EVM User's Guide: BP-CC1407P-X-FE

BP-CC1407P-8-FE and BP-CC1407P-9-FE for CC1407P OFDM, O-QPSK, and FSK Transceiver

Description

The BP-CC1407P-8-FE and BP-CC1407P-9-FE speed up development for the CC1407P High-Performance Sub-1GHz OFDM, O-QPSK, and FSK Transceiver . The CC1407P BoosterPack™ can be used together with a host LaunchPad™ for software development or directly connected to an XDS debugger for use with SmartRF™ Studio 8 for RF testing. A TRX Host Driver is part of the Simplelink™ TRX Plugin and can be ported to other MCUs.

Get Started

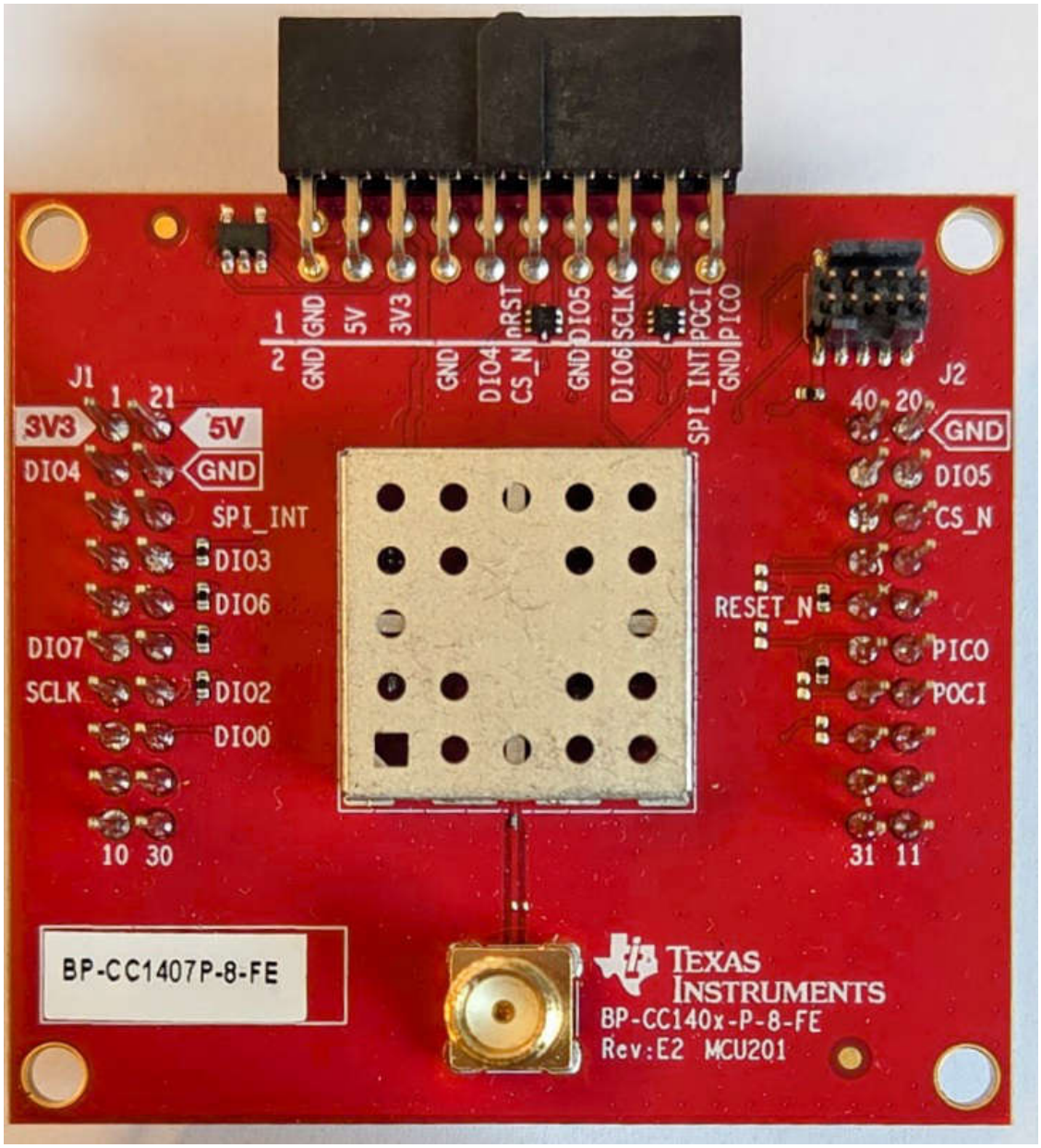
- Order the BP-CC1407P-8-FE or BP-CC1407P-9-FE BoosterPack
- Download the SDK listed under "Dependencies" in the release note for the SimpleLink™ Low Power Transceiver (TRX) plugin
- Download the comprehensive reference design files
- See the latest CC1407P product page

Features

- CC1407P High-Performance Sub-1GHz OFDM, O-QPSK, and FSK Transceiver

Applications

- Energy infrastructure
  - Energy storage systems: Wireless Battery Management System, Portable power station,
  - Smart meters: Electricity meter, Gas meter, Heat meter, Water meter, Data concentrators
  - Solar energy: Solar energy, wireless communications
  - Smart circuit breakers and electrical panels : Smart electrical panel, Solid state circuit breaker (SSCB)
- Building automation
  - Building security systems: Automated door and gate, Building security gateway, Door and window sensor, Electronic smart lock, Garage door system, Glass break detector, IP network camera; Occupancy detection (people tracking, people counting)
  - HVAC system: Air conditioner indoor unit, Air conditioner outdoor unit, HVAC controller, HVAC fluid leak detector, HVAC gateway, HVAC motor control, HVAC valve & actuator control, Thermostat, Wireless environmental sensor
  - Fire safety system: Fire alarm control panel (FACP), Gas detector, Smoke & heat detector
  - Lighting: Area & landscape lighting, Exit & emergency lighting, Lighting sensor, Residential lighting, Smart plug, Wireless control
- Industrial automation
  - Field transmitter and sensor: Flow transmitter, Position sensor, Level transmitter, Pressure transmitter, Temperature transmitter,
- Medical & healthcare
  - Hospital patient care: Electrocardiogram (ECG), Electronic bed & chair, Multiparameter patient monitor
- Robotics
  - Home service robot: Robotic lawn mower, Vacuum robot
  - Humanoid robot: Humanoid robot position sensor, Humanoid robot sensor module



1 Evaluation Module Overview

1.1 Introduction

The highest performance design or full entitlement (FE) design covers the broadest customer requirements, including showcasing the new integrated ultra-LNA (µLNA) that enables the integration of SAW filters without the drawback of losing 2dB to 3dB of receive sensitivity.

- Longest range (+22dBm transmit)
- Best sensitivity (4dB improvement using µLNA)
- Most robust receive in presence of 5G

1.2 Kit Contents

- CC1407P OFDM, O-QPSK, and FSK Transceiver
- +14dBm single-ended high efficiency PA for FSK
- +22dBm differential high power PA for FSK, O-QPSK, and OFDM
- Single-ended RX with uLNA enabled 2-port RF switch controlled directly by the CC140xP
- SMA connector
- 40-pin dual-gender BoosterPack connectors

1.3 Specification

The BoosterPack has been designed to enable the full performance of the device as follows:

- Up to +16dBm average output power with SUN OFDM
- Up to +22dBm output power with FSK, O-QPSK, and OFDM-LR
- Up to +14dBm output power in single-ended mode by using the high efficiency PA

1.4 Device Information

Both BoosterPacks include a SAW filter in the receive path. The board targeting the ETSI regulations is designated with -8 and the board targeting FCC and ARIB is designated with -9.

2 Hardware

Figure 2-1 shows the location of the CC1407P BoosterPack connectors. The CC1407P RF transceiver and antenna locations are also shown.

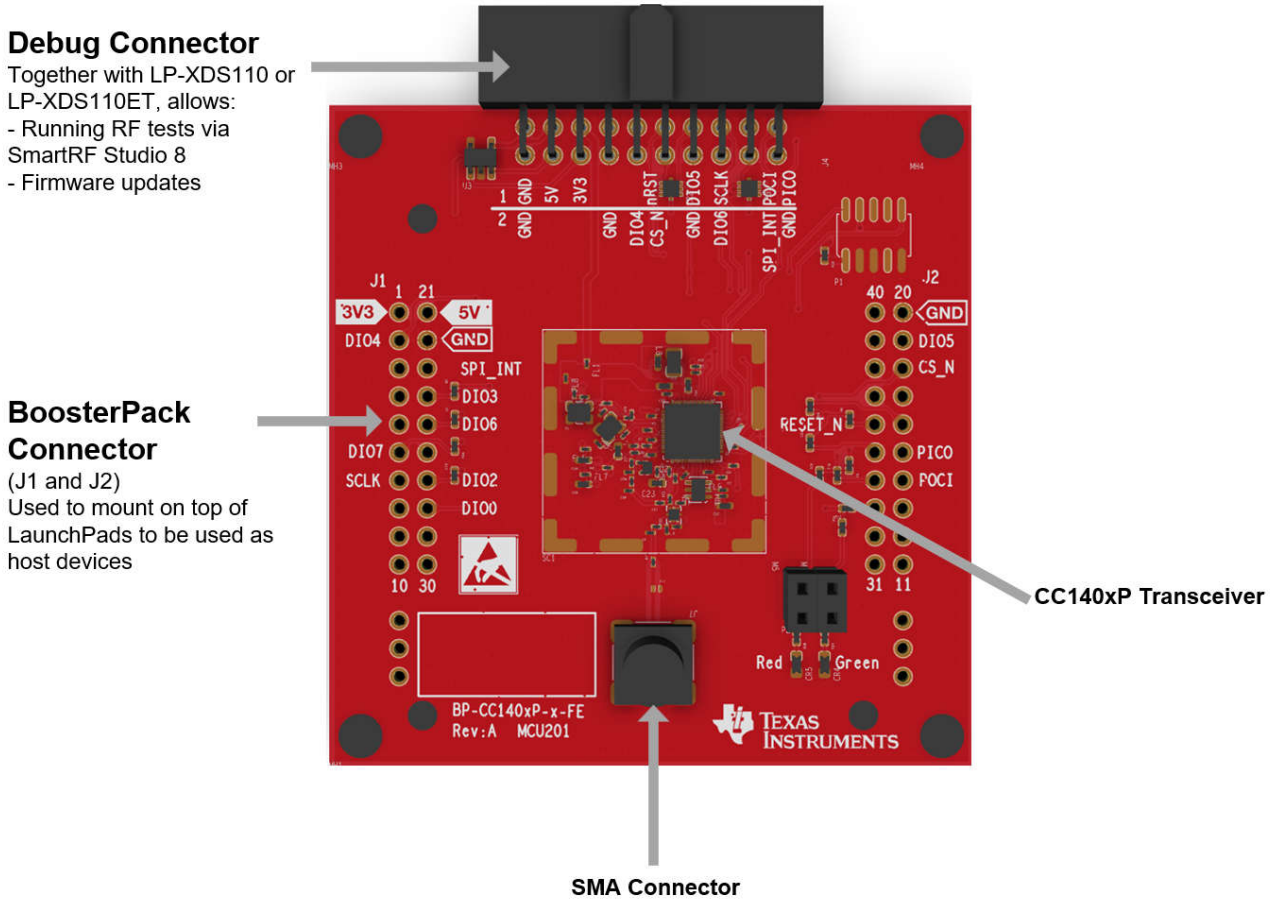


Figure 2-1. CC1407P BoosterPack Connector and User Interface Layout

2.1 Power Requirements

The BoosterPack is designed to be powered from an XDS debugger (LP-XDS110 or LP-XDS110ET) through the 20-pin edge connector, from a LaunchPad through the GND and 3V3 pin header, or from an external power supply directly connected to the GND and 3V3 pin header.

When powering from an XDS debugger, the voltage is fixed to 3.3V. When powering from a Launchpad, the voltage is also fixed to 3.3V if the Launchpad is connected to an XDS debugger. If an external power supply is used, care must be taken to keep the board voltage within the operating range (1.8V to 3.6V).

2.2 Hardware and Debug Setup

2.2.1 Setup to use a LaunchPad as the Host Device

The basic hardware setup is a CC1407P BoosterPack stacked on top of a CC13xx LaunchPad (LP-CC1312R7, LP-CC1352P7, LP-EM-CC1314R10, or LP-EM-CC1354P10) or an LP-CC2652R7. The LaunchPad acts as the host MCU for the CC1407P transceiver. The LP-EM-CC1314R10 and LP-EM-CC1354P10 are split LaunchPads, which means they need to be used together with an XDS debugger (LP-XDS110 or LP-XDS110ET). See Figure 2-2 for one possible setup.

