EVM User's Guide: LAUNCHXL-F28E12X

C2000™ F28E12x Series LaunchPad Development Kit

Description

The LAUNCHXL-F28E12X is a low-cost development board for the Texas Instruments C2000™ Real-Time Microcontroller (MCU) series of F28E12x devices. The LAUNCHXL-F28E12X is designed around the F28E120SC real-time MCU and highlights the control, analog, and communications peripherals, as well as the integrated nonvolatile memory. The LaunchPad™ also features a BoosterPack expansion connector (40-pins), a 5V encoder interface (eQEP) connector, power-domain isolation, and an on-board XDS110 debug probe.

Get Started

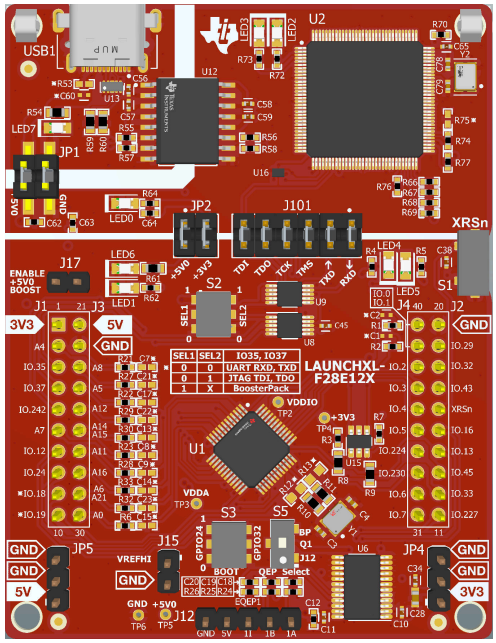
1. Order LAUNCHXL-F28E12X from TI.com.
2. Download the latest libraries.
3. Download the comprehensive reference design files.
4. See the latest device support files.

Features

- C2000 Series F28E120SCTPT (48-pin) microcontroller
- Onboard XDS110 debug probe
- Two user-controlled LEDs
- One microcontroller reset switch
- Selectable power domains:
  - USB (isolated)
  - BoosterPack
  - External power supply
- Enhanced Quadrature Encoder Pulse (QEP)-based encoder connector
- BoosterPack standard connectors (40-pins) featuring stackable headers to maximize expansion through the BoosterPack ecosystem

Applications

- Motor drives
- Appliances
- Hybrid, electric and powertrain systems
- Solar and EV charging
- Digital power
- Body electronics and lighting
- Test and measurement



F28E12x LaunchPad™ Board

1 Evaluation Module Overview

1.1 Introduction

The F28E12x LaunchPad (LAUNCHXL-F28E12X) from Texas Instruments (TI) provides a great way to learn and experiment with the F28E12x device. The F28E12x device is a member of TI's C2000 family of microcontrollers (MCUs). This 40-pin LaunchPad is intended to provide a well-filtered, robust design capable of working in most environments. This document provides the hardware details of the F28E12x LaunchPad and explains the functions, locations of jumpers, and connectors present on the board.

Note

This kit is designed to explore the functionality of the F28E12x microcontroller. The LaunchPad can be treated as a good reference design and is not intended to be a complete customer design. Full compliance to safety, EMI/EMC, and other regulations are left to the designer of the customer's system.

1.2 Kit Contents

The F28E12x Series LaunchPad Development Kit contains these items:

- C2000 F28E12x Series LaunchPad development board (LAUNCHXL-F28E12X)
- USB Type-A male to USB Type-C™ male cable
- Pinout Map

1.3 Specification

Table 1-1 summarizes the F28E12x LaunchPad specifications.

Table 1-1. LAUNCHXL-F28E12X Specifications

Parameter	Value
Board supply voltage	$5V_{DC}$ from one of the following sources: • USB Connector (USB1) - USB Type-C® cable connected to PC or other compatible power source. • BoosterPack™ 1 • Auxiliary power connectors $3.3V_{DC}$ from one of the following sources: • BoosterPack 1 • Auxiliary power connectors
Dimensions	3.00 in x 2.3 in x 0.925 in (7.62 cm x 5.84 cm x 2.35 cm) (L x W x H)
Break-out power output	• $3.3V_{DC}$ to BoosterPacks, limited by output of TPS7A80 LDO. This 3.3V plane is shared with on-board components. Total output power limit of TPS7A80 is 1.0A.
Assumed operating conditions	This kit is assumed to run at standard room conditions. The EVM can run at approximately standard ambient temperature and pressure (SATP) with moderate-to-low humidity.

Figure 1-1 highlights the key features of the F28E12x LaunchPad.

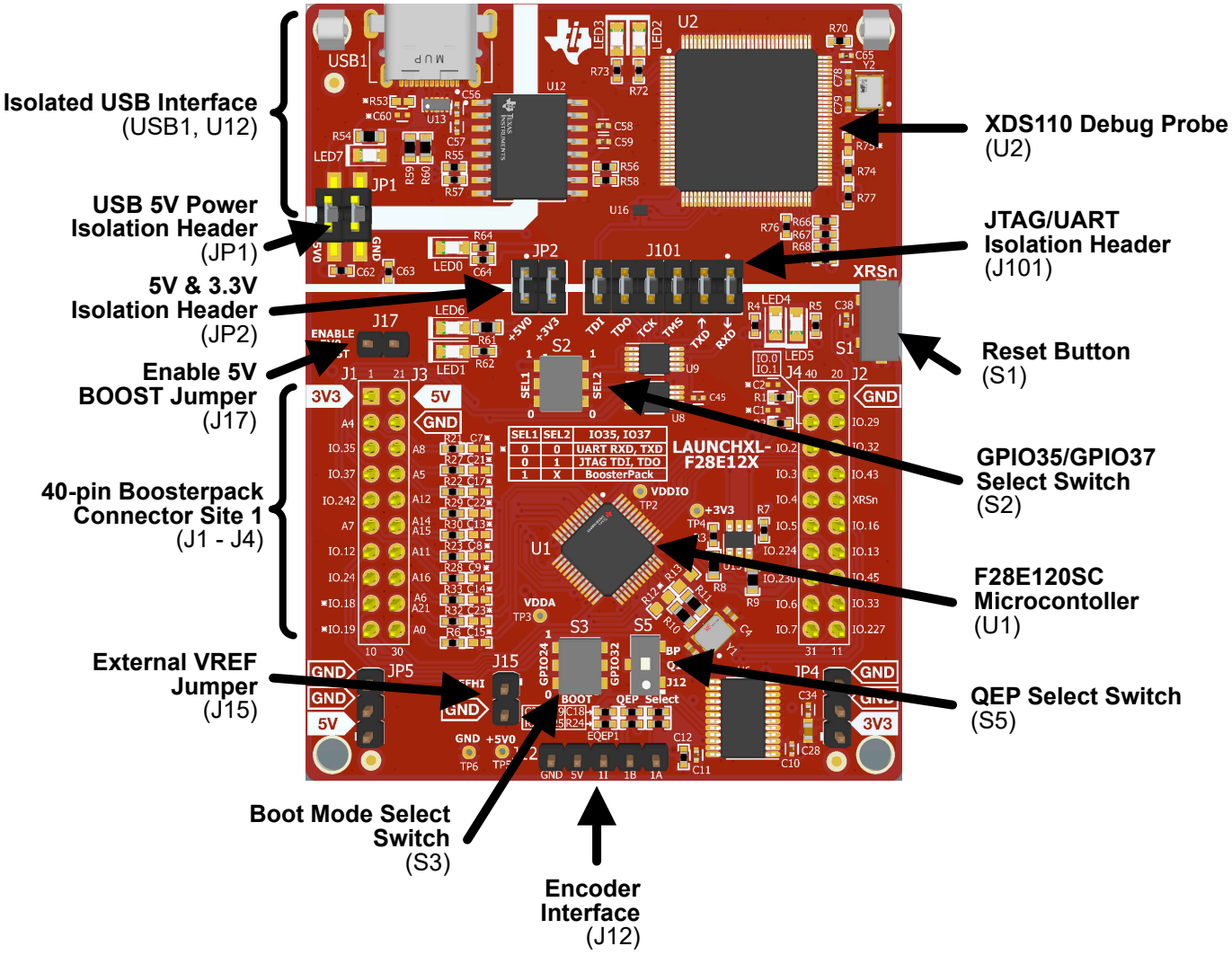


Figure 1-1. F28E12x LaunchPad Board Overview

1.3.1 External Power Supply or Accessory Requirements

Nominal Output Voltage: 5 VDC

Maximum Output Current: 3A

Efficiency Level V

Note

TI recommends using an external power supply or power accessory that complies with applicable regional safety standards such as (by example) UL, CSA, VDE, CCC, PSE, and so on.

