

**ABSTRACT**

The F2800157 controlCARD (TMDSCNCD2800157) from Texas Instruments (TI) provides a great way to learn and experiment with the F280015x devices. The F280015x device is a member of TI's C2000™ family of microcontrollers (MCUs). This 120-pin controlCARD is intended to provide a well-filtered robust design that is capable of working in most environments. This document provides the hardware details of the F2800157 controlCARD and explains the functions, locations of jumpers, and connectors present on the board.

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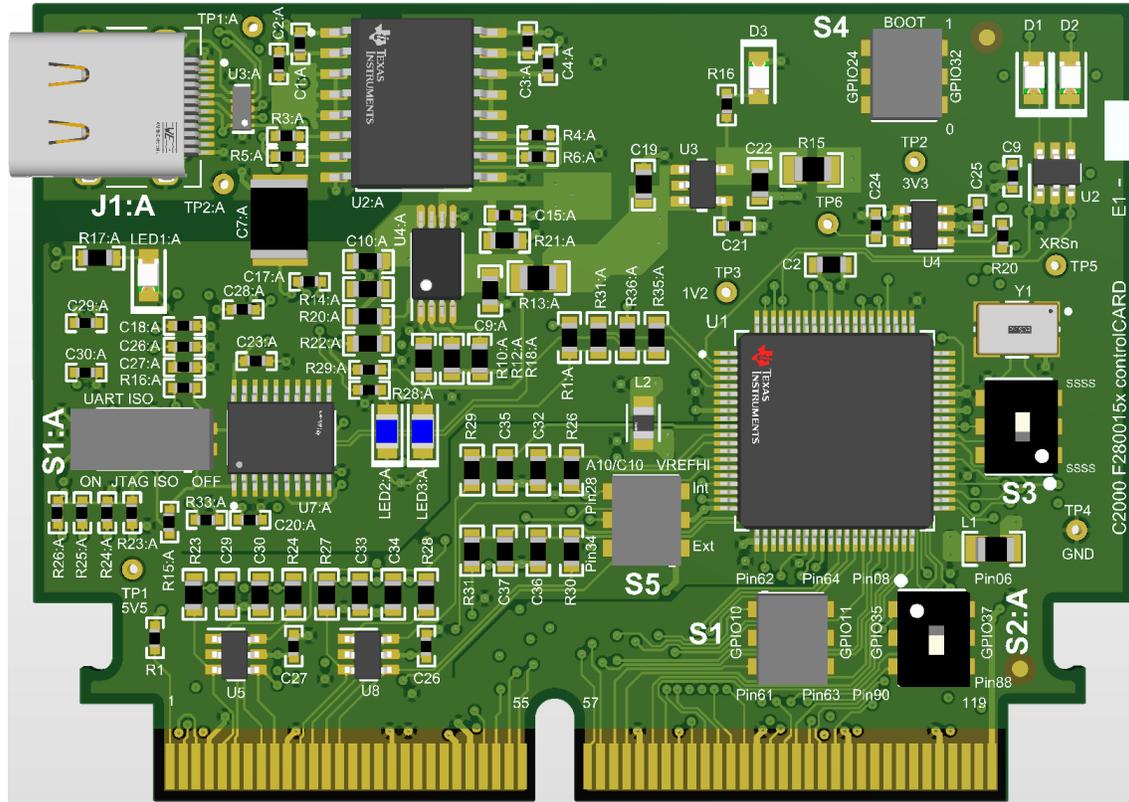
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## 1 Introduction



**Figure 1-1. F2800157 controlCARD**

Each controlCARD comes with a Hardware Developer's Kit, which is a full set of files necessary to evaluate and develop with a C2000 device. These files include:

- Schematics – Designed in Altium
- Bill of Materials (BOM)
- Layout PCB files - Designed in Altium
- Gerber files

The Hardware Developer's Kit for the controlCARD can be found in the [C2000Ware](#) at the following location:  
 - <install directory>\c2000\C2000Ware\_x\_xx\_xx\_xx\boards\controlCARDs\TMDSCNCD2800157\Rx\_x

### Note

This kit is designed to explore the functionality of the F280015x microcontroller. The controlCARD 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.

