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thinkRF R6000 Real-Time Spectrum Analyzer with GNSS

User Guide
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Table of Contents

Preface

This section describes the audience for, the organization of, and conventions used in this document. It also identifies related documentation and explains how to access electronic documentation.

Audience

This document is written for technical people who have basic understanding, familiarity and experience with network test and measurement equipment.

Conventions

The following conventions and notations are used in this document:

Note: This symbol means **take note**. Notes contain helpful suggestions or references to additional information and material.

Caution: This symbol means **be careful**. In this situation, you might do something that could result in equipment damage or loss of data.

Warning: This symbol means **danger**. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with the standard practices for preventing accidents.

Obtaining the Latest Documentation and Software

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Before contacting support, please have the following information available:

- R6000 serial number and the product version (located on the identification label on the R6000 device's underside)
- The firmware version running on the R6000
- Versions of thinkRF software you are using, potentially including the API libraries to third-party applications
- Operating system and version on your PC

Overview of the thinkRF R6000

The R6000 Real-Time Spectrum Analyzer (RTSA) with Global Navigation Satellite System (GNSS) is a high-performance software-defined RF receiver, digitizer and analyzer with integrated GNSS technology to offer location and time information in one package.

It is designed for stand-alone or remote real-time spectrum analysis, providing real-time triggering and loss-less capture of signals of interest. It offers industry leading combined sensitivity, tuning range, instantaneous bandwidth and scan rate. It offers Gigabit Ethernet connection and in the near future USB 3.1 for an even faster data transfer rate.

The R6000 is ideal for monitoring, management and surveillance of transmitters, whether they are in-building or spread across a geographic area. Applications include spectrum analysis, mobile wireless technology, research, test and measurement, spectrum monitoring and OEM integration. When the GNSS module is enabled, GNSS position and time information is sent to users through VRT context packets roughly every second.

In addition to the internal 30.72 MHz reference clock source and external 10 MHz source, the GNSS module also provides a 30.72 MHz reference clock source option for synchronized timestamps on VRT packets.

To facilitate easy integration into your new or existing applications, thinkRF supports two industrial standard protocols:

- the Standard Commands for Programmable Instruments (SCPI) protocol for controlling and obtaining status from the R6000, and
- the VITA 49 Radio Transport (VRT) protocol for digitized data and its associated context information.

In addition to the protocols, thinkRF provides libTRF, a multi-platform C/C++ API library that can be used for interfacing with thinkRF's RTSA devices (R5xx0 and R6000 series) and will be maintained into the future to support interfacing with future thinkRF devices. libTRF abstracts away the protocols, allowing for easy-to-use functions to interface and perform data acquisition and spectral analysis with the device.

In addition, the API supports and will be evolved to increasingly provide sophisticated signal processing capabilities that can be easily integrated into end-user application code.

thinkRF's S1000 Spectraware GUI (sometimes referred to as S1000) is a brand-new spectrum analysis web application designed to work with the current R5xx0, R6000

devices, and future RTSAs. S1000 is a window to the RTSA hardware products. It enables users to easily control, view and analyze signals such as 4G LTE, 5G NR, Wi-Fi, among other RF signals. S1000 interfaces to an RTSA via libTRF.

Getting Familiar with R6000

This section provides information about the front and rear panels, connection ports and identification label of the R6000.

Note: The type and placement of connectors and components on the panels and the case may vary depending upon the product variant and version.

Front Panel

The front panel of the R6000 contains the power switch with integrated LED power status and five SMA connectors: RF IN (the input connector for the RF antenna port), GNSS Antenna input, IF OUT, REF OUT, and REF IN.

Rear Panel

The rear panel of the R6000 contains Ethernet port, USB 3.1 port, various status LED Indicators as marked, factory reset button, GPIO port and the 12 VDC power input port. The power input connector is to be used only with the provided power adapter.

Underside

The underside of the thinkRF R6000 includes a label that identifies the device. The information on the label may vary depending on your product variant and version. The product “Version” number is important for identifying which firmware can be used to update your product.

Installing the thinkRF R6000

Ensure that you read and understand the following information about safety and electrostatic discharge before you unpack and install the R6000 device.

Warning: Only trained and qualified personnel should be allowed to install or replace this equipment. Read the installation instructions before you connect the system to its power source.

Preventing Electrostatic Discharge Damage

Electrostatic Discharge (ESD) is a single-event, rapid transfer of electrostatic charge between two objects, such as an operator and a piece of electrical equipment. ESD can occur when a high electrostatic field develops between two objects. ESD occurs when electronic components are improperly handled and is one of the major causes of device failures in the semiconductor industry.

Electrostatic discharge is more likely to occur with the combination of synthetic fibers and dry atmosphere. Always follow these steps to prevent ESD.

Warning: Never open the front or rear panels of the R6000 as personal injury may result and opening the chassis will void the warranty. There are no user-serviceable parts inside. Always contact thinkRF support for service through the online support form at http://www.thinkrf.com/support/.

