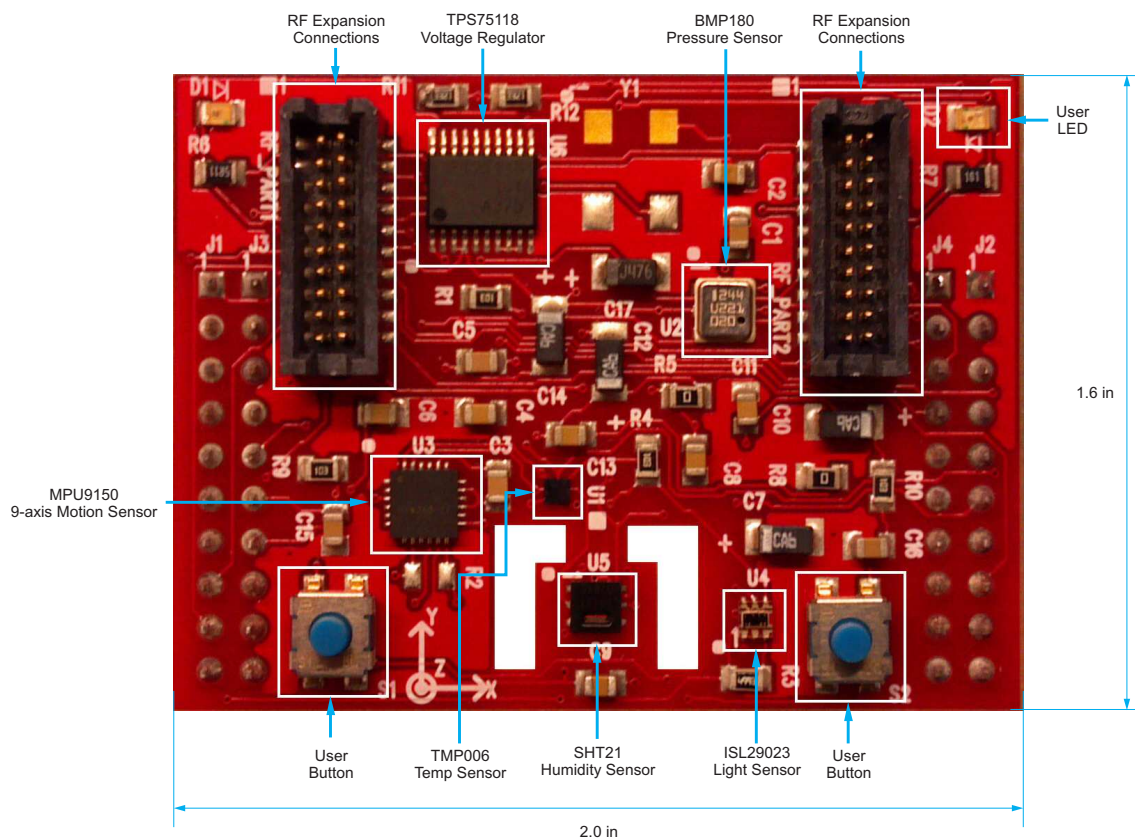


BOOSTXL-SENSHUB Sensor Hub BoosterPack

The Sensor Hub Booster Pack ([BOOSTXL-SENSHUB](#)) is a low-cost extension board for the Tiva™ C Series TM4C LaunchPad [EK-TM4C123GXL](#) evaluation platform for ARM® Cortex™-M4F-based microcontrollers (MCUs). This extension board, or BoosterPack, is specifically designed to expand the functionality of the Tiva TM4C LaunchPad. This user's manual provides an overview of the Sensor Hub BoosterPack software and hardware

Figure 1 shows a photo of the BOOST-XL-SENSHUB.

