|
| Termination | 50 Ω; use cables, attenuators, and loads rated for the required frequency and power levels |

| | |
|---|---|
| Standard Output | Maximum output is approximately 7 to 14 dBm, depending on frequency; minimum output can be set to −100 dBm or lower |
| Medium Power Output | Option 10; typical maximum output is at least 25 dBm; typical minimum output is no higher than −80 dBm |
| Port Switching | Set RF OFF before changing the output port, cable connections, or option settings |
| Reverse Power | Do not inject external RF or DC power into the RF ports. Use isolation and protection devices where there is a risk of reflected power or external power feed. |
| Maximum Allowable DC Voltage at RF Ports | ±10 VDC |

## 5.5 Dimensions Overview

| Model | Dimensions | Weight |
|---|---|---|
| T1060 | 87 × 78 × 38 mm | 281 g |

HAROGIC also offers core modules without an enclosure, with optional fan-based cooling solutions.

For detailed information about core modules, contact the HAROGIC sales representative.

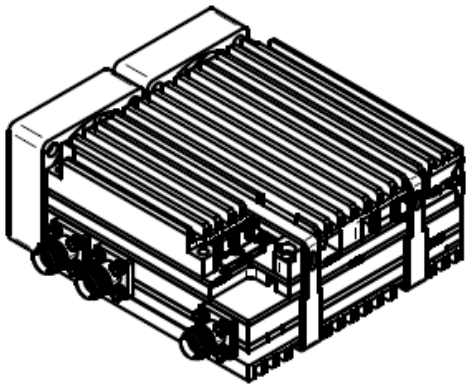

Figure 5-1 Typical Core Module Diagram

## 5.6 Cooling and Airflow

The maximum power consumption of the T1060 is approximately 25 W. The device is equipped with ventilation openings or cooling fins. The integration design should meet at least 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 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.

## 5.7 Operating Environment Rating

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

| Ambient Temp. | Operating Relative Humidity |
|---|---|
| 0 to 40 °C | 5% to 75% |
| > 40 °C | 5% to 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 1 GbE connection, confirm host access, and then prepare the system environment for running SGStudio.

## 6.1 Host-Side Physical Interfaces

The 1 GbE interface is the interface for remote control and data transfer on the T1000 Series. The HDMI and USB interfaces are used for local display, keyboard/mouse peripherals, and debugging.

### 6.1.1 1 GbE Ethernet Port

The T1000 Series provides a single 1 GbE 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 T1000 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 T1000 can connect to a network through its 1 GbE Ethernet (LAN) interface. When an T1000 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 T1000 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.

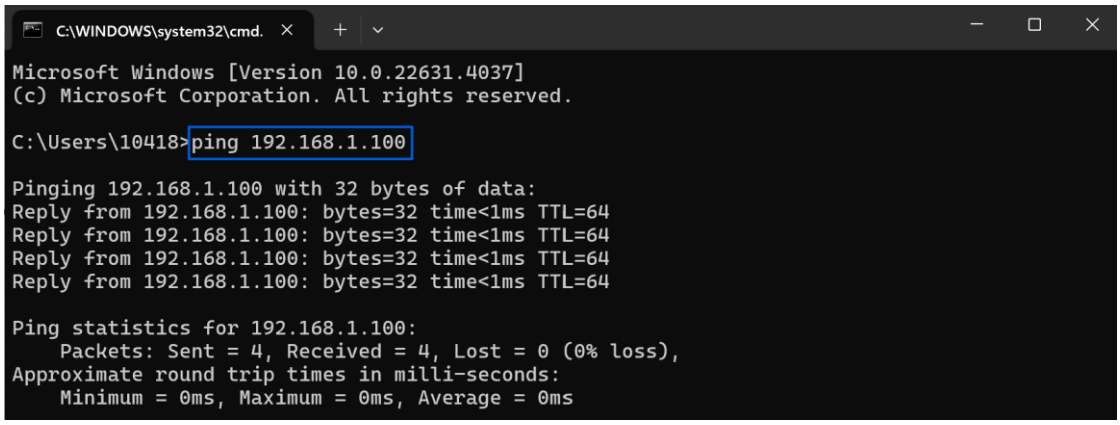


Figure 6-1 Verifying the Device Network Connection Using the ping Command

## 6.5 Accessing the T1000 Embedded Host

The T1000 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

T1000 series network configuration description:

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

Other: DHCP hostname can be modified.

### 6.5.2 Changing the Static IP Address

To change the default static IP address of a T1000 Series device, follow the steps below. The following example sets the IP address to 192.168.1.100:

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

  The static IP address is now configured. A reboot is required for the change to take effect.
- Enter reboot and wait for the system to restart. Note: Rebooting the Raspberry Pi host requires login as the root user.

```
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

## 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 11/10/8/7 (requires VS2019 C++ redistributables) |
| **Architecture** | Windows: x64 |
| **Processor** | Windows: Intel i3 or higher |
| **Memory** | 8 GB or more; 16 GB or more is recommended when generating digitally modulated waveforms with a PN order greater than 15. |
| **Storage** | Reserve sufficient storage capacity and sustained read/write performance based on the waveform file size and actual streaming data rate. |
| **Data Interface** | 1 GbE 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 5** |
| **Processor** | Broadcom BCM2712, quad core Cortex-A76 (ARMv8) 64-bit SoC @ 2.4 GHz |

| | |
|---|---|
| **Memory** | 4 GB LPDDR4-4267 SDRAM with ECC |
| **Storage** | 32 GB eMMC Flash Memory |
| **Built-in Operating System** | Debian 12 Bookworm 64-bit |
| **Wireless Module** | 2.4 GHz, 5 GHz Wi-Fi, Bluetooth 5.0, disabled by default and must be manually enabled |

## 6.7 Obtaining and Installing the Desktop Software

- Obtain the SGStudio installation package that matches the T1000 hardware and software/firmware versions from the media supplied with the product, an official HAROGIC distribution channel, or HAROGIC Technical Support.
- 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 director.

## 6.8 Default Data Storage Paths

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

| Relative Directory | Primary Contents |
|---|---|
| **data** | Default waveform files generated when creating custom waveforms, including WAV and other supported formats. |
| **images** | PNG images exported using the quick screenshot function. |

**Chapter Completion Criteria:** The host computer can successfully ping 192.168.1.100; the embedded host can be accessed via SSH or a local display when required; and the SGStudio version is compatible with the device.

# 7. Connecting to SGStudio and Verifying Device Status

On the host computer, select the device using an ETH connection, establish the connection, and verify the model, version information, temperature, and RF output status.

## 7.1 Starting SGStudio

- Confirm that the power supply, data connection, and storage preparations described in Chapter 6 have been completed.
- Launch SGStudio by running SGStudio\bin\SGStudio.exe from the SGStudio installation directory.
- Wait for the main interface to finish initializing.
- Check the status area for information such as the model, last six digits of the UID, API/FPGA/MCU versions, GUI version, and real-time temperature.

## 7.2 Interface Layout

The standard SGStudio interface consists of six main areas.

| Area | Primary Function |
|---|---|
| Menu | Save/open files (File), configure the device (Device), access system settings (System), and perform other operations. |
| RF Parameter Setting Area | Set the RF output frequency and power; enable/disable RF output and modulation; and configure sweep and other general RF parameters. |
| Mode Selection Area | Select operating modes, including amplitude modulation, frequency modulation, phase modulation, pulse, digital ramp sweep, AWGN, digital modulation, DSSS, OFDM, multitone, playback, and quick waveform. |
| Mode Parameter Setting Area | Configure parameters specific to the selected operating mode. |
| Instrument Status Area | Displays device status information such as the model, UID, software/firmware versions, and temperature. |

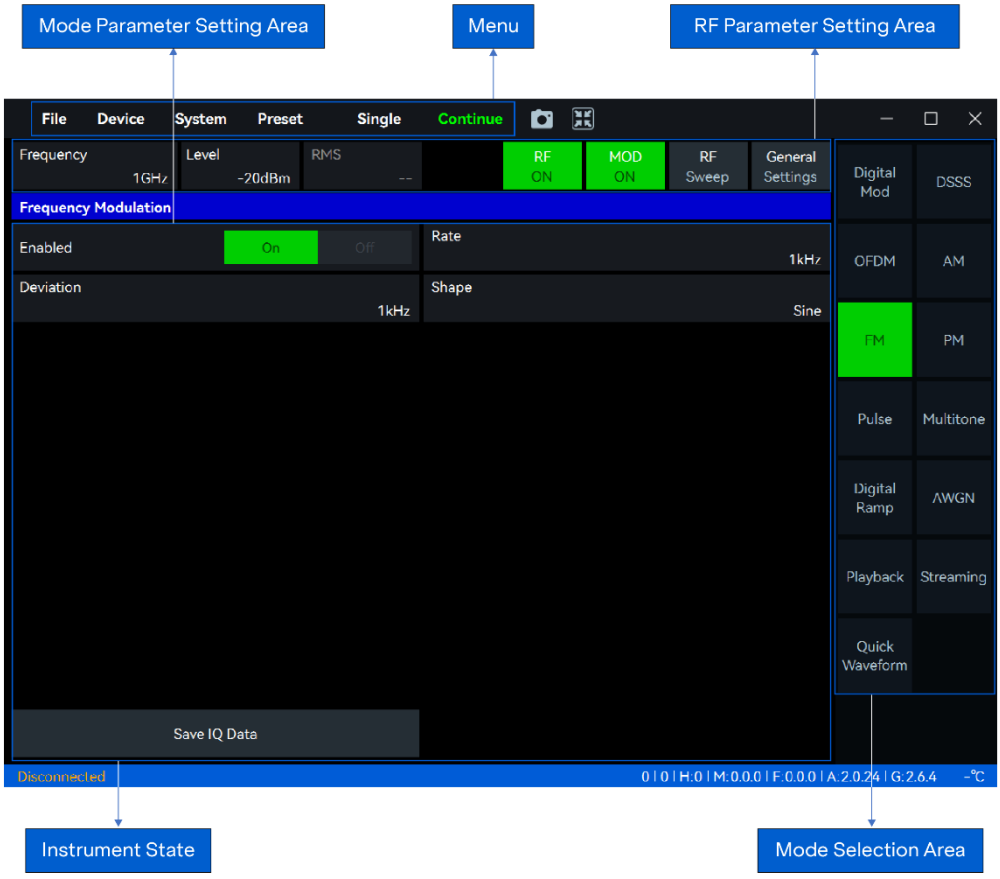


Figure 7-1 Software Interface Layout

## 7.3 Establishing the Device Connection

After confirming that the hardware is properly connected and the IP address is configured, open SGStudio on the host computer. From the menu bar, select Device, choose the device via ETH, and verify the device IP address and local host address.