Caution: To prevent ESD, wear an ESD-preventive wrist strap that you provide, ensuring that it makes good skin contact.

Caution: Do not touch any exposed contact pins or connector shells of interface ports that do not have a cable attached. If cables are connected at one end only, do not touch the exposed pins at the unconnected end of the cable.

Unpacking the Box

This section lists the items that come with your R6000 analyzer. If any of the items are missing or damaged, please contact your thinkRF customer service representative.

The R6000 shipping box contains the following:

- R6000 Real-Time Spectrum Analyzer
- Power adapter and cable
- Straight-through Ethernet cable

- Receiver antenna
- GNSS antenna and cable
- Precautions & Quickstart Guide

Note: The receiver antenna is included for your convenience and only intended to perform adequately across a limited frequency range.

Choosing the Mount Location for the R6000

Caution: To prevent damage to the R6000 radio receiver, do not install or operate the R6000 within 2 feet (60 cm) of devices that transmit more than +15 dBm power, such as Wi-Fi access points.

After you have selected a mount location, connect the R6000's receiver, GNSS antenna, Ethernet cable and power cable.

Connecting the Antennas, Ethernet and Power Cables

Caution: Never connect a transmitter directly to the receiver with a cable.

Follow these steps to connect the receiver and GNSS antennas, the Ethernet cable, and the power cable:

1. Screw the antenna on to the R6000 "RF IN" antenna input SMA connector on the device's front panel.

   Carefully turn the antenna screw by hand until you encounter resistance. See the System Specifications section for the maximum allowable input and cautions.

Caution: Do not overtighten the antenna connector on the jack. Using a wrench, pliers or even your hand to overtighten the antenna can cause permanent damage to the receiver. See the SMA Connectors section for the torque recommendations.

2. Screw the GNSS antenna on to the R6000 "GNSS" antenna input SMA connector on the device's front panel.

   Carefully turn the antenna screw by hand until you encounter resistance.

3. Connect one end of the Ethernet cable to the R6000's Ethernet port (on the rear panel) and the other end to an Ethernet port on your router or PC.
4. Connect the R6000 to its power adapter.

Warning: Use only the power adapter provided with the unit.

5. Plug the power adapter into a power outlet.
6. Push the power button to power on the unit. A blue color ring indicates the unit is on.

Note: See the Using the R6000 Administration Console section for a description of the R6000 status.

Connecting to the R6000

The R6000 analyzer is a network device. Typically, all communications and data capture with the R6000 occur via a Gigabit Ethernet connection, either directly from a computer or across an IP network.

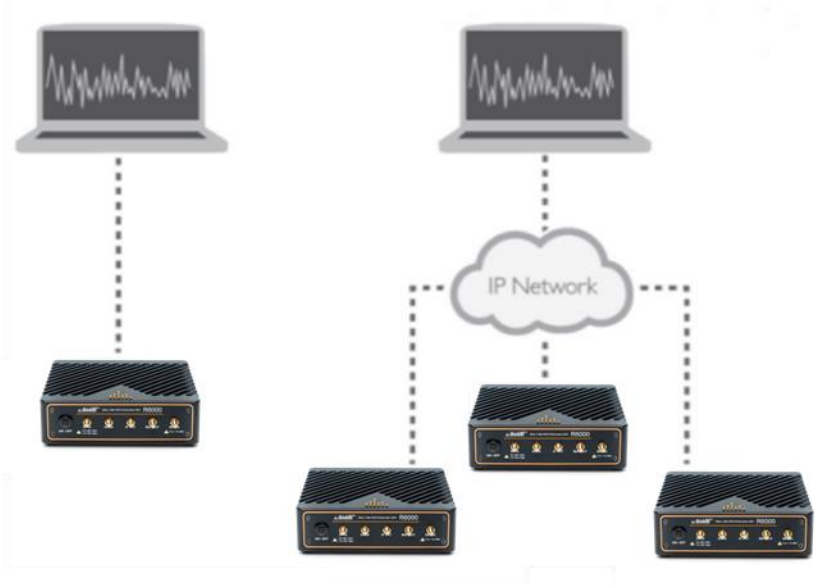
Determining Your Network Topology and IP Address Allocation

To connect with the R6000, you must decide the topology of your network connection and how your R6000 obtains its IP address.

Network Topology

The R6000 analyzer supports any IP network topology via its Ethernet port, including:

- direct connection to a computer across an RJ-45 Ethernet cable (as described in the Connecting Directly to the R6000 section)
- connection across a routed local network, whether on the same subnet or across different subnets or a routed wide-area network (WAN) such as the Internet (as described in the Connecting to the R6000 across a Network section)



IP Address Allocation

The R6000 analyzer also supports different methods for obtaining its IP address, including:

- **Dynamic IP address allocation (DHCP)**
  The IP address is assigned via the Dynamic Host Configuration Protocol (DHCP), for a routed network topology that has a DHCP server.

