



ThinkRF

S240v5 Real Time Spectrum Analysis Software User Guide

Version 1.3

April 23, 2021
Document no. 75-0042-210410
Copyright © 2017-2021 ThinkRF Corporation. All rights reserved.
All product names are trademarks of their respective companies.

Important notice

The information in this guide is furnished for informational use only and is subject to change without notice. ThinkRF Corporation assumes no responsibility or liability for any errors or inaccuracies that may appear in this document.

No part of this publication may be reproduced, published, or transmitted, in any form or by any means, electronic, mechanical, recording, or otherwise, for any purpose, without the prior written permission of ThinkRF Corporation.

Trademarks

ThinkRF, the ThinkRF logo and Product Names are trademarks of ThinkRF Corporation.

All other brand or product names are trademarks or registered trademarks of their respective companies or owners.

ThinkRF Corp

390 March Road
Kanata, ON K2K 0G7
(613) 369-5104

Table of Contents

Preface.....	5
Audience.....	5
Conventions.....	5
Obtaining Latest Documentation and Software	5
Document Feedback.....	5
Obtaining Technical Assistance	6
S240v5 Overview	7
User Interface	7
Spectral Plot and Configuration Panels.....	7
Control Buttons.....	8
Menu Bar	9
Getting Started.....	11
Installing S240v5 Software	11
Connecting to an RTSA Device	11
Configuring S240v5	13
Configuring Signal Capture.....	13
Configuring Amplitude Settings	13
Configuring Frequency Settings	13
Configuring Bandwidth Settings	14
Configuring A Trigger.....	15
Configuring Measurement Settings	16
Customizing the Spectral Plot Display	17
Adding Traces.....	18
Adding Markers and Peak Findings	18
Adding Cursors.....	20
Configuring Spur Mitigation	20
Known Limitations of the Spur Mitigation Feature.....	21
Configuring Device Options	21
Restoring S240v5 Defaults	22
Viewing Signal Data.....	23
Display Spectrogram	23
Display the Persistence Plot.....	24

Display the Time Domain Plot.....	24
Capturing Signal Data	26
Capturing a Screenshot.....	26
Saving Signal Data	26
Playing Back a Recorded Signal	28
Demodulating Data	29
Demodulation Panel	29
Fields on the Control Panel	29
Demodulation Graphs.....	31
Constellation Graph.....	31
Frequency Domain Graph	31
Time Domain Graph	31
How to Use Demodulation	31
Administration	33
Saving Configuration Settings	33
Loading Configuration Settings.....	33
Viewing Device Information	33
Accessing Product Documentation	34

Preface

The intended audience, document organization, and conventions used herein are described. Related documentation is identified as are instructions for accessing other electronic product documentation.

Audience

This document is intended for technical users who have a basic level of understanding, familiarity and experience with network test and measurement equipment.

Conventions

The following conventions are used in this document:

Grayed-out Font

Indicates a command or a feature is not available in the current release.

Courier Font

Illustrates an example command or a concept.

Light Blue Font

A clickable hyperlink to a referenced source.

Normal Bold Font

A concept or idea important enough that the reader's attention is being explicitly focused.

Red Font

Additional information for the topic.



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, undesired result or loss of data.

Obtaining Latest Documentation and Software

Please visit the ThinkRF website at <http://www.thinkrf.com/documentation/> to obtain the latest product documentation. Software and firmware releases are also available on the ThinkRF website at <https://support.thinkrf.com>.

Document Feedback

Please send any comments regarding ThinkRF documentation to support@thinkrf.com. We appreciate your feedback.

Obtaining Technical Assistance

For all customers who hold a valid end-user license, ThinkRF provides technical assistance 9 AM to 5 PM Eastern Time, Monday to Friday. Contact us at <https://support.thinkrf.com> or by calling **+1.613.369.5104**.

Before contacting support, please have the following information available:

- ThinkRF product's model, serial number (S/N), version (located on the identification label on the product's underside), and firmware version.
- The S240v5 version.

See [Viewing Device Information](#) section to obtain the information for the two points above.

- Versions of any ThinkRF software you are using, including any API libraries or third-party applications.
- The operating system and version you are using.

S240v5 Overview

The S240v5 Real Time Spectrum Analysis software (hereafter referred to as S240v5) is a spectrum analysis application designed to work with ThinkRF Real Time Spectrum Analyzers (RTSAs) starting with the R55x0 and R57x0 devices. This easy-to-use application provides standard and advanced spectrum analysis features including frequency and bandwidth controls, power measurements, triggering and multiple marker and trace configurations, to name a few.

ThinkRF RTSA devices are high-performance software-defined RF receivers, digitizers and analyzers. With patent-pending software-defined RF receiver technology, RTSA devices provide industry leading combined sensitivity, tuning range, instantaneous bandwidth (IBW) and scan rate. A hybrid RF receiver front-end (RFE) combines super-heterodyne, direct-conversion and direct digitization technologies with wide-band and narrow-band ADCs. Additionally, it provides hardware-based triggering and capture control, thereby enabling sophisticated sweeping and real-time capture.

S240v5 can be used to measure and analyze signals such as Wi-Fi, Bluetooth and LTE, and offers cursors and markers to track specific frequencies. Sophisticated FPGA-based frequency-domain level trigger in ThinkRF RTSA products enables the capture of elusive, time-varying signals across an instantaneous bandwidth (IBW) of up to 40MHz. Captured signal data can also be recorded to a CSV file for later replay.

S240v5 is built in Python 3 and runs on a Python 3 version of the ThinkRF PyRF development framework called PyRF3, which ThinkRF has open-sourced under BSD licensing. PyRF3 handles low-level details of connection, real-time acquisition, and signal processing. It provides feature-rich classes and comes with several examples with full source code, all specific to the requirements of signal analysis. PyRF3 is available to download from ThinkRF's [Knowledge base](#) site.



Note: This document version **1.3** of S240v5 User Guide works in particular with S240v5 software **v5.1.2** or higher. Recommend to [download](#) the latest S240v5 if your version is older.

User Interface

S240v5 is a new release of the S240 application with improved and easier to use features requiring fewer mouse clicks. It focuses on **Center, Span, Start** and **Stop** frequency settings coupled mode rather than on RFE modes as its primary control model. The application includes controls for **Frequency, Amplitude** and **Bandwidth** with additional plots such as **Spectrogram, Persistence** and **Time-Domain** data. It has also several measurement tools and the ability to record and playback signal data.



Note: This section provides an overview of the S240v5 user interface. See [Configuring S240v5](#) for details on how to use individual settings and options for each control.

Spectral Plot and Configuration Panels

The application is centered around its main Spectral Plot display (as shown in [Figure 1](#)). The Spectral Plot shows the processed power spectrum of the time-domain signal as a function of frequency in real-time. Current signal capture settings – frequencies,

S240v5 Overview

amplitude, resolution and video bandwidths (RBW and VBW), and sweep time and speed – are displayed below the plot. Trace, cursor (when available) and marker information are displayed above the plot.

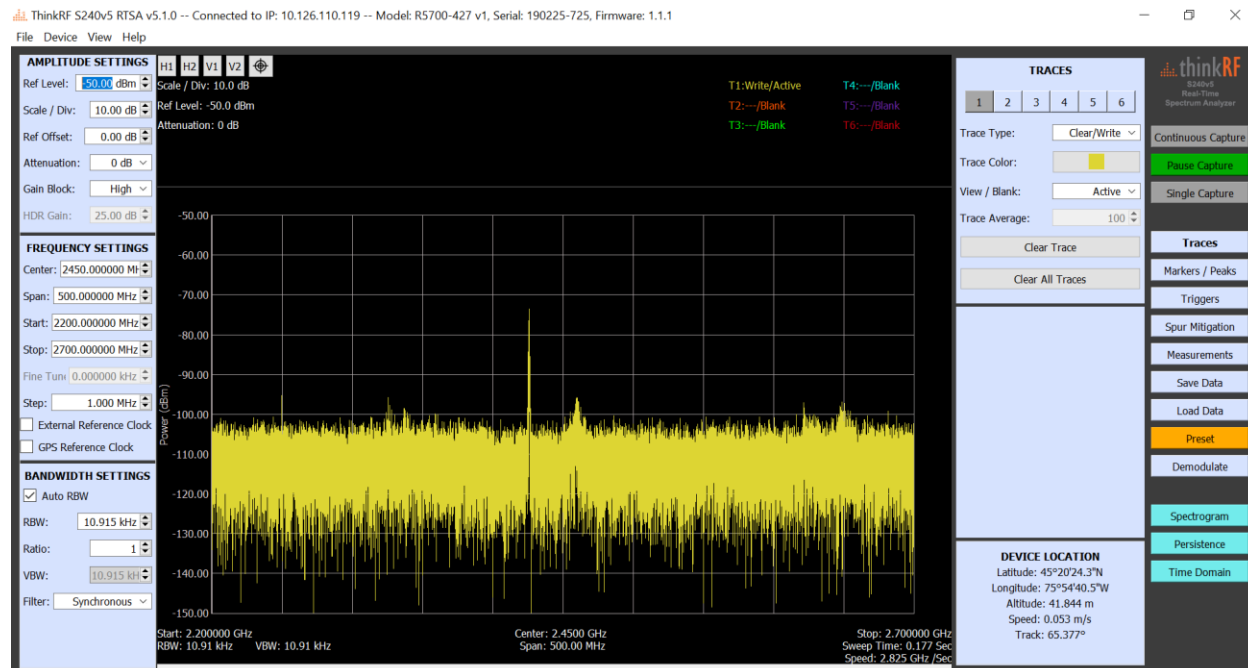


Figure 1: The S240v5 User Interface and Its Main Spectral Plot

Configuration panels surround the Spectral Plot section as such:

