Application Report
SWRA520–May 2016

CC1125 BoosterPack™ for 868/915 MHz BOOSTXL-CC1125

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ABSTRACT

The module BOOSTXL-CC1125 (CC1125 BoosterPack) is designed to support both the LaunchPad™ Development Kit and SmartRF™ Studio application software. The module can be configured by changing the on-board jumper position to select the power supply either from the LaunchPad or from the USB source according to the desired application. The default configuration of the jumper on the BoosterPack module is set for LaunchPad applications. The interface details of CC1125 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.

The module, BOOSTXL-CC1125 along with MSP-EXP430F5529 LaunchPad is certified to use on Sigfox wireless networks in EU region with a valid license from Sigfox.

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1 Introduction

The BOOSTXL-CC1125 (CC1125 BoosterPack) module is designed to use with the MSP-EXP430F5529 and MSP-EXP430G2553 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 that operates in the US 902 MHz to approximately 928 MHz and European 868 MHz to approximately 870 MHz ISM frequency bands. The module along with MSP-EXP430F5529 LaunchPad is certified to use on Sigfox wireless networks in EU region with a valid license from Sigfox. The MSP-EXP430G2553 LaunchPad may not be suitable to use for Sigfox applications due to the memory space constraint. The BOOSTXL-CC1125 module is shown in Figure 1 and Figure 2.

As the module is designed to support both LaunchPad and SmartRF Studio platforms, the board needs to be configured by changing the on-board jumper position to select the power supply either from the LaunchPad or from the USB source according to the desired application. The default configuration of the jumper on the BoosterPack module is set for LaunchPad applications. The interface details of BOOSTXL-CC1125 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.

The RF performance of BOOSTXL-CC1125 is similar to the RF performance of the CC1125 EM. For the expected performance and detailed specifications, see the C1125 data sheet [1].

The CC1125 device is fully integrated single-chip radio transceiver 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 SAW and IF filters. The device is mainly intended for the Industrial, Scientific and Medical (ISM) and Short Range Device (SRD) frequency bands at 164 MHz-192 MHz, 410 MHz-480 MHz and 820 MHz-960 MHz.

The CC1125 device provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication, and Wake-On-Radio. The main operating parameters of the CC1125 device can be controlled through an SPI interface. In a typical system, the CC1125 device is used with a microcontroller and only a few external passive components.