- **Dynamic IP address allocation (APIPA)**
  The IP address is assigned via the Automatic Private IP Addressing (APIPA) protocol (otherwise known as Auto-IP), where a DHCP server is not available. This method allows a direct connection to a computer that supports Auto-IP or to a local network using a switch. With Auto-IP, a host network device randomly assigns itself a link-local address in the 169.254.x.y subnet when it fails to contact a DHCP server. Many operating systems, including Windows, support Auto-IP.
- **Static IP address allocation**
  IP address is assigned locally. This method is applicable to any network topology.

By default, the R6000 is configured for DHCP. You can change the method of IP address allocation from one supported method to another.

For instructions on configuring a static IP address (via its web Administration Console), see the Configuring the R6000 IP Address section.

If your R6000 is configured with a static IP address, you can configure dynamic IP address allocation using the Administration Console as well, or via a hardware reset.

A hardware reset is the simplest method for reconfiguring the R6000 to dynamic IP allocation.

Connecting Directly to the R6000

This section provides instructions on connecting the R6000 analyzer directly to a computer via the Ethernet port.

The host PC might require a spare Ethernet interface that is not otherwise used as its primary network connection. For example, you may use a wireless connection for primary network connectivity or obtain a second Ethernet card or USB adapter to connect to the R6000.

Note: The Ethernet interfaces on both the PC and the R6000 must be configured for the same IP address allocation method before you can make a direct connection.

For the purposes of these instructions, thinkRF's S1000 Spectraware Real-Time Spectrum Analysis software is used to connect to the R6000.

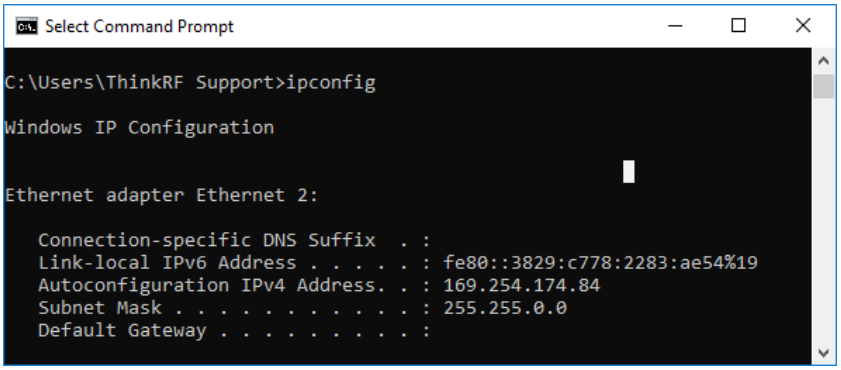
To connect your computer directly to the R6000:

1. Connect the Ethernet cable provided with the R6000 to the Ethernet port on the PC and the Ethernet port on the R6000.
2. Power up the R6000 and wait a minute for it to complete booting.
3. Check to ensure that the R6000 LINK indicator is illuminated. If it is not illuminated, your PC may not support automatic crossover on its Ethernet connection, and you may require an RJ-45 crossover Ethernet cable.
4. If you are using static IP allocation, go to the next step. If you are using dynamic IP address allocation, check the STS LED for the Auto-IP setup completion (this takes approximately one minute or longer).

Note: While the R6000 is searching for a DHCP server, the STS LED blinks yellow slowly until it obtains an IP address either via DHCP or Auto-IP. The STS LED blinks in a green heartbeat pattern if it has set up successfully to using an Auto-IP address.

5. Verify the PC's IP configuration by opening a Command window and typing the `ipconfig` command (in Windows OS) to show the IP addresses assigned to each interface.

   The Ethernet interface should show a 169.254.x.y address as shown in the example below:



6. Launch the S1000 software to determine the assigned IP address of the R6000.

In order for the S1000's Discovery tool (which used libTRF's discovery function) to locate the R6000, your computer and the R6000 must be configured for the same subnet. If you are using Auto-IP, then they will both be on the same 169.254.x.y subnet.

If you are using static IP and the s1000 cannot locate the R6000, you must have prior knowledge of its static IP address or reset the device to use DHCP for IP allocation using the reset switch on the rear panel.

Once you have the R6000 IP address, you can use it to communicate with the device.

Note: Link-local addresses used for Auto-IP are non-routable, so communication is limited to devices within the local subnet. This restriction may be an issue when running virtual machines (e.g. Mac Parallels, VirtualBox, etc.) that may be connected through virtual routers to the host PC's physical network interface.

Note: After obtaining a link-local address, the R6000 continues to request a DHCP address. If a DHCP server responds later, the link-local address is overwritten with the offered IP address. This new address is retained until the network cable is physically unplugged or the R6000 is restarted.

Connecting to the R6000 across a Network

You can connect to the R6000 analyzer from a computer across a local area network (LAN), whether on the same subnet or different subnets, or across a wide area network (WAN), such as WiFi.

Before you connect to the R6000, you must decide on your IP address allocation method. The PC and R6000 do not need to use the same IP address allocation method, but if you are using the S1000 software to locate the R6000, they must be on the same subnet.

If you are using DHCP, your router or network must support a DHCP server. You may have to query your router's allocation tables to determine the IP allocated to your R6000 MAC address.

