User's Guide
C2000™ F28002x Series LaunchPad™ Development Kit

TEXAS INSTRUMENTS

ABSTRACT

The LAUNCHXL-F280025C is a low-cost development board for the Texas Instruments C2000™ Real-Time Microcontroller series of F28002x devices. It is designed around the TMS320F280025C real-time MCU and highlights the control, analog, and communications peripherals, as well as the integrated nonvolatile memory. The LaunchPad also features two independent BoosterPack XL expansion connectors (80-pins), on-board Controller Area Network (CAN) transceiver, two 5 V encoder interface (eQEP) connectors, FSI connector, and an on-board XDS110 debug probe.

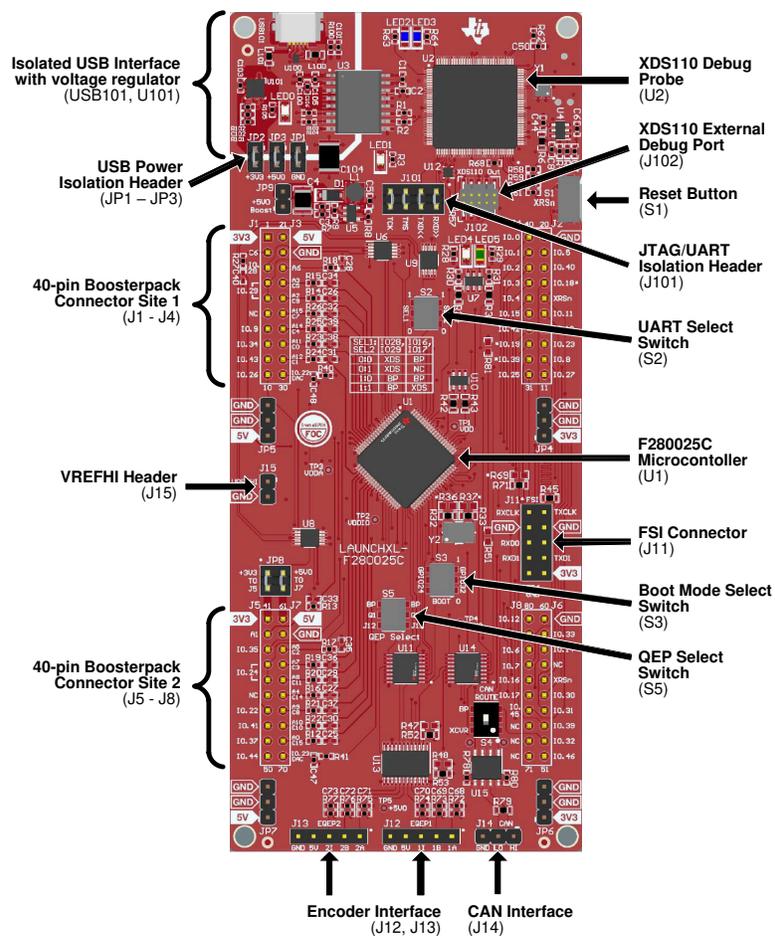Figure 1-1 highlights the key features of the F28002x LaunchPad.

Figure 1-1. F28002x LaunchPad Board Overview

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1 Board Overview

1.1 Kit Contents

The F28002x Series LaunchPad Development Kit contains these items:

- C2000 F28002x Series LaunchPad development board (LAUNCHXL-F280025C)
- USB micro-B plug to USB-A plug cable
- Quick Start Guide

1.2 Features

The F28002x LaunchPad has these features:

- C2000 Series F280025CPNS (80-pin) microcontroller:
    - With Configurable Logic Block (CLB) capability
- On-board XDS110 debug probe
- Two user-controlled LEDs
- One microcontroller reset switch
- Selectable power domains:
    - USB (isolated)
    - BoosterPack
    - External power supply
- CAN connector with on-board CAN transceiver
- Two independent Enhanced Quadrature Encoder Pulse (QEP)-based encoder connectors
- FSI peripheral connector
- Two independent BoosterPack XL standard connectors (80-pins) featuring stackable headers to maximize expansion through the BoosterPack ecosystem

1.3 Specifications

Table 1-1 summarizes the F28002x LaunchPad specifications.

Table 1-1. LAUNCHXL-F280025C Specifications

Parameter	Value
Board Supply Voltage	5 V_{DC} from one of the following sources: • USB Connector (USB101) - USB Micro-B cable connected to PC or other compatible power source. • BoosterPack 1 • BoosterPack 2 • Auxiliary power connectors
Dimensions	5.5 in x 2.3 in x .425 in (13.97 cm x 5.84 cm x 10.8 mm) (L x W x H)
Break-out Power Output	• Optional 5 V_{DC} to BoosterPacks, current limited by LMR62421. Nominal rating 2.1 Amps. Board input power supply limitations may also apply. • 3.3 V_{DC} to BoosterPacks, limited by output of TPS79601 LDO. This 3.3-V plane is shared with on-board components. Total output power limit of TPS79601 is 1 Amp.
Assumed Operating Conditions	This kit is assumed to run at standard room conditions. The EVM should run at approximately standard ambient temperature and pressure (SATP) with moderate-to-low humidity.

1.4 Using the F28002x LaunchPad

The recommended steps for using the F28002x LaunchPad are:

1. **Follow the instructions in Section 2.2 to begin running the LaunchPad demo program.** Within just a few minutes, you can control and monitor the F28002x LaunchPad with the pre-programmed quick start application. Additionally, the FAQ section included in this document can be helpful if there are any issues that might quickly be addressed.
2. **Experiment with BoosterPacks.** This development kit conforms to the latest revision of the BoosterPack pinout standard. It has two independent BoosterPack sites to enable a variety of expansion opportunities, such as two boosterpacks being used simultaneously. For more information about the TI LaunchPad and BoosterPack standard, see the TI LaunchPad web page at http://www.ti.com/launchpad.
3. **Take the first step towards developing your own control applications.** The F28002x LaunchPad is supported by the C2000Ware development package. After C2000Ware is installed, look for \f28002x \examples\launchxl_f280025c in the installation directory to find the pre-configured example applications for this board (to be added in first quarter 2021 C2000WARE release). Any of the other examples found within the \f28002x\examples directory can be used with minor modifications to run on the LaunchPad as well. For more details about software development, see Section 2.
   a. Check out this technical article featuring the F28002x Real-Time Microcontroller series about how developers can take advantage of the scalability and sustainability benefits these devices bring.
4. **Customize and integrate the hardware to align to your end application.** This development kit can be used as a reference for building your own custom boards and circuits based on C2000 F28002x series microcontrollers. The LaunchPad also functions as a foundation for expansion with custom BoosterPacks and other circuits. This document can serve as a starting point for such projects.
5. **Get Trained.** Review and download hours of written and video training materials on C2000 Real-time Microcontrollers and related LaunchPads. For more information, visit the C2000 Real-Time Control MCUs - Support & Training page.

1.5 BoosterPacks

The LAUNCHXL-F280025C provides a simple and inexpensive way to develop applications with the F28002x series microcontroller. BoosterPacks are pluggable add-on boards for the LaunchPad ecosystem 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 explore with the F28002x LaunchPad.

Some examples of BoosterPacks that are compatible with the F28002x LaunchPad are listed in Table 1-2. Please note that this is not an exhaustive list of supported BoosterPacks.

Table 1-2. Featured BoosterPacks for the F28002x LaunchPad

BoosterPack / Board	Application & Usage
BOOSTXL-3PHGANINV	Features a 48-V/10-A three-phase GaN inverter with precision in-line shunt-based phase current sensing for accurate control of precision drives such as servo drives.
BOOSTXL-DRV8323RS BOOSTXL-DRV8323RH	DRV8323RS/H Three-Phase, 15A smart gate driver with buck, shunt amps (SPI or Hardware Interface) Evaluation Module. Individual DC bus and phase voltage sense as well as individual low-side current shunt amplifiers, ideal for sensorless BLDC algorithms.

Table 1-2. Featured BoosterPacks for the F28002x LaunchPad (continued)

BoosterPack / Board	Application & Usage
TMDSFSIADAPEVM	FSI adapter board assists in understanding the functionality of the C2000's FSI communications peripheral. Enables evaluation of the peripheral for decentralized and point-to-point real-time control system use cases, such as those in industrial drives, servo, sensing networks, and solar system and industrial power.
BOOSTXL-BUCKCONV	Digital Power Buck Converter BoosterPack for learning the basics of digital power control with C2000 microcontrollers. The buck converter power stage supports dynamic loads and converts an external 9-VDC power supply to a configurable DC output voltage.
BOOSTXL-POSMGR	PositionManager BoosterPack is a flexible low voltage platform intended for evaluating interfaces to absolute encoders and analog sensors like resolvers and SinCos transducers.
BOOSTXL-SHARP128	Sharp® 128x128 Memory LCD and microSD Card BoosterPack, controlled using SPI. Display sensor readings, time, graphics, or other information using the LCD screen.

Note

Software support for the BoosterPacks and boards listed will vary.

Users can also design their own BoosterPacks for the F28002x LaunchPad. Ensure that compatbility requirements are met by referencing the signal pinout in the LAUNCHXL-F280025C Quick Start Guide (SPRUIW5) or schematic.

1.6 Hardware Revisions

This section contains an abbreviated revision history of the LAUNCHXL-F280025C as well as known issues with each revision.

