LAUNCHXL-F28027 C2000 Piccolo LaunchPad Experimenter Kit

User's Guide

TEXAS INSTRUMENTS

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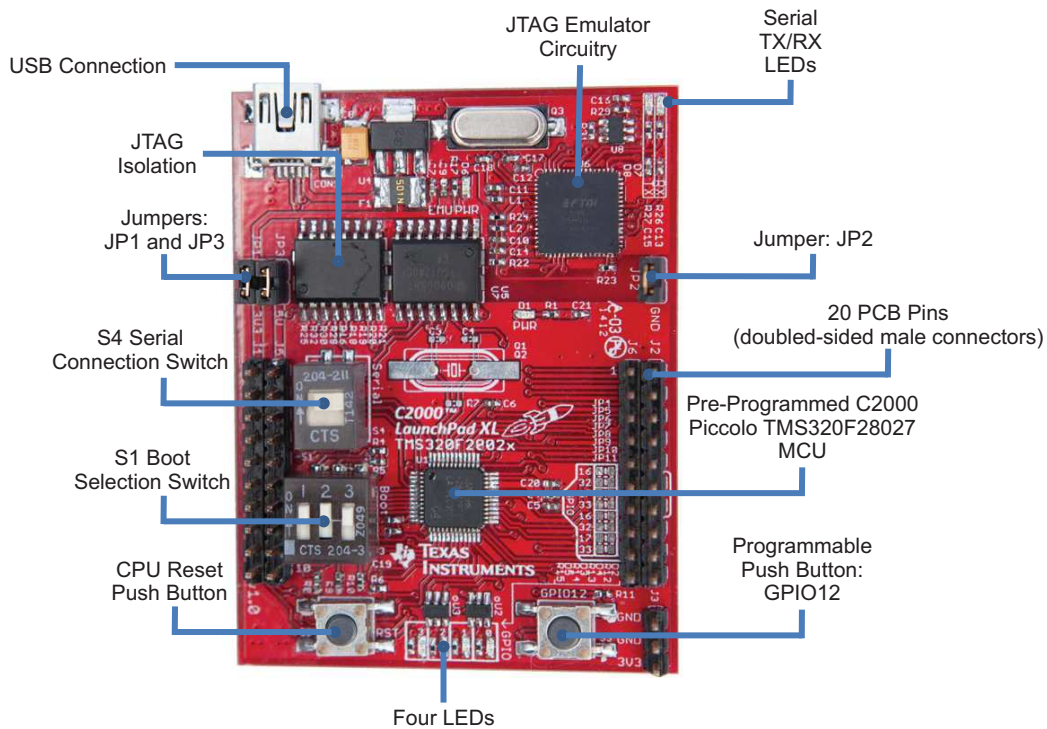
1.1   Overview

The C2000™ Piccolo™ LaunchPad™, LAUNCHXL-F28027, is a complete low-cost experimenter board for the Texas Instruments Piccolo F2802x devices. The LAUNCHXL-F28027 kit features all the hardware and software necessary to develop applications based on the F2802x microprocessor. The LaunchPad is based on the superset F28027 device, and easily allows users to migrate to lower cost F2802x devices once the design needs are known. It offers an on-board JTAG emulation tool allowing direct interface to a PC for easy programming, debugging, and evaluation. In addition to JTAG emulation, the USB interface provides a UART serial connection from the F2802x device to the host PC.

Users can download an unrestricted version of Code Composer Studio™ IDE version 5 to write, download, and debug applications on the LAUNCHXL-F28027 board. The debugger is unobtrusive, allowing the user to run an application at full speed with hardware breakpoints and single stepping available while consuming no extra hardware resources.

As shown in Figure 1, the LAUNCHXL-F28027 C2000 LaunchPad features include:

- USB debugging and programming interface via a high-speed galvanically isolated XDS100v2 emulator featuring a USB/UART connection.
- Superset F28027 device that allows applications to easily migrate to lower cost devices.
- Nibble (4-bit) wide LED display.
- Two push buttons for user feedback and device reset.
- Easily accessible device pins for debugging purposes or as sockets for adding customized extension boards.
- Boot selection and USB and UART disconnect switches.