To connect to the R6000 across a network:

1. Connect the Ethernet cable provided with the R6000 to the Ethernet port on the router and the Ethernet port on the R6000.
2. Power up the R6000 and wait a minute for it to complete booting.
3. Check to ensure that either your PC's or the R6000’s LINK indicator is illuminated.
4. If your R6000 is behind a firewall or a router with firewall capability, then your network's DHCP server is likely assigning private IP addresses (e.g. 192.168.x.x, 10.x.x.x, 172.x.x.x), and the firewall is likely providing some form of network address translation (NAT) function. If this is the case and you require access to the R6000 from outside your firewall, then you will likely have to configure the firewall to allow port forwarding on port 37000 and 37001. If necessary, consult your network administrator.
5. Use the S1000 to determine the R6000's assigned IP address.

If you are using static IP and the S1000 cannot locate the R6000, you need to have prior knowledge of its static IP address. If necessary, consult your network administrator.

Once you have the R6000 IP address, you can use it to communicate with the device.

Using the R6000 Administration Console

This section provides instructions on connecting to the R6000 via its web-based Administration Console. The Administration Console provides the ability to:

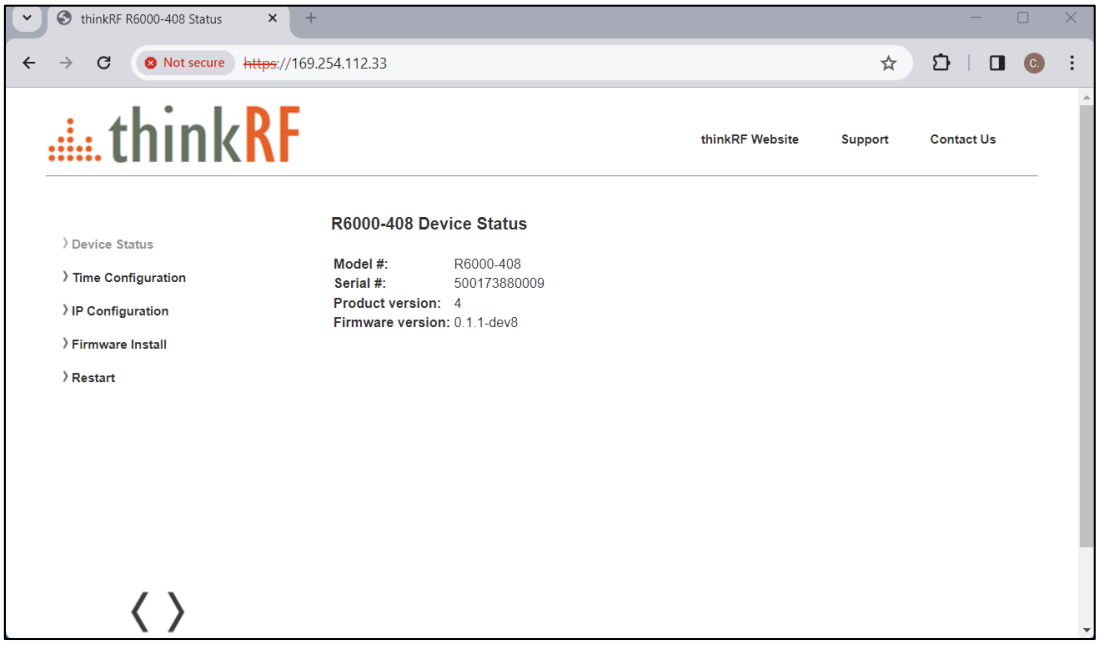
- obtain status information from the R6000
- change date and time configuration
- change IP configuration
- upgrade the R6000 firmware
- restart the R6000

All these functions may be performed over the network locally or remotely.

You can connect to the R6000 Administration Console by entering the IP address of your R6000 into a web browser. The IP address is shown in the S1000 software as the connected device.

Viewing Device Status

When you connect to the Administration Console, the main window shows Device Status by default, and includes information such as the device serial number and firmware version.