Figure 1. BOOSTXL-SENSHUB BoosterPack Extension Board



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1 Board Overview

The Sensor Hub BoosterPack is an extension board for the [TI MCU LaunchPad evaluation module](#) eco-system. It was designed specifically to extend the functionality of the Tiva TM4C1233 LaunchPad (EK-TM4C123GXL). The Sensor Hub enables customers to create and model innovative prototype solutions that leverage the processing and floating-point capabilities of the [TM4C123GH6PM](#) MCU coupled with motion and environmental sensors. The Sensor Hub BoosterPack plugs in to the BoosterPack XL headers located on the top of the LaunchPad. The BoosterPack also features a TI-standard extension module (EM) connector to further extend customer applications through a variety of wireless extension modules. This board and the available software also highlight the use of the new TivaWare® SensorLib sensor driver library, an easy-to-use, extendable foundation of sensor communication software.

NOTE: The Sensor Hub BoosterPack is fully compatible with both the Tiva™ C Series LaunchPad ([EK-TM4C123GXL](#)) and the Stellaris® LM4F120 LaunchPad (EK-LM4F120XL).

1.1 Kit Features

The BOOSTXL-SENSHUB BoosterPack offers the following features:

- [TMP006](#) infrared object temperature sensor
- 9-axis InvenSense [MPU9150 motion sensor](#):
 - 3-axis acceleration
 - 3-axis gyroscope
 - 3-axis magnetometer
- Bosch [BMP180 pressure sensor](#)
- Intersil [ISL29023 ambient and infrared light sensor](#)
- Sensirion [SHT21 humidity sensor](#)
- Two user pushbuttons
- One user LED
- One power LED
- EM connector for additional wireless expansion

1.2 Using the Sensor Hub BoosterPack

Follow these recommended steps to quickly configure your Sensor Hub for proper operation.

- Step 1. Review the BOOSTXL-SENSHUB BoosterPack Getting Started Guide (literature number [SPMU295](#), available for download at [www.ti.com](#)). This document guides you through downloading, installing, and running the associated TivaWare examples that demonstrate the Sensor Hub capabilities and functions.
- Step 2. Examine the additional examples that are provided with the downloaded software to understand the capabilities and limitations of each on-board sensor.
- Step 3. Create your own application using the Tiva C Series LaunchPad and Sensor Hub BoosterPack. Use the TivaWare for C Series Sensor Library to enable your innovative Tiva TM4C MCU applications.
- Step 4. Customize and integrate the hardware to suit a specific end application. This user's manual is an important reference for understanding circuit operation and completing hardware modifications.

1.3 Specifications

Table 1 summarizes the specifications for the BOOSTXL-SENSHUB BoosterPack.

Table 1. Sensor Hub BoosterPack Specifications

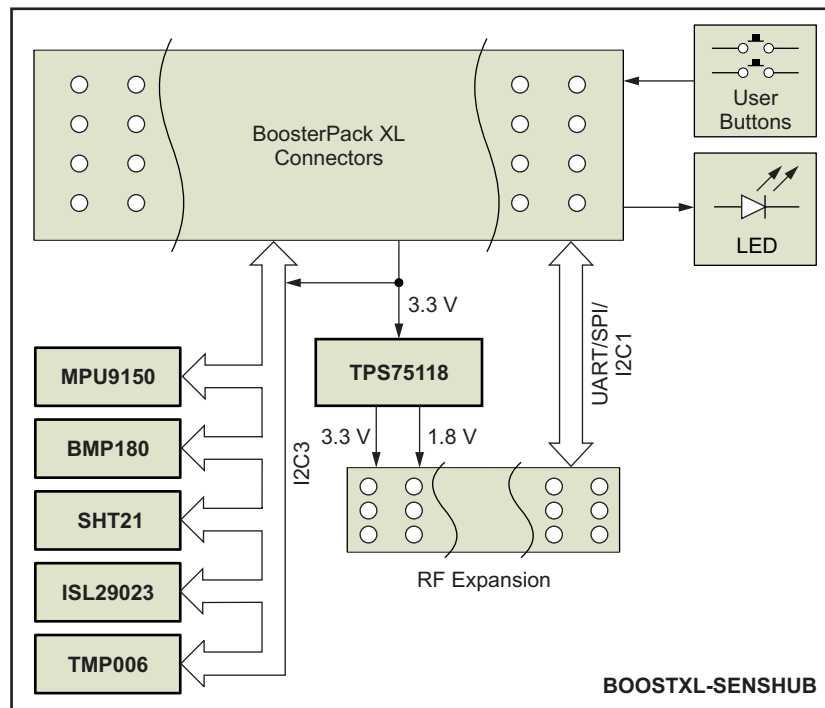
Parameter	Value
Board supply voltage	2.7 V to 5.5 V nominally supplied as 3.3 V from the BoosterPack interface
Dimensions	2.0 x 1.5 x 0.625 (in) 5.08 x 3.81 x 1.587 (cm)
RoHS status	Compliant

