

RF430FRL152HEVM User's Guide

This document is a description of the [RF430FRL152HEVM](#) product that is designed to fully explore all of the capabilities that the RF430FRL152H device offers. To more easily experiment with all of the features of the device and the firmware that is in the ROM, a PC application is available, and its use is also described here, including software and driver installation.

The family of RF430RL15xH devices includes the [RF430FRL152H](#), [RF430FRL153H](#), and [RF430FRL154H](#).

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1 Introduction

The RF430FRL152HEVM, including the user software, is a complete evaluation platform to evaluate the key features of the of the RF430FRL15xH devices:

- Passive communication and sensor measurement using ISO/IEC 15693
- Can program user code to FRAM memory through JTAG
- Collect sensor measurements over I²C using the Sensor Hub BoosterPack™ plug-in module ([BOOSTXL-SENSHUB](#))
- Can develop drivers for custom digital sensors
- Interfaces with the PC GUI application to fully experiment with application functionality

1.1 Overview

To start evaluating the RF430FRL152H device, an RF430FRL152HEVM is available. This evaluation board allows you to experiment with all of the capabilities of the low-voltage (1.5-V) dynamic tag with an MSP430™ core.

Because this dynamic tag uses ISO/IEC 15693 (NFC-capable) passive communication, it needs an ISO/IEC 15693 reader/writer to explore its full capabilities. To evaluate the device, TI recommends that you use the [MSP-EXP430G2 LaunchPad development kit](#) with the [TRF7970A BoosterPack plug-in module](#) and the PC application for the [RF430FRL152HEVM](#). Alternate options include the TRF7970AEVM (which is no longer available from TI) or a custom NFC/RFID-capable handset.

Features and benefits of the RF430FRL152H MCU include:

- ISO/IEC 15693 RF interface
- Low-voltage MSP430 MCU (L092 based)
- Nonvolatile low-power FRAM memory (2KB)
- Sigma-delta 14-bit analog-to-digital converter
- Single-cell battery (1.5-V) operation
- Can run batteryless from RF scavenged energy provided by NFC/RFID reader
- Supports temperature measurement using a thermistor
- Single-chip solution for a contact-less sensor

The RF430FRL152HEVM is a development platform to evaluate the capabilities of the RF430FRL15xH devices and allows experimenting with all the features of the RF430FRL152H.

- Integrated PCB antenna
- Power over RF, battery, or USB
- Onboard thermistor and reference resistor for temperature measurement
- Onboard light sensor
- NFC/RFID ISO 15693 communication with NFC/RFID enabled reader/writer or smart phone
- Connector to enable compatibility with TI LaunchPad™ development kits and BoosterPack plug-in modules
- JTAG header for connection of MSP430-FET Emulation tool for programming

1.2 What is Included

- RF430FRL152HEVM (see [Figure 1](#))
- USB cable
- Quick start guide

1.2.1 RF430FRL152HEVM

[Figure 1](#) shows an RF430FRL152HEVM.

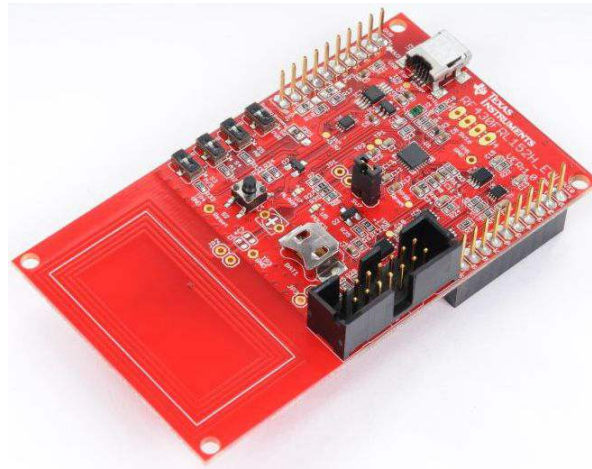


Figure 1. RF430FRL152HEVM

1.3 Required Additional Tools

- [RF430FRL152HEVM Windows GUI](#)
- [TRF7970A-BNDL](#): MSP-EXP430G2 LaunchPad development kit with TRF7970A BoosterPack plug-in module to communicate with the RF430FRL152HEVM
- OR
- [TRF7970AEVM](#) (no longer available for purchase from TI)

1.3.1 MSP-EXP430G2 LaunchPad Development Kit With TRF7970A BoosterPack Plug-in Module

The [TRF7970A-BNDL](#) bundle is the recommended evaluation method and it is fully supported by the latest version of the RF430FRL152HEVM PC GUI.



Figure 2. MSP-EXP430G2 LaunchPad Development Kit With TRF7970A BoosterPack Plug-in Module

To be used with the demo GUI, the MSP-EXP430G2 must be programmed with a special binary image (TRF7970A_BoosterPack_MSP430G2.out). This binary image can be found in the Debug folder of the zip file available at www.ti.com/lit/zip/sloc346.

TI recommends using a tool like [UniFlash](#) to easily program the MSP430 MCU with the binary image. Make sure to configure the jumpers as shown in [Figure 3](#), for "HW UART".



Figure 3. MSP-EXP430G2 Jumper Settings

1.3.2 TRF7970AEVM

[Figure 4](#) shows a TRF7970AEVM. If the TRF7970AEVM firmware has not been changed since purchase, no code updates are necessary. If there are communication issues with the RF430FRL152HEVM, make sure that the TRF7970AEVM is programmed with the default EVM firmware, which can be downloaded from <http://www.ti.com/lit/zip/sloc300>.



Figure 4. TRF7970AEVM

1.4 Recommended Additional Equipment

Optional recommended equipment:

- [SensorHub Booster Pack](#)
- [MSP430 FET](#) tool for code development, programming and debugging the device over JTAG

1.4.1 Sensor Hub BoosterPack Plug-in Module

[Figure 5](#) shows the Sensor Hub BoosterPack plug-in module. This EVM has temperature, humidity, and light sensors. There is demo firmware showing how to use each of these sensors. This board can be used as a reference to develop custom functionality for digital sensors in an application.



Figure 5. Sensor Hub BoosterPack Plug-in Module

1.5 Installation of the Software and Drivers

The most recent PC GUI and user's guide are available at www.ti.com/tool/RF430FRL152HEVM.

To install the PC GUI:

1. Download the [RF430FRL152HEVM Windows GUI](#) file to the PC.
2. Run the executable and follow the prompts to install the software.
3. To run the application click on the Start menu, All Programs, then the Texas Instruments folder, then the "RF430FRL152HEVM Application" and finally the "RF430FRL152H GUI Interface" program.

The USB drivers for the TRF7970AEVM are available from the [Silicon Labs website](#).

1.6 Update the EVM Firmware

The RF430FRL152HEVM comes loaded with firmware. However, updated firmware with fixes for the latest known erratas is available. Download this firmware from www.ti.com/lit/zip/slac691, and load the SensorHub example to have the same functionality as in the EVM.

2 Hardware Description

2.1 Block Diagram

Figure 6 shows the EVM block diagram.

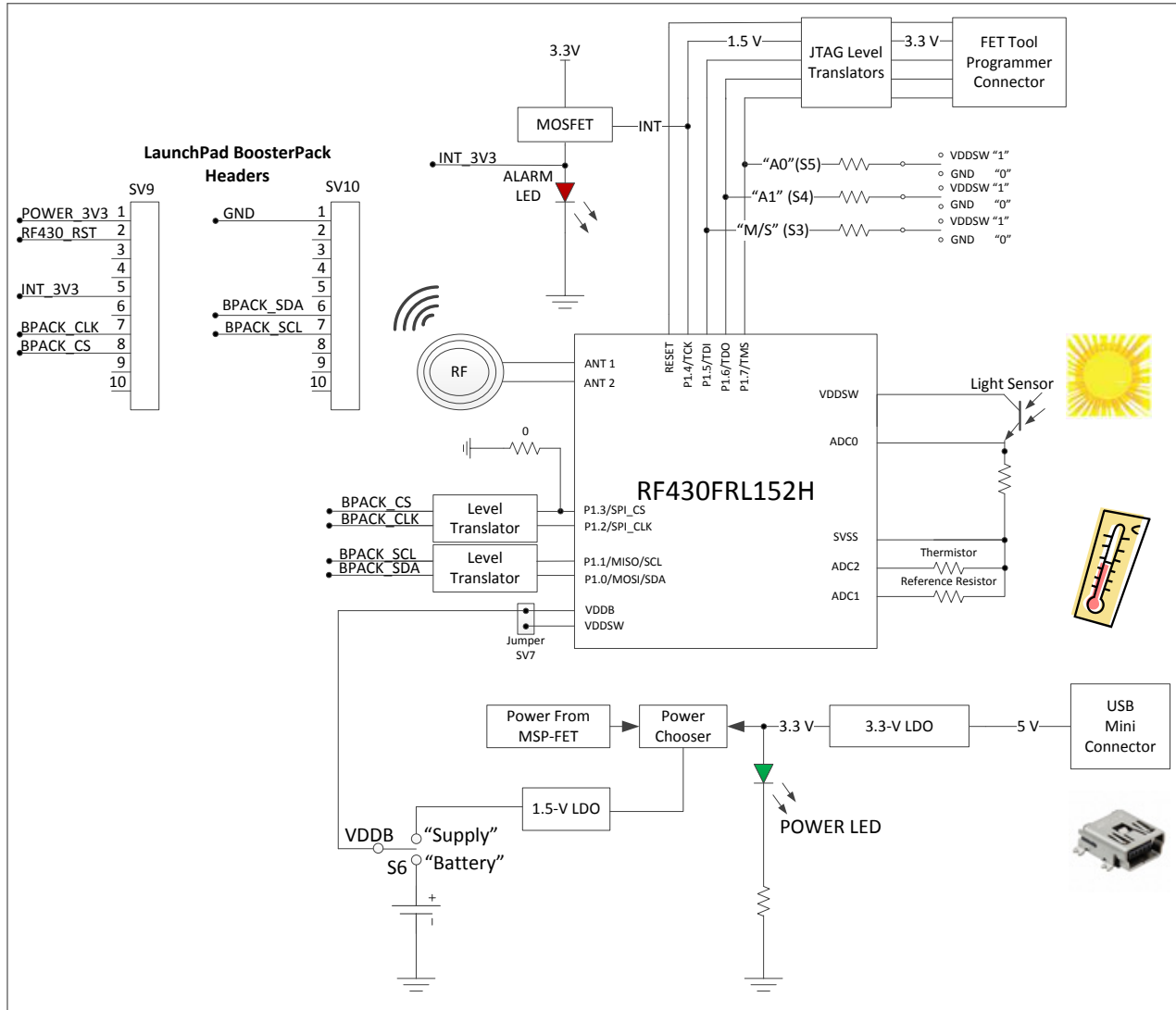


Figure 6. RF430FRL152HEVM Block Diagram

- The EVM board can be powered by RF scavenged energy, battery, FET emulator tool, or USB power. When powered through the USB connection or an MSP-FET emulation tool, switch S6 must be set to "Supply". If the EVM is powered by scavenged RF energy or a battery, switch S6 must be set to "Battery".
- Level translators are used on I²C, SPI, and FET emulator interfaces.
- The power (green) LED should turn on only when the board is powered by a USB connection.
- Jumper SV7 is needed to bypass the internal battery switch and provide power directly to the core. This jumper should be populated for most use cases.
- When the EVM is powered by the USB connection, the Alarm LED briefly flashes at power-up or stays illuminated if there is an interrupt from the RF430FRL152H. It is normal for the Alarm LED to stay lit during MSP-FET tool programming.

2.2 Hardware Overview

Figure 7 shows an overview of the RF430FRL152HEVM hardware.

