R&D Technical Documentation

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	Date	By	Date	By	
A	Apr14-2015	BG			**CSM-400UE**
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C	June25-2015	BG			**Description**
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E	July8-2015	BG			RF Transceiver module / Sub 1GHz
F	Aug11-2015	BG			
G	Aug26-2015	BG			
H	Oct14-2015	BG			
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J	Mar16-2017	GWH			
					3.3~5.0Vdc / USB Flash programmable
					Item Number
					66990004

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2. PROJECT DESCRIPTION

CSM-400UE is a modular 410-475MHz RF transceiver designed to provide the RF interface for Hetronic devices. The module is designed to be mounted onto Hetronic coder and decoder boards to convert digital information to RF signals and RF signals to digital information. CSM-400UE can be programmed to function in several different operating modes. Configuring the operating mode and functional settings of each mode allows CSM-400UE to be expandable to additional operating modes, new RF protocols and many frequency channels. CSM-400UE communicates with a PC using the CSM-CFG board as an USB and RS-232 adapter.

CSM-400UE uses an internal 3.1V regulator and requires a 3.3-5.0V external power supply. Absolute maximum survival supply voltage is limited to 12VDC. In applications, this will be provided by the host coder/decoder board. CSM-400UE can be configured to operate on any 6.25kHz channel from 410MHz - 475MHz. The RF output power is set to 10dBm (10mW). Depending on the protocol, CSM-400UE can operate at RF baudrates up to 50kbps. CSM-400UE is built around the TI CC1200 Sub-1GHz RF transceiver. RF front-end circuitry on the device limits effective performance to ~385MHz to ~500MHz, although the hard frequency limits for the 400 MHz range are from 410 to 475 MHz. RF sensitivity varies depending on the protocol being used.

All of the functionality of the CSM-400UE is configured in the firmware. CSM-CFG is also used to load the firmware bootloader over RS-232 and firmware application using the USB Flash Programmer tool. CSM-400UE can also connect to the PC H-Link tool over the CSM-CFG board. H-Link serves an important purpose for CSM-400UE: calibrating the on-board radio. **Every CSM-400UE module must be calibrated before use in a Hetronic product**. H-Link calibration compensates for production variation in the RF performance of the on-board radio.

CSM-400UE by default is configured to 'ELP-TRx' mode. This causes it to act as a transceiver for the Hetronic ELP protocol. In this mode it will only communicate with other ELP devices. In ELP Mode, radio control and data transfer are all handled over the DI and DO pins with 115.2k baud UART. The legacy 'AF' pin does not support audio output but is instead used for USB detection. CSM-400UE's frequency and encryption can be configured using the CSM Configuration Tool. For more information, see the CSM_CFG Technical Document.

3. __BLOCK DIAGRAM__

Figure 1: CSM-400UE Block Diagram

4. TECHNICAL SPECIFICATION

Parameter	Specification
Nominal Supply (BATT+)	3.2~5.0Vdc
Max Supply (BATT+)	5.5V
Min Supply (BATT+)	2.9Vdc
Max Input Voltage on I/O pins	5Vdc
Operating Temperature Range	-40°C ~ +80°C
Operating Frequency Range	410.0000MHz ~475.0000MHz
Channel Step	6.25 kHz minimum
Max Data Rate	50 kbps maximum
Antenna / Impedance	SMB / 50ohms
TRANSMITTER - ELP	
TX Operating Current	60mA
RF Output Power	-10 to +10dBm (configurable)
Frequency Deviation	14 kHz (ELP, 4-GFSK, 50 kbps)
Spurious emission	> -40dB
RECEIVER - ELP	
RX Operating Current	60mA
Sensitivity	-103 dBm (ELP, 4-GFSK, 50 kbps)
Adjacent Channel Selectivity	65dB

5. <u>CONNECTION DIAGRAM</u>

ANT

(Top)

VB
RXS
TXS
BATT+
GND

(Bottom)

DI
DO
RSSI
LD
LE
DATA
CLK

JTAG

Figure 2: CSM-400UE Connection Diagram

6. <u>FUNCTIONAL DESCRIPTION</u>

6.1. Configuration

CSM-400UE is configured by the CSM Configuration Tool software. For more information on this tool, see the CSM_CFG Tech Doc.

6.2. ELP Mode

In ELP Mode, the CSM-400UE acts as an ELP Transceiver. ELP is the Hetronic 'Event Link Protocol', which operates at 50kbps baudrate, 4GFSK modulation and 6.25kHz deviation. In this mode the radio can only be controlled and used with an ELP coder/decoder. Default output power is set to 0dBm but can be configured to +/-10dBm. In ELP Mode, the device is centered on a 12.5kHz channel, between 410MHz and 475MHz. In ELP Mode, CSM-400UE will only communicate with other radios using ELP. ELP Mode also allows the CSM-400UE to enable/disable encryption of the wireless data. Encryption-enabled and -disabled devices cannot communicate with each other.

6.3. Test Mode

In Test Mode, the CSM-400UE will function in one of several configurable Test Modes:

6.3.1. CW Test Mode

In CW Test Mode, the CSM-400UE will continually output a single-frequency tone for test measurement purposes. The frequency and peak output power of the CW tone are configurable.

6.3.2. ELP Random Transmit Mode

In ELP Random Transmit mode, the CSM-400UE will continually transmit a random string of data at the ELP settings: 50kbps, 4GFSK modulation with a 6.25kHz deviation.

6.3.3. ELP Random Receive Mode

In ELP Random Receive Mode, the CSM-400UE will continually receive any data broadcasted with the ELP settings in the ELP packet structure.