Configuring R6000 Time Synchronization

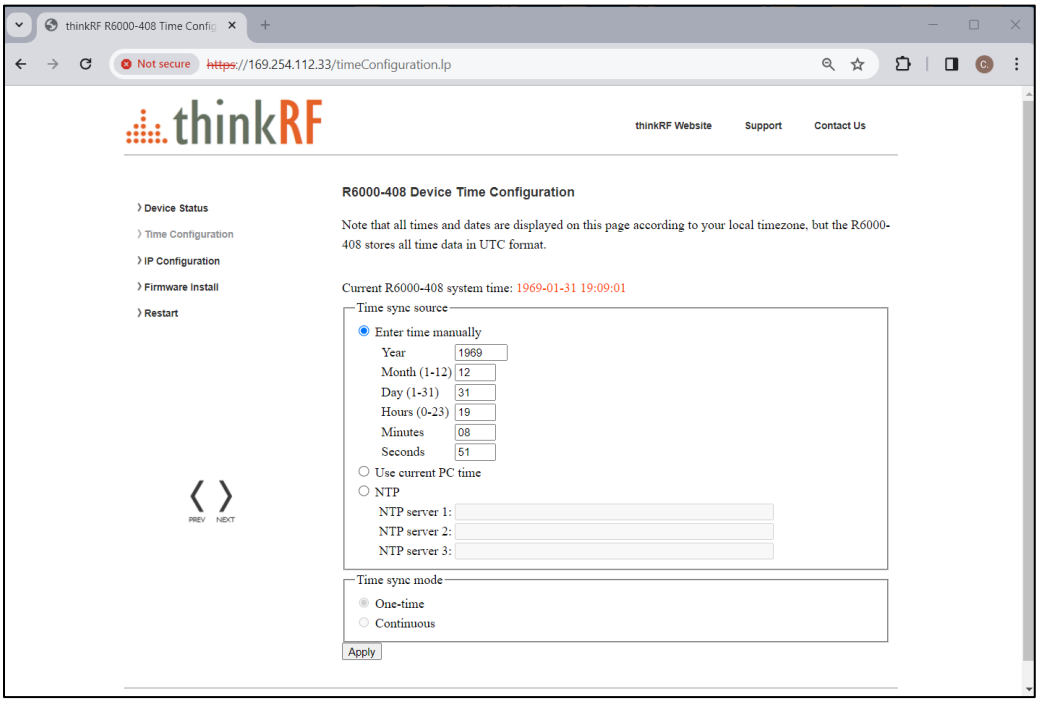
You can set the R6000 analyzer time manually, configure the R6000 to synchronize with the PC's time, or configure time synchronization with an NTP server.

Note: The R6000 stores its time based on the Coordinated Universal Time (UTC) and otherwise has no notion of local time-zones. Conversely, the web dialog translates and displays the R6000 time based on the local time-zone setting of the PC.

To configure the R6000 time synchronization method:

1. Click on the **Time Configuration** link in the left pane of the Administration Console.
2. In the **R6000 Device Time Configuration** window (main pane), select "**NTP**" as the time sync source.
3. Enter the IP addresses for up to 3 NTP servers (you can find the NTP server list at https://www.ntppool.org/en/
4. Select "**Continuous**" as the Time sync mode.

The R6000's time is synchronized to the NTP server on a regular basis (the interval is optimally determined automatically).



Note: It is important that NTP be set up in order to get a precise time and synchronize VRT timestamps with global time.

5. Click **Apply** to save your changes.

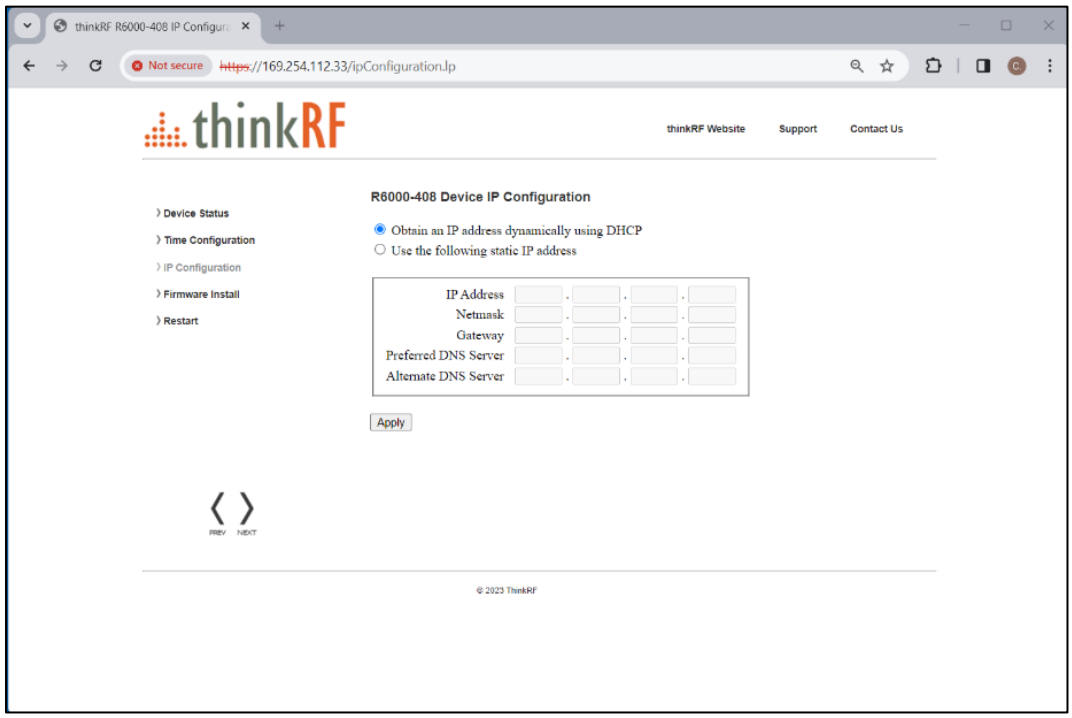
Configuring the R6000 IP Address

You can configure the R6000 to obtain an IP address dynamically (using DHCP) or you can set the IP address manually (using a static address).