1.6.1 Revision A

The first production revision of the LAUNCHXL-F280025C was released in December 2020. This revision can be identified by the "MCU089A" silkscreen labeling on the back side of the EVM between the BoosterPack Connector site 1 towards the top of the board.

Issues and concerns that have been identified on the EVM are listed below:

Known issues:

• No issues to report at this time of initial release.

Special notes and considerations to be aware of:

• Nothing to report at this time of initial release.

2 Software Development

This section provides general information about software development, as well as instructions for programming the LaunchPad. Software tools and packages for C2000 real-time controllers, like the F28002x, are listed in the C2000 Design and Development page.

2.1 Software Tools and Packages

Code Composer Studio (CCS) is a free integrated development environment (IDE) that supports TI's Microcontroller and Embedded Processors portfolio. CCS provides a feature rich environment for developing, programming, and debugging code on the C2000 family of MCUs.

C2000WARE is a repository of device-specific drivers, bit-field support files, libraries, peripheral examples, utilities, hardware files, and documentation for C2000 MCUs. C2000WARE provides a solid foundation to begin development and evaluation of the F28002x device on the LAUNCHXL-F280025C and minimize software development time.

Software Development Kits (SDKs) are provided to make it easy to evaluate C2000 MCUs within specific system use cases and reduce overall development time. The Motor Control SDK (C2000WARE-MOTORCONTROL-SDK) is targeted for various three-phase motor control applications, such as industrial drives and servo topologies. The Digital Power SDK (C2000WARE-DIGITALPOWER-SDK) is targeted for digital power system development for various AC-DC, DC-DC and DC-AC power supply applications.

2.2 F28002x LaunchPad Demo Program

The LAUNCHXL-F280025C includes a TMSF280025CPNS device pre-programmed with a demo program. When the LaunchPad is powered on the demo program begins with an LED blink sequence on LED4 and LED5. After a few seconds the device switches into an ADC sampling mode.

Every 1 second the ADC samples pin ADCINA6 and the sampled value is represented as follows: If the sample is above mid-scale (2048), the red LED4 will illuminate. If the sample is below mid-scale, the green LED5 will illuminate.

In addition to the LED indicators, ADC sample results are also displayed on your PC through the USB/UART connection. To view the UART information on your PC, first determine the COM port associated with the LaunchPad. To do this in Windows open the *Device Manager*. Look for an entry under Ports (COM & LPT) titled "XDS110 Class Application/User UART (COM*X*)", where *X* is a number. Remember this number for when you open a serial terminal.
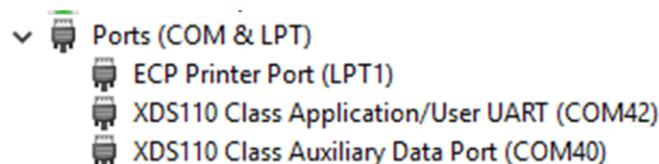

Figure 2-1. LaunchPad XDS110 COM Port

The demo application's UART data was tested using PuTTY, which is a free and open-source terminal emulator. To view the UART data in a serial terminal program open the COM port found using the Windows *Device Manager* with the following settings.

```
115200 Baud, 8 data bits, no parity, 1 stop bit.
```

After properly opening the serial port in your serial terminal, reset the LaunchPad by pressing the S1 reset button and observe the serial terminal to see the TI logo in ASCII art.
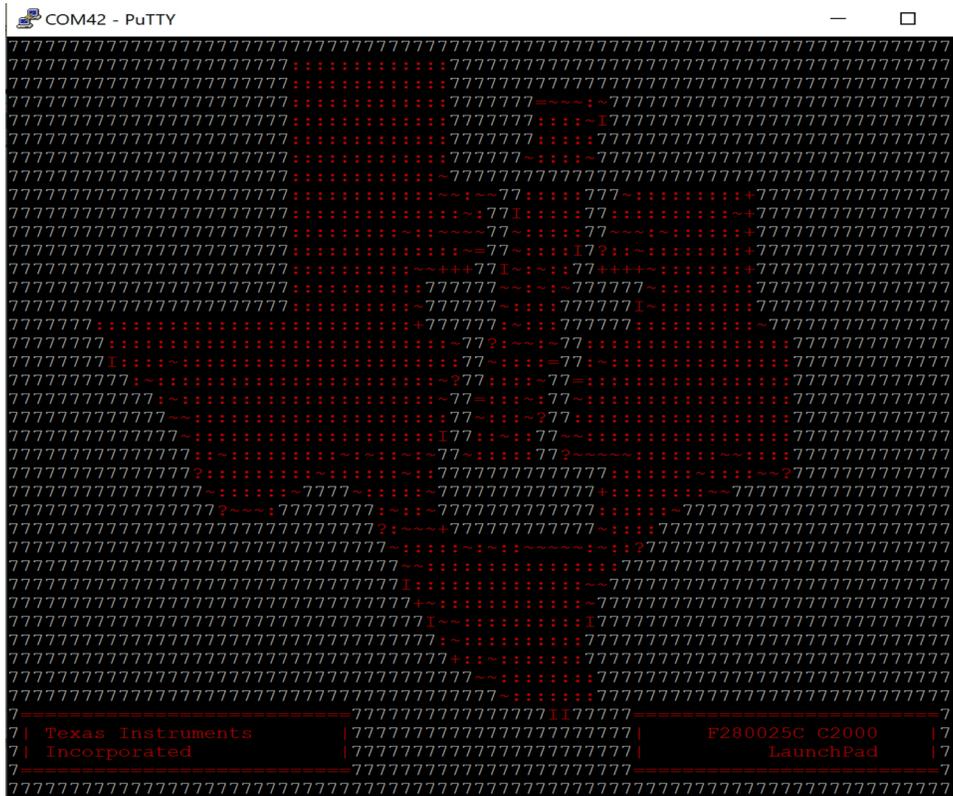
Figure 2-2. LaunchPad Demo Serial Terminal - TI Logo

After a few moments the ADC value sampled on the ADCINA6 pin will appear in the bottom right corner of the terminal and be updated each second. Jumper the ADCINA6 header to a 3.3V, GND, or other 0-3.3V signal header to see the on-screen value change.

Figure 2-3. LaunchPad Demo Serial Terminal - ADC Sampling

2.3 Programming and Running Other Software on the F28002x LaunchPad

The software packages described in Section 2.1 include example projects that can be loaded and run on the F28002x LaunchPad. If you installed the C2000WARE software to the default installation path of *C:\ti \c2000\C2000Ware_<version>*, you can find driverLib based example applications in *C:\ti \c2000\C2000Ware_<version>\examples\f28002x*. The on-board XDS110 is used with the On-Chip Flash Programmer tool to program applications to the F28002x LaunchPad.

Follow these steps to program example applications onto the F28002x LaunchPad development kit using the on-board XDS110 debug probe:

1. Install Code Composer Studio (CCS) on a PC running Microsoft Windows.
2. Connect the USB-A cable plug in to an available USB port on the PC and plug the Micro-B plug to the port (USB101) on the F28002x LaunchPad.
3. Verify that LED0, at the top of the board is illuminated indicating USB power as well as LED1, which indicates the target and debugger are powered.
4. Install Windows XDS110 and Virtual COM Port drivers if prompted. Installation instructions can be found at XDS110 Product Page.
5. Run CCS on the PC.

6. Import a F28002x project from C2000WARE, or another installed software package, into the CCS workspace.

7. Add the *_LAUNCHXL_F280025C* predefined symbol to the imported DriverLib example project in order for the software to use relevant F28002x LaunchPad signals.

   a. Open the projects Properties → Expand the *Build* tab → Expand the *C2000 Compiler* tab → Select *Predefined Symbol* → Add *_LAUNCHXL_F280025C* pre-define NAME

8. Right click the project name and select *Rebuild Project* in CCS*.*

9. Launch the LAUNCHXL-F280025C Target Configuration file and connect to the F28002x device. Ensure that the Target Configuration file is configured to use the 2-pin cJTAG advanced configuration. See FAQ section for additional details.

10. Click 'Load Program' and select the program's binary to load. The binary will be loaded onto the device and can now be run and debugged.