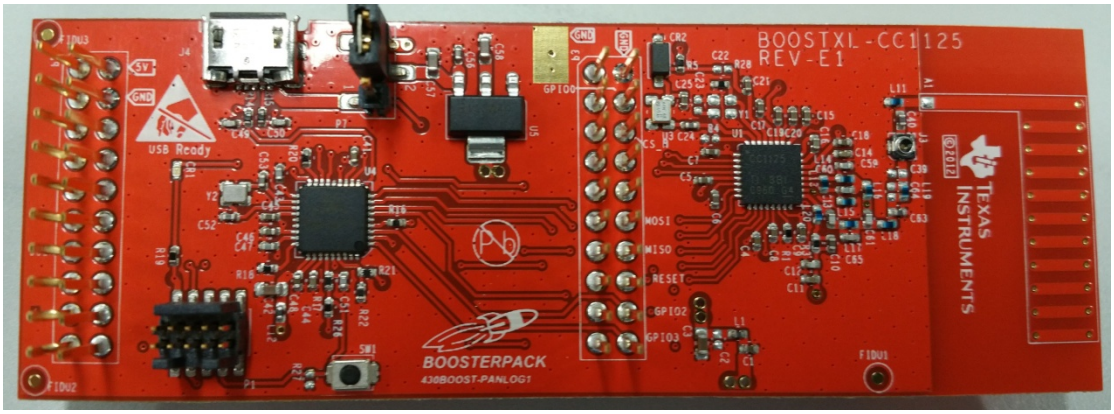

Figure 1. BOOSTXL-CC1125 - Top Side

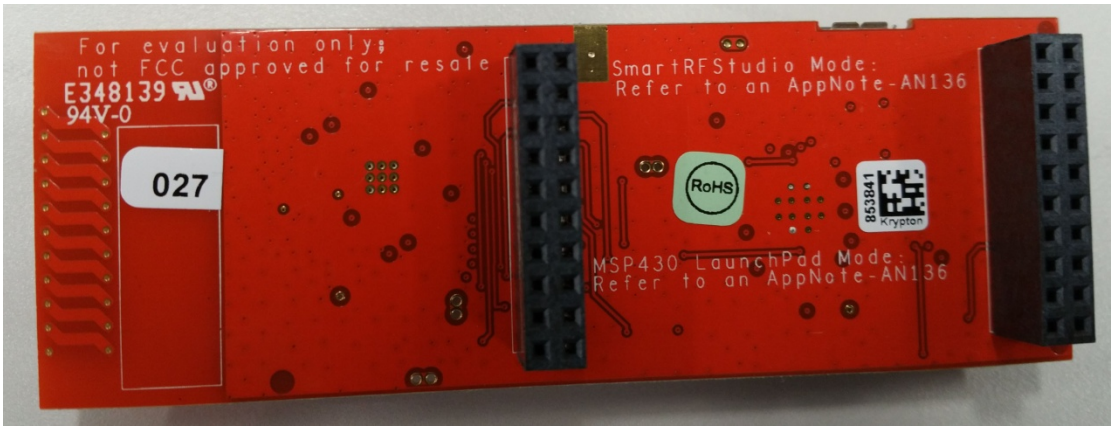

Figure 2. BOOSTXL-CC1125 - Bottom Side

Table 1. Acronyms Used in This Document

Acronym	Definition
BP	BoosterPack
CHF	Channel Filter
DEV	Deviation
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 CC1125 data sheet [1] 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 BOOSTXL-CC1125 performance is similar to CC1125 EM. For the detailed electrical specifications, see the CC1125 data sheet [1].

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		150	mA
Operating Temperature	-40	+85	°C

3.2 Current Consumption

Table 3. Current Consumption

Parameter	Condition	Typical	Unit
Standby Current	Without USB Interface	4	mA
Standby Current	With USB Interface	14	mA
Receive Current	Continuous mode	37	mA
Transmit Current	PA_CFG2 = 0x7F	64	mA
Transmit Current at 915MHz	PA_CFG2 = 0x7F	62	mA

3.3 Receive Parameters (High-Performance Mode)

T_c = 25°C, VDD = 5 V, f = 869.5 MHz, if nothing else is stated. All parameters were measured on the BOOSTXL-CC1125 reference design [3] at an antenna connector with a 50 Ω load. Radiated measurements were done with an on-board PCB antenna. Sensitivity limit is defined as 1% bit error rate (BER) with 3 bytes packet length.

Table 4. Receive Parameters

Parameter	Condition	Typical	Unit
Sensitivity	400 bps, 2FSK, DEV= 1 KHz, CHF = 3.8 KHz	-127.5	dBm
	1.2 kbps, 2GFSK, DEV=20 KHz, CHF=50 KHz	-123	
	4.8 kbps, OOK	-114	
	38.4 kbps, 2GFSK, DEV=20 KHz, CHF=100 KHz	-110	
	50 kbps, 2GFSK, DEV=25 KHz, CHF = 100 KHz	-110	
	200 kbps, 4GFSK, DEV = 83 kHz , CHF = 200 KHz	-103	
Saturation	Maximum input power level	+10	dBm

Table 4. Receive Parameters (continued)