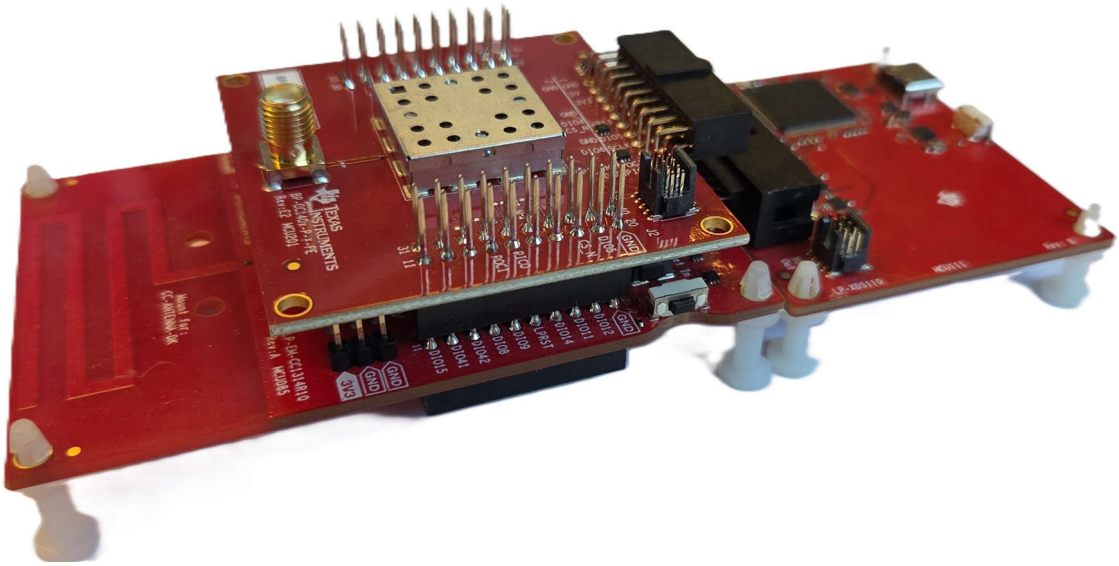


Figure 2-2. CC1407P BoosterPack Stacked on Top of the CC1314R10 LaunchPad (+ LP-XDS110)

2.2.2 Setup to use the BoosterPack with SmartRF Studio 8

An LP-XDS110 or LP-XDS110ET is used to interface between SmartRF Studio 8 and the CC1407P device on the BoosterPack through the 20-pin edge connector. To use the BoosterPack with SmartRF Studio 8, simply connect the 20-pin edge connector to the XDS debugger as shown in Figure 2-3 and connect the XDS debugger to a computer with a USB cable.

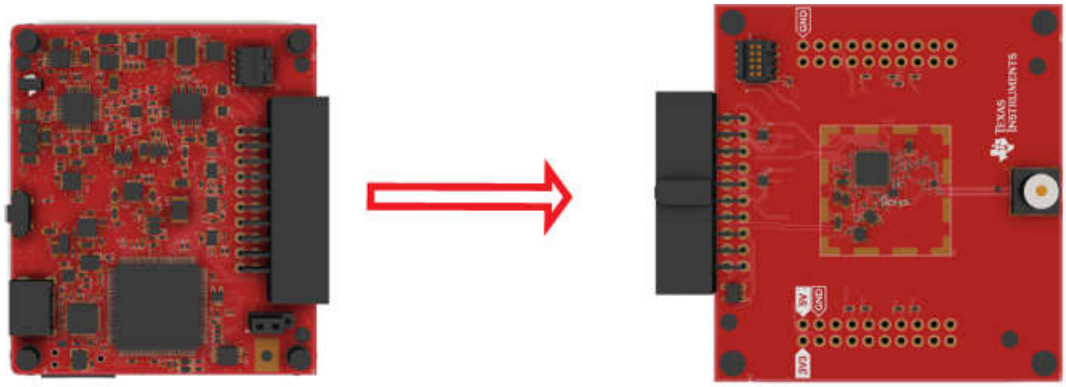


Figure 2-3. BoosterPack Connection to XDS Debugger

2.3 BoosterPack Connection Pinout

The BoosterPack header connection diagram can be seen in Figure 2-4.

Note

DIO2 and DIO3 are used by the CC1407P to control the RF switch.

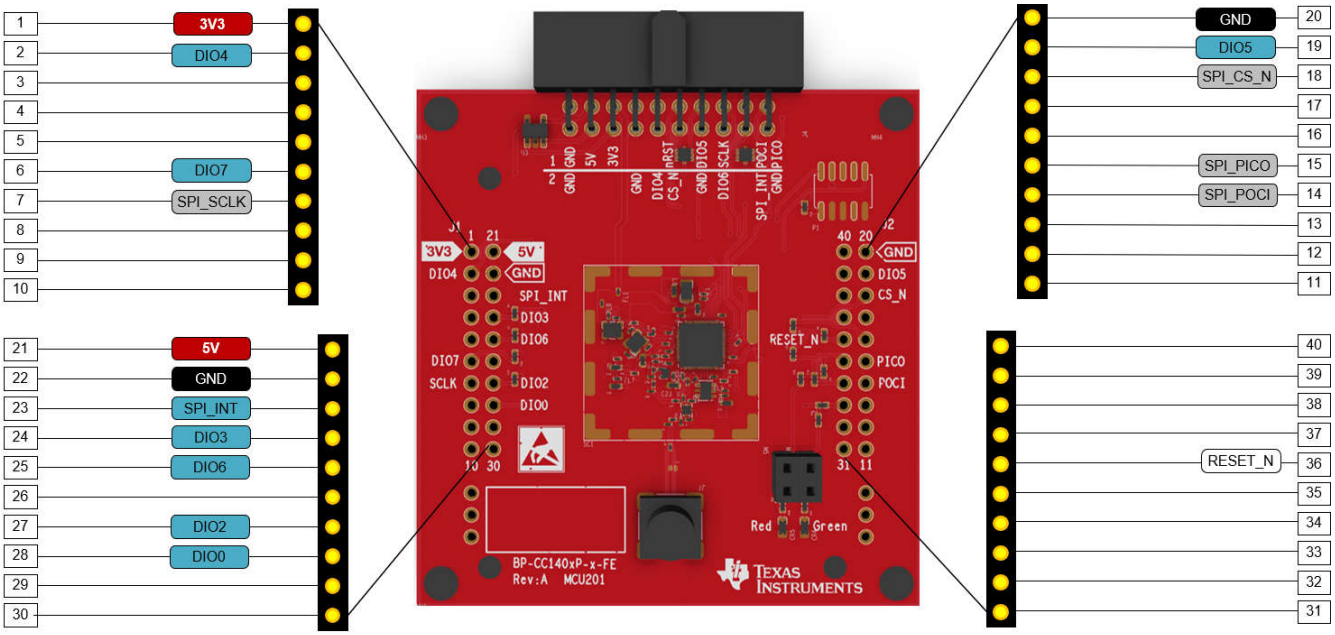


Figure 2-4. BoosterPack Pinout

Table 2-1 shows which signals are mandatory and which are optional.

Table 2-1. Optional and Mandatory Signals on the BoosterPack

BoosterPack Header Pin	Signal	Optional/Mandatory
1	3V3	Mandatory
2	DIO4	Optional
6	DIO7	Optional
7	SPI_SCLK	Mandatory
14	SPI_POCI	Mandatory
15	SPI_PICO	Mandatory
18	SPI_CS_N	Mandatory
19	DIO5	Optional
20	GND	Mandatory
21	5V	Optional
22	GND	Optional
23	SPI_INT	Mandatory
24	DIO3	Optional
25	DIO6	Optional
27	DIO2	Optional
28	DIO0	Optional
36	RESET_N	Mandatory

Table 2-2 shows what IO functions can be output on the different DIOs.

Table 2-2. Available IO Functions

Available IO Functions	Description
GPIO_SET_0	GPIO is set high
GPIO_SET_1	GPIO is set low
LOW_PA_AND_HIGH_PA	Goes high when low PA or high PA are enabled
LOW_PA_AND_LNA	Goes high when low PA or LNA are enabled
HIGH_PA_AND_LNA	Goes high when high PA or LNA are enabled
HIGH_PA_AND_LOW_PA_AND_LNA	Goes high when high PA, low PA or LNA are enabled
TCXO_EN(1)	Goes high when the TCXO needs to be enabled. (only applies if TCXO is selected as clock source)
INPUT_TRIGGER	Used to trigger the start of commands
SFD	GPIO goes high when the sync word is detected
ENERGY_DETECT	Goes high when energy is detected above the RSSI threshold
PREAMBLE_DETECT	Goes high when the preamble is detected
LNA	Goes high when the LNA is enabled
LOW_PA	Goes high when the low PA is enabled
HIGH_PA	Goes high when the high PA is enabled
RF_TRACE	Tracer signal
UNCHANGED	GPIO is unchanged

(1) Using a TCXO as a clock source is currently not supported. When TCXO is supported, only DIO2, DIO3, and DIO6 can be used to enable it.

2.4 GPIO Connections for CC1407P

Figure 2-5 shows signals to connect between host MCU and the CC1407P.

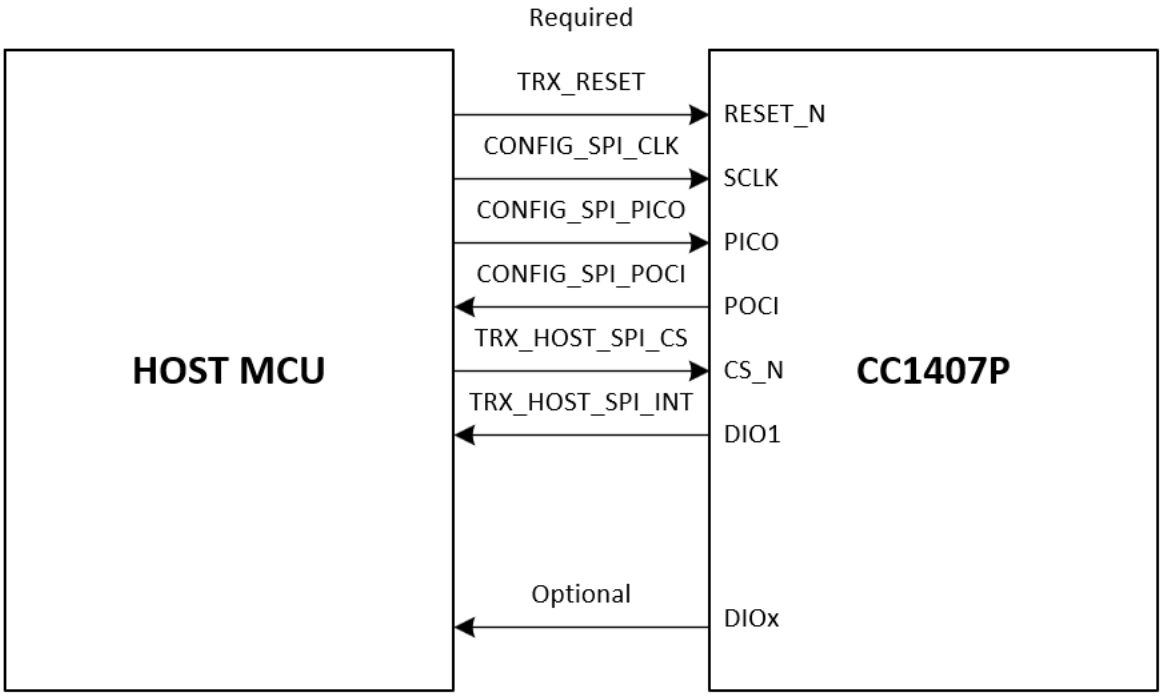


Figure 2-5. Connections between the CC1407P and the Host MCU

A description of the different signals is found in Table 2-3.

Table 2-3. Signal Description

CC140xP Pinout	Signal Name	Comment
RESET_N	TRX_RESET	CC1407P reset signal
SCLK	CONFIG_SPI_CLK	SPI Clock
PICO	CONFIG_SPI_PICO	SPI Peripheral In Controller Out
POCI	CONFIG_SPI_POCI	SPI Peripheral Out Controller In
CS_N	TRX_HOST_SPI_CS	SPI Chip Select
DIO1	TRX_HOST_SPI_ INT	Interrupt signal from the CC1407P to the host (used to signal data is ready to be transmitted to the host).

2.5 LEDs

The BoosterPack includes a red LED and a green LED. The LEDs can be controlled directly by the CC1407P or connected to GPIOs of the host device.

