

TM4C Series TM4C129E Crypto Connected LaunchPad Evaluation Kit

EK-TM4C129EXL

User's Guide



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Board Overview

The TM4C Series TM4C129E Crypto Connected LaunchPad™ Evaluation Board (EK-TM4C129EXL) is a low-cost evaluation platform for ARM® Cortex®-M4F-based microcontrollers. The Crypto Connected LaunchPad design highlights the TM4C129ENC PDT microcontroller with its on-chip crypto acceleration hardware, 10/100 Ethernet MAC and PHY, USB 2.0, hibernation module, motion control pulse-width modulation and a multitude of simultaneous serial connectivity. The Crypto Connected LaunchPad also features two user switches, four user LEDs, dedicated reset and wake switches, a breadboard expansion option and two independent BoosterPack XL expansion connectors. The pre-programmed out of the box demo on the Crypto Connected LaunchPad also enables remote monitoring and control of the evaluation board securely from an internet browser anywhere in the world. The web interface is provided by 3rd party, Exosite. Each Crypto Connected LaunchPad is enabled on the Exosite platform allowing users to create and customize their own secure Internet-of-Things (IoT) applications.

Figure 1-1 shows a photo of the Crypto Connected LaunchPad with key features highlighted.

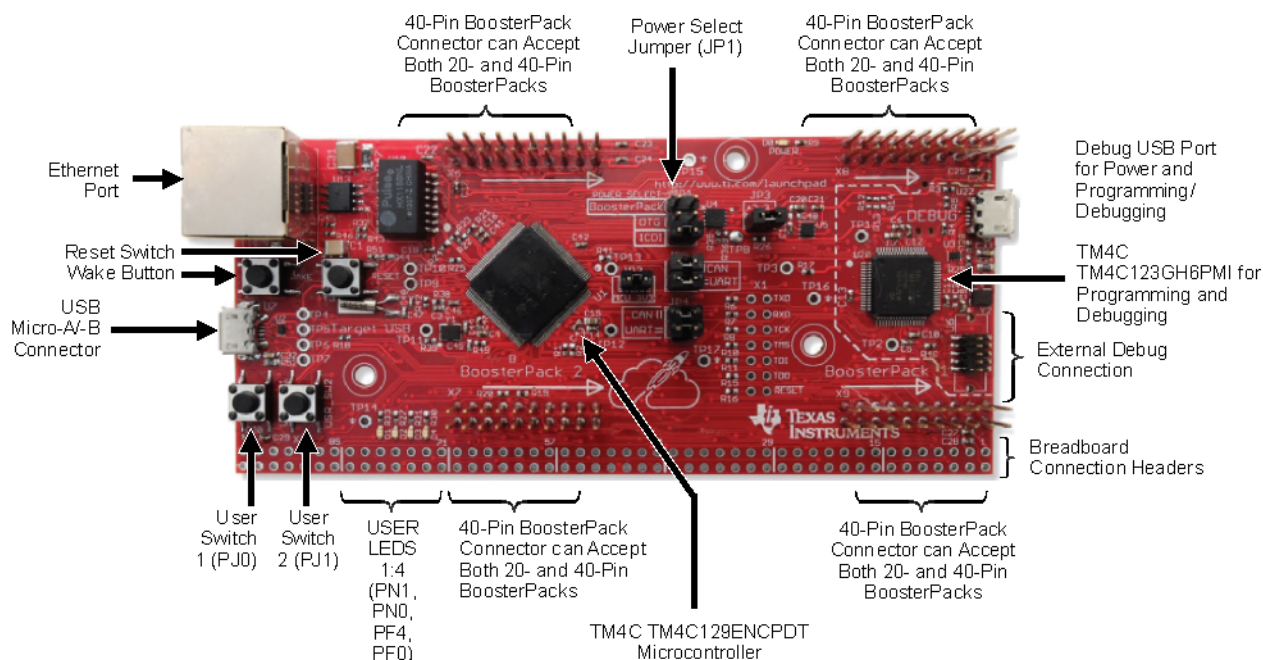


Figure 1-1. TM4C Series Crypto Connected LaunchPad Evaluation Board

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1.1 Kit Contents

The Crypto Connected LaunchPad Evaluation Kit contains the following items:

- TM4C Series TM4C129E Evaluation Board (EK-TM4C129EXL)
- Retractable Ethernet cable
- USB Micro-B plug to USB-A plug cable
- 90° 49x2 breadboard header
- *Meet the TM4C Series TM4C129E Crypto LaunchPad Evaluation Kit* ([SPMZ862](#))

1.2 Using the Crypto Connected LaunchPad

The recommended steps for using the Crypto Connected LaunchPad Evaluation Kit are:

1. **Follow the README First document included in the kit.** The README First helps you get the Crypto Connected LaunchPad up and running in minutes. Within just a few minutes you can be controlling and monitoring the Crypto Connected LaunchPad through the internet using Exosite and the pre-programmed out of the box demo.
2. **Experiment with BoosterPacks.** This evaluation kit conforms to the latest revision of the BoosterPack pinout standard. It has two independent BoosterPack connections to enable a multitude of expansion opportunities.
3. **Take the first step towards developing your own applications.** The Crypto Connected LaunchPad is supported by TivaWare™ for C Series. All the applications that work on TM4C series TM4C1294 Connected LaunchPad Evaluation Board (EK-TM4C1294XL) will work on the Crypto Connected LaunchPad. After installing TivaWare, look in the installation directory for *examples\boards\EK-TM4C1294XL*. You can find pre-configured example applications for the Connected LaunchPad board as well as for with selected BoosterPacks. These examples will work on the Crypto Connected LaunchPad board. Alternately, use Energia for a wiring framework-based cross-platform, fast-prototyping environment that works with this and other TI LaunchPads. For more details about software development, see [Chapter 3](#) of this document. TivaWare can be downloaded from the TI website at <http://www.ti.com/tool/sw-tm4c>. Energia can be found at <http://energia.nu>.
4. **Customize and integrate the hardware to suit your end application.** This evaluation kit can be used as a reference for building your own custom circuits based on TM4C microcontrollers or as a foundation for expansion with your custom BoosterPack or other circuit. This manual can serve as a starting point for this endeavor.
5. **Get Trained.** You can also download hours of written and video training materials on this and related LaunchPads. For more information, visit the TM4C Series LaunchPad Workshop Wiki.
6. **More Resources.** For more information and the available BoosterPacks, see the TI MCU LaunchPad web page (<http://www.ti.com/tiva-c-launchpad>).

1.3 Features

Your Crypto Connected LaunchPad includes the following features:

- TM4C129ENC PDT microcontroller
- Ethernet connectivity with fully integrated 10/100 Ethernet MAC and PHY motion control pulse width modulation (PWM)
- Crypto acceleration hardware blocks
- USB 2.0 Micro A/B connector
- Four user LEDs
- Two user buttons
- One independent hibernate wake switch
- One independent microcontroller reset switch

- Jumper for selecting power source:
 - ICDI USB
 - USB Device
 - BoosterPack
- Preloaded secure access of Internet-of-Things product to Exosite application
- I/O brought to board edge for breadboard expansion
- Two independent BoosterPack XL standard connectors featuring stackable headers to maximize expansion through BoosterPack ecosystem
 - For a complete list of BoosterPacks, see the TI MCU LaunchPad web page:
<http://www.ti.com/launchpad>

1.4 BoosterPacks

The Crypto Connected LaunchPad provides an easy and inexpensive way to develop applications with the TM4C129ENC PDT microcontroller. BoosterPacks are add-on boards that follow a pin-out standard created by Texas Instruments. The TI and third-party ecosystem of BoosterPacks greatly expands the peripherals and potential applications that you can easily explore with the Crypto Connected LaunchPad.

You can also build your own BoosterPack by following the design guidelines on TI's website. Texas Instruments even helps you promote your BoosterPack to other members of the community. TI offers a variety of avenues for you to reach potential customers with your solutions.

1.5 Energĭa

Energĭa is an open-source electronics prototyping platform started in January of 2012 with the goal of bringing the Wiring and Arduino framework to the TI LaunchPad community. Energĭa includes an integrated development environment (IDE) that is based on Processing.

Together with Energĭa, LaunchPads can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. LaunchPad projects can be stand-alone (only run on the target board, for example, your LaunchPad), or they can communicate with software running on your computer (Host PC). Energĭa projects are highly portable between supported LaunchPad platforms.

More information is available at <http://energia.nu>.

1.6 Specifications

Table 1-1 summarizes the specifications for the Crypto Connected LaunchPad.

Table 1-1. EK-TM4C129EXL Specifications

Parameter	Value
Board Supply Voltage	4.75 V _{DC} to 5.25 V _{DC} from one of the following sources: See schematic symbol JP1 for power input selection. <ul style="list-style-type: none"> • Debug USB U22 (ICDI) USB Micro-B cable connected to PC or other compatible power source. • Target USB (U7) USB Micro-B cable connected to PC or other compatible power source. • BoosterPack 1 (X8-4) • BoosterPack 2 (X6-4) • Breadboard expansion header (X11-2 or X11-97).
Dimensions	4.9 in x 2.2 in x .425 in (12.45 cm x 5.59 cm x 10.8 mm) (L x W x H)
Break-out Power Output	<ul style="list-style-type: none"> • 5 V_{DC} to BoosterPacks, current limited by TPS2052B. Nominal rating 1 Amp. Board input power supply limitations may also apply. • 3.3 V_{DC} to BoosterPacks, limited by output of TPS73733 LDO. This 3.3-V plane is shared with on-board components. Total output power limit of TPS73733 is 1 Amp.
RoHS Status	Compliant

Hardware Description

The Crypto Connected LaunchPad includes a TM4C129ENCPDT microcontroller with an integrated 10/100 Ethernet MAC and PHY and crypto acceleration blocks. This advanced ARM Cortex M4F MCU has a wide range of peripherals that are made available to users via the on-board accessories and the BoosterPack connectors. This chapter explains how those peripherals operate and interface to the microcontroller.

Figure 2-1 provides a high-level block diagram of the Crypto Connected LaunchPad.