7. ASSEMBLY DESCRIPTION

7.1. Lacquer Mask

Cover the marked areas of the board assembly before lacquering.
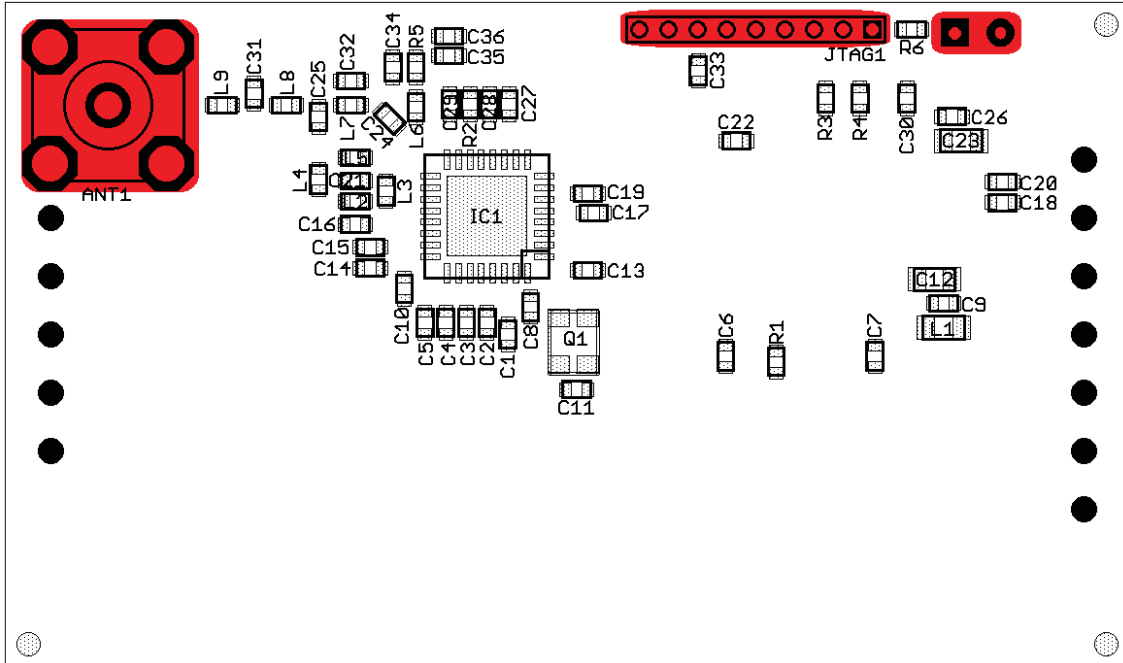Use only Hetronic approved lacquer.
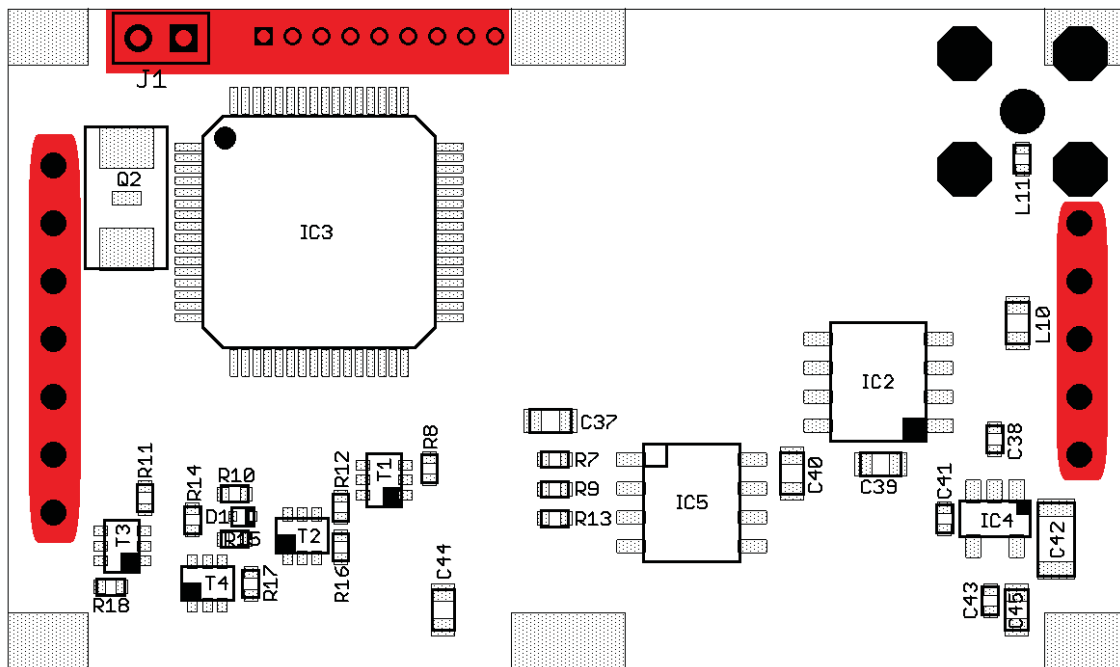

Figure 3: CSM-400UE Top Lacquer Mask

Figure 4: CSM-400UE Bottom Lacquer Mask

7.2. RF Shield