Parameter	Condition	Typical	Unit
Blocking and Selectivity	400 bps, 2FSK, DEV= 1 KHz, CHF = 3.8 kHz		dB
	±6.25 KHz from wanted signal	62	
	±12.5 KHz from wanted signal	63	
	±1 MHz from wanted signal	83	
	±2 MHz from wanted signal	87	
	±10 MHz from wanted signal	91	
	1.2 kbps, 2FSK, DEV= 4 KHz, CHF = 10 kHz		dB
	±12.5 KHz from wanted signal	58	
	±25 KHz from wanted signal	58	
	±1 MHz from wanted signal	78	
	±2 MHz from wanted signal	82	
	±10 MHz from wanted signal	86	
	38.4 kbps, 2-GFSK, DEV= 20 KHz, CHF = 100 kHz		dB
	±100 KHz from wanted signal	42	
	±200 KHz from wanted signal	43	
	±1 MHz from wanted signal	62	
	±2 MHz from wanted signal	66	
	±10 MHz from wanted signal	74	
	200 kbps, 4-GFSK, DEV= 83 KHz, CHF = 200 kHz		dB
	±200 KHz from wanted signal	36	
	±400 KHz from wanted signal	44	
	±1 MHz from wanted signal	55	
	±2 MHz from wanted signal	59	
	±10 MHz from wanted signal	67	
Spurious emission	Conducted – 30 MHz to approximately 13 GHz	-91	dBm
	Radiated emissions measured according to ETSI EN 300 220		
	1 to approximately 13 GHz (VCO leakage at @3.5 GHz)	-56	
	30 MHz to approximately 1 GHz	<-57	

3.4 Transmit Parameters

T_C = 25°C, VDD = 5 V, f = 869.5 MHz if nothing else is stated. All parameters are measured on the BOOSTXL-CC1125 reference design [3] at an antenna connector with a 50 Ω load. Radiated measurements were done with an on-board PCB antenna.

Table 5. Transmit Parameters

Parameter	Condition	Typical	Unit
Max Output Power	PA_CFG2 = 0x7F		dBm
	At 869.5 MHz	15.6	
	At 915 MHz	14.8	
Tx Output power	At 869.5 MHz (PA_CFG2 = 0x7D)	15.0	dBm
	At 915 MHz (PA_CFG2 = 0x74)	9.0	
Spurious emission	PA_CFG2 = 0x7D		dBm
	Conducted below 1 GHz	-50.2	
	Conducted above 1 GHz	-60	
	Radiated below 1 GHz	<-52	
	Radiated above 1 GHz	<-45	
Harmonic emission	At 869.5 MHz (PA_CFG2 = 0x7D)		
	Conducted 2nd harmonic	-57.6	dBm
	Conducted 3nd harmonic	-49.6	
	Conducted 4th harmonic	-58.1	
	Radiated 2nd harmonic	-48	
	Radiated 3nd harmonic	-44	
	Radiated 4th harmonic	-38	
	At 915 MHz (PA_CFG2 = 0x74)		
	Conducted 2nd harmonic	-58.6	
	Conducted 3nd harmonic	-56.2	
	Conducted 4th harmonic	-62.4	
	Radiated 2nd harmonic	-51.2	
	Radiated 3nd harmonic	-52	
	Radiated 4th harmonic	-41.9	

4 BOOSTXL-CC1125 Control and Interface Connections

The control and interface connector details of BOOSTXL-CC1125 module is shown in Figure 3. The BOOSTXL-CC1125 BoosterPack can be used with either LaunchPad or as a stand-alone module along with SmartRF Studio. The jumper on connector P7 should be configured as per the requirement.