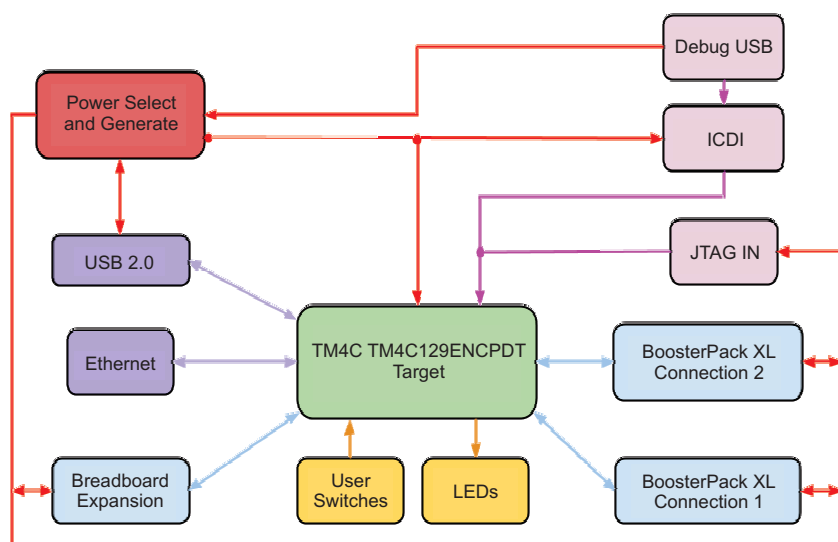


Figure 2-1. TM4C Crypto Connected LaunchPad Evaluation Board Block Diagram

2.1 Functional Description

2.1.1 Microcontroller

The TM4C129ENCPDT is a 32-bit ARM Cortex-M4F based microcontroller with 1024-kB Flash memory, 256-kB SRAM, 6-kB EEPROM, and 120 MHz operation; integrated 10/100 Ethernet MAC and PHY; integrated hardware crypto accelerators; integrated USB 2.0 connectivity with external high-speed USB 3.0 PHY capability; a hibernation module, a multitude of serial connectivity and motion control PWM; as well as a wide range of other peripherals. For more complete details, see the TM4C129ENCPDT microcontroller [data sheet](#).

Most of the microcontroller's signals are routed to 0.1-in (2.54-mm) pitch headers or through-hole solder pads. An internal multiplexor allows different peripheral functions to be assigned to each of these general-purpose input/output (GPIO) pads. When adding external circuitry, consider the additional load on the evaluation board power rails.

The TM4C129ENCPDT microcontroller is factory-programmed with an out of the box demo program. The out of the box program resides in on-chip Flash memory and runs each time power is applied, unless the out of the box application has been replaced with a user program. The out of the box application automatically connects to <https://ti.exosite.com> when an internet connection is provided through the RJ45 Ethernet jack on the evaluation board.

2.1.2 Ethernet Connectivity

The Crypto Connected LaunchPad is designed to connect directly to an Ethernet network using RJ45 style connectors. The microcontroller contains a fully integrated Ethernet MAC and PHY. This integration creates a simple, elegant and cost-saving Ethernet circuit design. Example code is available for both the uIP and LwIP TCP/IP protocol stacks. The embedded Ethernet on this device can be programmed to act as an HTTP server, client or both. The design and integration of the circuit and microcontroller also enable users to synchronize events over the network using the IEEE1588 precision time protocol.

When configured for an Ethernet operation, it is recommended that the user configure LED D3 and D4 to be controlled by the Ethernet MAC to indicate connection and transmit/receive status.

2.1.3 Crypto Accelerators

The Crypto Connected LaunchPad features the hardware acceleration blocks such as Advanced Encryption Standard (AES), Data Encryption Standard (DES), and Secure Hash Algorithm/MD5 Message Digest Algorithm (SHA/MD5) that offload data encryption and decryption functions from CPU. These hardware cipher blocks support the μ DMA operation and have improved performance over software cipher blocks.

The AES block is a symmetric cipher module that supports multiple encrypt and decrypt operations, feedback operating modes, authentication modes, key sizes (128 bit, 192 bit, or 256 bit) and key scheduling in hardware. The DES block is also a symmetric cipher module with DES/3DES encryption and decryption along with support for multiple feedback operating modes. The SHA/MD5 block is a hash module that can run functions like MD5, SHA-1, SHA224, SHA256 and Hash message authentication code (HMAC).

2.1.4 USB Connectivity

The Crypto Connected LaunchPad is designed to be USB 2.0 ready. A TPS2052B load switch is connected to and controlled by the microcontroller USB peripheral, which manages power to the USB micro A/B connector when functioning in a USB host. When functioning as a USB device, the entire Crypto Connected LaunchPad can be powered directly from the USB micro A/B connector. Use JP1 to select the desired power source.

USB 2.0 functionality is provided and supported directly out of the box with the target USB micro A/B connector. High-speed USB 3.0 functionality can be enabled by adding an external USB PHY. The USB external PHY control and data signals are provided on the breadboard expansion header X11.

2.1.5 Motion Control

The Crypto Connected LaunchPad includes the TM4C Series Motion Control PWM technology, featuring a PWM module capable of generating eight PWM outputs. The PWM module provides a great deal of flexibility and can generate simple PWM signals (for example, those signals required by a simple charge pump, as well as paired PWM signals with dead-band delays such as those required by a half-H bridge driver). Three generator blocks can also generate the full six channels of gate controls required by a 3-phase inverter bridge.

A quadrature encoder interface (QEI) is also available to provide motion control feedback.

For details about the availability of these signals on the BoosterPack interfaces, see the [BoosterPacks and Headers](#) of this document.

2.1.6 User Switches and LED's

Two user switches are provided for input and control of the TM4C129ENCPDT software. The switches are connected to GPIO pins PJ0 and PJ1.

A reset switch and a wake switch are also provided. The reset switch initiates a system reset of the microcontroller whenever it is pressed and released. Pressing the reset switch also asserts the reset signal to the BoosterPack and Breadboard headers. The wake switch is one way to bring the device out of hibernate mode.

Four user LEDs are provided on the board. D1 and D2 are connected to GPIOs PN1 and PN0. These LEDs are dedicated for use by the software application. D3 and D4 are connected to GPIOs PF4 and PF0, which can be controlled by user's software or the integrated Ethernet module of the microcontroller.

A power LED is also provided to indicate that 3.3 V power is present on the board.

2.1.7 BoosterPacks and Headers

2.1.7.1 BoosterPack 1

The Crypto Connected LaunchPad features two fully independent BoosterPack XL connectors. BoosterPack 1, located around the ICDI portion of the board, is fully compliant with the BoosterPack standard with the single exception of GPIO pin PA6 (X8-16), which does not provide analog capability. PA6 is located near the bottom of the inner left BoosterPack XL header.

Inter-integrated circuit (I2C) is provided in both the original BoosterPack standard configuration as well as the updated standard location. Use of I2C on the bottom left of the BoosterPack connections per the updated standard is highly encouraged whenever possible.

Motion control advanced PWM connections are provided on the inner right connector for motion control applications.

[Table 2-1](#) provides a complete listing of the BoosterPack pins and the GPIO alternate functions available on each pin. The TM4C129ENCPDT GPIO register GPIOCTL values are shown for each configuration. The headers in this table are labeled from left to right in ten pin columns. 'A' and 'D' make up the outer BoosterPack standard pins, 'B' and 'C' make up the inner BoosterPack XL standard pins.

Table 2-1. BoosterPack 1 GPIO and Signal Muxing

Header	Pin	Standard Function	GPIO	MCU Pin	Analog	Digital Function (GPIOCTL Bit Encoding)										
						1	2	3	5	6	7	8	11	13	14	15
A1	1	+3.3 V	3.3 V													
A1	2	Analog	PE4	123	AIN9	U1RI	-	-	-	-	-	-	-	-	-	SSI1XDAT0
A1	3	UART RX	PC4	25	C1-	U7Rx	-	-	-	-	-	-	-	-	-	EPI0S7
A1	4	UART TX	PC5	24	C1+	U7Tx	-	-	-	-	RTCCLK	-	-	-	-	EPI0S6
A1	5	GPIO	PC6	23	C0+	U5Rx	-	-	-	-	-	-	-	-	-	EPI0S5
A1	6	Analog	PE5	124	AIN8	-	-	-	-	-	-	-	-	-	-	SSI1XDAT1
A1	7	SPI CLK	PD3	4	AIN12	-	I2C8SDA	T1CCP1	-	-	-	-	-	-	-	SSI2CLK
A1	8	GPIO	PC7	22	C0-	U5Tx	-	-	-	-	-	-	-	-	-	EPI0S4
A1	9	I2C SCL	PB2	91	-	-	I2C0SCL	T5CCP0	-	-	-	-	-	-	USB0STP	EPI0S27
A1	10	I2C SDA	PB3	92	-	-	I2C0SDA	T5CCP1	-	-	-	-	-	-	USB0CLK	EPI0S28
B1	1	+5 volts	5 V													
B1	2	Ground	GND													
B1	3	Analog	PE0	15	AIN3	U1RTS	-	-	-	-	-	-	-	-	-	-
B1	4	Analog	PE1	14	AIN2	U1DSR	-	-	-	-	-	-	-	-	-	-
B1	5	Analog	PE2	13	AIN1	U1DCD	-	-	-	-	-	-	-	-	-	-
B1	6	Analog	PE3	12	AIN0	U1DTR	-	-	-	-	-	-	-	-	-	-
B1	7	Analog	PD7	128	AIN4	U2CTS	-	T4CCP1	USB0PFLT	-	-	NMI	-	-	-	SSI2XDAT0
B1	8	Analog	PA6	40	-	U2Rx	I2C6SCL	T3CCP0	USB0EPEN	-	-	-	-	SSI0XDAT2	-	EPI0S8
B1	9	A out	PM4	74	TMPR3	U0CTS	-	T4CCP0	-	-	-	-	-	-	-	-
B1	10	A out	PM5	73	TMPR2	U0DCD	-	T4CCP1	-	-	-	-	-	-	-	-

Table 2-1. BoosterPack 1 GPIO and Signal Muxing (continued)