3 Hardware Description

The F28002x LaunchPad includes a F280025CPNS MCU. This MCU is well suited for advanced real-time control systems in cost-sensitive applications. A large number of these peripherals are made available to users via the on-board accessories and the BoosterPack connectors. This section explains how those peripherals operate and interface to the MCU

Figure 3-1 shows a high-level block diagram of the F28002x LaunchPad:
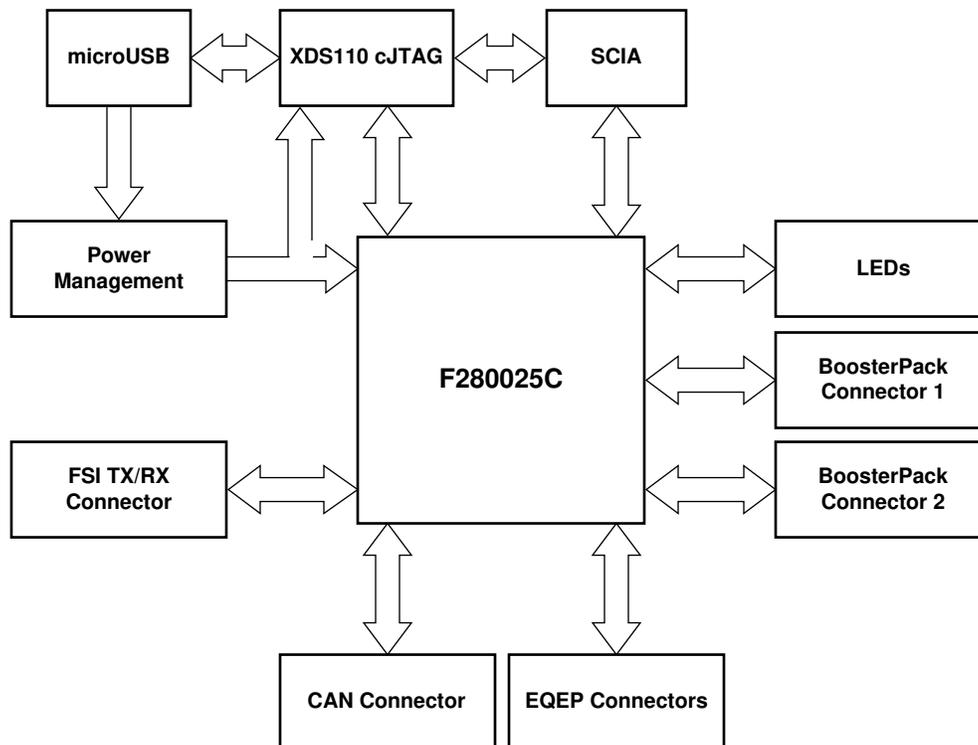

Figure 3-1. Piccolo F28002x LaunchPad Development Kit Block Diagram

3.1 Functional Description and Connections

3.1.1 Microcontroller

The TMS320F280025CPNS is a 32-bit floating-point microcontroller with 128KB Flash memory, 24KB RAM, and operates at 100 MHz. It includes advanced control peripherals, differentiated analog, and various communications peripherals. The device has been optimized for high-performance, real-time control applications and offers a low-cost system solution. For more details, see the *TMS320F28002x microcontrollers datasheet*.

Most of the microcontroller's signals are routed to 0.1 inch (2.54 mm) pitch headers laid out to comply with the TI BoosterPack standards with a few exceptions. The F28002x MCU's internal multiplexer allows different peripheral functions to be assigned to each of the General-Purpose Input/Output (GPIO) pins. The multiplexing options can be found in the device-specific data sheet. When adding external circuitry, consider the additional load on the development board's power rails.

The F28002x LaunchPad is factory-programmed with a quick start demo program. The quick start program resides in the on-chip Flash memory and executes each time power is applied, unless the application has been replaced with a user program. See **Section 2.2** for details on the LaunchPad's demo program.

3.1.2 LEDs

Two power indicator LEDs are included on the board: LED0 indicates when the 3.3 V is available on the USB side of the isolation barrier and LED1 indicates when 3.3 V is available on the device side of the isolation. LED1 indicates that there is power supplied to the F28002x device as well as the XDS110 debugger.

Two user LEDs are provided on the board: LED4 (red) and LED5 (green). These user LEDs are connected to GPIO31 and GPIO34 of the F280025C, respectively. The signals are connected to the SN74LVC2G07DBVR LED driver IC and are connected in an active low configuration; that is, drive the GPIO low to turn on the LED and high to turn it off. These LEDs are dedicated for use by the software application.

Two blue LEDs, LED2 and LED3, are connected to the XDS110 debug probe. These indicate debugger activity and are not controllable by any application software.

3.1.3 Encoder Connectors

The F28002x LaunchPad includes two headers, J12 and J13, which are used for connecting linear or rotary incremental encoders. These headers take 5 V signals that are stepped down to 3.3 V and wired to the F280025C MCU. These signals are connected to the eQEP modules on the device when switch S5 is set appropriately, see Table 3-3. Each header has the EQEPA, EQEPB, and EQEPI signals available for each eQEP module (1 and 2) as well as pins for GND and 5 V.

3.1.4 FSI

The F28002x MCU features the Fast Serial Interface (FSI) communications peripheral. The FSI enables robust high-speed communications and is intended to increase the amount of information transmitted while reducing the cost to communicate over an isolation barrier. The FSI signals TXCLK, TXD0, TXD1, RXCLK, RXD0, and RXD1 are available on J11. This header is set up in such a way that adding jumpers on the pins will connect the TX to RX channels for external loopback and evaluation. Additionally, there are two GND signals on the connector that can be used for a wrapped-pair connection to an external board with FSI. The GPIOs connected to this header are also routed to the BoosterPack connectors through 0Ω resistors. As the FSI can toggle at up to 100 MHz rates, the longer traces to the BoosterPack headers can create unintentional noise on the signal due to reflection. Eliminating these extended traces by removing the in-circuit resistors will help to limit any noise or reflections.

The LAUNCHXL-F280025C does not include any on-board isolation devices for the FSI signals. If interested in evaluating the FSI peripheral with isolation devices, or differential drivers/receivers, please see the TMDSFSIADAPEVM plug on board.

3.1.5 CAN

The F28002x LaunchPad includes a connector for a CAN network through J14. GPIO32 and GPIO33 are routed from the F280025CPNS to J14 through the on-board CAN Transceiver. Switch S4 is used to route GPIO32 and GPIO33 to either the CAN transceiver and connector or the boosterpack headers, see Section 3.3.4.

3.1.6 CLB

The configurable logic block (CLB) is a collection of blocks that can be interconnected using software to implement custon digital logic functions or enhance existing on-chip peripherals. The CLB is able to enhance existing peripherals through a set of crossbar interconnections, which provide a high level of connectivity to existing control peripherals such as enhanced pulse width modulators (ePWM), enhanced capture modules (eCAP), and enhanced quadrature encoder pulse modules (eQEP). The crossbars also allow the CLB to be connected to other internal peripheral signals of the device or external GPIO pins. In this way, the CLB can be configured to perform small logical functions to augment device peripheral inputs and outputs. Through the CLB, functions that would otherwise be accomplished using external logic devices, such as FPGAs or CPLDs, can now be implemented inside the C2000 MCU.

For more information on the CLB see the C2000™ Configurable Logic Block (CLB) training series.

3.1.7 Boot Modes

The F280025C boot ROM contains bootloading software that executes every time the device is powered on or reset. Two pins, GPIO24 and GPIO32, are wired to the Boot Select switch (S3). By default, both pins are set

HIGH (1) so the device will boot from Flash. For more information on the F28002x boot modes, see the [TMS320F28002x microcontrollers datasheet](link).

Table 3-1. Boot Select Switch Table - S3

BOOT MODE	GPIO24 (LEFT)	GPIO32 (RIGHT)
Boot from Parallel GPIO	0	0
Boot from SCI / Wait boot	0	1
Boot from CAN	1	0
Boot from Flash (default)	1	1

3.1.8 BoosterPack Headers

See the [LAUNCHXL-F280025C Quick Start Guide (SPRUIW5)](link) for the BoosterPack headers signal mapping.

3.1.8.1 BoosterPack Sites

The F28002x LaunchPad features two fully independent BoosterPack XL connectors. BoosterPack site #1, located above the F28002x MCU and below the XDS110 debugger, is compliant with the BoosterPack standard. BoosterPack site #2, located under the F28002x MCU, is compliant with the BoosterPack standard as well, but with less signals available on the pins. To expand the functions available to the user on this LaunchPad, some signals are also routed to alternate locations on the board. These alternate routes can be selected by manipulating the onboard switches or by adding or removing 0 Ω resistors. This is described in [Section 3.3](link).

The GPIO pin numbers as well as the BoosterPack compliant features can be viewed in the [LAUNCHXL-F280025C Quick Start Guide (SPRUIW5)](link). Each GPIO has multiple functions available through the F28002x device's GPIO mux. Some specific functions have been listed in the Quick Start Guide; the full GPIO mux table can be found in the [TMS320F28002x microcontrollers datasheet](link).

All of the analog signals (denoted ADCIN) of the F28002x MCU are routed to the J1/J3 and J5/J7 BoosterPack headers on the left side of the board. Close to the respective BoosterPack header each ADC input signal has component pads for a series resistor and parallel capacitor to create an RC filter. By default a 0 ohm resistor is populated and the capacitor is left un-populated. Users may wish to populate these components with specific values in order to filter out noise arriving at the device's ADC input.

3.1.9 Analog Voltage Reference Header

The analog subsystem of the F28002x allows for flexible voltage reference sources. The ADC modules are referenced to the VREFHIx and VREFLOx pin voltages. VREFHIx can either be driven externally or can be generated by an internal bandgap voltage reference. An external voltage can be supplied to header J15 as an external voltage source for VREFHIx. Note that there is no signal conditioning circuitry in place for the voltage reference. For best performance, some additional circuitry may be required.

3.1.10 Other Headers and Jumpers

The LaunchPad has multiple jumpers to select different power sources for the board. This LaunchPad also provides a way to isolate the connected USB from the device, allowing for safe operation and debugging in higher voltage applications.

3.1.10.1 USB Isolation Block

JP1, JP2, and JP3 are provided to enable isolation between the device and the connected USB in high-voltage applications. The area of isolation is defined by the white outline in the upper-left corner of the LaunchPad. JP1 separates the GND of USB region and the MCU region of the LaunchPad. JP2 separates 3.3 V, and JP3 separates 5 V. By default, all three jumpers are shorted and the power is supplied by the connected USB, meaning that the USB is NOT isolated from the MCU region. If power isolation is desired, remove the supplied shunts from JP1, JP2, and JP3. In this configuration, a 3.3 V supply must be connected to the MCU region to power the F280025C MCU and the other on-board circuitry, including the XDS110 debug probe. Some applications may not require 5 V to be supplied to the MCU region. In an isolated power application with JP3 removed, supplying 5 V to the MCU region is optional.

