GPIO Breakout BoosterPack

User's Guide

Literature Number: SPMU364
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Board Overview

The GPIO Breakout BoosterPack (BOOSTXL-IOBKOUT) is a low-cost IO breakout board for Tiva™ C Series LaunchPad BoosterPack XL pinout. Every available signal is connected to a 0.1” header position in addition to the majority being connected to 3.5 mm screw terminals for easy access when prototyping. Figure 1-1 shows the BOOSTXL-IOBKOUT.

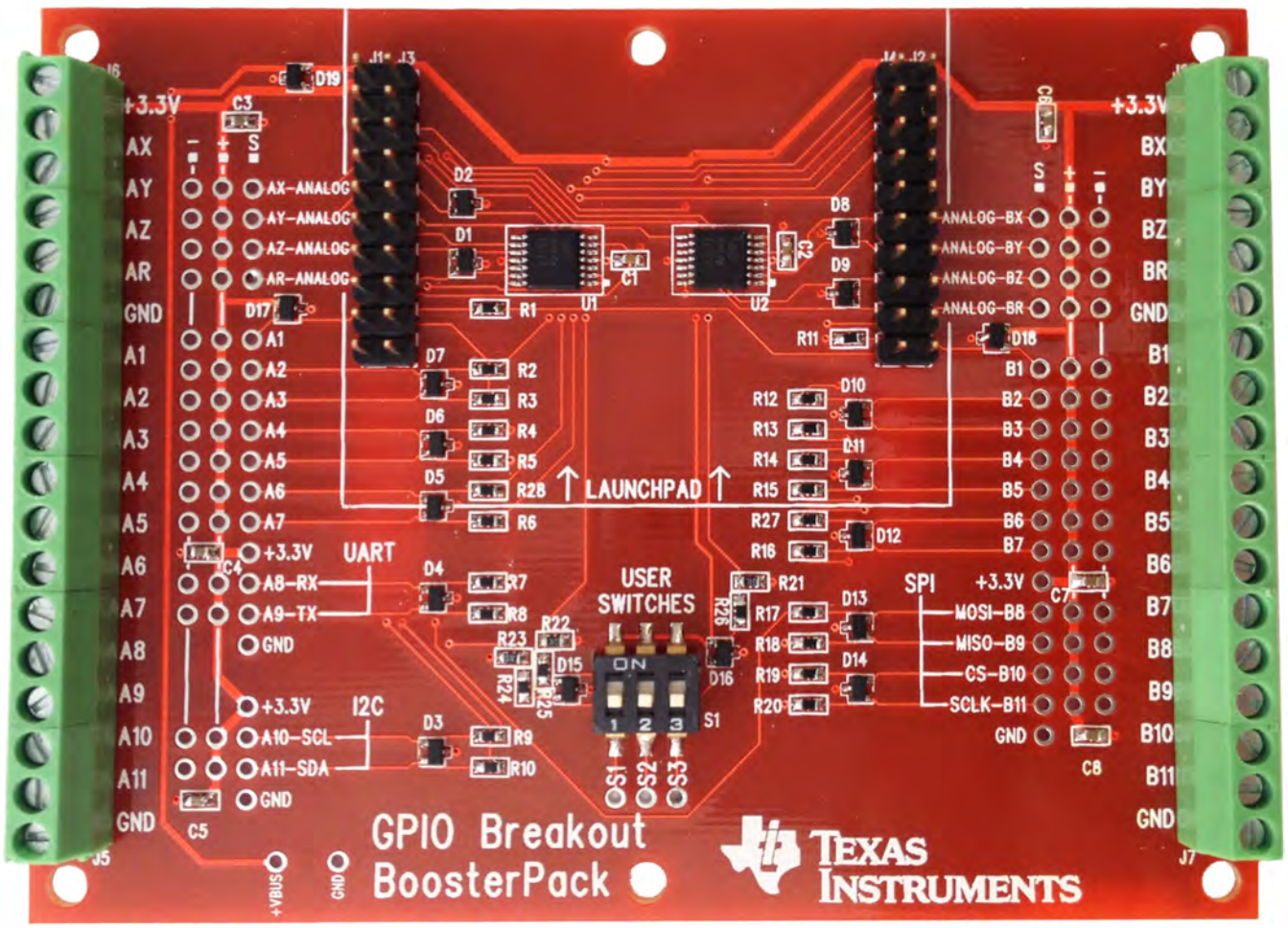


Figure 1-1. BOOSTXL-IOBKOUT BoosterPack

Tiva is a trademark of Texas Instruments.