CSM-400UE should have the RF shield (Hetronic Part 18864 TEMP) soldered to the 6 ground pads on the edge of the bottom side of the board. Ground pads are highlighted below. RF shield should not be attached until **after** programming, testing and calibration.
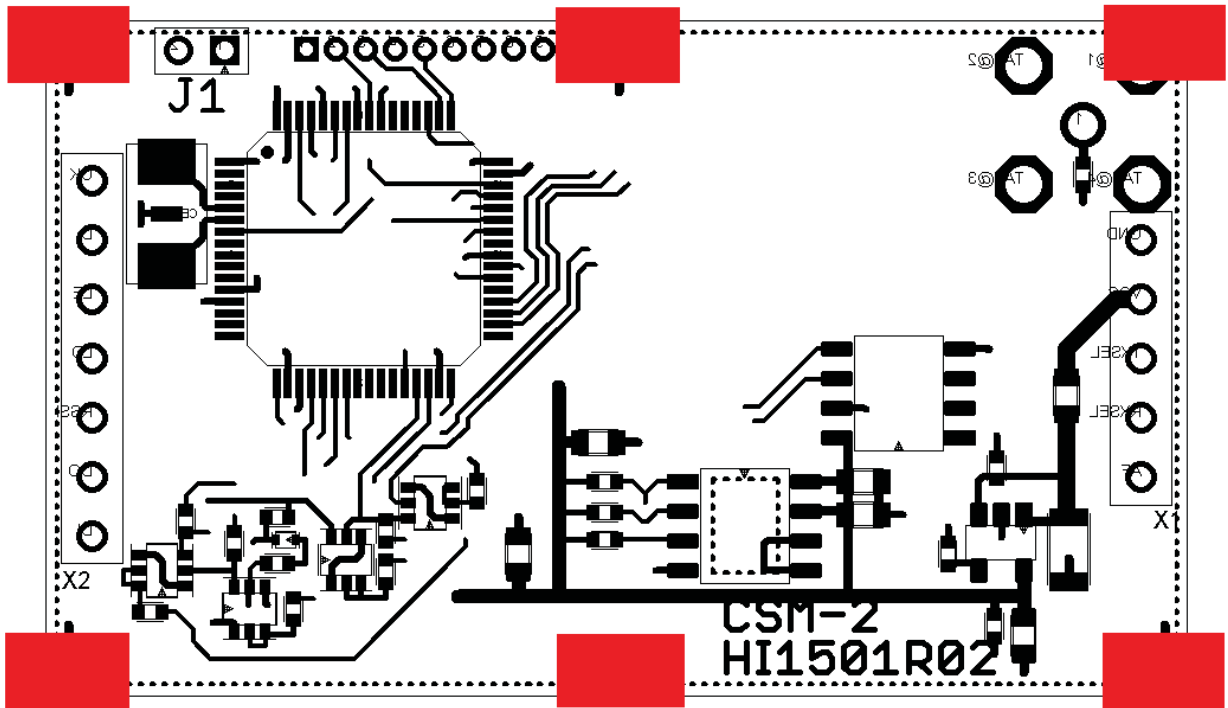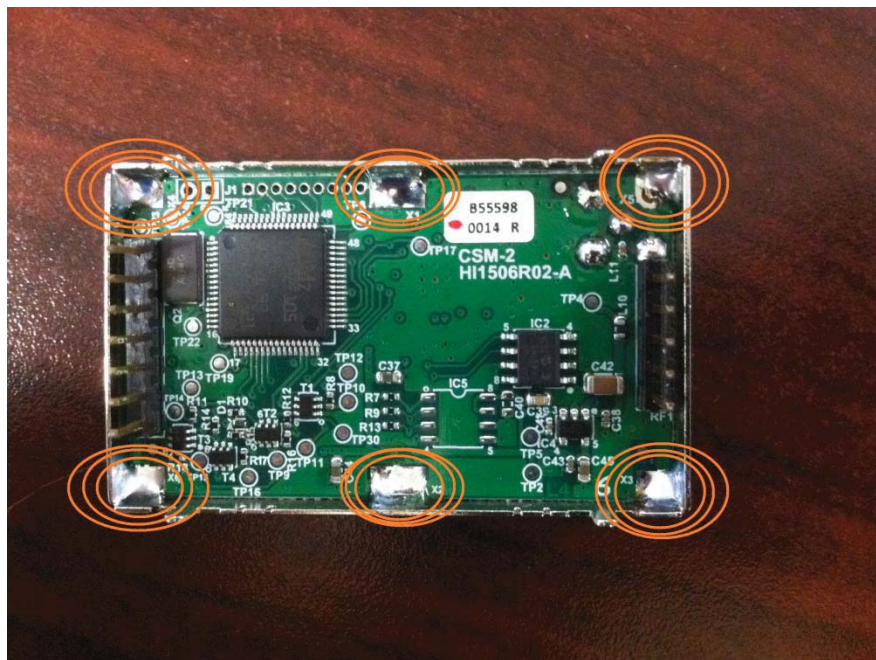