1.4 Device Information

The F28E120SC is a single-core 32-bit floating-point microcontroller with 128KB Flash memory, 16KB RAM, and operates at 160MHz. The microcontroller includes advanced control peripherals, differentiated analog, and various communications peripherals. The device has been optimized for high-performance real-time control applications. For more details, see the *F28E12x Real-Time Microcontrollers* data sheet.

Most of the microcontroller signals are routed to 0.1 inch (2.54mm) pitch headers laid out to comply with the TI BoosterPack standards, with a few exceptions. The F28E12x MCU 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 power rails.

The F28E12x 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. For details on the LaunchPad demo program, see Section 3.1.2.

2 Hardware

2.1 Hardware Description

The F28E12x LaunchPad includes an F28E120SC MCU, which is designed for advanced real-time control applications. A large number of these peripherals are made available to users using the on-board accessories and the BoosterPack connectors. This section explains how those peripherals operate and interface to the MCU.

Figure 2-1 shows a high-level block diagram of the F28E12x LaunchPad:

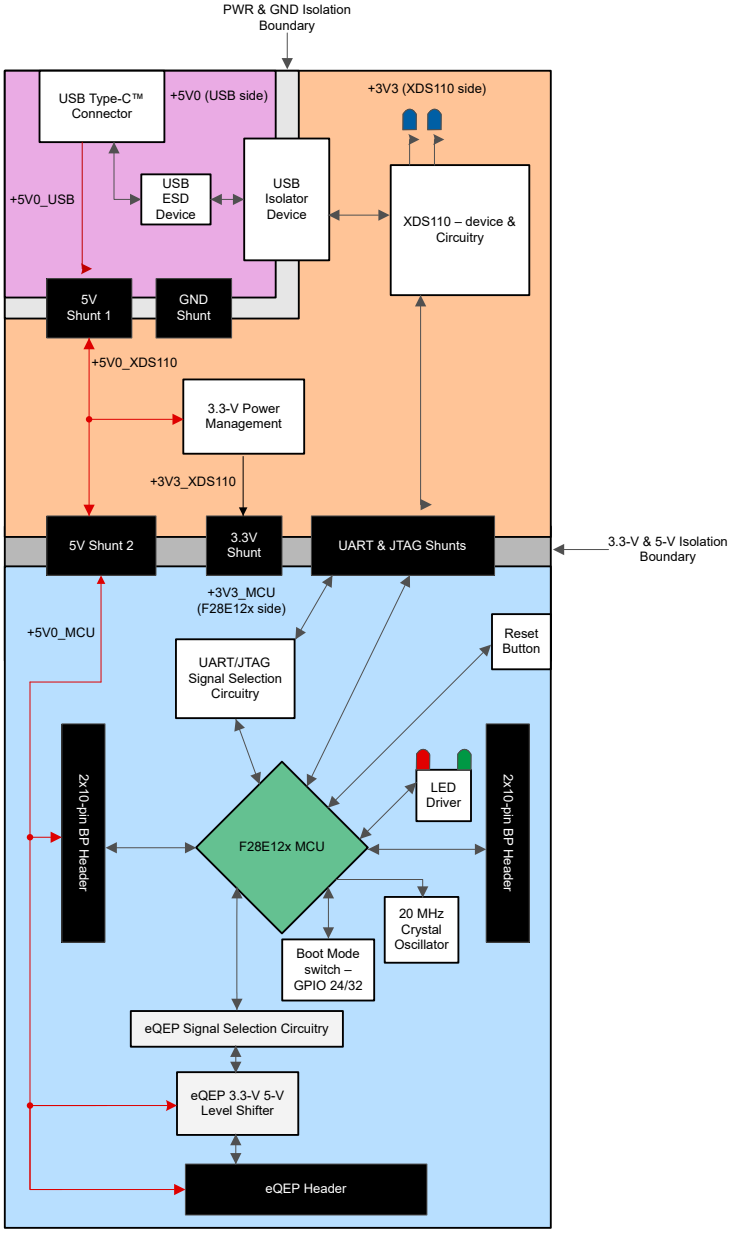


Figure 2-1. F28E12x LaunchPad Development Kit Block Diagram

2.1.1 Functional Description and Connections

2.1.1.1 Power Domains

The F28E12x LaunchPad has several power domains that can be connected or isolated from each other with removable shunts. The different 3.3V and 5V power domains are further described in Figure 2-2.