- *Left-side panels* contain frequently used settings for signal monitoring – Amplitude, Frequency and Bandwidth.
- The *near-right top panel* contains analysis settings of a topic that is selected by the control buttons on the far-right section of the S240v5.
- The *near-right middle panel* is currently unused, expanding and contracting to fill the space between the selected analysis panel and the device location panel.
- The *near-right bottom panel* contains a permanently displayed geolocation tracking data for the currently connected R57x0 device.

All configuration panels and control buttons are shown by default but can be hidden by opening the **View** menu and deselecting the **Show Control Panels** checkbox. In this mode, the plot section fills the application window.

Control Buttons

The following table summarizes the control buttons available in the far-right section with a brief description of their function.

Control Button	Function
Continuous Capture	Starts continuous capture and display of signals.
Pause Capture	Pauses the Continuous Capture.
Single Capture	Performs a single capture and display of the signal.

Control Button	Function
Traces	Displays on the near-right top panel options for configuring up to 6 individual traces on the Spectral Plot. See Adding Traces section for more information.
Marker / Peaks	Displays on the near-right top panel options for adding up to 12 markers to signal trace(s) and configuring signal peak detection. See Adding Markers section for more information.
Triggers	Displays on the near-right top options for enabling and configuring a frequency-domain level trigger for signal capture. It is available only when spans are from 40MHz to 100.001kHz. See Configuring A Trigger section for more information.
Spur Mitigation	Displays on the near-right top panel options to activate and configure spur mitigation or correction. See Configuring Spur Mitigation section for more information.
Measurements	Displays on the near-right top panel options for performing channel power or occupied bandwidth measurement. See Configuring Measurement Settings section for more information.
Save Data	Displays on the near-right top panel controls for saving signal data and application state for future playback. See Saving Signal Data section for more information.
Load Data	Pops up a file dialog for loading of previously saved signal data and application state for playback. See Playing Back a Recorded Signal section for more information.
Preset	Restores S240v5 to the application start-up state. See Restoring S240v5 Defaults section for more information.
Demodulate	Pops a modal dialog for the purposes of visualizing and demodulating signals in AM or FM modulations. See Demodulate Signals section for more information.
Spectrogram	Adds a spectrogram waterfall display of captured signals below the Spectral Plot. See Display Spectrogram section for more information.
Persistence	Adds a persistence plot display of captured signals below the Spectral Plot. See Display the Persistence Plot section for more information.
Time Domain	Adds a time-domain (I/Q) plot display of captured signal below the Spectral Plot. It is available only when spans are 40MHz or lower. See Display the Time Domain Plot section for more information.

Menu Bar

The user interface has a menu bar at the top that offers a tidy location for additional controls for the RTSA device or the application itself.

S240v5 Overview

Menu	Options	Function
File	Load Settings	Loads a previously saved configuration file, as explained in Loading Configuration Settings .
	Save Settings	Saves the current S240v5 settings into a .config file, as explained in Saving Configuration Settings .
	Exit	Closes the application.
Device	Connect...	Loads the Open Device dialog to allow for connecting to another RTSA device.
	Connected Device Info	Opens the Connected Device dialog to show the device information, as explained in Viewing Device Information .
	Internal/External Digitizer	Checkboxes for selecting an internal (default) or external digitizer for processing RTSA's signal.
	Restart Connected Device	Restarts the connected RTSA device.
View	Take Screenshot...	Captures the current S240v5's user interface view, as explained in Capturing a Screenshot .
	Show Control Panels	Shows (default) or hides all the control panels.
Help	RTSA S240v5 User Guide	Opens the S240v5 User Guide documentation.

See [Configuring Device Options](#) for more information on the **Device** menu.

Getting Started

Before installing S240v5, ensure that your PC meets the following minimum system requirements:

- Operating System: Windows 7, 8, 10 (32-bit or 64-bit).
- RAM: 4 gigabytes (GB). Recommend: 8 to 16 GB improves the performance.
- Hard Disk: 1 GB available. Recommend: SSD drive improves the record and playback performance.



Note: An Internet connection is required to download S240v5 from the ThinkRF website.

Installing S240v5 Software

Download the S240v5 installer from the [ThinkRF website](https://support.thinkrf.com/support/home) to install the software on your computer.

1. Open a web browser and go to <https://support.thinkrf.com/support/home> – you will be required to log into the site if haven't done so.
2. In the New Release/Updates section, locate the S240v5 software and download the file to your computer.
3. Double-click on the executable file to launch the Setup Wizard, then follow the prompts to select your installation options and install the software.
4. On the **Ready to Install** prompt screen, review your installation settings. Click **Install** to proceed with the installation, or **Back** to change your settings.
5. When the Setup Wizard has completed software installation, click **Finish** to exit the Wizard.



Notes:

- If you get a permission error during the installation, right-click the install file and select **Run as administrator**.
 - Also, you may receive an installation error from a third-party anti-virus software, in which case you are advised to disable the virus scanner prior to installing S240v5. However, the common “code 299” error can be safely ignored.
 - After installation, if your anti-virus software quarantines the S240v5 during run time, please add an exception to the anti-virus software for S240v5 and try again.
-

Connecting to an RTSA Device

Connect to an RTSA device to view its real-time signal data in the S240v5 application. When launched, S240v5 will automatically detect and display a dialog listing compatible RTSA devices that are connected to the network subnet on which the host computer of the application resides. The users also have the option to manually enter a known IP should it not be on the same subnet.



Caution: A new connection to an RTSA device that is already in use will disrupt or disconnect the existing capture application. Current RTSA devices do not handle multiple simultaneous connection.

1. Launch S240v5 from your computer's Start menu or desktop icon shortcut (if installed). The application will display an **Open Device** window.
2. Select an RTSA device from the list of "Devices Detected on Local Network".
If a RTSA device of interest is not on the list, you can either click the **Refresh** button to update the list or enter the IP address of the device manually in the **Manually Enter Device IP** field.
3. Click **Connect**. Note that an entry of a detected device can be double-clicked to connect directly.
Upon successful connection, the S240v5 user interface will start displaying captured signal using the default application settings.
4. To connect to a different RTSA product, click on the **Device** menu and select **Connect...**. The application will display the **Open Device** window. Repeat steps 2 and 3 as needed.

Configuring S240v5

The S240v5 RTSA application provides several options for controlling and displaying signal captured through a ThinkRF RTSA product. For example, you can specify the frequency span and amplitude, create a trigger, adjust the RBW and VBW settings, add or remove traces, and add and manipulate markers.



Note: This section provides explanation regarding how to use S240v5 to configure the connected RTSA, it does not go into details what the configuration on the device entails. Refer to the RTSA product specific documentations for such details (see [Obtaining Latest Documentation and Software](#)).

Configuring Signal Capture

This section describes the settings that affect the signal capture and display.

Configuring Amplitude Settings

The Amplitude Settings panel at the far-left top panel manages levels and offset for the device and the Spectral Plot.

Reference Level: Controls the upper value of the plot's Y-axis, which indicates the maximum power level that can be displayed. It can be changed to bring the signal into view when necessary. Default 10dB.

Scale / Division: Controls the distance between the horizontal lines (Y-axis tick marks) on the plot display, useful for zooming in or out to the signal. The range is 1dB to 16dB, with 10dB as the default.

Reference Offset: Changes the signal's location within the plotted scale. Also, uses for adjusting known discrepancies between the displayed signal and the actual signal reference location. Does not affect the input signal. Default 0dB.