Figure 5: RF Shield Solder Pads

Figure 6: CSM-400UE with Soldered Shield

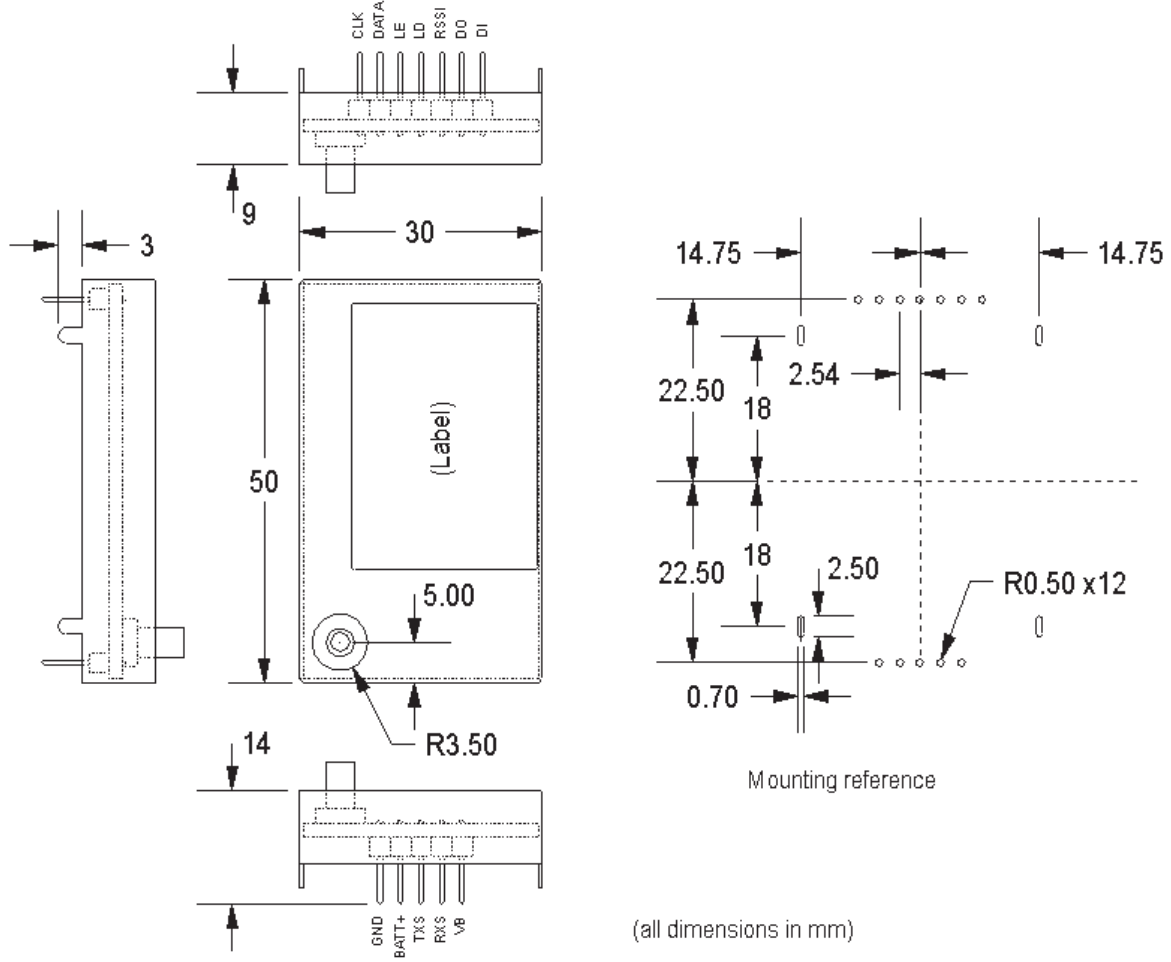# 8. MECHANICAL DRAWING

Figure 7: CSM-400UE Mechanical Drawing

9. <u>TEST PROCEDURE</u>

9.1. Equipment Needed

    1. CSM_CFG Adapter Board

    2. USB Cable

    3. RS-232 Cable

    4. 5V DC Power Supply

    5. SMB RF Cable

    6. 1GHz Spectrum Analyzer

    7. 1GHz RF Signal Generator

    8. PC

    9. H-Link PC Software and Dongle

    10. Digital Multimeter

    11. STMicroelectronics Flash Loader software

    12. Hetronic USB Flash Programmer software

9.2. Power Supply Verification

    1. Install the device in the CSM_CFG adapter. See figure below for connector reference:
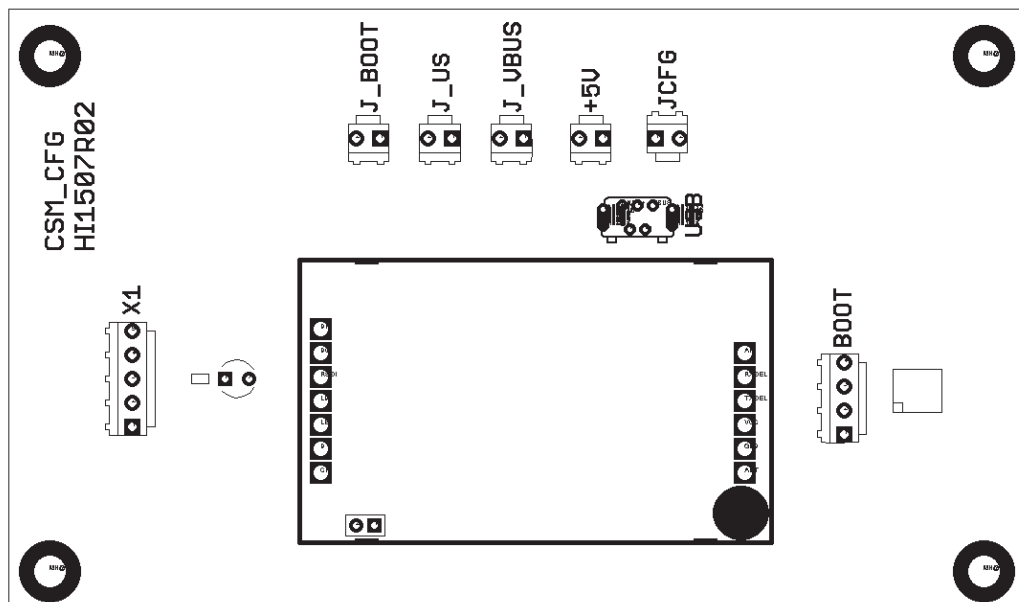
    2. Connect the adapter to the PC using a USB cable.

    3. Short the J_US jumper.

    4. Using DMM, verify 3.1V on the left-most pin of JTAG connector (closest to J1)
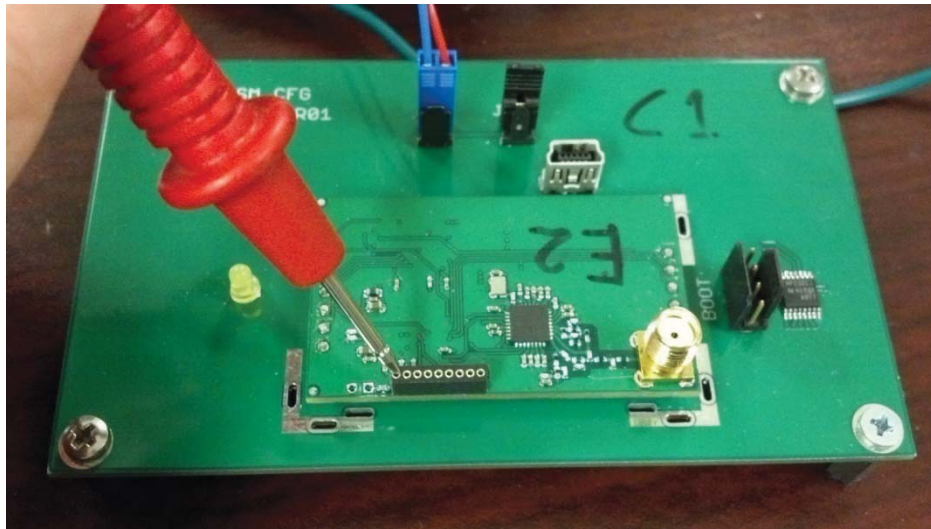
9.3. Bootloader Programming
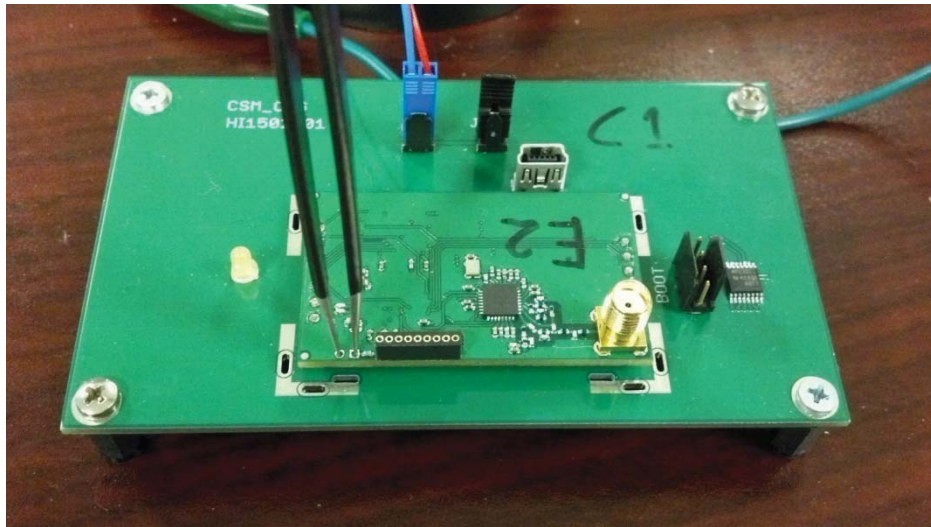
    1. Open the J_US jumper to remove power