When two jumpers are placed on **P2** as shown in Figure 2-6, the red LED is connected to **DIO5**, and the green LED is connected to **DIO6**. The CC1407P signals that can be routed to the LEDs are shown in Table 2-2.

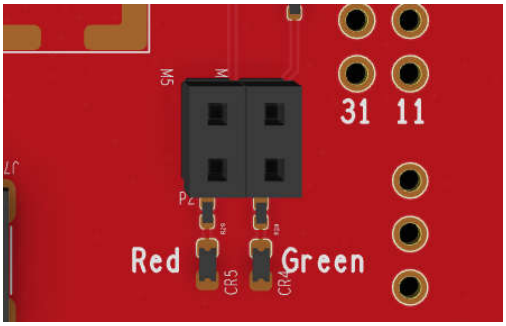


Figure 2-6. LED Jumpers Mounted on P2

When the two jumpers are removed as shown in Figure 2-7, a jumper cable can be placed on **pin 1** of **P2** to connect the red LED to a GPIO of the host device and on **pin 3** to connect the green LED.

The examples in the SimpleLink Low Power Transceiver (TRX) plugin use the LEDs of the LaunchPad (host device) to indicate various events such as packet reception and packet transmission. These signals can instead be connected to the LEDs of the BoosterPack. Refer to the examples to know which DIOs of host device are being used for LED control.

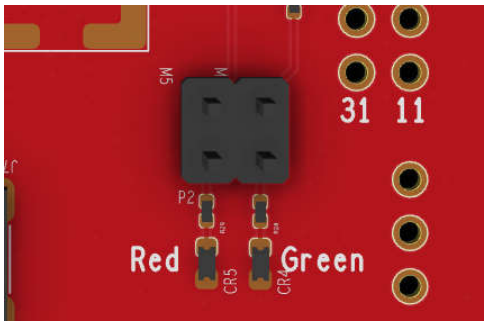


Figure 2-7. LED Jumpers Removed from P2

2.6 RX SAW Filter

The BP-CC1407P-8-FE and BP-CC1407P-9-FE feature a SAW filter connected between the µLNA and RF_N. The BP-CC1407P-8-FE has a SAW filter with a pass band of 863MHz to 870MHz and the SAW filter on the BP-CC1407P-9-FE has a pass band of 902MHz to 928MHz. Optionally, the BoosterPack can be used without a SAW filter by removing the SAW filter (FL2) shown in Figure 2-8 and placing a 100pF 0201 capacitor on C35 and on C36, as shown in Figure 2-9.

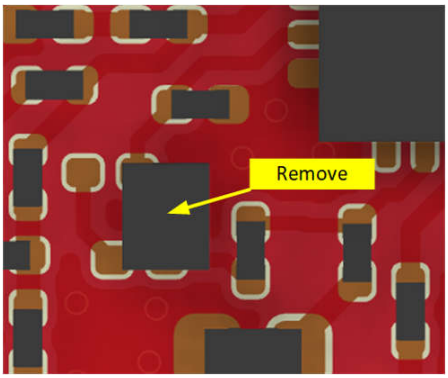


Figure 2-8. Remove FL2

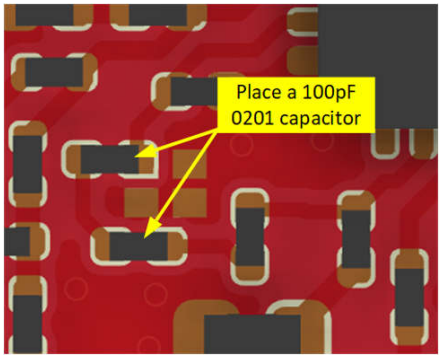


Figure 2-9. Place C35 and C36

3 Software

3.1 Getting Started

The best way to start development with your CC1407P BoosterPack is to download the SimpleLink™ Low Power Transceiver (TRX) plugin. The plugin contains the host driver and examples implemented for the following F2 family devices:

- CC1312R7
- CC1352P7
- CC2652R7
- CC1314R10
- CC1354P10

If you want to use the F2 example applications, you must first install the SimpleLink Low Power F2 SDK (install the version listed under "Dependencies" in the Plugins release note). After installing the SDK, install the plugin in the same directory as the SDK was installed by default (C:\ti).

The code examples for the CC1407P are found in the following location:

/simplelink_trx_plugin_x_xx_xx_xx\examples/rtos/LP_CCxxxx/trx_prop_rf/

Each example comes with a README.md file with detailed descriptions of the application. Please review the README file of the example you want to use.

3.2 SmartRF Studio 8

SmartRF Studio 8 is a tool that allows users to perform RF tests and to export PHY configurations through a graphical user interface. CC1407P devices in SmartRF Studio 8 are supported from version 1.4.0.97.

3.2.1 Code Export from SmartRF Studio

The code export window can be used to export code structures to configure the device and is useful when you want to generate new PHY settings to integrate into an embedded project or change PHY settings for an existing code example.

The rfPacketTxGenFSK example from the TRX plugin runs default the 2gfsk50kbps PHY, but can easily be changed to run with a general purpose PHY generated using SmartRF Studio.

1. Start by importing the rfPacketTxGenFSK from the TRX plugin to your example folder.

   Example: C:\CodeExamples\TRX\CC140xP
2. Under PHY SELECTION in SmartRF Studio (see Figure 3-1).
   a. Select the General purpose GFSK.
   b. Select Create custom PHY, and implement any necessary changes (for this example we are changing the sync word).
   c. Press the "Code Export" button.

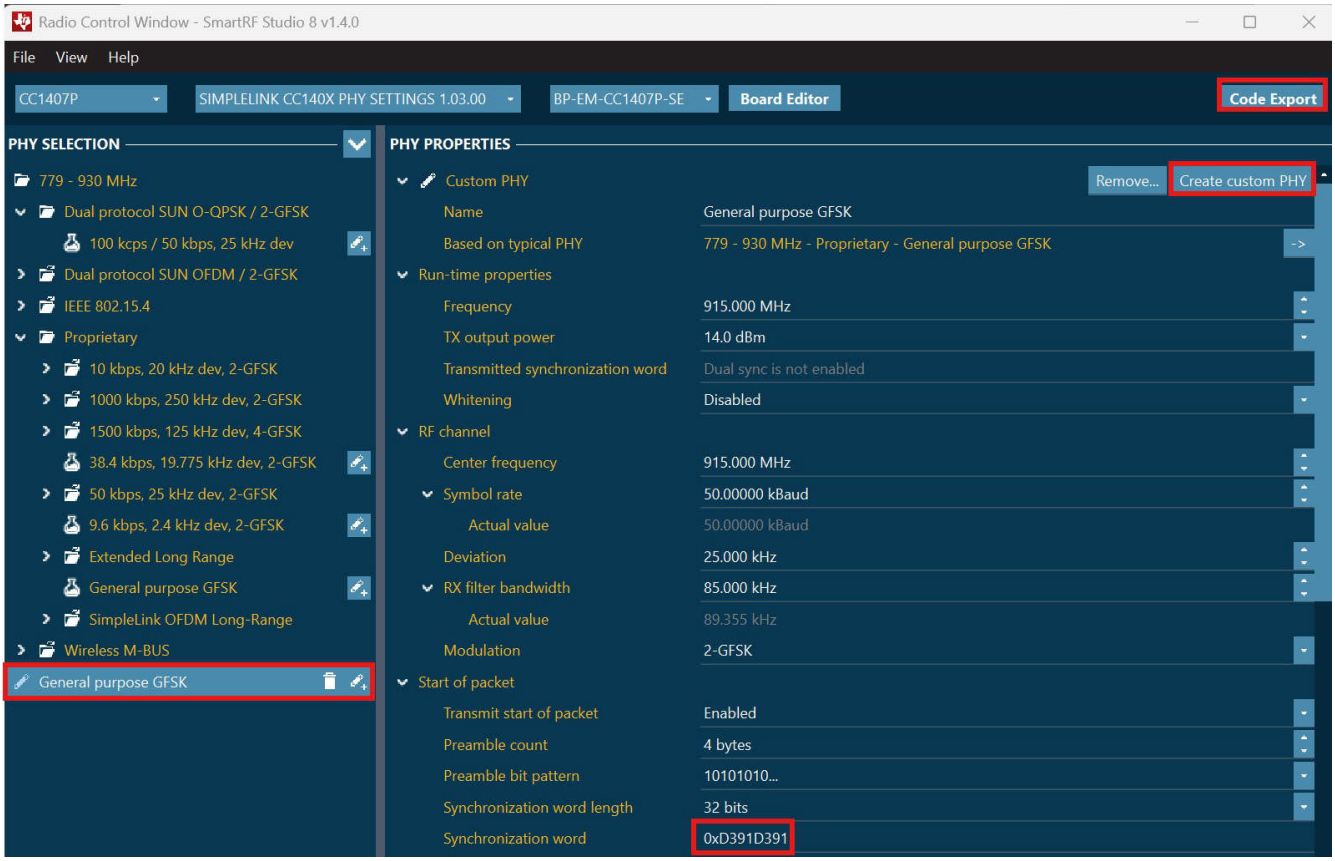


Figure 3-1. Export Modified genFsk PHY

3. Input the Output directory and Base file name for the new settings and select File->Save All (see Figure 3-2).

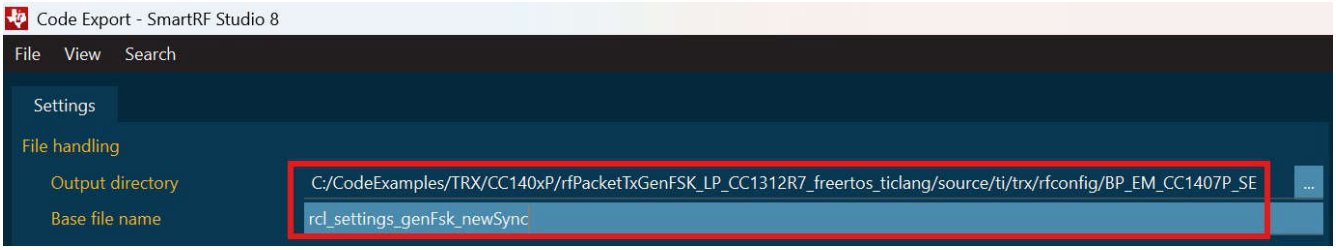


Figure 3-2. File Name and Location for Code Export

4. Select the folder where you want to store the files (see Figure 3-3).

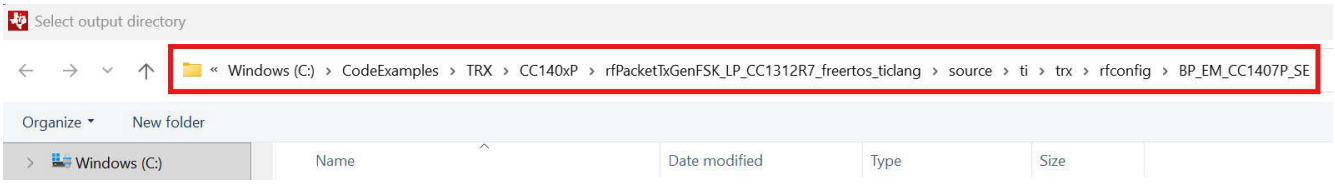


Figure 3-3. Output Directory

5. Implement the below changes to the rfPacketTxGenFSK (see Figure 3-4).

```
// LRF register configurations
//#include "source/ti/trx/rfconfig/BP_EM_CC1407P_SE/rcl_settings_2gfsk50kbps.h"
#include "source/ti/trx/rfconfig/BP_EM_CC1407P_SE/rcl_settings_genFsk_newSync.h"

// .
// .

/* Size of the PHY configuration structure (found in rcl_settings_2gfsk50kbps.h) */
//#define RF_CONFIG_SIZE (LRF_mainRegConfig_2gfsk50kbps_byteCount)

/* Pointer to the PHY configuration structure (found in rcl_settings_2gfsk50kbps.h) */
//#define RF_CONFIG_PTR  ((uint8_t *)LRF_mainRegConfig_2gfsk50kbps)

/* Size of Frontend Configuration structure (found in rcl_settings_2gfsk50kbps.h) */
//#define FE_CONFIG_SIZE (LRF_frontendRegConfig_2gfsk50kbps_byteCount)

/* Pointer to Frontend Configuration structure (found in rcl_settings_2gfsk50kbps.h) */
//#define FE_CONFIG_PTR  ((uint8_t *)LRF_frontendRegConfig_2gfsk50kbps)


/* Size of the PHY configuration structure (found in rcl_settings_genFsk_newSync.h) */
#define RF_CONFIG_SIZE (LRF_mainRegConfig_byteCount)

/* Pointer to the PHY configuration structure (found in rcl_settings_genFsk_newSync.h) */
#define RF_CONFIG_PTR  ((uint8_t *)LRF_mainRegConfig)

/* Size of Frontend Configuration structure (found in rcl_settings_genFsk_newSync.h) */
#define FE_CONFIG_SIZE (LRF_frontendRegConfig_byteCount)

/* Pointer to Frontend Configuration structure (found in rcl_settings_genFsk_newSync.h) */
#define FE_CONFIG_PTR  ((uint8_t *)LRF_frontendRegConfig)

// .
// .

cmdTx.slot = TX_CMD_SLOT;
cmdTx.cmd_id = TRX_RadioCommand_Transmit;
cmdTx.enable_on_true = false;
cmdTx.enable_on_false = false;
cmdTx.enable_on_compare = false;
cmdTx.trigger = Command_Trigger_Immediate;
cmdTx.conflict_policy = TRX_ConflictPolicy_AlwaysInterrupt;
cmdTx.allow_delay = false;
cmdTx.params.tx.phy0.config_id = RF_CONFIG_ID;

//cmdTx.params.tx.phy0.option_mask = TRX_PHY_FEATURE_WHITENING_DISABLED_2GFSK50KBPS;
cmdTx.params.tx.phy0.option_mask = TRX_PHY_FEATURE_WHITENING_DISABLED;

cmdTx.params.tx.pa = TRX_TxPa_High; //see also TRX_TxPa in TRX.h
cmdTx.params.tx.stream_id = TX_STREAM_ID;
cmdTx.params.tx.frequency = RF_FREQUENCY_KHZ;
cmdTx.params.tx.modem = TRX_RadioCommand_Modem_FSK;
cmdTx.params.tx.power.rawValue = TRX_MAX_POWER;
```