Attenuation: Applies a fix attenuation value to the device, which has the effect of raising or lowering the noise floor in the display. A default of 30dB is meant to protect the device from excessive signals on connection, while changing to 0dB for best dynamic range.

Gain Block: Applies a gain setting to the RTSA device (not available for RTSA -408 model). Increasing gain lowers the noise floor, improving SNR.

HDR Gain: Applies gain setting for RTSA's High Dynamic Range (HDR) RFE mode, which is enabled when the span drops to 100kHz and below with frequency ranges above 50MHz. Increasing gain lowers the noise floor, improving SNR.

Configuring Frequency Settings

Basing on chosen span and frequency ranges, the Frequency Settings at the far-left middle panel leads S240v5 to configure the device to switch between sweep-tuned mode or block capture mode as well as the RFE mode. Span and frequency ranges also affect down-sampling rate and dynamic ranges of the device as managed by S240v5.

Center – Span – Start – Stop: These four parameters run in *coupled mode* such that when one of the is changed, they all change when necessary to maintain accurate frequency endpoints, center frequency, and span. The minimum span is 50kHz, which

Configuring S240v5

can be reached by adjusting **Start** or **Stop** in the direction of the other endpoint. When reached, further adjustments move the **Center** frequency with the **Span** remaining at 50kHz. Hitting the minimum or maximum frequencies for the device adjust these four parameters appropriately until minimum frequency is reached.



Note: The Spectral Plot can appear to shudder or jump at times during frequency and span adjustments as frequency thresholds are crossed triggering RFE modes switching by S240v5 to the device.

The *coupled mode* causes the S240v5 to configure the RSA device as such:

- When a frequency range includes or is at the 50MHz or lower, the device uses the direct-digitization (baseband) technology with an IBW of 50MHz for the 50MHz or lower range. Data is trimmed from this 50MHz IBW to fit the Span required.
- For a frequency range beyond 50MHz with a Span value
 - above 40MHz, the device is set to use super-heterodyne technology in a swept-tuned mode with a sweep IBW of 40MHz.
 - from 40MHz to 100.001kHz, the device will use block capture mode with IBW of 40MHz but applies increasing down-sampling starting at 25MHz in order to enable smaller RBWs with reasonable sweep speeds.
 - at or below 100kHz, the device is switched to use block capture in HDR technology with an IBW of 100kHz. In this setting, the default RBW value is 3Hz, but in manual mode, the RBW could go down to 1Hz.




Caution: Increasing Span while leaving RBW in the manual mode at a very low value will dramatically increase sweep times, which might make S240v5 less responsive.



Note: Full span can be reached by placing the mouse cursor on top of the Span field and scroll the middle mouse button forward quickly until the maximum frequency is reached.

Fine Tune: This adjustment is disabled in the current version of S240v5.

Step: The step value for changing any frequency fields in this panel when pressing the up/down  arrows or for when using the middle mouse scroll on top of Center, Start and Stop fields (but not on Span which has its own mouse scroll “spin” steps).

External Reference Clock: Select this checkbox when there is an external 10MHz sync input provided to the connected device at the 10MHz IN port.

GPS Reference Clock: Visible only when connected to an R57x0 device. Select this checkbox when one or more R57x0 devices are being coordinated using their GPS clocks. This is appropriate for widely separated RTSA devices in a distributed system.

Configuring Bandwidth Settings

S240v5 provides the resolution bandwidth (RBW) field for specifying the frequency distance between two frequency points and the video bandwidth (VBW) field to reduce noise on the trace and make signals, that would otherwise be obscured by noise, easier to see on the display.

Configuring S240v5

Auto RBW: When selected (by default), causes the RBW and VBW to be recalculated on every frequency range adjustment to provide the optimum balance of resolution and speed.

RBW: Increase the RBW for faster sweep speeds or lower for finer signal resolutions. Adjusting this control directly will disable **Auto RBW**. There is a hard limit of 500,000 maximum number of data points on the man display to prevent the S240v5 becoming too resource consuming. This limit could affect the manual RBW value as the Span increases.



Caution: Usage of small RBWs in the Hz range (with Span under 5 MHz) could cause very slow sweep time due to the large data points for processing, which could take up to 1 minute or more for RBW of 10 Hz or lower. Recommend changing RBW to a value above 1 kHz before using the [Demodulating Data](#) feature, since the Demodulation does not use this RBW setting. This is to allow for a smoother switching back to the main panel after closing the Demodulation panel.

VBW: Tracks RBW whenever it changes. VBW can be changed on its own, however, to better isolate the signal from noise as mentioned above.

VBW Filter: Choose a filter to apply to the VBW. Defaulted to Synchronous.

Configuring A Trigger



Note: If a signal acquisition is configured for *spans from 40MHz down to 100.001kHz* and a frequency range above 50MHz, the near-right trigger panel will be enabled for configuring a trigger.

To set up a trigger,

1. Click the **Triggers** button on the right to access the **TRIGGERING** control panel.
2. Select a **Trigger Type** in the drop-down list. Default to Free Run (no triggering).
3. If frequency-domain **Level** trigger type is selected, the signal capture is defined by the Start and Stop frequencies and the power Level.
 - In the **Start** field, specify the minimum frequency that can trigger a signal capture.
 - In the **Stop** field, specify the maximum frequency that can trigger a signal capture.
 - In the **Level** field, specify the minimum power threshold that can trigger a signal capture.
 - The Spectral Plot will also show a drag-able rectangle (see [Figure 2](#)) representing Level trigger parameters: minimum frequency (left boundary), maximum frequency (right boundary), and power level (top boundary).

When a signal has satisfied this trigger condition, the *post-triggered* signals are captured and sends to the S240v5 for processing and displaying.



Hint: To quickly change the trigger settings, mouse dragging could be applied to the whole rectangular box when the mouse cursor is within the box or to each boundary line when the mouse cursor is right on top of the line.

Configuring S240v5

- The **Pulse** trigger option is to be used with an external synchronized pulse trigger setup, from which a pulse signal is provided to the RTSA's GPIO port to start the capture. Hence, external hardware will be required for this trigger setup. Contact ThinkRF for more information (see [Obtaining Technical Assistance](#)).



Notes:

- The **Frequency Settings** panel is disabled while a trigger is in operation, switch back to Free Run mode in order to change frequency and span settings.
- Toggling the Pause and Continuous or Single Capture buttons may be required to get the capture going when switching back to Free Run as the device might still be waiting for a valid trigger event.

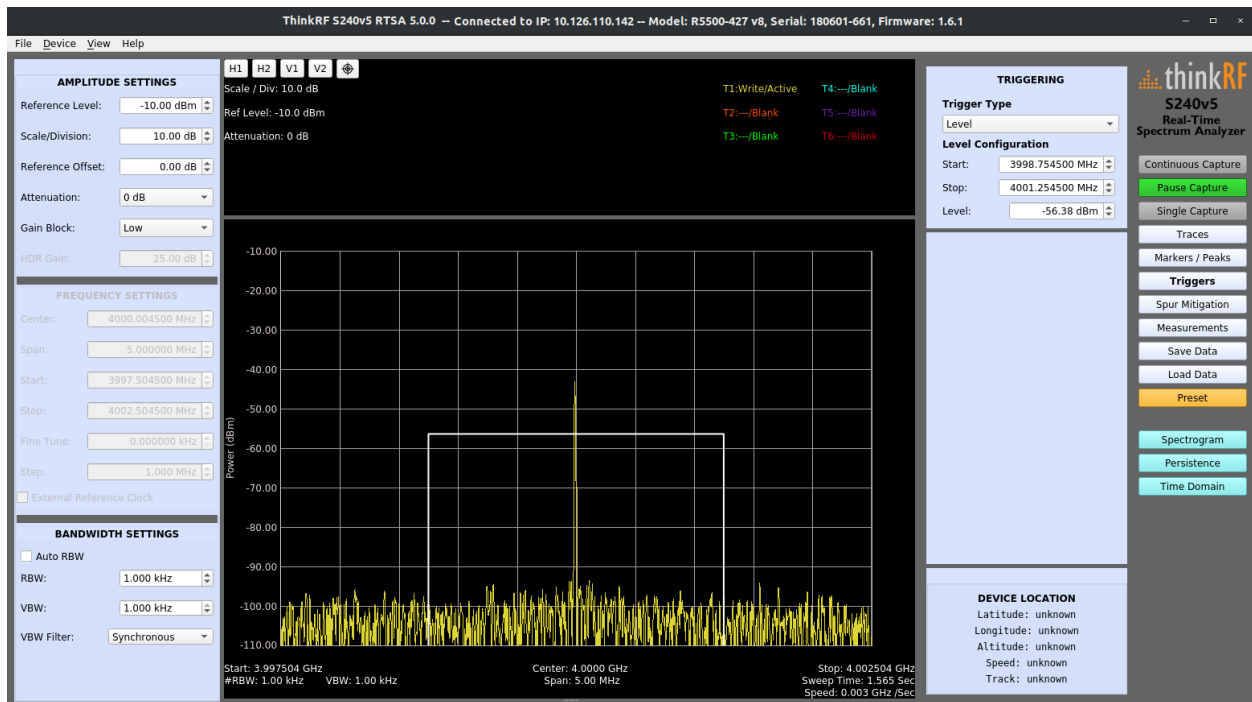


Figure 2: Level Trigger for A Signal Capture

Configuring Measurement Settings

S240v5 provides power measurement settings such as the channel power measurement for a specific span in the Spectral Plot or the bandwidth occupied of a given channel power percentage.