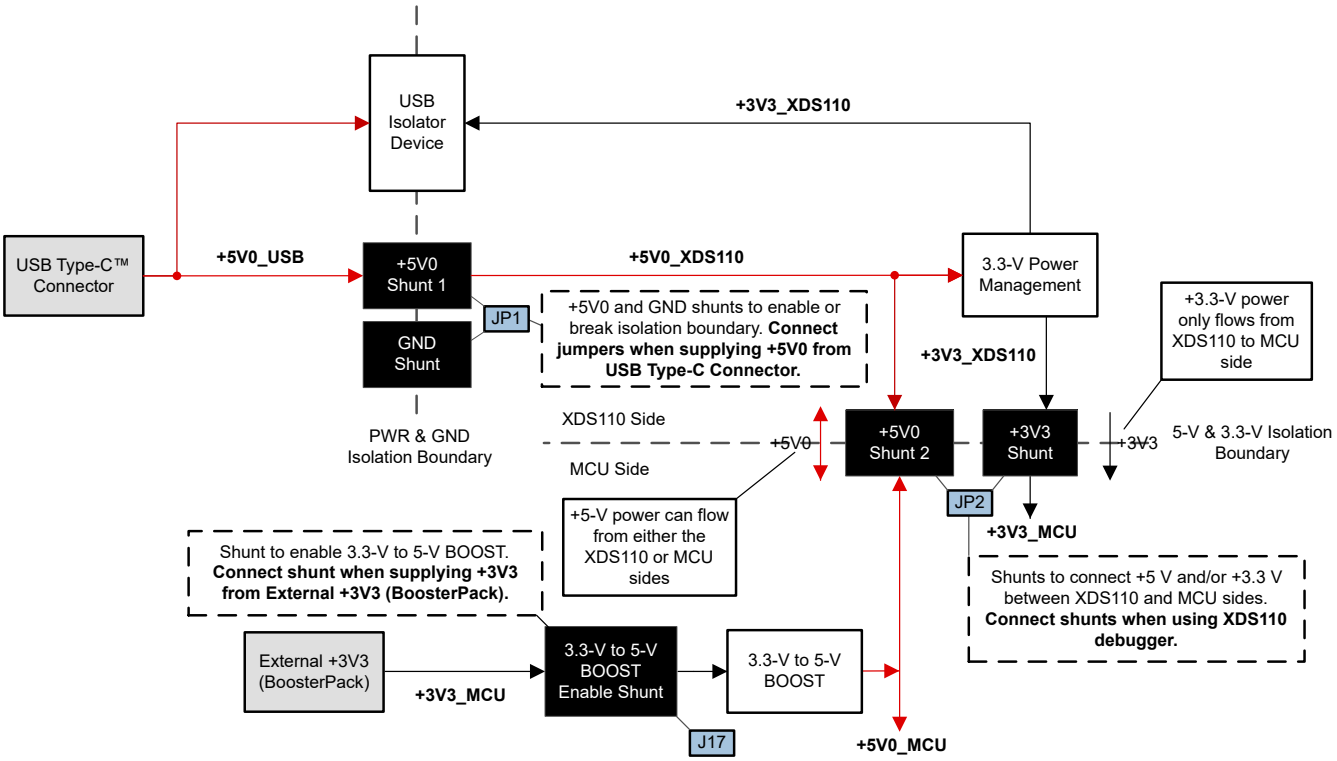


Figure 2-2. LaunchPad Power Distribution Diagram

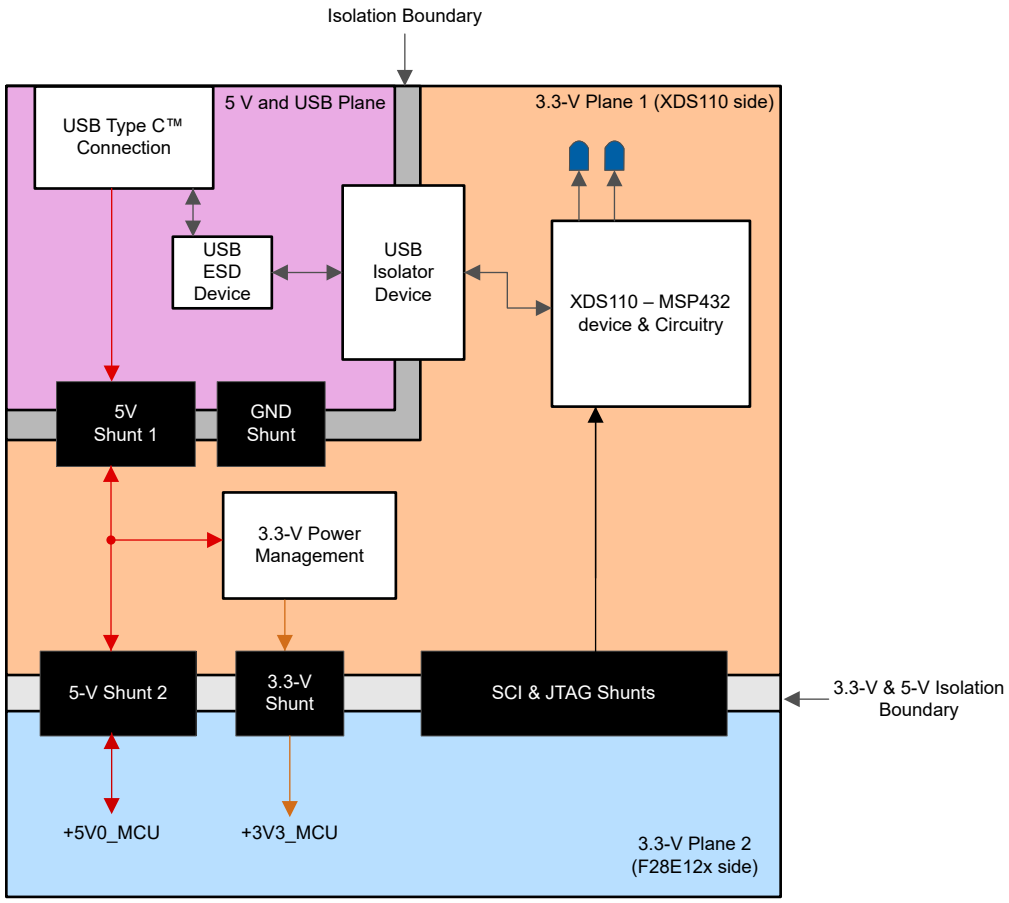


Figure 2-3. LaunchPad Power Plane Diagram

Table 2-1 describes the usage of the different removable shunts on the LaunchPad board.

Table 2-1. Power Domain Shunts

Shunt Identifier	Usage Description
JP1, +5V0	Connects the +5V power from the USB-C connector (+5V0_USB) to the +5-V power on the XDS side of the board (+5V0_XDS110). Bridges the power isolation between the USB and XDS planes.
JP1, GND	Connects the board Ground on the isolated USB-C connector side of the board (USB_GND) to the rest of the board ground (GND). Bridges the ground isolation between the USB side and the rest of the board.
JP2, +5V0	Connects the +5-V power from the XDS side of the board (+5V0_XDS110) to the +5-V power on the MCU side of the board (+5V0_MCU).
JP2, +3V3	Connects the +3.3-V power from the XDS side of the board (+3V3_XDS110) to the +3.3-V power on the MCU side of the board (+3V3_MCU).
J17	Enables the onboard 3.3V to 5V BOOST regulator to convert the +3.3V power rail to a +5V power rail.

The F28E12x LaunchPad features a flexible power domain scheme that allows users to supply power to the board in a variety of different configurations. Table 2-2 shows the different power configurations and the required shunts that need to be populated to supply power throughout the board.

Table 2-2. Power Configurations

Power Source	Connected Shunts	Description of Power Sources
USB-C Connector	JP1, JP2	**+5V0_USB:** supplied from the USB-C connector **+5V0_XDS110:** +5V0_USB passes through JP1 and is the same supply as +5V0_XDS110 **+5V0_MCU:** +5V0_XDS110 passes through JP2 and is the same supply as +5V0_MCU **+3V3_XDS110:** generated by the XDS-side 5V to 3.3V LDO regulator **+3V3_MCU:** +3V3_XDS110 passes through JP2 and is the same supply as +3V3_MCU
External +3.3-V (connected to BoosterPack header)	JP2 +5V0 (optional), J17	**+5V0_USB:** If debugging the device, then connect JP2 +5V0 shunt to provide power to the XDS110 debugger. +5V0_USB is supplied through the USB-C connector and is isolated from the MCU side +5V0 rail. Else if not debugging, +5V0_USB is not required and JP2 +5V0 can be disconnected **+5V0_XDS110:** Required only if debugging the device. +5V0_MCU passes through JP2 and is the same supply as +5V0_XDS110 **+5V0_MCU:** generated by the 3.3V to 5V BOOST regulator **+3V3_XDS110:** Required only if debugging the device. +3V3_XDS110 is generated by the XDS-side 5V to 3.3V LDO regulator. Make sure JP2 +3V3 shunt is disconnected to prevent contention on the 3.3V power rail **+3V3_MCU:** supplied by external +3.3V source
External +5.0-V (connected to BoosterPack header)	JP2	**+5V0_USB:** If debugging the device, +5V0_USB is supplied through the USB-C connector and is isolated from the MCU side +5V0 rail. Else if not debugging, +5V0_USB is not required. **+5V0_XDS110:** 5V0_XDS110 passes through JP2 and is the same supply as +5V0_MCU **+5V0_MCU:** supplied by external +5.0V source **+3V3_XDS110:** +3V3_XDS110 passes through JP2 and is the same supply as +3V3_MCU **+3V3_MCU:** generated by the XDS-side 5V to 3.3V LDO regulator

2.1.1.2 LEDs

Power indicator LEDs (red) are included on the F28E12x LaunchPad board. Table 2-3 shows descriptions of each LED.

Table 2-3. Power LED Indication Descriptions

LED Number	Indication Description
LED7	+5-V power from the USB Type-C™ connector
LED0	+3.3-V power on the XDS110 side of the PCB
LED6	+5-V power on the F28E12x side of the PCB
LED1	+3.3-V power on the F28E12x side of the PCB

Two user LEDs are provided on the board: LED4 (red) and LED5 (green), see Table 2-4. These user LEDs are connected to GPIO45 and GPIO33 of the F28E120SC, respectively. The signals are connected to the SN74LVC2G07 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 off the LED. These LEDs are dedicated for use by the software application.

Table 2-4. User-Configurable LED Descriptions

LED Number	Description
LED4	Active-low user-configurable LED controlled by GPIO45
LED5	Active-low user-configurable LED controlled by GPIO33

Two blue LEDs, LED2 and LED3, are connected to the XDS110 debug probe, see Table 2-5. These indicate debugger activity and are not controllable by any application software.

Table 2-5. XDS110 LED Descriptions

LED Number	Indication Description
LED2	Indicates that the XDS110 device is actively connected to a debugger target session (for example, CCS IDE debug session)
LED3	Indicates that the XDS110 device is powered and functional

2.1.1.3 Encoder Connectors

The F28E12x LaunchPad includes a header, J12, which is used for connecting linear or rotary incremental encoders. These headers take 5V input signals that are stepped down to 3.3V and wired to the F28E120SC MCU. These signals are connected to the eQEP modules on the device when switch S5 is set appropriately, see Table 2-9. Each header has the EQEPA, EQEPB, and EQEPI signals available for the eQEP module (1) as well as pins for GND and 5V.

2.1.1.4 Boot Modes

The F28E120SC 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 boots from Flash. For more information on the F28E12x boot modes, see the *F28E12x Real-Time Microcontrollers* data sheet.

Table 2-6. 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

2.1.1.5 BoosterPack Sites

The F28E12x LaunchPad features a BoosterPack connector. BoosterPack site 1 is compliant with the BoosterPack standard. 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 on-board switches or by adding and removing 0Ω resistors. This is described in Section 2.1.3.

The GPIO pin numbers as well as the BoosterPack compliant features can be viewed in the *LAUNCHXL-F28E12X Pinout Map* . Each GPIO has multiple functions available through the F28E12x device's GPIO mux. Some specific functions have been listed in the Pinout Map; the full GPIO mux table can be found in the *F28E12x Real-Time Microcontrollers data sheet*.