The primary indication of a successful connection is whether SGStudio displays the device status information. If no status information is displayed after startup, the device is not properly connected. Check the hardware connections, network configuration, and IP address settings.

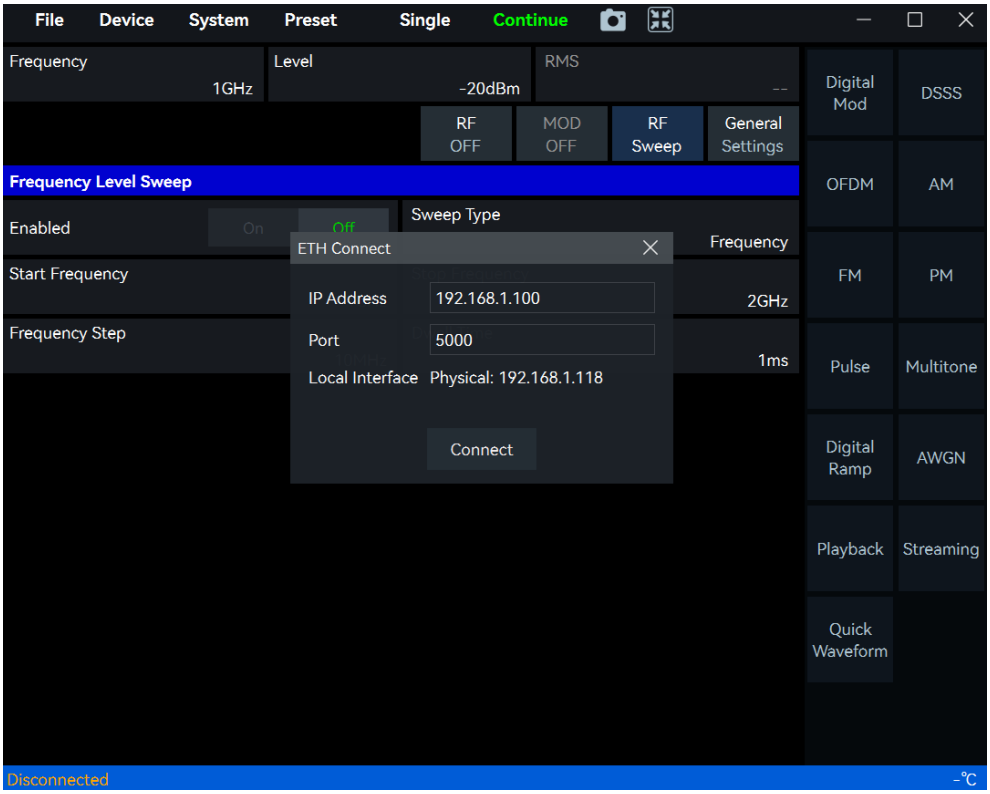


Figure 7-2 T1060 Network Connection Procedure

## 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;
- SGStudio GUI version;
- API, FPGA, MCU, and other firmware versions displayed in the interface.

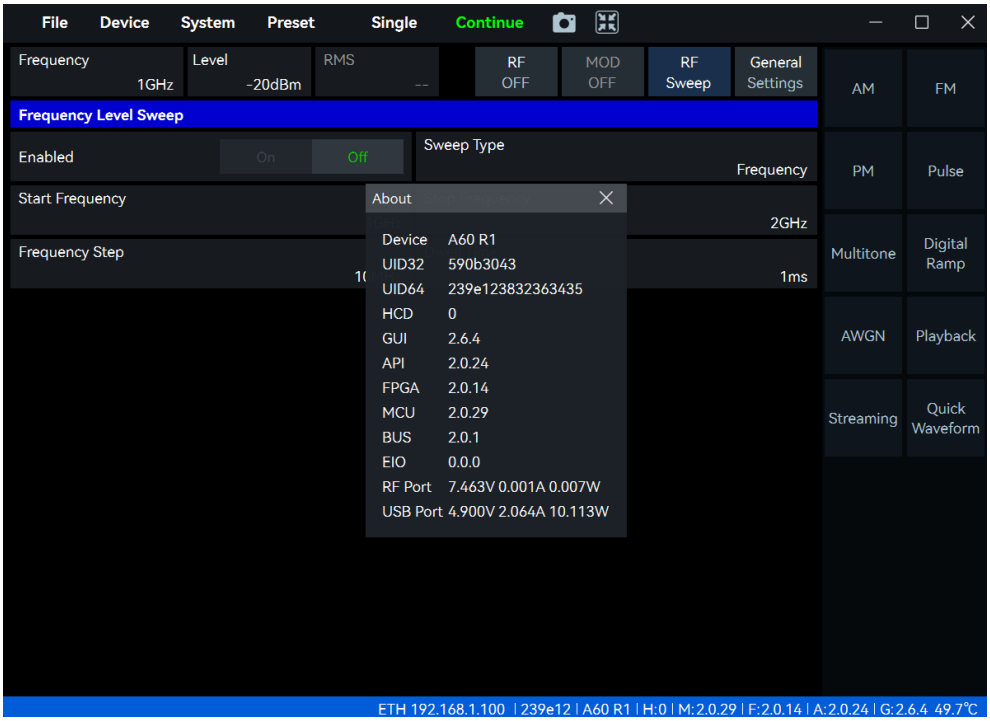


Figure 7-2 Figure 7-3 T1060 Device ID and Firmware Information Window

# 8. RF Signal Generation Using SGStudio

SGStudio can be used to generate RF signals, including continuous wave (CW), modulated signals, and custom waveforms. In these applications, the T1060 operates as an RF signal generator or vector signal generator.

SGStudio supports a variety of signal generation modes, including Single Tone, AM, FM, PM, Pulse, Digital Ramp Sweep, AWGN, Digital Modulation, Multitone, DSSS, OFDM, Playback, Streaming, and Fast Waveform. This chapter describes the configuration of these operating modes and the underlying signal generation mechanisms.

## 8.1 Overview of Operating Methods

In actual hardware operation, the modes described above are primarily implemented using three underlying operating methods: continuous wave, onboard memory playback, and high-speed real-time streaming. Select the appropriate operating method according to your test requirements.

Table 8- 1 Underlying Operating Methods

| Operating Method | Corresponding Software Button/Mode | Description |
|---|---|---|
| **CW Mode** | RF On Only | The hardware continuously generates a continuous wave (CW) signal directly without using waveform memory. |
| **Playback Mode** | AM, FM, PM, Pulse, Digital Ramp Sweep, AWGN, DSSS, OFDM, Digital Modulation, Playback, Quick Wave, Multitone | The core operating mode of the system. The software either generates IQ data blocks based on parameters or imports user-provided IQ data (up to 125 MB), downloads them to the device's onboard memory in a single transfer, and the hardware timer then drives looped or single-shot transmission. |
| **Streaming Mode** | Streaming Mode | Bypasses the onboard storage capacity limitation. Real-time generated IQ data streams are continuously and dynamically transferred to the transmission engine through a high-speed bus, making it suitable for ultra-long-duration signal simulation. |

## 8.2 CW Mode

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

The following example demonstrates operation from a host computer. Connect suitable RF measurement equipment or an antenna to the T1000 RF OUT, launch SGStudio, and click RF ON using the following example settings:

| Parameter | Example Value |
| --- | --- |
| Frequency | 1 GHz |
| Level | -20 dBm |
| RBW | Auto |
| Reference Level | 0dBm |

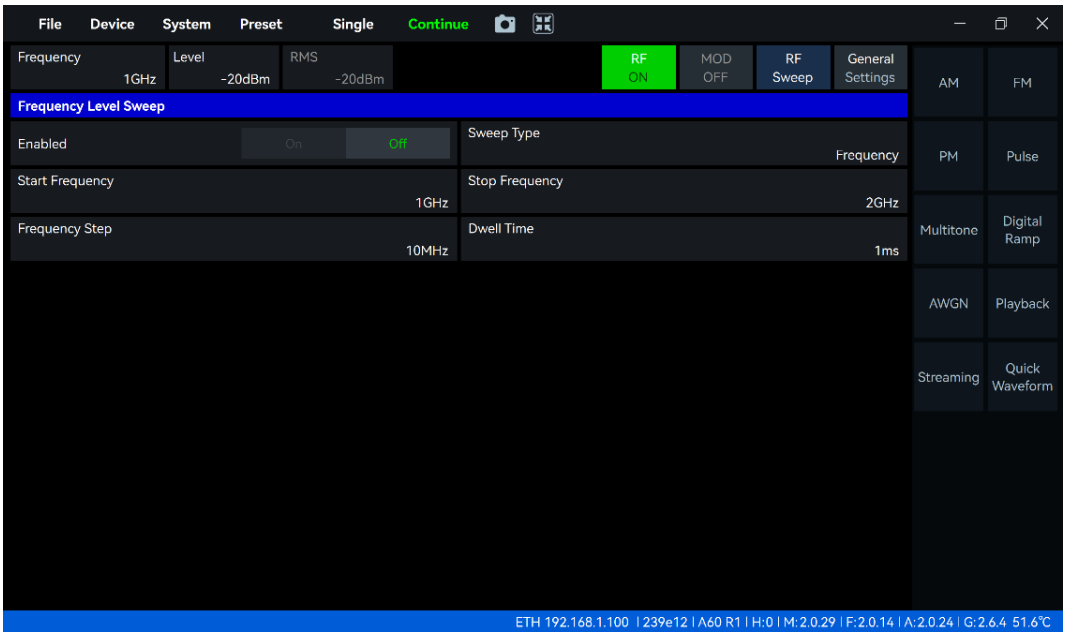


Figure 8-1 Enable RF ON in SGStudio

The HAROGIC R1090 RF Receiver can be used to monitor the output signal.


Figure 8-2 IQ Streaming Test Results Measured with the R1090 RF Receiver

## 8.3 Playback Mode

This mode adopts an onboard memory preloaded playback mechanism. When the signal type or parameters are modified, the host software immediately calculates and generates the corresponding IQ data and downloads the complete waveform into the instrument's internal memory. Since the waveform data is preloaded and resides entirely within the hardware, transmission does not rely on real-time bus transfer, enabling stable output at the instrument's maximum supported analog bandwidth (100 MHz).

## 8.4 Amplitude Modulation

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

- AM parameter configuration
- Baseband IQ data export

## 8.5 Frequency Modulation

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

- FM parameter configuration
