Application Report
SWRA492–October 2015

CC112x-CC1190 BoosterPack

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ABSTRACT

As the module is designed to support both LaunchPad™ and SmartRF™ Studio platforms, configure the board by changing the on-board jumper positions according to your application. The default configuration of the jumpers on the BoosterPack™ module is set for LaunchPad applications. The interface details of CC112x-CC1190 BoosterPack with LaunchPad and SmartRF Studio applications are shown in the subsequent sections of this document. The pass through connection feature on this BoosterPack allows to plug-in other BoosterPack modules to create multiple applications.

1 Introduction

The CC112x-CC1190 BoosterPack module is designed to use with the MSP-EXP430F5529 [10] and MSP-EXP430G2553 [11] LaunchPad development kits and as well as to work as a stand-alone module by using SmartRF Studio application software. The module is equipped with an integrated PCB trace antenna, which operates in the US 902~928 MHz and European 869~870 MHz ISM frequency bands. The module is certified to use on Sigfox wireless networks in US with a valid license from Sigfox. The CC112x-CC1190 BoosterPack module is shown in Figure 1 and Figure 2.

The RF performance of CC112x-CC1190 BoosterPack is similar to the RF performance of the CC1120-CC1190 EM. For the expected performance when using this design under FCC Section 15.247 in the 902-928 MHz frequency band, see *Using the CC1190 Front End with CC112x and CC120x under FCC 15.247* (SWRA387). The CC112x family of devices is fully integrated single-chip radio transceivers designed for high performance at very low power and low-voltage operation in cost effective wireless systems. All filters are integrated, removing the need for costly external IF filters. The device is mainly intended for the Industrial, Scientific and Medical (ISM) and Short Range Device (SRD) frequency bands at 164-192 MHz, 410-480 MHz and 820-960 MHz.

The CC1190 is a range extender for 850-950 MHz RF transceivers, transmitters, and System-on-Chip (SoC) devices from Texas Instruments. It increases the link budget by providing a power amplifier (PA) for increased output power, and a low-noise amplifier (LNA) with low noise figure for improved receiver sensitivity in addition to switches and RF matching for simple design of high performance wireless systems

Using the CC1190 Front End with CC112x and CC120x under FCC 15.247 (SWRA387) is also applicable for CC1121, CC1125, and CC120x.

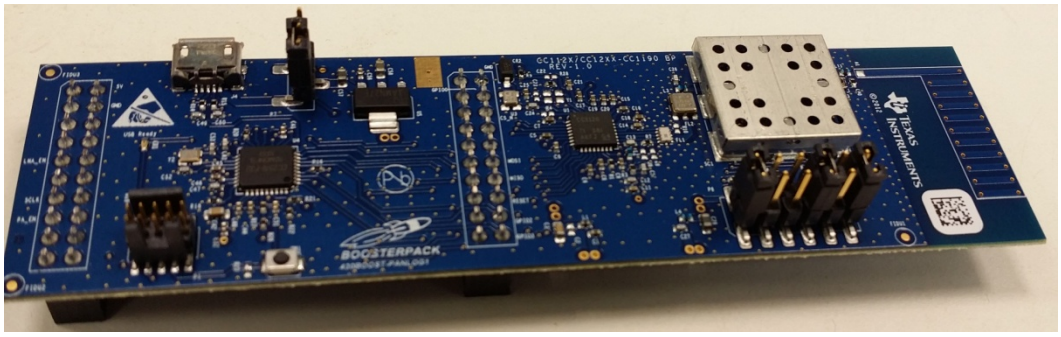

Figure 1. CC112x-CC1190 BoosterPack - Top Side

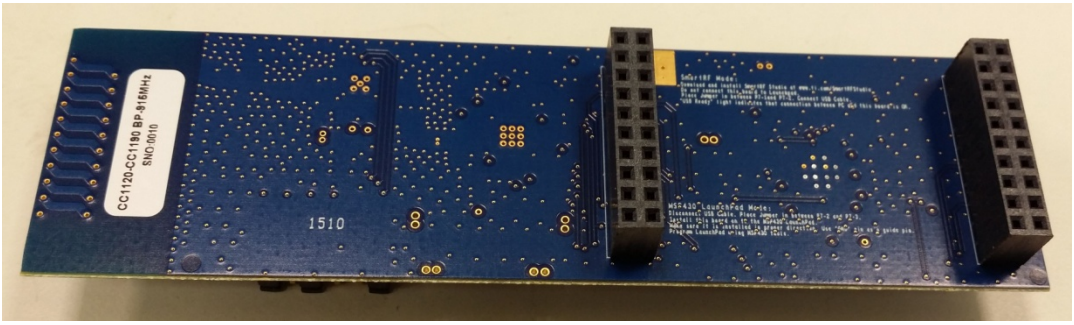

Figure 2. CC112x-CC1190 BoosterPack - Bottom Side

1.1 Acronyms and Definitions

Table 1. Acronyms and Definitions

Acronym	Definition
BP	BoosterPack
EM	Evaluation Module
FCC	Federal Communications Commission
HGM	High Gain Mode
LNA	Low Noise Amplifier
LGM	Low Gain Mode
PA	Power Amplifier
PCB	Printed Circuit Board
PER	Packet Error Rate
RF	Radio Frequency
RSSI	Receive Signal Strength Indicator
RX	Receive, Receive Mode
SRS	SmartRF Studio
TX	Transmit, Transmit Mode

2 Absolute Maximum Ratings

The absolute maximum ratings and operating conditions listed in the CC1120 data sheet [1] and the CC1190 data sheet [3] must be followed at all times. Stress exceeding one or more of these limiting values may cause permanent damage to any of the devices.