Caution: If the R6000 IP address is set to a static IP, the only way to communicate with the R6000 is via that IP address. If you mistakenly enter the wrong IP address and/or subnet mask, or forget the IP address, you can change the IP configuration by Resetting the R6000 to Factory Settings.

To configure the R6000 IP address:

1. Click on the **IP Configuration** link in the left pane of the Administration Console.
2. In the **R6000 Device IP Configuration** window (main pane), select the method for IP address allocation.



3. If you select the static IP address option, enter the IP address information as appropriate.
4. Click **Apply** to save your changes.

The configuration changes take effect immediately, and your current connection (based on the previous IP address) will no longer be valid.

Updating the R6000 Firmware

This section describes how to update the R6000 firmware.

The firmware installation file contains firmware images associated with the R6000's embedded operating system and applications. The update process copies the new images to the R6000 but does not remove the currently installed images. The new firmware installation will only take effect after the R6000 is restarted.

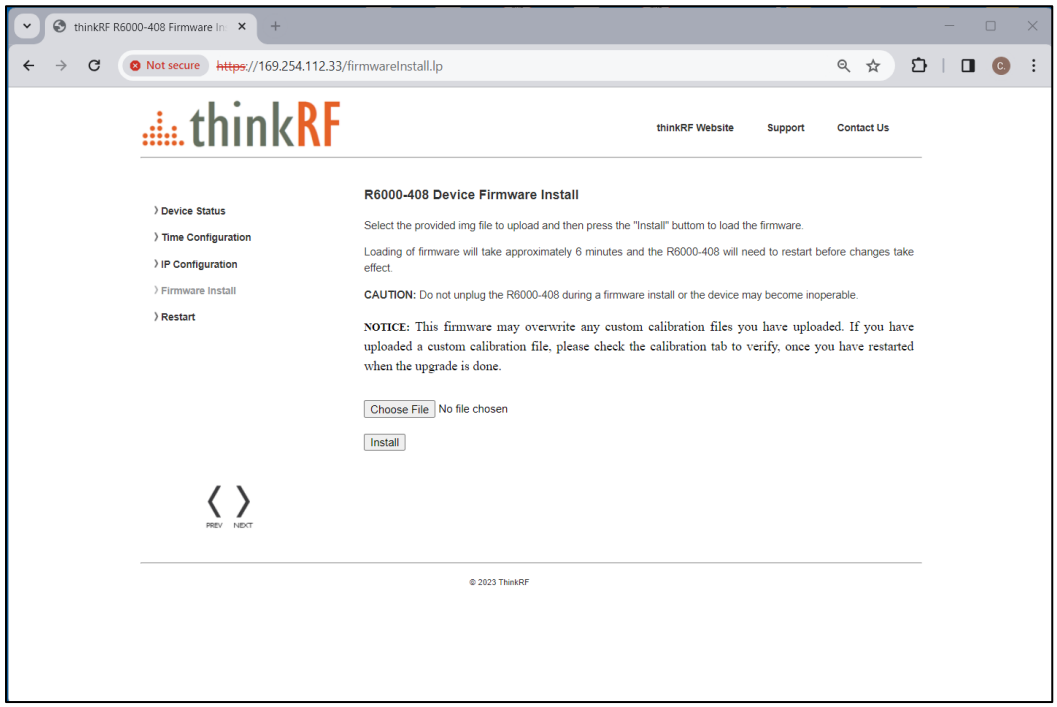
You can obtain the latest R6000 firmware file from the thinkRF website at https://www.thinkrf.com/firmware-updates/.

To update the R6000 firmware:

1. Click on the **Firmware Install** link in the left pane of the Administration Console.
2. In the **R6000 Device Firmware Install** window (main pane), enter or browse to the location of the `thinkRF_R6000_firmware_vX.Y.Z.img` (or similar *.img) firmware image file.
3. Click **Install** to install the firmware.

Warning: Do not unplug the R6000 during a firmware update or the device may become inoperable.

4. When the firmware image for the intended product version is installed, the **Installing** page appears, showing the progression of the firmware being uploaded and installed.



5. When firmware installation is complete, a web dialog appears requesting confirmation that you want to restart the R6000 for the changes to take effect. You can click **OK** to proceed or **Cancel** to defer the device restart.