- Baseband IQ data export

Take an FM signal with a carrier frequency of 1 GHz, peak power of −20 dBm, modulation rate of 5 kHz, frequency deviation of 75 kHz, and a sine-wave modulation waveform as an example.

**Parameter Description:** The following table describes the key parameters for frequency modulation.

**Frequency Modulation Parameter Description**

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

**Operating Procedure**

1. Click "FM" in the Mode Selection Area;
2. In the Frequency Modulation Control Area, set "Modulation Rate" to 5 kHz, "Frequency Deviation" to 75 kHz, select Sine as the Signal Type, and enable frequency modulation;
3. Set the carrier Frequency to 1 GHz and Power to −20 dBm, and enable the RF output;
4. The signal generator outputs an FM signal with a 1 GHz carrier frequency, −20 dBm peak power, 5 kHz modulation rate, 75 kHz frequency deviation, and sine-wave modulation.

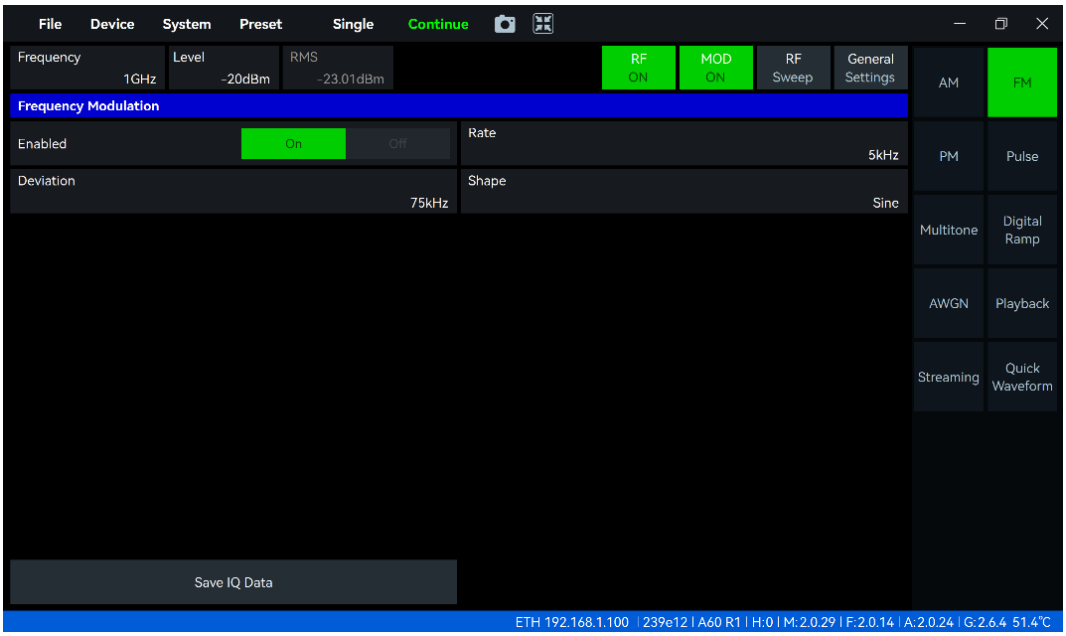


Figure 8-3 SGStudio FM Signal Generation

Connect the SMA RF output directly to an R1000 Series RF Receiver, and observe the IQ stream and time-frequency waterfall of the generated signal.

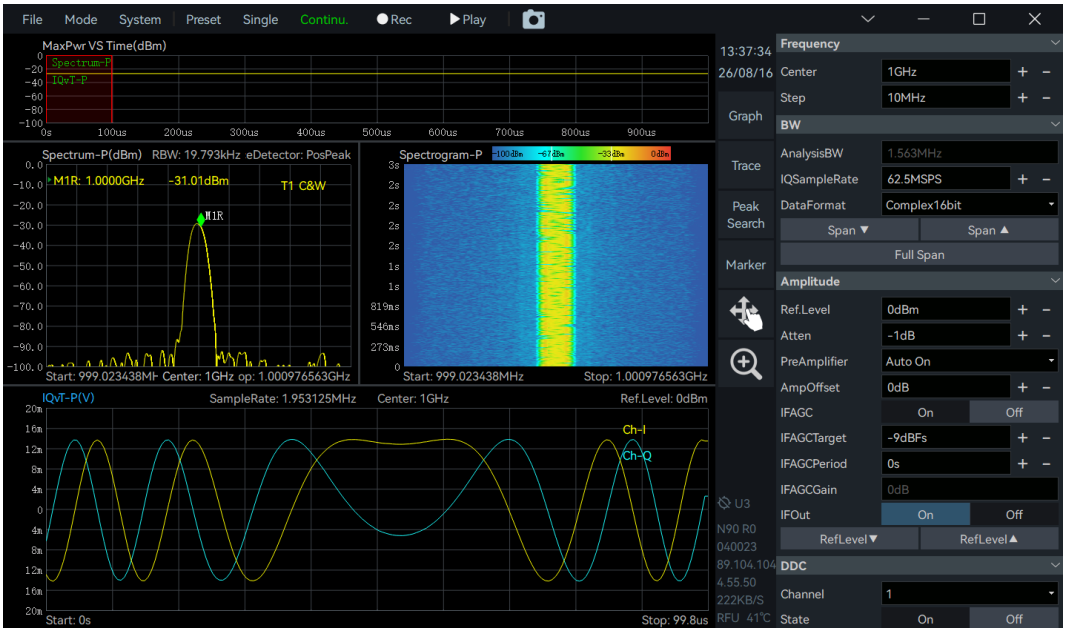


Figure 8-4 RF Signal Generated by the T1060 and Observed Using an R1000 Series RF Receiver with SAStudio

## 8.6 Phase Modulation

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

- PM parameter configuration
- Baseband IQ data export

## 8.7 Pulse

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

- Pulse parameter configuration
- Baseband IQ data export

## 8.8 Digital Ramp Sweep

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

- Sweep parameter configuration
- Baseband IQ data export

## 8.9 AWGN

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

- Bandwidth and length configuration
- Baseband IQ data export

## 8.10 Digital Modulation

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

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

## 8.11 DSSS

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

- DSSS core parameter configuration
- Raw baseband IQ data export

## 8.12 OFDM

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

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

## 8.13 Multitone

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

- Multitone signal generation
- Individual tone enable/disable control

- Fixed, random, and parabolic phase control
- In-band notch function

## 8.14 Playback

In Playback mode, T1060 supports downloading user-provided external waveform data in .wav format (up to 125 MB) into the instrument's internal memory for transmission, meeting the requirements of complex non-standard protocols or custom signal generation applications. The Playback mode provides the following functions:

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

## 8.15 Quick Waveform

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

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

In Quick Waveform mode, several waveform files in .wav format are preloaded, allowing users to quickly select and output the desired waveform. The preset waveforms include common digital modulation signals such as ASK, DPSK, FSK, PSK, and QAM, as well as three wireless protocol signals for quick access.

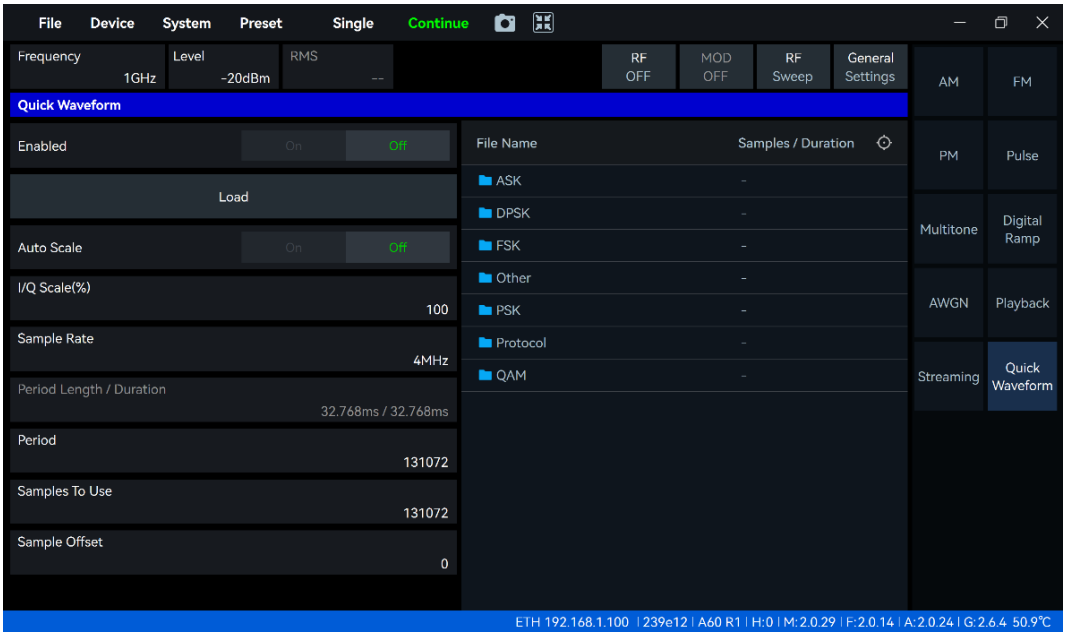


Figure 8-5 Outputting and Playing Back a Preset Waveform Using SGStudio

This section uses a preset Bluetooth signal as an example to describe the basic operating procedure for Quick Waveform mode.

1. Select "Quick Waveform" in the Mode Selection Area;
2. Select "Protocol/Bluetooth_7.5MHz.wav" from the file list, and click "Load File" to load the selected waveform into the T1060 internal memory;

3. After the file is successfully loaded, the software automatically parses and displays parameters such as the sample rate, total number of samples in the file, and signal duration. Adjust the relevant parameters as required, and enable Quick Waveform mode;