## 2 Hardware Quick Setup Guide

The controlCARD can be completely powered and operated from the USB-C connector. In this stand-alone mode the on-board isolated power supply will provide power to the F2800157 device; no additional hardware is required. Optionally, an external 5 V supply can be provided to power the F2800157 device. For a detailed explanation of the hardware configuration, see [Section 4.3](#).

### WARNING

When the controlCARD is used in a high-voltage setup, it is the user's responsibility to confirm that the voltages and isolation requirements are identified and understood prior to energizing the board or simulation. When energized, the controlCARD or components connected to the controlCARD cannot be touched. Furthermore, the capacitor C7:A must be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.

### 2.1 Configuration 1: Standalone

1. Connect a USB-C cable to J1:A.
2. Connect the other end of the USB cable to a USB2.0/USB3.x port.
3. LED1:A and D3 on the controlCARD illuminate.

### 2.2 Configuration 2: External 5-V Supply

1. Insert the TMDSCNCD2800157 controlCARD into a TMDSHSECDOCK, or other compatible docking station.
2. Connect a USB cable to J17 on the TMDSHSECDOCK.
3. Flip S1 to the "USB-ON" position on the TMDSHSECDOCK. The controlCARD automatically switches to the external 5-V supply.
4. LED1:A and D3 on the controlCARD illuminate.

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### Note

The TMDSCNCD2800157 controlCARD automatically switches to the external 5-V supply when present. No additional configuration is required.

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## 3 Errata

### 3.1 Warnings, Notes, and Errata

#### External power supply is needed when power requirements exceed USB limits

The F2800157 evaluation kit ships with a USB cable and is designed to be powered using USB. However, in extreme cases the board/controlCARD can require more power than the 5 V @ 500 mA (USB 3.0 - 900 mA) that a computer's USB port can provide. This is especially true when additional circuitry has been added to the TMDSHSECDOCK. In such cases, it is recommended to use an external 5-V power supply (2.5 mm inner diameter x 5.5 mm outer diameter) and plug the power supply into J1 on the TMDSHSECDOCK. A compatible power supply is:

- CUI SMM6-5-K-P6 + SMI-US-5

#### 5-V power supply instability can lead to device resets

The 5-V rail on the TMDSCNCD2800157 controlCARD can be powered from an on-board USB connector or from a baseboard like the TMDSHSECDOCK. A switch device on the controlCARD automatically selects the 5-V input power source for the controlCARD without the need for user configuration.

A loss of power or glitching on the baseboard 5-V power source can cause the automatic switch to disconnect from both power sources for several milliseconds. This momentary loss of power can cause a brownout condition on the MCU, triggering a device reset. To avoid this condition, make sure that the baseboard power supply remains at 0 V or 5 V during code execution.

#### CAN boot mode requires use of on-board crystal

The TMDSCNCD2800157 controlCARD supports the use of the CAN boot mode. This boot mode can be selected through switch S4. The CAN boot mode requires the use of an external crystal to clock the F2800157 device. Therefore, when using the CAN boot mode, the controlCARD must be configured to use the on-board crystal Y1 by setting switch S3 accordingly. See [Section 6](#) for more information on the S3 and S4 switches.

### 3.2 Warnings About Specific controlCARD Revisions

**Table 3-1. MCU106A**

| Issue  | Description   |
|--|---|
| 5-V power supply instability can lead to device resets | See <a href="#">Section 3.1</a> about power supply instability. |

**Table 3-2. MCU106E1**

| Issue  | Description  |
|--|--|
| Incorrect label on TP1                                 | TP1 is incorrectly labeled as 5V5 on the front side of the controlCARD PCB. TP1 corresponds to the HSEC_5V0 rail on the board. TP1 can be labeled 5V0. |
| 5-V power supply instability can lead to device resets | See <a href="#">Section 3.1</a> about power supply instability.  |