Header	Pin	Standard Function	GPIO	MCU Pin	Analog	Digital Function (GPIOCTL Bit Encoding)										
						1	2	3	5	6	7	8	11	13	14	15
C1	1	PWM	PF1	43	-	-	-	-	EN0LED2	M0PWM1	-	-	-	-	SSI3XDAT0	TRD1
C1	2	PWM	PF2	44	-	-	-	-	-	M0PWM2	-	-	-	-	SSI3Fss	TRD0
C1	3	PWM	PF3	45	-	-	-	-	-	M0PWM3	-	-	-	-	SSI3Clk	TRCLK
C1	4	PWM	PG0	49	-	-	I2C1SCL	-	EN0PPS	M0PWM4	-	-	-	-	-	EPI0S11
C1	5	Capture	PL4	85	-	-	-	T0CCP0	-	-	-	-	-	-	USB0D4	EPI0S26
C1	6	Capture	PL5	86	-	-	-	T0CCP1	-	-	-	-	-	-	USB0D5	EPI0S33
C1	7	GPIO	PL0	81	-	-	I2C2SDA	-	-	M0FAULT3	-	-	-	-	USB0D0	EPI0S16
C1	8	GPIO	PL1	82	-	-	I2C2SCL	-	-	PhA0	-	-	-	-	USB0D1	EPI0S17
C1	9	GPIO	PL2	83	-	-	-	-	C0o	PhB0	-	-	-	-	USB0D2	EPI0S18
C1	10	GPIO	PL3	84	-	-	-	-	C1o	IDX0	-	-	-	-	USB0D3	EPI0S19
D1	1	Ground	GND													
D1	2	PWM	PM3	75	-	-	-	T3CCP1	-	-	-	-	-	-	-	EPI0S12
D1	3	GPIO	PH2	31	-	U0DCD	-	-	-	-	-	-	-	-	-	EPI0S2
D1	4	GPIO	PH3	32	-	U0DSR	-	-	-	-	-	-	-	-	-	EPI0S3
D1	5	Reset	RESET													
D1	6	SPI MOSI	PD1	2	AIN14	-	I2C7SDA	T0CCP1	C1o	-	-	-	-	-	-	SSI2XDAT0
D1	7	SPI MISO	PD0	1	AIN15	-	I2C7SCL	T0CCP0	C0o	-	-	-	-	-	-	SSI2XDAT1
D1	8	GPIO	PN2	109	-	U1DCD	U2RTS	-	-	-	-	-	-	-	-	EPI0S29
D1	9	GPIO	PN3	110	-	U1DSR	U2CTS	-	-	-	-	-	-	-	-	EPI0S30
D1	10	GPIO	PP2	103	-	U0DTR	-	-	-	-	-	-	-	-	USB0NXT	EPI0S29

2.1.7.2 BoosterPack 2

The second BoosterPack XL interface is located near the middle of the board. This interface is fully compliant with the BoosterPack standard and adds features not covered by the BoosterPack standard that enable operation with additional BoosterPacks.

An additional analog signal is provided on the outer left header (X6-9). This signal can be used to monitor the touch panel on the popular Kentec EB-LM4F120-L35 BoosterPack.

Using the jumpers JP4 and JP5, Controller Area Network (CAN) digital receive and transmit signals can be optionally routed to the BoosterPack 2 interface. The location of these signals is consistent with the CAN interface on the TM4C Series TM4C123G LaunchPad and the Stellaris LM4F120 LaunchPad. In the default configuration, UART0 is used for the ICDI virtual UART and CAN is not present on the BoosterPack headers. In this configuration, the ROM serial bootloader can be used over the ICDI virtual UART. When the jumpers are configured for CAN on the BoosterPack, then UART2 must be used for the ICDI virtual UART.

To comply with both the original and the new BoosterPack standard, I2C is provided on both sides of the BoosterPack connection. Use of I2C on the bottom left of the BoosterPack connection is highly encouraged where possible, to be in compliance with the new BoosterPack standard. To provide I2C capability on the right side of the connector, per the original standard, two zero-ohm resistors (R19 and R20) are used to combine the SPI and I2C signals. These signals are not shared with any other pins on the LaunchPad and therefore removal of these zero-ohm resistors should not be required. Software should be certain that unused GPIO signals are configured as inputs.

Table 2-2 provides a complete listing of the BoosterPack pins and the GPIO alternate functions available at each pin. The TM4C129ENCPDT GPIO register GPIOCTL values are shown for each configuration. The headers in this table are labeled from left to right in ten pin columns. 'A' and 'D' make up the outer BoosterPack standard pins, 'B' and 'C' make up the inner BoosterPack XL standard pins.

Table 2-2. BoosterPack 2 GPIO and Signal Muxing

Header	Pin	Standard Function	GPIO	MCU Pin	Analog	Digital Function (FPIOCTL Bit Encoding)										
						1	2	3	5	6	7	8	11	13	14	15
A2	1		3.3 V													
A2	2	Analog	PD2	3	AIN13	-	I2C8SCL	T1CCP0	C2o	-	-	-	-	-	-	SSI2Fss
A2	3	UART RX	PP0	118	C2+	U6Rx	-	-	-	-	-	-	-	-	-	SSI3XDAT2
A2	4	UART TX	PP1	119	C2-	U6Tx	-	-	-	-	-	-	-	-	-	SSI3XDAT3
A2	5	GPIO (See JP4)	PD4	125	AIN7	U2Rx	-	T3CCP0	-	-	-	-	-	-	-	SSI1XDAT2
			PA0	33	-	U0Rx	I2C9SCL	T0CCP0	-	-	CANORx	-	-	-	-	-
A2	6	Analog (See JP5)	PD5	126	AIN6	U2Tx	-	T3CCP1	-	-	-	-	-	-	-	SSI1XDAT3
			PA1	34	-	U0Tx	I2C9SDA	T0CCP1	-	-	CAN0Tx	-	-	-	-	-
A2	7	SPI CLK	PQ0	5	-	-	-	-	-	-	-	-	-	-	SSI3Clk	EPI0S20
A2	8	GPIO	PP4	105	-	U3RTS	U0DSR	-	-	-	-	-	-	-	USB0D7	-
A2	9	I2C SCL	PN5	112	-	U1RI	U3CTS	I2C2SCL	-	-	-	-	-	-	-	EPIO0S35
A2	10	I2C SDA	PN4	111	-	U1DTR	U3RTS	I2C2SDA	-	-	-	-	-	-	-	EPIO0S34
B2	1		5 V													
B2	2		GND													
B2	3	Analog	PB4	121	AIN10	U0CTS	I2C5SCL	-	-	-	-	-	-	-	-	SSI1Fss

Table 2-2. BoosterPack 2 GPIO and Signal Muxing (continued)

Header	Pin	Standard Function	GPIO	MCU Pin	Analog	Digital Function (FPIOCTL Bit Encoding)										
						1	2	3	5	6	7	8	11	13	14	15
B2	4	Analog	PB5	120	AIN11	U0RTS	I2C5SDA	-	-	-	-	-	-	-	-	SSI1Clk
B2	5	Analog	PK0	18	AIN16	U4Rx	-	-	-	-	-	-	-	-	-	EPI0S0
B2	6	Analog	PK1	19	AIN17	U4Tx	-	-	-	-	-	-	-	-	-	EPI0S1
B2	7	Analog	PK2	20	AIN18	U4RTS	-	-	-	-	-	-	-	-	-	EPI0S2
B2	8	Analog	PK3	21	AIN19	u4CTS	-	-	-	-	-	-	-	-	-	EPI0S3
B2	9	A out	PA4	37	-	U3Rx	I2C7SCL	T2CCP0	-	-	-	-	-	-	-	SSI0XDAT0
B2	10	A out	PA5	38	-	U3Tx	I2C7SDA	T2CCP1	-	-	-	-	-	-	-	SSI0XDAT1
C2	1	PWM	PG1	50	-	-	I2C1SDA	-	-	M0PWM5	-	-	-	-	-	EPI0S10
C2	2	PWM	PK4	63	-	-	I2C3SCL	-	EN0LED0	M0PWM6	-	-	-	-	-	EPI0S32
C2	3	PWM	PK5	62	-	-	I2C3SDA	-	EN0LED2	M0PWM7	-	-	-	-	-	EPI0S31
C2	4	PWM	PM0	78	-	-	-	T2CCP0	-	-	-	-	-	-	-	EPI0S15
C2	5	Capture	PM1	77	-	-	-	T2CCP1	-	-	-	-	-	-	-	EPI0S14
C2	6	Capture	PM2	76	-	-	-	T3CCP0	-	-	-	-	-	-	-	EPI0S13
C2	7	GPIO	PH0	29	-	U0RTS	-	-	-	-	-	-	-	-	-	EPI0S0
C2	8	GPIO	PH1	30	-	U0CTS	-	-	-	-	-	-	-	-	-	EPI0S1
C2	9	GPIO	PK6	61	-	-	I2C4SCL	-	EN0LED1	M0FAULT1	-	-	-	-	-	EPI0S25
C2	10	GPIO	PK7	60	-	U0RI	I2C4SDA	-	RTCCLK	M0FAULT2	-	-	-	-	-	EPI0S24
D2	1					GND										
D2	2	PWM	PM7	71	TMPR0	U0RI	-	T5CCP1	-	-	-	-	-	-	-	-
D2	3	GPIO	PP5	106	-	U3CTS	I2C2SDL	-	-	-	-	-	-	-	USB0D6	-
D2	4	GPIO	PA7	41	-	U2Tx	I2C6SDA	T3CCP1	USB0PFLT	-	-	-	USB0EPEN	SSI0XDAT3	-	EPI0S9
D2	5					RESET										
D2	6	SPI MOSI	PQ2	11	-	-	-	-	-	-	-	-	-	-	SSI3XDAT0	EPI0S22
		I2C	PA3	36	-	U4Tx	I2C8SDA	T1CCP1	-	-	-	-	-	-	-	SSI0Fss
D2	7	SPI MISO	PQ3	27	-	-	-	-	-	-	-	-	-	-	SSI3XDAT1	EPI0S23
		I2C	PA2	35	-	U4Rx	I2C8SCL	T1CCP0	-	-	-	-	-	-	-	SSI0Clk
D2	8	GPIO	PP3	104	-	U1CTS	U0DCD	-	-	-	-	-	-	-	USB0DIR	EPI0S30
D2	9	GPIO	PQ1	6	-	-	-	-	-	-	-	-	-	-	SSI3Fss	EPI0S21
D2	10	GPIO	PM6	72	TMPR1	U0DSR	-	T5CCP0	-	-	-	-	-	-	-	-

2.1.7.3 Breadboard Connection

The breadboard adapter section of the board is a set of 98 holes on a 0.1 inch grid. Properly combined with a pair of right angle headers, the entire Crypto Connected LaunchPad can be plugged directly into a standard 300 mil (0.3 inch) wide solder-less breadboard. The right angle headers and breadboard are not provided with this kit. Suggested part numbers are Samtec TSW-149-09-L-S-RE and TSW-149-08-L-S-RA right angle pin headers and Twin industries TW-E40-1020 solder-less breadboard. Samtec TSW-149-09-F-S-RE and TSW-149-09-F-S-RA may be substituted.