All of the analog signals (denoted ADCIN) of the F28E12x MCU are routed to the J1/J3 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 unpopulated. Users can populate these components with specific values to filter out noise arriving at the device ADC input.

2.1.1.6 Analog Voltage Reference

The analog subsystem of the F28E12x 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 an external voltage reference. For best performance, some additional circuitry can be required.

2.1.1.7 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.

2.1.1.7.1 USB Isolation Block

JP1 is provided to enable isolation between the device and the connected USB in higher-voltage applications. The area of isolation is defined by the white outline on the upper-left corner of the LaunchPad. JP1 has two removable shunts to separate the GND and 5V power of the USB region and the XDS110 and F28E12x MCU region of the LaunchPad. By default, both shunts are populated and the power is supplied by the connected USB, meaning that the USB is NOT isolated from the XDS110 and F28E12x MCU regions. If power isolation is desired, remove the supplied shunts from JP1. In this configuration, one of the two external power options below are required:

- An external 5V supply to power the 3.3V LDO (TPS7A80), which provides 3.3V to the XDS110 and F28E12x MCU regions of the board.
- An external 3.3V supply to power the F28E12x MCU region of the board. 5V is generated using the onboard 5V BOOST (TPS61241).

In an isolated power application with JP1 shunts removed, make sure the proper shunts on the F28E12x MCU region of the board are populated. Refer to Section 2.1.1.1 for greater detail.

2.1.1.7.2 Alternate Power

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

- **JP4** is provided as an extra connection point for a 3.3V supply to be connected to the LaunchPad.
- **JP5** is provided as an extra connection point for a 5V supply to be connected to the LaunchPad.

2.1.1.7.3 5V Step-up Converter

J17 cuts off the power to the on-board boost converter and prevents the TPS61241 step-up DC/DC converter (U23) from powering the 5V power domain of the LaunchPad. This voltage regulator can step up 3.3V to 5V if no other 5V supply is connected. Do not place a shunt on J17 unless JP2 is open and no other 5V supply is connected to the LaunchPad.

2.1.1.8 Programmable Gain Amplifier (PGA)

The F28E12x MCU features an on-chip Programmable Gain Amplifier (PGA) to amplify an input voltage for increasing the dynamic range of the downstream ADC and CMPSS modules. The integrated PGA helps to reduce the cost and design effort for many control applications that traditionally require external, stand-alone amplifiers. On-chip integration makes sure that the PGA is compatible with the downstream ADC and CMPSS modules. Software selectable gain and filter settings make the PGA adaptable to various performance needs. For more information on the PGAs, see the device-specific data sheet and technical reference manual.

The F28E12x LaunchPad was designed to optimize the routing of certain PGA signals to the BoosterPack connectors. This design choice allows for the evaluation of the on-chip PGA, if desired. One PGA module with pin multiplexer support for 3 positive inputs and 2 negative inputs are routed to the BoosterPack Connector. An RC filter can be placed on each of these signals to provide additional filtering of the input signal. By default, 0Ω series resistor and pads for a decoupling capacitor are placed on each PGA input signal. These values can be modified based on application requirements. Wherever a PGA signal is brought to the BoosterPack connector, an ADC input is also provided.

Table 2-7 summarizes the available PGA signals and connections. For the full connection details, see the *LAUNCHXL-F28E12X Schematic*.

Table 2-7. PGA Signals and Associated Connections

Booster Pack Site	Pin Position	PGA Signal	ADC Input Signal	Note
1	J3.27	PGA1_INP1	ADCINA11	Populate RC filter if required
	J3.28	PGA1_INP2	ADCINA16	Populate RC filter if required
	J3.29	PGA1_INP3	ADCINA6/ADCINA21	Populate RC filter if required
	J1.2	PGA1_INM1	ADCINA4	Disconnected by default. Jump to board GND or external voltage as needed.
	J3.30	PGA1_INM2	ADCINA0	Disconnected by default. Jump to board GND or external voltage as needed.
	J3.23	PGA1_OUT	ADCINA8	Used for verifying output of PGA1

2.1.2 Debug Interface

2.1.2.1 XDS110 Debug Probe

The F28E12x LaunchPad includes an on-board XDS110 Debug Probe. The XDS110 allows for the programming and debugging of the F28E120SC device using Code Composer Studio (CCS) IDE or any other supported tool chains. In the default configuration, the XDS110 is wired to support 4-pin JTAG mode. 2-pin cJTAG is also supported. See Section 2.1.3.2 for limitations.

2.1.2.2 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 F28E12x to the debug probe to be passed on to the USB host. By default, the F28E12x SCIA maps to the virtual COM port of the XDS110 using GPIO35 and GPIO37. See Section 2.1.3.2 for limitations.

To enable SCI boot on the F28E12x LaunchPad, follow the below steps:

1. Make sure S2 is configured to enable UART communication to the Virtual Com Port.
2. Make sure S3 is configured to Boot from SCI or Wait boot.
3. Remove the two jumpers on J101 corresponding to TXD and RXD.
4. Use a jumper wire to connect GPIO29 (J2.19) to TXD on J101 on the XDS-side.
5. Use a jumper wire to connect GPIO28/ADCINA16 (J3.28) to RXD on J101 on the XDS-side.

Refer to Serial Flash Programming of C2000 Microcontrollers for additional information on utilizing the SCI bootloader.

2.1.3 Alternate Routing

2.1.3.1 Overview

The F28E120SC MCU is a very versatile device in a small-size package. To balance compatibility with BoosterPack standards as well as showcasing the versatility of the F28E120SC, 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 can be lost. The switches and resistors are configured to not connect multiple functions to the same header.

2.1.3.2 GPIO35/GPIO37 Routing

To allow for more flexibility when evaluating the F28E12x MCU, this LaunchPad features multiple configurations for routing the GPIO35 and GPIO37 pins. By default, GPIO35 (RXD) and GPIO37 (TXD) are routed to the virtual COM port and are not available on the BoosterPack connector. These GPIO pins support both the SCIA peripheral and the high-speed UARTA peripheral. Alternatively, GPIO35 (TDI) and GPIO37 (TDO) can be routed as JTAG signals to the XDS110 debugger to enable debugging with 4-pin JTAG. When UART or 4-pin JTAG are not needed, 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 in Table 2-8.

Table 2-8. GPIO35/GPIO37 Select Table - S2

SEL1 (Left)	SEL2 (Right)	GPIO35 Function	GPIO37 Function	Intended Use Case
0	0	UART RXD	UART TXD	2-pin cJTAG + serial UART
0	1	JTAG TDI	JTAG TDO	4-pin JTAG
1	x	BP Header J1.3	BP Header J1.4	BoosterPack function

Note that using 4-pin JTAG with serial UART communication to the virtual COM port is not supported on LAUNCHXL-F28E12X hardware. If UART communication is needed, use the 2-pin cJTAG + serial UART configuration.

2.1.3.3 eQEP Routing

The LaunchPad has the ability to connect to a linear or rotary encoder through the F28E12x on-chip eQEP interface: Header J12 is connected to eQEP1. By default, this connection is not active and the GPIOs are routed to the BoosterPack connectors. The 5V eQEP input signals from the J12 connector are stepped down through a TI SN74LVC8T245 Level Translator (U6) to 3.3V. The signals are then routed through a TI SN74LV4053A triple 2-channel analog multiplexer or demultiplexer ICs (U7). Switch S5 controls the select inputs of the ICs to configure the eQEP signal destinations to be either the J12 connectors or BoosterPack headers, as described in Table 2-9.

Table 2-9. QEP Select Table - S5

QEP1 SEL	QEP1 Signals (GPIO6/7/43)
0 (down)	J12
1 (up)	BP Headers

2.1.3.4 X1, X2 Routing

The F28E12x 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 and X2 and GPIO19 and X1 can be routed to the BoosterPack connectors through 0Ω resistors. If GPIO18 or GPIO19 are needed at the BoosterPack connectors, then 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 *F28E12x Real-Time Microcontrollers* data sheet.