3 Electrical Specifications

As the CC112x-CC1190 BoosterPack performance is similar to CC1120-CC1190EM. For the detailed electrical specifications, see [8].

3.1 Operating Conditions

Table 2. Operating Conditions

Parameter	Min	Max	Unit
Operating Frequency	850	950	MHz
Operating Supply Voltage	4.0	5.5	V
Operating Supply Current at 5 V		400	mA
Operating Temperature	-40	+85	°C

4 CC1190 Control Logic

The control logic for CC1190 for different modes are shown in Table 3.

Table 3. CC1190 Control Logic

PA_EN	LNA_EN	HGM	Mode of Operation
0	0	X	Power Down
0	1	0	RX LGM
0	1	1	RX HGM
1	0	0	TX LGM
1	0	1	TX HGM

5 CC112x-CC1190 BP Control and Interface Connections

The control and interface connector details of CC112x-CC1190 BP module is shown in Figure 3. The CCC112x-CC1190 BoosterPack can be used with either LaunchPad or as a stand-alone module along with SmartRF Studio. The jumpers on connectors P6 and P7 should be configured as per the requirement.

- J4 – USB Interface Connector for SmartRF Studio application
- SW1 – USB Reset Switch
- P1 – Debug (CC Debugger) Interface connector
- P2 and P3 – LaunchPad Interface Connectors
- P6 – CC1190 Control selection jumpers
- P7 – Power Supply selection jumpers

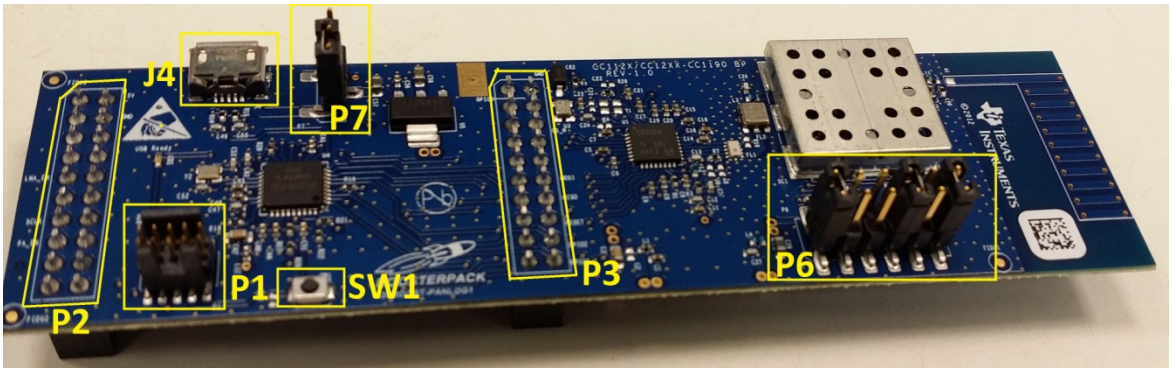

Figure 3. CC112x-CC1190 BP – Connectors

6 CC112x-CC1190 BP Interface With MSP430 LaunchPad

The CC112x-CC1190 BP module is compatible to use with the MSP-EXP430F5529 and MSP-EXP430G2553 LauchPad development kits. The CC112x-CC1190 BoosterPack can be interfaced with the LaunchPad by using the following steps.