A detailed explanation of how to install the headers is available on the TI LaunchPad Wiki or at <http://users.ece.utexas.edu/~valvano/EE345L/Labs/Fall2011/LM3S1968soldering.pdf>.

Nearly all microcontroller signals are made available at the breadboard adapter holes (X11). These signals are grouped by function, where possible. For example, all EPI signals are grouped on one side of the connector. Many of the analog signals are grouped near VREF, and UART, SSI and I2C signals are grouped by peripheral to make expansion and customization simpler.

Table 2-3 and Table 2-4 show the GPIO pin and signal muxing for the X11 breadboard adapter pads.

Table 2-3. X11 Breadboard Adapter Odd-Numbered Pad GPIO and Signal Muxing

Pin	Port	MCU PIN	Analog	Digital Function (GPIOCTL Bit Encoding)										
				1	2	3	5	6	7	8	11	13	14	15
1								3V3						
3								GND						
5	PB4	121	AIN10	U0CTS	I2C5SCL	-	-	-	-	-	-	-	-	SSI1Fss
7	PB5	120	AIN11	U0RTS	I2C5SDA	-	-	-	-	-	-	-	-	SSI1Clk
9	PH0	29	-	U0RTS	-	-	-	-	-	-	-	-	-	EPI0S0
11	PH1	30	-	U0CTS	-	-	-	-	-	-	-	-	-	EPI0S1
13	PH2	31	-	U0DCD	-	-	-	-	-	-	-	-	-	EPI0S2
15	PH3	32	-	U0DSR	-	-	-	-	-	-	-	-	-	EPI0S3
17	PC7	22	C0-	U5Tx	-	-	-	-	-	-	-	-	-	EPI0S4
19	PC6	23	C0+	U5Rx	-	-	-	-	-	-	-	-	-	EPI0S5
21	PC5	24	C1+	U7Tx	-	-	-	-	RTCCLK	-	-	-	-	EPI0S6
23	PC4	25	C1-	U7Rx	-	-	-	-	-	-	-	-	-	EPI0S7
25	PA6	40	-	U2Rx	I2C6SCL	T3CCP0	USB0EPEN	-	-	-	-	SSI0XDAT2	-	EPI0S8
27	PA7	41	-	U2Tx	I2C6SDA	T3CCP1	USB0PFLT	-	-	-	USB0EPEN	SSI0XDAT3	-	EPI0S9
29	PG1	50	-	-	I2C1SDA	-	-	M0PWM5	-	-	-	-	-	EPI0S10
31	PG0	49	-	-	I2C1SCL	-	EN0PPS	M0PWM4	-	-	-	-	-	EPI0S11
33	PM3	75	-	-	-	T3CCP1	-	-	-	-	-	-	-	EPI0S12
35								GND						
37	PM2	76	-	-	-	T3CCP0	-	-	-	-	-	-	-	EPI0S13
39	PM1	77	-	-	-	T2CCP1	-	-	-	-	-	-	-	EPI0S14

Table 2-3. X11 Breadboard Adapter Odd-Numbered Pad GPIO and Signal Muxing (continued)

Pin	Port	MCU PIN	Analog	Digital Function (GPIOCTL Bit Encoding)										
				1	2	3	5	6	7	8	11	13	14	15
41	PM0	78	-	-	-	T2CCP0	-	-	-	-	-	-	-	EPI0S15
43	PL0	81	-	-	I2C2SDA	-	-	M0FAULT3	-	-	-	-	USB0D0	EPI0S16
45	PL1	82	-	-	I2C2SCL	-	-	PhA0	-	-	-	-	USB0D1	EPI0S17
47	PL2	83	-	-	-	-	C0o	PhB0	-	-	-	-	USB0D2	EPI0S18
49	PL3	84	-	-	-	-	C1o	IDX0	-	-	-	-	USB0D3	EPI0S19
51	PQ0	5	-	-	-	-	-	-	-	-	-	-	SSI3Clk	EPI0S20
53	PQ1	6	-	-	-	-	-	-	-	-	-	-	SSI3Fss	EPI0S21
55	PQ2	11	-	-	-	-	-	-	-	-	-	-	SSI3XDAT0	EPI0S22
57	PQ3	27	-	-	-	-	-	-	-	-	-	-	SSI3XDAT1	EPI0S23
59	PK7	60	-	U0RI	I2C4SDA	-			-	-	-	-	-	EPI0S24
61	GND													
63	PK6	61	-	-	I2C4SCL	-	EN0LED1	M0FAULT1	-	-	-	-	-	EPI0S25
65	PL4	85	-	-	-	T0CCP0	-	-	-	-	-	-	USB0D4	EPI0S26
67	PB2	91	-	-	I2C0SCL	T5CCP0	-	-	-	-	-	-	USB0STP	EPI0S27
69	PB3	92	-	-	I2C0SDA	T5CCP1	-	-	-	-	-	-	USB0CLK	EPI0S28
71	PP2	103	-	U0DTR	-	-	-	-	-	-	-	-	USB0NXT	EPI0S29
73	PP3	104	-	U1CTS	U0DCD	-	-	-	RTCCLK	-	-	-	USB0DIR	EPI0S30
75	PK5	62	-	-	I2C3SDA	-	EN0LED2	M0PWM7	-	-	-	-	-	EPI0S31
77	PK4	63	-	-	I2C3SCL	-	EN0LED0	M0PWM6	-	-	-	-	-	EPI0S32
79	PL5	86	-	-	-	T0CCP1	-	-	-	-	-	-	USB0D5	EPI0S33
81	PN4	111	-	U1DTR	U3RTS	I2C2SDA	-	-	-	-	-	-	-	EPI0S34
83	PN5	112	-	U1RI	U3CTS	I2C2SCL	-	-	-	-	-	-	-	EPI0S35
85	PN0	107	-	U1RTS	-	-	-	-	-	-	-	-	-	-
87	PN1	108	-	U1CTS	-	-	-	-	-	-	-	-	-	-
89	PN2	109	-	U1DCD	U2RTS	-	-	-	-	-	-	-	-	EPI0S29
91	PN3	110	-	U1DSR	U2CTS	-	-	-	-	-	-	-	-	EPI0S30
93	PQ4	102	-	U1Rx	-	-	-	-	-	DIVSCLK	-	-	-	-
95	WAKE													
97	5 V													

Table 2-4. X11 Breadboard Adapter Even-Numbered Pad GPIO and Signal Muxing

Pin	Port	MCU PIN	Analog	Digital Function (GPIOCTL Bit Encoding)										
				1	2	3	5	6	7	8	11	13	14	15
2				5 V										
4				GND										
6	PA2	35	-	U4Rx	I2C8SCL	T1CCP0	-	-	-	-	-	-	-	SSIOCIk
8	PA3	36	-	U4Tx	I2C8SDA	T1CCP1	-	-	-	-	-	-	-	SSIOFss
10	PA4	37	-	U3Rx	I2C7SCL	T2CCP0	-	-	-	-	-	-	-	SSI0XDAT0
12	PA5	38	-	U3Tx	I2C7SDA	T2CCP1	-	-	-	-	-	-	-	SSI0XDAT1
14	PE0	15	AIN3	U1RTS	-	-	-	-	-	-	-	-	-	-
16	PE1	14	AIN2	U1DSR	-	-	-	-	-	-	-	-	-	-
18	PE2	13	AIN1	U1DCD	-	-	-	-	-	-	-	-	-	-
20	PE3	12	AIN0	U1DTR	-	-	-	-	-	-	-	-	-	-
22	PE4	123	AIN9	U1RI	-	-	-	-	-	-	-	-	-	SSI1XDAT0
24	PE5	124	AIN8	-	-	-	-	-	-	-	-	-	-	SSI1XDAT1
26	PK0	18	AIN16	U4Rx	-	-	-	-	-	-	-	-	-	EPI0S0
28	PK1	19	AIN17	U4Tx	-	-	-	-	-	-	-	-	-	EPI0S1
30	PK2	20	AIN18	U4RTS	-	-	-	-	-	-	-	-	-	EPI0S2
32	PK3	21	AIN19	U4CTS	-	-	-	-	-	-	-	-	-	EPI0S3
34				VREF										
36				GND										
38	PD5	126	AIN6	U2Tx	-	T3CCP1	-	-	-	-	-	-	-	SSI1XDAT3
40	PD4	125	AIN7	U2Rx	-	T3CCP0	-	-	-	-	-	-	-	SSI1XDAT2
42	PD7	128	AIN4	U2CTS	-	T4CCP1	USB0PFLT	-	-	NMI	-	-	-	SSI2XDAT2
44	PD6	127	AIN5	U2RTS	-	T4CCP0	USB0EPEN	-	-	-	-	-	-	SSI2XDAT3
46	PD3	4	AIN12	-	I2C8SDA	T1CCP1	-	-	-	-	-	-	-	SSI2CIk
48	PD1	2	AIN14	-	I2C7SDA	T0CCP1	C1o	-	-	-	-	-	-	SSI2XDAT0
50	PD0	1	AIN15	-	I2C7SCL	T0CCP0	C0o	-	-	-	-	-	-	SSI2XDAT1
52	PD2	3	AIN13	-	I2C8SCL	T1CCP0	C2o	-	-	-	-	-	-	SSI2Fss
54	PP0	118	C2+	U6Rx	-	-	-	-	-	-	-	-	-	SSI3XDAT2
56	PP1	119	C2-	U6Tx	-	-	-	-	-	-	-	-	-	SSI3XDAT3
58	PB0	95	USB0ID	U1Rx	I2C5SCL	T4CCP0	-	-	CAN1Rx	-	-	-	-	-
60	PB1	96	USB0VBUS	U1Tx	I2C5SDA	T4CCP1	-	-	CAN1Tx	-	-	-	-	-
62				GND										
64	PF4	46	-	-	-	-	EN0LED1	M0FAULT0	-	-	-	-	SSI3XDAT2	TRD3
66	PF0	42	-	-	-	-	EN0LED0	M0PWM0	-	-	-	-	SSI3XDAT1	TRD2

Table 2-4. X11 Breadboard Adapter Even-Numbered Pad GPIO and Signal Muxing (continued)