1.1 Kit Contents

The BOOSTXL-IOBKOUT comes with the following:

- GPIO Breakout BoosterPack

1.2 Features

The BOOSTXL-IOBKOUT BoosterPack includes the following features:

- 3.5 mm screw terminal for all unused I/O
  - 8 analog
  - 22 digital
  - 2 3.3-V terminals
  - 4 ground terminals
- Analog channels equipped with unity-gain amplifiers
- ESD protection on every I/O signal and power rail
- 3-position user DIP switch
- Plated through-holes on a 0.1" grid for each I/O signal
- Six 0.125"-diameter mounting holes
- Dual HID gamepad demo

1.3 Specifications

Table 1-1 shows the specifications for the BOOSTXL-IOBKOUT BoosterPack.

Table 1-1. Specifications

Parameter	Value
Board supply voltage	3.3V (via LaunchPad headers)
Analog input voltage range	0V to +3.3V
Digital input maximum voltage	LaunchPad dependent (absolute maximum +5.0V)
Digital input minimum voltage	0V
Dimensions	3.0" x 4.0" x 0.5" (without LaunchPad)
RoHS status	Compliant

Hardware Description

The BOOSTXL-IOBKOUT BoosterPack provides many useful features that aid in prototyping a variety of projects with Tiva™ C Series LaunchPads (see Figure 2-1). This chapter describes the BOOSTXL-IOBKOUT hardware features.

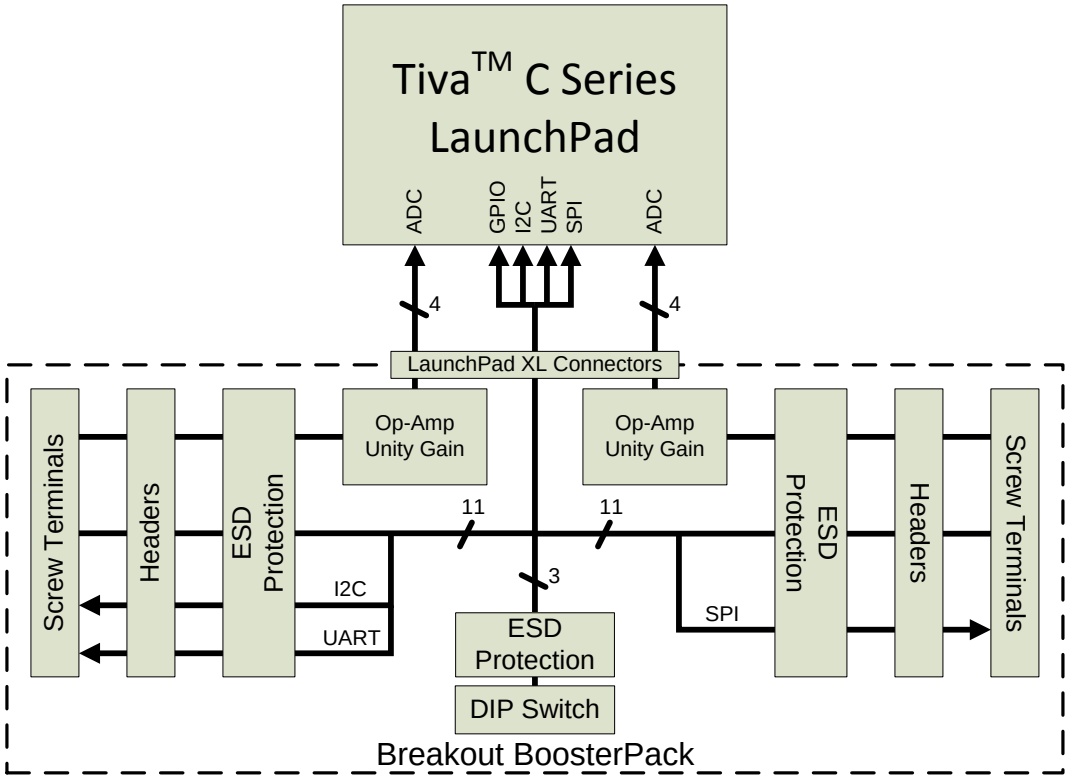


Figure 2-1. BOOSTXL-IOBKOUT BoosterPack Block Diagram

2.1 BoosterPack XL Connector

The BoosterPack XL connector attaches the BoosterPack to the Tiva™ C Series LaunchPad. Table 2-1 describes how the BoosterPack XL connector maps to the broken-out signals on the BOOSTXL-IOBKOUT.