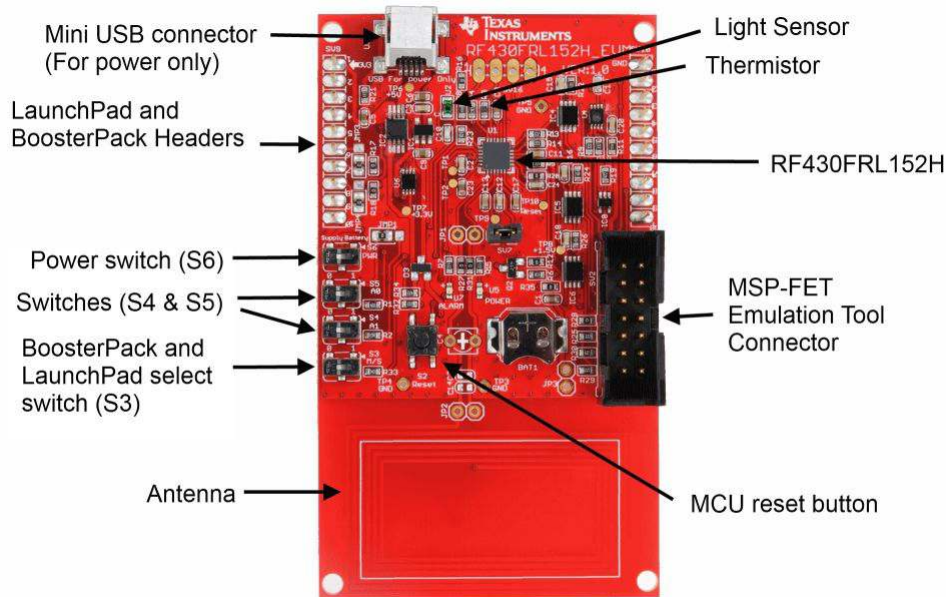


Figure 7. RF430FRL152HEVM Hardware

2.3 Hardware Configurations

2.3.1 Passive (Unpowered) Operation

In this mode, the RF430FRL152H is powered entirely from the RF field generated by the reader.

1. Set S6 to "Battery".
2. Set S3 to "S" (slave mode).
3. Make sure that USB and the MSP-FET emulation tool are not connected.
4. Place the EVM antenna on top of a NFC reader/writer to communicate.

Neither the "Alarm" or the "Power" LEDs illuminate in this mode of operation at any time. At this time a NFC/RFID reader may be used to communicate to the RF430FRL152HEVM.

2.3.2 Debugging or Programming

The following instructions show how to program the FRAM memory or debug the RF430FRL152H using a MSP-FET emulation tool. In this configuration the EVM is powered by the MSP-FET emulation tool.

1. Set switch S6 (near the BoosterPack plug-in module headers) to "Supply".
2. Connect the MSP-FET430 emulation tool to the JTAG header, SV2.
3. Start a debug session using IAR or CSS IDE.
4. Connection with the USB cable is not necessary for debugging or programming the RF430FRL152H.

Note: The Alarm LED may be illuminated during the debugging process if the USB cable is connected. This is normal behavior.

Note: If the USB cable is not connected, the power LED (U5) and the Alarm LED (7) are not illuminated even if the emulation tool is connected. This is normal behavior.

The MSP-FET emulation tool can be used to program or debug the EVM at this point.

2.3.3 Using a BoosterPack Plug-in Module or Digital Sensors

An example of this use case is using the Sensor Hub BoosterPack plug-in module. In this configuration the EVM is powered by the USB connection.

1. Set switch S6 (near the BoosterPack plug-in module headers) to "Supply".
2. Set switch S3 to "M" (master mode).
3. Attach the BoosterPack plug-in module on top of the EVM, making sure it is in the correct orientation (pin 1 on the EVM matches pin 1 on the BoosterPack plug-in module headers).
4. Connect the USB cable to either the BoosterPack plug-in module or the RF430FRL152HEVM.

Note: When the USB cable is attached, the power LED (U5) stays illuminated. The Alarm LED (U7) should momentarily illuminate and then turn off.

Now the TRF7970AEVM can be used to communicate to the part and initiate samples of the various sensors.

2.3.4 Using a Host Controller

In this mode, the host LaunchPad development kit is connected underneath the RF430FRL152HEVM. Make sure the orientations match.

1. Set switch S6 (near the BoosterPack plug-in module headers) to "Supply" setting.
2. Set S3 to "S" (slave mode).
3. For a host that uses I²C, S5 and S4 determine the two least significant bits of the I²C slave address for the RF430FRL152H. For most cases, set these switches to the "0" positions.
4. For a host that uses SPI, S5 and S4 determine the SPI mode. For most cases, set these switches to the "0" positions.
5. Set S5 or S4 to desired setting at this time.
6. Connect the LaunchPad development kit and the EVM together.
7. Power either the LaunchPad development kit or the EVM by connecting either to a USB cable.

Note: When the USB cable is attached, the power LED (U5) stay illuminated. The Alarm LED (U7) should momentarily illuminate and then turn off.

2.3.5 Powering the EVM Using a Battery

1. Insert an SR66 1.5-V battery into the battery holder (BAT1).
2. Note: The first time that a battery is inserted, the battery holder may be tight. Carefully holding the board with a flat object, firmly slide in the battery. Make sure that the positive side of the battery is facing the positive (or top) side of the battery holder.
3. Set S6 to "Battery".
4. If the battery switch is open (the battery switch is inside the RF430FRL152H), SV7 needs to have a jumper to power the part. If the battery switch is closed, then SV7 does not need a jumper to power the RF430FRL152H.

Note: In this mode, the alarm and power LEDs are not illuminated. The device is still powered and operational.

Note: Also if S5, S4, or S3 positions are changed after powering the EVM, a reset is required for the changed settings to take effect. This can be done through the PC GUI or by pressing the reset switch (S2).

Note: If a battery is installed and another configuration (for example, debugging or using a BoosterPack plug-in module) is required, set switch S6 to "Supply" to disconnect the battery and not drain it.

3 GUI Introduction

Figure 8 shows the Setup tab.

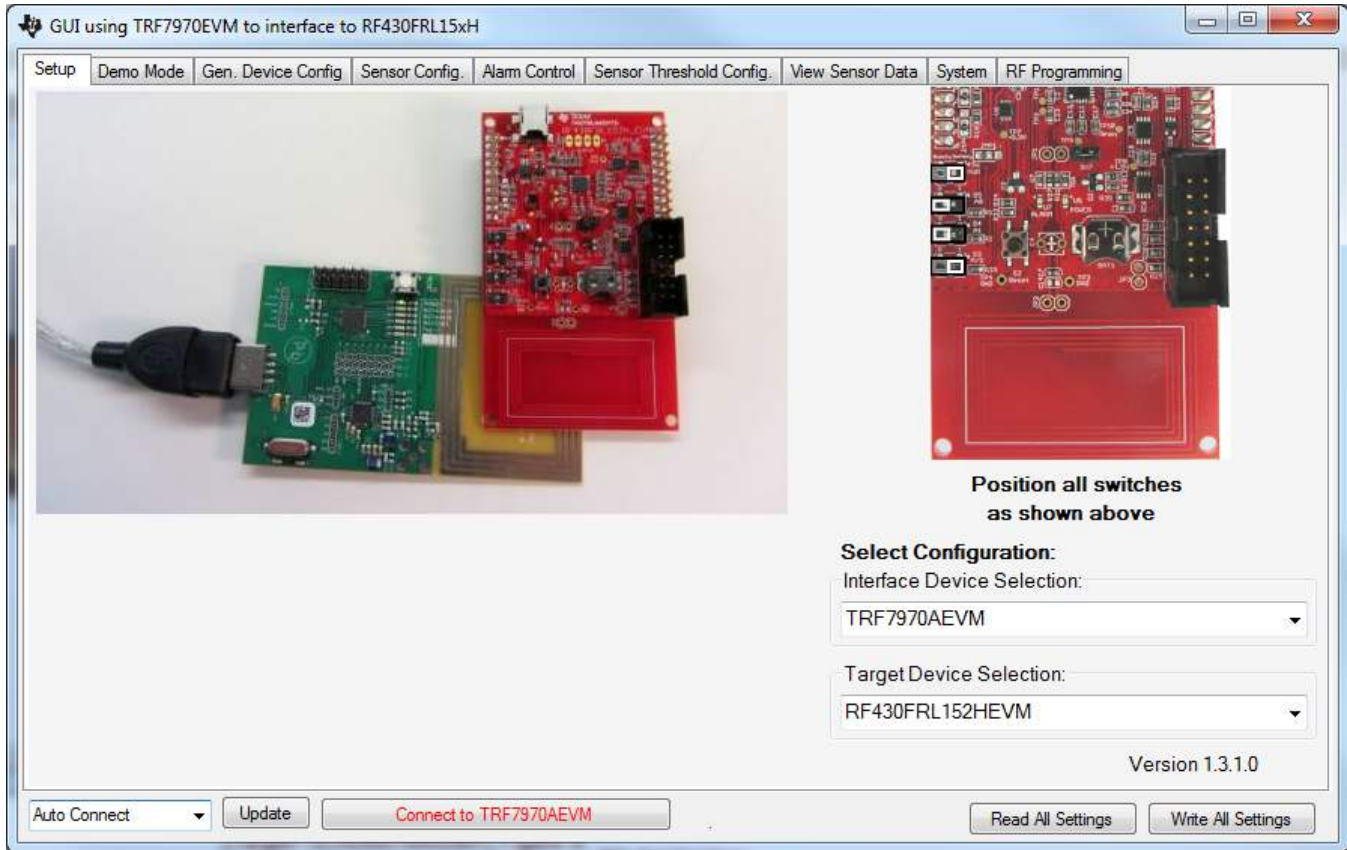


Figure 8. PC Application

Table 1. GUI Tabs

Name	Contents and Functions
Setup	Explains how to configure the system.
Demo Mode	Using an RF430FRL152HEVM, this tab allows automatic setup, measurement, and display of the thermistor and light sensor's measurements with one click of a button.
General Device Configuration	Controls that allow starting the sampling process, choosing the sensors to be used, and selecting the sampling frequency, among other options.
Sensor Configuration	Settings for the ADC for each analog sensor and also advanced settings.
Alarm Control	Settings for enabling and disabling the alarm settings.
Sensor Threshold Configuration	Settings for alarm thresholds for each sensor.
View Sensor Data	After a sampling process has completed, this tab allows the user to view the logged data.
System	Settings to the system control register can be made here.

4 Overview

This section describes the meaning of each of the options on each tab. Remember, checking an option does not immediately cause that option to be set. It is only set after a "Write" button click is performed. Any changes that have occurred on the part, like new status, will not be visible until a "Read" button click has been done.

4.1 Connection to the EVM

Before any configuration can be done to the device using this application, a serial connection must be established. This can be done with the controls on the bottom of the application.

There is a drop-down list in which either a particular port can be chosen, if it is already known, or an automatic selection can be chosen.

When this is done, click on "Connect to TRF7970AEVM". If the connection succeeds, the text of the button changes to "Disconnect from TRF7970AEVM".

If the EVM is plugged in after the application starts, then the drop-down list does not have the currently available COM port selection. Click on the "Update" button to update the list.

4.2 Typical Sequence

In a typical sequence (for example, to do a thermistor measurement) follow these steps. These steps are more fully described in the [RF430FRL15xH Firmware User's Guide](#).

1. Configure the thermistor measurement parameters:

1. Select the thermistor sensor.
2. Set how many times it needs to be sampled.
3. If sampled more than one time, select the delay between the samples.
4. Select the ADC configuration (resolution, PGA setting, and type of filter).

These settings are written to the virtual registers in the FRAM memory using RF communication.

2. Write the start bit in the control register to start the sampling process.
3. There is a delay while the sampling process is being performed.
4. After sampling is complete, the requested measurements are stored into the log memory, typically FRAM (after the virtual registers).

4.3 Setup Tab

1. Select the board that is being used in "Interface Device Selection".
2. Select the device that is being tested in "Target Device Selection".
3. If the RF430FRL152HEVM is selected, an option to select whether or not a Sensor Hub BoosterPack plug-in module is being used is presented. Make the selection (see [Figure 9](#)).