3.1.10.2 BoosterPack Site 2 Power Isolation

JP8 is included to isolate 3.3 V and 5 V from the BoosterPack site 2 headers. This might be required if two BoosterPacks are simultaneously connected to the LaunchPad and both provide power to the LaunchPad. If this is the case, power can be isolated by removing the shunts on JP8 and there will be no contention between the two BoosterPacks.

3.1.10.3 Alternate Power

Additional jumpers are provided outside of the BoosterPack connector for additional external power connections for 3.3 V or 5 V. These can be used to supply an external board or for powering the LaunchPad with an external supply. When using these connection points, ensure that no other power supplies are connected.

JP4 and JP6 are provided as extra connection points for a 3.3 V supply to be connected to the LaunchPad.

JP5 and JP7 are provided as extra connection points for a 5 V supply to be connected to the LaunchPad.

3.1.10.4 5 V Step-up Converter

JP9 isolates the output of the LMR62421 Simple Switcher step-up voltage regulator(U3) from the 5 V power domain of the LaunchPad. This voltage regulator can step up 3.3 V to 5 V if no other 5 V supply is connected. Do not place a shunt on J9 unless JP3 is open and no other 5 V supply is connected to the LaunchPad.

3.2 Debug Interface

3.2.1 XDS110 Debug Probe

The F28002x LaunchPad includes an on-board XDS110 Debug Probe. The XDS110 allows for the programming and debugging of the F280025C using Code Composer Studio (CCS), or any other supported tool chains. In the current configuration, the XDS110 is only wired to support 2-pin cJTAG mode. This uses only the TMS and TCK JTAG pins and allows for TDI and TDO to be reallocated for application needs. TDI and TDO are available on GPIO35 and GPIO37. Though these pins are not routed to the debug probe, by default, they are available at the BoosterPack connector.

3.2.2 XDS110 Output

The connector J102 is provided to debug an external target with the on-board XDS110 debug probe. This connector allows the LaunchPad to be used as a stand-alone XDS110 debug probe. If the LaunchPad is being used in this manner, ensure that all of the jumpers are removed from J101. This isolates the JTAG signals from going to the F280025C MCU.

3.2.3 Virtual COM Port

When plugged into a USB host, the XDS110 enumerates as both a debugger and a virtual COM port. J101 allows the user to connect the SCI UART from the F280025C to the debug probe to be passed on to the USB host. By default, SCIA maps to the virtual COM port of the XDS110 using GPIO28 and GPIO29. Alternately, GPIO16 and GPIO17 can be used for SCIA. This is accomplished by manipulating the on-board switch S2. For the appropriate switch settings, see Section 3.3.2.

3.3 Alternate Routing

3.3.1 Overview

The F280025C MCU is a very versatile device in a small package. To balance compatibility with BoosterPack standards, as well as showcasing the versatility of the F280025C, some complexity was added to the design. Most features aligning with the BoosterPack standard are available by default. The additional functions are configured using switches or static resistors which can be added or removed. This section covers the alternate functions and how to enable them. Note that by enabling certain alternate features, standard BoosterPack functionality may be lost. The switches are configured such that it is not possible to connect multiple functions to the same header.

3.3.2 UART Routing

This LaunchPad allows for one of two sets of pins to be used for the SCIA UART routed to the virtual COM port of the XDS110. By default, GPIO28 (SCIA_RX) and GPIO29 (SCIA_TX) are routed to the virtual COM port and not available on the BoosterPack connector. Alternately, GPIO16 (SCIA_TX) and GPIO17 (SCIA_RX) can be

routed to the virtual COM port. When UART functionality is not needed at the virtual COM port, the GPIOs can be routed to the BoosterPack connectors for BoosterPack standard functions. The routing destination of these signal pairs are selected using the on-board switch S2, as described below in Table 3-2.

Table 3-2. SCI UART Select Table - S2

SEL1 (LEFT)	SEL2 (RIGHT)	GPIO28/29	GPIO16/17
0	0	XDS110 COM Port	BP Headers
0	1	XDS110 COM Port	No Connect
1	0	BP Headers	BP Headers
1	1	BP Headers	XDS110 COM Port

3.3.3 EQEP Routing

The LaunchPad has the ability to connect to two independent linear or rotary encoders through the F28002x on-chip eQEP interfaces: Header J12 is connected to eQEP1 and header J13 is connected to eQEP2. By default, this connection is not active and the GPIOs are routed to the BoosterPack connectors. The eQEP signals are routed through TI SN74LV4053A Triple 2-Channel Analog Multiplexer/Demultiplexer ICs (U11/U14). Once the eQEP signals have been selected through U11/U14, the 3.3 V signals are stepped up through a TI SN74LVC8T245 Level Translator (U13) to 5 V at the connectors. Switch S5 controls the select inputs of the ICs to configure the eQEP signal destinations to be either the J12/J13 connectors or BoosterPack headers, as described below in Table 3-3.

Table 3-3. QEP Select Table - S5

QEP1 SEL (LEFT)	QEP2 SEL (RIGHT)	QEP1 Signals (GPIO44/37/43)	QEP2 Signals (GPIO14/25/26)
0 (down)	0 (down)	J12	J13
0 (down)	1 (up)	J12	BP Headers
1 (up)	0 (down)	BP Headers	J13
1 (up)	1 (up)	BP Headers	BP Headers

3.3.4 CAN Routing

The LaunchPad can be connected to a CAN bus through J14. GPIO32 and GPIO33 are routed to the on-board TI SN65HVD234 3.3 V CAN Transceiver, U15. By setting S4 to DOWN (on), GPIO32 and GPIO33 are routed to the transceiver. If S4 is set to UP (off), the GPIOs are routed to the BoosterPack connectors. Note that GPIO32 is also a boot mode select pin of the F28002x device and may be pulled up or down, see Section 3.1.7.

3.3.5 FSI Routing

One set of GPIOs with available FSI functionality are directly connected to both the BoosterPack connectors as well as the FSI header, J11. To simplify the layout of the LaunchPad, 0-Ω resistors are placed on the signal trace to remove the BoosterPack Connection from the circuit. The mapping between the GPIOs, the resistors, and the FSI signals are listed in Table 3-4.

Table 3-4. FSI to BoosterPack Isolation Resistors

GPIO	Resistor	FSI Signal
GPIO46	R54	FSITXA_D1
GPIO6	R49	FSITXA_D0
GPIO7	R45	FSITXA_CLK
GPIO41	R55	FSIRXA_D1
GPIO12	R50	FSIRXA_D0
GPIO13	R44	FSIRXA_CLK

3.3.6 X1/X2 Routing

The F280025C crystal oscillator output signal, X2, is multiplexed with GPIO18 and the crystal oscillator input, X1, is multiplexed with GPIO19. By default, the Launchpad uses an on-board crystal oscillator, Y2, as the clock source for the on-chip Phase-Locked Loop (PLL) that requires both X1 and X2 signals of the MCU. To balance the requirement of having cleanly routed oscillator signals and bringing all possible GPIOs to the BoosterPack connectors, both GPIO18/X2 and GPIO19/X1 can be routed to the BoosterPack connectors through 0 Ω resistors. If GPIO18 or GPIO19 are needed at the BoosterPack connectors, the on-chip zero-pin oscillators must be used as the clock source for the on-chip PLL. For more information on the X1/X2 configurations, see the *TMS320F28002x microcontrollers datasheet*.

If GPIO18 functionality is needed at the BoosterPack Connector:

1. Remove R32 to separate GPIO18 from Y2.
2. Populate R36 to connect GPIO18 to the BoosterPack connector

If GPIO19 functionality is needed at the BoosterPack Connector:

1. Remove R33 to separate GPIO19 from Y2.
2. Populate R37 to connect GPIO19 to the BoosterPack connector

3.3.7 PWM DAC

The LaunchPad provides two PWM DAC signals at the BoosterPack headers using GPIO22 (BP pin 30) and GPIO23 (BP pin 70) buffered outputs through U10. The intended purpose of the PWM DAC signals are to utilize PWMs of the F28002x device as digitial-to-analog converters (DAC). This method involves low-pass filtering the PWM signal to remove its high-frequency components and ideally leave only the DC component. Please see the Using PWM as a DAC application report for more information.

By default GPIO22 and GPIO23 are connected to the U10 dual buffer through 0 ohm resistors R42 and R43 for the PWM DAC outputs. These resistors can be removed to disconnect the signals from U10 and PWM DAC pins as needed.

3.3.8 Other GPIOs

By default GPIO39 is routed to pin 53 of BoosterPack header J8/J6. Alternatively, GPIO39 can be routed to pin 32 of BoosterPack header J4/J2 by populating 0 ohm resistor R69. R71 can then be removed to isolate the signal from the J8/J6 header if desired.

4 Board Design

The entire LAUNCHXL-F280025C design files can be downloaded at this link: https://www.ti.com/lit/zip/SPRR426.