## 4 Getting Familiar with the controlCARD

### 4.1 F2800157 controlCARD Features

- **F2800157 Microcontroller** – High performance C2000 microcontroller is located on the controlCARD.
- **120-pin HSEC8 Edge Card Interface** – Allows for compatibility with all of C2000 180-pin controlCARD-based application kits and controlCARDs. Compatibility with 100-pin controlCARDs can be accomplished using the TMSADAP180TO100 adapter card (sold separately).
- **Built-in Isolated JTAG Emulation** – An XDS110 emulator provides a convenient interface to Code Composer Studio™ IDE without additional hardware. Flipping a switch allows an external JTAG emulator to be used.
- **Built-in Isolated Power Supply** - Passes the 5-V supply from the USB-C connector through an isolation barrier. Allows for the controlCARD to be completely powered and operated from the USB-C connector. The F2800157 is fully isolated from the USB port.
- **Automatic Power Supply Switch** - The controlCARD automatically switches to external 5-V power when present. No additional configuration is required.
- **Connectivity** – The controlCARD contains connectors that allow the user to experiment with isolated universal asynchronous receiver/transmitter (UART)/SCI with the F280015x MCU.
- **Key Signal Breakout** – Most GPIO, analog-to-digital converter (ADC) and other key signals routed to hard gold connector fingers.
- **Robust Power Supply Filtering** – Single 5-V input supply powers an on-card 3.3-V LDO. All MCU inputs are then decoupled using LC filters near the device.
- **ADC Clamping** – ADC inputs are clamped by protection diodes.
- **Anti-Aliasing Filters** – Noise filters (small RC filters) can be easily added on ADC input pins.

### 4.2 Assumed Operating Conditions

This kit is assumed to run at standard room conditions. Standard ambient temperature and pressure (SATP) with moderate-to-low humidity is assumed.

#### 4.2.1 External Power Supply or Accessory Requirements

**Nominal Output Voltage:** 5 VDC

**Maximum Output Current:** 3 A

**Efficiency Level V**

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#### 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.

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### 4.3 Using the controlCARD

For the controlCARD to operate, the controlCARD MCU must be powered. This is done through the USB-C connector on the controlCARD or by inputting 5 V through the HSEC connector using the accompanying baseboard. For example, if using a TMDSHSECDOCK docking station baseboard, 5 VDC can be input into the docking station J1 or J17. Then, S1 needs to be toggled to the appropriate position.

Based on the way the controlCARD is used, additional hardware settings are necessary (see [Table 4-1](#)).

#### WARNING

When the controlCARD is used in a high-voltage setup, confirm that the voltages and isolation requirements are identified and understood prior to energizing the board or simulation. When energized, the controlCARD or components connected to the controlCARD cannot be touched. Furthermore, the capacitor C7:A must be removed to minimize the possibility of leakage-current flowing across the isolation barrier of the controlCARD.

**Table 4-1. Emulator Switch Selections**

| Switch  | Debug using CCS IDE and the on-card XDS110 Emulator (2-pin cJTAG mode, default)  | Debug using CCS IDE and an External Emulator using the Baseboard   | Standalone (Boot from FLASH or other Boot Mode)   |
|---|--|--|---|
| <b>S1:A</b>   | Position 1: ON (left, <b>default</b> ) to connect the embedded XDS110 emulator to the MCU<br><br>Position 2: ON (left, <b>default</b> ) to connect the embedded XDS110 UART COM port to the MCU GPIO28 and GPIO29 pins   | Position 1: OFF (right) to disconnect the embedded XDS110 emulator from the MCU<br><br>Position 2: OFF (right) to disconnect the MCU GPIO28 and GPIO29 pins from the embedded XDS110 UART COM port   | Position 1: OFF (right) to disconnect the embedded XDS110 emulator from the MCU<br><br>Position 2: OFF (right) to disconnect the MCU GPIO28 and GPIO29 pins from the embedded XDS110 UART COM port  |
| <b>S2:A</b>   | DOWN ( <b>default</b> ) - Disconnects GPIO35/TDI and GPIO37/TDO from the embedded XDS110 emulator; 2-pin cJTAG mode must be used<br><br>Alternatively this switch be set to UP to connect the GPIO35 and GPIO37 to the embedded XDS110 emulator and enable 4-pin JTAG mode | DOWN ( <b>default</b> ) - Disconnects GPIO35/TDI and GPIO37/TDO from the external emulator; 2-pin cJTAG mode must be used<br><br>Alternatively this switch be set to UP to connect the GPIO35 and GPIO37 to the external emulator and enable 4-pin JTAG mode | DOWN ( <b>default</b> ) - Disconnects GPIO35/TDI and GPIO37/TDO from the embedded XDS110 emulator   |
| <b>S3</b>   | Up ( <b>default</b> ) - Enables GPIO19/X1 and GPIO18/X2 connection to the on-board XTAL (Y1).<br><br>Down - Disables GPIO19/X1 and GPIO18/X2 connection to the on-board XTAL (Y1); on-chip INTOSC must be used<br><br>Setup S3 as desired                                  | Up ( <b>default</b> ) - Enables GPIO19/X1 and GPIO18/X2 connection to the on-board XTAL (Y1).<br><br>Down - Disables GPIO19/X1 and GPIO18/X2 connection to the on-board XTAL (Y1); on-chip INTOSC must be used<br><br>Setup S3 as desired                    | Up ( <b>default</b> ) - Enables GPIO19/X1 and GPIO18/X2 connection to the on-board XTAL (Y1).<br><br>Down - Disables GPIO19/X1 and GPIO18/X2 connection to the on-board XTAL (Y1); on-chip INTOSC must be used<br><br>Setup S3 as desired |
| <b>S4</b>   | Setup S4 as desired<br><br>Putting the C2000 device into Wait Mode can reduce risk of connectivity issues  | Setup S4 as desired<br><br>Putting the C2000 device into Wait Mode can reduce risk of connectivity issues  | Set S4 as desired   |
| <b>J1:A</b>   | Connect a USB-C cable between J1:A and your computer<br><br>In CCS, use this target configuration: TMS320F2800157 device with an XDS110 emulator, 2-pin cJTAG mode (based on S2:A default configuration)   | ---  | ---   |
| <b>Baseboard JTAG connector (J2 on Docking Station)</b> | ---  | Connect an external emulator<br><br>In CCS IDE, use this target configuration: TMS320F2800157 device with 2-pin cJTAG mode (based on S2:A default configuration)   | ---   |