Pin	Port	MCU PIN	Analog	Digital Function (GPIOCTL Bit Encoding)										
				1	2	3	5	6	7	8	11	13	14	15
68	PF1	43	-	-	-	-	EN0LED2	M0PWM1	-	-	-	-	SSI3XDAT0	TRD1
70	PF2	44	-	-	-	-	-	M0PWM2	-	-	-	-	SSI3Fss	TRD0
72	PF3	45	-	-	-	-	-	M0PWM3	-	-	-	-	SSI3Cik	TRCLK
74	PA0	33	-	U0Rx	I2C9SCL	T0CCP0	-	-	CAN0Rx	-	-	-	-	-
76	PA1	34	-	U0Tx	I2C9SDA	T0CCP1	-	-	CAN0Tx	-	-	-	-	-
78	PP4	105	-	U3RTS	U0DSR	-	-	-	-	-	-	-	USB0D7	-
80	PP5	106	-	U3CTS	I2C2SCL	-	-	-	-	-	-	-	USB0D6	-
82	PJ0	116	-	U3Rx	-	-	-	-	-	-	-	-	-	-
84	PJ1	117	-	U3Tx	-	-	-	-	-	-	-	-	-	-
86	PM7	71	TMPR0	U0RI	-	T5CCP1	-	-	-	-	-	-	-	-
88	PM6	72	TMPR1	U0DSR	-	T5CCP0	-	-	-	-	-	-	-	-
90	PM5	73	TMPR2	U0DCD	-	T4CCP1	-	-	-	-	-	-	-	-
92	PM4	74	TMPR3	U0CTS	-	T4CCP0	-	-	-	-	-	-	-	-
94	RESET													
96	GND													
98	3V3													

2.1.7.4 Other Headers and Jumpers

JP1 is provided to select the power input source for the Crypto Connected LaunchPad. The top position is for BoosterPack power; this position also disconnects both USB voltages from the board's primary 5-V input. In the top position, the TPS2052B does not limit current so additional care should be exercised. The middle position draws power from the USB connector on the left side of the board near the Ethernet jack. The bottom position is the default, in which power is drawn from the ICDI (Debug) USB connection.

JP2 separates the MCU 3.3-V power domain from the rest of the 3.3-V power on the board allowing an ammeter to be used to obtain more accurate measurements of microcontroller power consumption.

JP3 isolates the output of the TPS73733 LDO from the board's 3.3-V power domain.

JP4 and JP5 are used to configure CAN signals to the BoosterPack 2 interface. In the default horizontal configuration, CAN is not present on the BoosterPack. UART2 goes to the BoosterPack and UART 0 goes to the ICDI virtual serial port to provide ROM serial bootloader capability. In the vertical CAN-enabled configuration, UART2 goes to the ICDI virtual serial port and CAN signals are available on the BoosterPack. The ROM serial bootloader is not available to the ICDI virtual serial port while the jumpers are in the CAN position.

Figure 2-2 shows the default configuration and relative location of the jumpers on the board.

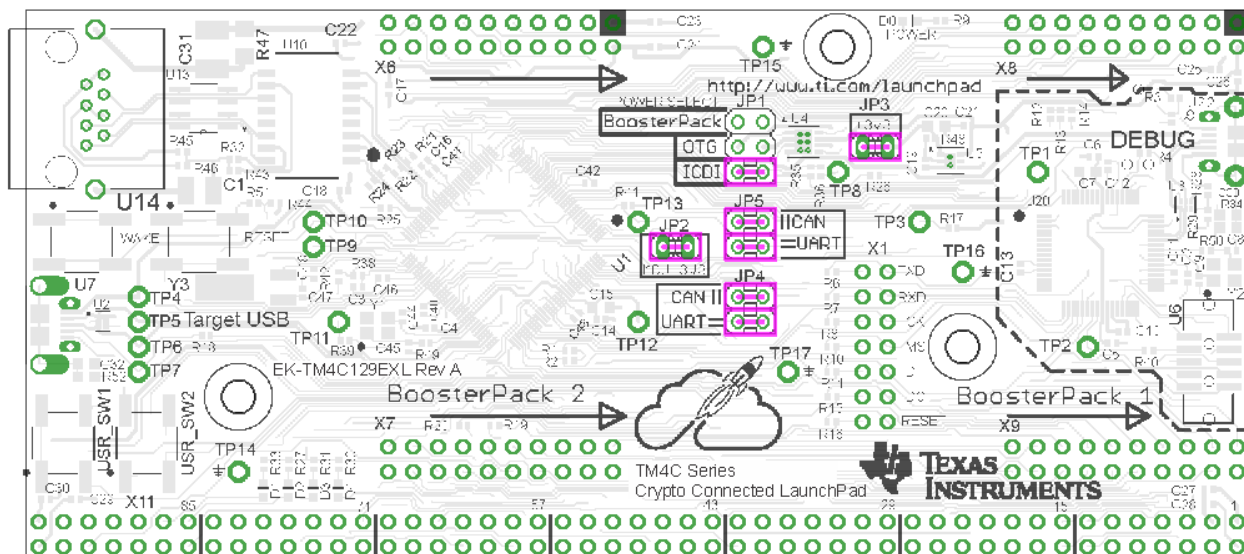


Figure 2-2. Default Jumper Locations

2.2 Power Management

2.2.1 Power Supplies

The Crypto Connected LaunchPad can be powered from three different input options:

- On-board ICDI USB cable (Debug, Default)
- Target USB cable
- BoosterPack or Breadboard adapter connection

The JP1 power-select jumper is used to select one of the power sources.

In addition, the JP3 power jumper can be used to isolate the 3.3-V output of the TPS73733 from the board's 3.3-V rail.

A TPS2052B load switch is used to regulate and control power to the Target USB connector when the microcontroller is acting in USB host mode. This load switch also limits current to the BoosterPack and Breadboard adapter headers when the JP1 jumper is in the ICDI position.

2.2.2 Low Power Modes

The Crypto Connected LaunchPad demonstrates several low power microcontroller modes. In run mode, the microcontroller can be clocked from several sources such as the internal precision oscillator or an external crystal oscillator. Either of these sources can then optionally drive an internal PLL to increase the effective frequency of the system up to 120 MHz. In this way, the run mode clock speed can be used to manage run mode current consumption.

The microcontroller also provides sleep and deep sleep modes and internal voltage adjustments to the flash and SRAM to further refine power consumption when the processor is not in use but peripherals must remain active. Each peripheral can be individually clock gated in these modes so that current consumption by unused peripherals is minimized. A wide variety of conditions from internal and external sources can trigger a return to run mode.

The lowest power setting of the microcontroller is hibernation, which requires a small amount of supporting external circuitry available on the Crypto Connected LaunchPad. The Crypto Connected LaunchPad can achieve microcontroller current consumption modes under 2 micro-Amps using hibernate VDD3ON mode. Hibernation with VDD3ON mode is not supported on this board. The Crypto Connected LaunchPad can be woken from hibernate by several triggers including the dedicated wake button, the reset button, an internal RTC timer and a subset of the device GPIO pins. The hibernation module provides a small area of internal SRAM that can preserve data through a hibernate cycle.

2.2.3 Clocking

The Crypto Connected LaunchPad uses a 25 MHz crystal (Y1) to drive the main TM4C129ENCPDT internal clock circuit. Most software examples use the internal PLL to multiply this clock to higher frequencies up to 120 MHz for core and peripheral timing. The 25-MHz crystal is required when using the integrated Ethernet MAC and PHY.

The Hibernation module is clocked from an external 32.768-KHz crystal (Y3).

2.2.4 Reset

The RESET signal to the TM4C129ENCPDT microcontroller connects to the RESET switch, BoosterPack connectors, Breadboard adapter and to the ICDI circuit for a debugger-controller reset.

External reset is asserted (active low) under the following conditions:

- Power-on reset (filtered by and R-C network)
- RESET switch is held down.
- By the ICDI circuit when instructed by the debugger (this capability is optional, and may not be supported by all debuggers)
- By an external circuit attached to the BoosterPack or Breadboard connectors.

2.3 Debug Interface

2.3.1 In-Circuit Debug Interface (ICDI)

The Crypto Connected LaunchPad comes with an on-board ICDI. The ICDI allows for the programming and debugging of the TM4C129ENCPDT using LM Flash Programmer and/or any of the supported tool chains. Note that ICDI only supports JTAG debugging at this time. It is possible to use other JTAG emulators instead of the on board ICDI, by connecting to U6. When the ICDI detects an external debug adapter connection on the JTAG connector U6 and disables the ICDI outputs to allow the external debug adapter to drive the debug circuit. For more information, see [Section 2.3.2](#).

Debug out of the ICDI is possible by removing resistors R6, R7, R8, R10, R11, R15, R16 and R40 from the Crypto Connected LaunchPad and use the ICDI to drive JTAG signals out on U6 for the purpose of programming or debugging other boards. To restore the connection to the on-board TM4C129ENCPDT microcontroller, install jumpers from the odd to even pins of X1 or re-install the resistors. Removal of R40 disables the detection of an attached external debugger. R40 must be installed to use an external debug adapter to program or debug the Crypto Connected LaunchPad.

2.3.2 External Debugger

The connector U6 is provided for the attachment of an external debug adapter such as the IAR J-Link or Keil ULINK. This connector follows the ARM standard 10-pin JTAG pinout. This interface can use either JTAG or SWD if supported by the external debug adapter.

2.3.3 Virtual COM Port

When plugged into a USB host, the ICDI enumerates as both a debugger and a virtual COM port. JP4 and JP5 control the selection of which UART from the TM4C129ENCPDT is connected to the virtual COM port. In the default configuration, UART0 maps to the virtual COM port of the ICDI. In the CAN jumper configuration, UART2 maps to the virtual COM port of the ICDI.

Software Development

This chapter provides general information on software development as well as instructions for flash memory programming.

3.1 Secure IoT Demo

3.1.1 Software Description

The out-of-box “Secure IoT” application demonstrates the use of Transport Layer Security/Secure Sockets Layer (TLS/SSL) protocol to connect an IoT product to a cloud server securely. This application runs on TI-RTOS and uses WolfSSL library for TLS/SSL support. The WolfSSL library uses the hardware encryption accelerators, available on the Crypto Connected LaunchPad board, which enables the development of connected applications with data encryption (for secure communication) at relatively higher performance. This application connects to Exosite’s cloud server using HTTPS protocol.

The “Secure IoT” application records information about the Crypto Connected LaunchPad and user activity on this board, which is securely reported to Exosite cloud server. A command-line interface is provided to interact with the application. With the command-line interface one can control the eval board like changing the state of the LED or play a game of tic-tac-toe either locally or with a remote user.