1. Install the CC112x-CC1190 BoosterPack on to the LaunchPad as shown in Figure 4.

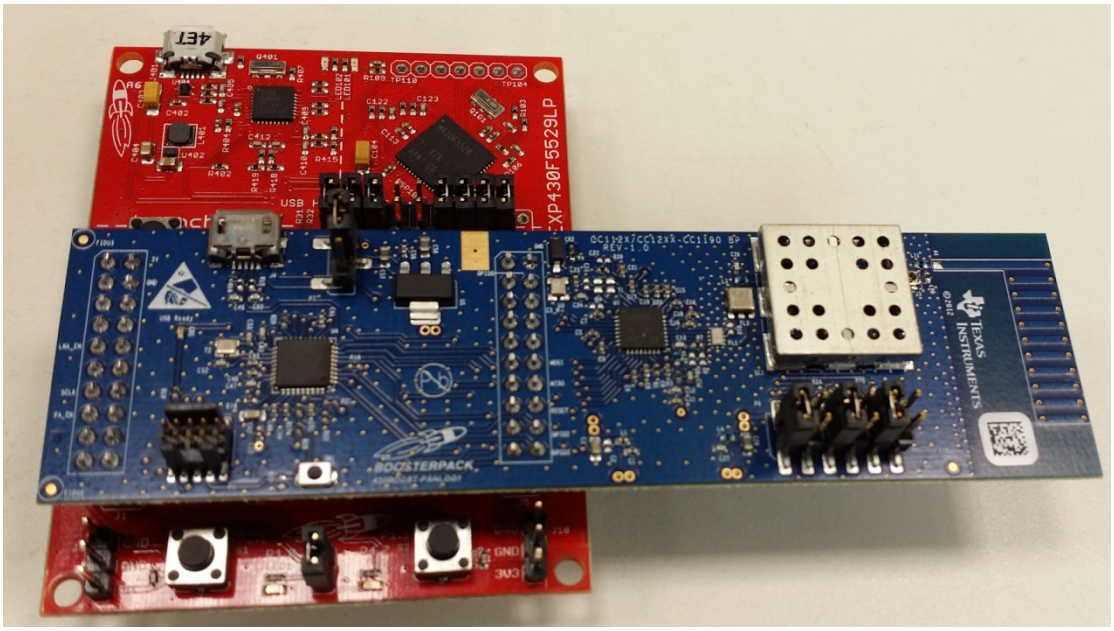

Figure 4. CC112x-CC1190 BoosterPack With LaunchPad

2. **Power Supply Selection**:

   Connector P7 on the BoosterPack is used in selecting the options for power supply.

   For use with MSP-EXP430F5529 LaunchPad, place the Jumper in between P7-2 to P7-3 to select the LaunchPad supply as the power source to the BoosterPack. The location of the connector P7 with the jumper position is shown in Figure 5.

   For use with MSP-EXP430G2553 LaunchPad, remove the Jumper from P7 and connect an external 5 V (400 mA capable) power supply Positive lead to the center pin (2) of P7 and the Ground lead to the nearby Ground Pad.

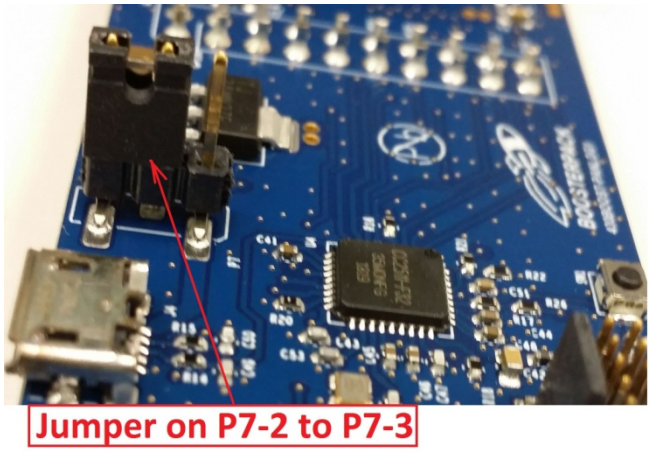

Figure 5. PS Jumper Location for LaunchPad Application

3. **CC1190 Control**:

   The CC1190 on the BoosterPack can be controlled directly from the LaunchPad by using the control signals HGM, LNA_EN and PA_EN. HGM can be controlled only through hardware jumper selection on the BoosterPak and the other two control signals LNA_EN and PA_EN can be controlled with the combination of software from the LaunchPad and hardware jumper selection on the BoosterPack. Connector P6 on the BoosterPack is used for CC1190 control signals selection. For the details of logic for different modes (TX, RX and Power Down) of the CC1190 operation, see the Section 4. The placement of jumpers on P6 is shown in Figure 6.