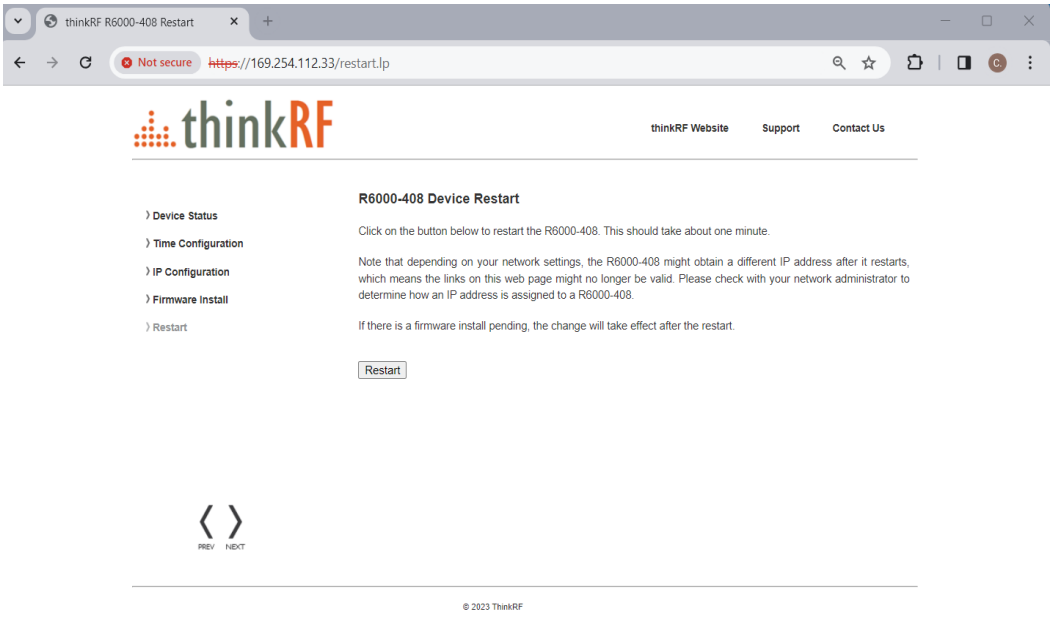
Note: If the R6000 is not restarted immediately after a firmware installation process, the newly installed firmware will take effect upon the next restart of the R6000 regardless of whether it is a software restart or a power-on reset.

In addition, the boot-up might take over a minute when Auto-IP connection method is used.

You can also restart the R6000 via the Administration Console. Performing a device reset from the Administration Console is equivalent to a power-on reset.

To restart the R6000:

1. Click on the **Restart** link in the left pane of the Administration Console.
2. In the **R6000 Device Restart** window (main pane), click **Restart**.



Depending on your network settings, the R6000 may obtain a different IP address after it restarts, which will result in the links to the Administration Console being interrupted. This will only happen when the unit is not in static IP address mode, or a factory reset has been initiated.

Please check with your network administrator to determine the IP address of the R6000.

Using the GNSS Module

The R6000's Global Navigation Satellite System (GNSS) supports location coordination activities with several different satellite constellations, including GPS/QZSS, GLONASS, and BeiDou. The R6000 GNSS module supports up to 2 concurrent receptions.

Location position and time are transmitted through VRT packets, along with timestamping and data output for captures.

The R6000 GNSS module supports GPS and GLONASS. Please refer to the *R6000 datasheet* for detailed specifications.

Configuring the R6000 GNSS Module

The GNSS module can be configured via direct SCPI control (see R6000 Programmer's Guide), the libTRF API. Its configuration can also be viewed and adjusted from the Device -> Device Location menu in the S1000 software.

Selecting the GNSS 30.72 MHz Reference Source

In addition to the internal 30.72 MHz and external 10 MHz reference clock sources available with the R6000, the GNSS module also provides a 30.72 MHz reference clock source option for synchronized timestamps on VRT packets.

You can configure the R6000 to use the GNSS reference clock using the same methods as mentioned above. For more information on the GNSS reference source, please refer to the *R6000 Programmer's Guide*.

Getting Real-Time Geolocation Data

GNSS timestamped information is recorded in the GNSS VRT packets, which are returned approximately every 1 second. Refer to "Formatted GNSS Geolocation Fields" in the VRT section of the *R6000 Programmer's Guide* for more information. libTRF API provides this information in its data structure as well.

Resetting the R6000 to Factory Settings

If for any reason you cannot connect to the R6000 via the Ethernet port, you can restore device factory settings to reset IP configuration and obtain an IP address dynamically using DHCP.

Performing a factory resent also sets the reference level calibration back to factory default values.

Follow these steps to reset your R6000:

1. If not already powered on, power on the R6000.
2. When the R6000 is powered on, *press and release* the Reset button on the rear panel of the device. You can insert a pin or paperclip to push the Reset button.

   The device will immediately reboot, loading the default factory settings.
3. Wait for the device to finish booting up (approximately 20 seconds), then use libTRF's Discovery tool or S1000 to determine the unit's IP.

Status Indicator LEDs

The rear panel of the R6000 analyzer includes status indicator LEDs as shown in the following figure and described in the following sections.

Status Indicator LED

Pattern	Meaning
Fast blink red	Hardware failure
Slow blink red	Firmware failure
Slow blink amber	Waiting for DHCP
Slow blink green	Busy
Heartbeat green	AutoIP
Solid green	Ready

Status RF Lock LED

Pattern	Meaning
Solid red	Unlocked
Solid green	Locked

REF Stat LED

Pattern	Meaning
Solid red	Internal reference, unlocked
Slow blink red	External reference, unlocked
Slow blink amber	GNSS reference, no fix
Slow blink green	GNSS or external reference, locked
Solid green	Internal reference, locked

Hardware Reference

This section provides physical and performance specifications, and port and cable pinouts for the R6000.