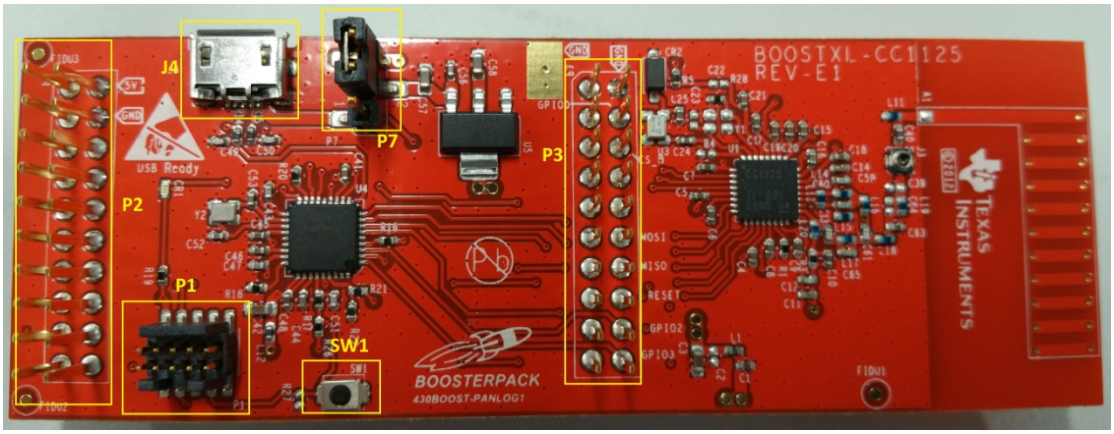

Figure 3. BOOSTXL-CC1125 – Connectors

5 BOOSTXL-CC1125 Interface With MSP430 LaunchPad

The BOOSTXL-CC1125 module is compatible to use with the MSP-EXP430F5529 and MSP-EXP430G2553 LauchPad development kits. The BOOSTXL-CC1125 can be interfaced with the LaunchPad by using the following steps:

1. Install the BOOSTXL-CC1125 on to the LaunchPad as shown in Figure 4.

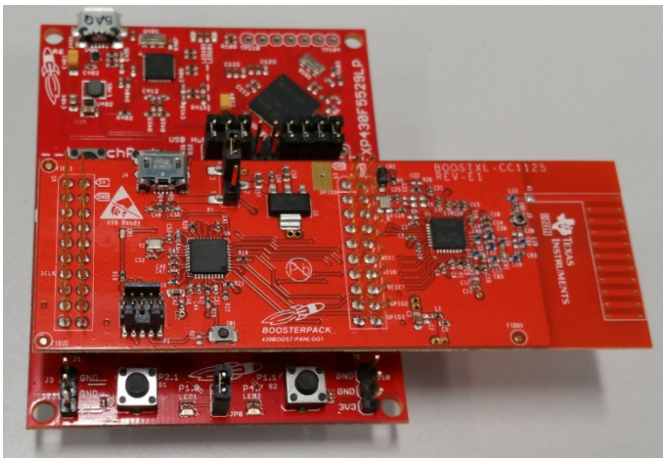

Figure 4. BOOSTXL-CC1125 With LaunchPad

2. Power Supply Selection: Connector P7 on the BoosterPack is used in selecting the options for power supply.
   (a) 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.
   (b) For use with MSP-EXP430G2553 LaunchPad, remove the Jumper from P7 and connect an external 5 V (100 mA capable) power supply positive lead to the center pin (2) of P7 and the ground lead to the nearby ground pad.

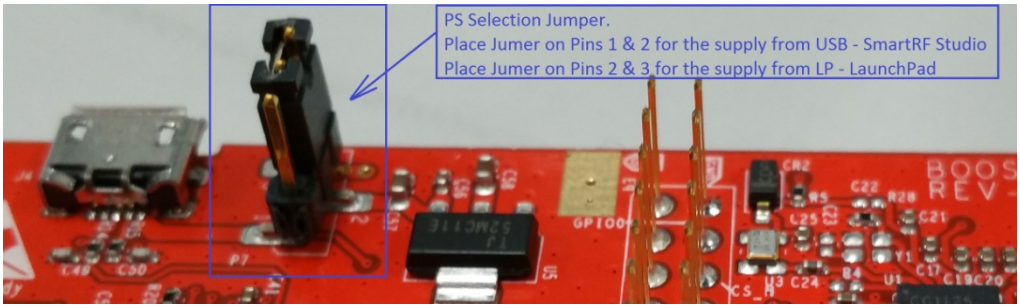

Figure 5. PS Jumper Location for LaunchPad Application

3. Connect USB cable to the LaunchPad.
4. Run the desired program (example PER test) on the LaunchPad.

6 BOOSTXL-CC1125 Interface With SmartRF Studio

The BOOSTXL-CC1125 can be controlled directly from SmartRF Studio 7 software [9] to evaluate the RF performance and functionality. The SmartRF Studio software is highly recommended for obtaining optimum register settings. The jumpers on the connector 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 6.