Figure 3-4. Necessary Code Changes

3.3 Transceiver Firmware Update

Although TI owns the development of the firmware running on the CC1407P, the end user still plays a critical role in the security story of the device.

Your CC1407P comes preloaded with trusted firmware, but updates from TI, which can provide additional security or additional features, are supported. The CC1407P comes equipped with a Secure Serial Bootloader (SSBL). An example, ssbl_host, is available in the TRX plugin, that can be used to download new firmware. SmartRF Studio 8 can also be used to update the transceiver firmware.

Note

If you are not able to update the firmware using SmartRF Studio or the ssbl_host, please contact TI.

3.4 Updating the Transceiver Firmware using SmartRF Studio 8

1. Connect the CC1407P BoosterPack to the XDS110.
2. Open SmartRF Studio 8.
3. Under device selection, the CC140xP device and the current firmware version is shown (Figure 3-5).

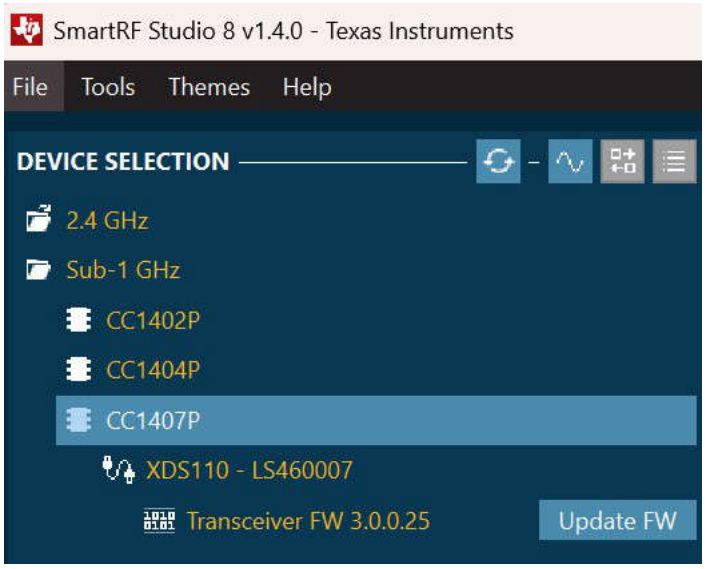


Figure 3-5. Device and Current Firmware Version

4. Select the "Update FW" button.
5. SmartRF Studio for CC1407P includes a firmware version and is shown under "Included firmware version" (Figure 3-6). If the CC1407P needs to be updated with a different firmware, select "Firmware update binary file" and select the location of the binary file.

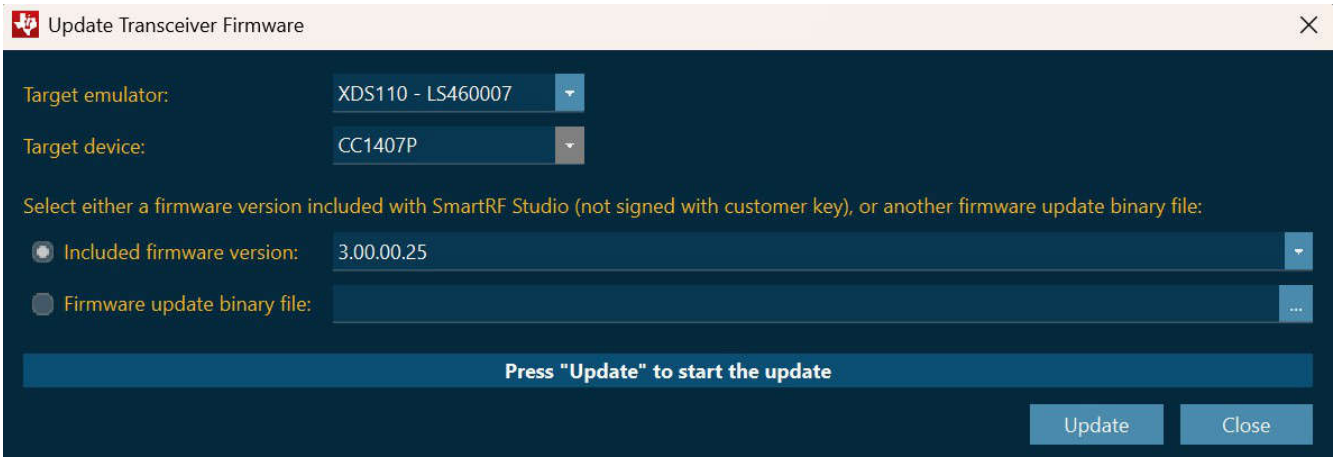


Figure 3-6. Included Firmware Version

6. Select "Update".
7. If the update is successful, the message "Update completed successfully" is shown (Figure 3-7).

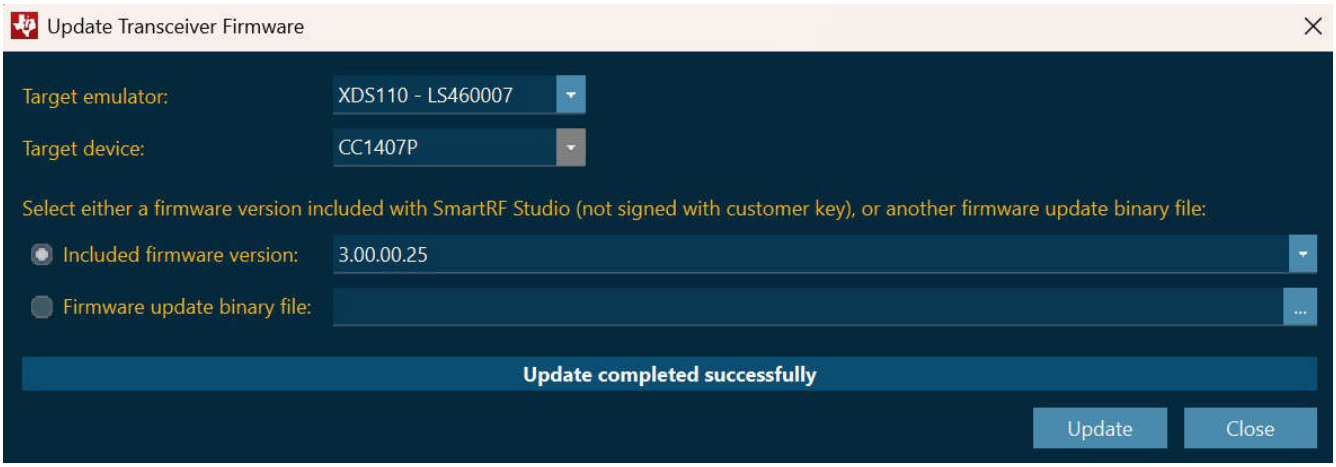


Figure 3-7. Update Completed Successfully

8. In the main SmartRF Studio window, the new firmware version is shown for the device.

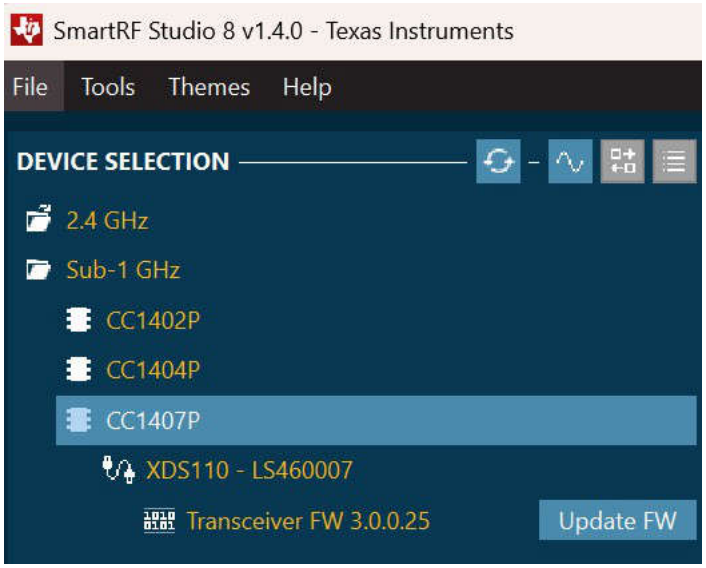


Figure 3-8. New Firmware Version

3.5 Updating the Transceiver Firmware using the ssbl_host Example

Software requirements:

- CCS
- Uniflash
- Signed CC1407P firmware binary image

In this example the LP-EM-CC1314R10 is used as the host device; however, the other supported host devices can also be used.

Steps to perform firmware update using the ssbl_host example:

1. In CCS, import the SSBL host example found at the following location:

   <plugin_install_dir>\examples\rtos\LP_EM_CC1314R10\trx_prop_rf\ssbl_host
2. Build the project.
3. Flash the CC1314R10 device with the built hex or out file.

4. In the ssbl_host project, verify where the transceiver firmware is expected to be located in the CC1314R10 flash memory.

   In ssbl_host_main.c, search for the variable trxFwUpdateBuffer. The address this variable points to is where the transceiver firmware binary is flashed to in the CC1314R10 device using Uniflash.

```
static const uint32_t *trxFwUpdateBuffer = (uint32_t *)0x10000;
```

5. Open Uniflash, select the device you are using, and select "Start" (Figure 3-9).

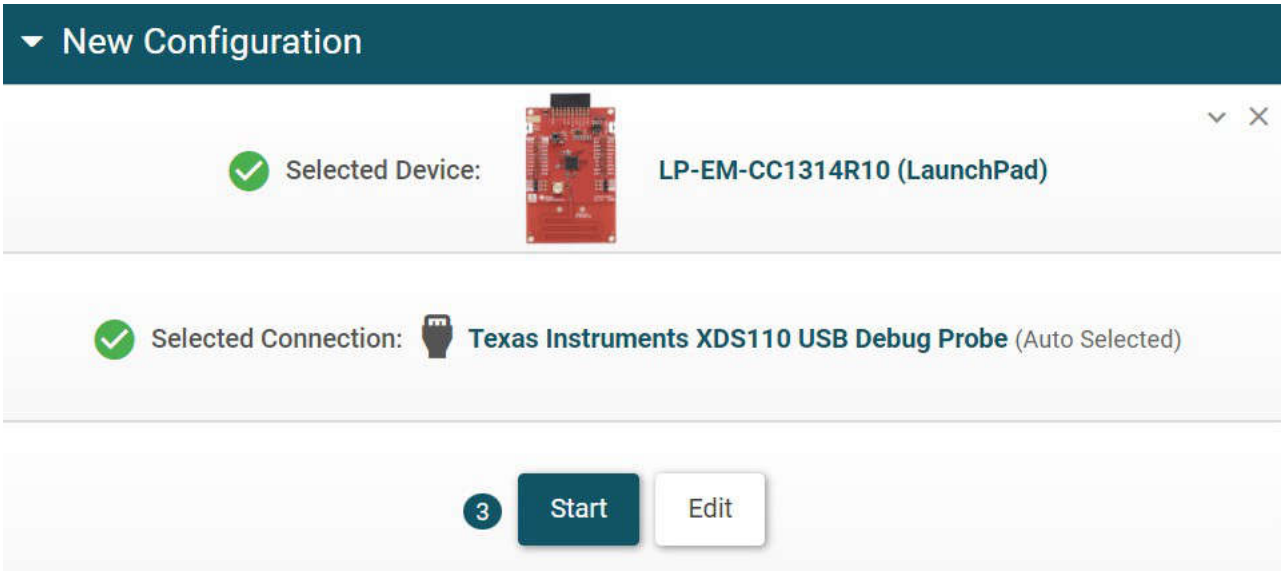


Figure 3-9. Select Device in UniFlash

6. Flash the signed CC1407P firmware binary image to address 0x10000. If the address that trxFwUpdateBuffer points to has changed, make sure to use the new address.