4.1 Schematic

This section contains the complete schematics for the F28002x LaunchPad, as shown in Figure 4-1 to Figure 4-5. Additionally, the LaunchPad's schematic can be found at this link: https://www.ti.com/lit/sprr425.
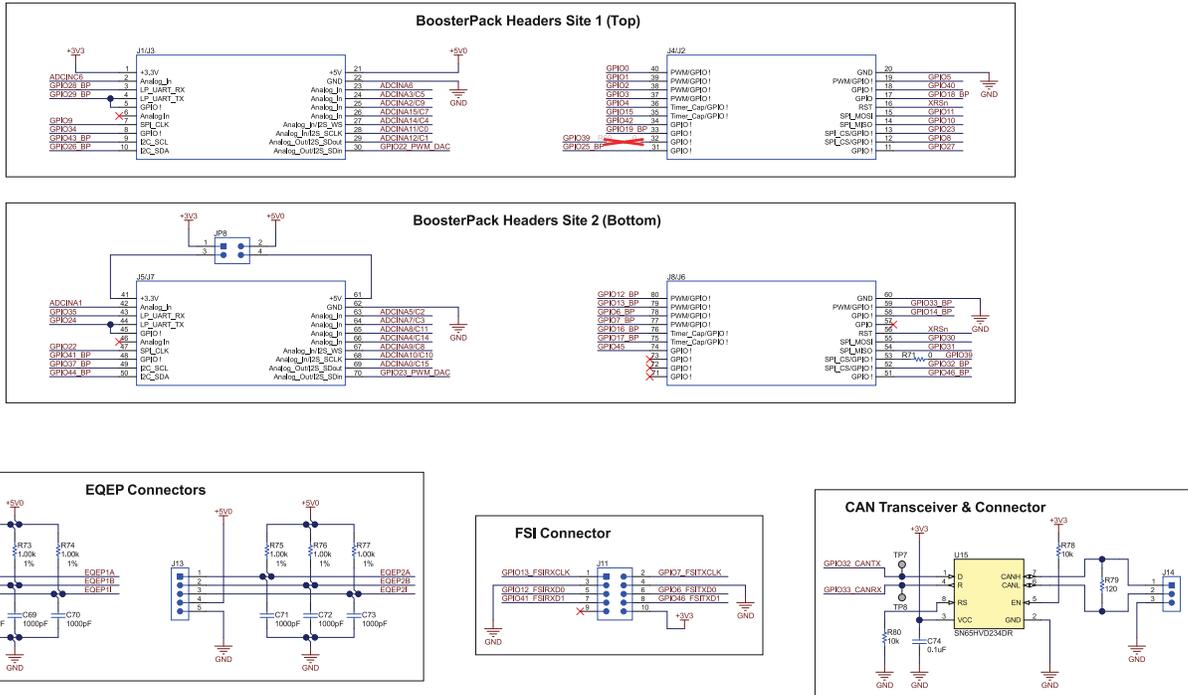

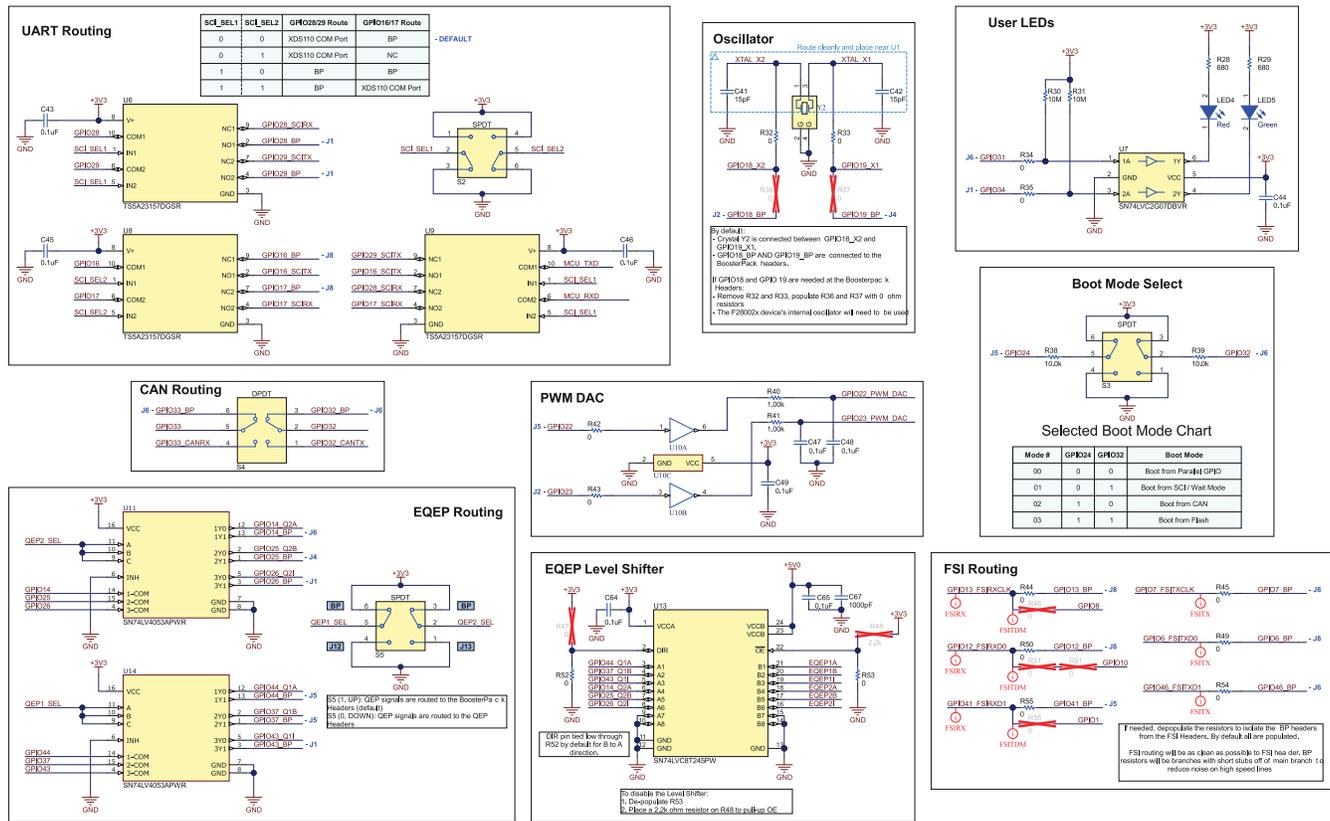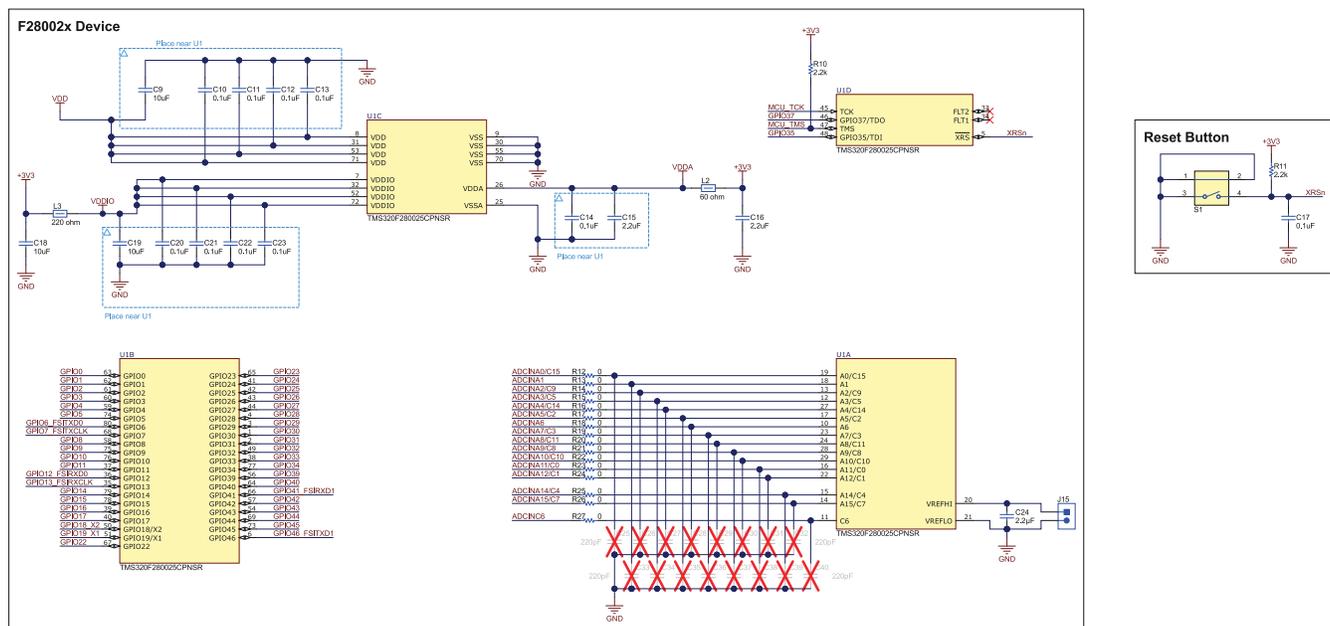**Figure 4-1. MCU089A_Connectors.SchDoc**

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Figure 4-2. MCU089A_AltRouting_Misc.SchDoc