Figure 1. LAUNCHXL-F28027 Board Overview

1.2 Kit Contents

The LAUNCHXL-F28027 C2000 LaunchPad experimenter kit includes the following items:
- C2000 LaunchPad Board (LAUNCHXL-F28027)
- Mini USB-B Cable, 0.5m
- Quick Start Guide

1.3 Revisions

The first production revision of the LAUNCHXL-F28027 C2000 Piccolo LaunchPad, version 1.0, was released in July of 2012 and is currently the only revision available.

2 Installation

The C2000 LaunchPad installation consists of three easy steps:
1. Download Code Composer Studio and controlSUITE™.
2. Install Code Composer Studio and controlSUITE.
3. Connect and install the C2000 LaunchPad to the PC.

Now the LaunchPad is ready to develop applications or run the pre-programmed demo.

2.1 Download the Required Software

Code Composer Studio IDE is available for free without any restriction when used with the XDS100 emulator on the C2000 LaunchPad. The software can be downloaded from the C2000 LaunchPad page at www.ti.com/c2000-launchpad. At this site, you can also download a copy of controlSUITE that includes drivers, examples, and other support software needed to get started.

2.2 Install the Software

Once downloaded, install Code Composer Studio and the controlSUITE package.

2.3 Install the Hardware

After Code Composer Studio is installed, plug the supplied USB cable into the C2000 LaunchPad board and into an available USB port on your computer.

Windows® will automatically detect the hardware and ask you to install software drivers. Let Windows run a search for the drivers and automatically install them. After Windows successfully installs the drivers for the integrated XDS100v2 emulator, your LaunchPad is now ready for use.

3 Getting Started with the LAUNCHXL-F28027

3.1 Getting Started

The first time the LAUNCHXL-F28027 is used, a demo application automatically starts when the board is powered from a USB host. If your board does not start the demo application, try placing S1 in the following positions and resetting the board: UP - UP - DOWN. To start the demo, connect the LAUNCHXL-F28027 with the included mini-USB cable to a free USB port. The demo application starts with the LEDs flashing to show the device is active.

3.2 Demo Application, Internal Temperature Measurement

The LAUNCHXL-F28027 includes a pre-programmed TMS320F28027 device. When the LaunchPad is connected via USB, the demo starts with an LED flash sequence that points toward S3. Press S3 to start the temperature measurement mode.

A reference temperature is taken at the beginning of this mode and the LEDs of the LaunchPad are used to display any difference between the current temperature and the reference temperature. Initially, the LED connected to GPIO3 is lit to indicate an 8 in binary, which corresponds to the current temperature being equal to the reference temperature. As the temperature drifts away from the reference, the difference is displayed as a binary increment or decrement of the nibble wide LED display. For instance, if the reference temperature was 30ºC and the current temperature is 33ºC, the LEDs would be (from left to right) ON, OFF, ON, and ON which would be 11 in binary (33-30=3 and 11-8=3). A new reference temperature may be set at any time by pressing S3 again.

In addition to the LED display, temperature information is also displayed on your PC through the USB/UART connection. To view the UART information on your PC, first figure out the COM port associated with the LaunchPad. To do this in Windows, right click on *My Computer* and click on *Properties*. In the dialog box that appears, click on the Hardware tab and open *Device Manager*. Look for an entry under Ports (COM & LPT) titled "USB Serial Port (COMX)", where X is a number. Remember this number for when you open a serial terminal. The demo applications UART data was written and debugged using PuTTY, and for the best user experience we recommend you use PuTTY to view the UART data. Open your serial terminal program and open the COM port you found previously in device manager with the following settings: 115200 Baud, 8 data bits, no parity, 1 stop bit. After opening the serial port in your serial terminal, reset the Launchpad with the reset push button and observe the serial terminal for a surprise.

3.3 Program and Debug the Temperature Measurement Demo Application

The project and associated source code for the C2000 Piccolo LaunchPad demo is included in the controlSUITE software package and should automatically be found by the TI Resource Explorer in Code Composer Studio v5. In the resource explorer, open the controlSUITE folder and then the Development Tools entry and look for the C2000 LaunchPad line item. Expand this item and LAUNCHXL-F28027, then select the LaunchPad Demo Application. Follow the steps in the main pane of the resource explorer to import, build, debug, and run this application.