    2. Short connector J1 on device to start device in boot mode

    3. Short the J_US jumper to apply power

    4. Connect RS-232 cable to connector BOOT on CSM_CFG

    5. Start STMicro Flash Loader

    6. Set appropriate COM port and other UART settings, then click Next

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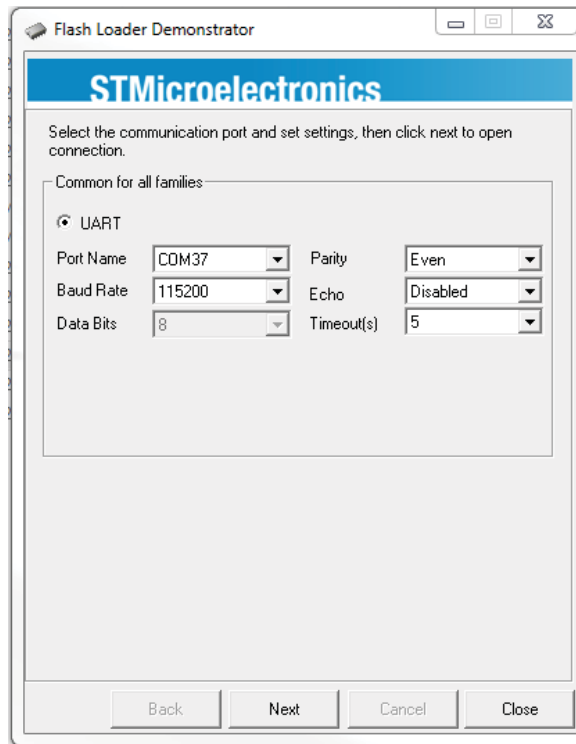
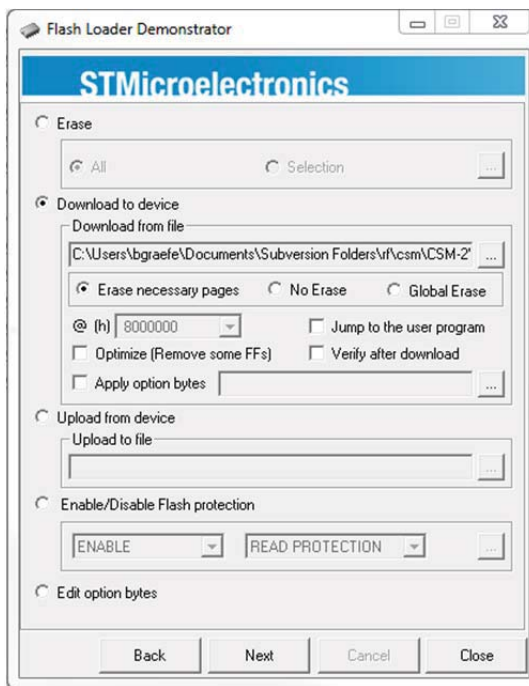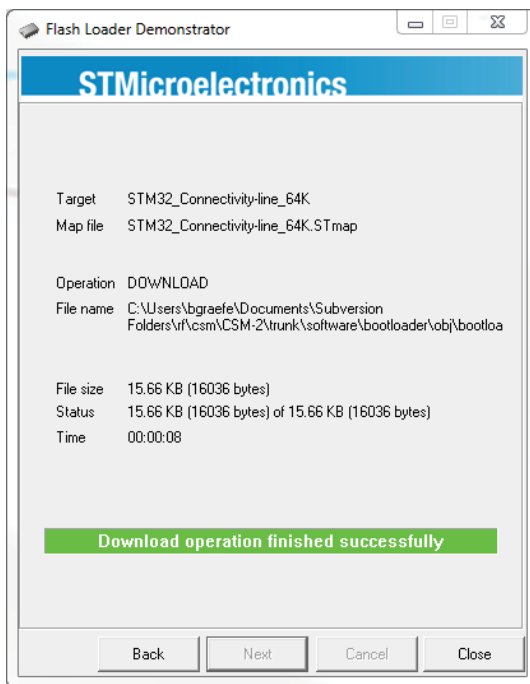7. On the following 'Target is Readable' page, click Next. On the following 'Target Select' page, click Next.

8. On the following page, select 'Download to device' and browse to bootloader.hex. Then click Next.

9. Wait for the Flash Loader to finish loading and the 'Download operation finished successfully' is displayed. Then click Close.

10. Disconnect RS-232 cable from CSM_CFG. Remove 5VDC from CSM_CFG. Open jumper J1 on CSM400UE.

9.4. Main Flash Application Programming

1. Open jumper J_US to remove power

2. Close jumper J_VBUS, then close jumper J_US to put the module in boot mode

3. Verify solid yellow LED on CSM_CFG

4. Start the USB Flash Programmer program.

5. After the USBFP connects to the CSM400UE, set the Memory Space to Application
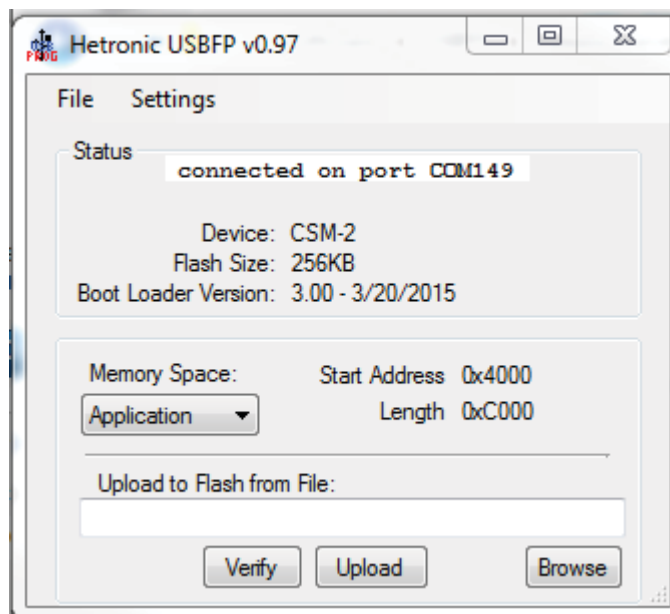
6. Click Browse to select csm2_app_rx.hex.

7. Click Upload. On the pop-up window click Yes.
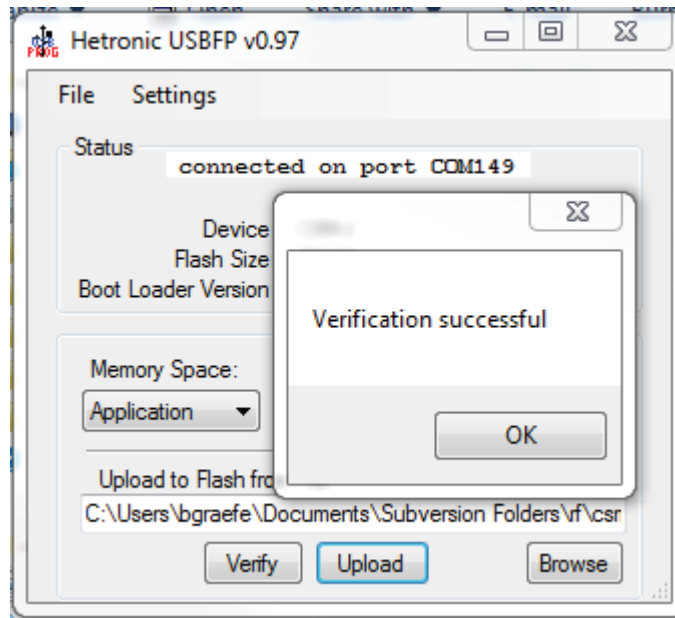
8. Wait for the loading to complete. On the Verification successful window click OK.

9. Close the USBFP software. Remove the USB cable from the CSM_CFG.

9.5. Calibration

After programming, each CSM-400UE must be calibrated at least once prior to operation. This calibration is to compensate for small variations in RF characteristics due to component tolerances.