For more details about example usage, see the “Readme.txt” file available with the “Secure IoT” application.

3.1.2 Source Code Download and Build Instructions

The source code and binary files for the “Secure IoT” application are provided as part of an installer at <http://www.ti.com/lit/zip/spmc022>.

Instructions for downloading and installing TI-RTOS and WolfSSL along with detailed instructions on building WolfSSL libraries for TI-RTOS are provided at http://processors.wiki.ti.com/index.php/Using_wolfSSL_with_TI-RTOS. This application works with TI-RTOS v2.14.00.10 or later and WolfSSL v3.6.6 or later.

After building the WolfSSL libraries for TI-RTOS with support for TM4C hardware ciphers, follow the instructions under “Build Details - Application” in the “Readme.txt” file available with the “Secure IoT” application’s installation.

3.2 TivaWare for C Series Software

3.2.1 Software Description

The TivaWare software provides drivers for all of the peripheral devices supplied in the design. The TM4C Series Peripheral Driver Library is used to operate the on-chip peripherals as part of TivaWare.

TivaWare includes a set of example applications that use the TivaWare Peripheral Driver Library. These applications demonstrate the capabilities of the TM4C129ENCPDT microcontroller, as well as provide a starting point for the development of the final application for use on the Crypto Connected LaunchPad evaluation board. Example applications provided for the TM4C Series TM4C1294 Connected LaunchPad and examples paired with selected BoosterPacks will work with the Crypto Connected LaunchPad.

3.2.2 Source Code

The complete source code including the source code installation instructions are provided at <http://www.ti.com/tool/sw-tm4c>. The source code and binary files are installed in the TivaWare software tree.

3.2.3 Tool Options

The source code installation includes directories containing projects, makefiles, and binaries for the following tool-chains:

- Keil ARM RealView® Microcontroller Development System
- IAR Embedded Workbench® for ARM
- Generic GNU C Compiler
- Texas Instruments' Code Composer Studio™ IDE

Download evaluation versions of these tools from the [Tools & Software](#) section of www.ti.com/tiva. Due to code size restrictions, the evaluation tools may not build all example programs. A full license is necessary to re-build or debug all examples.

For detailed information on using the tools, see the documentation included in the tool chain installation or visit the website of the tools supplier.

3.3 Programming the Crypto Connected LaunchPad

The TivaWare software package includes pre-built binaries for each of the example applications. If you installed the TivaWare software to the default installation path of `C:\ti\TivaWare_C_Series_<version>`, you can find the example applications in `C:\ti\TivaWare_C_Series-<version>\examples\boards\ek-tm4c1294xl`. The on-board ICDI is used with the LM Flash Programmer tool to program applications on the Crypto Connected LaunchPad.

Follow these steps to program example applications into the Crypto Connected LaunchPad evaluation board using the ICDI:

1. Install [LM Flash Programmer](#) on a PC running Microsoft Windows.
2. Place JP1 into the ICDI position on the Crypto Connected LaunchPad.
3. Connect the USB-A cable plug in to an available USB port on the PC and plug the Micro-B plug to the Debug USB port (U22) on the Crypto Connected LaunchPad.
4. Verify that LED D0 at the top of the board is illuminated.
5. Install Windows ICDI and Virtual COM Port drivers if prompted. Installation instructions can be found in the *Stellaris® In-Circuit Debug Interface (ICDI) and Virtual COM Port Driver Installation Instructions (SPMU287)*.
6. Run the LM Flash Programmer application on the PC.
7. In the Configuration tap, use the Quick Set control to select "TM4C1294XL LaunchPad".
8. 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-TM4C1294XL`).
9. Each example application has its own directory. Navigate to the example directory that you want to load and then into the sub-directory for one of the supported tool chains that contains the binary (*.bin) file. Select the binary file and click Open.
10. Set the Erase Method to Erase Necessary Pages, check the Verify After Program box, and check Reset MCU After Program. The example program starts execution once the verify process is complete.

References

4.1 References

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

- *TivaWare for C Series* (<http://www.ti.com/tool/sw-tm4c>)
- *TivaWare Peripheral Driver Library Users' Guide* (SPMU298)
- *Quick Start Guide: Crypto Connected LaunchPad Evaluation Kit (EK-TM4C129EXL)* (SPMZ862)
- *LM Flash Programmer Tool* (<http://www.ti.com/lmflashprogrammer>)
- *TPS73733 Low-Dropout Regulator with Reverse Current Protection* (<http://www.ti.com/product/tps79733>)
- *Texas Instruments Code Composer Studio website* (<http://www.ti.com/ccs>)
- *Tiva TM4C129ENC PDT Microcontroller Data Sheet* (SPMS441)
- *Build Your Own BoosterPack* information regarding the BoosterPack standard (<http://www.ti.com/byob>)
- *Stellaris® In-Circuit Debug Interface (ICDI) and Virtual COM Port Driver Installation Instructions* (SPMU287)
- *TI-RTOS* (<http://www.ti.com/tool/TI-RTOS>)

Additional Support:

- *Keil RealView MDK-ARM* (<http://www.keil.com/arm/mdk.asp>)
- *IAR Embedded Workbench for ARM* (<http://iar.com/ewarm/>)
- *Sourcery CodeBench* development tools (<http://www.mentor.com/embedded-software/sourcery-tools/sourcery-codebench/overview>)
- *Exosite* (<http://ti.exosite.com>)
- *WolfSSL* (<http://wolfssl.com>)

PCB Layout and Bill of Materials

A.1 Component Locations

Figure A-1 is a dimensioned drawing of the Crypto Connected LaunchPad that shows the location of selected features of the board, as well as the component locations.

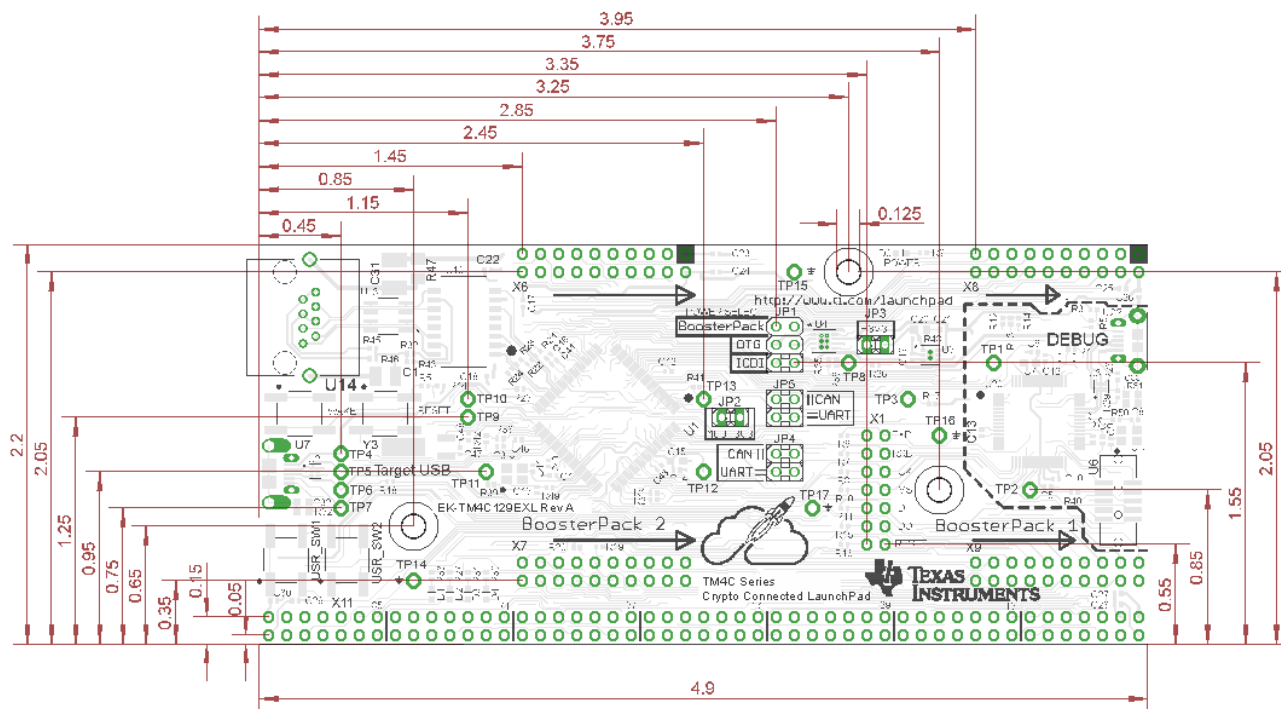


Figure A-1. Crypto Connected LaunchPad Dimensions and Component Locations

A.2 Bill of Materials

Table A-1 is the Crypto Connected LaunchPad bill of materials list.