- Click the **Measurements** button on the right-side of S240v5 to access the **Measurements** control panel.
- Click on **Channel Power** button to open its settings and view computed result. This will disable the Occupied Bandwidth measurement if activated.
 - Start**: the lower boundary of the channel power region of interest
 - Stop**: the upper boundary of the channel power region of interest

The frequency values are filled with default values (50% of the current spectrum) upon activated. These values are also reflected on the Spectral Plot as the boundaries of a transparent blue high-lighted channel power region of interest, as shown in [Figure 3](#).

Configuring S240v5



Hint: Mouse dragging could be applied to the high-lighted region or to each vertical line to quickly change the frequency settings and the channel power computation.

The measured channel power result is displayed in the **Channel Power** control section.

- Click on the **Channel Power** button again to deactivate it.
- Click on **Occupied Bandwidth** to measure the bandwidth occupied by a specific portion of the channel power. This will disable the Channel Power measurement if activated.
 - The Occupied Bandwidth measurement is defined by the **Power %** of the spectrum span display in Spectral Plot, which is defaulted to 99.999% upon activated.
 - The Spectral Plot will show at the center a blue high-lighted region representing the calculated occupied bandwidth of the percentage specified.

The occupied bandwidth result is displayed in the **Occupied Bandwidth** control section.

- Click on the **Occupied Bandwidth** button again to deactivate it.

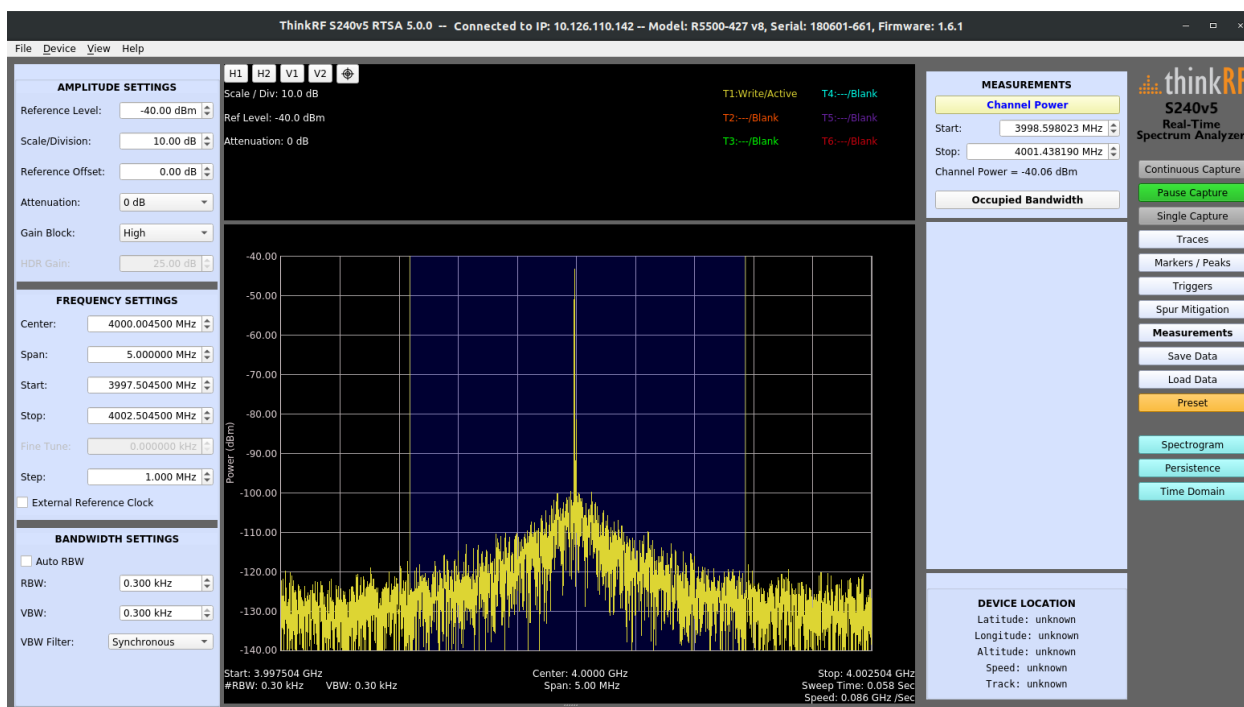


Figure 3: Channel Power Measurement

Customizing the Spectral Plot Display

S240v5 supports up to six active power spectral traces on the Spectral Plot and up to twelve markers for peak detection and analysis on the active traces. Additionally, up to two horizontal and two vertical cursor lines may be added to the Spectral Plot to mark specific power or frequency locations, respectively. A crosshair cursor is also available for convenient reading of the power and frequency values at the crosshair point.

Adding Traces

You can configure up to six active traces in the signal display. By default, the first trace is initially configured to actively display the power spectrum of the captured signal. The following procedure applies to each trace:

1. Click on the **Traces** button to access the **Trace** control panel.
2. Activate a trace by clicking on a number (from 1 to 6) in the trace list at the top of the Trace panel. The trace will be defaulted to “Clear/Write” and “Active”.
3. In the **Trace Type** drop-down list, select a display mode for the trace:

Trace Type	Description
Clear/Write	Plot the power spectrum result of each captured signal.
Max Hold	Plot and hold the maximum power values across frequency for the captured signals.
Min Hold	Plot and hold the minimum power values across frequency for the captured signals.
Average	Plot the <i>moving average</i> power values of the number of captures set in Trace Average field.

4. The **Trace Color** field may be used to select a different color for the trace if desired.
5. In the **View / Blank** drop-down list, select a state for the trace:

View Type	Description
Active	Trace is active on the Spectral Plot.
View	Pause the current trace, which is equivalent to <i>Trace Hold</i> on other spectrum analyzer equipment.
Blank	Trace is turned off.

Repeat steps 2 - 5 for each additional trace (to a maximum of six).



Note: Each trace’s type, color and status are also indicated on the information section above the Spectral Plot. Except for the color, the trace’s setting will remain the same until it is turned off.

6. Click the **Clear Trace** button to reset the selected trace on the display. This means that if the trace is of Min Hold, Max Hold or Average, accumulated results will be discarded and the trace will start fresh.
7. Click the **Clear All Traces** button to reset all traces on the display.
8. To turn off a trace, set **View / Blank** to the Blank option.

Adding Markers and Peak Findings

Up to twelve markers may be added, configured and have their results saved to a CSV file. Markers are positioned on the Spectral Plot in association to an active trace to identify peaks or differences in power and frequency relative to another primary marker. When peak search is applied, the *currently selected* marker is positioned at the highest peak on the signal.

Configuring S240v5

Follow these steps to use the Marker / Peaks feature:

1. Click on the **Marker / Peaks** button to access the **Markers / Peaks** control panel.
2. Select a marker (from 1 to 12) from the marker list at the top of this control panel.
3. In the **Marker Mode** drop-down list, select a mode:

Mode	Description
Normal (Primary Marker)	The marker tracks the amplitude (power) value of the active trace but remains at the same frequency position, unless Continuous Peak search is applied. Upon first activation, the marker is positioned at the Center frequency by default. The marker appears as a diamond shape in the display.
Fixed (Primary Marker)	The marker stays at the same frequency and power level, regardless of changes in the amplitude of the incoming signal. The marker appears as a plus-sign shape in the display.
Off	The marker is removed from the display.
Delta <n>	When more than one marker is active and at least one is a primary marker, a marker may be set as a delta marker relative to a primary marker <n>. For example, if there are two primary markers on the signal display, you can designate Marker 3 as Delta 1 (relative to marker 1) or Delta 2 (relative to marker 2). The delta marker appears on the display as an inverted triangle icon with its marker and delta numbers hovering above it.



Note: A *currently selected* marker (and the only) will be high-lighted with purple color in the display and have its power and frequency values shown on right side of the information section above the Spectral Plot. Other active markers will be identified by no-fill marker shapes. All markers' value may be displayed in a Marker Table as mentioned below.