4 Hardware Configuration

The C2000 LaunchPad gives users several options as to how to configure the board.

4.1 Power Domain

The C2000 LaunchPad has two separate power domains for the purpose of allowing JTAG isolation. Jumpers JP1, JP2, and JP3 configure whether the USB power is passed to the target device.

Jumper	Power Domain
JP1	3.3 V
JP2	Ground
JP3	5 V

4.2 Serial Connectivity

The LAUNCHXL-F28027 has a USB to UART adapter built in. This makes it easy to print debug information back to the host PC even in isolated environments. However, in some cases the user may wish to connect the Piccolo SCI peripheral (C2000 UART peripheral) to a BoosterPack or other hardware via the header pins. If the SCI pins are connected to both the header pins, the XDS100 UART channel contention would exist and the pins would not be driven to the correct voltage levels. To solve this issue we have included a switch to allow the user to disconnect the Piccolo serial pins from the XDS100 UART connection. When S4 is in the up position, the Piccolo device's SCI is connected to the XDS100 and you are able to receive and send serial information from or to the board. When S4 is in the down position, the Piccolo device's SCI is disconnected from the XDS100 and BoosterPacks, which use serial communication, and can communicate with the Piccolo device.

4.3 Boot Mode Selection

The LaunchPad's F28027 device includes a boot ROM that performs some basic start-up checks and allows for the device to boot in many different ways. Most users will either want to perform an emulation boot or a boot to flash (if they are running the application standalone). S1 has been provided to allow users to easily configure the pins that the bootROM checks to make this decision. The switches on S1 correspond to:

Switch	Function
1	GPIO34
2	GPIO37
3	TRSTn

Keep in mind that the debugger does not connect if the device is not in the emulation boot mode (TRST switch in the up position). More information about boot mode selection can be found in the *TMS320x2802x Piccolo Boot ROM Reference Guide* (SPRUFN6).

4.4 Connecting a Crystal

Although the Piccolo device present on the LAUNCHXL-F28027 has an internal oscillator — and for most applications this is sufficient — the LaunchPad offers a footprint for surface mount or through-hole HC-49 crystals for users who require a more precise clock. If you wish to use an external crystal, solder the crystal to the Q1/Q2 footprint and appropriate load capacitors to the C3 and C4 footprints. You also need to configure the device to use the external oscillator in software.

4.5 Connecting a Satellite Board

The C2000 LaunchPad is the perfect experimenter board to start hardware development with the F2802x devices. Connectors J1, J2, J5, and J6 and the power supply at J3 are aligned in a 0.1-in (2.54-mm) grid to allow an easy and inexpensive development of a breadboard extension module. These satellite boards can access all of the GPIO and analog signals. The alignment of the connectors and the pin out can be found in Section 5.

4.6 Device Migration Path

Applications developed on the LAUNCHXL-F28027 can easily be migrated to any of these lower cost devices in the F2802x family:

Part Number	Description
TMS320F28027[1]	32-bit Real Time Microcontroller, 60 MHz, 32K Flash, 6K RAM, 4 HRPWM
TMS320F28026	32-bit Real Time Microcontroller, 60 MHz, 16K Flash, 6K RAM, 4 HRPWM
TMS320F28023	32-bit Real Time Microcontroller, 50 MHz, 32K Flash, 6K RAM, 4 HRPWM
TMS320F28022	32-bit Real Time Microcontroller, 50 MHz, 16K Flash, 6K RAM, 4 HRPWM
TMS320F28021	32-bit Real Time Microcontroller, 40 MHz, 32K Flash, 5K RAM
TMS320F28020	32-bit Real Time Microcontroller, 40 MHz, 16K Flash, 3K RAM
TMS320F280200	32-bit Real Time Microcontroller, 40 MHz, 8K Flash, 3K RAM

[1] This device is present on the LAUNCHXL-F28027.

5 LAUNCHXL-F28027 Hardware

5.1 Device Pin Out

Table 1 lists the pin out and pin mux options for the C2000 LaunchPad.