Figure 4-3. MCU089A_F280025C_Device.SchDoc
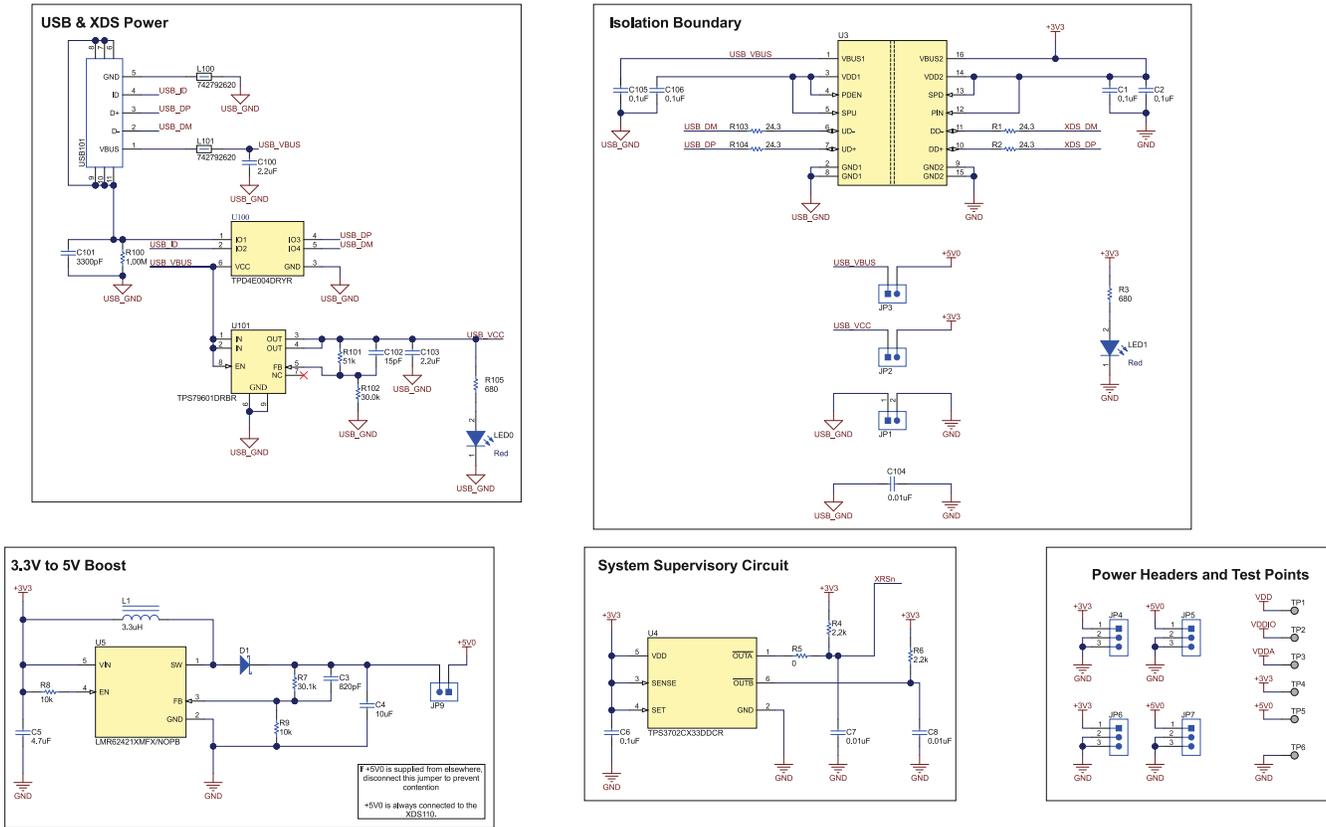
Figure 4-4. MCU089A_XDS110_USB_Power.SchDoc
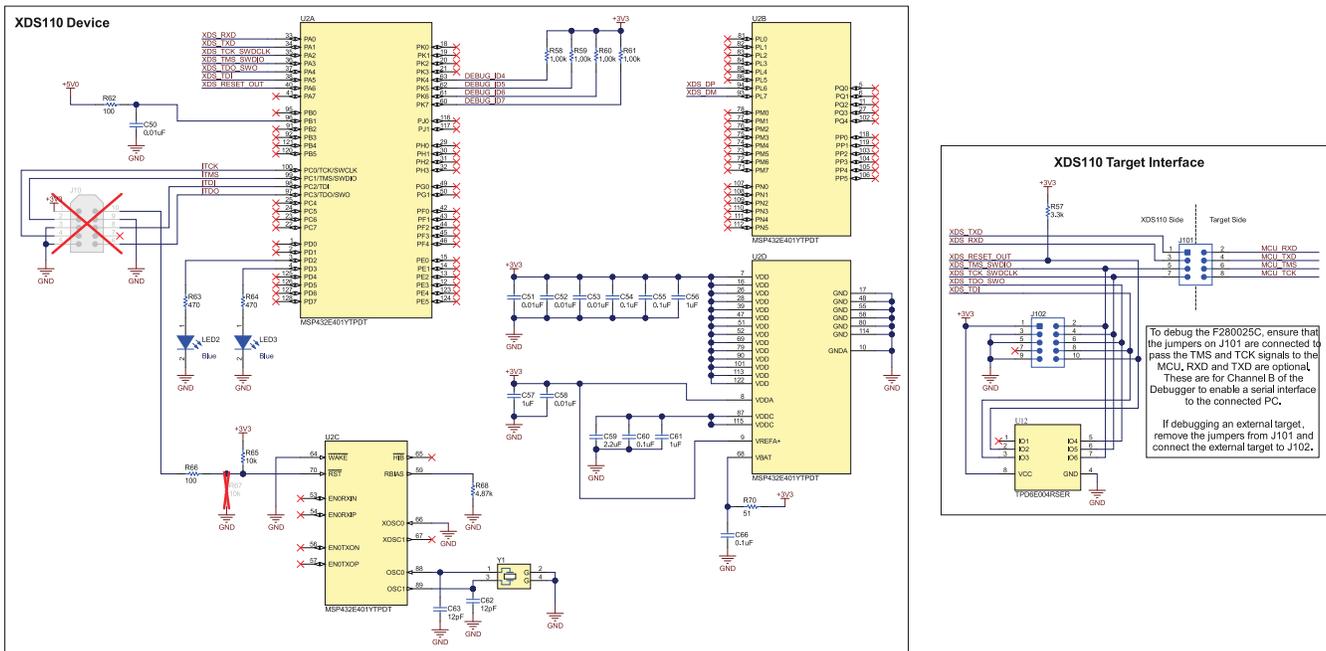
Figure 4-5. MCU089A_XDS110_MCU.SchDoc