4. In the **Marker Trace** field, assign the marker to an active trace from the trace drop-down list containing all active traces on the display.
5. In the **Frequency** field, specify a frequency value to position the marker.



Hint: A marker can be clicked and dragged directly on the display to a desired frequency position. This action will also make the marker as the *currently selected*.

6. The **Power** field, read-only, shows the power level of the marker in real-time.
7. Optionally, a marker can be configured to indicate a peak in its associated trace by clicking on one of the following buttons:
 - **Peak Search:** positions the marker at the highest peak signal of the current trace.
 - **Next Peak:** positions the marker at the next highest peak signal, wherever it occurs.
 - **Next Peak Left:** positions the marker at the highest peak signal to the left of the current marker position.

Configuring S240v5

- **Next Peak Right:** positions the marker at the highest peak signal to the right of the current marker position.
 - **Marker -> Center:** changes the center frequency to match the current marker position.
8. Select the **Continuous Peak** checkbox to have the Normal or Delta (not Fixed) marker tracks the highest peak on each new capture as it occurs on the display. When this checkbox is selected, all the Next Peak options are not effective as the results are quickly overwritten by the Continuous search.
 9. Select the **Pk Threshold** checkbox to enable definition of the minimum power threshold for the peak detection. Markers are not assigned to peaks that fall below this power level.

Repeat steps 2 to 9 for each additional marker (to a maximum of twelve).

10. Optionally, select the **Marker Table On** checkbox to display a table listing all active markers (with their corresponding marker mode, trace assignment, frequency, and power level) below the Spectral Plot.



Hint: Entries in the Marker Table are clickable. The clicked-on entry will become the *currently selected* marker on the display.

11. Optionally, the information of the current markers (power level and frequency position) may be saved in a CSV file by clicking on the **Save Marker Table** button. Specify a file name and location in the **CSV File** dialog. The initial save location for the marker table is the default folder created at installation time.
12. To remove a single marker, change the **Marker Mode** field to **Off**.
13. To remove all markers from the display, click **All Markers Off**.

Adding Cursors

The cursor buttons are available at the top of display. The selected cursor button will turn green.

1. To add a horizontal cursor, click the **H1** or **H2** button.
2. To add a vertical cursor, click the **V1** or **V2** button.

When selected, the horizontal or vertical cursor's spin-box will appear above the Spectral Plot, allowing for specification of the cursor position. By default, the cursor line will be positioned in the center of the display. The cursors are also draggable by mouse over the top of the cursor, click and drag them to the desired location on the plot display.

3. To add a crosshair cursor, click the **Crosshair** button (⊕).

When the Crosshair cursor is activated, activated horizontal or vertical cursors are no longer mouse selectable for dragging; use their spin-box fields to change the position.

4. To remove any cursors from the display, click on their button again.

Configuring Spur Mitigation

The S240v5 RTSA application provides a set of settings to correct for the effects of input-related spurs. The application's algorithm identifies the spur level and suppresses it using the Spur Mitigation control. From **release version 5.1.2** onward, the control will be available only when:

Configuring S240v5

- The **Stop** frequency is *not at* maximum and the **Start** frequency is from 50MHz or higher; or
- The **Stop** frequency is *at max* and the **Start** frequency is from 52MHz or higher.

These limits are because there is no frequency tuning in DD range (DC to 50MHz) & a shift in the center frequency is needed for the spur mitigation algorithm to work.

To use the feature,

1. Click on the **Spur Mitigation** button on the right-hand side panel to access the Spur Mitigation control panel.
2. When available at the valid frequency range, select the **Spur Mitigation** checkbox to enable.
3. In the **Spur Level** field, enter a power level value to target a specific spur(s) that has the power level at that value or higher.
4. In the **Spur Bandwidth** field, enter a bandwidth value to correct the spur.



Note: When Spur Mitigation is applied, the signal display's update rate will be affected. The finer the RBW, the slower the update rate.

Known Limitations of the Spur Mitigation Feature

The Spur Mitigation algorithm used is called "Dual Scan" (also known as "Dual Pass" or "Two Pass"), where a band is swept twice with a small frequency shift. Any signal activity that appears in one scan and doesn't appear in the other is considered false (i.e. spur) and will be removed. This algorithm, like many others, has its own limitations and some are listed here:

- When the injected signal is the same as the center frequency of the sweep's step, in some rare cases, its measured value might be affected by the algorithm.
- If an input related spur is a signal harmonic, that spur will not be effectively removed.
- The finer the RBW, the slower the spectral display is updated as the algorithm is working on the data.

Configuring Device Options

Less frequently use device-specific control settings are available in the **Device** menu on the menu bar. The Device menu's options are:

- **Connect...:** Opens the **Open Device** dialog for selecting or entering a new device for signal display and analysis.
- **Connected Device Info:** Opens a dialog showing the current device's statistics and location. This dialog can be moved and kept open for convenient viewing while S240v5's controls are still accessible or S240v5 is in full-screen mode.
- **Internal Digitizer:** This checkbox is checked by default, indicating that the RTSA's digitizer technology is performing the data capture and digitization for subsequent analysis. Enabling this option will deselect the External Digitizer as these two digitizers operate exclusively.

Configuring S240v5

- **External Digitizer:** This checkbox is for routing the RTSA's analog data to an external digitizer (such as one with faster throughput or special digital signal processing) and bypassing all internal digitizing functions. Selecting this option, thus, will deselect the Internal Digitizer as these two digitizers operate exclusively.



Note: The signal display is no longer active when you select this option; however, the S240v5 could still be used to control the connected device.

- **Restart Connected Device:** Initiates a restart of the connected device. The command takes effect immediately and there is no intermediate verification of intent.

Restoring S240v5 Defaults

The **Preset** button in the far-right of S240v5 provides a mean to reset all parameter values to the application's start-up defaults. If you want to save your custom settings before restoring the system defaults, see the [Saving Configuration Settings](#) section.

Viewing Signal Data

Besides the main Spectral Plot, the S240v5 application supports the following additional displays:

- Spectrogram,
- Persistence plot, and
- Time Domain plot

Display Spectrogram

The Spectrogram (a.k.a. waterfall plot) displays spectrum changes over time in a three-dimensional view, as shown in [Figure 4](#). Time is displayed on the vertical axis and frequency on the horizontal axis. The amplitude of the frequency components is expressed by user-adjustable color gradients locating to the left of the display.

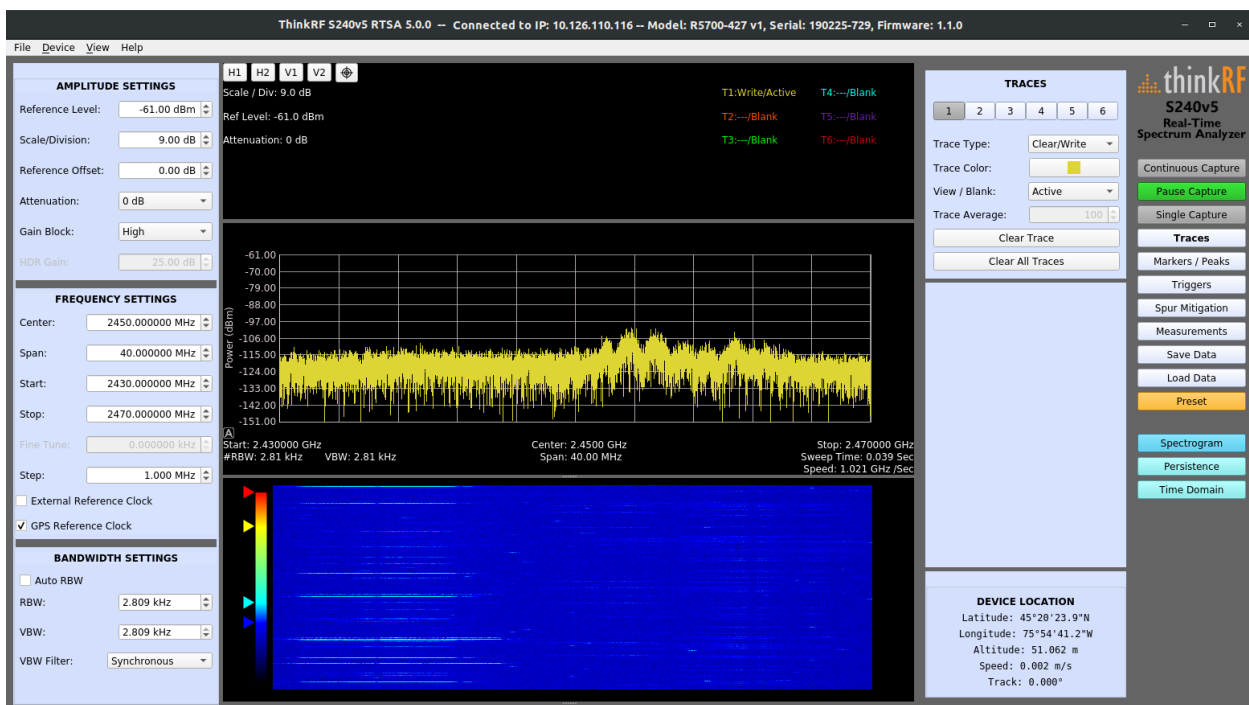


Figure 4: Spectrogram Plot

1. Click on the **Spectrogram** button located on the far-right of S240v5. The spectrogram appears below the Spectral Plot.
2. The color gradients of the signal display can be enhanced by sliding the triangles on the color palette (left side of the display) to adjust the threshold at which the signal changes the power levels. This allows for better contrasting of signal levels against the noise floor level.
3. To hide the Spectrogram, click on the **Spectrogram** button again.