4. Set the carrier frequency to 2.4 GHz and the peak power to −20 dBm, and enable the RF output;

5. After the above settings are completed, the T1060 outputs the Bluetooth waveform at a carrier frequency of 2.4 GHz and a peak power of −20 dBm.

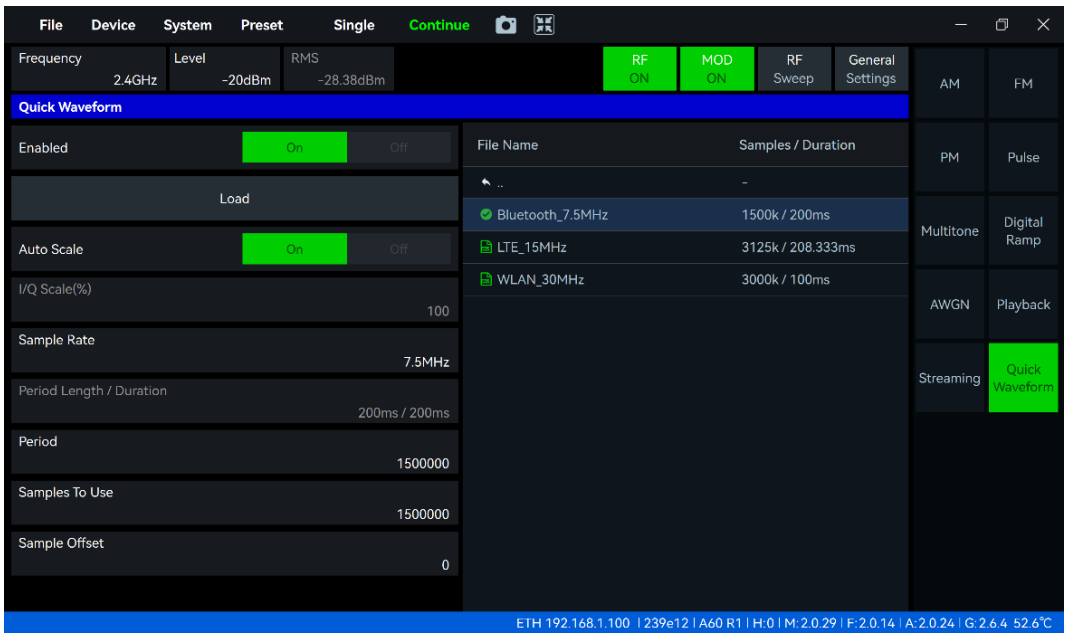


Figure 8-6 Fast Playback of a Bluetooth Waveform

6. To observe the signal using SAStudio, connect the T1060 RF output directly to the RF IN of an R1000 Series RF Receiver using an RF cable. Set the receiver to IQ Streaming mode, enable the time-frequency waterfall display under Graph, set the center frequency to 2.4 GHz, and set the reference level to −10 dBm.

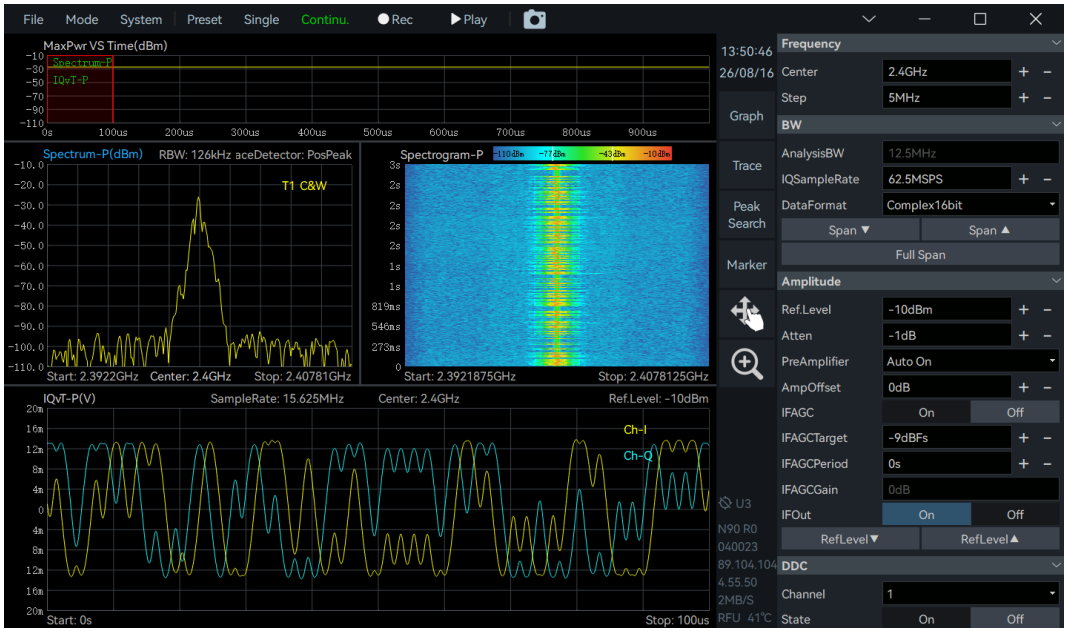


Figure 8-7 Signal Captured by an R1000 Series RF Receiver in SAStudio IQ Streaming Mode

## 8.16 Streaming Mode

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

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

**For detailed information on all SGStudio functions, refer to the HAROGIC SGStudio User Guide.**

# 9. Medium-Power Output and LO Mode

## 9.1 Medium-Power Output

The T1060 can be equipped with the optional medium-power output. With this option installed, the maximum output power can be increased to 25 dBm, and various signals can be output through the dedicated medium-power RF output port. When medium-power output is selected, the RF signal is output from the HP OUT port, while no signal is output from the RF OUT port.

To configure medium-power output in SGStudio:

- Click General Settings in the RF Control Area. In the RF Hardware section, set Output Port to HPPort;
- Connect the RF cable to the medium-power RF output port of the device;
- Set the required output frequency, power, and signal type, then enable RF - High Power to output the configured signal.

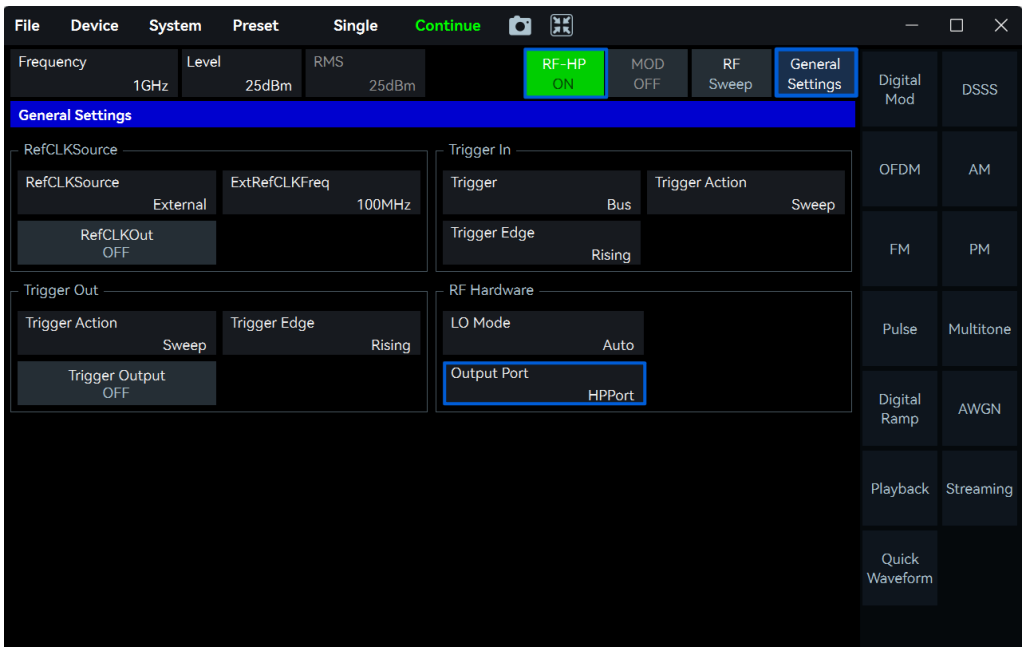


Figure 9-1 25 dBm CW Signal from the Medium-Power Output

## 9.2 LO Mode

The T1060 supports the following LO modes, as described below:

**Table 9-1 LO Mode Parameter Description**

| LO Mode | |
|---|---|
| **Auto** | The instrument automatically selects the optimal operating parameters based on the current output frequency, frequency step, and operating status. |

| | |
|---|---|
| **Low Phase Noise** | Adjusts the phase-locked loop (PLL) control strategy to improve signal phase stability and optimize close-in phase noise. |
| **Low Spurious** | Optimizes the LO output spectrum to effectively suppress fractional spurs and related spurious components, improving spectral purity. |

# 10. GNSS, Reference Clock, PPS, and Synchronization

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

## 10.1 Hardware Interfaces and Electrical Requirements

This section first describes the connectors and electrical requirements for GNSS, external reference input, and reference output, followed by the corresponding SGStudio settings. The reference clock input and output use MMCX (F) connectors, while the GNSS input uses an SMA (F) connector.

## 10.2 GNSS Input

The GNSS input port can supply power to a GNSS antenna. Contact HAROGIC Sales if a compatible GNSS antenna is required.

The T1060 comes standard with a built-in GNSS module providing 1PPS timing accuracy of ±100 ns. With Option 05, a higher-precision GNSS module is provided. When GNSS is locked under clear-sky conditions, with the antenna having an unobstructed view of sky, the 1PPS timing accuracy is ≤ 20 ns.

## 10.3 External 10 MHz Reference Input

The RI interface uses an MMCX (F) connector. The external reference clock input requirements are: 10 MHz, amplitude ≥ 1.5 Vpp, and input impedance of 330 Ω. Sine waves, square waves, and clipped sine waves are supported. Users can select the external reference and set the frequency to 10 MHz in SGStudio, or configure it through the API.

Click "General Settings" in the main settings area, select "External" under RefCLKSource, and set "ExtRefCLKFreq" to 10 MHz.

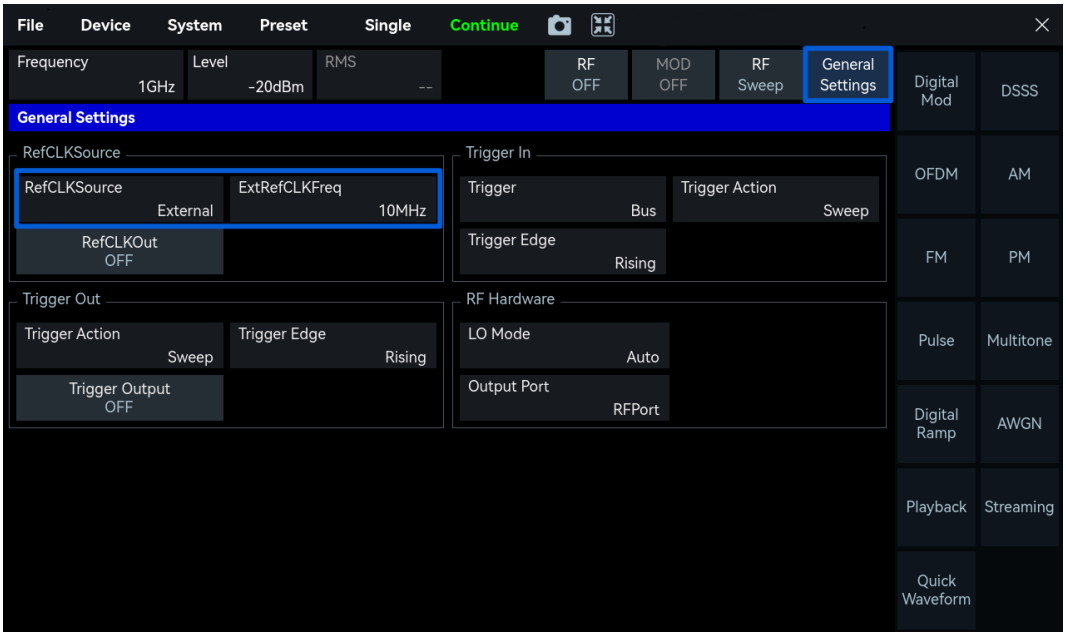


Figure 10-1 Selecting an External 10 MHz Reference Source in SGStudio