2 Hardware Description

The Sensor Hub BoosterPack includes five motion and environmental sensors. It also enables RF expansion and access to user LEDs and buttons. The hardware is designed to enable innovative applications that fuse sensor information and Tiva C Series software processing through the functionality of the Tiva C Series LaunchPad.

Figure 2 shows a block diagram of the Sensor Hub BoosterPack.

Figure 2. BOOSTXL-SENSHUB BoosterPack Block Diagram



2.1 Functional Description

This section provides a functional description of the Sensor Hub BoosterPack.

2.1.1 BoosterPack XL Connector

The BoosterPack XL connector attaches the BoosterPack to the Tiva TM4C LaunchPad. This BoosterPack is specifically designed to match the pin function with the Tiva TM4C LaunchPad. Basic I²C and UART communication to the sensors and RF expansion connectors are also available when the Sensor Hub is connected to either the [C2000 or MSP430 LaunchPad](#).

[Table 2](#) describes the BoosterPack XL interface connections and the respective uses on the Sensor Hub BoosterPack. It also shows which pins remain available for additional expansion at the user's discretion.

Table 2. BoosterPack XL Interface Connections⁽¹⁾

Pin	Function	Pin	Function	Pin	Function	Pin	Function
J1.1	3.3 V IN	J2.1	Ground	J3.1		J4.1	
J1.2		J2.2	Interrupt	J3.2		J4.2	
J1.3	UART RX	J2.3	Interrupt	J3.3		J4.3	RF GPIO
J1.4	UART TX	J2.4		J3.4		J4.4	UART RTS
J1.5		J2.5		J3.5	USER LED	J4.5	UART CTS
J1.6	Interrupt	J2.6	Sensor I2C	J3.6	User Button	J4.6	RF Shutdown
J1.7		J2.7	Sensor I2C	J3.7	User Button	J4.7	RF Reset
J1.8	SSI TX	J2.8	SSI RX	J3.8	RF GPIO	J4.8	RF GPIO
J1.9	RF I2C	J2.9	SSI SS	J3.9	RF GPIO	J4.9	
J1.10	RF I2C	J2.10	SSI CLK	J3.10		J4.10	

⁽¹⁾ Shaded cells indicate unused pins that are available for additional expansion.

2.1.2 TMP006 Temperature Sensor

The TMP006 provides both direct and indirect temperature measurements. It contains an on-chip temperature sensor to directly measure ambient temperature conditions. It also allows contactless infrared object temperature measurement.

2.1.3 InvenSense MPU9150 9-Axis Motion Sensor

The MPU9150 is a 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer in a single package. This device is the primary motion sensor on the Sensor Hub. It is used by the demonstration software as the raw motion inputs, which are fused by a direct cosine matrix into roll, pitch, and yaw measurements.

2.1.4 Intersil ISL29023 Ambient and Infrared Light Sensor

The ISL29023 provides sensor measurements of light conditions across both the ambient (human-visible) spectrum and the infrared spectrum.

2.1.5 Sensirion SHT21 Humidity Sensor

The SHT21 provides relative humidity measurements.

2.1.6 Bosch BMP180 Barometric Pressure Sensor

The BMP180 measures barometric pressure conditions. It can be used to enhance the motion sensor by determining relative changes in altitude.

2.1.7 Low-Power RF Expansion Connection

The RF expansion connection provides a wide array of options to the end application.

2.1.8 TPS75118 Voltage Regulator

The TPS75118 regulates the 3.3-V supply from the LaunchPad down to 1.8 V for the input to the RF expansion connector.

3 Software Development

This section provides general information on software development as well as instructions for Flash memory programming. **Note:** This information presumes that the Sensor Hub BoosterPack is connected to a Tiva TM4C1233 LaunchPad.