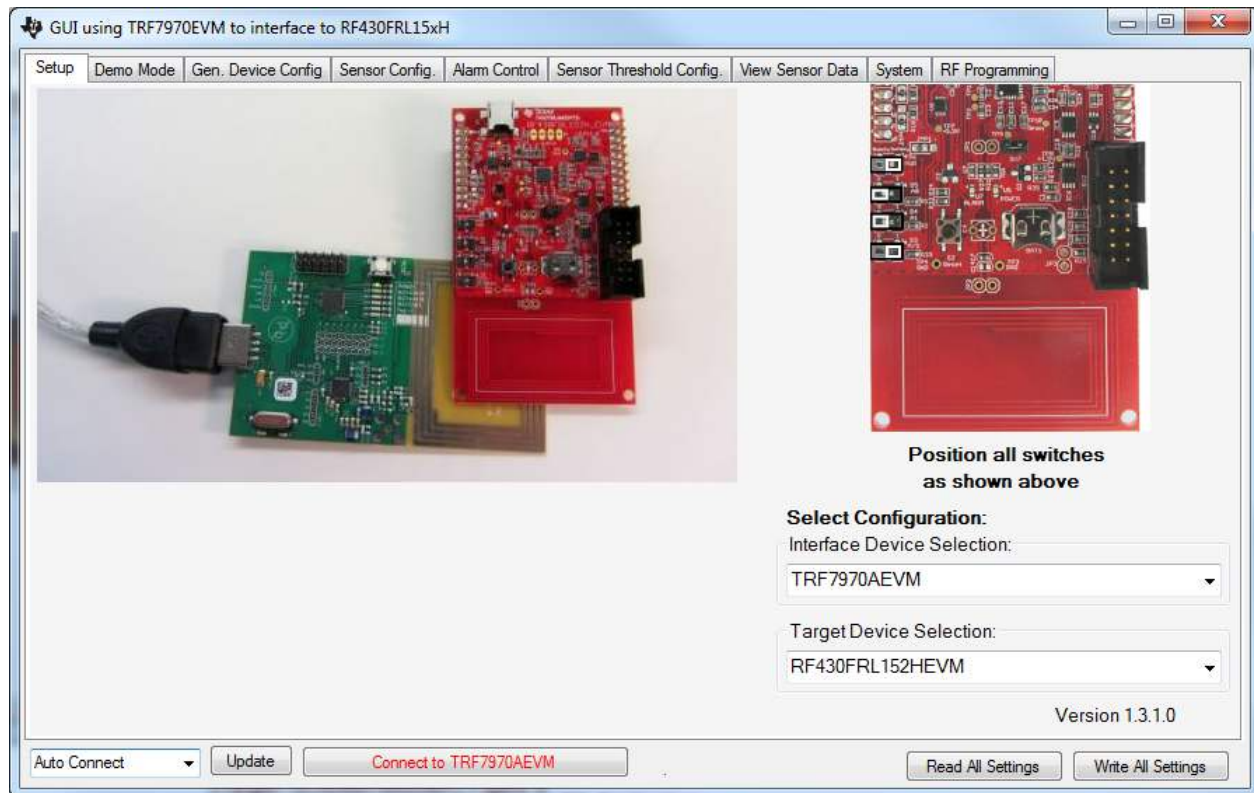


Figure 9. Setup Tab

4.4 Demo Mode Tab

Using this page a user can easily run a sensor acquisition. After positioning the boards as shown on the Setup tab, then pressing the "Start Demo" button, measurement will be started and temperature data and other sensor data like light intensity will be shown (see Figure 10).

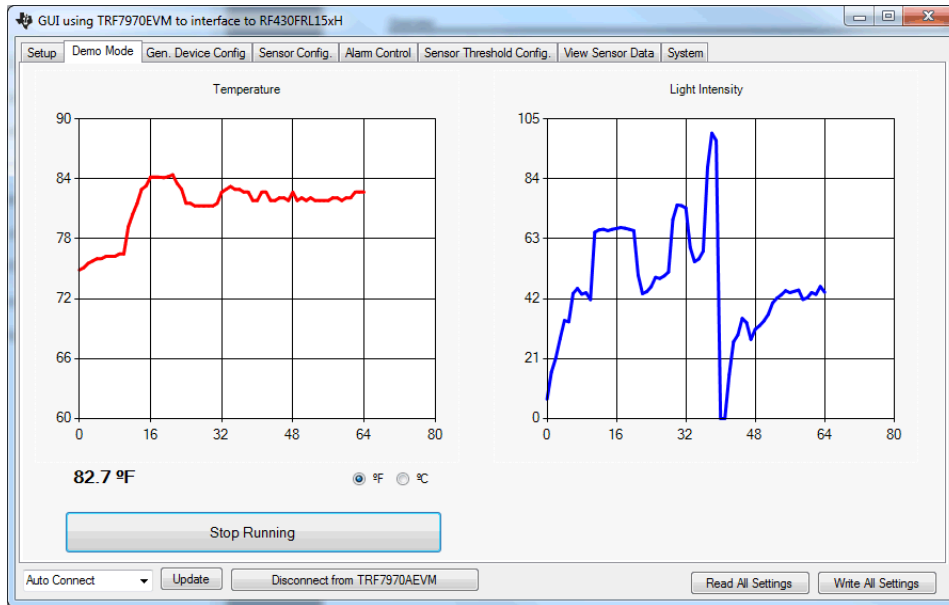


Figure 10. Demo Tab

4.5 General Device Configuration Tab

Figure 11 shows the "Gen. Device Config" tab.

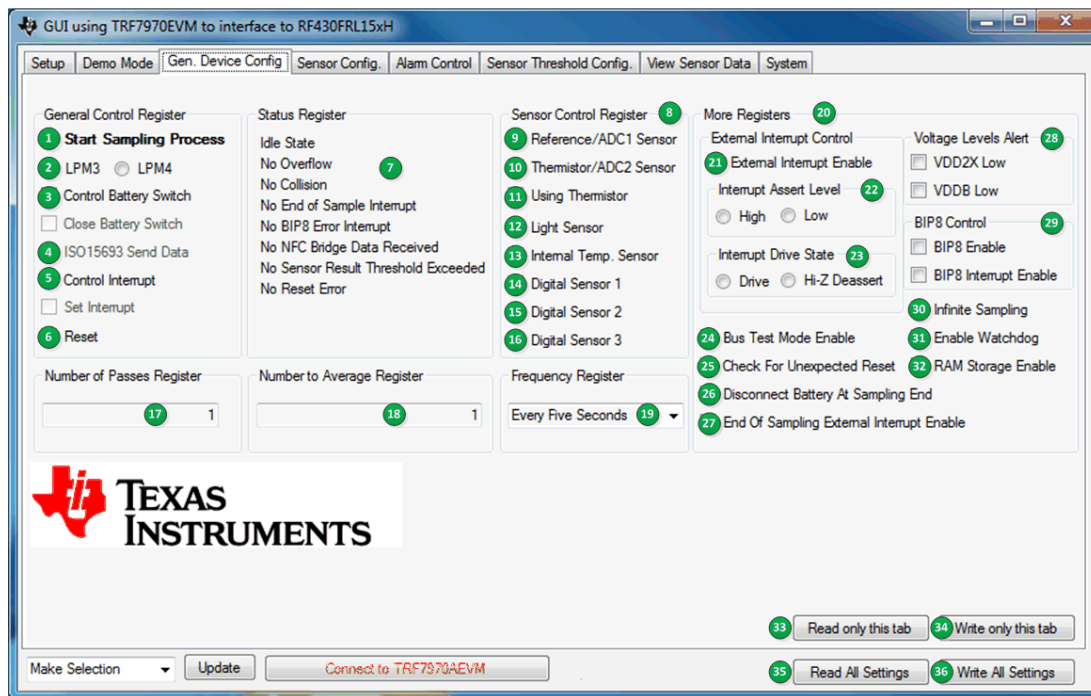


Figure 11. General Device Configuration Tab

1. Start Sampling Process
Setting this bit causes the application ROM code to start the sampling process of all the sensors that were selected, based on all of the configurations.
2. LPM3 and LPM4
Selects which power mode is used when the device enters idle mode.
3. Control Battery Switch and Close Battery Switch
Controls the state of the battery switch on the device. To change the state, check "Control Battery Switch" and then to close the battery switch, check "Close Battery Switch". Otherwise, leave it unchecked, and the battery switch is set to open. The "Control Battery Switch" option is reset after the command is executed by the application ROM code.
4. ISO 15693 Send Data
Allows sending of raw ISO/IEC 15693 commands. Disabled in the current version of the GUI.
5. Control Interrupt and Set Interrupt
Controls the state of the external interrupt on the device. To change the state, check "Control Interrupt", and then to set the interrupt, check "Set Interrupt". Otherwise, leave it unchecked, and the interrupt and the associated flags are cleared. The "Control Interrupt" option is reset after the command is executed by the application ROM code. To generate an external interrupt manually with the GUI, more settings must be done using the "External Interrupt Control"
6. Reset
Causes a PUC (a reset) to be generated on the device. The connection is maintained.
7. Status Register
This group box displays any interrupt or status that have occurred on the device.
Reset all status flags on next write resets all status to idle mode after the tab write.
8. Sensor Control Register
Allows the selection of any sensor to be sampled. Selection of one or multiple sensors is possible.

9. Reference / ADC1 Sensor

Analog Input. If "Using Thermistor", check 11. This causes the input to be configured for an external reference resistor measurement. Otherwise, it can function as a stand-alone generic analog sensor (ADC1).

10. Thermistor / ADC2 Sensor

Analog Input. If "Using Thermistor", check 11. This causes the input to be configured for an external thermistor measurement. Otherwise, it can function as a stand-alone generic analog sensor (ADC2).

11. Using Thermistor

If using a thermistor, this option must be selected for the application ROM code to properly set up the measurement.

12. ADC0 / Light Sensor

When using a RF430FRL152HEVM, this is an option to sample the light sensor. Otherwise, it is a generic analog sensor (ADC0).

13. Internal Temperature Sensor

Allows sampling of the internal temperature sensor on the part.

14. Digital Sensor 1

If using the RF430FRL152HEVM together with the Sensor Hub BoosterPack plug-in module, this samples the SHT21 temperature sensor. Otherwise, it is an option to sample a generic digital sensor.

15. Digital Sensor 2

If using the RF430FRL152HEVM together with the Sensor Hub BoosterPack plug-in module, this samples the SHT21 humidity sensor. Otherwise, it is an option to sample a generic digital sensor.

16. Digital Sensor 3

If using the RF430FRL152HEVM together with the Sensor Hub BoosterPack plug-in module, this option samples the ISL29023 light sensor. Otherwise, it is an option to sample a generic digital sensor.

17. Number of Passes Register

One pass is sampling all of the selected sensors one time.

18. Averaging Register

Any value higher than 1 causes that many samples to be averaged into one result. Averaging mode in the "Alarm Control" tab selects the type of averaging used per sensor.

19. Frequency Register

Selects the delay to be made in between each of the sampling passes. Note this delay must not be less than the time to complete sampling all of the sensors one time. If it is less, then a "collision" occurs.

20. More Registers

This advanced section is not required in most cases. However, it is described below.

Gating option to enable the external GPIO interrupt.

21. Interrupt Assert Level

The level to be driven or pulled to if there is an interrupt

22. Interrupt Drive State

Determines if the device drives an interrupt or is high impedance (user must provide the appropriate pullup or pulldown resistor).

23. Bus Test Mode Enable

Allows access to protected memory using an I²C or SPI host.

24. Check For Unexpected Reset
If this option is selected, and an unexpected reset occurs, the reset code is logged at the end of the logging memory.
25. Disconnect Battery At Sampling End
When the sampling process has been completed, this option causes the ROM code to open the battery switch.
26. End of Sampling External Interrupt Enable
When the sampling process has completed, this option causes an external interrupt to be generated.
27. Voltage Levels Alert
When these are set, it indicates that the voltage levels have gone too low on a particular rail at some point. Not self clearing.
28. BIP8 Control
Error detection for I²C or SPI protocol
29. Infinite Sampling
Samples until the "Start Sampling Process" option is unchecked.
30. Enable Watchdog
Enables the watchdog during a sampling process.
31. RAM Storage Enable
Writes sampling results into RAM memory instead of FRAM.
32. Read only this tab
Reads Gen. Device Config and populates the results on this tab.
33. Write only this tab
Writes Gen. Device Config with all of the settings on this tab.
34. Read All Tabs
Reads all of the information on all of the tabs from the virtual FRAM registers in the device using RF and populates the fields in the tabs.
35. Write All Tabs
Writes all of the information to the virtual FRAM registers in the device over RF from all of the settings.