   (a) High Gain Mode: Place Jumper on P6-1 to P6-2

   (b) Low Gain Mode: Place Jumper on P6-3 to P6-4

   (c) LNA_EN: Place Jumper on P6-5 to P6-6

   (d) PA_EN: Place Jumper on P6-9 to P6-10

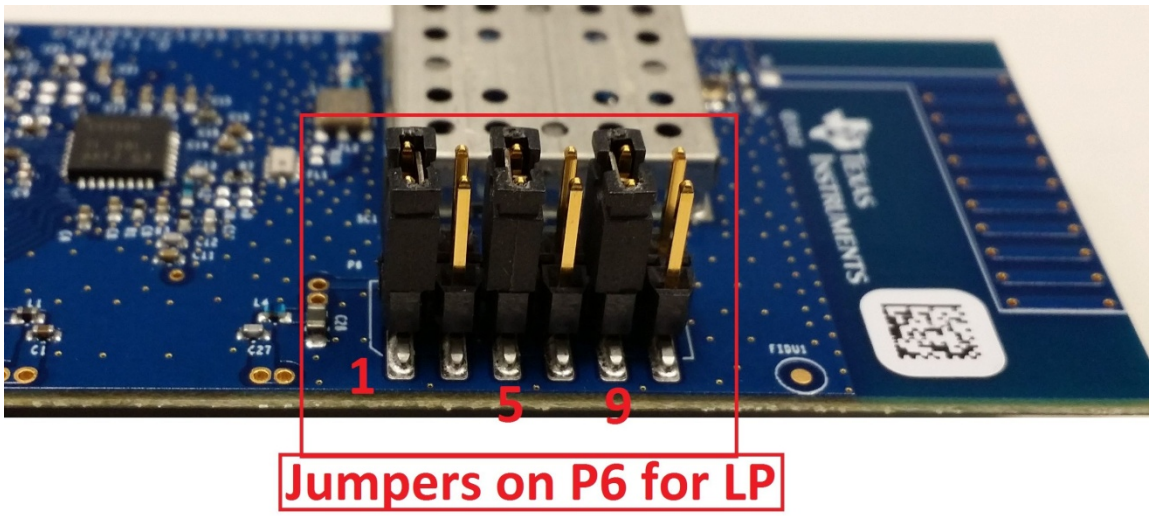

Figure 6. CC1190 Jumper Location for LaunchPad Application

4. Connect USB cable to the MSP-EXP430F5529 [10] or MSP-EXP430G2553 [11], the LaunchPad being used.
5. Run the program (example PER test) on the LaunchPad. For details, see the *CC112x-CC1190 Boost Software Examples* (SWRA493).

7 CC112x-CC1190 BP Interface With SmartRF Studio

The CC112x-CC1190 BoosterPack can be controlled directly from SmartRF Studio 7 software [6] to evaluate performance and functionality. The SmartRF Studio software is highly recommended for obtaining optimum register settings. The jumpers on the connectors P6 and P7 should be configured as per the required mode and it is shown in the following steps.

1. Connect the USB cable from the PC to the J4 of the BoosterPack as shown in Figure 7.

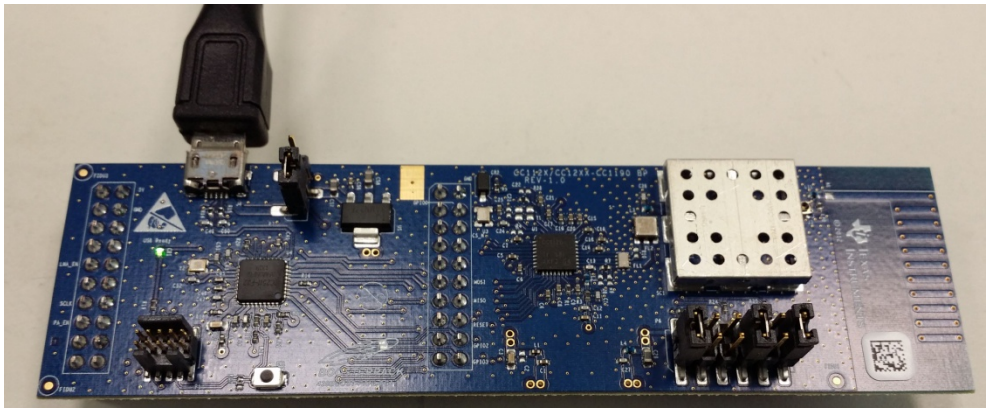

Figure 7. CC112x-CC1190 BP With USB Cable

2. **Power Supply Selection**:

   Place the Jumper in between P7-1 to P7-2 to select the USB supply as the power source for the BoosterPack. The location of P7 with Jumper position is shown in Figure 8.