3.1 Software Description

The TivaWare software provided with the Tiva C Series LaunchPad includes functional drivers for all of the peripheral devices supplied in the design. The TivaWare for C Series Peripheral Driver Library is used to configure and operate the on-chip peripherals as part of TivaWare.

The TivaWare package includes a set of example applications that use the TivaWare Peripheral Driver Library. These applications demonstrate the capabilities of the TM4C1233H6 microcontroller, as well as provide a starting point for the user to develop the final application for use on the Tiva C Series LaunchPad evaluation board and the BOOSTXL-SENSHUB BoosterPack.

3.2 Source Code

The complete source code, including the source code installation instructions, are available at www.ti.com/tool/boostxl-senshub. The source code and binary files are installed in the TivaWare for C Series Peripheral Driver Library tree.

3.3 Tool Options

The source code installation includes directories that contain projects and/or makefiles for the following tool chains:

- Keil™ ARM RealView® Microcontroller Development System
- IAR Embedded Workbench for ARM
- Sourcery CodeBench
- Texas Instruments' Code Composer Studio™ IDE

Download evaluation versions of these tools from www.ti.com/tiva-c. As a result of code size restrictions, the evaluation tools may not build all example programs. A full license is necessary to rebuild or debug all examples.

Instructions on installing and using each of the evaluation tools can be found in the Quickstart guides (for example, Quickstart-Keil, Quickstart-IAR), which are available for download from the Evaluation Kit section of our website at www.ti.com/tiva-c.

For detailed information on using each tool, see the documentation included with the respective tool chain installation or visit the website of the respective tool supplier.

3.4 Programming the Tiva TM4C LaunchPad Evaluation Board

The [Tiva TM4C LaunchPad software package](#) includes pre-built binaries for each of the example applications. If you installed TivaWare for C Series to the default installation path of `C:\ti\TivaWare_C_Series_<version>`, you can find these example applications in `C:\ti\TivaWare_C_Series_<version>\examples\boards\lek-tm4c123gx1`. The onboard [ICDI](#) is used with the [LM Flash Programmer](#) tool to program applications on the Tiva C Series LaunchPad.

Follow these steps to program example applications into the Tiva C Series LaunchPad evaluation board using the ICDI:

1. Install the LM Flash Programmer on a PC running Microsoft® Windows® XP, Windows 7, or later Windows OS.
2. Switch the POWER SELECT switch to the right to use Debug mode.

3. Connect the USB-A cable plug to an available port on the PC and the Micro-B plug to the **Debug** USB port on the board.
4. Verify that the POWER LED D4 on the board is lit.
5. Run the LM Flash Programmer program.
6. In the *Configuration* tab, use the **Quick Set** control to select the Tiva C Series LaunchPad evaluation board.
7. Move to the *Program* tab and click the **Browse** button. Navigate to the example applications directory (the default location is `C:\ti\TivaWare_C_Series_<version>\examples\boards\ek-tm4c123gxl-senshub`).
8. Each example application has its own directory. Navigate to the example directory that you want to load, then navigate to the directory that contains the binary (*.bin) files. Select the desired binary file and click **Open**.
9. Set the Erase Method to *Erase Necessary Pages*. Check the **Verify After Program** box, and check the **Reset MCU After Program** option.
10. Click the **Program** button to start the Erase, Download, and Verify process. Program execution starts once the Verify process is complete.

4 References, PCB Layout, and Bill of Materials

Complete schematics for the Sensor Hub BoosterPack are appended to this user's guide.