NOTE: Settings made on the following tabs do not take effect until a "Write only this tab" or "Write All Tabs" button is clicked:
Gen. Device Config.
Sensor Config.
Alarm Control
Sensor Threshold Config.

Likewise, the settings on these tabs are not updated until a "Read only this tab" or "Read All Tabs" button is clicked.

4.6 Sensor Configuration Tab

The options for the four different analog sensors can be controlled from this tab (see [Figure 12](#)). The options can be changed only if the corresponding sensor is enabled in the "Gen. Device Config" tab.

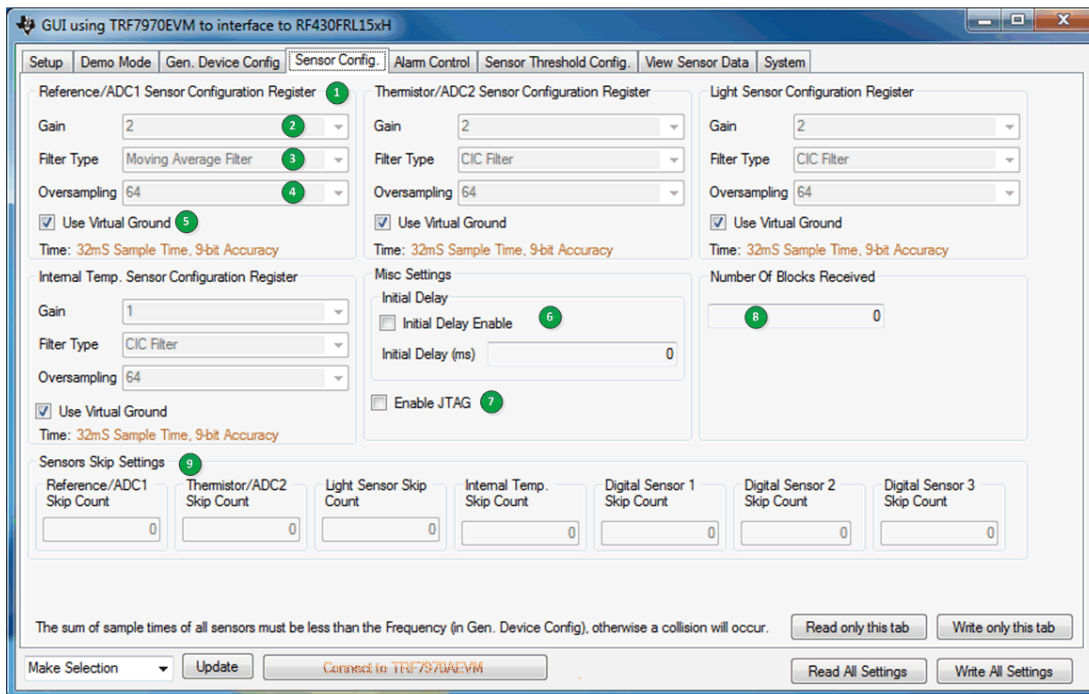


Figure 12. Sensor Configuration Tab

1. **Sensor Configuration Sensor**
Allows control of the analog-to-digital configuration for a particular sensor.
2. **Gain**
Selects the programmable gain amplifier (PGA) before the ADC.
3. **Filter Type**
Select the filter to be used.
4. **Oversampling**
Determines the resolution and time of the sample.
5. **Use Virtual Ground**
If selected, raises the ADC and sensor ground level several hundred millivolts. It is recommended that this setting is consistent for all of the sensors.
6. **Initial Delay Enable / Initial Delay (ms)**
Creates a delay of configured time after starting the sampling process.
7. **Enable JTAG**
Because JTAG is normally disabled on the device, and if there is trouble establishing a JTAG connection, enabling this option can help establish connection. This setting takes effect only after a reset or power cycle.
8. **Number of Blocks Received**
This is a counter that indicates how many ISO/IEC blocks have been received. Can be reset.
9. **Sensor Skip Settings**
Allows control of the duty cycle for a sensor.

4.7 Alarm Control Tab

The alarm control options for the four different analog sensors can be controlled from this tab (see [Figure 13](#)). The options can be changed only if the corresponding sensor is enabled in the "Gen. Device Config" tab.

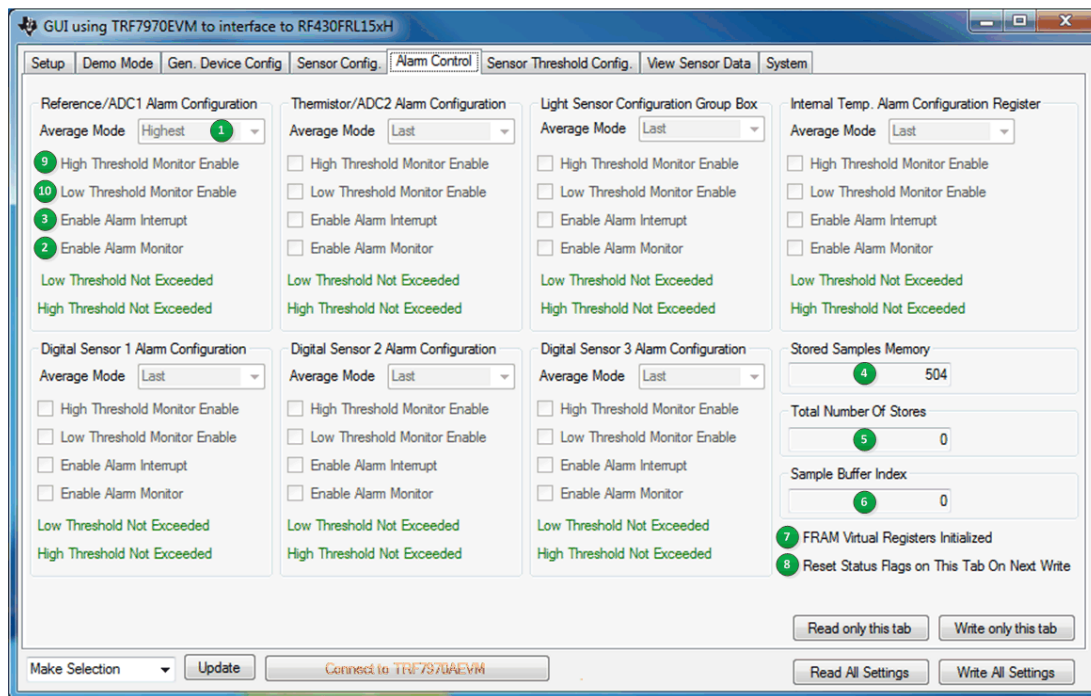


Figure 13. Alarm Control Tab

1. Averaging Mode

True averaging is done only if the "Average" option is selected. The Lowest or Highest options store only the lowest or highest, respectively, sample for the selected sensor. The number of samples done before the result is stored is set in the "Averaging Register" setting on the "Gen. Device Config" tab. The "First" option stores the first sample of the selected sensor. If averaging is selected, during sampling passes after the first sample was stored, the remaining passes will skip this sensor.

2. Enable Alarm Monitor

Enables a check for high or low thresholds for a particular sensor. The results are given in the labels below.

3. Enable Alarm Interrupt

Enables a GPIO interrupt if a high or low threshold has been exceeded. The "Enable Alarm Monitor" must also be selected for this to take effect.

4. Stored Sample Memory

Defines the length of the logged samples memory section.

5. Total Number Of Stores

Reports how many samples were written to the log memory.

6. Sample Buffer Index

Reports the index location of the last sample stored.

7. FRAM Virtual Registers Initialized

If checked, indicates that the FRAM memory has been initialized.

8. Reset Status Flags on This Tab On Next Write

Resets all of the flags on this tab the next time the "Write" button is clicked.

9. High Threshold Monitor Enable
Enables monitoring of that particular sensor for a sample value that exceeds or is equal to the threshold value set in "Sensor Threshold Config." tab. If the sample meets that condition, the status for that sensor (in the same group box) changes to indicate that condition.
10. Low Threshold Monitor Enable
Enables monitoring of that particular sensor for a sample value for that is less than or equal to the threshold value set in "Sensor Threshold Config." tab. If the sample meets that condition, the status for that sensor (in the same group box) changes to indicate that condition.

4.8 Sensor Threshold Configuration Tab

Figure 14 shows the Sensor Threshold Configuration tab. A sensor must be enabled in the "Gen. Device Config" tab to allow the Sensor Threshold Configuration tab to change its threshold.

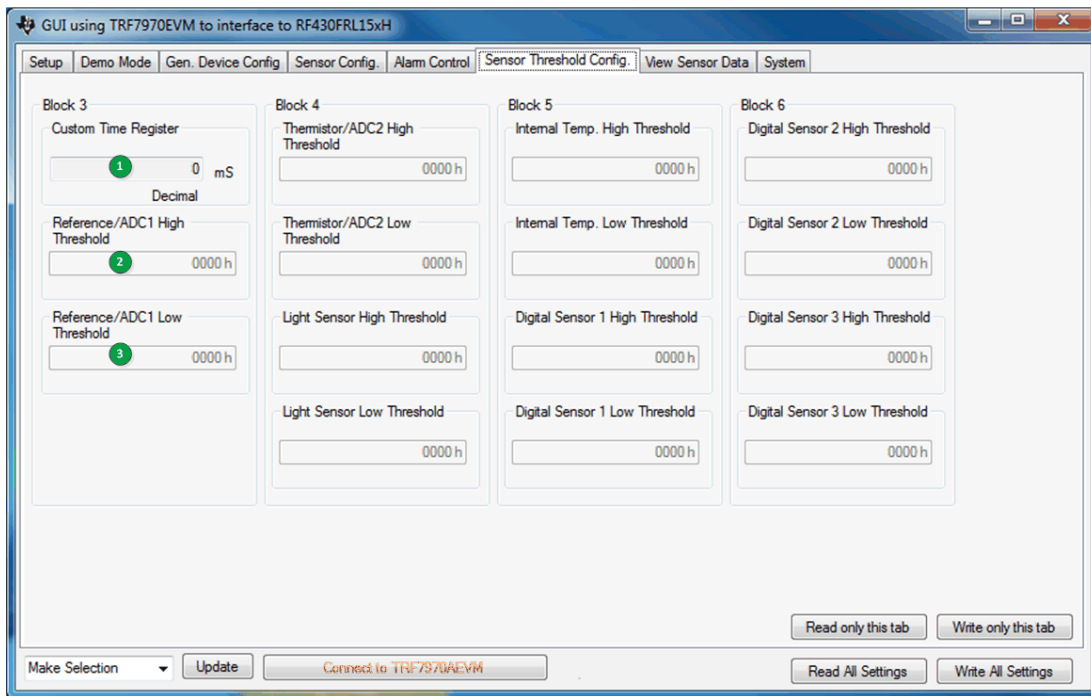


Figure 14. Sensor Threshold Configuration

1. Custom Time Register
Available only if the "Frequency Register" has been set to the "Custom Time" option. Resolution is in milliseconds.
2. High Threshold
If the sensor sample result meets or exceeds the high threshold set here, an alarm is generated. Operation depends on settings in the "Alarm Control" tab.
3. Low Threshold
If the sensor sample result is lower or meets the low threshold set here, an alarm is generated. Operation depends on settings in the "Alarm Control" tab.

4.9 View Sensor Data Tab

After a sampling process has been completed, the logged data can be viewed using this tab (see [Figure 15](#)).

Click the "Read Logged Data" button to display the results in a table to the left of the button. Make sure that you do not change any settings on the GUI before clicking the button, because the settings are used to determine what type of sampling process occurred.