If GPIO18 functionality is needed at the BoosterPack Connector:

1. Remove R10 to separate GPIO18 from Y2.
2. Populate R12 to connect GPIO18 to the BoosterPack connector

If GPIO19 functionality is needed at the BoosterPack Connector:

1. Remove R11 to separate GPIO19 from Y2.
2. Populate R13 to connect GPIO19 to the BoosterPack connector.

2.1.3.5 PWM DAC

In addition to the buffered DAC output available on BP pin 30, the F28E12x LaunchPad provides up to two PWM DAC signals at the BoosterPack headers using GPIO0 (BP pin 40) and GPIO1 (BP pin 39). The intended purpose of the PWM DAC signals are to utilize PWMs of the F28E12x device as digital-to-analog converters (DAC). This method involves low-pass filtering the PWM signal to remove the high-frequency components and leave only the DC component. For more information, see the *Using PWM Output as a Digital-to-Analog Converter on a TMS320F280x Digital Signal Control*.

By default, the RC filter is not populated. Instead a 0 ohm resistor is populated and the capacitor is left un-populated.

2.2 Using the F28E12x LaunchPad

The recommended steps for using the F28E12x LaunchPad are:

1. **Follow the instructions in Section 3.1.2 to begin running the LaunchPad demo program.** Within just a few minutes, you can control and monitor the F28E12x 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 can quickly be addressed.
2. **Experiment with BoosterPacks.** This development kit conforms to the latest revision of the BoosterPack pinout standard. This development kit 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.
3. **Take the first step towards developing your own control applications.** The F28E12x LaunchPad is supported by the C2000Ware development package. After C2000Ware is installed, look for \f28e12x\examples\c28x\launchxl_f28e12x in the installation directory to find the pre-configured example applications for this board. Any of the other examples found within the \f28e12x\examples directory can be used with minor modifications to run on the LaunchPad as well. For more details about software development, see Section 3.1.
   a. For applications, features and benefits information, see the *F28E12x Real-Time Microcontrollers* data sheet.
   b. Check out this technical article featuring C2000 Real-Time Microcontrollers 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 F28E12x 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.
   a. See *Getting Started With C2000™ Real-Time Control Microcontrollers (MCUs)*
   b. See the TI Training and Videos page
   c. See the *C28x Academy* page

2.3 BoosterPacks

The LAUNCHXL-F28E12X provides a simple and inexpensive way to develop applications with the F28E12x 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 F28E12x LaunchPad.

Some examples of BoosterPacks that are compatible with the F28E12x LaunchPad are listed in Table 2-10. Note that this is not an exhaustive list of hardware supported BoosterPacks.

Table 2-10. Featured BoosterPacks for the F28E12x LaunchPad

BoosterPack/Board	Application and Usage
BOOSTXL-DRV8320RS	DRV8320RS 15A, 3-phase brushless DC drive stage. Features individual DC bus and phase voltage sense, making this evaluation module good for sensorless BLDC algorithms.
BOOSTXL-3PHGANINV	Features a 48V/10A three-phase GaN inverter with precision in-line shunt-based phase current sensing for accurate control of precision drives such as servo drives.
BOOSTXL-LMG2100-MD	Implements a 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.
DRV8353RS-EVM	15A, 3-phase brushless DC drive stage based on the DRV8353RS gate driver and CSD19532Q5B NexFET™ MOSFETs.
DRV8316REVM	DRV8316REVM provides three half-H-bridge integrated MOSFET drivers for driving a three-phase brushless DC (BLDC) motor with 8A peak current drive, for 12V/24V DC rails or battery powered applications.

Table 2-10. Featured BoosterPacks for the F28E12x LaunchPad (continued)

BoosterPack/Board	Application and Usage
DRV8317HEVM	The DRV8317 is a 4.5V to 20V, 5A peak integrated three-phase FET-driver IC for motor drive applications. The DRV8317 provides three integrated half-bridges capable of directly driving a three-phase brushless DC motor.
DRV8300DRGE-EVM	The DRV8300DRGE-EVM is a 30A, 3-phase brushless DC drive stage which includes three current shunt amplifiers for low-side current measurement as well as feedback for PV_{DD}/GV_{DD} voltage and board temperature.
DRV8328AEVM	DRV8328AEVM is a 30A, 3-phase brushless DC drive stage which includes a current shunt amplifier for low-side current measurement as well as configurability to evaluate all variants of the DRV8328 device (A, B, C, and D).
DRV8329AEVM	DRV8329AEVM is a 30A, 3-phase brushless DC drive stage which includes a current shunt amplifier for low-side current measurement, 80mA LDO, dead time control pin, VDS overcurrent level pin, and gate driver shutoff pin.
DRV8334EVM	DRV8334EVM is a 30A 3-phase brushless DC drive stage which allows for quick evaluation of the DRV8334 device which spins a BLDC motor with trapezoidal commutation and control.
DRV8161EVM	DRV8161EVM is a 30A, three-phase brushless DC drive stage using three DRV8161 gate drivers for spinning BLDC motors. The EVM allows quick evaluation of the DRV8161 device which spins a BLDC motor with trapezoidal commutation and control.
DRV7308EVM	The DRV7308EVM is a module designed for thorough evaluation of the DRV7308 motor driver. The device is a 250W, 450V integrated triple gallium nitride (GaN) FET half-bridge gate driver for motor driver applications. The DRV7308EVM provides three 650V E-mode GaN FET half-bridges capable of directly driving a three-phase brushless-DC motor.
DRV8376EVM	DRV8376EVM is an integrated driver IC EVM for three-phase motor driver applications and provides single-chip power stage design for customers driving 4.5V to 65V brushless DC motors.
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-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 varies.

Users can also design BoosterPacks for the F28E12x LaunchPad. Make sure that compatibility requirements are met by referencing the signal pin mapping in the *LAUNCHXL-F28E12X Pinout Map* or *LAUNCHXL-F28E12X Schematic*.

2.4 Hardware Revisions

This section contains an abbreviated revision history of the LAUNCHXL-F28E12X as well as known issues with each revision.

2.4.1 Revision A

The second production revision of the LAUNCHXL-F28E12x was released in August 2025. This revision can be identified by the *MCU152A* labeling on the back side of the EVM between the BoosterPack Connector.

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

Known issues:

- No issues to report at this time of release.

Special notes and considerations to be aware of:

- Note that this revision of LAUNCHXL-F28E12X is identical to Revision E2 boards except with an updated version of the F28E120SC device. As such, only a label is provided to indicate Revision A and the silkscreen still reads as Revision E2. All design files and schematics applicable for Revision E2 are also applicable to Revision A.

2.4.2 Revision E2

The first production revision of the LAUNCHXL-F28E12x was released in April 2025. This revision can be identified by the "MCU152E2" silkscreen labeling on the back side of the EVM between the BoosterPack Connector.

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.

3 Software

3.1 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 F28E12x, are listed in the C2000 Evaluation & Development page.

3.1.1 Software Tools and Packages

Code Composer Studio (CCS) is a free integrated development environment (IDE) that supports TI's Microcontroller and Embedded Processors portfolio. Code Composer Studio™ (CCS) IDE 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 F28E12x device on the LAUNCHXL-F28E12X and minimize software development time.

Software Development Kits (SDKs) are provided to make evaluating C2000 MCUs easy within specific system use cases and reduce overall development time. The Motor Control SDK (C2000WARE-MOTORCONTROL-SDK) is targeted for various motor control applications, such as industrial drives. 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.

3.1.2 F28E12x LaunchPad Demo Program

The LAUNCHXL-F28E12X includes an F28E120SC 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 ADCINA8 and the sampled value is represented as follows: If the sample is above mid-scale (2048), the red LED4 illuminates. If the sample is below mid-scale, the green LED5 illuminates.

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 (see Figure 3-1). 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.

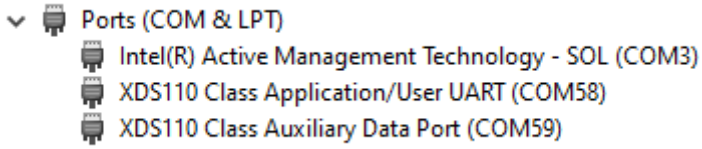


Figure 3-1. LaunchPad XDS110 COM Port

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 (see Figure 3-2).