Code Composer Studio™ is an Integrated Development Environment (IDE) used to debug and develop software for the C2000 series of MCUs. CCS IDE can be downloaded from the following link:  
<http://www.ti.com/tool/ccstudio>.

### Note

By default, the TMDSCNCD2800157 controlCARD is configured for 2-pin cJTAG mode. The Code Composer Studio IDE target configuration used to communicate with the embedded XDS110 emulator must be configured for 2-pin cJTAG mode.

Also, GPIO19/X1 and GPIO18/X2 pins are connected on the on-board crystal (Y1) and are not connected to the 120-pin HSEC8 Edge Card Interface.

These and other hardware settings can be modified through switches on the controlCARD. For more details, see [Table 4-1](#).

The following PDF documents are provided, as part of C2000Ware, to describe where each of the F280015x MCU pins appear on the controlCARD connector/docking station:

- **TMDSCNCD2800157\_<rev>\_120cCARD\_pinout** – Indicates where each MCU pin goes on the HSEC controlCARD connector or the 120/180-pin controlCARD docking station.
- **TMDSCNCD2800157\_<rev>\_100DIM\_map** – Indicates where each MCU pin goes on the DIM100 controlCARD connector or the DIM100 docking station. This assumes that the TMDSDAP180TO100 adapter card is used.

More information on the controlCARD docking station can be found in the [C2000Ware](#) at the following location:  
<install\_directory>\c2000\C2000Ware\_<rev>\boards\controlCARDs\TMDSCNCD2800157\Rx\_x

## 4.4 Experimentation Software

[Code Composer Studio \(CCS\) Integrated Development Environment \(IDE\)](#) is recommended for developing and debugging software for the C2000 series of MCUs. The CCS IDE is free to download and use with the controlCARD. Introductory videos for CCS IDE are available at [training.ti.com](#).

[C2000Ware](#) contains a full suite of example software designed to work with the F280015x controlCARD.

This software package includes many example projects that allow the user to experiment with the ADC, PWM, and other C2000 peripherals.

Support files for both register-level and driver-level programming are included with C2000Ware:

- Register header files are located at:  
<install\_directory>\ti\c2000\C2000Ware\_<rev>\device\_support\F280015x\examples
- Driverlib programming examples are located at:  
<install\_directory>\ti\c2000\C2000Ware\_<rev>\driverlib\F280015x\examples

For users new to the F280015x series of devices and CCS IDE, TI's [C2000 Academy](#) provides several easy-to-follow training modules and hands-on lab exercises to help users get started quickly.

## 5 Special Notes

### 5.1 XDS110 Emulator and SCI (UART) Connectivity

The F2800157 controlCARD provides emulation and USB-to-UART adapter functionality on the controlCARD. This allows for a convenient method to debug and demonstrate the F280015x MCU.