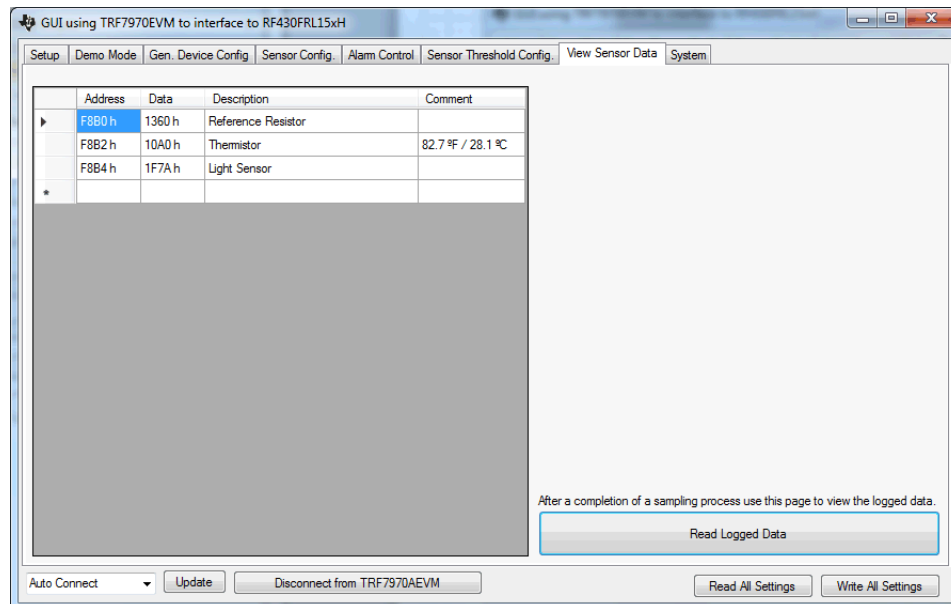


Figure 15. View Sensor Data Tab

5 Setup of Demo System

The following sections describe how to setup a demo with and without the Sensor Hub BoosterPack plug-in module, and also for custom configuring and operation of the device.

5.1 Set up the RF430FRL152HEVM With Sensor Hub Demo Using the PC

This section describes how to setup and run the Sensor Hub BoosterPack plug-in module demo. With this setup, the RF430FRL152HEVM samples over I²C three different sensors on the SensorHub BoosterPack plug-in module. They are temperature and humidity (SHT21) and a light sensor (ISL29023). After collecting the samples, the data is transmitted over RF to the TRF7970AEVM which reports them to the PC application. Finally the results are plotted on the graphs.

1. Connect the TRF7970AEVM to the PC with a USB cable.
2. On the RF430FRL152HEVM, use a pencil or pen to position the switches as shown in [Table 2](#)

Table 2. Switch Positions For Sensor Hub Operation

Switch ID	Position	Comment
S6	Supply	This will source power from the USB cable
S5	0	Does not matter what state this switch is in
S4	0	Does not matter what state this switch is in
S3	M	Device starts in I ² C/SPI master mode

3. Attach the Sensor Hub BoosterPack plug-in module on top of the RF430FRL152HEVM. Make sure that the orientation is correct (see [Figure 16](#)).
4. Connect the RF430FRL152HEVM to the PC using the provided USB cable. Note that this USB connection is only for the power supply, and no data is passed through it.
5. Position the RF430FRL152HEVM antenna on the antenna portion of the TRF7970AEVM as shown in [Figure 16](#). It is recommended to have an insulator between the two antennas or to hold them at a distance from each other to prevent any short circuits.

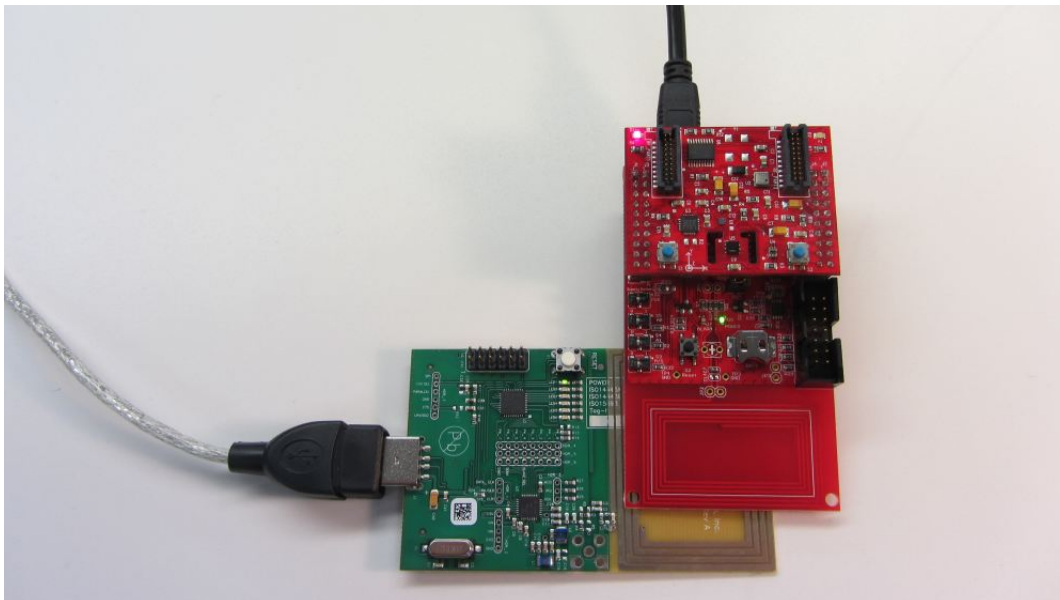


Figure 16. BoosterPack Plug-in Module Configuration

6. Open the RF430FRL15xH GUI Interface application by going to the Start menu→All Programs→Texas Instruments→RF430FRL152H GUI .
7. Click the "Connect to TRF7970AEVM" button on the bottom of the window.
8. A few seconds after you click the "Connect" button, the label next to the button should show

"Connected to TRF7970AEVM on COMx". If this is not shown, then a connection has not been made. In this case, disconnect the TRF7970AEVM and reconnect it, then restart at step 1. If this still does not solve the problem, make sure that the TRF7970AEVM has the latest firmware downloaded from the TRF7970AEVM tool folder.

9. In the "Setup Tab", select the "With Sensor Hub BoosterPack" and "RF430FRL152HEVM" options on the Device Interface Selection.
10. Select the "Demo Mode" tab.
11. Click the "Start Sensor Hub Demo" button.
12. The GUI starts to plot the temperature and light intensity samples on the graphs.
 1. To plot these values, the PC GUI configures the RF430FRL152HEVM through the TRF7970AEVM to take three different samples from the Sensor Hub BoosterPack plug-in module. The RF430FRL152HEVM already has the drivers loaded into the FRAM to enable the measurements to be made.
 2. When the samples are complete, the PC GUI reads the result from FRAM of the RF430FRL152HEVM through the TRF7970AEVM and plots it on the graphs in the PC GUI.
13. To change the measurements, you can place your hand over the light sensor or heat the thermistor (U5).

5.2 Set up the RF430FRL152HEVM Demo Using the PC

This section describes how to setup and run the sensor demo. With this setup, the RF430FRL152HEVM samples, using the onboard ADC, two external sensors, the thermistor and the light sensor. After collecting the samples, the data is transmitted over RF to the TRF7970AEVM which reports them to the PC application. Finally the results are plotted on the graphs. In this demo the RF430FRL152HEVM is run completely wireless, with no power or data connections.

1. Connect the TRF7970AEVM to the PC with a USB cable.
2. On the RF430FRL152HEVM, use a pen or pencil to set the mini-switches as shown in [Table 3](#).

Table 3. Switch Positions For Passive Operation

Switch ID	Position	Comment
S6	Battery	There is no need for a battery to be present
S5	0	Does not matter what state this switch is in
S4	0	Does not matter what state this switch is in
S3	S	Device starts in I ² C/SPI slave mode

3. **The RF430FRL152HEVM should not be connected to a USB cable for this demo.** If it is connected, set switch S6 to the "Supply" position. The rest of the steps are the same.
 Note: If EnergyTrace technology is used, a USB cable should not be used and the EVM must be powered from the MSP-FET tool.
4. Position the RF430FRL152HEVM antenna on the antenna portion of the TRF7970AEVM as shown in [Figure 17](#). It is recommended to have an insulator between the two antennas or to hold them at a distance from each other to prevent any short circuits.

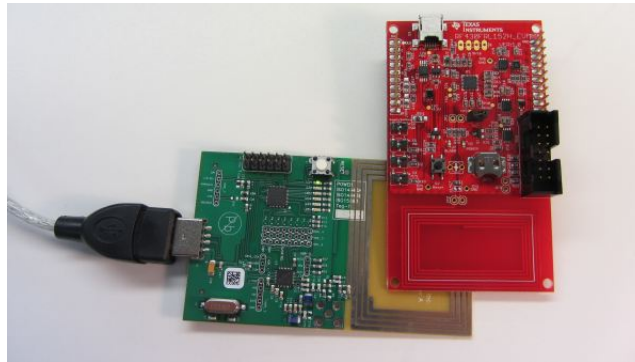


Figure 17. Position the EVMs

5. Open the RF430FRL15xH GUI Interface application by going to the Start menu→All Programs→Texas Instruments→RF430FRL152H GUI .
6. Press the "Connect to TRF7970AEVM" button on the bottom of the window.
7. A few seconds after you click the "Connect" button, the label next to the button should show "Connected to TRF7970AEVM on COMx".
If this is not displayed, then a connection has not been made. In this case, disconnect the TRF7970AEVM and reconnect it, then restart at step 1. If this still does not solve the problem, make sure that the TRF7970AEVM has the latest firmware downloaded from the TRF7970AEVM tool folder.
8. In the "Setup Tab" select the "Without Sensor Hub BoosterPack" and "RF430FRL152HEVM" options.
9. Go to the "Demo Mode" tab.
10. Click the "Start Demo" button.
11. The GUI starts to plot the temperature and light intensity samples on the graphs.
 1. To plot these values, the PC GUI configures the RF430FRL152HEVM through the TRF7970AEVM to take two different samples from the analog thermistor and light sensors.
 2. When the samples are complete, the PC GUI reads the result from FRAM of the RF430FRL152HEVM through the TRF7970AEVM and plots it on the graphs in the PC GUI.
12. To change the measurements, you can place your hand over the light sensor or press the thermistor with a finger to affect the temperature result. The light sensor and the thermistor locations on the EVM are shown in [Section 2](#).

The thermistor temperature measurement may not reach the true skin temperature, because some of the heat dissipates into the EVM.

The light sensor reading value does not increase in the presence of extra light (for example, if you shine a flashlight on it), because of design reasons with the light sensor selected for this EVM. However, the light sensor shows a change for reduced light. Note that the light sensor on the Sensor Hub BoosterPack plug-in module does not have this same limitation.

5.3 Using the PC Application for Advanced Custom Control of the RF430FRL152HEVM

This section describes how to set up the RF430FRL152HEVM for a custom sampling process. The example used here describes how to perform sampling of three sensors (reference, thermistor, and light sensor) with four passes at a rate of one sample per second. Various ADC configurations are made using the "Sensor Config." tab. This is a simple demonstration, and you can create more complex sampling processes and control as needed.

1. Follow the steps in [Section 5.1](#) to start the PC application and connect to the TRF7970AEVM.
2. In the "Setup" tab, make sure that "Without Sensor Hub BoosterPack" and "RF430FRL152HEVM" are selected.
3. On the "Sensor Config." tab, for the reference and thermistor group boxes (near the top of the tab), make the following settings: gain of 2, filter type of CIC filter, oversampling of 256. When gain of 2 is used, the thermistor and reference input voltage does not use most of the analog voltage range. The CIC filter allows for shorter conversion times (using 256 oversampling).

4. For the light sensor configuration, select gain of 1, CIC filter, and oversampling of 256.
5. Also on the same group boxes, select "Use Virtual Ground". Virtual ground allows the ADC module and inputs to be raised above ground voltage by several hundred mV. Raising the ground allows the ADC to more accurately measure voltages near ground. This setting must be chosen, because the RF430FRL152HEVM was designed with virtual ground powering the thermistor and light sensors (the SVSS pin is the virtual ground).
6. [Figure 18](#) shows the "Sensor Config." tab with these settings.