4.2 PCB Layout

The layout source files for the LAUNCHXL-F280025C are included in the design files download https://www.ti.com/lit/zip/SPRR426.
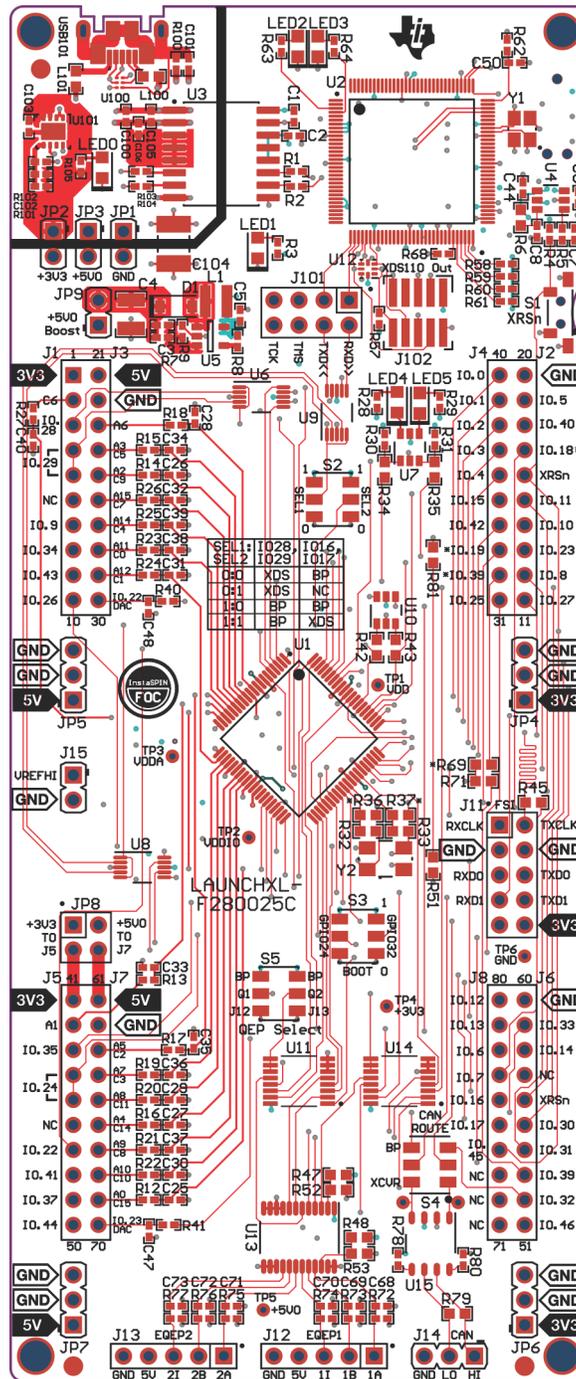
Figure 4-6. Top Signal - Layer 1
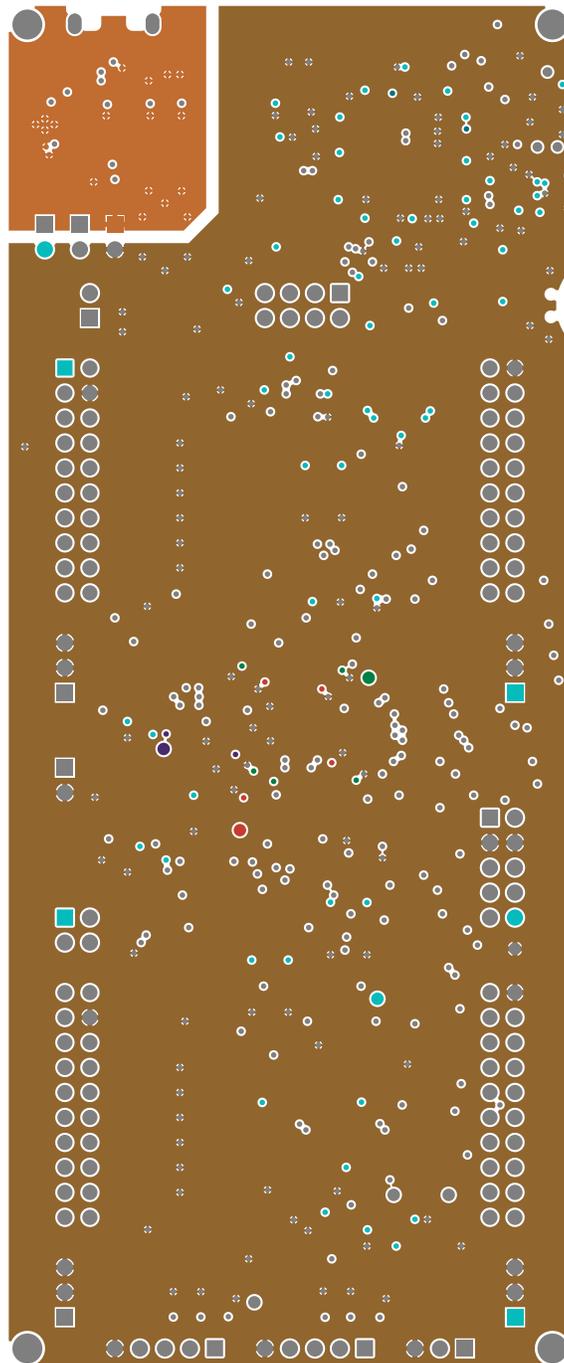
Figure 4-7. GND - Layer 2
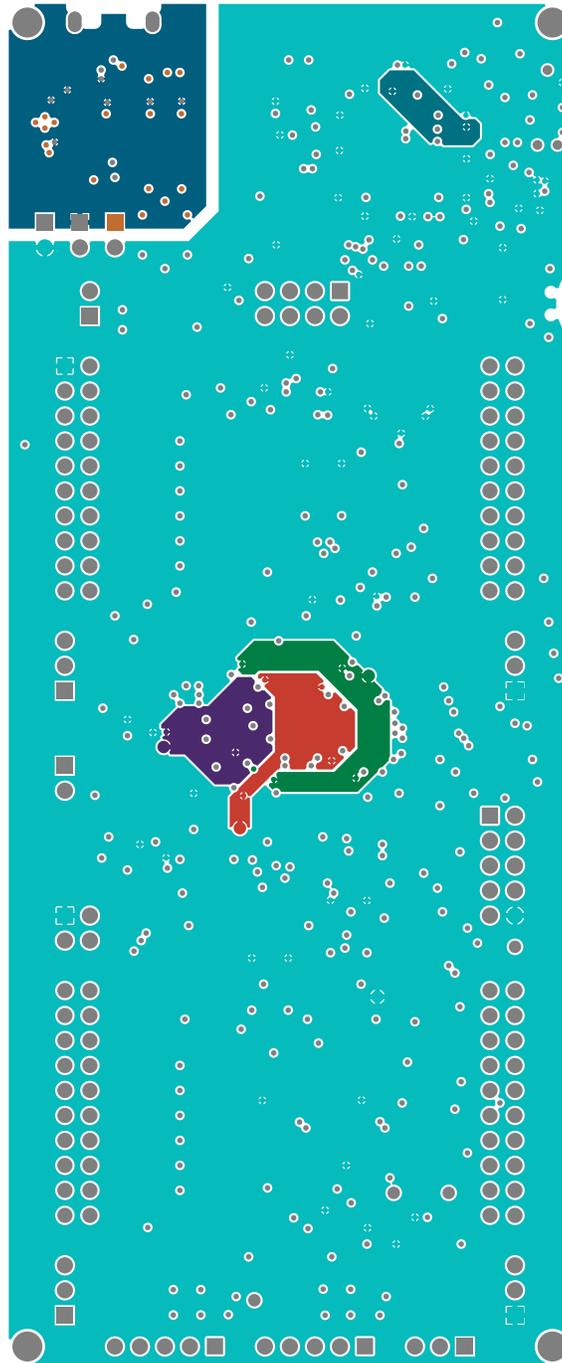
Figure 4-8. PWR - Layer 3
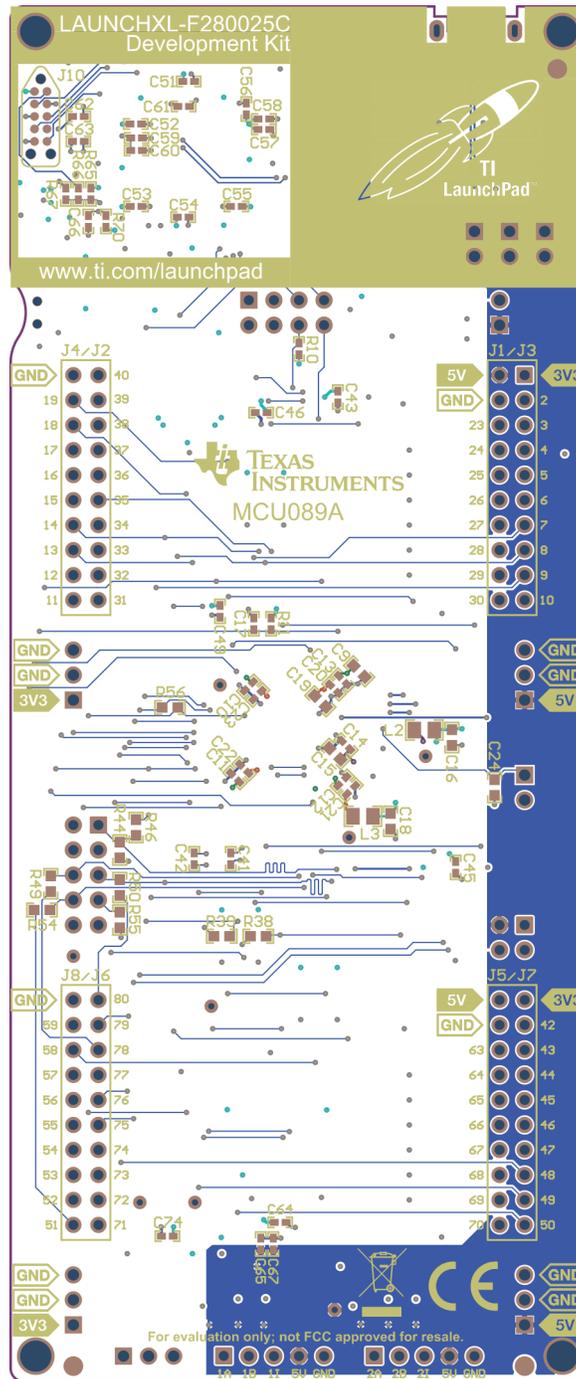
Figure 4-9. Bottom Signal - Layer 4

4.3 BOM

The BOM for the LAUNCHXL-F280025C is included in the design files download https://www.ti.com/lit/zip/SPRR426.