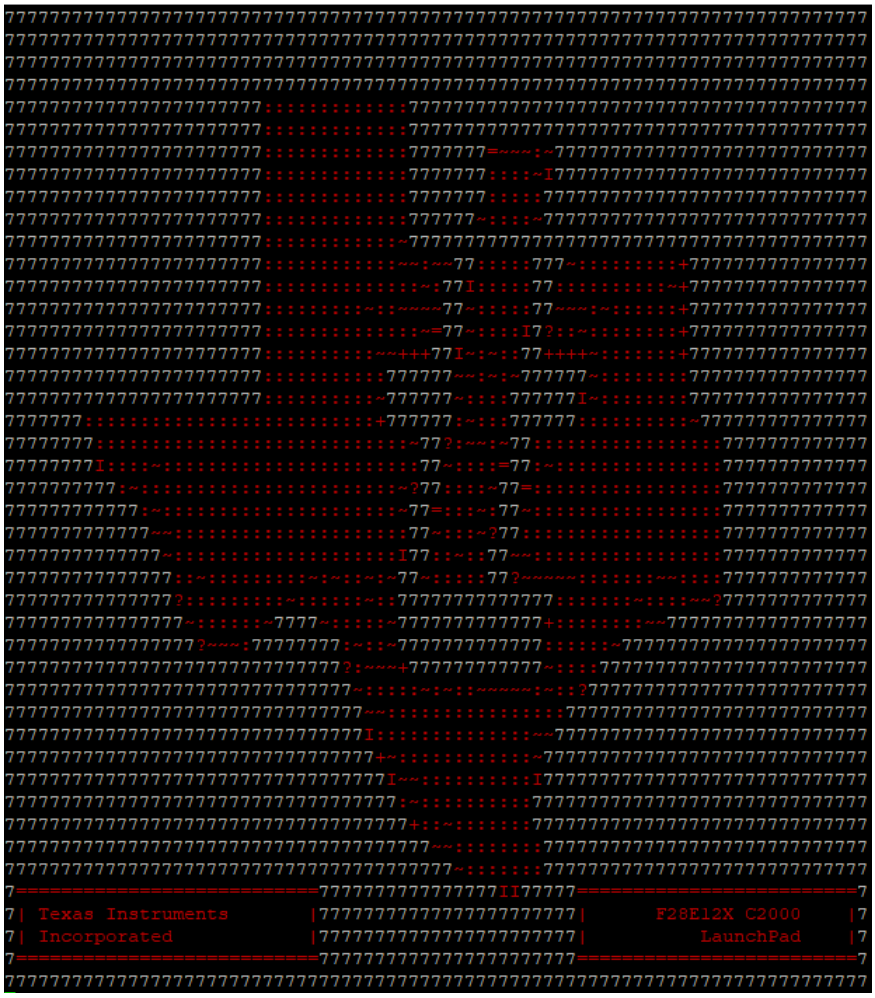


Figure 3-2. LaunchPad Demo Serial Terminal - TI Logo

After a few moments, the ADC value sampled on the ADCINA8 pin appears in the bottom-right corner of the terminal and is updated each second (see Figure 3-3). Using a jumper wire, connect the ADCINA8 header to a 3.3V, GND, or other 0-3.3V signal to see the on-screen value change.

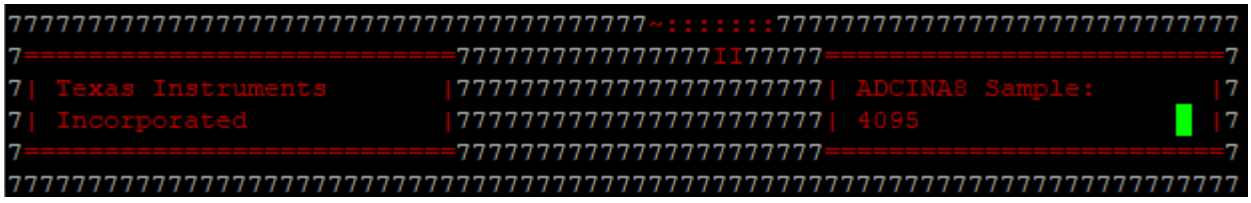


Figure 3-3. LaunchPad Demo Serial Terminal - ADC Sampling

3.1.3 Programming and Running Other Software on the F28E12x LaunchPad

The software packages described in Section 3.1.1 include example projects that can be loaded and run on the F28E12x 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\f28e12x*. The on-board XDS110 is used with the On-Chip Flash Programmer tool to program applications to the F28E12x LaunchPad.

Follow these steps to program example applications onto the F28E12x LaunchPad development kit using the on-board XDS110 debug probe:

1. Install Code Composer Studio (CCS) IDE 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 USB Type-C™ plug to the port (USB1) on the F28E12x LaunchPad.
3. Verify the following LEDs are illuminated:
   a. LED7, at the top left of the board, indicating 5V USB power.
   b. LED0 indicating 3.3V power to the XDS110 debug probe.
   c. LED6 indicating 5.0V power to the F28E120SC MCU.
   d. LED1 indicating 3.3V power to the F28E120SC MCU.
4. Install Windows XDS110 and Virtual COM Port drivers if prompted. Installation instructions can be found at XDS110 Product Page.
5. Run CCS IDE on the PC.
6. Import a F28E12x project from C2000WARE, or another installed software package, into the CCS IDE workspace.
7. Add the *_LAUNCHXL_F28E12X* predefined symbol to the imported DriverLib example project for the software to use relevant F28E12x LaunchPad signals.
   a. Open the projects Properties → Expand the *Build* tab → Expand the *C2000 Compiler* tab → Select *Predefined Symbol* → Add *_LAUNCHXL_F28E12X* predefine NAME.
8. Right click the project name and select *Rebuild Project* in CCS IDE.
9. Launch the LAUNCHXL-F28E12X Target Configuration file and connect to the F28E12x device. Make sure that the Target Configuration file is configured to use the 2-pin cJTAG advanced configuration. For additional details, see FAQ section.
10. Click 'Load Program' and select the program's binary to load. The binary is loaded onto the device and can now be run and debugged.

4 Hardware Design Files

The entire LAUNCHXL-F28E12X design files are available for download at this link: *LAUNCHXL-F28E12X design files* .

4.1 Schematic

The LaunchPad's schematic can be found at this link: *LAUNCHXL-F28E12X Schematic* .

4.2 PCB Layout

The layout source files for the LAUNCHXL-F28E12X are included in the *LAUNCHXL-F28E12X design files* download.