Display the Persistence Plot

The Persistence plot is a view of how long a signal remains present; as the signal grows weaker, the trace fades in color to eventually disappear as time lapses, as shown in [Figure 5](#). The amplitude is displayed on the vertical axis, and the frequency on the horizontal axis.

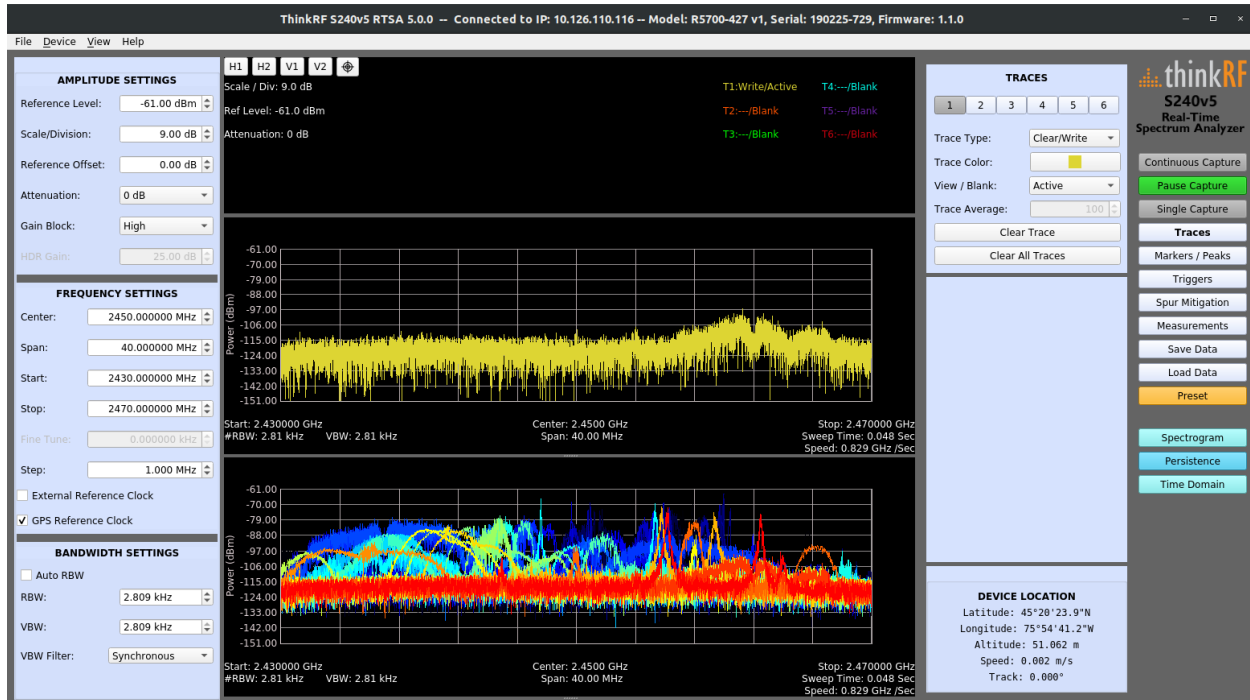


Figure 5: Persistence Plot

1. Click on the **Persistence** button located on the far-right of S240v5. The Persistence plot appears below the Spectral Plot or Spectrogram when activated.
2. To hide the Persistence plot, click on the **Persistence** button again.

Display the Time Domain Plot

A Time Domain plot of a captured signal complements the frequency-domain display and is useful for visualizing the signal's voltage level over time.

The Time Domain plot shows a time-domain waveform in green for in-phase (I) data and another in red for the quadrature (Q) data when available. Quadrature data is only available when down-sampling applied at frequencies above 50MHz range, which happens automatically for Span values of 40MHz down to 100.001kHz. [Figure 6](#) shows an example of the time-domain I/Q waveforms.

Viewing Signal Data

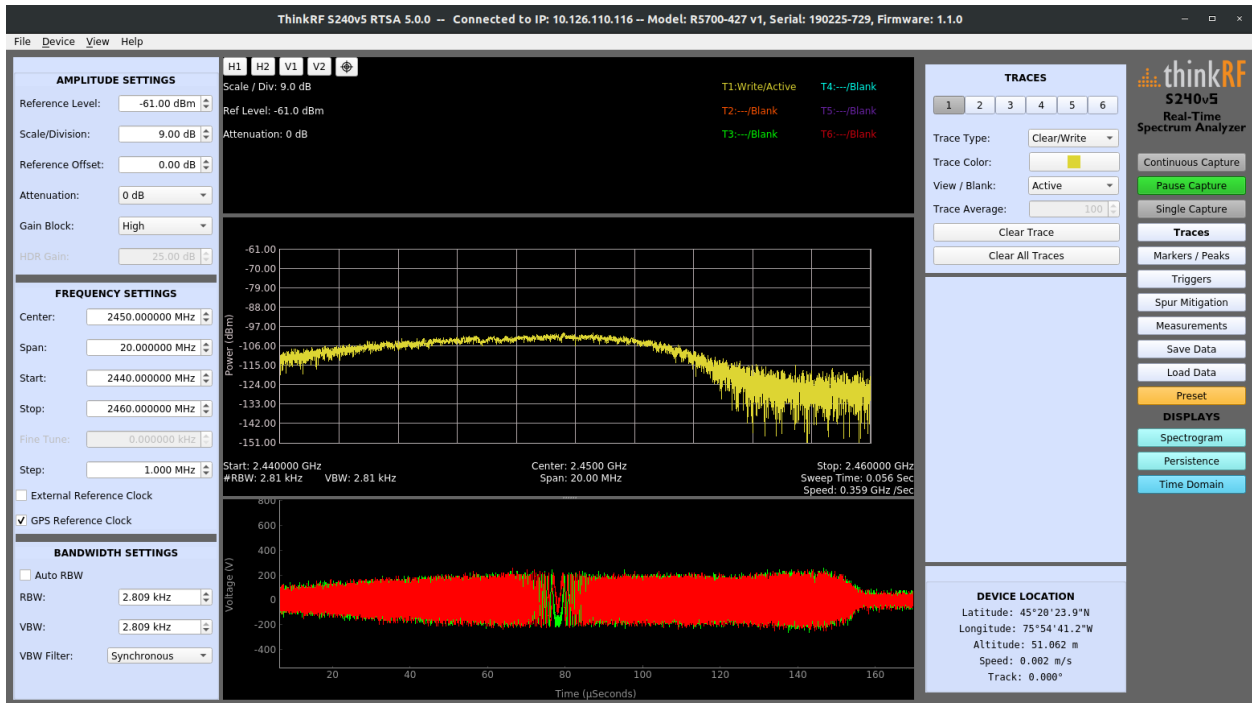


Figure 6: Time Domain Plots

1. Click on the **Time Domain** button located on the far-right of S240v5. The Time Domain plot appears below the Spectral Plot (or Spectrogram or Persistence when either or both are activated).
2. To hide the Time Domain plot, click on the **Time Domain** button again.

Capturing Signal Data

In addition to viewing real-time signal data in real time on the S240v5 application, signal data and information can also be saved for playback or for further processing by another application.

Capturing a Screenshot

S240v5 allows for capturing a screenshot of the current window. The screenshot is stored in the PNG file format.

1. Open the **View** menu and click on **Take Screenshot...** option.
2. In the save **PNG File** window, specify a file name (or use the default) and a storage location.
3. Click **Save** to save the image.

Saving Signal Data

S240v5 allows for exporting real-time signal data in a CSV file to a storage location for playback or further processing by another application. Recommends using a fast writing storage location (such as onto the host PC's SSD hard drive) for fast data transferring.