Table 1. C2000 LaunchPad Pin Out and Pin Mux Options

Mux Value						Mux Value			
3	2	1	0	J1 Pin	J5 Pin	0	1	2	3
			+3.3V	1	1	+5V			
			ADCINA6	2	2	GND			
TZ2	SDAA	SCIRXDA	GPIO28	3	3	ADCINA7			
TZ3	SCLA	SCITXDA	GPIO29	4	4	ADCINA3			
Rsvd	Rsvd	COMP2OUT	GPIO34	5	5	ADCINA1			
			ADCINA4	6	6	ADCINA0			
	SCITXDA	SPICLK	GPIO18	7	7	ADCINB1			
			ADCINA2	8	8	ADCINB3			
			ADCINB2	9	9	ADCINB7			
			ADCINB4	10	10	NC			
3	2	1	0	J6 Pin	J2 Pin	0	1	2	3
Rsvd	Rsvd	EPWM1A	GPIO0	1	1	GND			
COMP1OUT	Rsvd	EPWM1B	GPIO1	2	2	GPIO19	SPISTEA	SCIRXDA	ECAP1
Rsvd	Rsvd	EPWM2A	GPIO2	3	3	GPIO12	TZ1	SCITXDA	Rsvd
COMP2OUT	Rsvd	EPWM2B	GPIO3	4	4	NC			
Rsvd	Rsvd	EPWM3A	GPIO4	5	5	RESET#			
ECAP1	Rsvd	EPWM3B	GPIO5	6	6	GPIO16/32	SPISIMOA/SDAA	Rsvd/EPWMSYNCI	TZ2/ADCSOCA
TZ2/ADCSOCA	Rsvd/EPWMSYNCI	SPISIMOA/SDAA	GPIO16/32	7	7	GPIO17/33	SPISOMIA/SCLA	Rsvd/EPWMSYNCO	TZ3/ADCSOCB
TZ3/ADCSOCB	Rsvd/EPWMSYNCO	SPISOMIA/SCLA	GPIO17/33	8	8	GPIO6	EPWM4A	EPWMSYNCI	EPWMSYNCO
			NC	9	9	GPIO7	EPWM4B	SCIRXDA	Rsvd
			NC	10	10	ADCINB6			