Table 2-1. BoosterPack XL Interface Connections

Pin	Function		Pin	Function		Pin	Function		Pin	Function
J1.1	+3.3V		J3.1	+VBUS		J4.1	S2		J2.1	GND
J1.2	BR		J3.2	GND		J4.2	S3		J2.2	A7
J1.3	A8		J3.3	BY		J4.3	A6		J2.3	A2
J1.4	A9		J3.4	BX		J4.4	B2		J2.4	B1
J1.5	A4		J3.5	AR		J4.5	B3		J2.5	NC
J1.6	BZ		J3.6	AZ		J4.6	B4		J2.6	NC
J1.7	A5		J3.7	AY		J4.7	B5		J2.7	NC
J1.8	B8		J3.8	AX		J4.8	B6		J2.8	B9
J1.9	A10		J3.9	A3		J4.9	B7		J2.9	B10
J1.10	A11		J3.10	S1		J4.10	A1		J2.10	B11

2.2 Tiva™ C Series LaunchPad Compatibility

Every available pin on the Tiva™ C Series LaunchPad is brought out to screw terminals or header positions. In the majority of cases, the pins are brought out to both. Table 2-2 describes the Tiva C Series ports and pins that map to the signals on the BOOSTXL-IOBKOUT. Analog signals and the suggested locations for I2C, SSI, and UART are also labeled.

Table 2-2. Tiva Port and Pin Mapping

A-Side Signals	Port/Function		B-Side Signals	Port/Functions		User Switches	Port/Functions
A1	PF4		B1	PF0		S1	PF1
A2	PE0		B2	PC4		S2	PF2
A3	PE3		B3	PC5		S3	PF3
A4	PE4		B4	PC6			
A5	PB4		B5	PC7			
A6	PB3		B6	PD6			
A7	PB2		B7	PD7			
A8	PB0/U1RX		B8	PA5/SSI0TX(1)			
A9	PB1/U1TX		B9	PA4/SSI0RX(1)			
AR	PD2/AIN5		BR	PB5/AIN11			
AX	PE2/AIN1		BX	PD1/AIN6			
AY	PE1/AIN2		BY	PD0/AIN7			
AZ	PD3/AIN4		BZ	PE5/AIN8			
A10	PA6/I2C1SCL		B10	PA3/SSI0FSS1(1)			
A11	PA7/I2C1SDA		B11	PA2/SSI0CLK(1)			

(1) SSI signals in these positions do not match the standard BoosterPack pinout for SSI. Please see Section 2.3, Standard BoosterPack Pinout Compatibility

2.3 Standard BoosterPack Pinout Compatibility

The Breakout BoosterPack has the ability to be connected to other LaunchPads that follow the standard LaunchPad pinout. Please refer to Table 2-3 and the BOOSTXLK-IOBKOUT Schematic (Appendix D) when considering using a non-Tiva™ C Series LaunchPad.

Table 2-3. Standard BoosterPack Pinout Compatibility

Pin	Breakout Use	Standard		Pin	Breakout Use	Standard
J1.1	+3.3V	+3.3V		J2.1	GND	GND
J1.2	BR-ANALOG	Analog In		J2.2	A7	GPIO
J1.3	A8-RX	UART-RX		J2.3	A2	GPIO
J1.4	A9-TX	UART-TX		J2.4	B1	GPIO
J1.5	A4	GPIO		J2.5	NC	Reset
J1.6	BZ-ANALOG	Analog In		J2.6	NC	SPI-MOSI
J1.7	A5	SPI-CLK		J2.7	NC	SPI-MISO
J1.8	B8-MOSI	GPIO		J2.8	B9-MISO	GPIO
J1.9	A10-SCL	I2C-SCL		J2.9	B10-CS	SPI-CS
J1.10	A11-SDA	I2C-SDA		J2.10	B11-SCLK	GPIO
Pin	**Breakout Use**	**Standard**		**Pin**	**Breakout Use**	**Standard**
J3.1	+VBUS	+VBUS		J4.1	S2	GPIO
J3.2	GND	GND		J4.2	S3	GPIO
J3.3	BY-ANALOG	Analog In		J4.3	A6	GPIO
J3.4	BX-ANALOG	Analog In		J4.4	B2	GPIO
J3.5	AR-ANALOG	Analog In		J4.5	B3	GPIO
J3.6	AZ-ANALOG	Analog In		J4.6	B4	GPIO
J3.7	AY-ANALOG	Analog In		J4.7	B5	GPIO
J3.8	AX-ANALOG	Analog In		J4.8	B6	GPIO
J3.9	A3	Reserved		J4.9	B7	GPIO
J3.10	S1	Reserved		J4.10	A1	GPIO

Because the BOOSTXL-IOBKOUT is almost entirely a pin-for-pin breakout, the differences between the standard BoosterPack pinout and the Breakout signals are mostly labeling. However, each analog input is connected through a unity-gain amplifier and not directly to the terminals (please see Section 2.6, Analog Signals). Always refer to the BoosterPack Schematic (Appendix D) when connecting hardware.