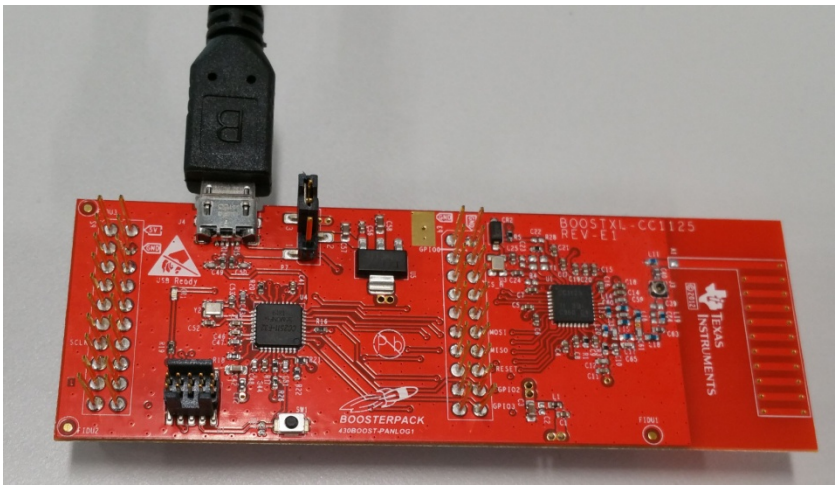

Figure 6. BOOSTXL-CC1125 With USB Cable

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 7.

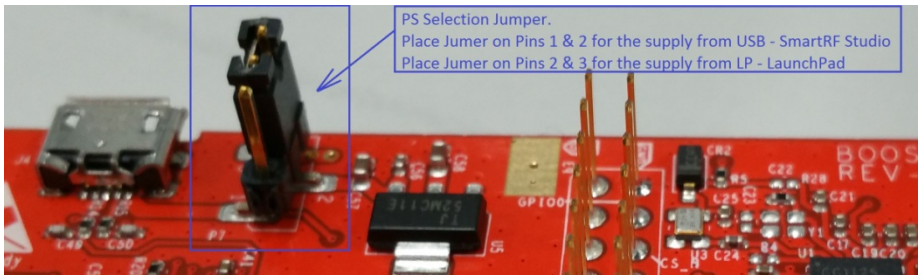

Figure 7. PS Jumper Location for SmartRFStudio Application

6.1 SmartRF Studio Configuration

The BOOSTXL-CC1125 can be configured by using the SmartRF Studio 7 software [9]. The SmartRF Studio software is highly recommended for obtaining optimum register settings. The following steps describe:

1. Open SmartRFStudio on the PC. It shows “CC1125 “in the List of Connected Devices Window. A screen shot of SRS window is shown in Figure 8.

Figure 8. SmartRF Studio Window

2. Double Click on CC1125 (in the list of connected devices in SRS window).
3. It opens up another window called “Device Control Panel”, which is shown in Figure 9.