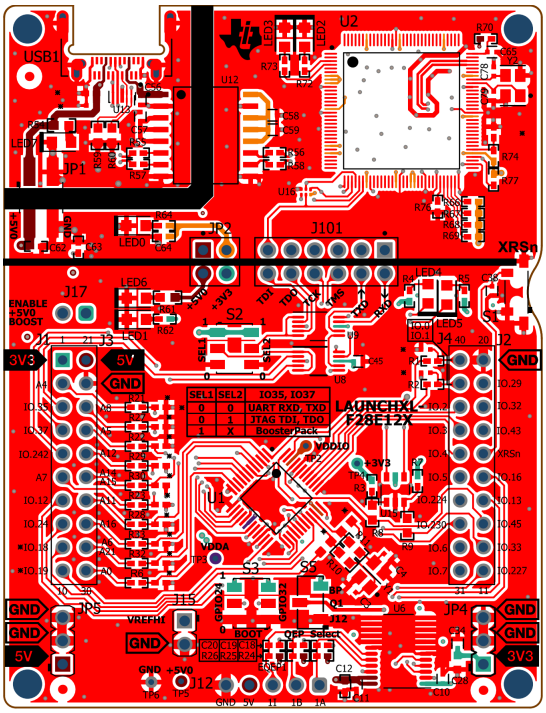


Figure 4-1. Top Signal - Layer 1

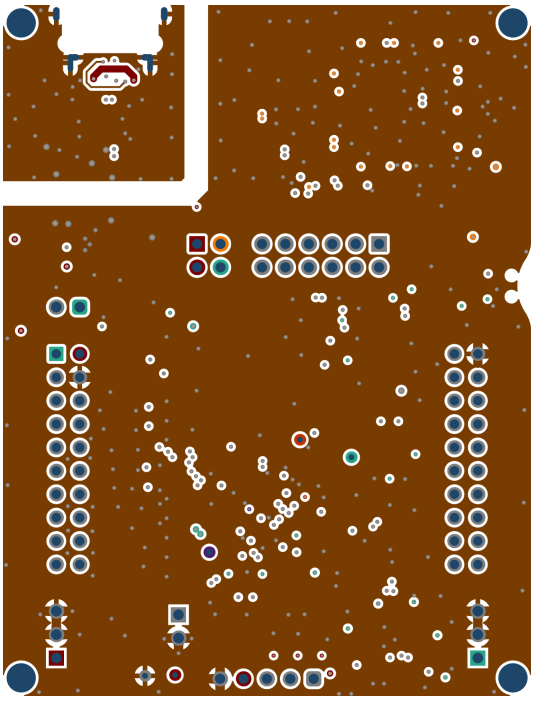


Figure 4-2. GND - Layer 2

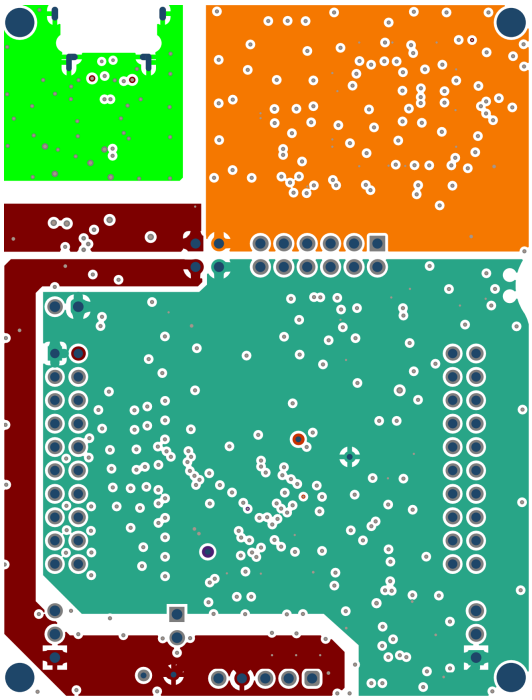


Figure 4-3. PWR - Layer 3

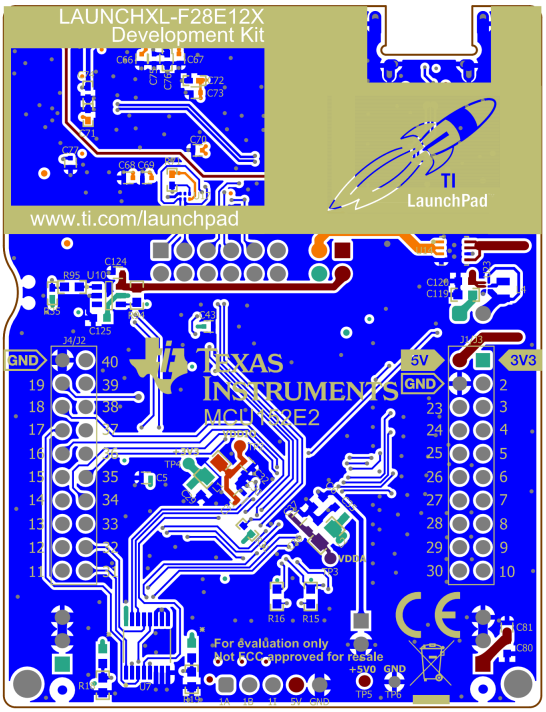


Figure 4-4. Bottom Signal- Layer 4

4.2.1 LAUNCHXL-F28E12X Board Dimensions

Figure 4-5 is a dimensional drawing of the F28E12x LaunchPad that shows the location of selected features of the board as well as the component locations.

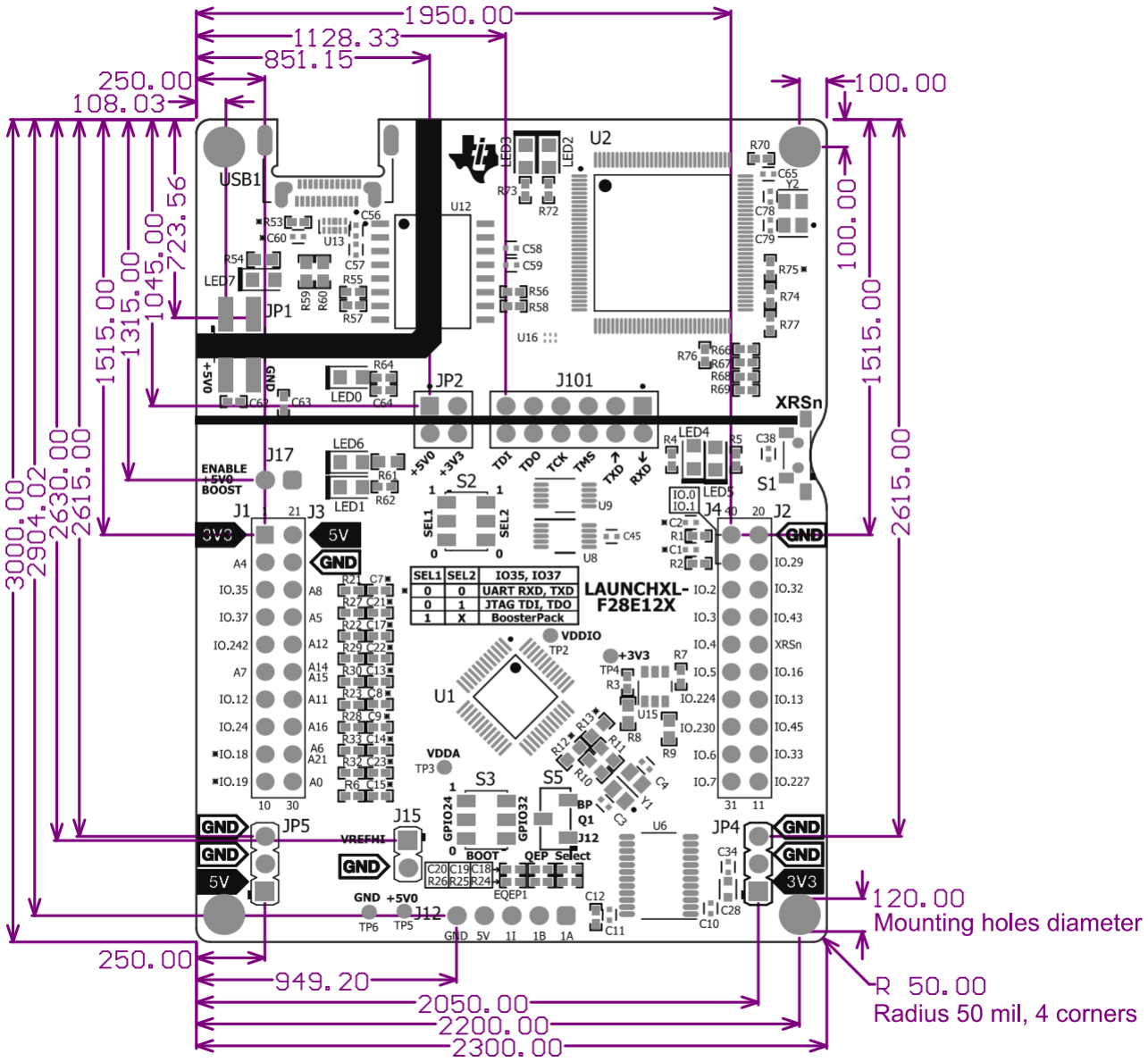


Figure 4-5. F28E12x LaunchPad Dimensions and Component Locations

4.3 Bill of Materials (BOM)

The BOM for the LAUNCHXL-F28E12X is included in the *LAUNCHXL-F28E12X design files* download.

5 Additional Information

5.1 Frequently Asked Questions

1. Why isn't my C2000 device getting any power even though I have the USB-C cable connected to USB1?
   a. Make sure that the USB 5V power and GND jumpers are connected (JP1).
   b. Make sure that the XDS110 5V and 3.3V power jumpers are connected (JP2).
2. Can other programming and debug tools (such as an XDS200 debug probe) be used with the F28E12x LaunchPad?
   a. The F28E12x LaunchPad utilizes an on-board XDS110 debug probe in a 4-pin JTAG configuration.
3. What versions of Code Composer Studio IDE can be used to develop software for the F28E12x LaunchPad?
   a. The on-board XDS110 debug probe is compatible with Code Composer Studio development environment version 6.1.0 and later.
4. Why can't I connect to the LaunchPad in Code Composer Studio IDE?
   a. Are shunts present on J101 for TCK and TMS?
   b. Is the XDS110 and the F28E120SC MCU powered? Are LED7, LED0, LED6 and LED1 illuminated? For further details on powering the LaunchPad, see Section 2.1.1.1.
      i. If JP1 shunts are disconnected, the power provided through the USB is isolated from the rest of the board. Make sure that 3.3V or 5V is supplied to any of the available connectors on the target side of the isolation.
   c. Is the USB-C cable connected to the PCB and is the USB region receiving power? Is LED7 illuminated?
      i. The XDS region must be powered with the 5V from the USB cable. LED7 illuminates when 5V USB power is connected. The XDS-side 5V to 3.3V LDO regulator requires 5V on the USB side to generate the +3V3 rail for the XDS110 device.
   d. Make sure that the S2 switch configuration matches the target configuration being used. Open the Target Configuration file (.ccxml) in Code Composer Studio IDE. Click on the Advanced tab. In the JTAG / SWD / cJTAG mode field, if *JTAG (1149.1) SWD and cJTAG are disabled* is selected, make sure S2 is in JTAG TDI, TDO mode. If *cJTAG (1149.7) 2-pin advanced modes* is selected, any S2 configuration can be used. Alternately, a working Target configuration file is included in the launchxl_ex1_f28e12x_demo project *F28E120SC.ccxml*. Use this without modifications.