Table A-1. Crypto Connected LaunchPad Bill of Materials

Item	Ref	Qty	Description	Mfg	Part Number
1	C1	1	Capacitor, 1000 pF, 2kV, 20%, X7R, 1210	Kemet	C1210C102MGRACU
2	C3, C4, C5, C10, C11, C12, C13, C16, C17, C18, C19, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C40, C41, C42, C43, C46	26	Capacitor, 0.1 μ F 16 V, 10%, 0402 X7R	Taiyo Yuden	EMK105B7104KV-F
3	C31	1	Capacitor, 4700 pF, 2kV, 10%, X7R, 1812	AVX	1812GC472KAT1A
4	C32, C33	2	Capacitor, 3300 pF, 50 V, 10%, X7R, 0603	TDK	C1608X7R1H332K
5	C6, C14	2	Capacitor, 1 μ F, X5R, 10 V, low ESR, 0402	Johanson Dielectrics Inc	100R07X105KV4T
6	C7, C15, C20	3	Capacitor, 2.2 μ F, 16 V, 10%, 0603, X5R	Murata	GRM188R61C225KE15D
7	C8, C9, C44, C45, C47, C48	6	Capacitor, 12 pF, 50 V, 5%, 0402, COG	Murata	GRM1555C1H120JZ01D
8	D0, D1, D2, D3, D4	5	Green LED 0603	Everlight	19-217/G7C-AL1M2B/3T
9	J1, J2, J3, J4, J5, J6, J7	7	Jumper, 0.100, Gold, Black, Open	3M	969102-0000-DA
				Kobiconn	151-8000-E
10	JP1	1	Header, 2x3, 0.100, T-hole, vertical unshrouded, 0.230 mate, gold	FCI	67996-206HLF
11	JP2, JP3	2	Header, 1x2, 0.100, T-hole, vertical unshrouded, 0.220 mate	3M	961102-6404-AR
				FCI	68001-102HLF
				Anyone	1x2-head
12	JP4, JP5	2	Header, 2x2, 0.100, T-hole, vertical unshrouded, 0.230 mate	FCI	67997-104HLF
				4UCON	00998
13	R1, R2, R3, R4, R5, R29, R35, R44	8	Resistor, 10k Ω , 1/10W, 5%, 0402 thick film	Yageo	RC0402FR-0710KL
14	R17, R26, R36	3	100k 5% 0402 resistor SMD	Rohm	MCR01MRTJ104
15	R18, R51	2	Resistor 0402 100 Ω 5%	Rohm	MCR1MRTJ101
16	R23, R21, R22, R24	4	Resistor 49.9 Ω 0402. 1 %	Rohm	MCR01MRTF49R9
17	R25	1	Resistor 4.87k 1% 0402 SMD	Rohm	MCR01MRTF4871
18	R28	1	Resistor, 5.6k Ω , 1/10W, 5%, 0402	Panasonic	ERJ-2GEJ562X
19	R32, R43, R45, R46	4	Resistor 75 Ω 0402 5%	Rohm	MCR01MRTJ750
20	R34, R52	2	Resistor, 1M Ω , 1/10W, 5% 0603 SMD	Panasonic	ERJ-3GEYJ105V
21	R38	1	Resistor, 51 Ω , 1/10W, 5%, 0402	Panasonic	ERJ-2GEJ510X

Table A-1. Crypto Connected LaunchPad Bill of Materials (continued)

Item	Ref	Qty	Description	Mfg	Part Number
22	R42	1	Resistor, 1M Ω , 1/10W, 5%, 0402	Rohm	MCR01MRTF1004
23	R47	1	RES 1M Ω 5% 1206 TF	Panasonic	ERJ-8GEYJ105V
24	R49, R50	2	Resistor, 2.0k Ω , 1/10W, 5%, 0402	Panasonic	ERJ-3GEYJ202V
25	R6, R7, R8, R10, R11, R15, R16, R19, R20, R39, R40, R41	12	Resistor, 0 Ω , 1/10W, 5%, 0402	Panasonic	ERJ-2GE0R00X
26	R9, R27, R30, R31, R33	5	Resistor, 330 Ω , 1/10W, 5%, 0402	Yageo	RC0402FR-07330RL
27	RESET, USR_SW1, USR_SW2, WAKE	4	Switch, Tact 6mm SMT, 160gf	Omron	B3S-1000
28	U1	1	TM4C, MCU TM4C129ENCPDT 128 QFP with cryptographic modules and Ethernet MAC + PHY	Texas Instruments	TM4C129ENCPDT
29	U10	1	Transformer, Ethernet, 1 to 1. SOIC 16	Pulse Electronics	HX1198FNL
30	U13	1	Diode, 8 chan, ± 15 KV, ESD protection array, SO-8	Semtech	SLVU2.8-4.TBT
31	U14	1	Connector, RJ45 NO MAG, shielded THRU HOLE	TE Connectivity	1-406541-5
32	U2, U3	2	IC 4CH ESD solution w/clamp 6SON	Texas Instruments	TPD4S012DRYR
33	U20	1	Stellaris TM4C MCU TM4C123GH6PMI	Texas Instruments	TM4C123GH6PMI
34	U22	1	USB Micro B receptacle right angle with guides	FCI	10118194-0001LF
35	U4	1	Fault protected power switch, dual channel, 8-SON	Texas Instruments	TPS2052BDRBR
36	U5	1	3.3 V LDO TI TPS73733DRV fixed out 5 V in	Texas Instruments	TPS73733DRV
37	U6	1	Header 2x5, 0.050, SM, vertical shrouded	Samtec	SHF-105-01-S-D-SM
				Don Connex Electronics	C44-10BSA1-G
38	U7	1	USB Micro AB receptacle. Right angle with through guides	Hirose	ZX62D-AB-5P8
39	X6, X7, X8, X9	4	Header, 2x10, T-hole vertical unshrouded stacking	Samtec	SSW-110-23-S-D
				Major League Electronics	SSHQ-110-D-08-F-LF
40	Y1	1	Crystal 25 MHz 3.2 x 2.5 mm	NDK	nx3225ga-25.000m-std-crg-2
41	Y2	1	Crystal 16 MHz 3.2 x 2.5 mm 4 pin	NDK	NX3225GA-16.000M-STD-CRG-2
42	Y3	1	Crystal, 32.768 KHz radial CAN	Citizen Finetech Miyota	CMR200T-32.768KDZY-UT

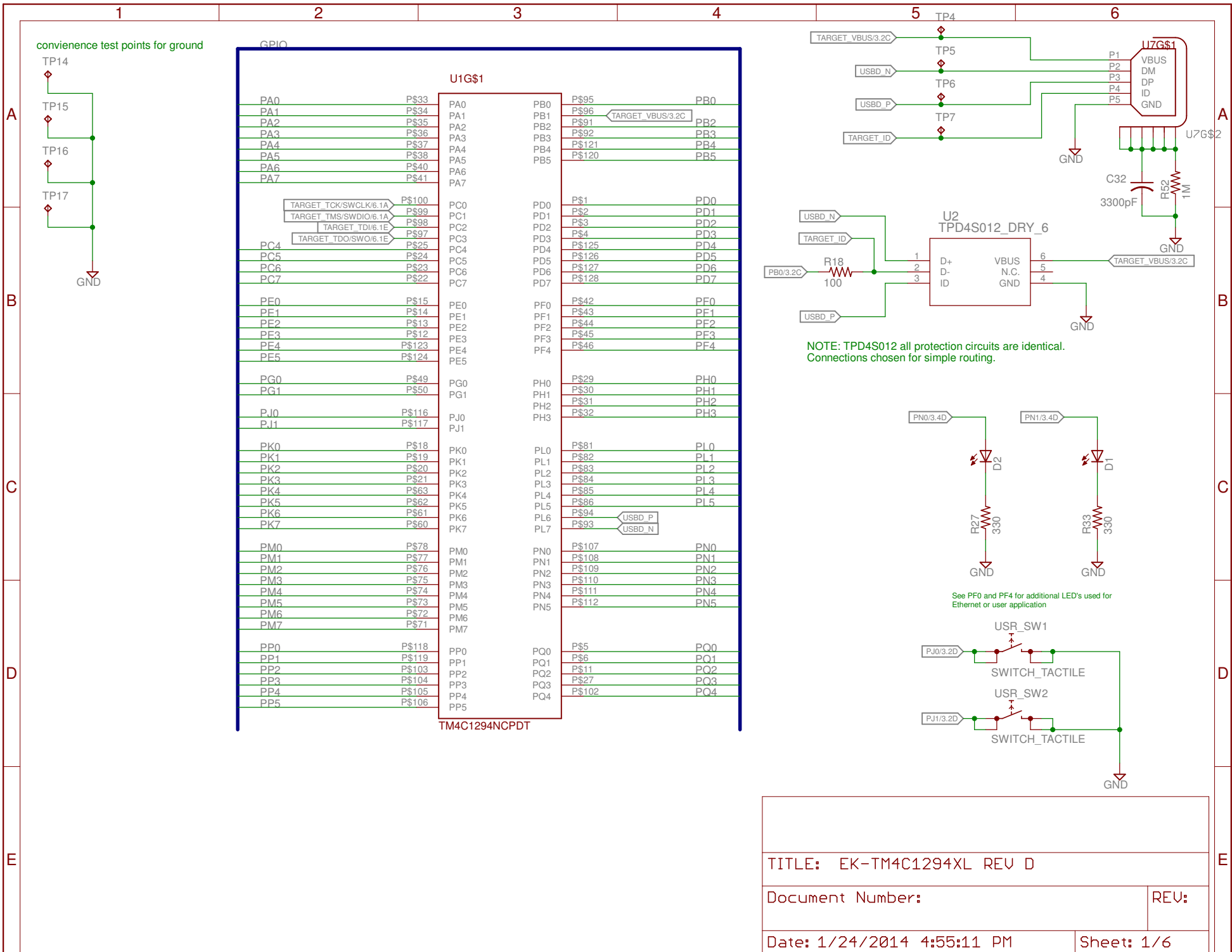
Table A-1. Crypto Connected LaunchPad Bill of Materials (continued)