2.4 EK-TM4C123GXL LaunchPad Shared Signals

The BOOSTXL-IOBKOUT breaks out every available signal on the Tiva™ C Series TM4C123G LaunchPad. Therefore, some of these signals are shared with on-board features of the LaunchPad. Table 2-4 describes which signals are shared with features on the LaunchPad.

Table 2-4. Shared Tiva LaunchPad Signals

Pin	Port/Function	LaunchPad Feature	BoosterPack Function
J2.4	PF0	User Switch 2	B1
J2.5	Reset	Reset	NC
J2.6	PB7	Tied to J3.4 (PD1)	NC
J2.7	PB6	Tied to J3.3 (PD0)	NC
J3.3	PD0/AIN7	Tied to J2.7 (PB6)	BY
J3.4	PD1/AIN6	Tied to J2.6 (PB7)	BX
J3.10	PF1	LED Red	S1
J4.1	PF2	LED Blue	S2
J4.2	PF3	LED Green	S3
J4.10	PF4	User Switch 1	A1

Please see the BoosterPack Schematic (Appendix D) and the EK-TM3C123GXL User's Guide (SPMU296) for more information.

2.5 Screw Terminals and Header Positions

The available LaunchPad signals are brought out to three main sections on the GPIO Breakout BoosterPack: A-Side, B-Side, and User Switches.

A-Side and B-Side signals are all broken out to 3.5 mm-screw terminals with +3.3 V and Ground terminals interspersed throughout. The three remaining signals are brought out to the User Switches in a 3-switch DIP switch. Figure 2-2 shows the screw terminal and switch arrangement.