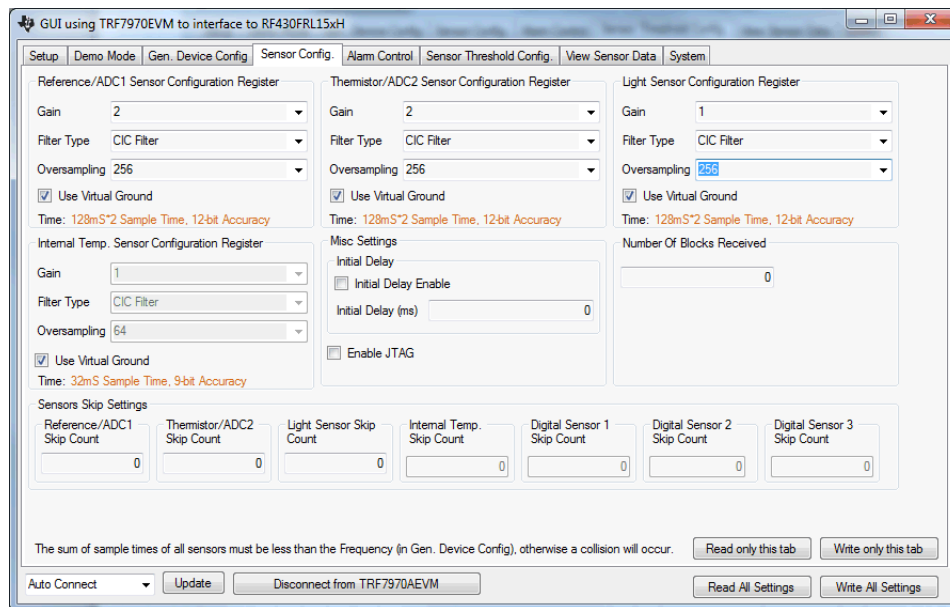


Figure 18. Custom Sensor Configuration Tab

7. Click the "Write only this tab" button on the bottom of the tab.
8. Go to the "Gen. Device Config" tab, and select the "Reference/ADC1", "Thermistor/ADC2", "Using Thermistor", and "Light Sensor" options in the "Sensor Control Register" group box. These settings determine which sensors are selected to be sampled.
9. Set "Number of Passes Register" to 4. This causes four sampling passes. A pass is sampling each of the selected sensors in the "Sensor Control Register" once, in the order that they are selected.
10. Set "Frequency Register" to the "Every Second" option. This setting causes the selected delay to occur between sampling processes.
11. Check "Start Sampling Process".
12. [Figure 19](#) shows the "Gen. Device Config" tab with these settings.

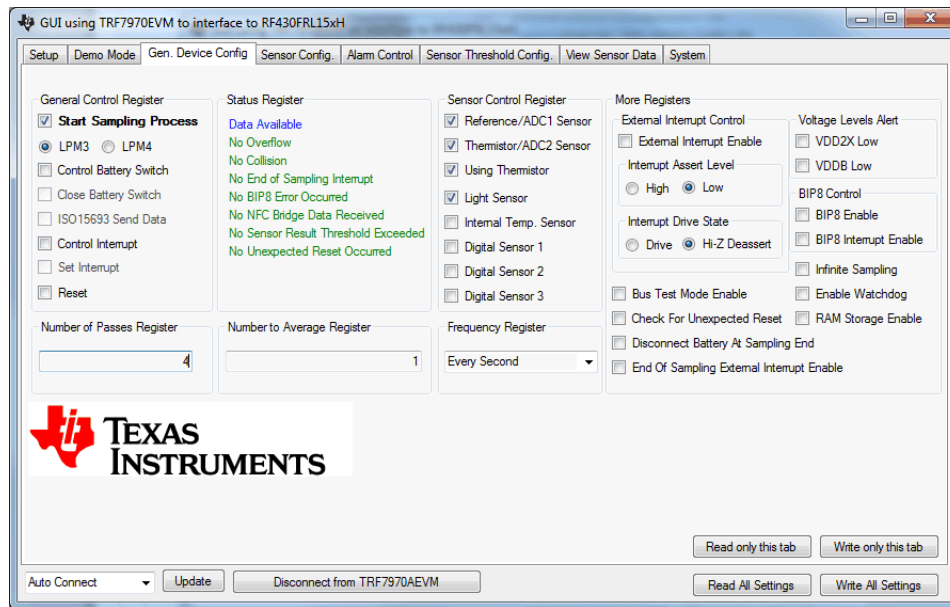


Figure 19. Custom General Device Configuration

13. Click the "Write only this tab" button.
14. The sampling process starts. You can click the "Read only this tab" button to check on the status of the sampling process. While the RF430FRL152H is still sampling, the "Status Register" displays the text "Sampling in Progress".
15. Continue to click the "Read only this tab" button until the "Status Register" displays the text "Data Available". The sampling process should take three seconds to complete.
16. When data is available, go to the "View Sensor Data" tab and click the "Read Logged Data" button. The GUI reads the logged data from the EVM and displays it (see Figure 20). This logged data is not designed to be human-readable. However, one use case of this function is to show the correlation and order of data to the sensor that took that data. In the logged data memory, the sensor that took that sample is not given and must be determined based on the configuration of the settings. However, the GUI shows which sensor is sampled and the expected order.

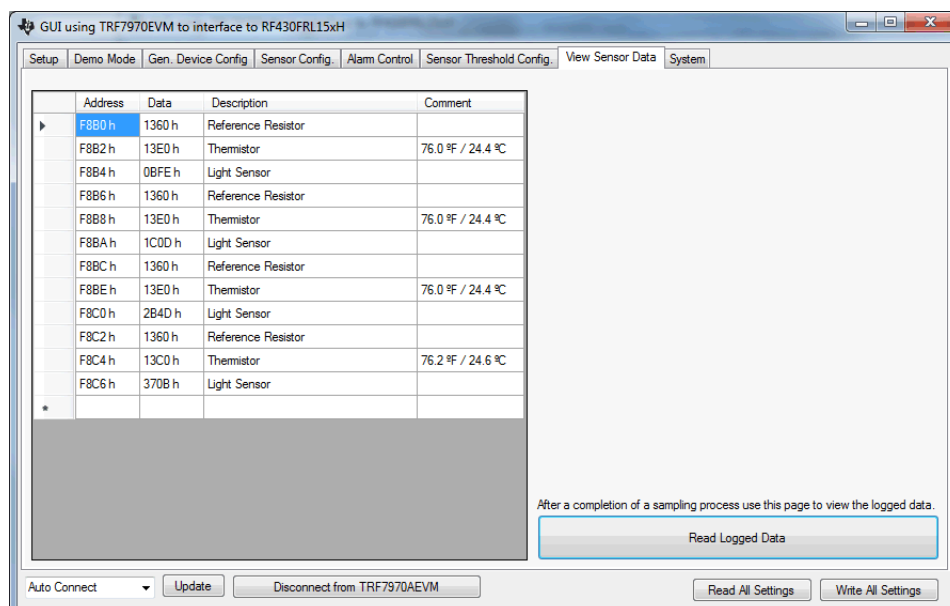


Figure 20. Custom View Data

6 Changing Firmware System Settings

This section describes how to change the firmware system settings of the RF430FRL15xH. [Figure 21](#) shows the System tab. [Table 4](#) describes the available settings.

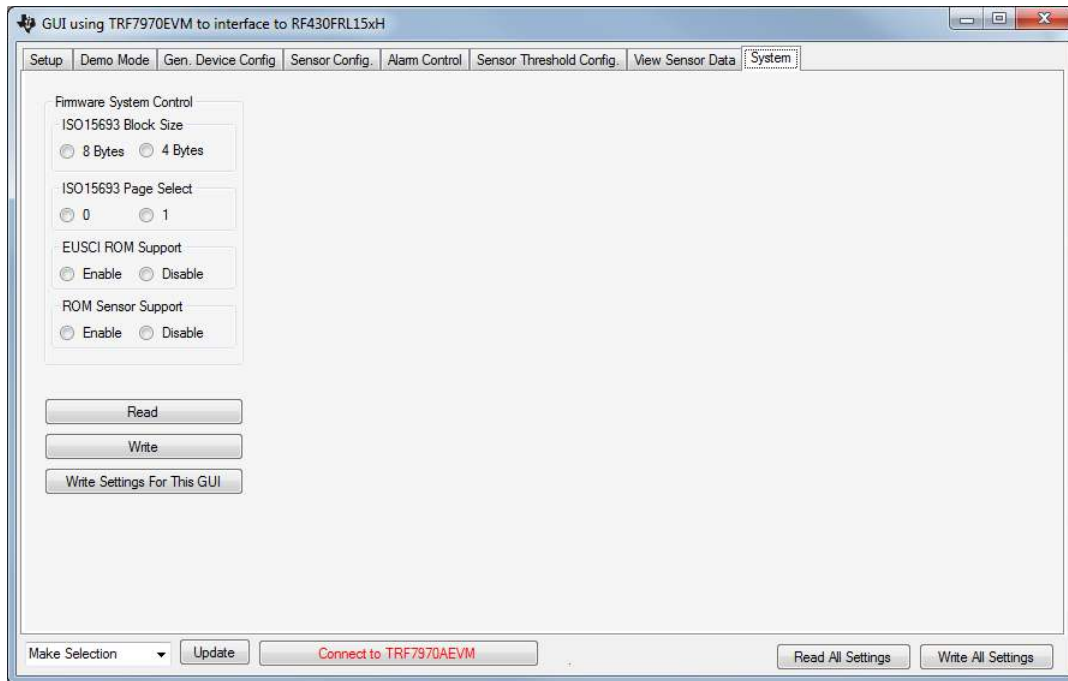


Figure 21. System Tab

Table 4. Firmware System Settings

Switch ID	Comment
Block Size	ISO/IEC 15693 RF setting. Determines the amount of bytes that can be read and written using a single block.
Page Select	RF stack setting. If 4 byte block setting is used, then to access the entire FRAM, two pages are necessary. This control switches between them. Not needed when 8 byte block size is used.
EUSCI Support	Enables or disables support for I ² C/SPI module. When disabled host controller and digital sensor ROM support is not functional. Forced off in RF430FRL153H since it does not have an eUSCI module.
Sensor Support	ROM support for using ADC (SD14) is disabled. Forced off in RF430FRL154H since it does not have an SD14 module.

To change these settings first, click the "Read" button to load the current settings. After changing them, click the "Write" button to send them over RF.

To automatically set the setting for the PC application, click "Write Settings For This GUI".

7 Over-the-Air Programming

This section describes how to program the RF430FRL15xH using RF. [Figure 22](#) shows the screen used for RF programming.

NOTE: The RF programmer cannot program the complete FRAM memory. This is because not all the FRAM memory is accessible over RF. The region that it can program is F867h to FFFFh.

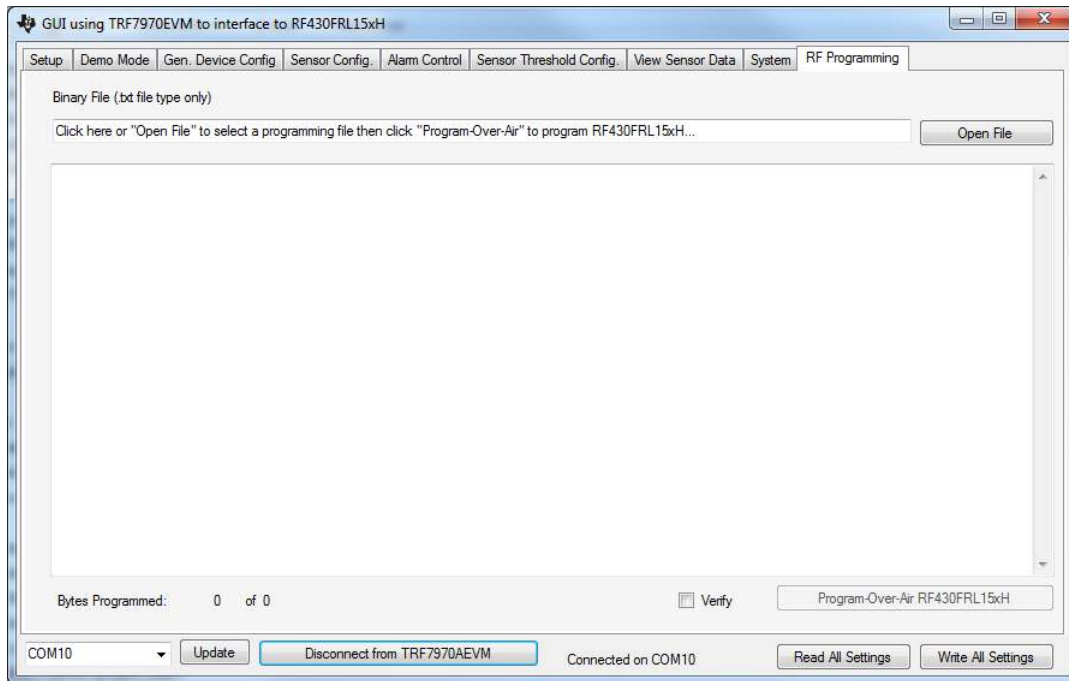


Figure 22. RF Programming

7.1 Procedure

NOTE: Only .txt format file types are accepted by this program. CCS and IAR can generate this formats (see [Section 7.2](#) for instructions).