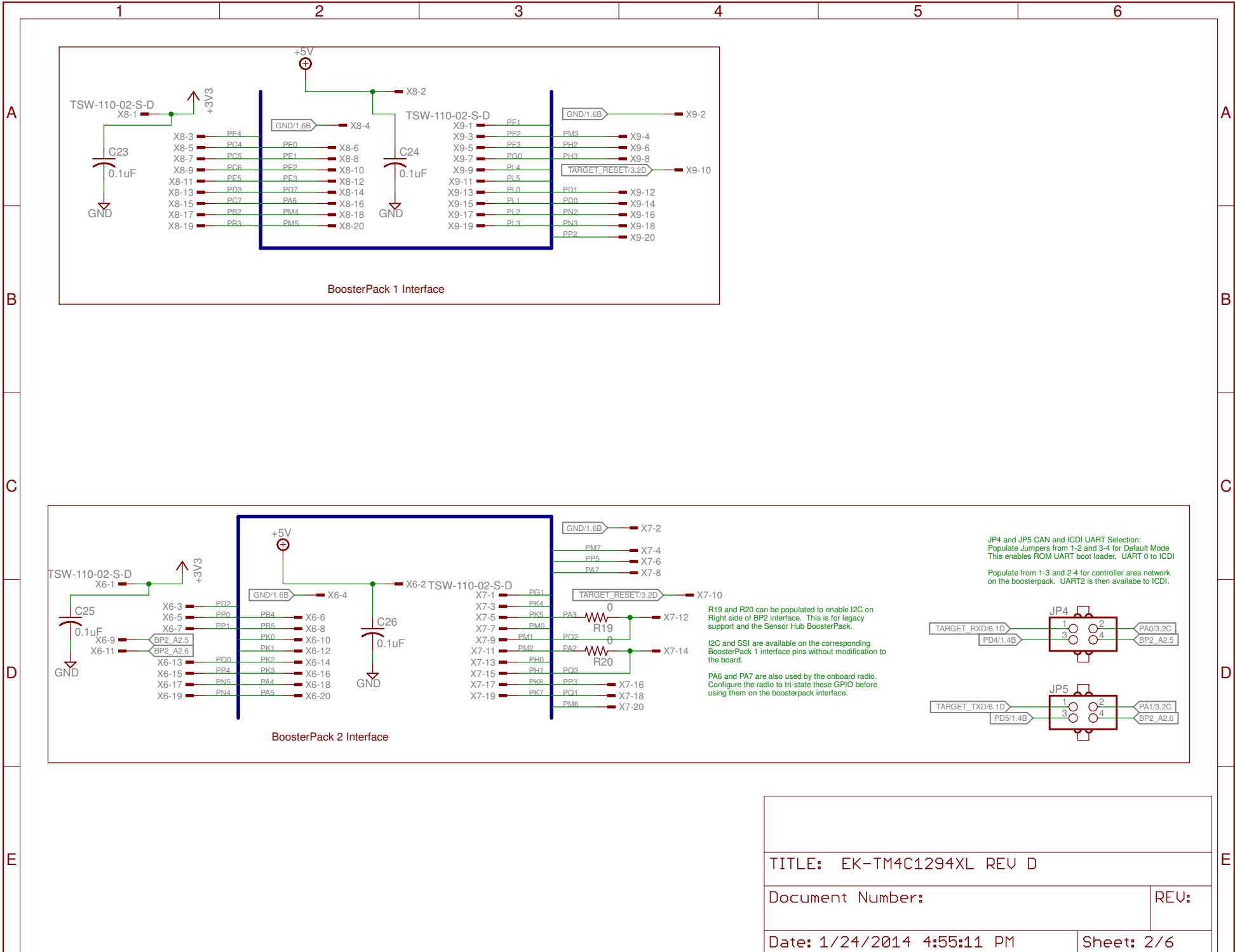
Item	Ref	Qty	Description	Mfg	Part Number
PCB Do Not Populate List (Shown for information only)					
43	C2	1	Capacitor, 0.1 μ F 16 V, 10%, 0402 X7R	Taiyo Yuden	EMK105B7104KV-F
44	H1, H4, H6	3	Screw, #4 x 0.625" Pan head, sheet metal, Phillips/slotted (for fan)	McMaster	90077A112
45	R12, R13, R14	3	Resistor, 5.6k Ω , 1/10W, 5%, 0402	Panasonic	ERJ-2GEJ562X
46	R48	1	Resistor 0402 1% 52.3k	Rohm	TRR01MZPF5232
47	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17	17	Terminal, test point miniature loop, red, T-hole	Keystone	5000
48	X1	1	Header, 2x7, 0.100, T-hole, vertical, unshrouded, 0.230 mate	FCI	67997-114HLF
49	X11A	1	Valvano style bread board connect. Right angle extended, 1 x 49 0.100 pitch.	Samtec	TSW-149-09-F-S-RE
50	X11B	1	Valvano style breadboard header	Samtec	TSW-149-08-F-S-RA

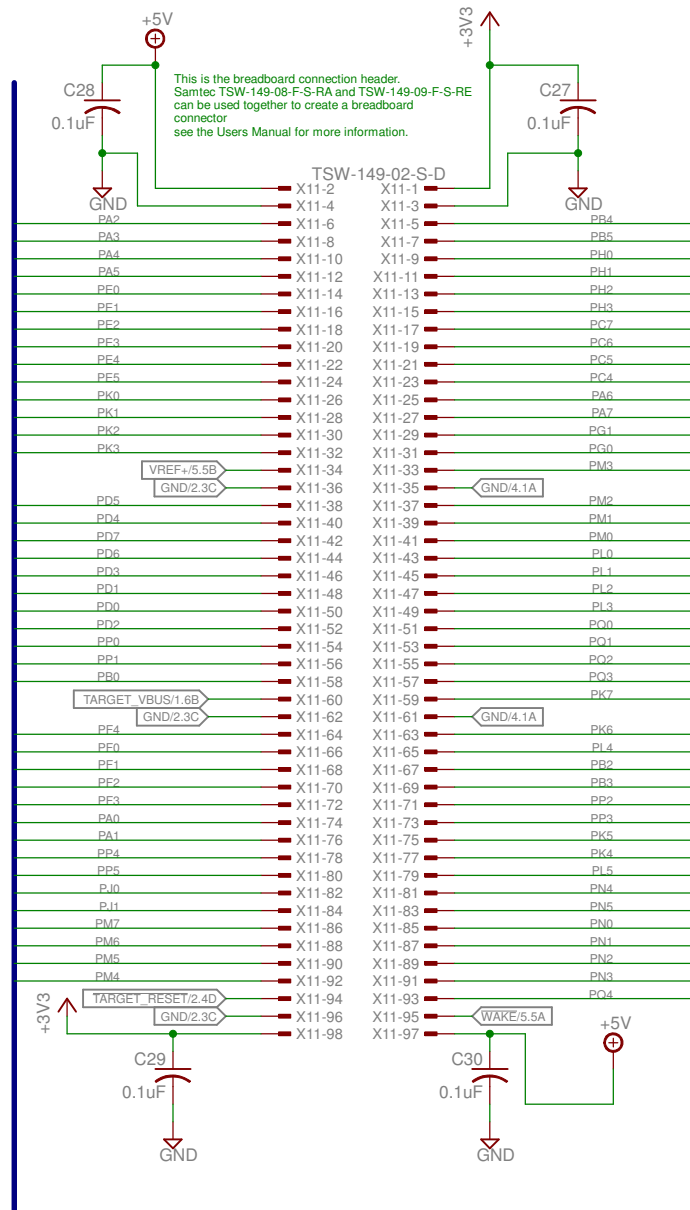
Schematic

This section contains the complete schematics for the TM4C Series TM4C129E Crypto Connected LaunchPad.

- Microcontroller, USB, Buttons, and LED's
- BoosterPack connectors
- Breadboard connector
- Ethernet and Ethernet LED's
- Power
- In-Circuit Debug Interface







NOTE: PB0 and PB1 are used in some configurations with 5V signals especially in USB Host or OTG mode. Be aware the 5V may be present on these pins depending on system jumper configuration

These pins are only 5V tolerant when configured for USB mode applications.

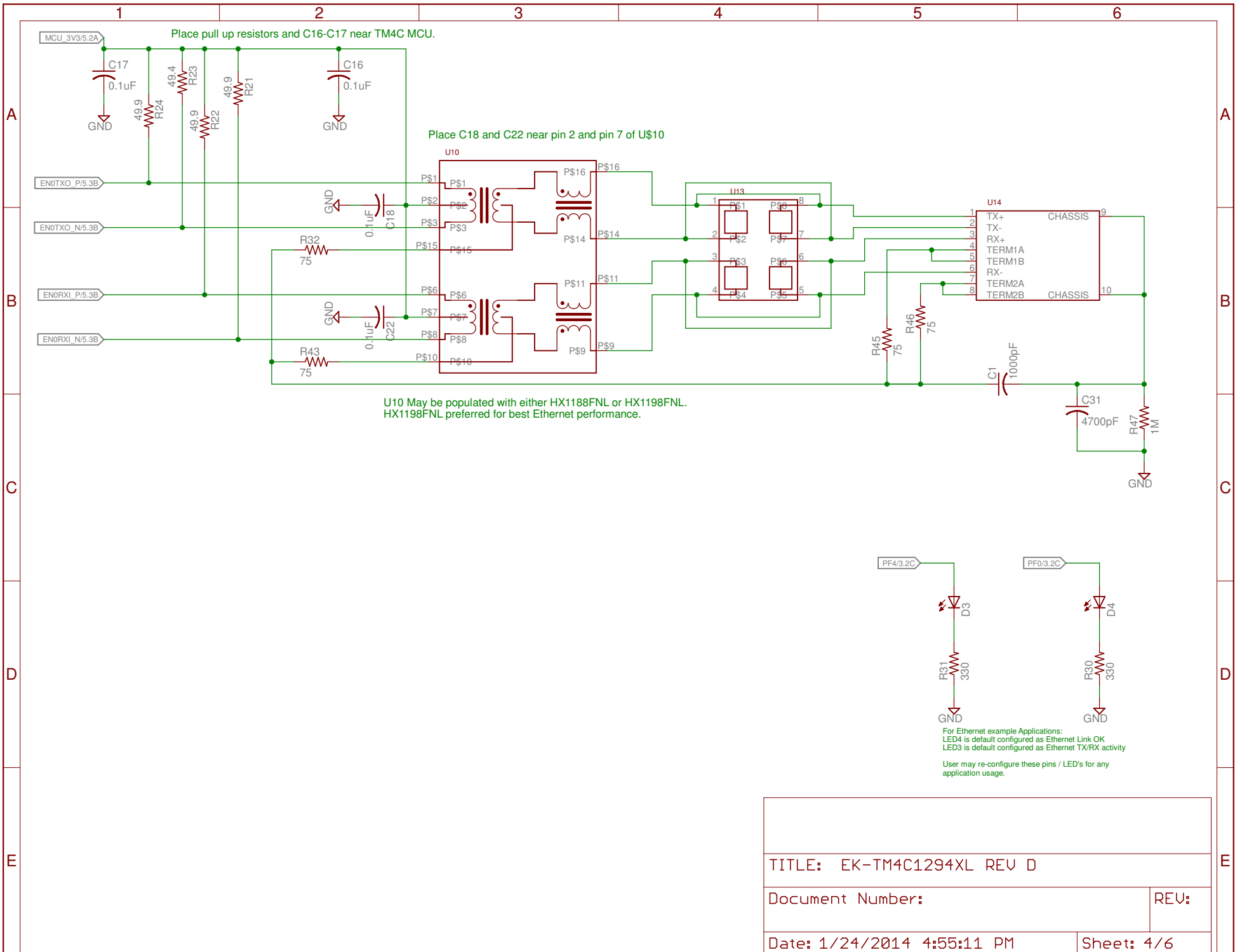
TITLE: EK-TM4C1294XL REV D

Document Number:

REV:

Date: 1/24/2014 4:55:11 PM

Sheet: 3/6



Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (September 2015) to A Revision	Page
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- | | |
|--|-------------------|
| • GLOBAL: Updated/Changed all instances of "UART4" to "UART2"..... | 5 |
|--|-------------------|

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- 3 *Regulatory Notices:*

- 3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 Canada

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

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

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/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/lstds/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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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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.

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