   Select "Load Image" after you have selected the binary (Figure 3-10).

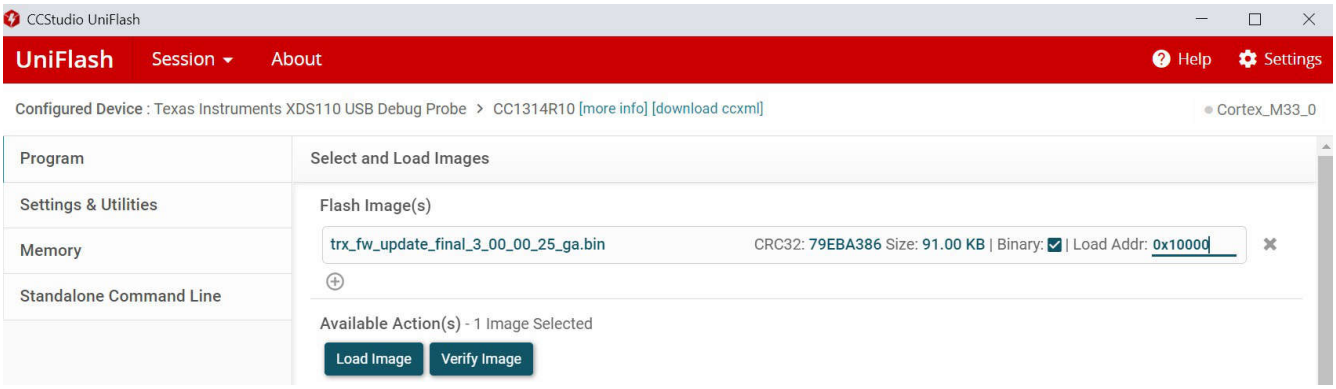


Figure 3-10. Load Flash Image

   The signed binary image, trx_fw_update_final_3_00_00_25_ga.bin, can be found under:

   <install_dir>\SmartRF Studio 8\sdk_support_defs\simplelink_cc140x_phy_settings_1_03_00

7. The CC1314 device now contains the ssbl_host and the CC1407P firmware binary image.
8. Mount the CC140xP BoosterPack on top of the CC1314 LaunchPad.
9. Press the XDS110 reset button.
10. The red LED on the LaunchPad turns on once the firmware update process begins. After a couple of seconds, the red LED turns off and the green LED on the LaunchPad blinks if the update process was successful.

3.6 Porting Guidelines

A TRX Host RF Driver is included in the TRX plugin. This driver is a simplified interface for controlling the CC1407P over SPI. The API supports initializing the TRX, scheduling RF commands, and several utility functions including time synchronization. The Platform Hardware Abstraction Layer (HAL) provides the TRX Host Driver with access to hardware resources through a common interface. These resources are largely used to facilitate communication between the Host and the CC1407P, including resources such as SPI and GPIO. Users must implement this interface according to their hardware specifications. Porting guidelines are included as part of the TRX Host RF Driver documentation in the TRX plugin:

<plugin_install_dir>\docs\trx_prop_rf\html\platform-hal.html#platform-hal-porting-guidelines

4 Hardware Design Files

4.1 Schematics

Figure 4-1, Figure 4-2, and Figure 4-3 show the schematic implementation of the BP-CC1407P-8-FE and Figure 4-4, Figure 4-5, and Figure 4-6 show the schematic implementation of the BP-CC1407P-9-FE.

The full BP-CC1407P-8-FE and BP-CC1407P-9-FE reference schematic can be downloaded here: BP-CC140XP-X-FE.