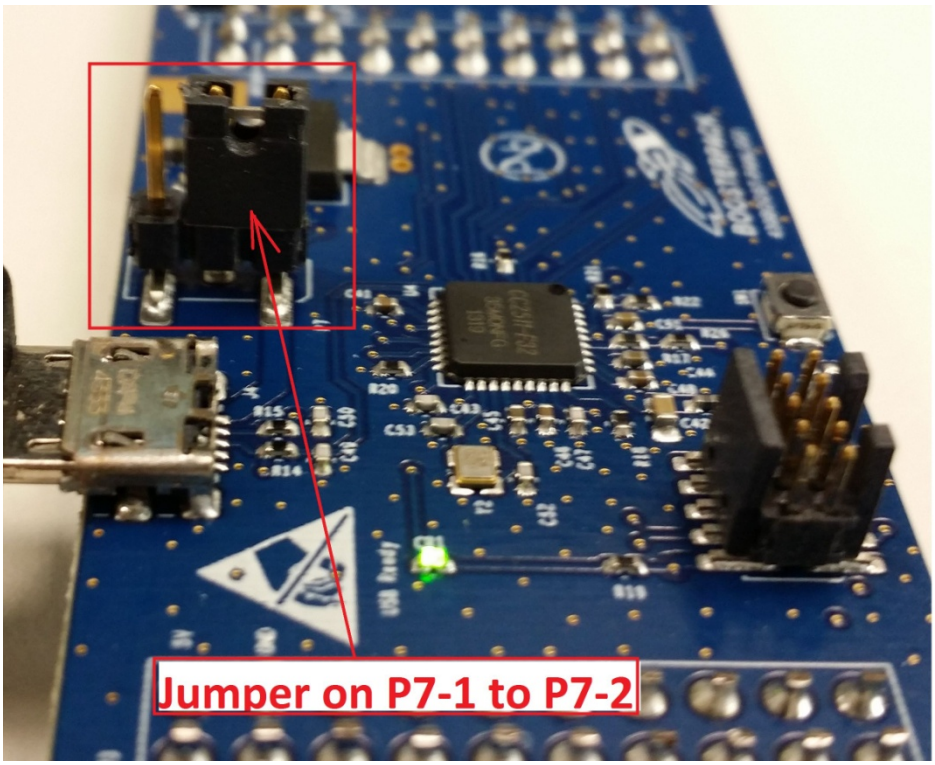

Figure 8. PS Jumper Location for SmartRFStudio Application

3. **CC1190 Control**:

   The CC1190 on the BoosterPack can be controlled directly from the SmartRF Studio. Connector P6 on the BoosterPack is used for CC1190 control signals selection. Refer to CC1190 Control Logic section for the details of logic for different modes (TX, RX and Power Down) of CC1190 operation. HGM, LNA_EN and PA_EN control signals are used to control CC1190. HGM can be controlled only through hardware jumper selection on the BoosterPak and the other two control signals LNA_EN and PA_EN can be controlled with the combination of Register settings from the SmartRF Studio and hardware jumper selection on the BoosterPack. The Jumper configurations for different modes of operations are shown below.

4. **Transmit Continuous Mode**:

   Place the Jumpers as shown below:

   (a) High Gain Mode: Place Jumper on P6-1 to P6-2

   (b) Low Gain Mode: Place Jumper on P6-3 to P6-4

   (c) LNA_EN: Place Jumper on P6-7 to P6-8 and set IOCG2 = 0x33 on SRS

   (d) PA_EN: Place Jumper on P6-11 to P6-12 and set IOCG0 = 0x73 on SRS

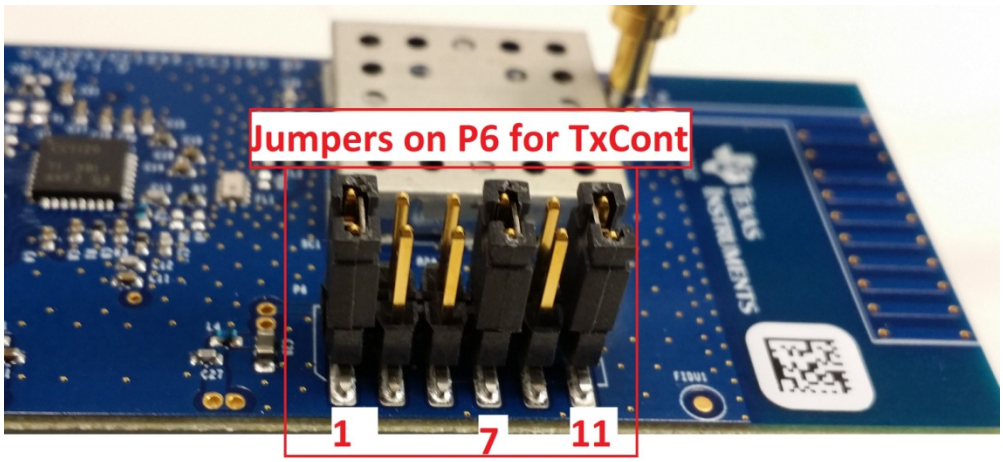

Figure 9. CC1190 Jumper Placement for TxCont -SRS Application

5. **Receive Continuous Mode**:
   Place the Jumpers as shown below:
   (a) High Gain Mode: Place Jumper on P6-1 to P6-2
   (b) Low Gain Mode: Place Jumper on P6-3 to P6-4
   (c) LNA_EN: Place Jumper on P6-7 to P6-8 and set IOCG2 = 0x73 on SRS
   (d) PA_EN: Place Jumper on P6-11 to P6-12 and set IOCG0 = 0x33 on SRS