When saving data, S240v5 also saves a .config file with full application settings and will automatically load those settings to restore the visual application state when playing back a data file.



Caution: S240v5 does not impose a limit on the file size for signal recording to a CSV file. If recording is not explicitly stopped, the application continues to write data to the file until the local hard drive is full.

To record data to a file:

1. Click the **Save Data** button to access the **Save Data** control panel.
2. Optionally, enter a comment in the **Comments** box. The text entered will be added to the top of the saved .csv file. This allows, for example, a way to describe what the signal is or any necessary details.
3. Optionally, add a suffix for the filename in **Filename Suffix:** field. This is convenient for differentiating and fast identifying of files within many saved files.
4. Optionally, click on the **destination directory icon** (📁) and specify a path in the **Select Directory** window or use the default (a 'recordings' directory that is created during S240v5 installation, and where the installed directory is).
5. Click on **Save Data** to use defaults file name and storage location or see **Save Data As...** in the next step to specify them manually.

Save Data defaults the file name to 'csv-<date>-<time>[_suffix].csv'. <date> and <time> are system generated and [_suffix] is optional and specified using the **Filename Suffix:** field mentioned above.

Save Data also defaults the save location to a 'recordings' directory specified through the 📁 directory field mentioned above.

Capturing Signal Data

- If a specific file name and/or storage location for the CSV file is preferred, click on **Save Data As ...** and browse to a location and/or specify a file name in the **CSV File** window, then click **Save**.

The RTSA application begins saving signal data to the CSV file. See the Caution above.

- To stop saving signal data to the CSV file, click **Stop Saving**.

The stored CSV file has the following format:

```

!,version,<#>
!,options,[empty or list RTSA variants, ex: GPS]
!,comment,[text from the Comments: field]
!,device_id,b'<manufacturer>,<model>,<SN>,<Firmware #>'
data,mode,fstart,fstop,size,timestamp
,<RFE mode>,<value>,<value>,<SPP_size>,<formatted time>
<power_data1>
<power_data2>
.
. Data of the first package with SPP size (Samples per Packet)
.
<power_dataSPP_size>
[!,geolocation,<Latitude>,<Longitude>,<Altitude>,<Speed>,<Track>]
[,<RFE mode>,<value>,<value>,<SPP_size>,<formatted time>]
[power_data1]
[power_data2]
.
. Data of the second package with SPP size if available
.
[power_dataSPP_size]
[!,geolocation,<Latitude>,<Longitude>,<Altitude>,<Speed>,<Track>]
[,<RFE mode>,<value>,<value>,<SPP_size>,<formatted time>]
.
. Data of the Nth package with SPP size if available
.
EOF

```

with

- bolded font** denotes information identifier word, explained in the table below;
- italicized text* emphasizes information to be filled in during saving;
- <...> denotes persistent data; and
- [...] as when available.

The following table describes the information identifiers used in the saved file.

Identifier	Description
version	The S240v5 version
options	The RTSA product's option (i.e. GPS, WBIQ, etc)
comment	User's text from the S240v5's Comments: field
device_id	The RTSA's identification string (from *IDN? query command)
data	The power value of the captured signal, one per line for each sample. The number of data points corresponds to the value specified in the <code>size</code> parameter.
mode	The RFE mode of the device during the signal capture: <ul style="list-style-type: none"> - SH (super-heterodyne 40MHz IBW) - HDR (high dynamic range, 100kHz IBW) - DD (baseband, 50MHz IBW)

Capturing Signal Data

<code>fstart</code>	The start of the frequency range (Hz)
<code>fstop</code>	The end of the frequency range (Hz)
<code>size</code>	Number of data points in a package of a captured signal. A CSV file could have many such package.
<code>timestamp</code>	Formatted ISO timestamp representing the time at which the data was captured in the device
<code>geolocation</code>	The geolocation data is present in the R57x0 product family and is emitted to the file approximately once per second during recording. The fields provided are: <ul style="list-style-type: none">- Latitude (decimal degree)- Longitude (decimal degree)- Altitude (meter)- Speed (meter per second)- Track (degree)
<code>EOF</code>	Marker indicating End Of File

Playing Back a Recorded Signal

S240v5 can playback a previously recorded signal.

1. Click the **Load Data** button to browse for the saved .csv file in the **CSV File** window.
2. Select the .csv file and click **Open** (or double click on the file).

S240v5 first loads the application state stored in the .config file that was created during saving the .csv file in the same location. S240v5 then loads the signal data and plays back the recorded signal in a loop.

Playback can use the **Pause**, **Continuous** and **Single Capture** buttons in the same way as real time signals are controlled.

Non-device related controls, such as **Spur Mitigation**, **Measurements**, **VBW**, traces and markers, cursors and the three other plots, can be applied to the playback data as well. While device related controls, such as Frequency settings, RBW, trigger, and internal/external digitizer, are not applicable nor accessible.

To stop playback of the recorded file, do one of the following:

- press the **Pause Capture** button,
- open a different file for playback (go to step 1. above),
- connect to a device using the **Device > Connect...** menu option, or
- exit the S240v5 application.

Demodulating Data

S240v5 can demodulate AM and FM signals. A modal dialog is launched to control the session and the receiver is placed into gapless streaming mode. Launch the demodulation panel (see Figure 7 below) by clicking the “Demodulation” button on the far-right control panel of S240v5 (refer to Figure 1).



Note: FM demodulation has been extensively tested on broadcast signals but is considered a *beta* feature for narrow-band FM. AM demodulation is considered an *alpha* feature for all scenarios and not yet tuned down to AM broadcast frequencies.

Demodulation Panel

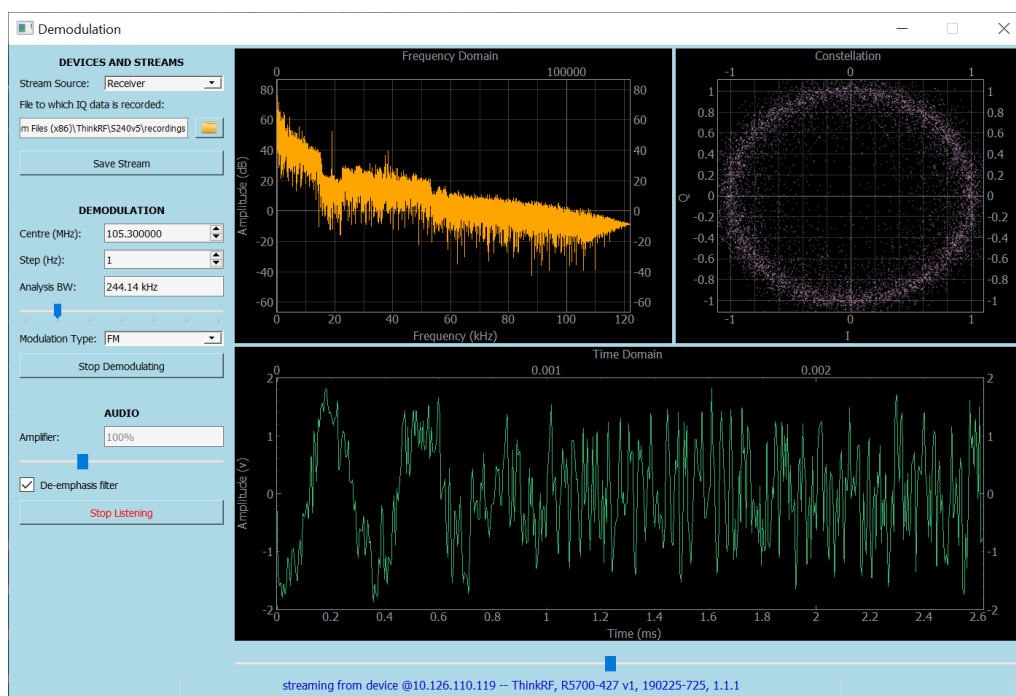



Figure 7: Demodulation Dialog

The demodulation dialog has a control panel on the left side and three graphs that dominate the right side. At the bottom, there is a status bar and a slider indicating when frames are received from the stream source, which can be a receiver or a file.

Fields on the Control Panel

Name	Description
Stream Source	A drop box with choices of Receiver and File . When Receiver is selected, the device is performing real-time capture in stream mode using current settings. When File is selected, a previously saved VRT file is 'connected' (opened) for playback. If a VRT file has not yet been selected, the connection will happen when that occurs.