Follow these steps to select and program the binary file using RF (also see [Figure 23](#)).

1. Create a .txt file of the program to be programmed.
2. Click on the "Open File" button.
3. Find and select the .txt file that was created in step 1.
4. Click "Verify" if verification of programming is needed.
5. Make sure that the RF430FRL15xH is positioned above the TRF7970A reader/writer.
6. Click "Program-Over-Air RF430FRL15xH" to start the programming.
7. Status progress is provided by text in the text box and also in numerical form as "Bytes Programmed".
8. After programming completes, power down the RF430FRL15xH by removing it from the field or disconnecting the power supply. When power is applied again, the RF430FRL15xH resets and the new program takes effect.

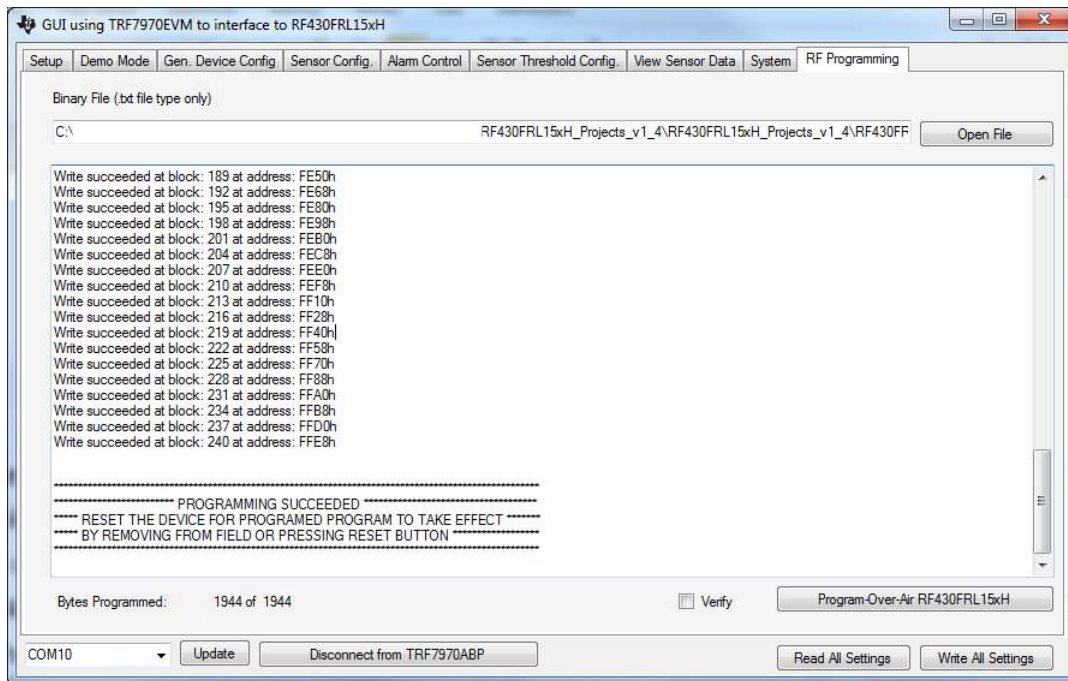


Figure 23. RF Programming Completed

7.2 Generating a TXT File

7.2.1 Using CCS

Follow these steps to generate a .txt file from CCS (see Figure 24):

1. Right click on the project.
2. Select the "Build" option.
3. In the "Post-build steps" in the "Steps" tab enter this text:
`"${CG_TOOL_HEX}" --ti_txt "${BuildArtifactFileName}" -o "${BuildArtifactFileName}.txt" -order MS -romwidth 16`
4. Compile the project. The .txt binary output is saved to the "Debug" folder.

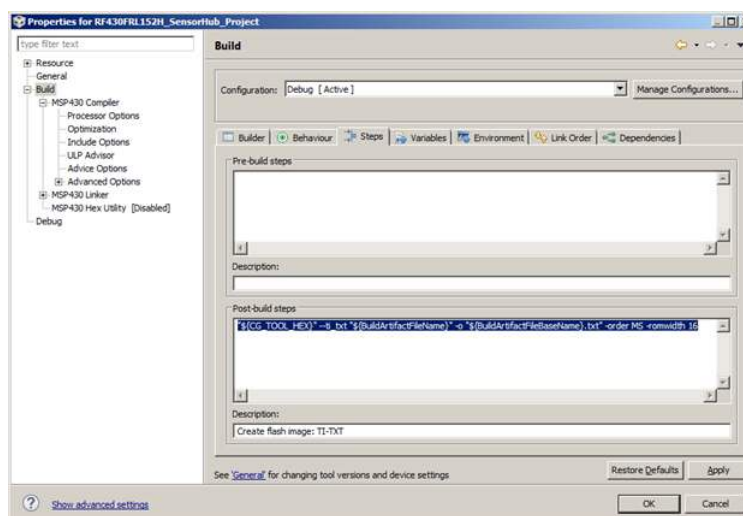


Figure 24. CCS TXT Generation

7.2.2 Using IAR

Follow these steps to generate a .txt file from IAR (see [Figure 25](#)):

1. Right click on the project and select the “Options” setting.
2. In the “Linker” category, select the “Extra Output” tab and select “Generate extra output”.
3. Select the “msp430-txt” setting in the “Output format”. Leave “Format variant” set to “None”.
4. Compile the project. The .txt binary output is saved to the “Debug” folder.

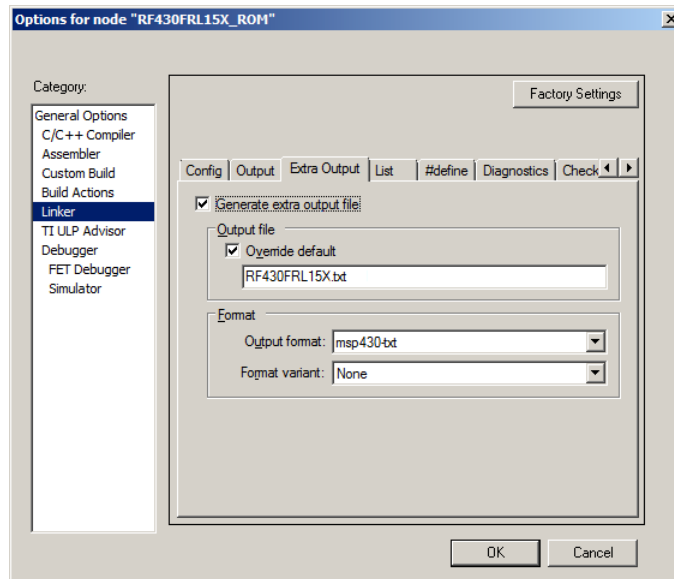


Figure 25. IAR TXT Generation

8 RF430FRL152HEVM Schematics

A single full-sheet schematic is available [here](#).