## 10.4 Reference Output

The RO interface uses an MMCX (F) connector. 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 SGStudio or control it through the API.

In SGStudio, click "General Settings" in the main settings area and enable "RefCLKOut" under "RefCLKSource".

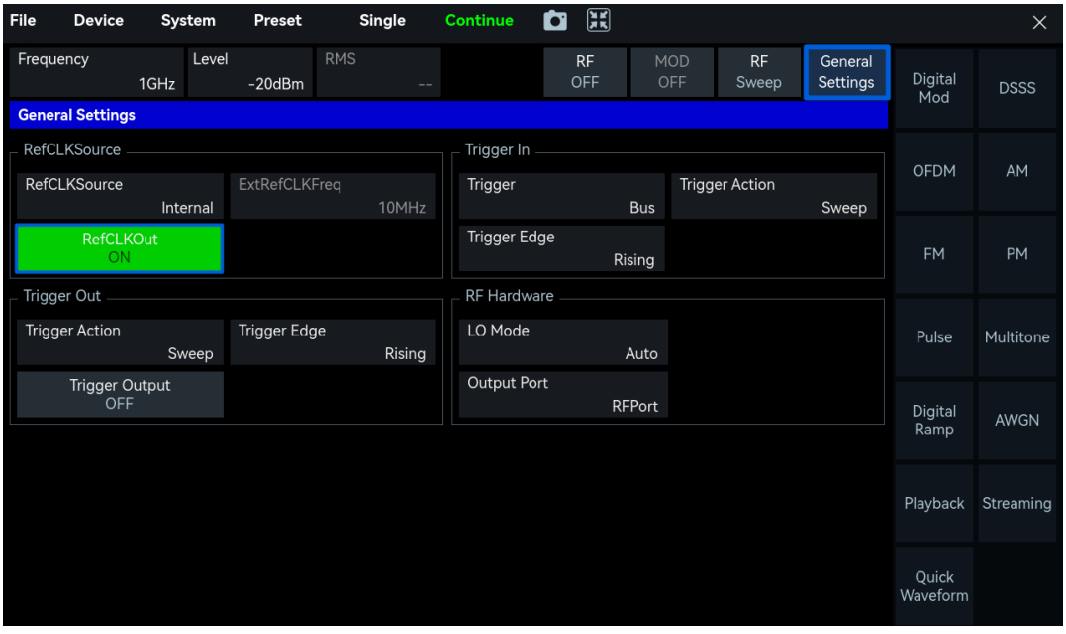


Figure 10- 2 Enabling the Reference Clock Output in SGStudio

## 10.5 GNSS Lock and 1PPS

Note: After connecting an external GNSS antenna to the T1060, the GNSS status can be viewed directly in SGStudio.

Click "System" -> "GNSS Info" on the menu bar, select the "External" antenna, and wait 1 to 3 minutes for GNSS to acquire lock. The parameters in the GNSS Information dialog are described in the following table.

**Table 10-1 GNSS Parameter Description**

| GNSS | |
|---|---|
| **Antenna** | Select Internal or External antenna (currently only the external antenna is supported). |
| **Format** | Supports two time formats: Local Time and UTC Time. |
| **Date** | Current date obtained from GNSS positioning. |
| **Time** | Current time obtained from GNSS positioning. |
| **Longitude** | Longitude of the current position. |
| **Latitude** | Latitude of the current position. |
| **Altitude** | Altitude of the current position. |
| **Number of Satellites** | Number of satellites used for positioning. |
| **SNR (Max.)** | Maximum SNR among the acquired satellites. |
| **SNR (Min.)** | Minimum SNR among the acquired satellites. |
| **SNR (Average)** | Average SNR of the acquired satellites. |

### 10.5.1 Using the Default GNSS Source

- Connect the GNSS antenna to the GNSS antenna port of the device/GNSS module;
- Click System -> GNSS Information, and set GNSS Source to Default in the GNSS Information dialog;
- Wait 1 to 3 minutes for GNSS to acquire lock. The GNSS lock indicator in the status bar can be used to determine the lock status. Once locked, GNSS Locked is displayed. For descriptions of the parameters in the GNSS Information dialog, refer to Table 10-1.

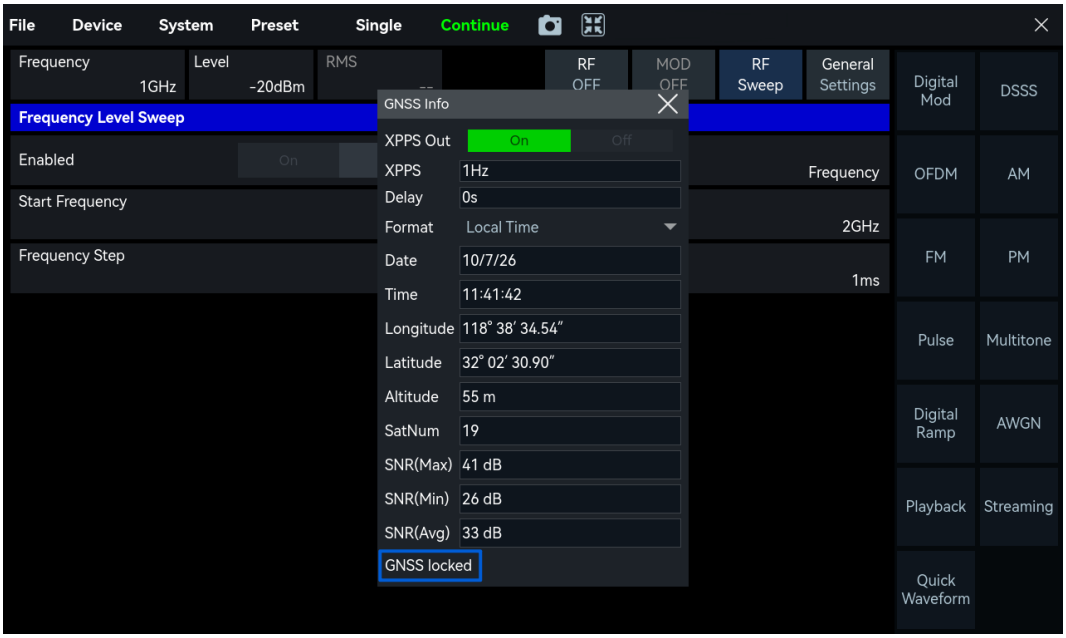


Figure 10-3 GNSS Lock with an External Antenna

## 10.5.2 Using the 1PPS Trigger from the Default GNSS Source

This section describes how to configure the 1PPS trigger function of the built-in GNSS module.

- Refer to Using the Default GNSS Source and ensure that GNSS is locked;
- Set XPPS to 1 Hz in the GNSS Information dialog;
- Click General Settings in the main settings area. In the Trigger submenu, set TriggerSource to GNSS-1PPS to use the 1PPS signal from the GNSS module as the trigger source.

# 11. Triggering and AUXIO

First, verify the 3.3 V CMOS electrical limits and connection orientation, and then select the trigger source, edge, delay, and pre-trigger settings.

## 11.1 Trigger Capabilities

The T1000 Series supports bus triggering and external digital triggering. The external trigger input uses 3.3 V CMOS signaling with high input impedance and supports a maximum trigger rate of 500 triggers per second. The trigger output also uses 3.3 V CMOS signaling.

## 11.2 AUXIO Trigger Board

This section describes how to connect and use the dedicated trigger board with the T1000 Series RF Transmitter platform, including the trigger input and output functions. Connect the AUXIO interface of the T1000 to Port 10 on the dedicated trigger board (shown below Figure 11-2) using a 14-pin ribbon cable.

- Note: The ribbon cable connector is keyed to prevent reverse insertion. Make sure the connector is oriented correctly and do not force it into place. When correctly aligned, the connector can be inserted easily.

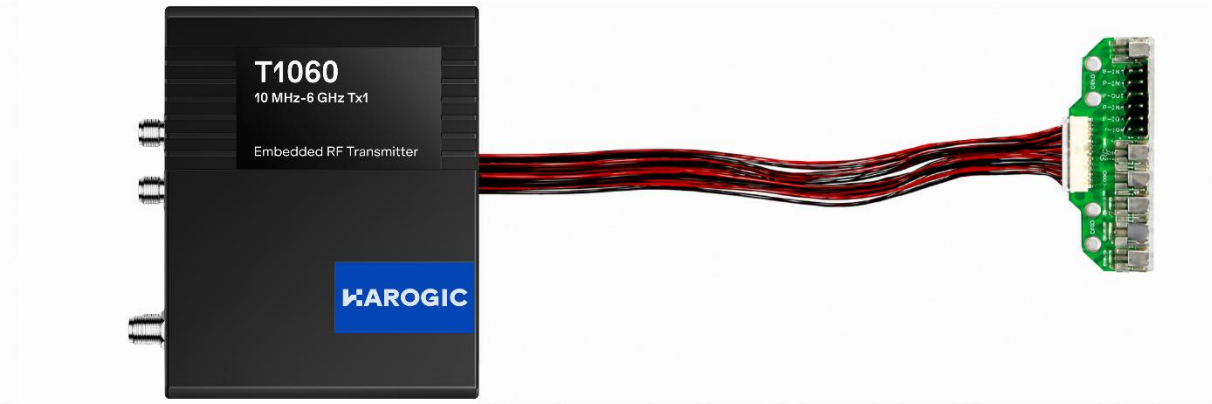


Figure11-1 Connection Diagram of the AUXIO Trigger Board and T1000

### 11.2.1 Introduction to the AUXIO Expansion Board for the T1000 Series

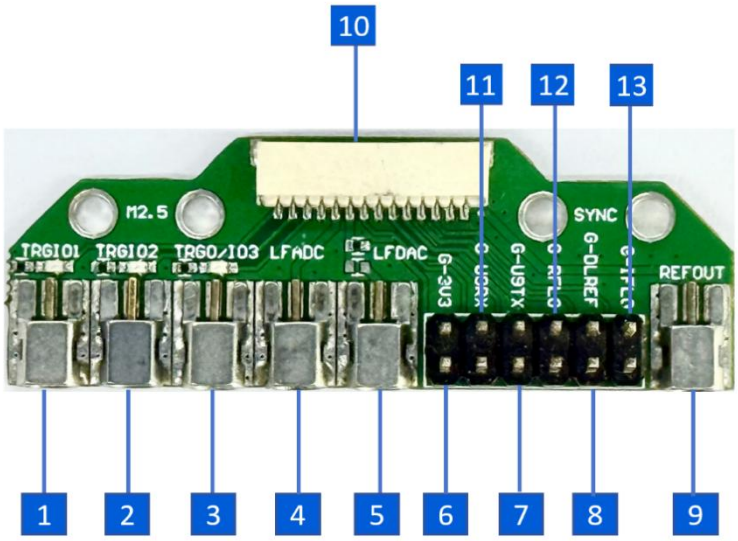


Figure11-2 T1000 Series Trigger Board Interface Diagram