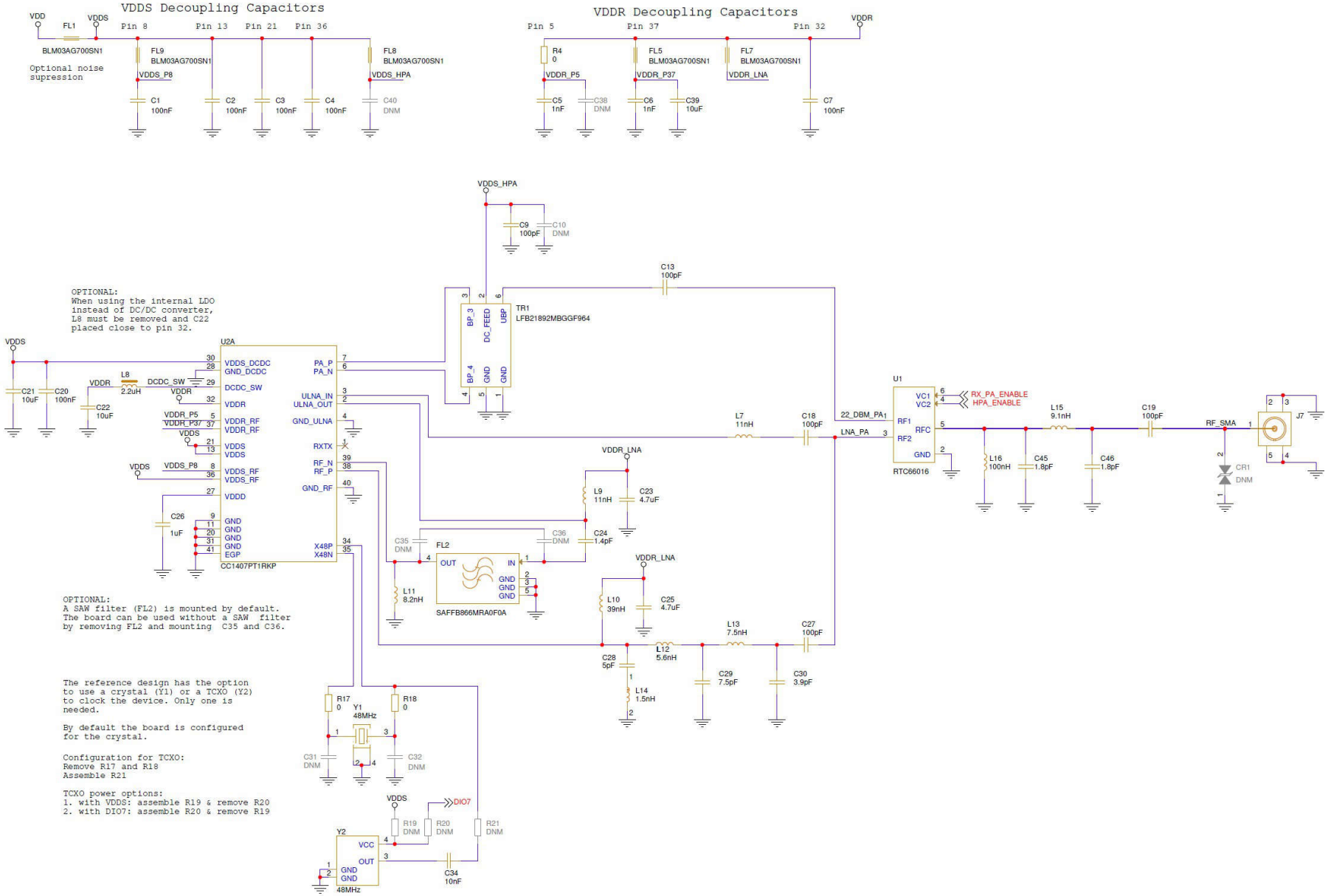


Figure 4-1. BP-CC1407P-8-FE Schematics Page 1

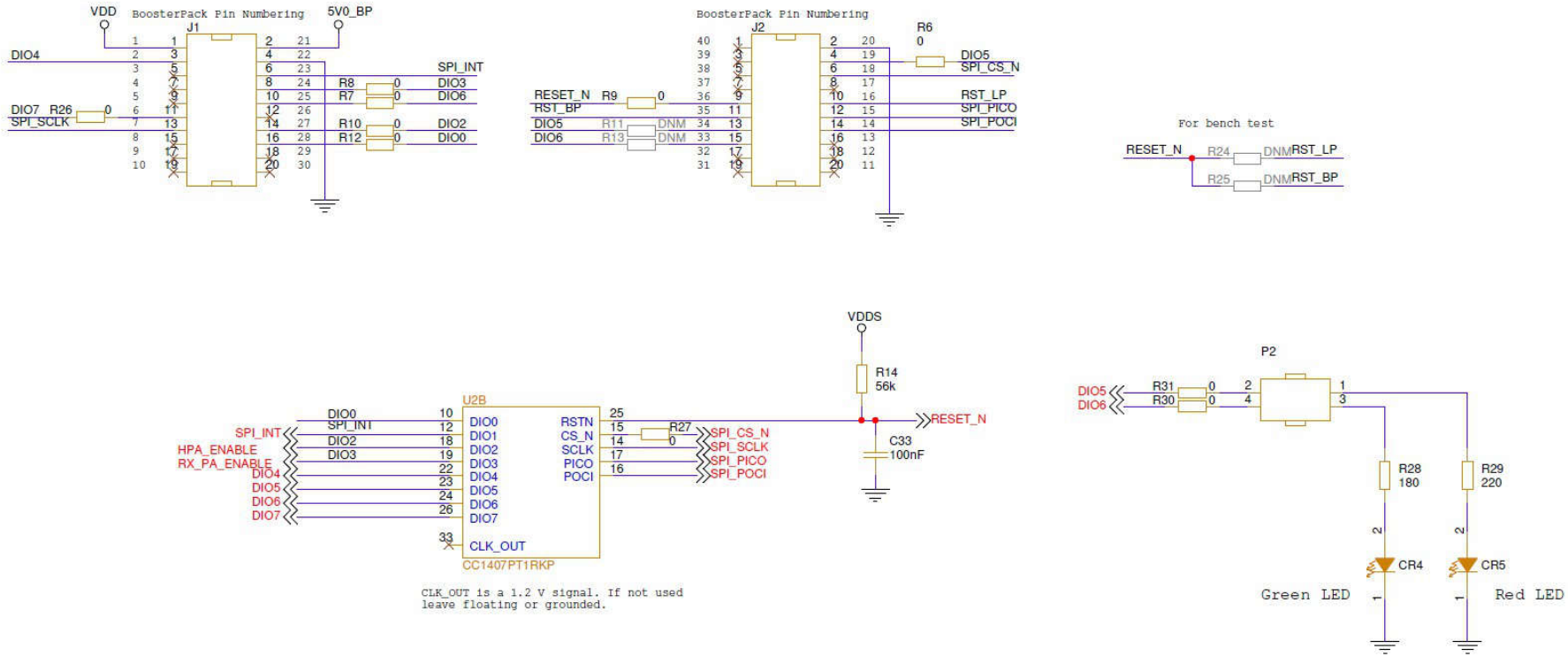


Figure 4-2. BP-CC1407P-8-FE Schematics Page 2

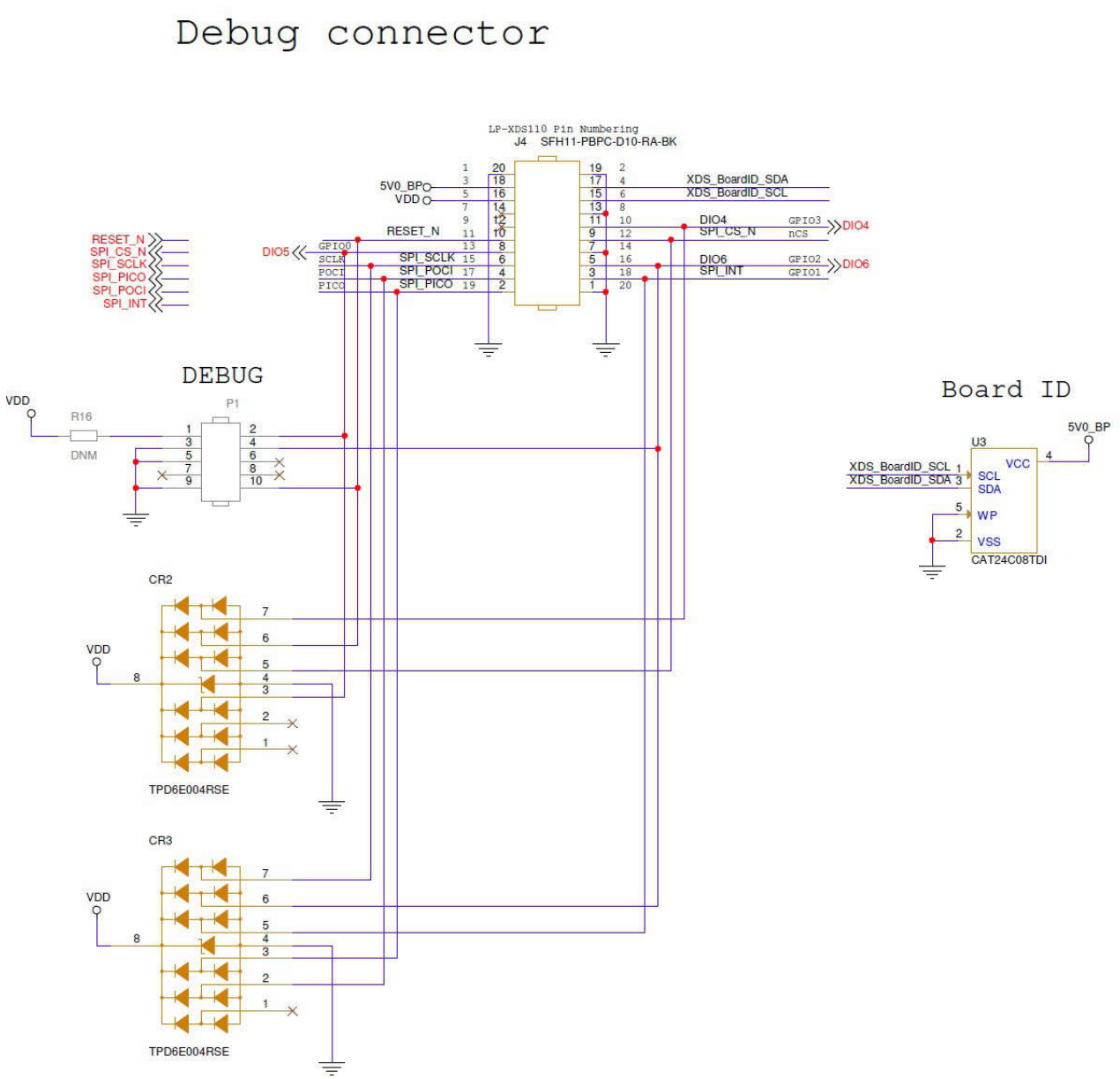


Figure 4-3. BP-CC1407P-8-FE Schematics Page 3

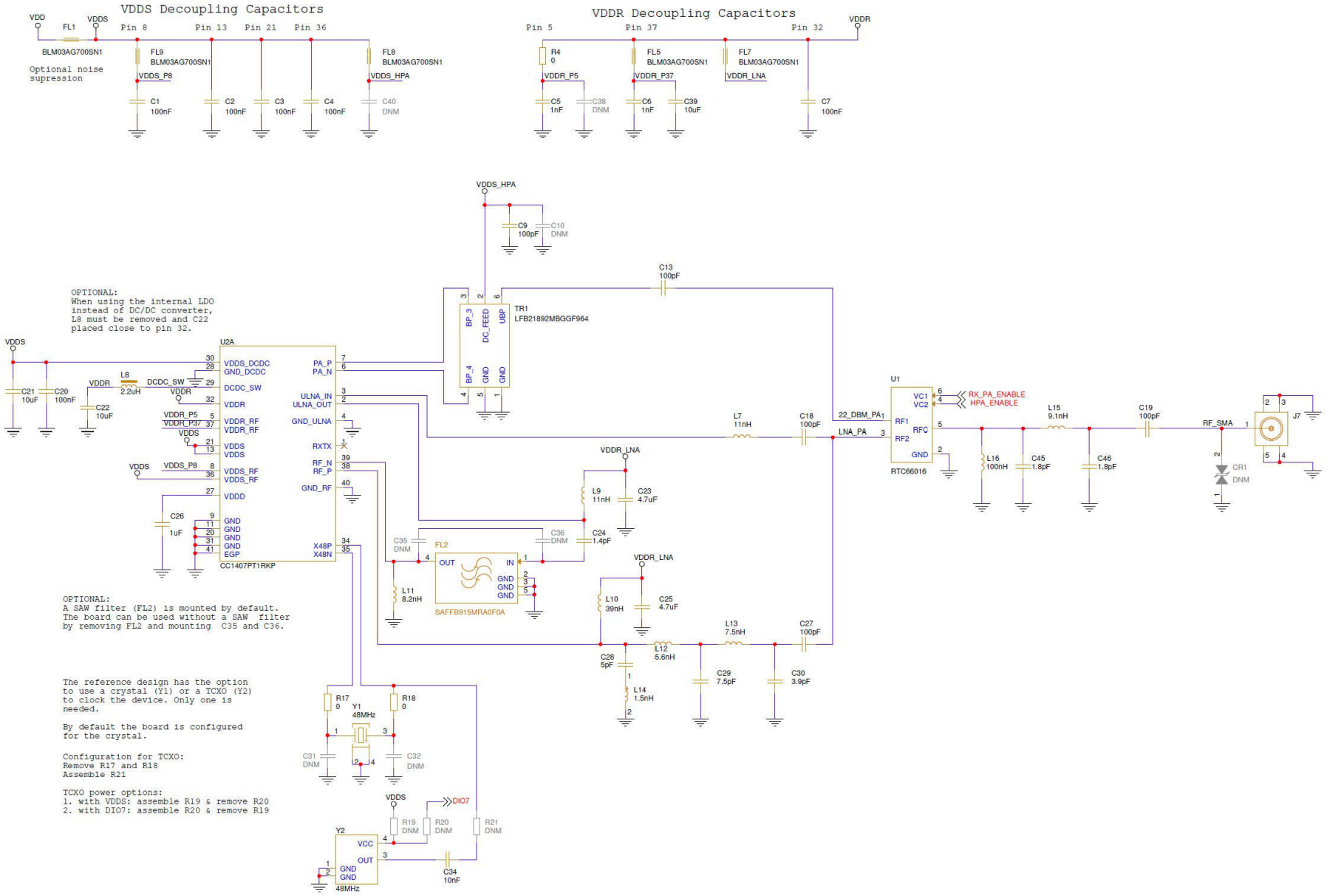


Figure 4-4. BP-CC1407P-9-FE Schematics Page 1

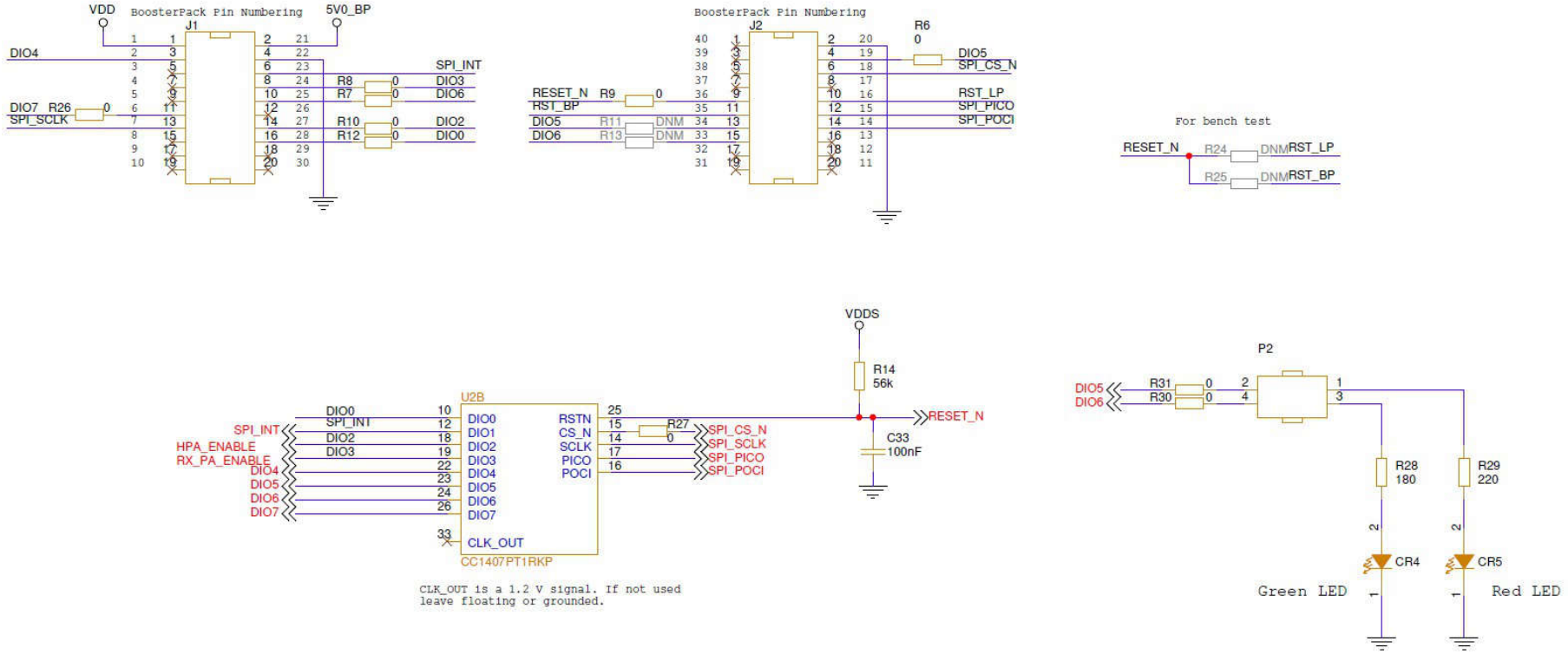


Figure 4-5. BP-CC1407P-9-FE Schematics Page 2

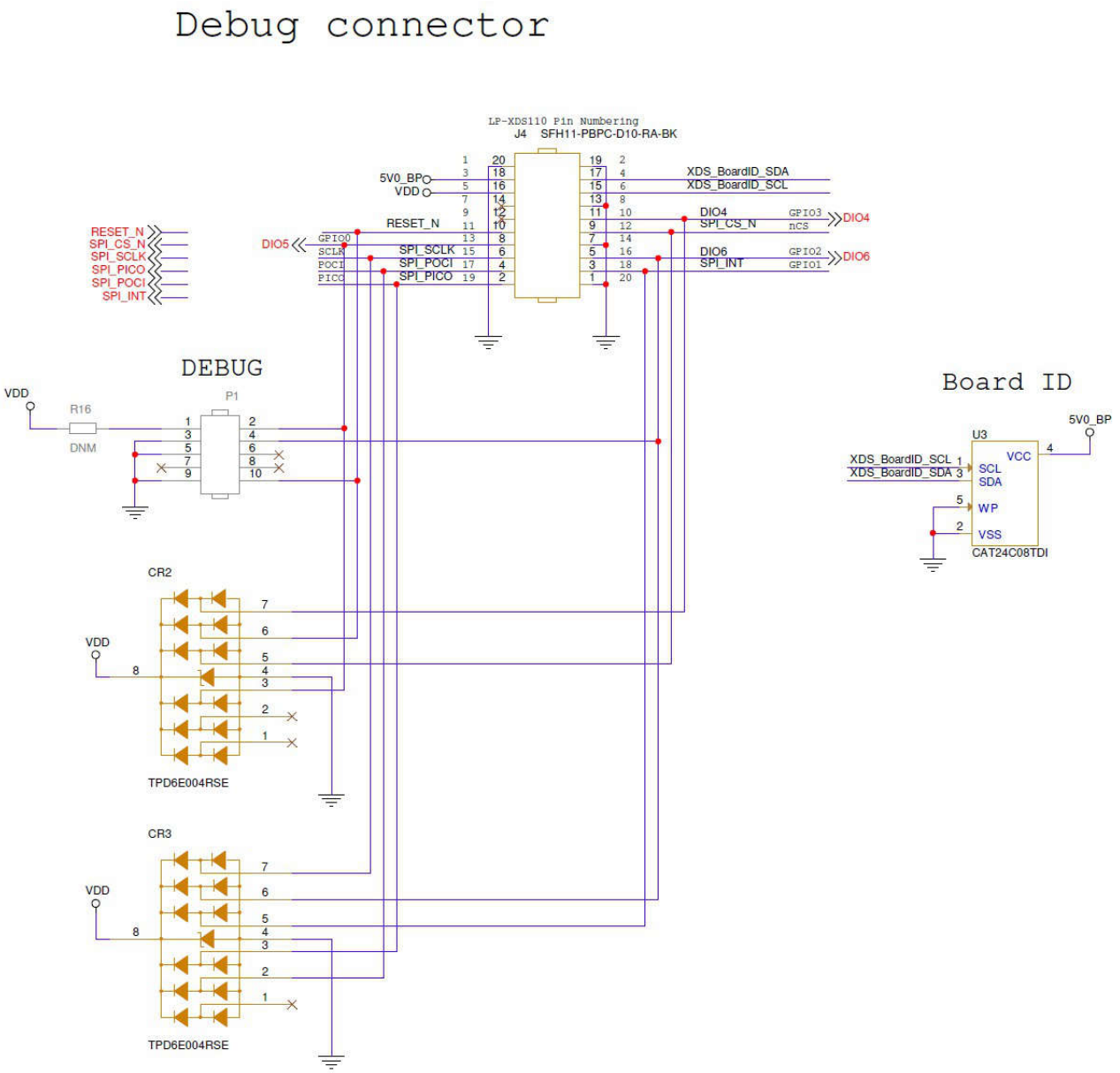


Figure 4-6. BP-CC1407P-9-FE Schematics Page 3

4.2 PCB Layouts

The top-side and bottom-side PCB layout view of the BP-CC1407P-8-FE and BP-CC1407P-9-FE can be seen in Figure 4-7 and Figure 4-8, respectively. The full layout files can be downloaded from http://www.ti.com/tool/BP-CC1407P-X-FE.