5.2 Schematics

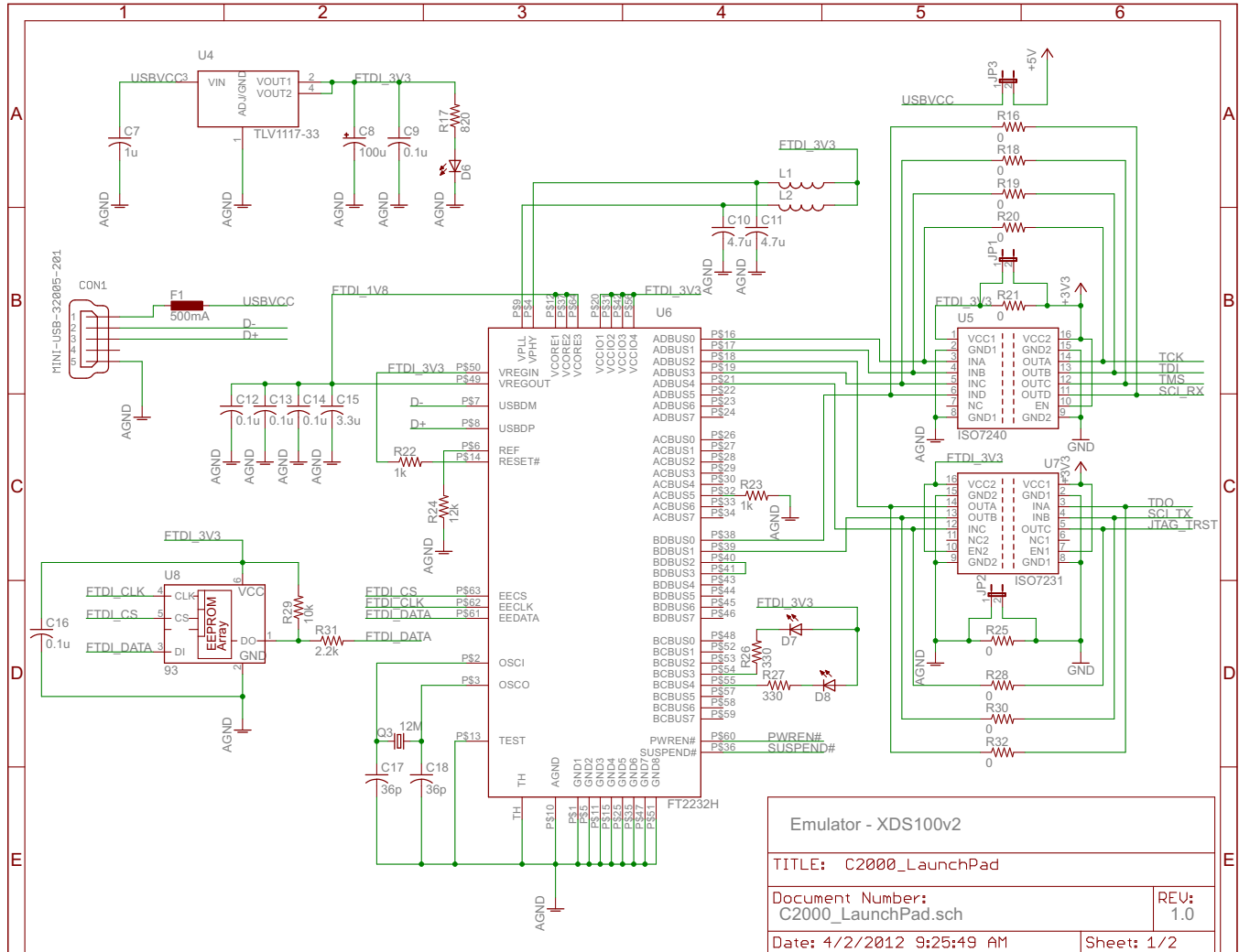Figure 2 and Figure 3 show the C2000 LaunchPad schematics sheets.

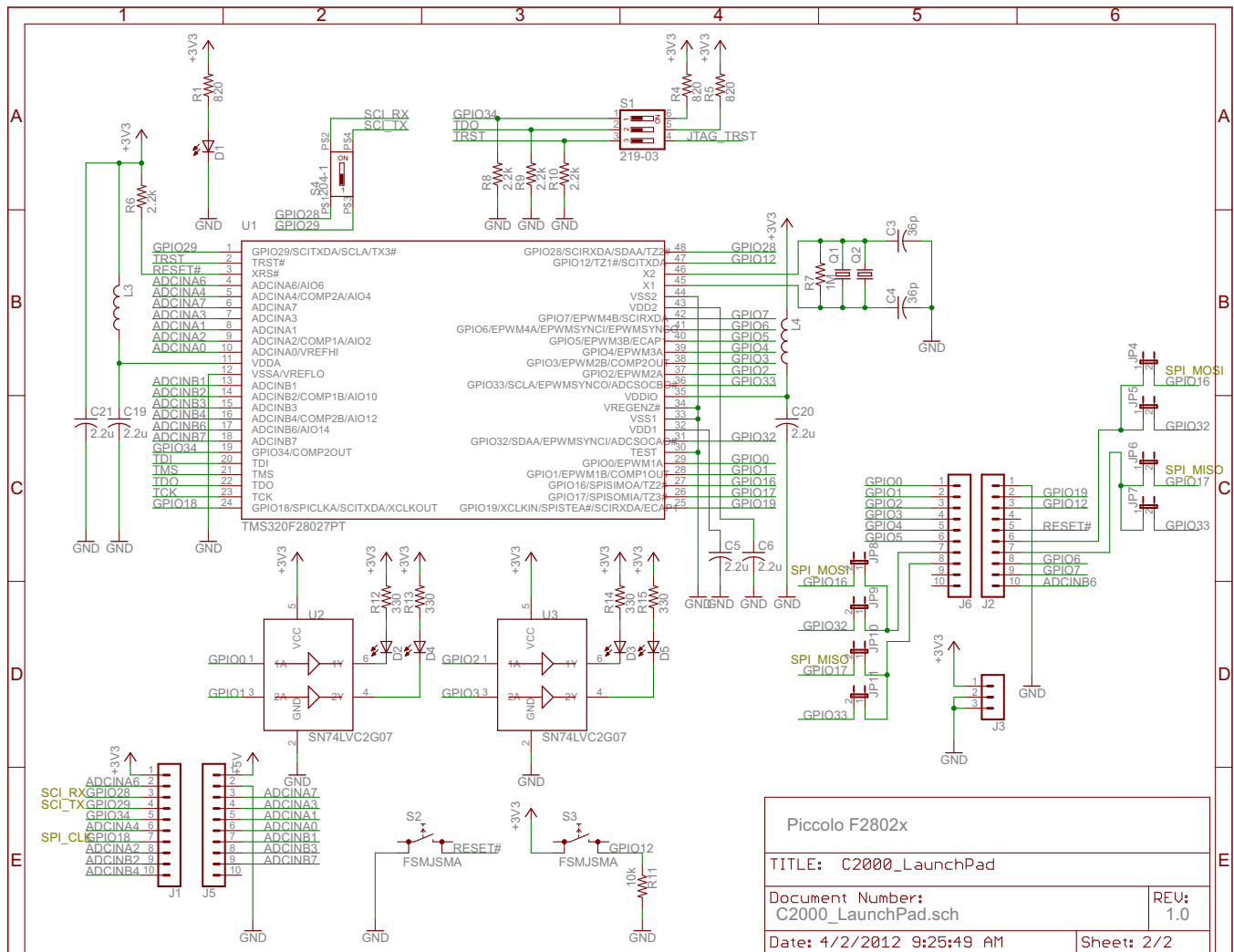**Figure 2. C2000 LaunchPad Schematic—Sheet 1 of 2**