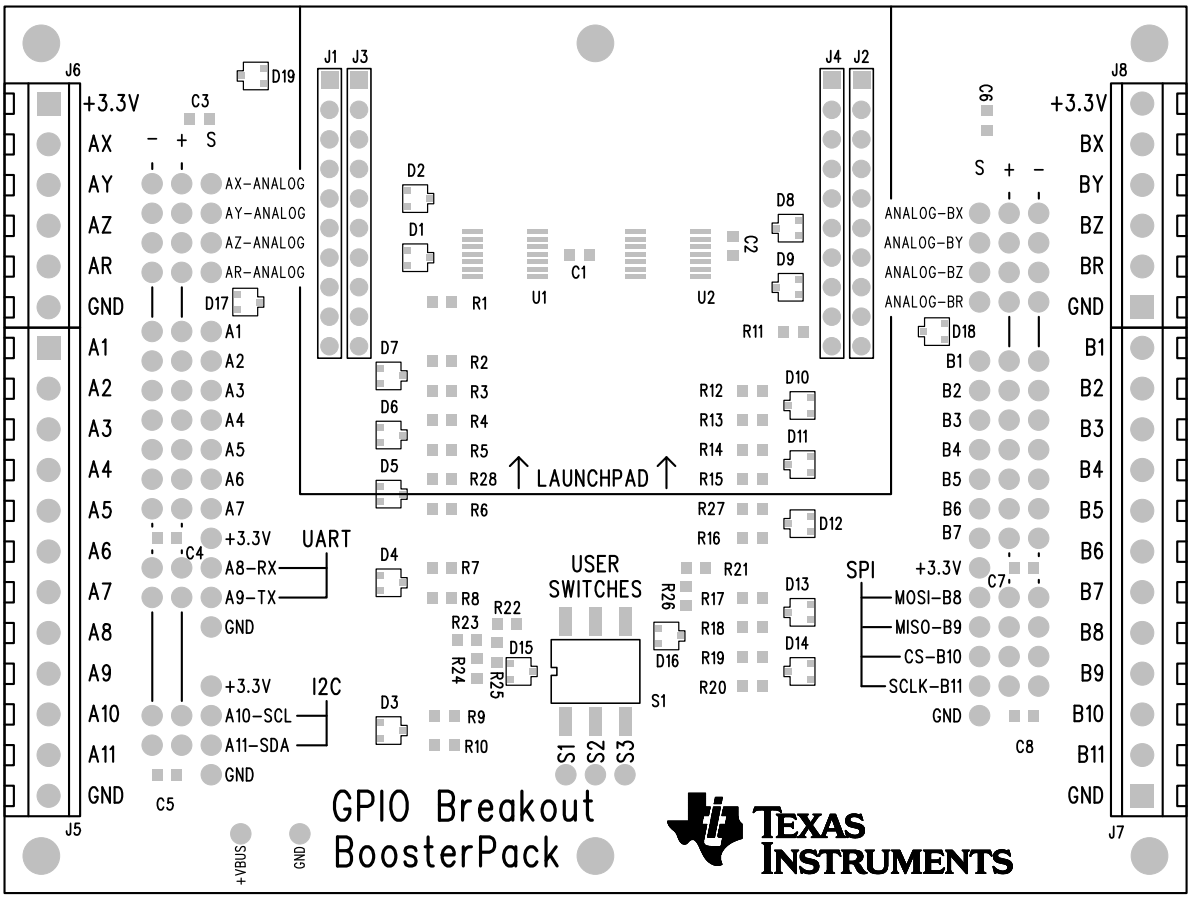


Figure 2-2. Screw Terminal, Headers, and User Switch Arrangements

Additionally, every signal is brought out to a 0.1” header position. These can be populated by standard 0.1” breakaway pin headers. All A-Side and B-Side header positions have +3.3V and Ground headers directly adjacent in a Signal-Power-Ground arrangement as shown in Figure 2-2. This arrangement is the same as a standard servo-style connection used in many hobbyist applications.

2.6 Analog Signals

Each of the eight analog inputs is first passed through a Texas Instruments TLV2374 Rail-to-Rail Operational Amplifier (op amp). The op amps are connected as unity-gain amplifiers in order to provide a low-impedance source to the LaunchPad MCU's Analog to Digital Converter (ADC).

The TLV2374 is a Rail-to-Rail Input/Output Op Amp. Therefore, the signal applied to the terminals (op amp input) can be any level from 0 V to +3.3 V, while the input to the ADC (op amp output) can also swing from 0 V to +3.3 V.

Please see the BoosterPack Schematic (Appendix D) for more information.

2.7 ESD Protection

All breakout signals and power rails on the GPIO Breakout BoosterPack are also protected from Electrostatic Discharge (ESD).

GPIO signals are protected by a 33-Ω series resistor and an NXP PESD5V0L2UU Unidirectional ESD Protection Diode, while the analog signals and power rails are protected by the diodes only. The PESD5V0L2UU diodes offer up to 30 kV of ESD protection with a reverse standoff voltage of +5.0 V and a breakdown voltage typically at +6.2 V.

Please see the BoosterPack Schematic (Appendix D) and the PESD5V0L2UU datasheet for more information.

Software

The GPIO Breakout BoosterPack makes it easy to connect custom circuits to any Tiva™ C Series LaunchPad for many different applications. One possible application is a custom USB HID Gamepad.

3.1 Dual HID Gamepad Demo Application

The GPIO Breakout BoosterPack software development package includes a demo application that enumerates the Tiva C Series LaunchPad as a set of two USB HID gamepads. Table 3-1 outlines the pin mapping between the BoosterPack and the HID gamepad data structure.

Table 3-1. BoosterPack and Gamepad Pin Mapping

BoosterPack	Tiva Pin	Gamepad A	Gamepad B
AX	PE2/AIN1	X-Axis	
AY	PE1/AIN2	Y-Axis	
AZ	PD3/AIN4	Z-Axis	
AR	PD2/AIN5	X-Rotation	
A1	PF4	Button 1	
A2	PE0	Button 2	
A3	PE3	Button 3	
A4	PE4	Button 4	
A5	PB4	Button 5	
A6	PB3	Button 6	
A7	PB2	Button 7	
A8	PB0	Button 8	
A9	PB1	Button 9	
A10	PA6	Button 10	
A11	PA7	Button 11	
BX	PD1/AIN6		X-Axis
BY	PD0/AIN7		Y-Axis
BZ	PE5/AIN8		Z-Axis
BR	PB5/AIN11		X-Rotation
B1	PF0		Button 1
B2	PC4		Button 2
B3	PC5		Button 3
B4	PC6		Button 4
B5	PC7		Button 5
B6	PD6		Button 6
B7	PD7		Button 7

Table 3-1. BoosterPack and Gamepad Pin Mapping (continued)

BoosterPack	Tiva Pin	Gamepad A	Gamepad B
B8	PA5		Button 8
B9	PA4		Button 9
B10	PA3		Button 10
B11	PA2		Button 11
S1	PF1	Button 14	
S2	PF2	Button 15	
S3	PF3	Button 16	

The analog 0V – 3.3V input range is mapped to the gamepad axes as an integer scale from +511 to -512. Figure 3-1 shows the axis mapping.