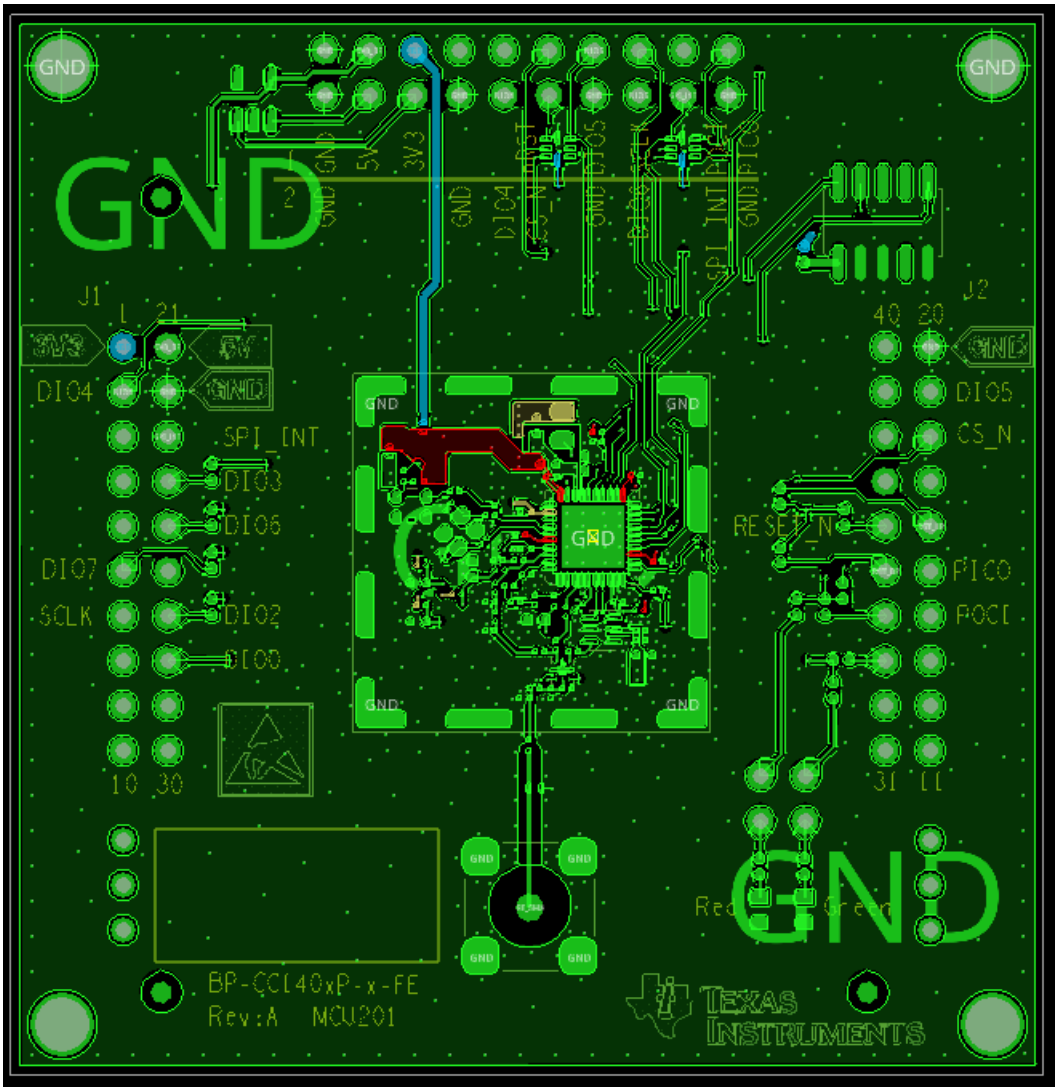


Figure 4-7. Top-Side PCB Layout View

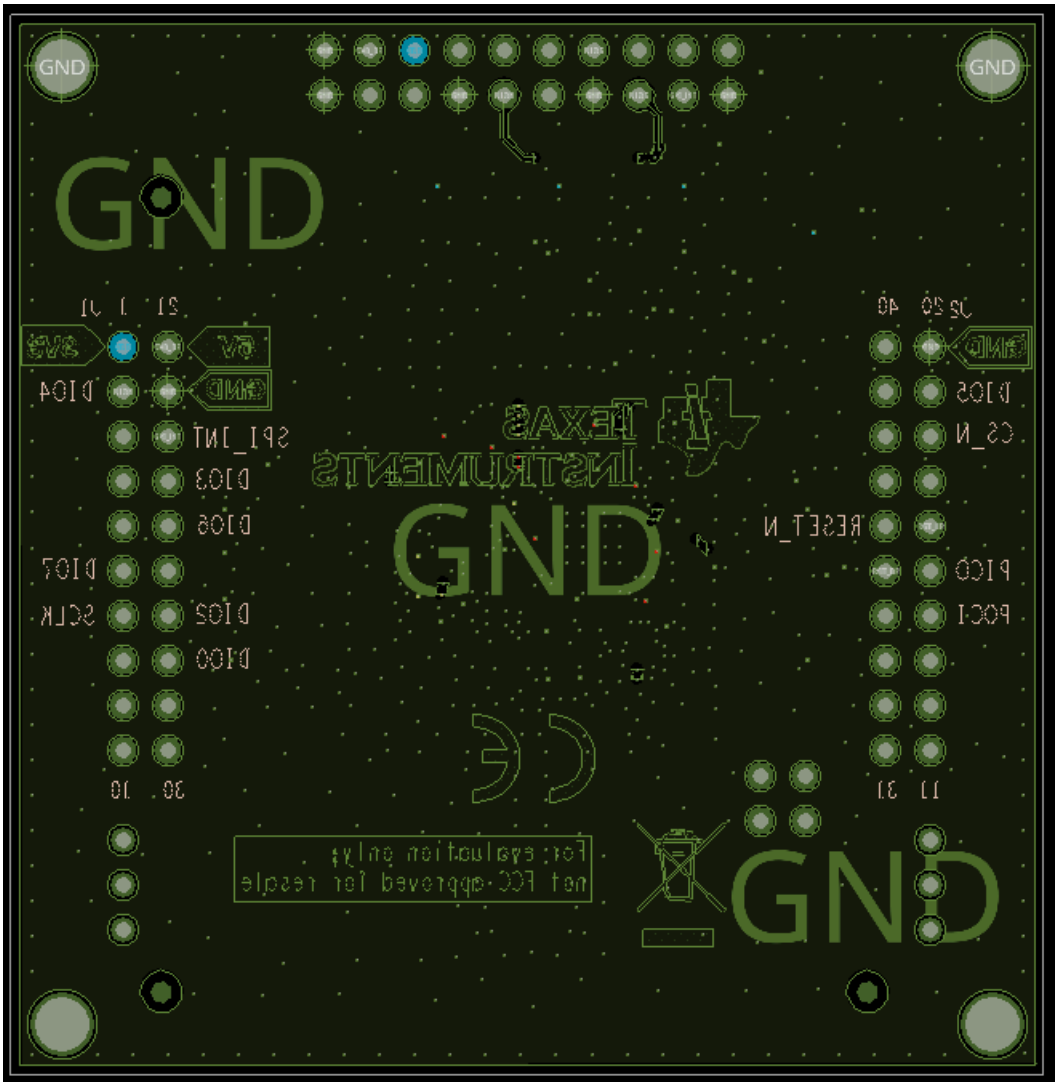


Figure 4-8. Bottom-Side PCB Layout View

4.3 Bill of Materials (BOM)

The bill of materials for BP-CC1407P-8-FE and BP-CC1407P-9-FE are the same except for the SAW filter (FL2) and the component mounted on R27. Table 4-1 shows the common components. Table 4-2 shows the different components used for BP-CC1407P-8-FE and Table 4-3 shows the different components used for BP-CC1407P-9-FE.

Table 4-1. Bill of Materials (Common Components)

Quantity	Designator	Value	Description	Manufacturer	Part Number
7	C1 C2 C3 C4 C7 C20 C33	100nF	CAPACITOR, CERAMIC X7S, 100nF, -10%/+10%, 10V, -55DEGC/ +125DEGC, 0201, SMD	MURATA	GRM033C71A104KE14D
2	C5 C6	1nF	CAPACITOR, CERAMIC C0G/NP0, 1nF, -5%/+5%, 25V, -55DEGC/ +125DEGC, 0201, SMD	MURATA	GRM0335C1E102JA01D
5	C9 C13 C18 C19 C27	100pF	CAPACITOR, CERAMIC C0G/NP0, 100pF, -2%/+2%, 50V, -55DEGC/ +125DEGC, 0201, SMD	MURATA	GRM0335C1H101GA01D
3	C21 C22 C39	10uF	CAPACITOR, CERAMIC X6S, 10uF, -20%/+20%, 6.3V, -55DEGC/ +105DEGC, 0402, SMD	MURATA	GRT155C80J106ME13D
2	C23 C25	4.7uF	CAPACITOR, CERAMIC X6S, 4.7uF, -20%/+20%, 6.3V, -55DEGC/ +105DEGC, 0402, SMD	MURATA	GRM155C80J475MEAAD
1	C24	1.4pF	CAPACITOR, CERAMIC C0G/ NP0, 1.4pF, -0.1pF/+0.1pF, 50V, -55DEGC/+125DEGC, 0201, SMD	MURATA	GRM0335C1H1R4BA01J
1	C26	1uF	CAPACITOR, CERAMIC X7R, 1uF, -20%/+20%, 6.3V, -55DEGC/ +125DEGC, 0402, SMD	MURATA	GRM155R70J105MA12D
1	C28	5pF	CAPACITOR, CERAMIC C0G/NP0, 5pF, -0.1pF/+0.1pF, 50V, -55DEGC/ +125DEGC, 0201, SMD	MURATA	GRM0335C1H5R0BA01J
1	C29	7.5pF	CAPACITOR, CERAMIC C0G/ NP0, 7.5pF, -0.1pF/+0.1pF, 50V, -55DEGC/+125DEGC, 0201, SMD	MURATA	GRM0335C1H7R5BA01J
1	C30	3.9pF	CAPACITOR, CERAMIC C0G/ NP0, 3.9pF, -0.1pF/+0.1pF, 50V, -55DEGC/+125DEGC, 0201, SMD	MURATA	GRM0335C1H3R9BA01J

Table 4-1. Bill of Materials (Common Components) (continued)