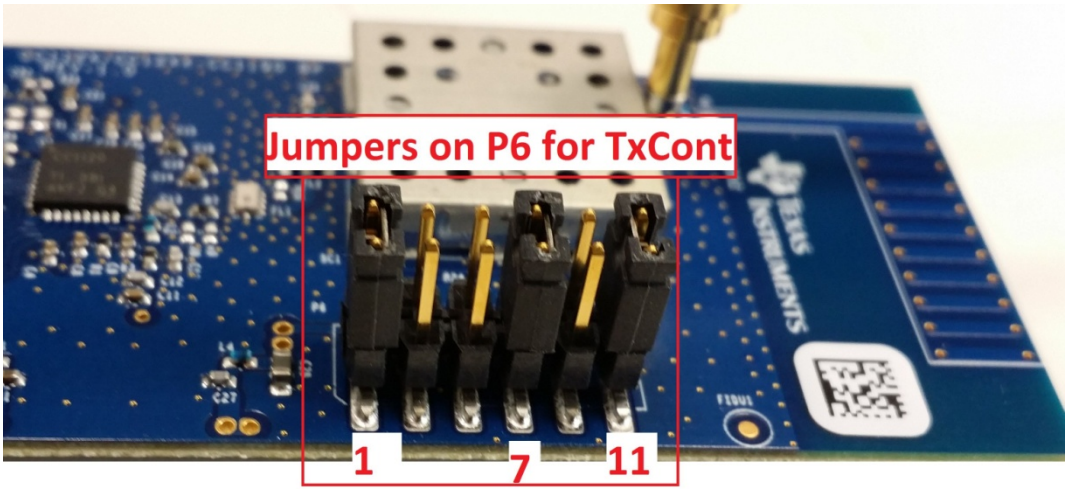

Figure 10. CC1190 Jumper Placement for RxCont -SRS Application

6. **Transmit Packet Mode**:
   Place the Jumpers as shown below:
   (a) High Gain Mode: Place Jumper on P6-1 to P6-2
   (b) Low Gain Mode: Place Jumper on P6-3 to P6-4
   (c) LNA_EN: Place Link on P6-4 to P6-5 (in high-gain mode)
   (d) LNA_EN: Place Link on P6-1 to P6-5 (in low-gain mode)
   (e) PA_EN: Place Jumper on P6-11 to P6-12
   (f) Register settings on SRS: Default settings

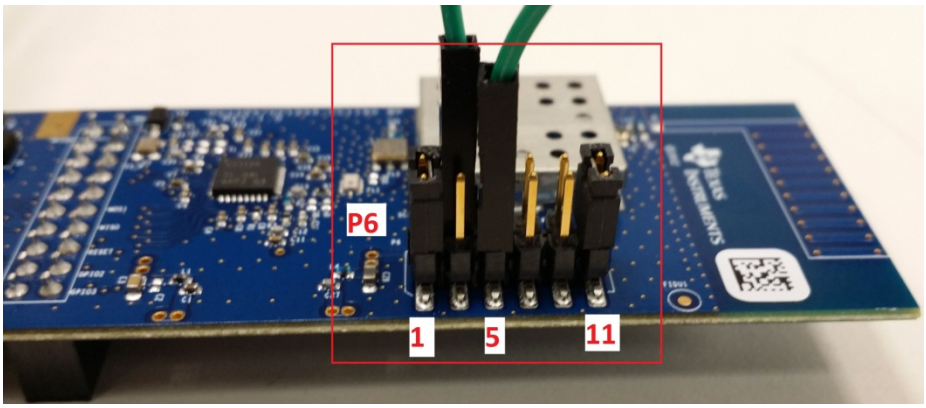

Figure 11. CC1190 Jumper Placement for Tx Packet Mode -SRS

7. **Receive Packet Mode**:
   Place the Jumpers as shown below:
   (a) High Gain Mode: Place Jumper on P6-1 to P6-2
   (b) Low Gain Mode: Place Jumper on P6-3 to P6-4
   (c) LNA_EN: Place Jumper on P6-3 to P6-5 (in high-gain mode)
   (d) LNA_EN: Place Link on P6-2 to P6-5 (in low-gain mode)
   (e) PA_EN: Place Jumper on P6-11 to P6-12
   (f) Register settings on SRS: Default settings

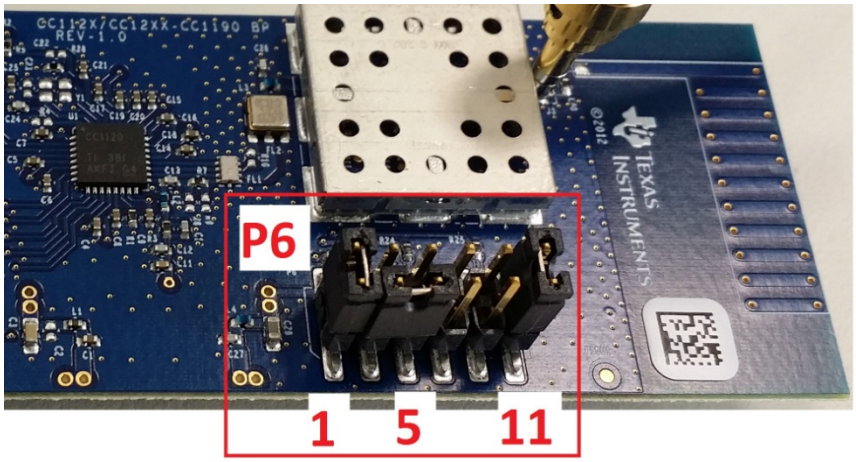

Figure 12. CC1190 Jumper Placement for Rx Packet Mode -SRS

7.1 SmartRF Studio Configuration

The CC1120-CC1190 BoosterPack can be configured using the SmartRF Studio 7 software [6]. The SmartRF Studio software is highly recommended for obtaining optimum register settings. Use the following steps:

1. Open SmartRFStudio on the PC. It shows "CC112x" in the List of Connected Devies Window. A screen shot of SRS window is shown in Figure 13.