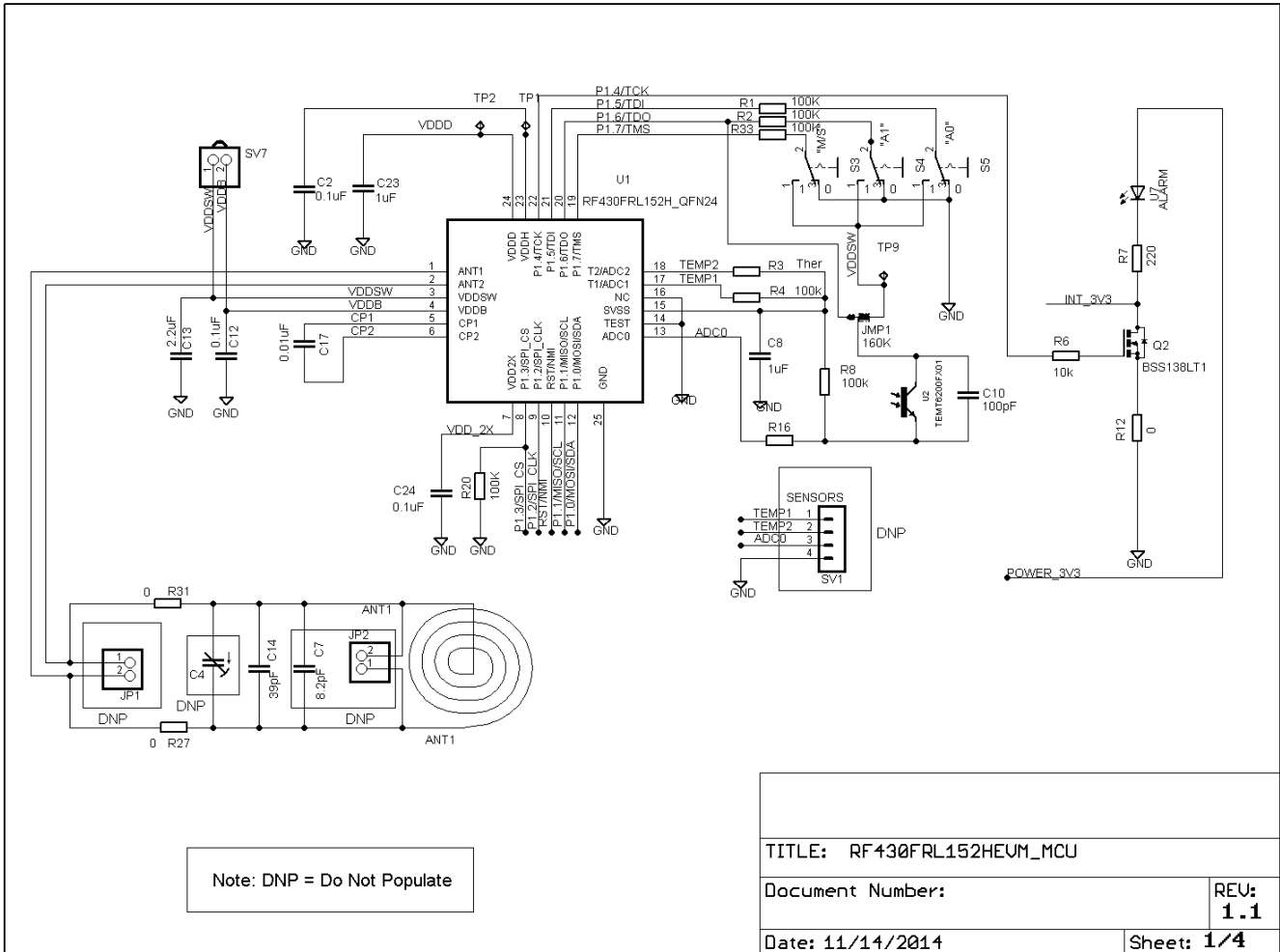


Figure 26. MCU Section Schematic

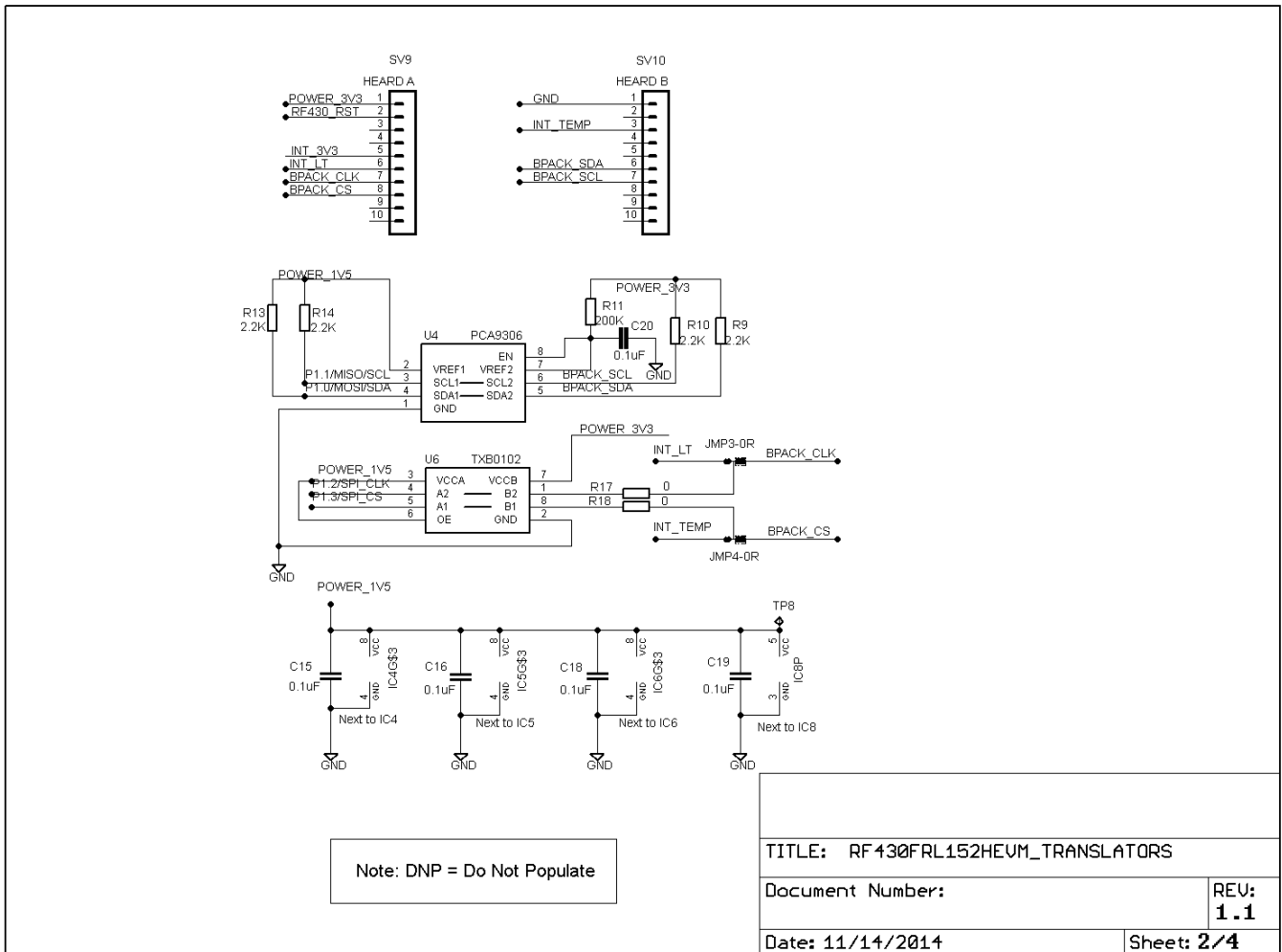


Figure 27. I²C or SPI Translators Section Schematic

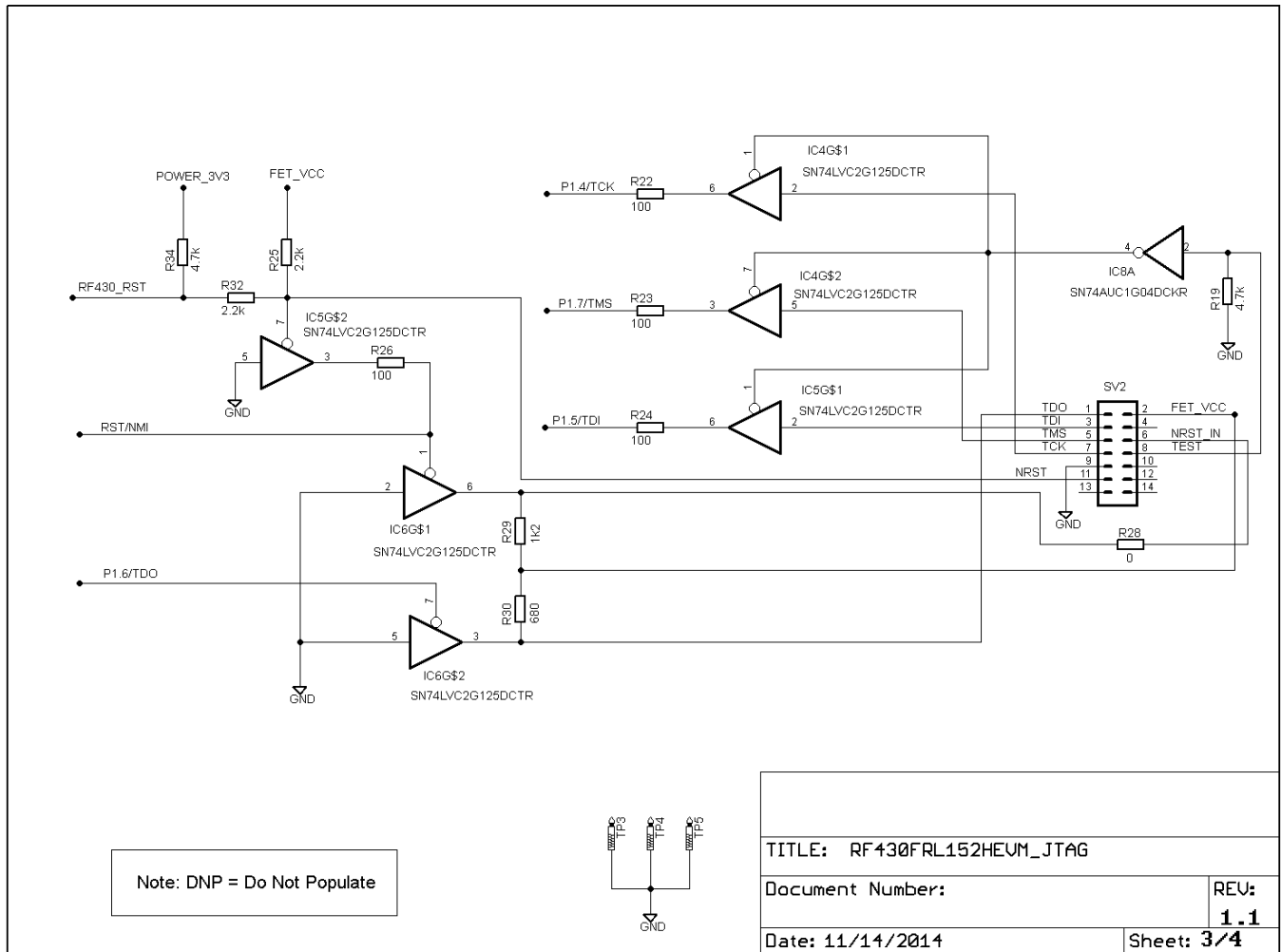


Figure 28. JTAG Section Schematic

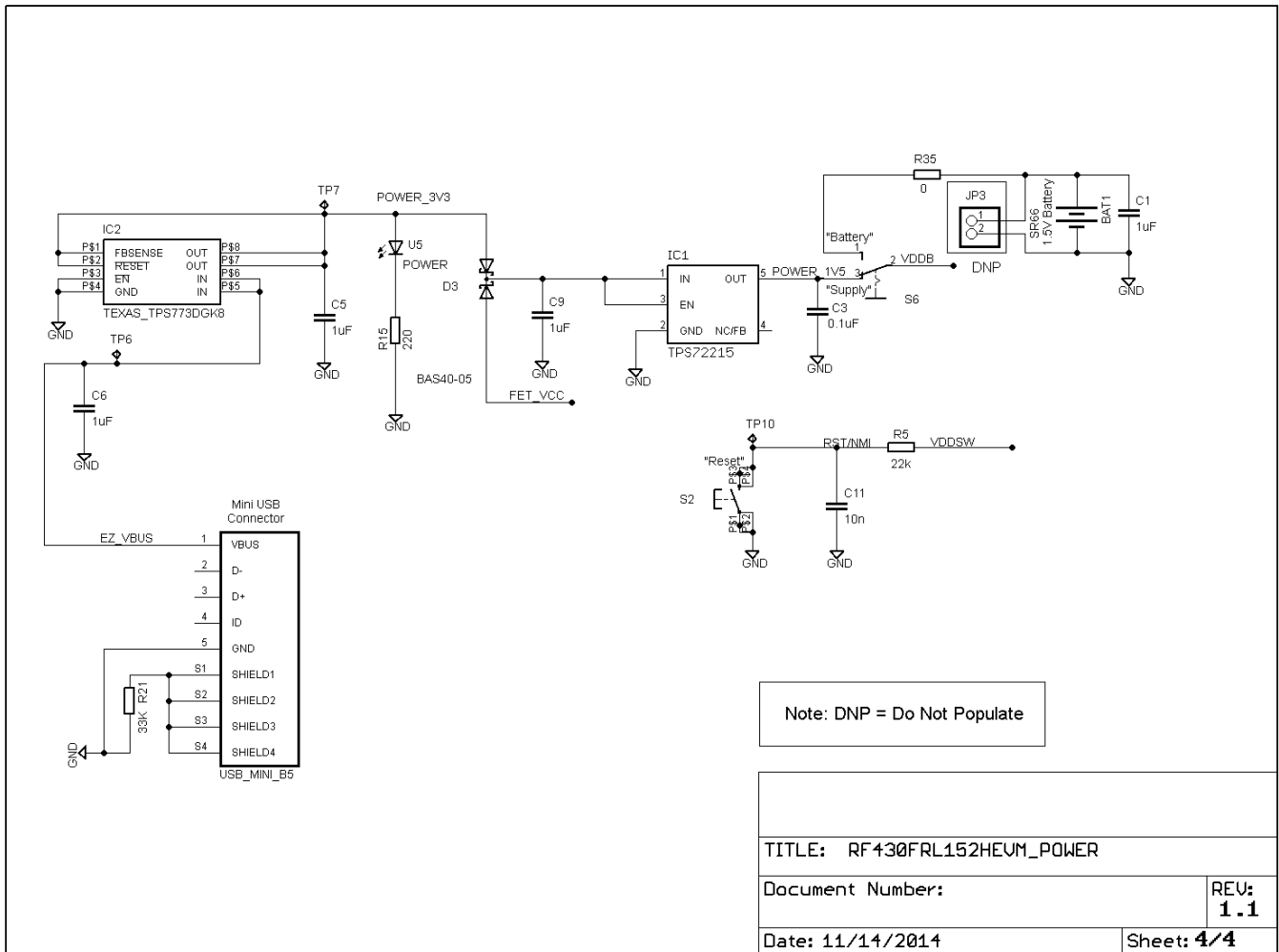


Figure 29. Power Section Schematic

9 References

The primary sources of RF430FRL15xH information are:

1. [RF430FRL152H Evaluation Module](#)
2. [Sensor Hub BoosterPack plug-in module](#)
3. [TRF7970A Evaluation Module](#)
4. [Near Field Communications Overview](#)
5. [Low-Power Microcontrollers Overview](#)

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from June 30, 2017 to July 3, 2018	Page
• Updated recommended evaluation tools in the second paragraph in Section 1.1 , <i>Overview</i>	3
• Updated Section 1.3 , <i>Required Additional Tools</i>	4
• Updates to recommend TRF7970A-BNDL and moved Section 1.3.1 , <i>MSP-EXP430G2 LaunchPad Development Kit With TRF7970A BoosterPack Plug-in Module</i>	4
• Removed paragraph with obsolete information about location of MSP430G2_TRF7970ABP_Binary.out in Section 1.3.1 , <i>MSP-EXP430G2 LaunchPad Development Kit With TRF7970A BoosterPack Plug-in Module</i>	4
• Updated Section 1.3.2 , <i>TRF7970AEVM</i>	5

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CAUTION

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Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
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Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

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2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page
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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

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4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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