9.5.1. Output Power Calibration

The output power of the module varies across its frequency range; this calibration procedure applies an internal offset to the output power depending on frequency to compensate for that variation:

1. Insert CSM-400UE into CSM_CFG and connect the USB cable. Connect CSM-400UE ANT to a calibrated Spectrum Analyzer using low-loss cable.

2. Close the J_US jumper, then J_VBUS. Insert the H-Link dongle into the PC.

3. Start the H-Link software. Press "Connect". This should load the CSM-400UE H-Link configuration menu. Go to the 'Calibration' tab.
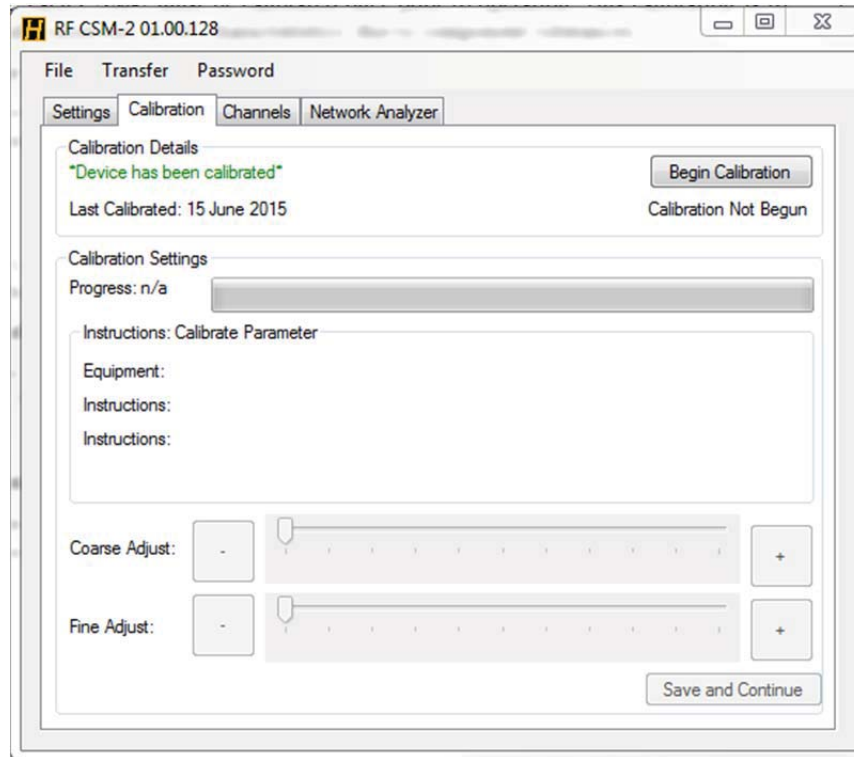
4. If the module has not yet been calibrated, a 'WARNING: Device not calibrated!' will be displayed. If the module has been calibrated, H-Link will show the date of the last calibration. Click 'Begin Calibration'.

5. Follow the instructions listed to configure the Spectrum Analyzer to 150MHz bandwidth centered at 450MHz. You should see a peak at 390MHz. Use the Peak Search function to find the peak power at 390MHz.
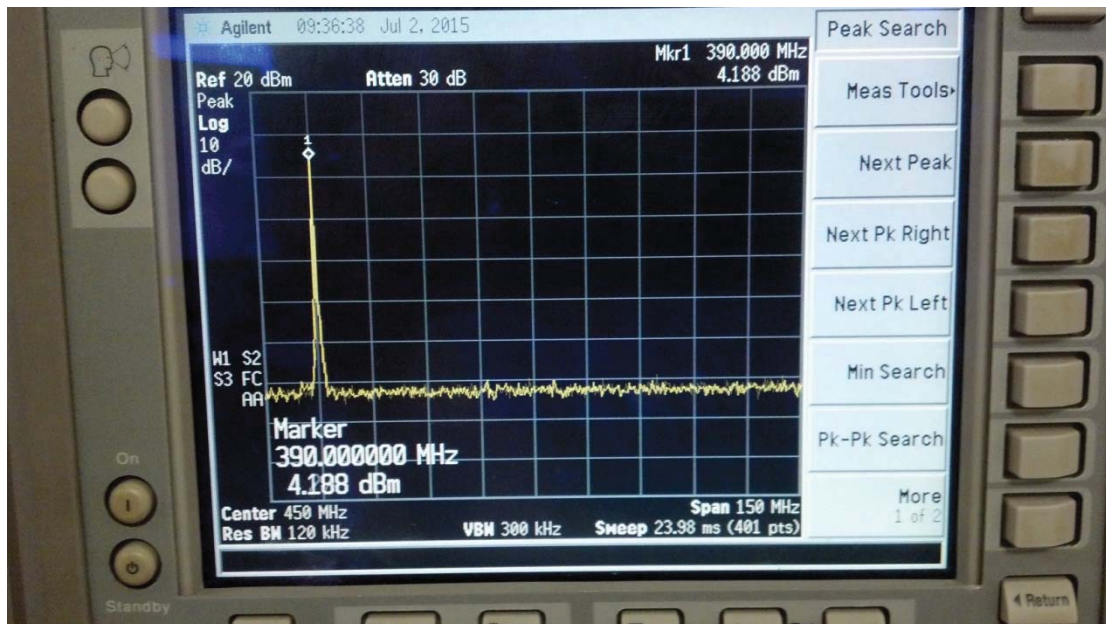
6. Use the "+" and "-" Coarse Adjust buttons to increase or decrease the peak power at 390MHz. Continue adjusting the power until it is with +/- 0.3dB of 0dBm.
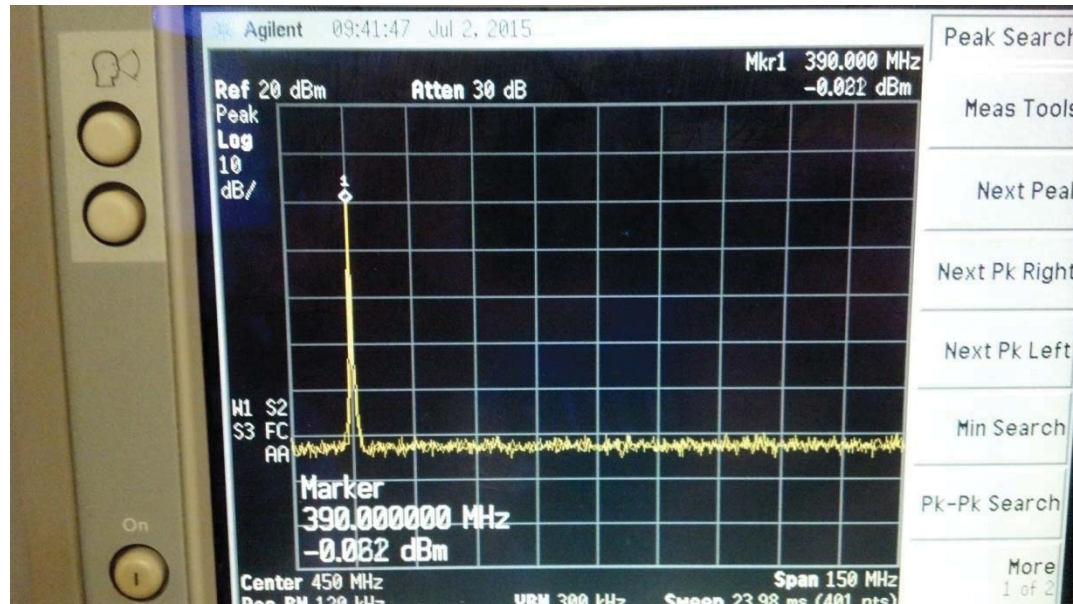

7. When the peak is within +/-0.3dBm, click 'Save and Continue', then click 'Yes' when prompted 'are you sure?'. This will move the peak frequency to 395MHz.