Figure 13. SmartRF Studio Window

2. Double Click on CC112x (in List of connected devices in SRS window).
3. It opens up another window called “Device Control Panel”, which is shown in Figure 14.

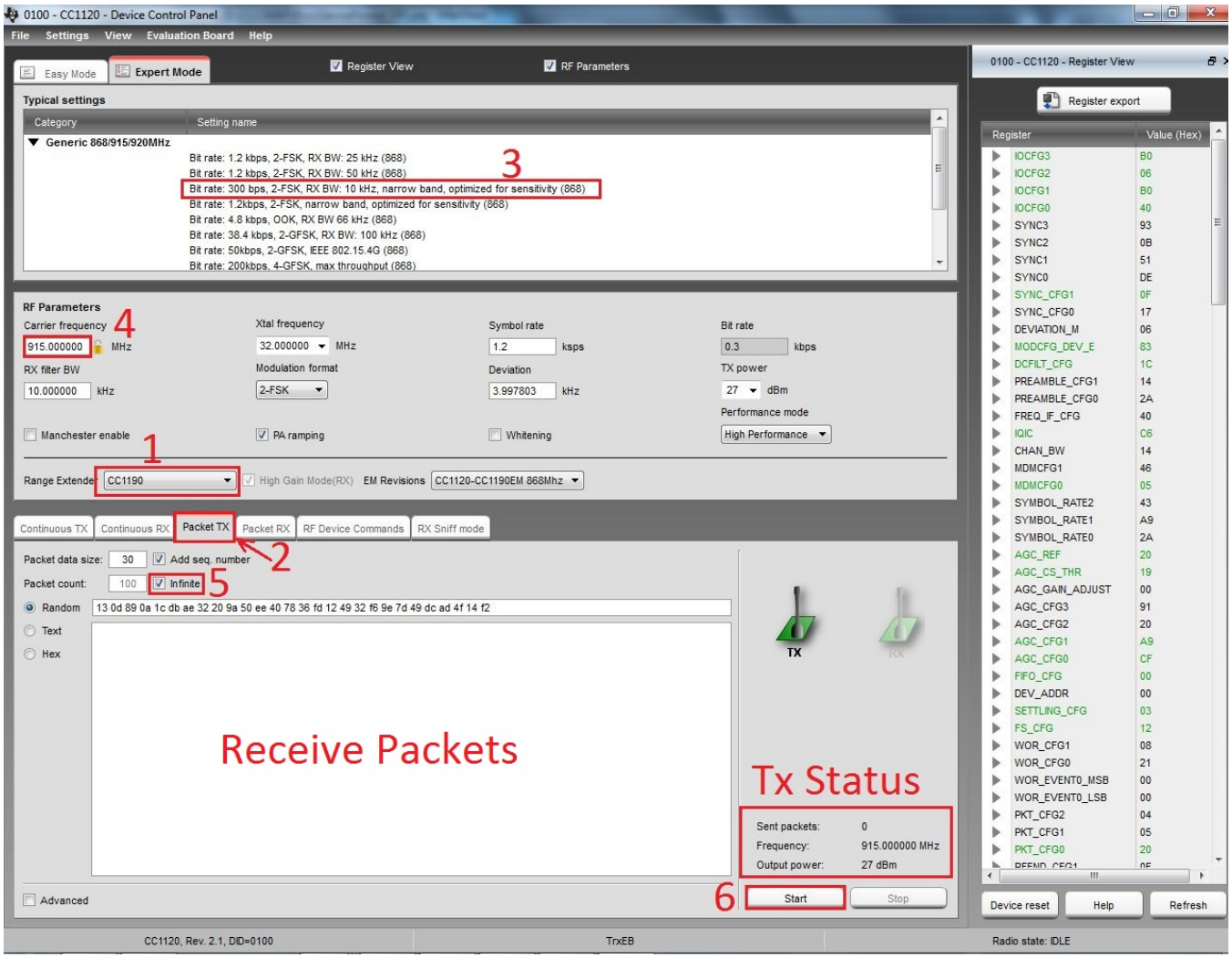

Figure 14. Device Control Panel Window –SmartRF Studio

4. Follow the steps 1 through 6 in the same order as shown in figure 14.
   (a) Step-1 – Select Range Extender (CC1190) option.
   (b) Step-2 – Select Mode – Packet Tx for Transmit board and Packet Rx for Receive board.
   (c) Step-3 – Select Typical Setting – For example 300 bps.
   (d) Step-4 – Select Carrier Frequency – For example 915 MHz.
   (e) Step-5 – Select the Number of packets to be sent or Received, for example, Infinite.
   (f) Step-6 – Click on the “Start” button either for Transmit or Receive.
   (g) Tx Status or Rx status can be seen in the status area, for example, Tx Status.
   (h) Receive packets can be seen Receive packets window.