**Table 11-1 T1000 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 |

## 11.3 Configuring Triggering in SGStudio

### 11.3.1 Trigger Input

Click "General Settings" -> "Trigger Input" in the main settings area, select External, and set Trigger Edge to Rising Edge or another required option. The trigger action can be set to Sweep or Hop. In Sweep mode, each trigger initiates a complete sweep. In Hop mode, each trigger advances the output by one step.

Parameter Description:

Table 11-2 Trigger Input Parameter Description

| Trigger Input | |
|---|---|
| Trigger Input | Supports Bus Trigger, External Trigger, and XPPS Trigger. |
| Trigger Action | Effective only when frequency/power sweep is enabled.<br>**Sweep:** Upon receiving a trigger signal, the system starts the preset frequency/power sweep. During the sweep, the transition timing between frequency/power points is determined by the dwell time.<br>**Hop:** Upon receiving a trigger signal, the system performs only a single-step transition to the next RF state in the preset sweep sequence. In this mode, the dwell time is ignored, and the hopping rate is determined by the arrival rate of the trigger pulses. |
| Trigger Edge | Supports rising-edge and falling-edge triggering. In Bus Trigger mode, the Trigger Edge setting is ignored. |

**Operating Procedure:**

The following example uses an AM signal with a frequency sweep:

1. Refer to Section 11.2 to connect the external trigger input;
2. Select "AM" in the Mode Selection Area. In the Mode Parameter Setting Area, set "Modulation Rate" to 200 kHz, leave the other parameters at their default values, and enable AM mode;
3. Click "Frequency/Power Sweep" in the RF Parameter Setting Area. In the Mode Parameter Setting Area, set "Frequency Step" to 100 MHz, leave the other parameters at their default values, and enable Frequency/Power Sweep mode;
4. Click "General Settings" in the RF Parameter Setting Area, set Trigger Source to External Trigger, and set Trigger Action to Hop;
5. Enable the RF output. The device now enters the trigger-ready state. Each valid external trigger causes the system to hop to the next frequency point in 100 MHz steps while outputting an AM signal with a modulation rate of 200 kHz.

### 11.3.2 Trigger Output

Click "General Settings" -> "Trigger Output" in the main settings area and select the Trigger Action, which can be set to Sweep or Hop. Set "Trigger Edge" to Rising Edge or Falling Edge, then enable the trigger output to complete the configuration.

**Table 11-3 Trigger Output Parameter Description**

| Trigger Output | |
|---|---|
| **Trigger Output** | Enables or disables the trigger output function. |
| **Trigger Action** | **Sweep:** Outputs a trigger after completion of each frequency/power sweep.<br>**Hop:** Outputs a trigger after completion of each frequency hop. |
| **Trigger Edge** | Sets the output trigger to a rising edge or falling edge. |

# 12. Migrating from SGStudio to the H2 API

SGStudio helps users verify that the device and configured parameters operate as expected, while the H2 API enables the same capabilities to be integrated into custom applications.

## 12.1 Why Use the H2 API

The H2 API should be used for applications requiring unattended operation, automated configuration, multi-device coordination, custom processing of continuous data streams, remote management, or integration with other systems. SGStudio can remain available as a debugging and verification tool, but it is not required to run a customer application.

## 12.2 H2 API, SDK and Example Applications

| Component | Purpose |
|---|---|
| H2 API | Defines programming interfaces for device discovery/connection, transmit configuration, waveform loading, status monitoring, and error handling. |
| 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 verify the development environment before starting application development. |

## 12.3 Running the First RF Signal Generation Example

The materials supplied with the device include examples for C/C++, C#, Python, MATLAB, Qt, and other development environments. On Windows, the C++ examples can be found under:

```
Windows\example\Cpp_Examples\C++_Example
```

- Obtain the H2 API, SDK, and Example Applications release package that matches the software and firmware versions of the T1000.
- Select a basic transmit example and configure the device connection parameters.
- Start with settings similar to those already verified in SGStudio, such as the center frequency and output level.
- Run the example and check the device information and returned status. An R1000 Series RF Receiver can also be used to verify the actual RF signal output.
- Stop the example and release the device.

**Note:**

Opening the Device over ETH: The T1060 client application should use the device_open_eth interface provided by the current SDK. If an existing application uses device_open_usb as its device-opening interface, it must be modified according to the H2 API Programming Guide before it can be used with the T1060. Do not allow an example application and SGStudio to access the device simultaneously.

## 12.4 Minimum Protection Recommendations for Unattended Applications

- Keep RF OFF by default at startup. Enable RF output only after the network connection, temperature, lock status, waveform, and load conditions have all been verified.
- Implement RF OFF handling for watchdog events, task timeouts, streaming underruns, connection loss, and abnormal temperatures.
- At a minimum, task logs should record the UID, version information, configuration, waveform identifier, start/end times, alarms, and reason for termination.
- Keep RF OFF after a process restart, system reboot, or power restoration. Do not automatically resume high-power RF transmission.

## 12.5 Development Documentation and Technical Support

Obtain the H2 API reference, SDK documentation, and Example Applications corresponding to the current release from the SDK package supplied with the device or through official HAROGIC channels. When requesting technical support, provide the information listed in 7.4.

| Development Question | Reference Document |
|---|---|
| Functions, enumerations, structures, error codes, timestamps, and synchronization semantics | H2 API Programming Guide |
| Where to find examples, how to build and run them, and how to adapt them for the T1000 | API Example Application Guide |
| Whether a parameter available in SGStudio can also be configured through the API | Refer first to the conceptual mapping in this chapter, then use the API reference for the current SDK as the authoritative source. |
| GNU Radio and similar environments | Use GNU Radio to create applications, and obtain the latest GNU Radio and SoapySDR examples via Git. These examples are continuously maintained in the HAROGIC Git Repo. |

# 13. Software Updates, Maintenance, and Service

Establish a recoverable baseline before an update, maintain stable power and network connections during the update, and revalidate the minimum RF transmit path after the update.

## 13.1 Software and Firmware Updates

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

Automatic operating system updates on the Raspberry Pi are disabled by default. To ensure compatibility with the product software and API, system updates are not recommended. Contact HAROGIC Technical Support if assistance is required.

## 13.2 Version Requirements

- Refer to Section 7.4 to check the model, UID, and software/firmware versions.
- Ensure that the GUI version is 2.6.4 or later. Read the corresponding release notes before performing an update.
- If the software indicates that an update cannot be performed, contact HAROGIC Technical Support.

## 13.3 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 13-1 Update Methods**

| Update Method | Description |
|---|---|
| Online | Automatically connects to the remote server to download and install the latest software and firmware versions. |
| Local | Manually loads and installs an update package from a USB flash drive or local storage device. |

## 13.4 Online Update

- Click "System" -> "Update" to open the Update window.
- Select the "Update Notification" checkbox. When the device is connected to the network, the Update window automatically appears if a new version is detected during software startup or operation.
- Set "Update Method" to "Online". The system starts downloading the update package, and the Update button is temporarily disabled. After the package has been successfully downloaded and parsed, detailed update information is displayed and the Update button becomes available.
- Carefully compare the current and target version information and review the list of new features and fixes. After confirming the information, click "Update" in the lower-right corner.
- The software automatically exits and enters the update process. Keep the update window open until the progress bar is complete and the software automatically restarts to the main interface.
- Close the update information window, then click "System" -> "About" on the menu bar to check the current software and firmware versions.

## 13.5 Local Update

Obtain the latest SGStudio version and release notes from the official HAROGIC Download Center:

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

To perform a local update:

- Click "System" > "Update" on the software menu bar to open the Update window.
- Select "Local", click Open, and select the target software installation package. After the corresponding version information appears in the Update Contents area, click "Update" in the lower-right corner.
- The software automatically exits and enters the update process. Keep the update window open until the progress bar is complete and the software automatically restarts to the main interface.
- **During the update:** Maintain stable device power, network connectivity, and the update window. Do not close the software, disconnect any cables, or force a restart. Before batch or remote updates, first verify the update, rollback, and minimum functionality on a representative device.

## 13.6 Accessories, Routine Inspection, Cleaning, and Service Information

### Accessories and Options

| Category | Item | Remarks |
|---|---|---|

| | | |
|---|---|---|
| Standard | Power adapter, USB-C power cable, 1 GbE Ethernet cable, documentation USB flash drive | Standard items supplied with the product |
| Optional Accessory | AUXIO IO Expansion Board | Contact HAROGIC Sales for purchase. |
| Option | T1 Temperature Class (40) | -20 to 65 ℃ |
| Optional Accessory | GNSS Antenna | Contact HAROGIC Sales for purchase. |

### 13.6.1 Routine Inspection

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

### 13.6.2 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. Use appropriate tools and procedures when cleaning RF or electrical connectors.

For long-term storage, use suitable antistatic packaging and connector protective caps. Keep the device dry and protect it from excessive mechanical pressure.

### 13.6.3 Information to Record Before Service

Before contacting Technical Support or returning the device for service, record at least the following information: device model, serial number, installed options, system image/firmware/API/software versions, connection topology, power supply model, reproducible steps, and relevant logs or screenshots.

It is recommended to use "System" -> "About" in SGStudio to obtain the relevant device and version information.


T1060
10 MHz-6 GHz Tx1
Embedded RF Transmitter
HAROGIC
HP OUT
RF OUT 50Ω
GNSS Antenna

# 14. Troubleshooting

Narrow down the cause in the following order: power, connection, software, RF, waveform, synchronization, and update. Retain reproducible evidence for further troubleshooting.

## 14.1 Hardware Troubleshooting Table

| Symptom | Safety Checks and Possible Causes | Recommended Action |
|---|---|---|
| Device Does Not Power On | Check whether the power cable is loose, and verify the power supply specifications and connector contact. | Disconnect external peripherals and verify the device nameplate, supplied power adapter, and cables. |
| 1 GbE Connection Failure | Cable issue, IP address conflict, subnet configuration, or firewall settings. | Confirm that a Gigabit Ethernet cable is used. Refer to the Quick Start Guide and check the connection using SGStudio. If necessary, restart the computer and the T1000. |

**For other issues, contact HAROGIC Technical Support.**

## 14.2 Quick Troubleshooting for Network, Software, GNSS, and IQ

Use the following items to quickly narrow down the cause. If the issue persists, 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 power-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. Check the device for abnormal heating or odor. If the issue persists, contact Technical Support.

### Unable to Access the T1000 over the Network

Check that a Gigabit Ethernet cable is being used and that the computer is connected through the appropriate 1 GbE LAN port. Confirm that the host computer and T1000 are configured on the same subnet as described in this manual, and check whether the firewall is blocking the software connection.

### SGStudio Cannot Detect the Device

Ensure that SGStudio version 2.6.4 or later is installed. If the installed version is earlier, update to the latest version and confirm that ETH is selected as the connection method. Check whether the device can be reached using ping. If the device responds to ping but still cannot be detected, try restarting the computer or the T1000.

### GNSS Does Not Lock

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

### No RF Output

Confirm that the device is properly connected and powered on and that SGStudio can connect to the device. Check RF ON, the selected output port, output power/frequency, MOD status, load, and cables. It is recommended to return to a minimum configuration of −40 dBm CW and test RF OUT first. Do not apply an external signal to an RF output port.

### Red or Yellow Device Status Indicator

Only one status indicator color is displayed at a time. Green indicates normal operation, red indicates an abnormal device status, and yellow indicates a remote update failure.

A red or yellow indicator may indicate an abnormal condition related to temperature, power, update status, or the software/firmware version combination. Turn RF OFF while maintaining power and retaining relevant logs. If the yellow indicator shows an update failure, do not disconnect power without confirming the appropriate recovery procedure.


T1060
10 MHz-6 GHz Tx1
Embedded RF Transmitter
HP OUT
RF OUT 50Ω
GNSS Antenna
HAROGIC

# Appendix A Related Documentation

| Document | Description |
| --- | --- |
| HAROGIC T1000 Series RF Transmitter Product Manual | Product datasheet covering key features, application scenarios, specification overview, and detailed technical specifications. |
| HAROGIC T1000 Series RF Transmitter Quick Start Guide | Provides a 30-minute quick-start procedure covering power-on, network connection, access to the embedded host, hardware configuration using the desktop software, RF signal generation, and modulated signal generation. |
| HAROGIC T1000 Series RF Transmitter User Guide | Complete user workflow for the T1000, including interfaces, power supply, network configuration, hardware configuration and RF signal generation using the desktop software, GNSS, triggering, and hardware/software troubleshooting. |
| HAROGIC SGStudio User Guide | Comprehensive SGStudio user guide covering device configuration, functional verification, modulated signal generation, custom waveform playback, and other signal generation modes. |
| HAROGIC H2 API Programming Guide | Covers API concepts, sessions, modes, parameters, data structures, error codes, timestamps, synchronization, and triggering. |
| HAROGIC H2 API Example User Guide | Covers example directories, environments, building, execution, and language adaptation for C/C++, Qt, Python, MATLAB, and C#. |
| HAROGIC Git Repo. | Provides resources for developing applications with GNU Radio and obtaining the latest GNU Radio and SoapySDR examples via Git. The examples are continuously maintained online. |

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