Note that the MSP432 chip, support circuitry, and associated components are placed in Macro A (the left section of the controlCARD). Each of these components contains an additional “:A” within the component reference designator (that is, R2:A for resistor 2 in Macro A) (see [Figure 6-1](#) and [Figure 6-2](#)).

The configuration of the switches on S1:A determine if either the on-board emulator or an external emulator is connected to the MCU, and if the SCI (UART) pins on the MCU are connected to the COM port on the USB-C connector (see [Table 4-1](#)).

### 5.2 Clocking Methodology

This controlCARD is required to support a broad range of TI's baseboards. Several designs rely on GPIO18 and GPIO19 for SPIA, while others require these GPIO to be utilized as a precision clock input source. To accommodate both of these systems, a switch (S3) has been added to the design. This methodology can not be

used in a final system as this methodology increases EMI emissions and creates robustness susceptibilities. The system designer must choose the best way to implement the clocking circuitry for a given system.

### 5.3 Evaluation of the Analog-to-Digital Converters (ADCs)

When using the F2800157 on-chip ADCs, there are some useful guideline to follow to realize the performance numbers listed in the device-specific data manual. This is especially true for the AC parameters such as: SNR, THD, and SINAD. Furthermore, it can also be shown that there is a direct correlation between the SNR of the ADC result and the spread of ADC codes seen for a DC input; as such, these tips improve the range and standard deviation of a DC input as well. Finally, while topics addressed are with respect to the controlCARD, the topics are applicable to other implementations using the F2800157 MCU as well.

**On-board resistors and capacitors:** By default all inline resistors to the ADC pins are a simple 0- $\Omega$  shunt and all capacitors to the ground plane are not populated. While this circuit can be used to supply the ADC inputs with a voltage, likely both the resistor (R) and capacitor (C) need to be populated based on the voltage source characteristics. Referring to the ADC Input Model, the ADC input has their own RC network made up of the internal sample and hold capacitor, switch resistance, and parasitic capacitance. By changing the inline resistance and parallel capacitor, we can optimize the input circuit to assist with settling time and/or filtering the input signal. Finally, it is recommended in general to use Negative-Positive 0 PPM/ $^{\circ}$ C (NP0/C0G) capacitors as these have better stability over temperature and across input frequencies than other types of capacitors.

**Voltage source and drive circuitry:** While the on-chip ADCs are 12-bit architecture (4096 distinct output codes when converting an analog signal to the digital domain), the translation only is as precise as the input provided to the ADC. The typical rule of thumb when defining the source resolution to realize the full specification of an ADC is to have a 1-bit better source than the converter. In this case, that means that ideally the analog input can be accurate to 13-bits.

Typically voltage supplies or regulators are not designed to be precise, but rather accommodate a wide range of current loads within a certain tolerance and for this reason are not ideal to show the performance of a higher bit ADC, like the one on the F2800157. This also does not take into account that many times the supply in question is providing the main voltage to power the MCU itself; which also introduces noise and other artifacts into the signal.

In addition to the quality of the input signal, there is also the aspect of the load presented to the ADC when the ADC samples the input. Ideally, an input to an ADC has zero impedance so as not to impact the internal R/C network when the sampling event takes place. In many applications, however, the voltages that are sampled by the ADC are derived from a series of resistor networks, often large in value to decrease the active current consumption of the system. A solution to isolate the source impedance from the ADC sampling network is to place an operational amplifier in the signal path. Not only does this isolate the impedance of the signal from the ADC, it also shields the source itself from any effects the sampling network can have on the system.

**Recommended source for evaluation:** The [Precision Signal Injector \(PSI\) EVM](#) from TI can be used to validate the ADC performance on the F2800157 ControlCARD. This EVM supports both single ended as well as differential ended outputs using a [16-bit DAC](#) as the signal source then passed through a [high precision op-amp](#) with post amplifier filtering. The EVM is powered and controlled through a standard USB connection from a host PC and includes a GUI to control its output. The outputs are routed through single or dual SMA type connectors; it is highly recommended to place an additional female SMA connector ([Figure 5-1](#)) on the controlCARD docking station to receive the signal by way of SMA for best noise immunity. For the local RC network, 30- $\Omega$  resistors and 300-pF capacitors were used. Using this setup the ADC parameters were observed to be consistent with the numbers in the device-specific data sheet.