Figure 3. C2000 LaunchPad Schematic—Sheet 2 of 2

5.3 PCB Layout

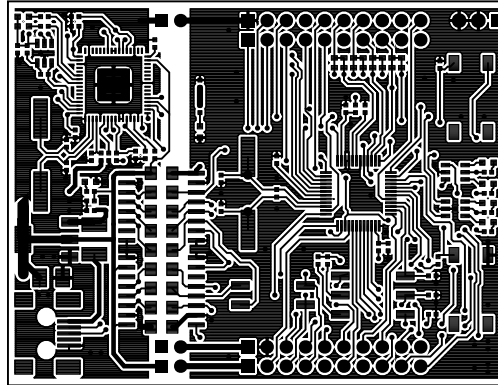Figure 4, Figure 5, and Figure 6 show the LAUNCHXL-F28027 PCB layout.

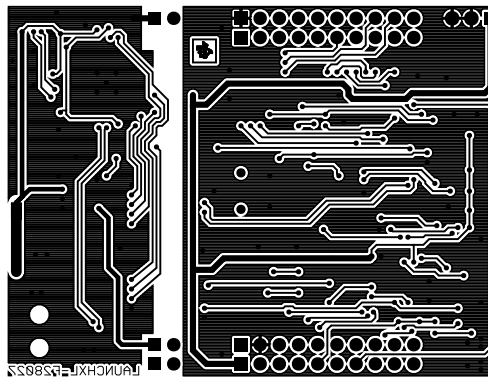**Figure 4. LAUNCHXL-F28027 PCB Layout—Top Layer**

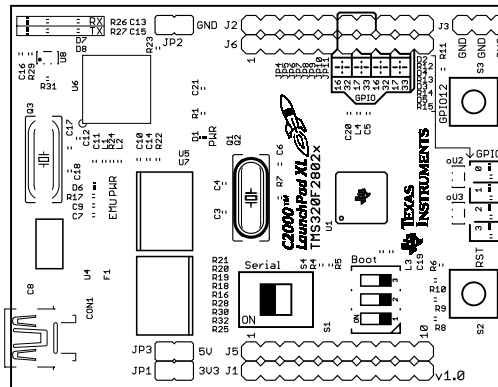**Figure 5. LAUNCHXL-F28027 PCB Layout—Bottom Layer**

Figure 6. LAUNCHXL-F28027 PCB Layout—Silkscreen Image

5.4 Bill of Materials (BOM)

Table 2 lists the LAUNCHXL-F28027 bill of materials.