8 Reference Design

The CC1120-CC1190 BoosterPack reference design includes schematic and gerber files [4]. The same design can be used for both 915 MHz and 868 MHz applications with different bill of materials. The same design can also be used for SigFox applications in 915 MHz frequency band with different bill of materials. It is highly recommended to follow the reference design for optimum performance. The reference design also includes bill of materials with manufacturers and part numbers.

8.1 Power Decoupling

Proper power supply decoupling must be used for optimum performance. The capacitors C31, C32 and C33 ensure good RF ground after L7 and thus prevent RF leakage into the power supply lines causing oscillations. The power supply filtering consisting of C27, C28 and L4 ensure well defined impedance looking towards the power supply.

8.2 Input/Output Matching and Filtering

The PA and the LNA of the CC1190 are single ended input/output. A balun is required to transform the differential LNA input of the CC112x to single ended output of the CC1190 PA. The values of the matching components between the SAW filter and the CC1190 PA input are chosen to present optimum source impedance to the CC1190 PA input with respect to stability.

The resistive pad (12dB) in between the PA output of CC112x to the input of the Balun is an option for SigFox application. This pad allows the use of higher power levels from CC112x to drive CC1190 in order to use the fine resolution power step sizes available at higher power levels of CC112x in adjusting the output power of CC1190. The power level should be set to high on CC112x, when this module used for SigFox application. This resistive pad is not required for applications other than SigFox.

The CC1190 PA performance is highly dependent on the impedance presented at the output, and the LNA performance is highly dependent on the impedance presented at the input. The impedance is defined by L7 and all components towards the antenna. These components also ensure the required filtering of harmonics to pass regulatory requirements.

The layout and component values need to be copied exactly to obtain the same performance as presented in this application report.

8.3 Bias Resistor

R11 is a bias resistor. The bias resistor is used to set an accurate bias current for internal use in the CC1190.

8.4 SAW Filter

A SAW is recommended for the CC112x-CC1190 BoosterPack design to attenuate spurs below the carrier frequency that will otherwise violate spurious emission limits under Section 15.209 and 15.205 The SAW filter is matched to the CC1190 PA input/LNA output impedance using a series inductor and a shunt capacitor.

8.5 Debug Connector

Debug connector P1 can be used to interface with CC Debugger and to flash CC2511 with the USB-Bootloader program.

8.6 Reset Switch

Reset switch SW1 can be used to reset the USB port of the BoosterPack.

8.7 PCB Layout Considerations

The Texas Instruments reference design uses a 1.24 mm (0.049”) 4-layer PCB solution. Note that the different layers have different thickness. It is recommended to follow the recommendation given in the CC1120–CC1190 BoosterPack reference design [4] to ensure optimum performance.

The top layer is used for components and signal routing, and the open areas are filled with metallization connected to ground using several vias. The areas under the two chips are used for grounding and must be well connected to the ground plane with multiple vias. Footprint recommendation for the CC1190 is provided in the CC1190 data sheet [3].

Layer two is a complete ground plane and is not used for any routing. This is done to ensure short return current paths. The low impedance of the ground plane prevents any unwanted signal coupling between any of the nodes that are decoupled to it.

Layer three is a mixed plane. The power supply and some of the digital lines are routed on this layer. Wider traces were used for power supply routing. The open areas are filled with metallization connected to ground using several vias.

Layer four is used for routing, and as for layer one, open areas are filled with metallization connected to ground using several vias.

8.8 Shielding

RF shielding is necessary to keep the radiated harmonics below the regulatory limits.

9 References

1. *CC1120 High-Performance RF Transceiver for Narrowband Systems Data Sheet* (SWRS112)
2. *CC112X/CC1175 Low-Power High Performance Sub-1 GHz RF Transceivers/Transmitter User's Guide* (SWRU295)
3. *CC1190 850 – 950 MHz RF Front End Data Sheet* (SWRS089)
4. *CC112x–CC1190 BoosterPack 915/868 MHz Reference Design* (SWRR145)
5. *CC1120_CC1190EM 915MHz Reference Design 1.0.1* (SWRR089)
6. *CC1120-CC1190EM868 Reference Design* (SWRR092)
7. *CC112x-CC1190 Boost Software Examples* (SWRA493)
8. *Using the CC1190 Front End With CC112x and CC120x Under FCC 15.247* (SWRA387)
9. *CC Debugger User's Guide* (SWRU197)
10. *MSP430F5529 LaunchPad™ Development Kit (MSP-EXP430F5529LP) User's Guide* (SLAU533)
11. *MSP-EXP430G2 LaunchPad Evaluation Kit User's Guide* (SLAU318)
12. FCC Rules
13. *SmartRF Studio 7 v1.18.0* (SWRC176)

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

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3 *Regulatory Notices:*

   3.1 *United States*

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

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

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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

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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.

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