8. Repeat Step 6 and 7 for 395MHz, and each incremental frequency after that. The frequency will continue to increment by 5MHz up to 475MHz. After the 475MHz peak is calibrated, click 'Save and Continue' to continue to Frequency Calibration.
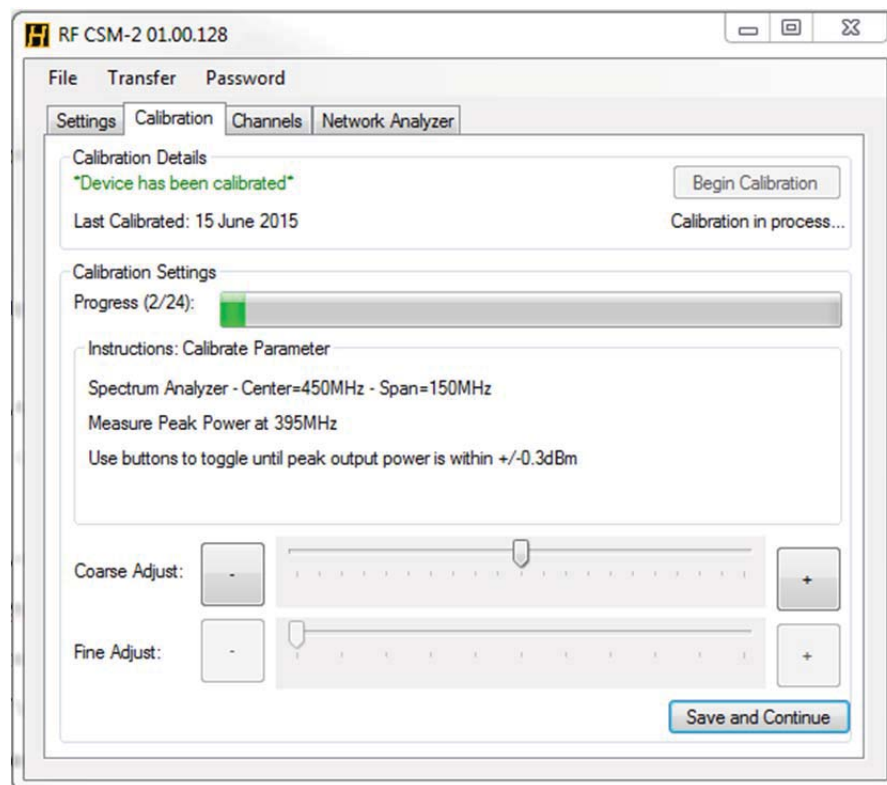
9.5.2. Frequency Calibration

This procedure fine-tunes the frequency setting of the module by applying a constant offset to the Frequency Synthesizer.

1. Follow the instructions displayed to configure the Spectrum Analyzer: set Center Frequency to 450MHz, Span to 100kHz, Resolution BW to 100Hz and Video BW to 30Hz. This should show the frequency synthesizer error more precisely.
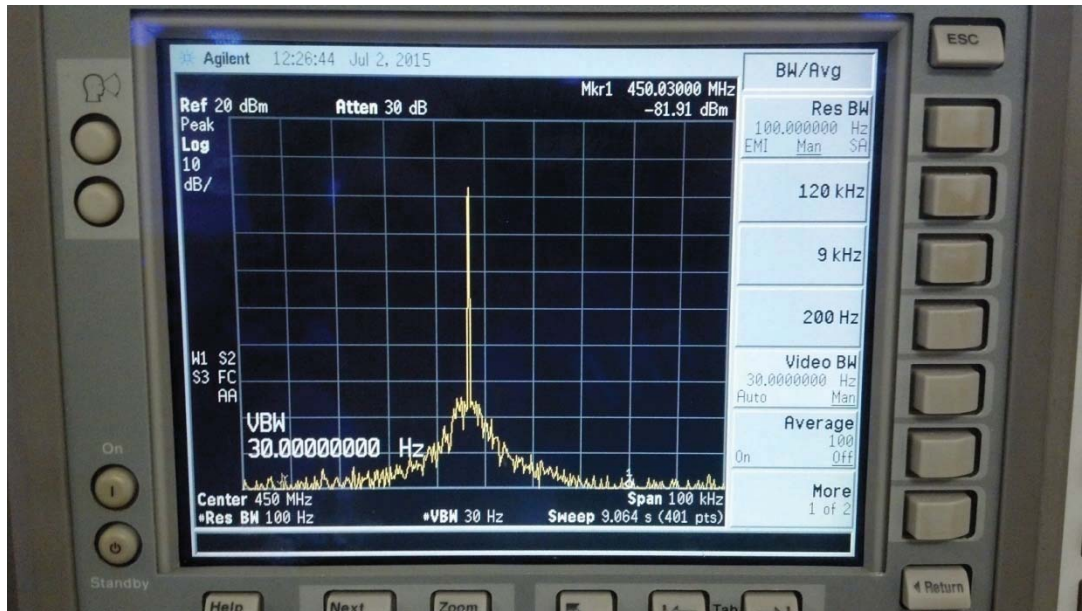
2. Use the "+" and "-" Coarse Adjust buttons to increase/decrease the frequency from the module until it is approximately centered at 450MHz.
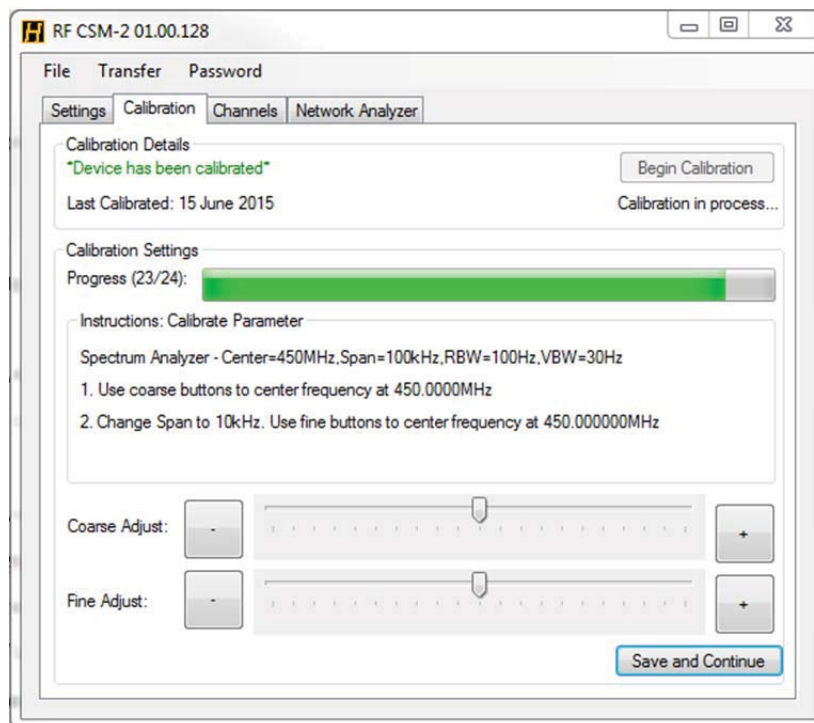
3. Configure the Spectrum Analyzer span to 10kHz to see the frequency error more precisely. Use the "+" and "-" Fine Adjust buttons to increase/decrease the frequency from the module until it is exactly 450MHz.