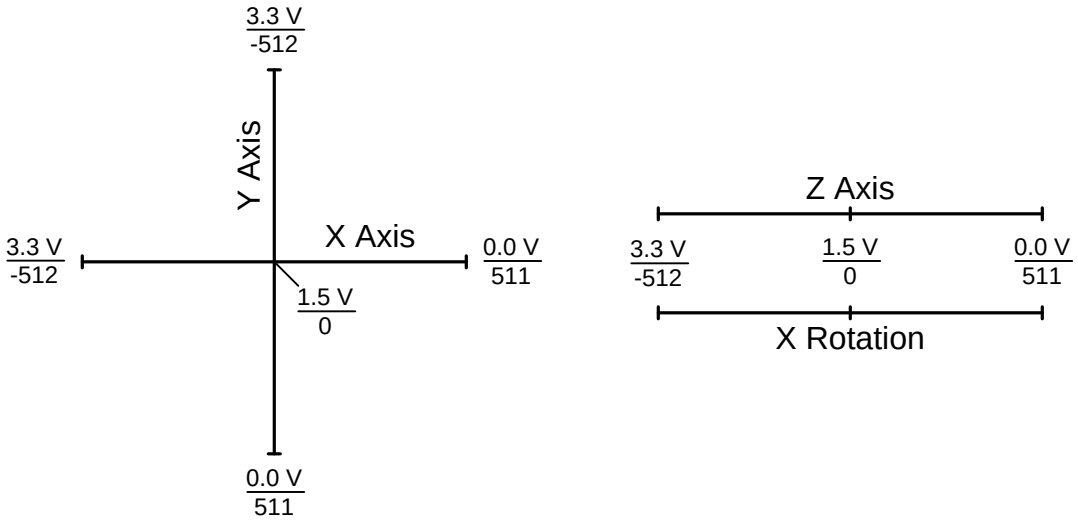


Figure 3-1. Gamepad Axis Mapping

Digital inputs are active low with internal pull-ups enabled. Simply ground the digital inputs to register a button as “pressed.”

Please see the EK-TM4C123GXL-BOOSTXL-IOBKOUT Firmware Development Package User’s Guide in the TivaWare for C Series software package.

Bill of Materials

Table A-1. Bill of Materials

Item	Ref	Qty	Description	Mfg	Part Number
1	C1, C2, C3, C4, C5, C6, C7, C8	8	Capacitor, 0.1uF 50V, 10% 0603 X7R	Murata	GRM188R71H104KA93D
2	D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19	19	Dual TVS Diode, 5V Standoff, 5.8V Breakdown	NXP	PESD5V0L2UU
3	J1, J4	2	Header, 2x10, 0.100, T-Hole, Vertical Unshrouded, 0.230 Mate, gold	FCI	67997-220HLF
4	J5, J7	2	Connector, 3.5mm Terminal Block, 3.5mm, 12 Pos	On Shore Technology	ED555/12DS
5	J6, J8	2	Connector, 3.5mm Terminal Block, 3.5mm, 6 Pos	On Shore Technology	ED555/6DS
6	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R24, R25, R26, R27, R28	25	Resistor, 33 Ohm, 1/10W, 5%, SMD, Thick	Panasonic	ERJ-3GEYJ330V
7	R21, R22, R23	3	Resistor, 10K Ohm 1/10W 5% 0603 SMD	Panasonic	ERJ-3GEYJ103V
8	S1	1	DIP Switch, SMT, 3-Pos, SPST	CTS	219-3MST
9	U1, U2	2	Op Amp, 3 MHz, Quad, Rail-to-Rail, 14TSSOP	Texas Instruments	TLV2374IPWR
10	PCB	1	PCB, BP-BREAKOUT, Rev 3.0, 2-layer		