Table 2. LAUNCHXL-F28027 Bill of Materials

Reference	Quantity per Board	Description
R12, R13, R14, R15, R26, R27	6	RES 330 Ω 1/10W 5% 0402 SMD
R1, R4, R5, R17	4	RES 820 Ω 1/10W 5% 0402 SMD
R22, R23	2	RES 1.0K Ω 1/10W 5% 0402 SMD
R6, R8, R9, R10, R31	5	RES 2.2K Ω 1/10W 5% 0402 SMD
R11, R29	2	RES 10K Ω 1/10W 5% 0402 SMD
R24	1	RES 12K Ω 1/16W .5% 0402 SMD
R7	1	RES 1.0M Ω 1/10W 5% 0402 SMD
R16, R18, R19, R20, R21, R25, R28, R30, R32	9	RES 0.0 Ω 1/4W 1206 SMD
L1, L2	2	FERRITE BEAD 600 Ω 0402
L3	1	FERRITE BEAD 220 Ω 0402
L4	1	FERRITE CHIP 60 Ω 1.5A 0402
C9, C12, C13, C14, C16	5	CAP .10 µF 16 V CERAMIC Y5V 0402
C7	1	CAP CER 1.0 µF 6.3 V X5R 20% 0402
C5, C6, C19, C20, C21	5	CAP CER 2.2 µF 6.3 V 20% X5R 0402
C15	1	CAP CER 3.3 µF 4.0 V X5R 0402
C10, C11	2	CAP CER 4.7 µF 4 V X5R 0402
C3, C4	2	CAP CER 36PF 50 V C0G 0402
C17, C18	2	CAP CER 36PF 50 V C0G 0402
C8	1	CAP TANTALUM 100 µF 6.3 V 10% SMD
F1	1	PTC RESETTABLE .50A 15 V 1812
S1	1	SWITCH DIP 3POS TOP SLIDE SMT
S4	1	SWITCH DIP DPST 1POS SMT
S2, S3	2	SW TACT SPST-NO MOM 160GF SMD
Q1, Q2	1	Crystal
Q3	1	CRYSTAL 12.0000 MHZ 18PF SMD
D6	1	LED RED HIGH BRIGHT ESS SMD
D1	1	LED GREEN HIGH BRIGHT ESS SMD
D2, D3, D4, D5, D7, D8	6	LED BLUE HIGH BRIGHT ESS SMD
JP1, JP2, JP3	3	BERGSTIK II .100" SR STRAIGHT
J1 and J5, J2 and J6	2	CONN HEADER .100 DUAL STR 20POS
J3	1	CONN HEADER .100 SNGL STR 3POS
CON1	1	CONN RECEPT MINI-USB TYPE B SMT
U4	1	IC LDO REG 800MA 3.3 V SOT223-4
U2, U3	2	IC BUFF/DVR DL NON-INV SOT236
U5	1	ISOLAT DGTL 2.5 KVRMS 4CH 16-SOIC
U7	1	ISOLAT DGTL 3 KVRMS 3CH 16-SOIC
U6	1	IC USB HS DUAL UART and FIFO 64-QFN
U8	1	IC EEPROM 2KBIT 3 MHZ SOT23-6
U1	1	IC MCU 32 BIT 64KB FLASH 48LQFP

6   Suggested Reading

The following documents describe the C2000 devices. Copies of these documents are available on the Internet at http://www.ti.com/c2000 and www.ti.com/c2000-launchpad, or click on the links below:

- *TMS320F28027/28026/28023/28022/28021/28020/280200 Piccolo Microcontrollers Data Manual* (SPRS523)
- *TMS320F28027/28026/28023/28022/28021/28020/2802x0 Piccolo MCU Silicon Errata* (SPRZ292)
- *TMS320x2802x, 2803x Piccolo Analog-to-Digital Converter (ADC) and Comparator Reference Guide* (SPRUGE5)
- *TMS320x2802x, 2803x Piccolo High Resolution Pulse Width Modulator (HRPWM) Reference Guide* (SPRUGE8)
- *TMS320x2802x, 2803x Piccolo Inter-Integrated Circuit (I2C) Reference Guide* (SPRUFZ9)
- *TMS320x2802x, 2803x Piccolo Enhanced Pulse Width Modulator (ePWM) Module Reference Guide* (SPRUGE9)
- *TMS320x2802x/TMS320F2802xx Piccolo System Control and Interrupts Reference Guide* (SPRUFN3)
- *TMS320x2802x Piccolo Boot ROM Reference Guide* (SPRUFN6)
- *TMS320x2802x, 2803x Piccolo Serial Communications Interface (SCI) Reference Guide* (SPRUGH1)
- *TMS320x2802x, 2803x Piccolo Enhanced Capture (eCAP) Module Reference Guide* (SPRUFZ8)
- *TMS320C28x Instruction Set Simulator Technical Overview* (SPRU608)
- *TMS320C28x Optimizing C/C++ Compiler v6.1 User's Guide* (SPRU514)
- *TMS320C28x Assembly Language Tools v6.1 User's Guide* (SPRU513)

7 Frequently Asked Questions (FAQ)

1. Can other programming and debug tools (such as an XDS510 emulator) be used with the C2000 LaunchPad?

   While a user could potentially connect an external emulator to the F28027 device present on the LaunchPad, it would require some rework of the board. It is recommended that users who want to use an external emulator purchase a controlCard and docking station that includes an external JTAG connector.

2. What versions of Code Composer Studio can be used to develop software for the C2000 LaunchPad?

   It is highly recommend that novice users develop applications with Code Composer Studio v5. The drivers, examples, and other associated software are tailored to make the user experience as smooth as possible in Code Composer Studio v5. However, there is nothing to prevent a user from creating projects in Code Composer Studio v3 or v4 with the source files available in controlSUITE. Keep in mind that all the projects for the C2000 LaunchPad are Code Composer Studio v5 projects and will not import into Code Composer Studio v3 or v4. Only expert users should attempt to use the LaunchPad with Code Composer Studio v3 or v4.

3. Why can't I connect to the LaunchPad in Code Composer Studio?

   There are a number of things that could cause this and they all have an easy fix.

   - Is S1 switch 3 in the down position?

     This is the TRST pin that enables and disables JTAG functionality on the chip. This switch must be in the up position for the emulator to be able to connect.

   - Are both power LEDs lit?

     The board has two power domains because of the isolated JTAG interface. For low-voltage application development, JTAG isolation is not needed and the power domains can be combined to allow for convenience (that is, the board can be powered completely through the USB). Ensure that jumpers are placed on the posts of JP1, JP2, and JP3.

   - Are drivers correctly installed for the XDS100v2 present on the LaunchPad?

     Right click on *My Computer* and select properties. Navigate to the *Hardware* tab in the dialog box and open the device manager. Scroll to the bottom of the list and expand the *USB Serial Bus controllers* item. Are there two entries for *TI XDS100 Channel A/B*? If not, try unplugging and replugging in the board. Does Windows give you any messages in the system tray? In Device Manger, do either of the entries have a yellow exclamation mark over their icon? If so, try reinstalling the drivers.

4. Why is the serial connection not working?

   There are a few things that could cause this and they are easy to fix.

   - Is S4 in the up position?

     S4 connects the F28027 device serial peripheral to the XDS100 serial port, so this switch must be turned on (up) for serial connectivity to function.

   - Are you using the correct COM port?

     Right click on *My Computer* and select properties. Navigate to the *Hardware* tab in the dialog box and open the device manager. Scroll to *Ports (COM & LPT)* and expand this entry. Is there a USB Serial Port listed? If so, read the COM number to the right of the entry; this is the COM number you should be using.

   - Are you using the correct baud rate?

     Most, if not all, of the examples are configured for a baud rate of 115200 when the CPU is running at 60 MHz. If you have changed the PLL settings or written your own application you may have to recalculate the baud rate for your specific application. For information on how to do this, see the *TMS320x2802x, 2803x Piccolo Serial Communications Interface (SCI) Reference Guide* (SPRUGH1).

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