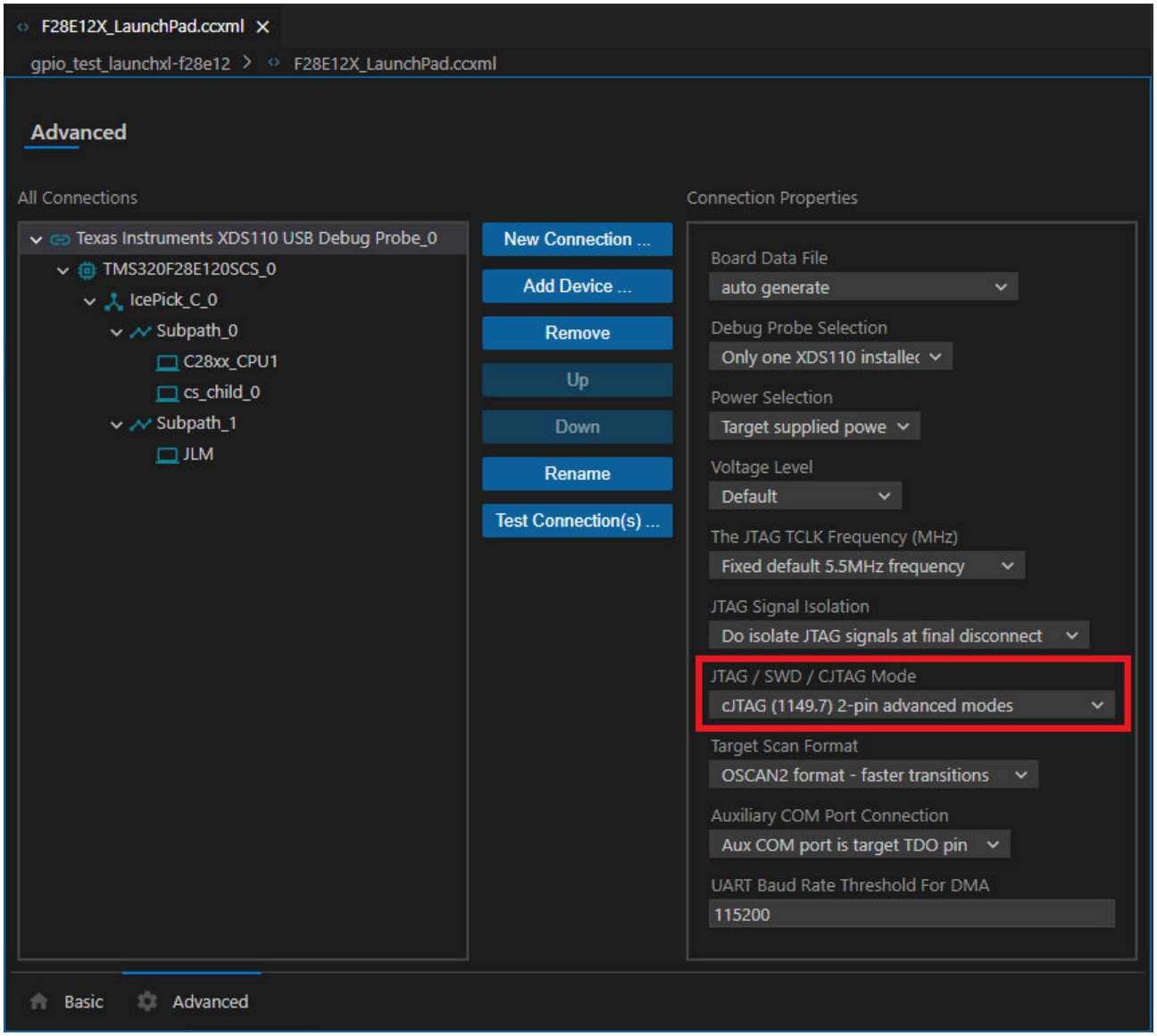


Figure 5-1. Target Configuration Advanced Options

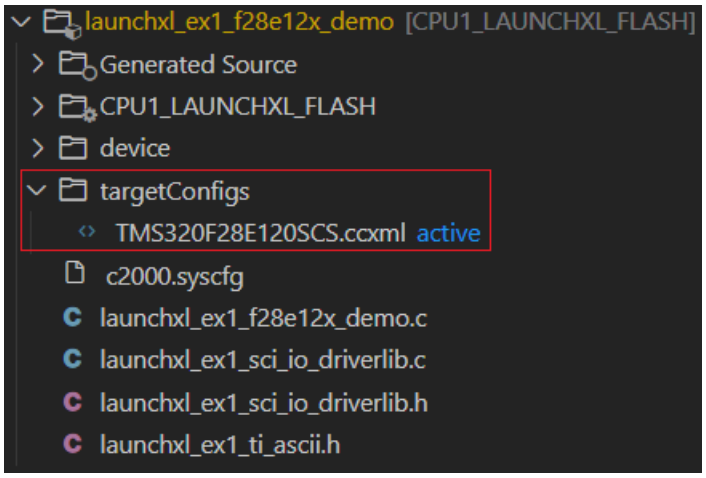


Figure 5-2. Target Configuration Included in the Demo Project

5. Why is the serial connection not working?

a. 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 to use.

b. 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 160MHz. If you have changed the PLL settings or developed your own code, you can recalculate the baud rate for your specific application. For information on how to do this, see the *F28E12x Real-Time Microcontrollers Technical Reference Manual*.

c. Is the UART channel connection to the debug probe enabled and does this match the channel configured in software?
   i. The F28E12x LaunchPad provides options for customizing the use of GPIO35 and GPIO37. In this program, use GPIO35 and GPIO37 as UART signals to establish a serial connection to the debug probe. Make sure that S2 is configured to the appropriate UART channel for the application software. For details, see Section 2.1.3.2.

5.2 Trademarks

6 References

6.1 Reference Documents

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

- *F28E120SCT C2000 Real-Time Microcontrollers*
- Texas Instruments: *F28E12x Real-Time Microcontrollers* data sheet
- Texas Instruments: *F28E12x Real-Time Microcontrollers Technical Reference Manual*
- Texas Instruments: *Getting Started With C2000™ Real-Time Control Microcontrollers (MCUs)*
- Texas Instruments: *The Essential Guide for Developing with C2000™ Real-Time Microcontrollers*
- Texas Instruments: *F28E12x Real-Time MCUs Silicon Errata*
- Texas Instruments: *LAUNCHXL-F28E12X LaunchPad Pinout Map*
- *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 the functions. A consolidated list of these components with links to the TI product pages is shown below.

- *ISOUSB111 Full/Low Speed Isolated USB Repeater*
- *MSP432E401Y SimpleLink™ 32-bit Arm Cortex-M4F MCU*
- *SN74LV4053A Triple 2-Channel Analog Multiplexer/Demultiplexer IC*
- *SN74LVC2G07 Dual Buffer/Driver With Open-Drain Output*
- *SN74LVC8T245 8-Bit Dual-Supply Bus Transceiver with Configurable Voltage-Level Shifting and Three-State Outputs*
- *TPD4E004 4-Channel ESD Protection Array for High-Speed Data Interfaces*
- *TPD4E05U06 4-Channel ESD Protection Array for for USB, HDMI & High Speed Interfaces*
- *TPS3808E Low-Quiescent-Current, Programmable-Delay Supervisory Circuit*
- *TPS61241 5V, 500mA, 4MHz Step-Up DC/DC Converter*
- *TPS7A80 Low-Noise, Wide-Bandwidth, High PSRR, Low-Dropout 1A Linear Regulator*
- *TS5A23157 5V, 2:1 (SPDT), 2-channel analog switch*

7 Revision History

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

Changes from Revision * (April 2025) to Revision A (July 2025)	Page
• Updated the entire document to reflect Revision A of EVM	1
• Added Section 1.3.1	3

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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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/lsds/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。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

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.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

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.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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