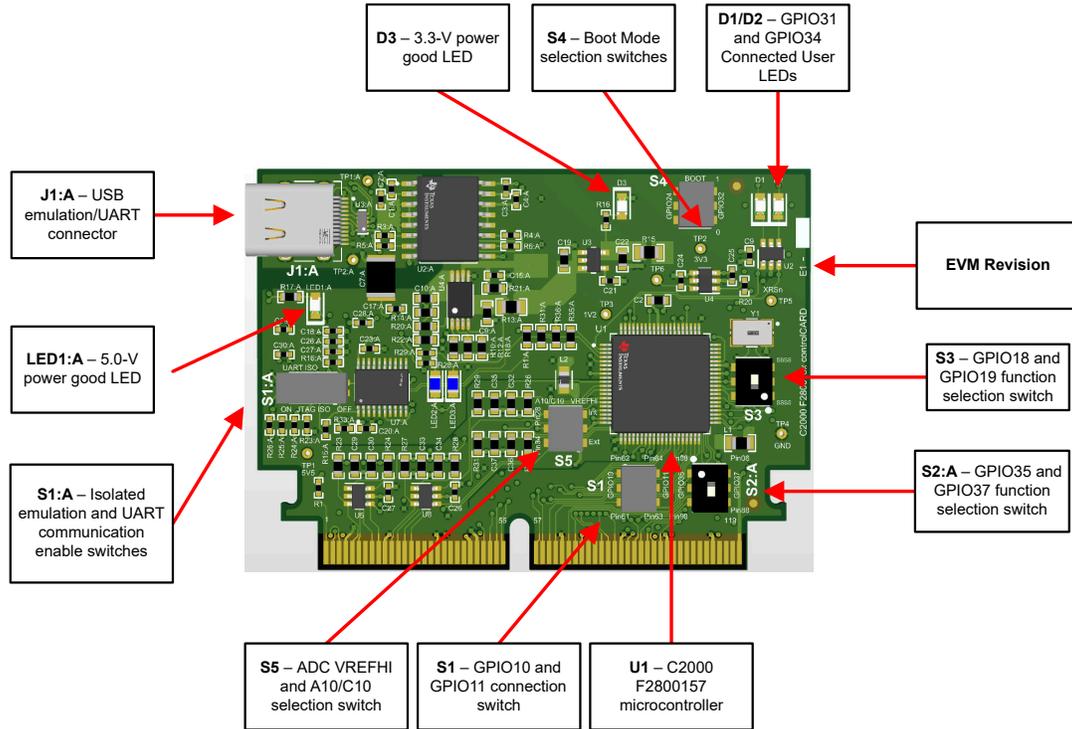


**Figure 5-1. Female SMA Connector**

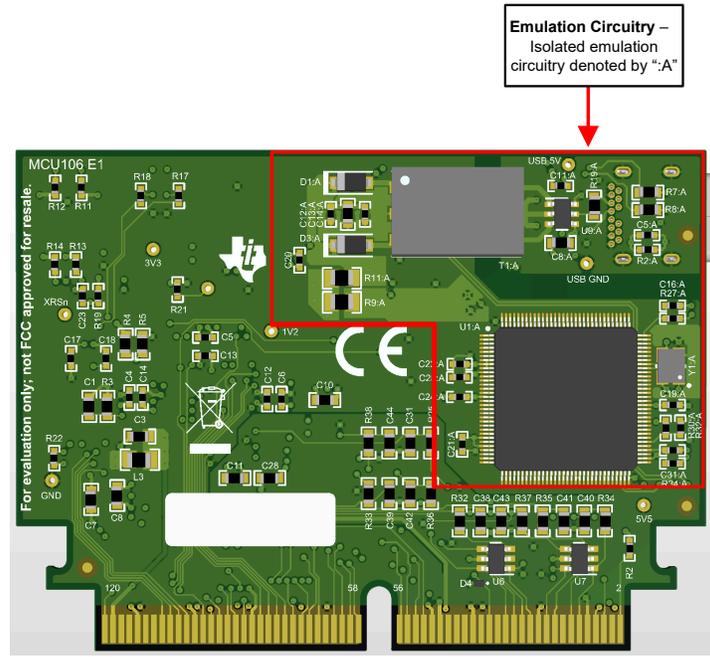
## 6 Hardware References

**WARNING**

When the controlCARD is used in a high-voltage setup, confirm that the voltages and isolation requirements are identified and understood prior to energizing the board or simulation. When energized, the controlCARD or components connected to the controlCARD cannot be touched. Furthermore, the capacitor C7:A must be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.