System Specifications

The following table outlines the physical and electrical specifications for the R6000.

Description	Design Specification
Dimensions H x W x D (D with rubber feet)	150 x 110 x 60 mm (5.9” x 4.3” x 2.4”)
Weight (approximately)	1.2 kg (2.6 lbs)
Digital interface ports	RJ45 Ethernet 10/100/1000, 15-pin female D-Subminiature
Analog interface ports	RF IN, 10 MHz REF IN and OUT, GPS, IF Output
Input supply voltage	12 VDC +/- 5%
Input supply current	2.3 A maximum
Operating temperature	32 to 122°F (0 to 50°C)

SMA Connectors

The SMA connectors on the front and rear panels are all female jacks with 50Ω nominal impedance.

Note: The recommended torque setting for all SMA connectors is 45 N.cm (4lbs.in). An example of a torque wrench that can be used for this is Huber-Suhner P/N 74 Z-0-0-79.

Caution: Injecting signal levels that exceed the specifications described in the following table will result in permanent damage to the receiver.

The following table outlines the maximum and minimum power level restrictions on the SMA connectors.

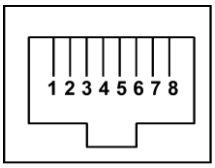
Connector Name	Direction	Max Power Level	Min Power Level
RF IN[1]	in	+20 dBm, 10 V DC	N/A
10 MHz IN[2]	in	+ 10 dBm	-10 dBm
10 MHz OUT	out	N/A	N/A
GNSS	in	N/A	N/A
IF Out	Out		

[1] It is recommended that the output of a signal source be verified with the use of a power meter prior to connecting the source directly to the RF IN connector. Never exceed the damage level of +20 dBm. Additionally, any external signal sources connected to RF IN must be turned on only after powering on the R6000 and turned off prior to powering down the R6000.

[2] The 10 MHz reference input must be powered down prior to powering down the R6000.

Ethernet RJ-45 Port Pinout

The following figure shows the R6000 Ethernet RJ-45 pinout:

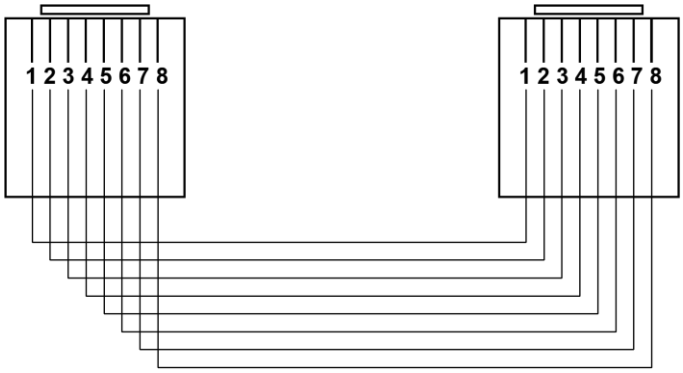


Pin	Signal
1	BI_DA+
2	BI_DA-
3	BI_DB+
4	BI_DC+
5	BI_DC-
6	BI_DB-
7	BI_DD+
8	BI_DD-

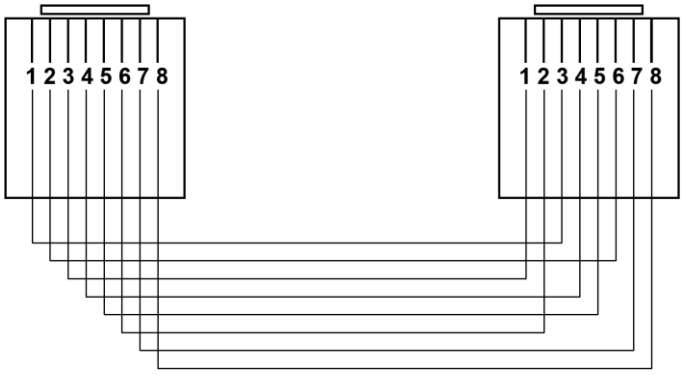
GPIO Port Pinout

The GPIO (General Purpose Input/Output) port will be instrumented in future releases. As new GPIO capabilities are released this section will be updated.

RJ-45 Straight-Through Ethernet Cable



RJ-45 Crossover Ethernet Cable



Operational Considerations and Maintenance

The R6000 should be operated only within its specified operation temperature and specification of 0°C to 50°C. The ideal operating temperature for optimum performance is between 20°C to 25°C.

Caution: Do not expose the device to direct sunlight or radiation from other sources of heat.

Some regular maintenance is needed to maintain the unit in its good working state. This includes:

- cleaning the box with a slightly damp cloth from time to time to remove any dust or debris that may accumulate in the device through any openings
- keeping all connectors clean (especially the threads) with a soft cloth
- cleaning the device with a fan (for example, an air can) to remove dust