4.1 References

In addition to this document, the following references are available for download at www.ti.com:

- BOOSTXL-SENSHUB BoosterPack Getting Started Guide (literature number [SPMU295](#))
- Tiva C Series TM4C123GH6PM Microcontroller Data Sheet (literature number [SPMS376](#)).
- TivaWare for C Series Driver Library. Available for download at www.ti.com/tool/sw-tm4c-drl.
- TivaWare for C Series Driver Library User's Manual (literature number [SPMU298](#)).
- TPS75118 Fast Transient Response, 1.5-A, Low-Dropout Regulator Data Sheet (literature number [SLVS241](#))
- TMP006 Infrared Thermopile Sensor Data Sheet (literature number [SBOS518](#))
- Texas Instruments' Code Composer Studio IDE website: www.ti.com/ccs

Additional support:

- RealView MDK (www.keil.com/arm/rvmdkkit.asp)
- IAR Embedded Workbench (www.iar.com)
- Sourcery CodeBench development tools (www.codesourcery.com/gnu_toolchains/arm)
- InvenSense MPU9150 (www.invensense.com/mems/gyro/mpu9150.html)
- Intersil ISL29023 (www.intersil.com/en/products/optoelectronics/ambient-light-sensors/light-to-digital-sensors/ISL29023.html)
- Bosch BMP180 (www.bosch-sensortec.com/homepage/products_3/environmental_sensors_1/bmp180_1/bmp180)
- Sensirion SHT21 (www.sensirion.com/en/products/humidity-temperature/humidity-sensor-sht21)

4.2 Bill of Materials (BOM)

Table 3 shows the bill of materials for the BOOSTXL-SENSHUB BoosterPack board.