**Figure 6-1. Key Components on the controlCARD - Front**



**Figure 6-2. Key Components on the controlCARD - Back**

**Table 6-1. Hardware Connections**

| Connectors  |   |
|-------------|---|
| <b>J1:A</b> | Emulation/UART connector/Power - USB-C connector used to provide XDS110 emulation and USB-to-<br>UART (SCI) communication through MSP432 logic. S1:A determines which connections are enabled to the<br>MCU.<br>The USB-C connector also provides power on the controlCARD. |

| LEDs                 |   |
|----------------------|---|
| <b>LED1:A</b>        | Turns on (red) when 5 V is supplied to the controlCARD<br>(5 V can be supplied either through the USB-C connector or externally through the HSEC connector) |
| <b>LED2:A/LED3:A</b> | JTAG/UART RX/TX toggle indicator (blue)   |
| <b>D1</b>            | Controlled by GPIO31 with negative logic (red)  |
| <b>D2</b>            | Controlled by GPIO34 with negative logic (red)  |
| <b>D3</b>            | Turns on (green) when 3.3V is supplied to the controlCARD from the on-board LDO (U3)  |

| Resistors and Capacitors |  |
|--------------------------|--|
| <b>R23-R38</b>           | <b>ADC RC input filter resistors:</b> Series resistors which can be used to create an RC filter on the ADC's<br>input.   |
| <b>C29-C44</b>           | <b>ADC RC input filter capacitors:</b> Optional capacitors, not populated by default, for the ADC input's RC<br>filters. |

| <b>Switches</b> |  |
|-----------------|--|
| <b>S1:A</b>     | <p>Isolated emulation and UART communication enable switches:</p> <p><b>S1:A Position 1 – USB JTAG Enable:</b></p> <ul style="list-style-type: none"> <li>• <b>ON (default)</b> – All 4 JTAG signals from the embedded XDS110 emulation logic are passed across the isolation barrier. By default, only the TMS and TCK signals are connected to the MCU. This setting is valid when the MCU is being debugged or programmed using the embedded XDS110 emulator in <b>2-pin cJTAG</b> mode. To enable full JTAG mode, S2:A must be additionally configured.</li> <li>• <b>OFF</b> – The 4 JTAG signals from the embedded XDS110 emulation logic are NOT passed across the isolation barrier and are not connected to the MCU. This setting is valid when the device boots from FLASH, boots from a peripheral directly, or when an external JTAG emulator is used.</li> </ul> <p><b>S1:A Position 2 – USB UART communication enable:</b></p> <ul style="list-style-type: none"> <li>• <b>ON (default)</b> – The C2000 MCU GPIO28 and GPIO29 are connected to the embedded XDS110. This allows UART communication to a computer COM port. However, in this position, GPIO28 and GPIO29 are reserved for COM port use. The corresponding pins on the 180-pin controlCARD connector cannot be used for another function.</li> <li>• <b>OFF</b> – The C2000 MCU GPIO28 and GPIO29 are NOT connected to the embedded XDS110. The corresponding pins on the 180-pin controlCARD connector can be used for another function.</li> </ul> |
| <b>S2:A</b>     | <p><b>GPIO35/TDI and GPIO37/TDO Function Switch:</b><br/>This switch selects the function of the GPIO35 and GPIO37 pins</p> <ul style="list-style-type: none"> <li>• <b>UP position</b> - GPIO35 and GPIO37 are connected to HSEC pins 6 and 8, respectively. This setting is valid when using these pins as TDI and TDO in full JTAG mode.</li> <li>• <b>DOWN position (default)</b> - GPIO35 and GPIO37 are connected to HSEC pins 80 and 82, respectively. This setting is valid when using these pins as GPIO.</li> </ul>  |
| <b>S1</b>       | <p><b>GPIO10 and GPIO11 HSEC Connection Switch:</b><br/>This switch selects which HSEC pins the GPIO10 and GPIO11 pins are connected to</p> <ul style="list-style-type: none"> <li>• <b>UP position</b> - GPIO10 and GPIO11 are connected to HSEC pins 62 and 64, respectively.</li> <li>• <b>DOWN (default) position</b> - GPIO10 and GPIO11 are connected to HSEC pins 61 and 63, respectively.</li> </ul>   |
| <b>S3</b>       | <p><b>GPIO19/X1 and GPIO18/X2 Function Switch:</b><br/>This switch selects the function of the GPIO18 and GPIO19 pins</p> <ul style="list-style-type: none"> <li>• <b>UP position (default)</b> - GPIO18 and GPIO19 are connected to the on-board crystal (Y1). This setting is valid when using the external crystal.</li> <li>• <b>DOWN position</b> - GPIO18 and GPIO19 are connected to HSEC pins 71 and 73, respectively. This setting is valid when using the on-chip internal oscillator.</li> </ul>  |
| <b>S4</b>       | <p><b>Boot Mode Switch:</b> Controls the Boot Options of the F280015x device, see <a href="#">Table 6-2</a>. For a full description, see the device-specific data manual.</p>  |
| <b>S5</b>       | <p><b>Analog Configuration Switch:</b> This switch selects the source for VREFHI and the routing of the A10/C10 ADC channel.</p> <p><b>S4 Position 1 (left switch) –</b><br/>ADC channel A10/C10 HSEC pin selection</p> <ul style="list-style-type: none"> <li>• <b>UP position</b> – Channel A10/C10 goes to HSEC pin 34</li> <li>• <b>DOWN position (default)</b> – Channel A10/C10 goes to HSEC pin 28</li> </ul> <p><b>Position 2 (right switch) -</b><br/>ADC voltage reference selection</p> <ul style="list-style-type: none"> <li>• <b>UP position</b> – External voltage reference</li> <li>• <b>DOWN position (default)</b> – Internal voltage reference</li> </ul> <p>Note that additional software configuration is required to enable the ADC internal or external voltage reference.</p>   |