Demodulating Data

File to which IQ data is recorded	Visible when Receiver source is selected in the Stream Source drop box. The data path starts at the default recordings path, which is a subfolder under the application's install location. Pressing the  folder button next to the path opens a dialog that allows the user to name a VRT file or choose a directory (although the default recordings directory is always the starting point for locations). It is not necessary to name recorded files as they are named automatically for the time and date of the start of recording.
File from which IQ data is played	Visible when File source is selected in the Stream Source drop box. The directory starts in the recordings folder as mentioned above, navigating to your own directory might be needed. Saved *.vrt files can be selected for playback. Selecting one of these will cause it to be opened and the stream contained within to be played.
Save Stream	Enabled when demodulation is active in Receiver source mode. The button starts saving the active stream to the selected file as described above. Two files are always created with the extensions vrt and vrtmeta. Both files must be present in the same folder for the stream to be playable.
Centre (MHz)	The frequency to which the Receiver was tuned or to which the Receiver was tuned when the File being played was recorded.
Step (Hz)	The number of Hz by which the Center frequency will step when the Center's up and down buttons are pressed. When the Step's up and down buttons are pressed, it's value changes by powers of 10.
Analysis BW	The bandwidth (BW) used to demodulate and filter the signal. The FM demodulator, which is the default modulation, defaults to 244kHz. The AM demodulator defaults to 15kHz. Options are fixed as powers of 2 and are selected using the slider.
Modulation Type	Options are AM and FM (default).
Demodulate / Stop Demodulating	This button starts and stops the demodulation process. The stream keeps running when not active and frames are simply discarded.
Amplifier	The audio starts at 100% and can be boosted to 300% or dropped to zero using the slider.
De-emphasis filter	FM radio adds pre-emphasis at higher frequencies to compensate for spectral noise. This checkbox determines whether compensating de-emphasis is applied (ON is default) while demodulating the audio.
Listening / Stop Listening	This button starts the audio stream flowing and is available only when the Demodulate button is pressed. The audio can be paused at any time, which will empty the audio buffer until the button is pressed again.

Demodulation Graphs

Constellation Graph

The constellation graph is always active when there is a connected device or file. It displays the calibrated signal prior to demodulation (i.e. IQ data) on a unity graph, which is essentially signal power and phase.

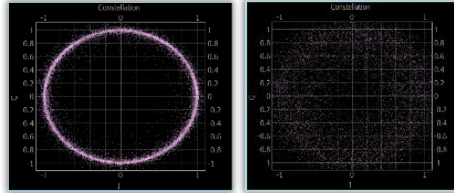


Figure 8: Strong Signal Figure 9: Weak Signal

The quality of an FM signal is denoted by how closely the values are plotted to a perfectly clean circle. A perfect circle (see Figure 8) denotes a clean, strong signal, which will be obvious when listening to the demodulated signal. As the circle gets more diffuse (see Figure 9), the quality of the audio diminishes.

However, even a completely diffused field of noise might carry a faint signal, at which the **Amplifier** slider can triple the volume as needed.

Frequency Domain Graph

The frequency domain graph shows the power spectral density of the signal after demodulation. Thus, it is only shown while demodulating. An FM signal has an obvious signature that can be seen in Figure 7 above. The 19kHz carrier is clearly visible while the smaller 38kHz carrier for the stereo signal is also visible. Mono stations do not show these features but retain the characteristic caterpillar signal shape as shown in Figure 10.

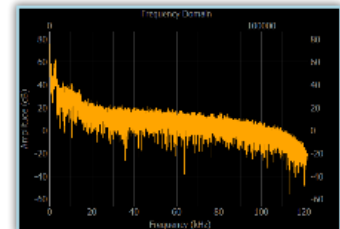


Figure 10: Mono FM Signal

Time Domain Graph

The time domain graph shows signal amplitude in voltage over time, which corresponds to the audio that is played when the signal is down-sampled and sent to the audio system.

There will be some amount of lag from the displayed signal to the audible signal owing to the need to buffer the audio stream to mitigate the risk of annoying dropouts.

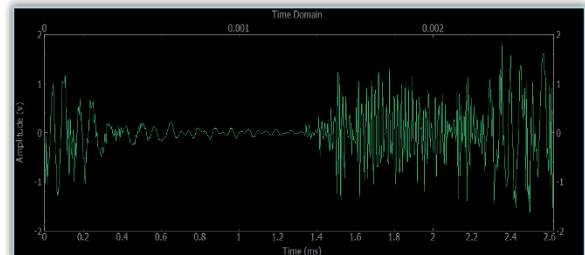


Figure 11: Speech Signal

Plotted data is down-sampled significantly in order to improve clarity of the displayed signal, but simpler signals, such as speech in Figure 11, provide a clearer relationship to the audio buffer lag owing to pauses as shown in that figure.

How to Use Demodulation

A few simple scenarios are discussed here.

To start demodulating a signal, the following steps are needed first:

- Ensure that the desired signal is centered in the S240v5 main dialog. This can be accomplished by typing the frequency in the **Center** field on the **Frequency**

Demodulating Data


Settings panel or by using the **Markers / Peaks** panel and the **Marker->Center** button to center the signal.

- The **Gain Block** field should be set to **High**.
- The **Attenuation** field should be set to **0**. This is important in order to prevent weak signals from failing to demodulate.
- Recommend setting RBW to a value at kHz range. This allows for a smoother switching back to the main display when the Demodulation dialog is closed.

At this point, the **Demodulate** button can be pressed to launch the feature.

To record a stream to file, simply press the **Save Stream** button, which is only enabled when **Stream Source** is set to **Receiver** mode. A pair of **vrt** and **vrtmeta** files are automatically created and the button's label changes to **Stop Saving Stream**. When the **Stop Saving Stream** button is pressed, the final data is written, the metadata is updated with total data packets contained, and the files are closed.

Note that while it is a good idea to rename the **vrt** and **vrtmeta** files once a recording is completed; however, ensure that both *.vrt and *.vrtmeta files' name **MUST** always match. This is important for the playback as mentioned in the next step.

To play a stream from a file, select **File** for the Stream Source. Then click the  folder button of the **File from which IQ data is played** field and find the *.vrt file desired.

As soon as a *.vrt file is selected, the vrt and its associated vrtmeta files are opened and the stream begins playing, just as if the original receiver was the source. The context data in the metadata file is used to update the stream controls in the **Demodulation** panel at the left, and the controls are frozen as a file has no flexibility where the center frequency is concerned for example.

Modulation Type and **Analysis BW** can be explored to see what signals are present. **Amplifier** and **De-emphasis filter** option also remain active during playback.

Administration

In addition to signal capture functionality, the S240v5 application provides additional features that allow you to save and store configuration profiles and to customize the configuration panel display.

Saving Configuration Settings

S240v5 allows for saving current configuration settings in a file that can be reloaded later.

To save the existing S240v5 settings,

1. Open the **File** menu and select the **Save Settings** option.

The RTSA application opens a **Configuration File** dialog window at the default 'settings' directory that was created during the S240v5 installation.

2. In the **Configuration File** window, specify the name and/or browse to a storage location for the configuration file.
3. Click **Save**.

S240v5 saves the current application state in a settings file with the .config extension to the specified location. The contents of a saved *.config file can be view in a text editor; however, manual modification of this file is not recommended.

Loading Configuration Settings

S240v5 application settings can be customized basing on a previously saved configuration file.

1. Open the **File** menu and select the **Load Settings** option.

The application opens a **Configuration File** dialog window at the default 'recordings' directory created during the S240v5 installation. Navigate to the storage location of the .config file to be opened.

2. Select the .config file and click **Open** (or double click on the file).

S240v5 loads configuration settings from the file and updates the application state accordingly.

Viewing Device Information

Information specific to the connected RTSA device is made visible at all time on the title bar of the window as well as the software version of the S240v5 application.

The information is also made available in a floatable **Connected Device** dialog, accessible by clicking on **Device > Connected Device Info**. The dialog can be positioned anywhere on any screen while still having access to the S240v5 controls and display.

The dialog displays the following information of the RTSA device currently connected to:

- **Model:** the device's model number
- **Serial Number:** the device's serial number

Administration

- **Product Version:** the device's hardware version
- **Firmware Version:** the device installed firmware version

For the R57x0 product family with inbuilt GNSS module, the panel displays the following additional position information with real-time updates approximately one second apart:

- **Latitude:** degrees, minutes, and seconds
- **Longitude:** degrees, minutes, and seconds
- **Altitude:** meters (m)
- **Speed:** meter per second (m/s)
- **Track:** the direction of traveling in degrees

Accessing Product Documentation

Access to this User Guide PDF document is available in the S240v5's **Help** menu. Adobe Reader or equivalent software must be installed in order to view this document.

See [Obtaining Latest Documentation and Software](#) for any other documentation related to the device or S240v5.