Table 3. BOOSTXL-SENSHUB Bill of Materials⁽¹⁾⁽²⁾⁽³⁾

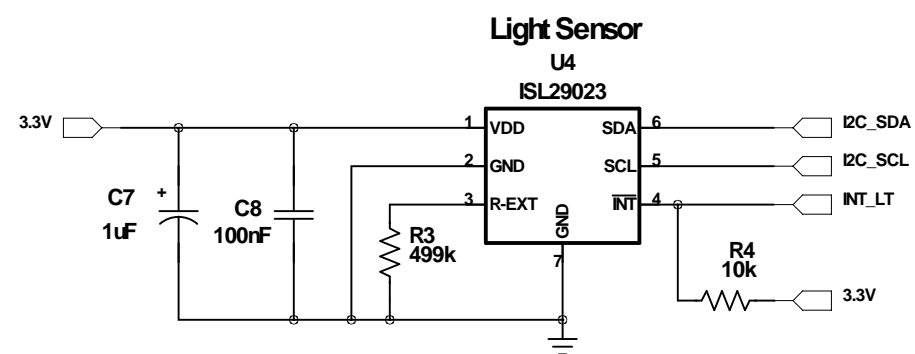
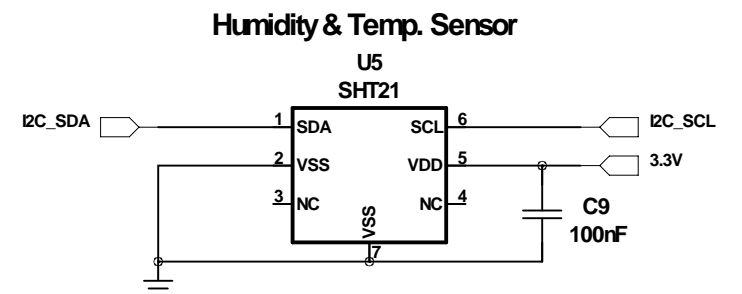
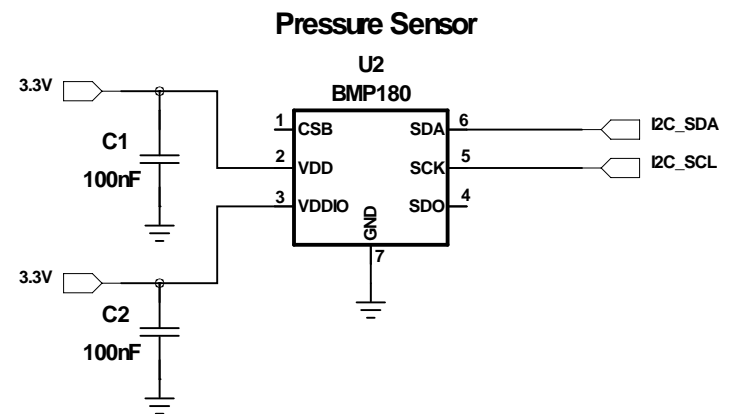
Item	Ref Des	Qty	Value	Description	Manufacturer	Manufacturer Part No
1	U2	1	BMP180	IC, digital, barometric pressure sensor	Bosch	BMP180
2	C1-2, C8-9, C11, C13, C15-16	8	100 nF	Capacitor, ceramic, NPO or C0G or X5R, 10 V or higher, 0805 ⁽⁴⁾	Murata	GRM21BR71E104KA01L
3	C4, C6	2	100 nF	Capacitor, ceramic, X7R, ±10%, 10 V or higher, 0805 ⁽⁴⁾	Murata	GRM21BR71E104KA01L
4	C5	1	10 nF	Capacitor, ceramic, X7R, ±10%, 10 V or higher, 0805 ⁽⁴⁾	Murata	GRM216R71H103KA01D
5	C3	1	2.2 nF	Capacitor, ceramic, X7R, ±10%, 50 V or higher, 0805 ⁽⁴⁾	Kemet	C0805C222K5RACTU
6	C7, C10, C12, C14	4	1 µF	Capacitor, tantalum, 10 V or higher, Type A	AVX Corp.	TAJA105M020RNJ
7	C17	1	47 µF	Capacitor, tantalum, 10 V or higher, Type A	Nichicon	F931A476MAA
—	Y1	0	32.768 kHz	Clock oscillator, 2.5 x 3.2 mm	Do not populate	Do not populate
8	D1	1	Red	Light emitting diode, 1.7 V forward voltage or less, 0805	Stanley	BR1112H-TR
9	D2	1	Yellow	Light emitting diode, 0805	Knightbright	APT2012YC
10	J1-4	4	PEC10SAAN	Header, female, 10-pin, 100-mil spacing, 0.100 inch x 10	Sullins	PPTC101LFBN-RC
11	RF_PART1-2	2	TFM-110-02-SM-D-A-K-TR	Header, SMT 10x2 pin, shrouded, 0.225 x 0.625 inch	Samtec	TFM-110-02-SM-D-A-K-TR
12	U4	1	ISL29023	IC, integrated digital light sensor with interrupt	Intersil	ISL29023
13	U3	1	MPU-9150	IC, nine-axis MEMS motion tracking device	InvenSense	MPU-9150
14	R1, R4, R9-10	4	10 kΩ	Surface mount resistor, 1/10 W or higher, 0805	Yageo	RC0805JR-0710KL
—	R2	0	10 kΩ	Surface mount resistor, 1/10 W or higher, 0805	Do not populate	Do not populate
15	R6	1	5.1 Ω	Surface mount resistor, 1/10 W or higher, 0805	Yageo	RC0805JR-075R1L
16	R7	1	100 Ω	Surface mount resistor, 1/10 W or higher, 0805	Yageo	RC0805JR-07100RL
17	R5, R8	2	0 Ω	Surface mount resistor, 1/10 W or higher, 0805	Yageo	RC0805JR-070RL
18	R3	1	499 kΩ	Surface mount resistor, 1/10 W or higher, 0805	Yageo	RC0805FR-07499KL
19	R11-12	2	3.3 kΩ	Surface mount resistor, 1/10 W or higher, 0805	Yageo	RC0805JR-073K3L
20	U5	1	SHT21	IC, humidity and temperature sensor	Sensirion AG	SHT21
21	S1-2	2	7914G	Switch, 1P1T, PB momentary, 100 mA, SM, 0.19 x 0.18 inch	Bourns	7914G
22	U1	1	TMP006AIYZFT	IC, infrared thermopile sensor	Texas Instruments	TMP006YZF
23	U6	1	TPS75118Q PWP	IC, low dropout voltage regulator, 1.8 V, 1.5 A	Texas Instruments	TPS75118QPWP

⁽¹⁾ These assemblies are ESD sensitive. ESD precautions shall be observed.