| Test Points  |   |
|--------------|---|
| <b>TP1:A</b> | <b>USB 5.0 V input:</b> This is the 5 V supply from the USB-C connector   |
| <b>TP2:A</b> | <b>USB GND input:</b> This GND from the USB-C connector   |
| <b>TP1</b>   | <b>HSEC 5.0 V input:</b> 5.0 V input provided to the controlCARD  |
| <b>TP2</b>   | <b>Unfiltered 3.3 V:</b> Provides power to the F280015x device  |
| <b>TP3</b>   | <b>MCU 1.2 V:</b> VDD 'core supply' to the F280015x device. Note that this controlCARD has been designed to use the internal voltage regulator by default. The internal voltage regulator can be disabled by removing R5 and populating R4. An external 1.2-V source must be supplied through the HSEC connector. |
| <b>TP4</b>   | <b>Device Ground</b>  |
| <b>TP5</b>   | <b>XRSn of F280015x device:</b> Connected to the XRSn pin of the F280015x device.   |

### Note

On the front of the controlCARD, test points are indicated by their TPx number.  
On the back of the controlCARD, test points are indicated by their signal.

**Table 6-2. S4, Bootmode Selection Table**

| Mode | Switch Position 1 (left switch, GPIO24) | Switch Position 2 (right switch, GPIO32) | Boot From     |
|------|---|--|---------------|
| 00   | 0 (down, default)                       | 0 (down, default)                        | Parallel I/O  |
| 01   | 1 (up)                                  | 0 (down)                                 | SCI/Wait Boot |
| 02   | 0 (down)                                | 1 (up)                                   | CAN           |
| 03   | 1 (up)                                  | 1 (up)                                   | Flash         |

## 7 Revision History

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

| Changes from Revision * (April 2022) to Revision A (January 2023) | Page |
|---|------|
| • Added second paragraph in <a href="#">Section 1</a> .....       | 2    |
| • Changed <a href="#">Section 3.1</a> .....                       | 4    |
| • Changed <a href="#">Section 3.2</a> .....                       | 4    |
| • Added <a href="#">Section 4.2.1</a> .....                       | 5    |
| • Changed S4 in <a href="#">Table 4-1</a> .....                   | 5    |

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2. *Limited Warranty and Related Remedies/Disclaimers:*
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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 DEGRADATION 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.

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

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

- 
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