Quantity	Designator	Value	Description	Manufacturer	Part Number
1	C34	10nF	CAPACITOR, CERAMIC X7R, 10nF, -10%/+10%, 10V, -55DEGC/+125DEGC, 0201, SMD	MURATA	GRM033R71A103KA01D
2	C45 C46	1.8pF	CAPACITOR, CERAMIC C0G/NP0, 1.8pF, -0.1pF/+0.1pF, 50V, -55DEGC/+125DEGC, 0201, SMD	MURATA	GRM0335C1H1R8BA01J
2	CR2 CR3	TPD6E004RSE	DIODE, PROTECTION, ESD ARRAY - 6 CHANNELS, VCC:0.9V TO 5.5V, VBR:7V, -40DEGC/+85DEGC, QFN8, SMD	TEXAS INSTRUMENTS	TPD6E004RSER
1	CR4	150060VS55040	OPTO, LED, SINGLE, GREEN, 573nm, AlInGaP, 2V, 0.02A, 0.048W, 0603, SMD	WURTH	150060VS55040
1	CR5	150060RS55040	OPTO, LED, SINGLE, RED, 624nm, AlInGaP, 2V, 0.02A, 0.048W, 0603, SMD	WURTH	150060RS55040
5	FL1 FL5 FL7 FL8 FL9	BLM03AG700SN1	FILTER, EMI, FERRITE BEAD, 70@100MHz, 0.2A, -55DEGC/+125DEGC, 0201, SMD	MURATA	BLM03AG700SN1D
2	J1 J2	SSQ-110-23-L-D	CONNECTOR, HEADER, FEMALE, STRAIGHT, 2 ROW(S), 20 PIN(S), 2.54mm, PTH	SAMTEC	SSQ-110-23-L-D
1	J4	SFH11-PBPC-D10-RA-BK	CONNECTOR, HEADER, FEMALE, RIGHT ANGLE, 2 ROW(S), 20 PIN(S), PITCH 2.54mm, PTH	SULLINS	SFH11-PBPC-D10-RA-BK
1	J7	SMA-10V21-TGG	CONNECTOR, COAX, RF, FEMALE, STRAIGHT, 1 PIN(S), SMD	HUS-TSAN	SMA-10V21-TGG
2	J8 J9	PPTC031LFBN	CONNECTOR, HEADER, FEMALE, STRAIGHT, 1 ROW(S), 3 PIN(S), PITCH 2.54mm, PTH	SULLINS	PPTC031LFBN-RC
1	L7	11nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 11nH, -5%/+5%, 0.3A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03HQ11NJ02D

Table 4-1. Bill of Materials (Common Components) (continued)

Quantity	Designator	Value	Description	Manufacturer	Part Number
1	L8	2.2uH	INDUCTOR, POWER, METAL ALLOY POWDER CORE, SHIELDED, 2.2uH, -20%/+20%, 2.5A, -40DEGC/+125DEGC, 0805, SMD	MURATA	DFE21CCN2R2MELL
1	L9	11nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 11nH, -5%/+5%, 0.25A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03TN11NJ02D
1	L10	39nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 39nH, -5%/+5%, 0.15A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03HQ39NJ02D
1	L11	8.2nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 8.2nH, -5%/+5%, 0.25A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03TN8N2J02D
1	L12	5.6nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 5.6nH, -5%/+5%, 0.4A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03HQ5N6J02D
1	L13	7.5nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 7.5nH, -5%/+5%, Ir:0.4A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03HQ7N5J02D
1	L14	1.5nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 1.5nH, -5%/+5%, 0.6A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03TN1N5B02D
1	L15	9.1nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 9.1nH, -5%/+5%, 0.25A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03TN9N1J02D

Table 4-1. Bill of Materials (Common Components) (continued)

Quantity	Designator	Value	Description	Manufacturer	Part Number
1	L16	100nH	INDUCTOR, RF, NON-MAGNETIC CORE, UNSHIELDED, 100nH, -5%/+5%, 0.08A, -55DEGC/+125DEGC, 0201, SMD	MURATA	LQP03TNR10J02D
4	M1 M2 M3 M4	DCB-12D	MECHANICAL, ACCESSORY, SPACER SUPPORT, PCB DIA. 3mm, NYLON 66, NPTH	SUZHOU SOLY ELECTRICIAN	DCB-12D
2	M5 M6	SNT-100-BK-G	MECHANICAL, SHUNT, CURRENT RATING 4.3A PER PIN, 2.54 X 5.08 X 6.1mm, BLACK	SAMTEC	SNT-100-BK-G
1	P2	BB02-HJ041-KB1-603000	CONNECTOR, HEADER, MALE, STRAIGHT, 2 ROW(S), 4 PIN(S), PITCH 2.54mm, PTH	GRADCONN	BB02-HJ041-KB1-603000
4	R4 R12 R17 R18	0	RESISTOR, THICK FILM, JUMPER, 0, 0R/+0.05R, 0.05W, 1A, -55DEGC/+155DEGC, 0201, SMD	VISHAY	CRCW02010000Z0ED
8	R6 R7 R8 R9 R10 R26 R30 R31	0	RESISTOR, THICK FILM, JUMPER, 0, 0R/+0.02R, 0.063W, 1.5A, -55DEGC/+155DEGC, 0402, SMD	VISHAY	CRCW04020000Z0ED
1	R14	56k	RESISTOR, THICK FILM, 56k, -5%/+5%, 0.05W, 30V, -55DEGC/+155DEGC, 0201, SMD	VISHAY	CRCW020156K0JNED
1	R28	180	RESISTOR, THICK FILM, 180, -5%/+5%, 0.063W, 50V, -55DEGC/+155DEGC, 0402, SMD	VISHAY	CRCW0402180RJNED
1	R29	220	RESISTOR, THICK FILM, 220, -5%/+5%, 0.063W, 50V, -55DEGC/+155DEGC, 0402, SMD	VISHAY	CRCW0402220RJNED
1	SC1	SMS-255F	MECHANICAL, SHIELD, SURFACE MOUNT SHIELD FRAME, 19.05 X 19.05 X 5.08, SMD	LEADER TECH	SMS-255F
1	SC2	SMS-255C	MECHANICAL, SHIELD, SURFACE MOUNT SHIELD COVER, 18.9 X 18.9 X 2, NOT APPLY	LEADER TECH	SMS-255C

Table 4-1. Bill of Materials (Common Components) (continued)

Quantity	Designator	Value	Description	Manufacturer	Part Number
1	TR1	LFB21892MBGGF964	FILTER, RF, BANDPASS, 863MHz TO 928MHz, -40DEGC/+105DEGC, 0805-6, SMD	MURATA	LFB21892MBGGF964
1	U1	RTC66016	IC, ANALOG, RF, SPDT ANTENNA SWITCH, 1.2V TO 3.6V / 0V TO 0.4V, QFN6, SMD	RICHWAVE	RTC66016
1	U2	CC1407PT1RKP	IC, ANALOG, CUSTOM, TEXAS INSTRUMENTS, CC1407P, QFN40-EP, SMD	TEXAS INSTRUMENTS	CC1407PT1RKP
1	U3	CAT24C08TDI	IC, MEMORY, EEPROM, SERIAL, I2C, 8kbit, 1k X 8bit, 900ns, 1.7V TO 5.5V, TSOT23-5, SMD	ONSEMI	CAT24C08TDI-GT3
1	Y1	48MHz	CRYSTAL, RESONATOR, 48MHz, -30PPM/+30PPM, -40DEGC/+125DEGC, SMD	TAI-SAW	TZ3908AAAO43
1	Y2	48MHz	CRYSTAL, OSCILLATOR, TCXO, 48MHz, -2.5PPM/+2.5PPM, 1.8V TO 3.3V, -40DEGC/+105DEGC, SMD	TAI-SAW	TX0678E

Table 4-2. Different Components for BP-CC1407P-8-FE

Quantity	Designator	Value	Description	Manufacturer	Part Number
1	FL2	SAFFB866MRA0F0A	FILTER, SAW, 50, 866.5MHz, -20DEGC/+85DEGC, SMD	MURATA	SAFFB866MRA0F0AR1X
1	R27	0	RESISTOR, THICK FILM, JUMPER, 0, 0R/+0.05R, 0.05W, 1A, -55DEGC/ +155DEGC, 0201, SMD	VISHAY	CRCW02010000Z0ED

Table 4-3. Different Componenets for BP-CC1407P-9-FE

Quantity	Designator	Value	Description	Manufacturer	Part Number
1	FL2	SAFFB915MRA0F0A	FILTER, SAW, 50, 915MHz, -20DEGC/+85DEGC, SMD	MURATA	SAFFB915MRA0F0AR1X
1	R27	BLM03HB191SN1	FILTER, EMI, FERRITE BEAD, 190@100MHz, 0.15A, -55DEGC/+125DEGC, 0201, SMD	MURATA	BLM03HB191SN1D

5 Additional Information

5.1 Known Hardware or Software Issues

- Firmware Support for Hardware Design
  - RF front-end configuration support only for BP-CC140xP-8-FE. Other RF configurations will be supported in the future.

    It is possible to do testing with the BP-CC140xP-9-FE as well, as the PHY settings are the same. The only difference between the two designs (-8 and -9) is the SAW filter in RX. Due to the SAW filter, it is important that the correct frequency is being used. For BP-CC140xP-8-FE, the frequency must be between 862MHz and 870MHz, and for the BP-CC140xP-9-FE the frequency must be between 902MHz and 928MHz. Transmitting with the -8 on 915MHz band is not a problem, however receiving is a problem due to the SAW filter (approximately 40dB degraded signal level). The same applies to -9 on868 MHz band.

    Depending on the example and the board, changing the frequency before loading the example can be necessary.
- Increased Tx 3rd harmonic
  - On BP-CC140xP-8-FE Rev. E3 and BP-CC140xP-9-FE Rev. E3, the 3rd harmonic is above the FCC emissions limits under the following conditions:
    - Output power: 14dBm or 13dBm
    - VDDS: 1.83V to 2.2V

  The issue is resolved in Rev. A of the development boards.
- API Limitations
  - 600µs settling time for Wi-SUN MDR RX
- Ferrite Bead on Chip Select Trace
  - The BoosterPack headers are not optimal from a RF emission perspective because the headers are unwanted radiators. To improve the FCC radiated performance with the BoosterPack headers, a ferrite bead (R27) was added on the chip select trace in the BP-CC140xP-**9**-FE design.
- Output Power
  - The output power is currently limited to 21.5dBm on the high power PA (to achieve 21.5dBm, external power supply of 3.6V needs to be used)
  - When selecting highest possible output power for an OFDM PHY, the average output power is 16dBm
- Power Consumption
  - Due to a known limitation in the Transceiver FW, a workaround is needed in the Host driver to be able to evaluate standby
    - In the project root of the imported example, modify the host driver source file source/ti/trx/host_lite/hal/platform_spi.c. Replace the function Plat_SPI_assertCs() with the following code

```
Plat_SPI_Status Plat_SPI_assertCs(Plat_SPI_Handle handle)
{
    unsigned int key;
    Plat_Util_startCriticalSection((uintptr_t)&key);
    Plat_SPI_Status status = Plat_SPI_Invalid_Handle;

    // Restore POCI pull-up before initiating a transaction
    restorePociPullUp();

    uint32_t elapsedUs = 0U;
    while (elapsedUs < 40)
    {
        Plat_Util_blockCPU(1U);
        elapsedUs++;
    }

    if(NULL != handle)
    {
        if(PLAT_SPI_IS_OPEN(handle))
        {
```

```
            if(PLAT_SPI_IS_TRX_READY(handle))
            {
                GPIO_write(TRX_HOST_SPI_CS, 0U);
                PLAT_SPI_SET_TRX_NOT_READY(handle);

                // Wait for the TRX to drive POCI low, signalling it is ready
                // to receive. This handshake is tied to the CS falling edge;
                // continuation transactions reuse the already-low CS and must
                // not repeat it (see spi_transport transactionCompleteCb).
                elapsedUs = 0U;
                status = Plat_SPI_Success;
                while(0U != GPIO_read(CONFIG_SPI_POCI))
                {
                    Plat_Util_blockCPU(1U);
                    elapsedUs++;
                    if(elapsedUs >= PLAT_SPI_POCI_WAIT_TIMEOUT_US)
                    {
                        // Undo CS assertion and restart the ready timer so
                        // the caller can retry cleanly.
                        GPIO_write(TRX_HOST_SPI_CS, 1U);
                        startReadyTimer(handle);
                        status = Plat_SPI_Failed;
                        break;
                    }
                }
            }
            else
            {
                status = Plat_SPI_Cs_Not_Ready;
            }
        }
        else
        {
            status = Plat_SPI_Failed;
        }
    }
    Plat_Util_endCriticalSection((uintptr_t)&key);

    return(status);
}
```

- Modify the dwellTimeUs variable in the deviceConfig structure in the example to 1000U and change the powerPolicy field to 1

Note

Not all of the available examples are written in a way that make showcasing Standby mode possible. The RX examples utilize continuous RX mode, so the CC140xP never enters Standby, and hence power saving has not been implemented in the application either (Host device never enters Standby).

Trademarks

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User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *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.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

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.

Concerning EVMs Including Detachable Antennas:

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.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

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.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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