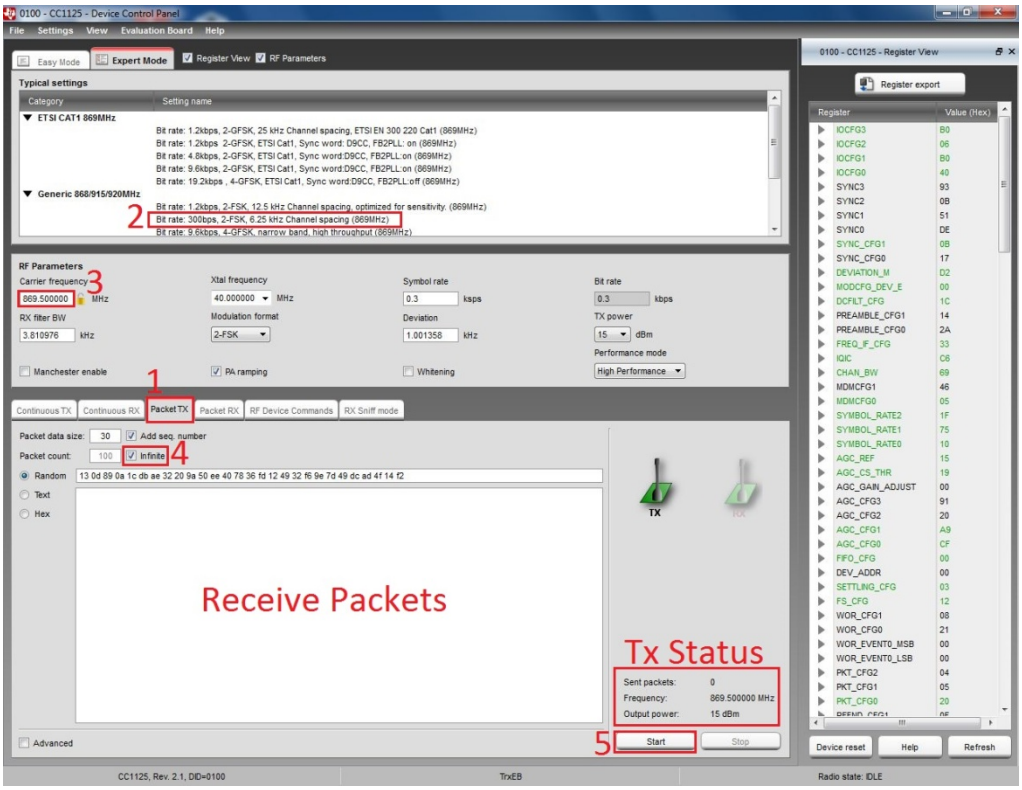

Figure 9. Device Control Panel Window – SmartRF Studio

Follow the steps 1 through 5 in the same order as shown in Figure 9.

Step 1. Select Mode – Packet Tx for Transmit board and Packet Rx for Receive board.

Step 2. Select Typical Setting – For example 300 bps

Step 3. Select Carrier Frequency – For example 869.5 MHz

Step 4. Select the number of packets to be sent or Received – for example, infinite

Step 5. Click on “Start” button either for Transmit or Receive.

7 Reference Design

The BOOSTXL-CC1125 BoosterPack reference design includes the Schematic, PCB Layout and complete bill of materials (BOM) [3]. The same design can be used for both 868 MHz and 915 MHz band applications with minor changes in the BOM. It is highly recommended to follow the reference design for optimum performance.

7.1 Input/Output Matching and Filtering

A balun is required to transform the differential LNA input of the CC1125 to a single ended output configuration. C40 and L11 are part of the antenna matching circuit and these values may need to be tuned on prototype boards for better antenna return loss. Only C40 and L11 values are different for 868 MHz and 915 MHz bands but all the other components used in the design are same for both 868/915 MHz band.

7.2 Bias Resistor

R1 is a bias resistor. The bias resistor is used to set an accurate bias current for internal use in the CC1125 data sheet [1].

7.3 Crystal Oscillator

A 40 MHz TCXO is recommended to use in the design for ultra narrow band applications. For the detailed specification of TCXO, see the CC1125 data sheet [1].

7.4 Debug Connector

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

7.5 Reset Switch

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

7.6 RF Connector

RF Switch connector, J3 is provided in the design to facilitate the connection to the test equipment for test and measurement application. When the mating test probe/cable is connected to J3, the built-in-switch in the connector disconnects the path to the PCB Trace Antenna A1 automatically. This helps in isolating the antenna A1 from the test equipment.

7.7 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 layer stack-up given in the BOOSTXL-CC1125 BoosterPack reference design [3] 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 area underneath the chip is used for grounding and must be well connected to the ground plane with multiple vias. Footprint recommendation for the CC1125 is given in the CC1125 data sheet [1].

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 the open areas are filled with metallization connected to ground using several vias.

8 References

1. CC1125 Ultra-High Performance RF Narrowband Transceiver Data Sheet
2. CC112X/CC1175 Low-Power High Performance Sub-1 GHz RF Transceivers/Transmitter User's Guide
3. BOOSTXL-CC1125- 868/915 MHz Reference Design
4. CC1125EM 868/915 MHz Reference Design
5. CC Debugger User's Guide
6. MSP430F5529 LaunchPad™ Development Kit (MSP-EXP430F5529LP) User's Guide
7. MSP-EXP430G2 LaunchPad™ Development Kit User's Guide
8. FCC rules
9. SmartRF™ Studio 7

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