Board Drawing

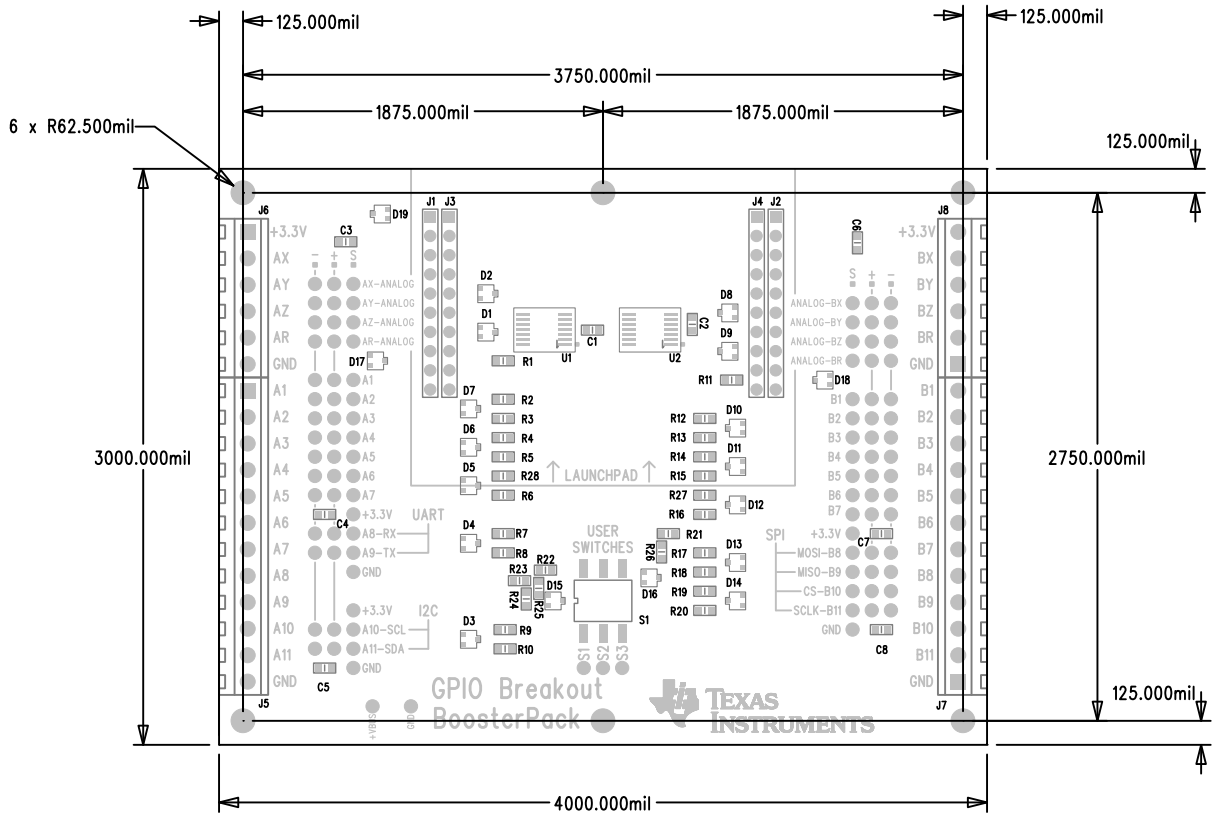


Figure B-1. Board Drawing

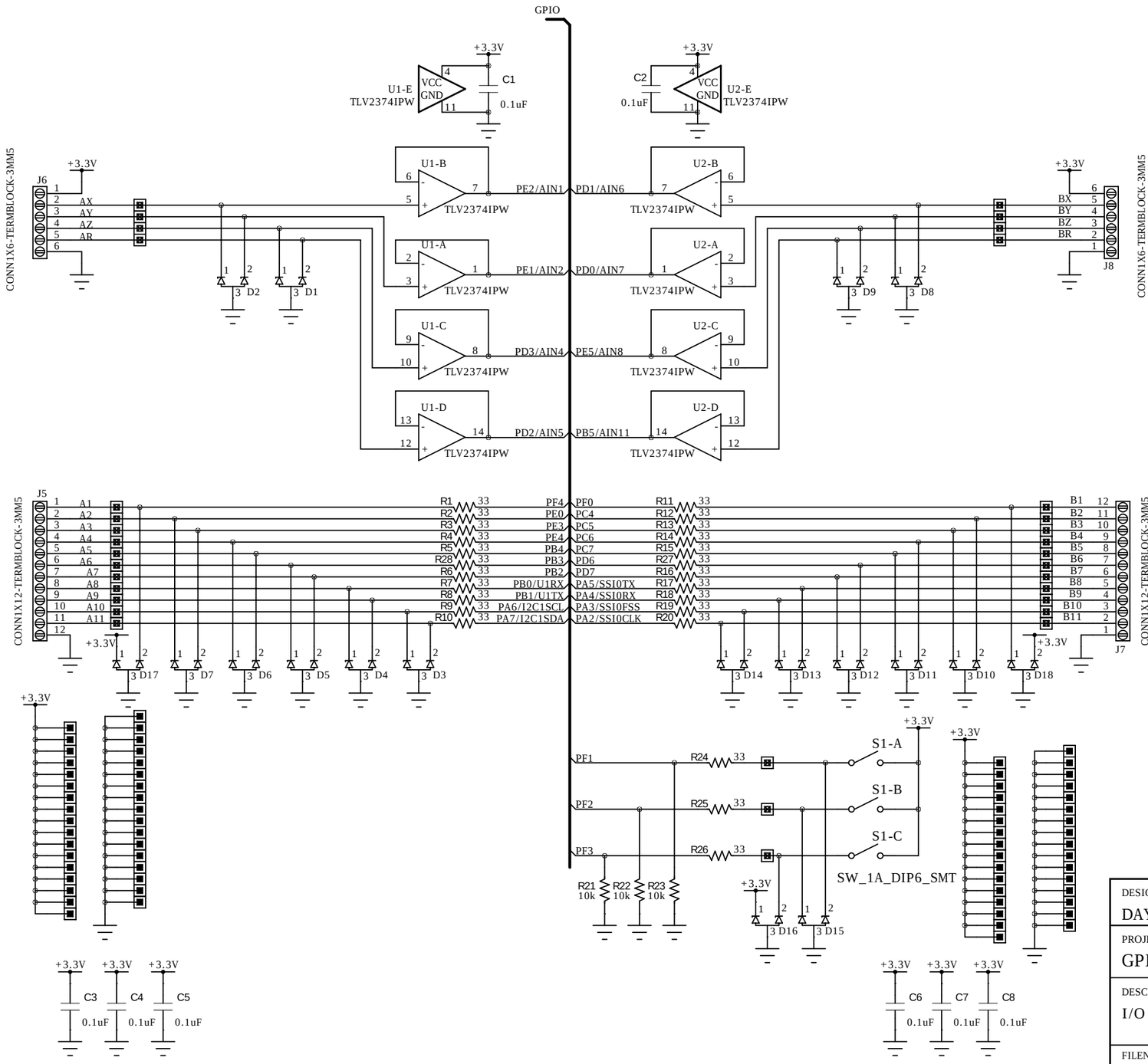
References

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

- EK-LM4F120XL User's Guide (literature number SPMU289)
- EK-TM4C123GXL User's Guide (literature number SPMU296)
- BoosterPack Standard - http://processors.wiki.ti.com/index.php/BYOB
- PESD5V0L2UU Datasheet - http://www.nxp.com/documents/data_sheet/PESD5V0L2UU_PESD6V0L2UU.pdf
- TivaWare for C Series - http://www.ti.com/tool/sw-tm4c

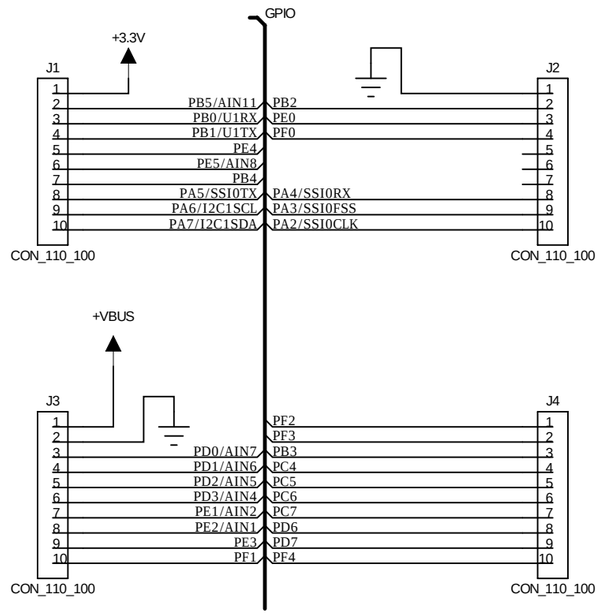
Schematics

This section contains the complete schematics for the Tiva C Series GPIO Breakout Booster Pack.



BOOSTERPACK HEADERS

Nets labels are for TM4C123GXL LaunchPad



DESIGNER: DAY	REVISION: 3.0	DATE: 12/3/2013
PROJECT: GPIO Breakout Booster Pack		
DESCRIPTION: I/O breakout for Tiva C Series LaunchPads		
FILENAME: BreakoutBP.sch		

TEXAS INSTRUMENTS
TIVA C SERIES MICROCONTROLLERS
108 WILD BASIN ROAD, SUITE 350
AUSTIN TX, 78746
www.ti.com/tiva

PART NO.: BP-BREAKOUT-3.0	SHEET: 1 OF 1

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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.

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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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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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EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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