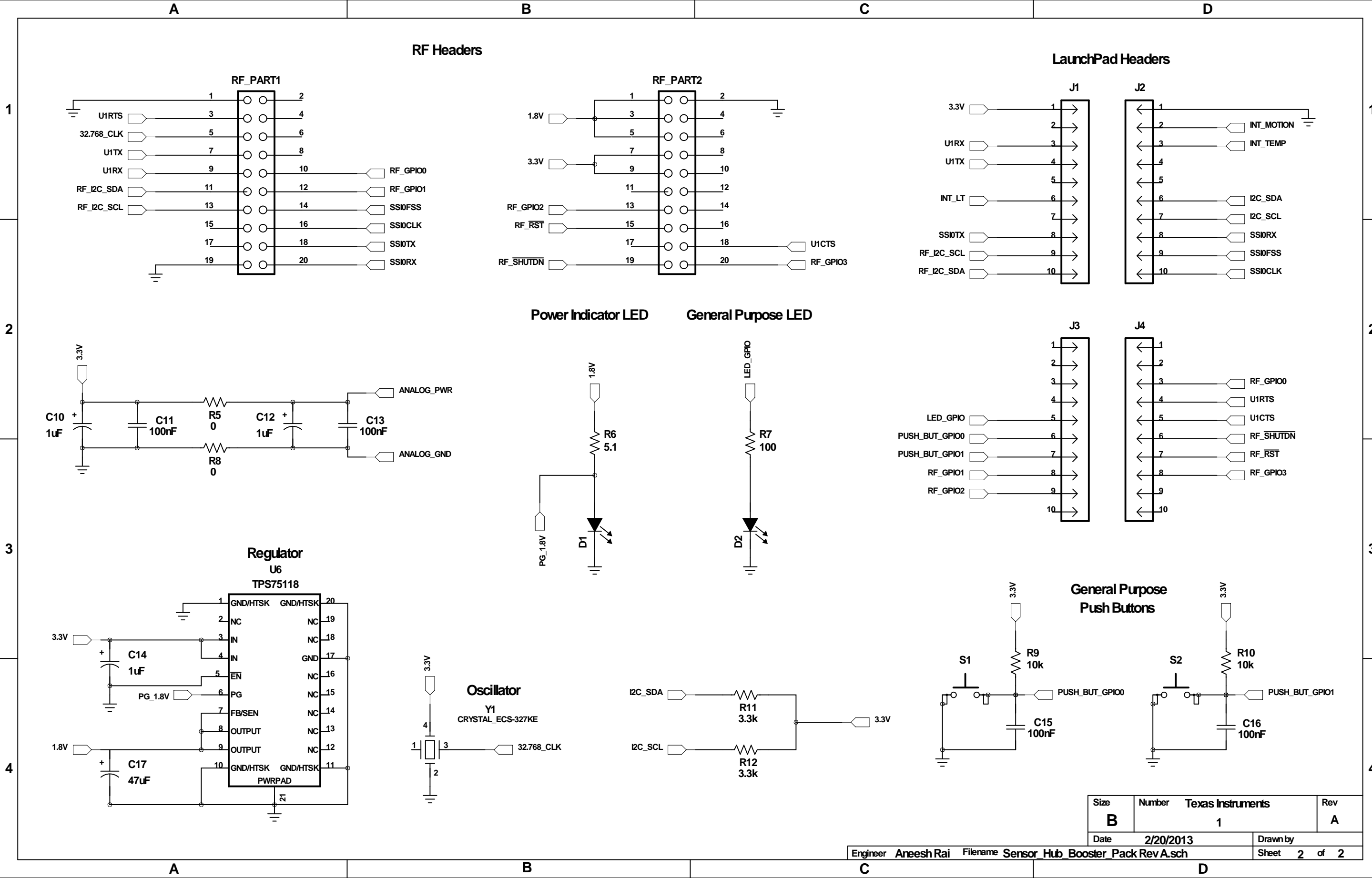
⁽²⁾ These assemblies must be clean and free from flux and all contaminants. Use of *no clean* flux is not acceptable.

⁽³⁾ These assemblies must comply with workmanship standards IPC-A-610 Class 2.

⁽⁴⁾ A dielectric with a higher thermal range and/or lower capacitance variation is also permitted (for example, X7R, X9R).



Engineer Aneesh Rai	Filename Sensor_Hub_Booster_Pack Rev A.sch	Sheet 1 of 2
C	D	2/20/2013



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User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

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This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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