4.4 LAUNCHXL-F280025C Board Dimensions

Figure 4-10 is a dimensional drawing of the F28002x LaunchPad that shows the location of selected features of the board as well as the component locations.
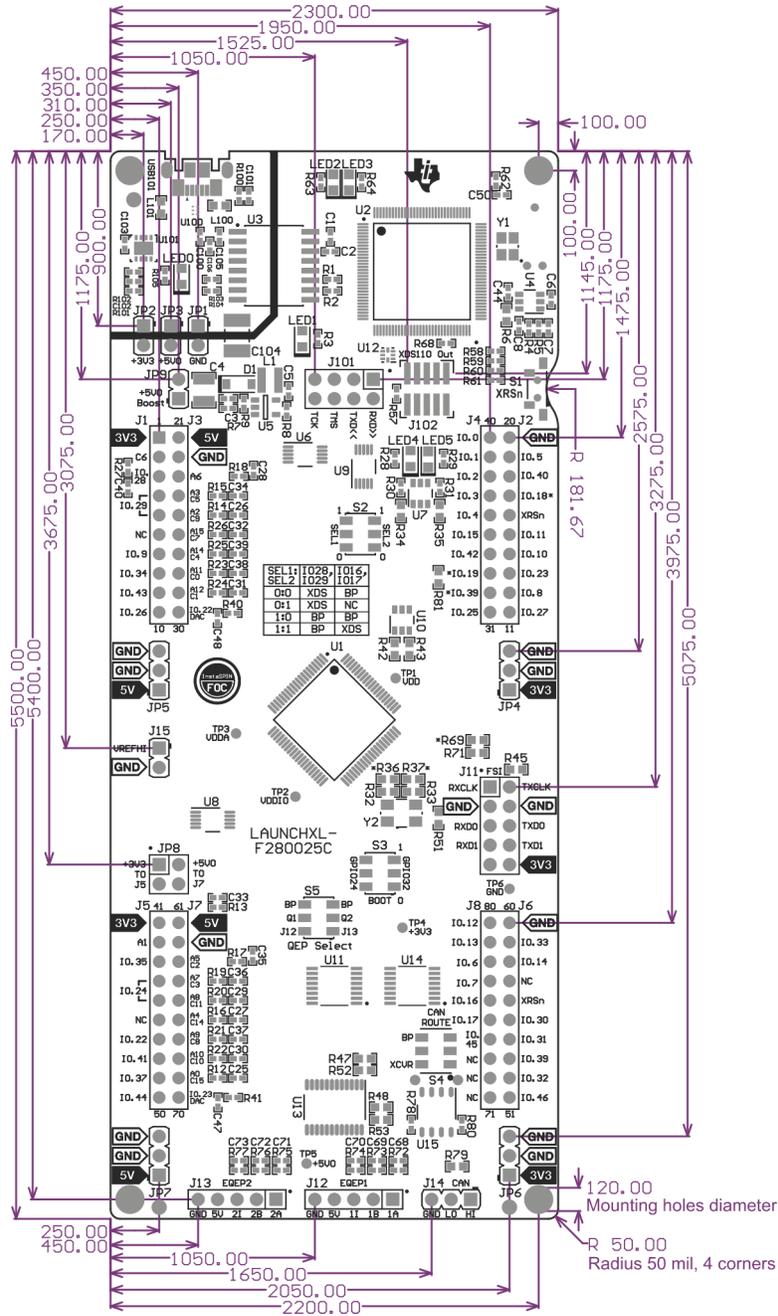
Figure 4-10. F28002x LaunchPad Dimensions and Component Locations

5 Frequently Asked Questions

1. Can other programming and debug tools (such as an XDS200 debug probe) be used with the F28002x LaunchPad?
    a. The F28002x LaunchPad utilizes an on-board XDS110 debug probe in a 2-pin cJTAG configuration. cJTAG only uses the TMS and TCK pins of the debug probe. TDI and TDO are present on the BoosterPack connectors and can be connected to a debug probe through jumper wires, if necessary.
2. What versions of Code Composer Studio can be used to develop software for the F28002x LaunchPad?
    a. The on-board XDS110 debug probe is compatible with Code Composer Studio development environment version 6.1.0 and later.
3. Why can't I connect to the LaunchPad in Code Composer Studio?
    a. Are shunts present on J101 for TCK and TMS?
    b. Is the XDS110 and the F280025C MCU powered? Is LED1 illuminated?
        i. If JP1, JP2, and JP3 are disconnected, the power provided through the USB is isolated from the rest of the board. Ensure that 3.3 V is supplied to any of the available connectors on the target side of the isolation.
    c. Is the micro-USB connected to the PCB and is the USB region receiving power? Is LED0 illuminated?
        i. The USB region must be powered with the 5 V from the USB cable. LED0 will illuminate when the 5V is stepped down to 3.3 V for the USB isolation chip to operate and pass the signals across the isolation barrier.
    d. Ensure that the target configuration is set up to use cJTAG in 2-pin advanced mode. Open the Target Configuration file (.ccxml) in Code Composer Studio. Click on the Advanced tab and select cJTAG (1149.7) 2-pin advanced modes from the drop-down labeled JTAG/SWD/cJTAG Mode. Leave the Target Scan Format as OSCAN2 format. Alternately, a working Target configuration file is included in the launcxl_ex1_f280025c_demo project "TMS320F280025C_LaunchPad.ccxml" (to be added in the first quarter 2021 C2000WARE release). You can use this without modifications.
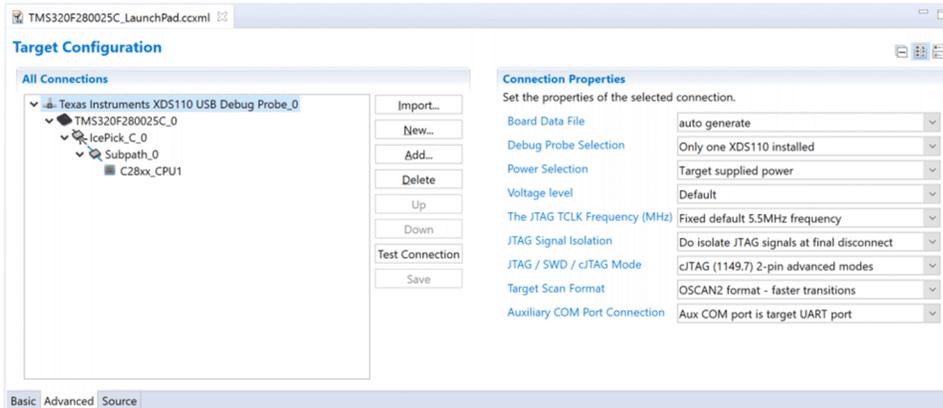

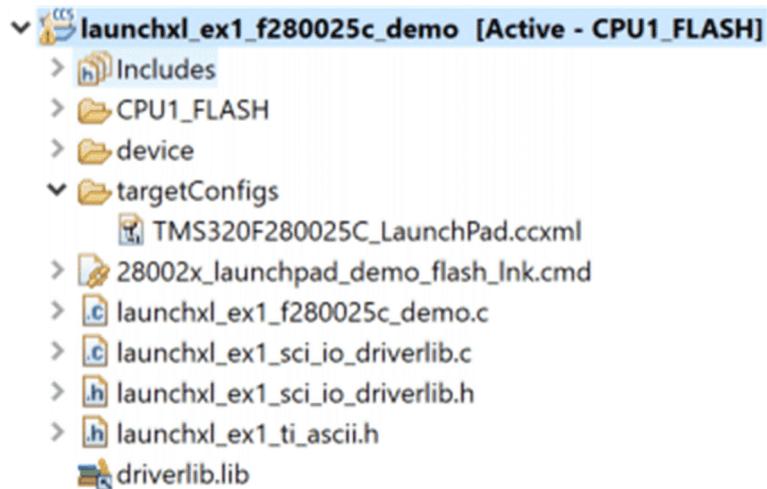**Figure 5-1. Target Configuration Advanced Options**

Figure 5-2. Target Configuration included in the demo project

4. Why is the serial connection not working?
    a. Are shunts present on J101 for TXD and RXD?
    b. Are you using the correct COM port?
        i.   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 XDS110 Class Application/User UART listed? If so, read the COM number to the right of the entry; this is the COM number you should be using.
    c. 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 100 MHz. If you have changed the PLL settings or developed your own code you may have to recalculate the baud rate for your specific application. For information on how to do this, see the TMS320F28002x C2000 Real-Time Microcontrollers Technical Reference Manual.
    d. Does the UART channel wired to the debug probe match the UART channel configured in software?
        i.   The F28002x LaunchPad provides an option for one of two possible UART channels to be routed to the debug probe through J101. Ensure that S2 is configured to the appropriate UART channel for the application software. See Section 3.3.2 for details.

6 References

6.1 Reference Documents

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

- *TMS320F280025C C2000 Real-Time Microcontrollers*
- *TMS320F28002x C2000 Real-Time Microcontrollers Datasheet*
- *TMS320F28002x C2000 Real-Time Microcontrollers Technical Reference Manual*
- The Essential Guide for Developing with C2000™ Real-Time Microcontrollers
- *TMS320F28002x C2000 Real-Time Microcontrollers Silicon Errata*
- *LAUNCHXL-F280025C LaunchPad Quick Start Guide*
- *C2000Ware for C2000 MCUs*
- *Application Specific Designs & Evaluation with C2000 Real-Time Microcontrollers*
- C2000WARE Quick Start Guide
- *Texas Instruments Code Composer Studio*
- *Texas Instruments LaunchPad Development Environment*

6.2 Other TI Components Used in This Design

This LaunchPad uses various other TI components for its functions. A consolidated list of these components with links to their TI product pages is shown below.

- *MSP432E401Y SimpleLink™ 32-bit Arm Cortex-M4F MCU*
- *LMR62421 Simple Switcher 2.7 V to 5.5 V, 2.1 A Step-Up Regulator*
- *SN65HVD234 3.3 V CAN Transceiver*
- *SN74LV4053A Triple 2-Channel Analog Multiplexer/Demultiplexer IC*
- *SN74LVC2G07 Dual Buffer/Driver With Open-Drain Output*
- *SN74LVC2G34 Dual Buffer/Driver With Push-Pull Output*
- *TPD4E004 4-Channel ESD Protection Array for High-Speed Data Interfaces*
- *TPD6E004 Low-Capacitance 6-Channel +/-15 kV ESD Protection Array for High-Speed Data Interfaces*
- *TPS3702 High-Accuracy, Fixed-Threshold OV/UV Monitor*
- *TPS796 Ultralow-Noise, High PSRR, Fast, RF, 1-A Low-Dropout Linear Regulator*
- *SN74LVC8T245 8-Bit Dual-Supply Bus Transceiver with Configurable Voltage-Level Shifting and Three-State Outputs*

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