4. When finished, press 'Save and Continue'.
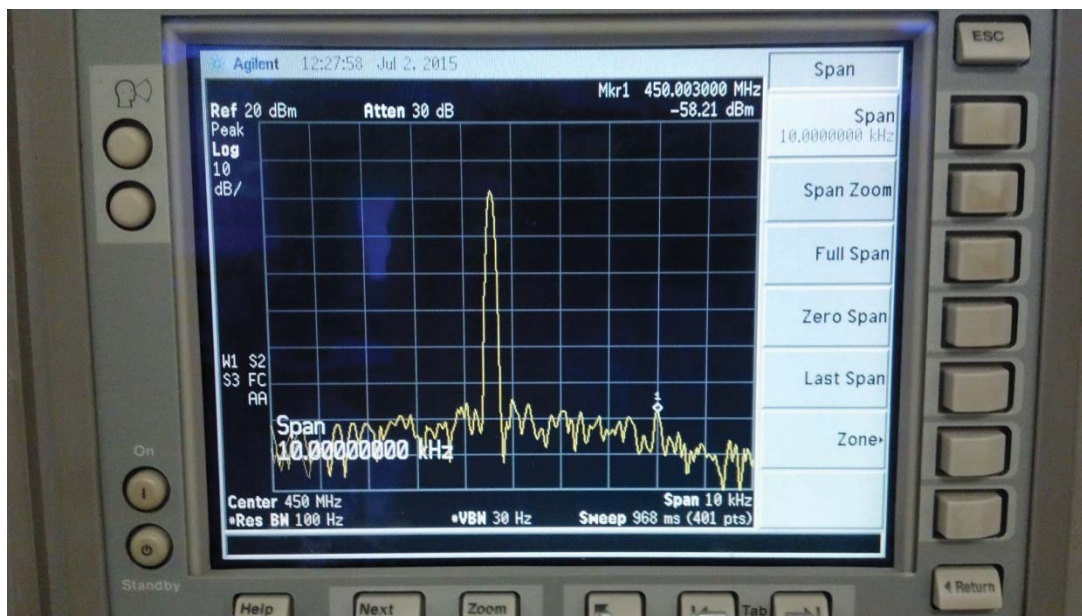
9.5.3. RSSI Calibration

The CSM-400UE has a built-in power detector capability. This calibration sets the reference level so the power detector can return received RF power in dBm:

1. Connect the output of the RF Signal Generator to the antenna port of the radio module using a low-loss cable. Configure the Signal Generator to output 450.000000MHz, no modulation, at a power of exactly -60dBm.

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2. The PC should display what the current un-calibrated power measurement is as "RSSI = [x]dBm". Use the "+" and "-" Coarse Adjust buttons to adjust the measured power level until it reads "-60dBm".
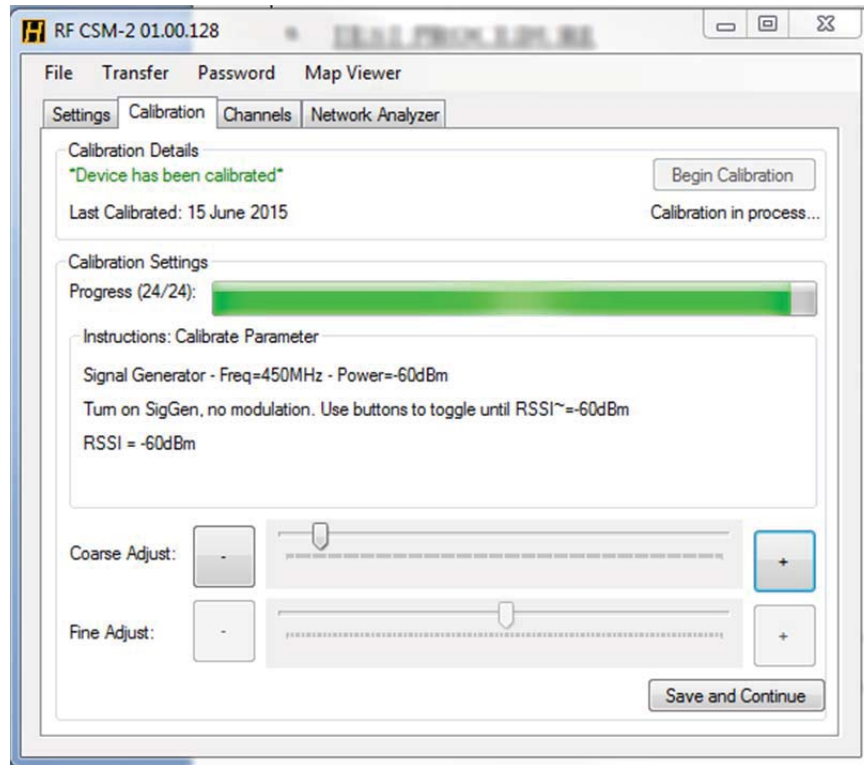
3. When finished, press 'Save and Continue'. Device Calibration is now complete. Before disconnecting the module, go to the 'Transfer' drop-down on the top bar and select 'Save Settings to Device'. Click 'Yes' when asked if user is sure, and wait for the settings to fully download.

4. When settings are finished downloading, close H-Link, open the J_US and J_VBUS jumpers before removing the module.