

**ABSTRACT**

The F2800137 controlCARD (TMDSCNCD2800137) from Texas Instruments (TI) provides a great way to learn and experiment with the F280013x devices. The F280013x 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 F2800137 controlCARD and explains the functions, locations of jumpers, and connectors present on the board.

Table of Contents

| | |
|----------------------------------------------------------------|-----------|
| 1 Introduction | 2 |
| 2 Hardware Quick Setup Guide | 3 |
| 2.1 Configuration 1: Standalone..... | 3 |
| 2.2 Configuration 2: External 5 V Supply..... | 3 |
| 3 Errata | 4 |
| 3.1 Warnings, Notes, and Errata..... | 4 |
| 3.2 Warnings About Specific controlCARD Revisions..... | 4 |
| 4 Getting Familiar with the controlCARD | 5 |
| 4.1 F2800137 controlCARD Features..... | 5 |
| 4.2 Assumed Operating Conditions..... | 5 |
| 4.3 Power Supply Requirements..... | 5 |
| 4.4 Using the controlCARD..... | 5 |
| 4.5 Experimentation Software..... | 7 |
| 5 Special Notes | 7 |
| 5.1 XDS110 Emulator and SCI (UART) Connectivity..... | 7 |
| 5.2 Clocking Methodology..... | 7 |
| 5.3 Evaluation of the Analog-to-Digital Converters (ADCs)..... | 7 |
| 6 Hardware References | 9 |
| 7 Revision History | 12 |

List of Figures

| | |
|------------------------------------------------------------|----|
| Figure 1-1. F2800137 controlCARD..... | 2 |
| Figure 5-1. Female SMA Connector..... | 8 |
| Figure 6-1. Key Components on the controlCARD - Front..... | 9 |
| Figure 6-2. Key Components on the controlCARD - Back..... | 10 |

List of Tables

| | |
|----------------------------------------------|----|
| Table 3-1. MCU102A..... | 4 |
| Table 3-2. MCU102E1..... | 4 |
| Table 4-1. Emulator Switch Selections..... | 6 |
| Table 6-1. Hardware Connections..... | 10 |
| Table 6-2. S3, Bootmode Selection Table..... | 12 |

Trademarks

C2000™ and Code Composer Studio™ are trademarks of Texas Instruments.
All trademarks are the property of their respective owners.

1 Introduction

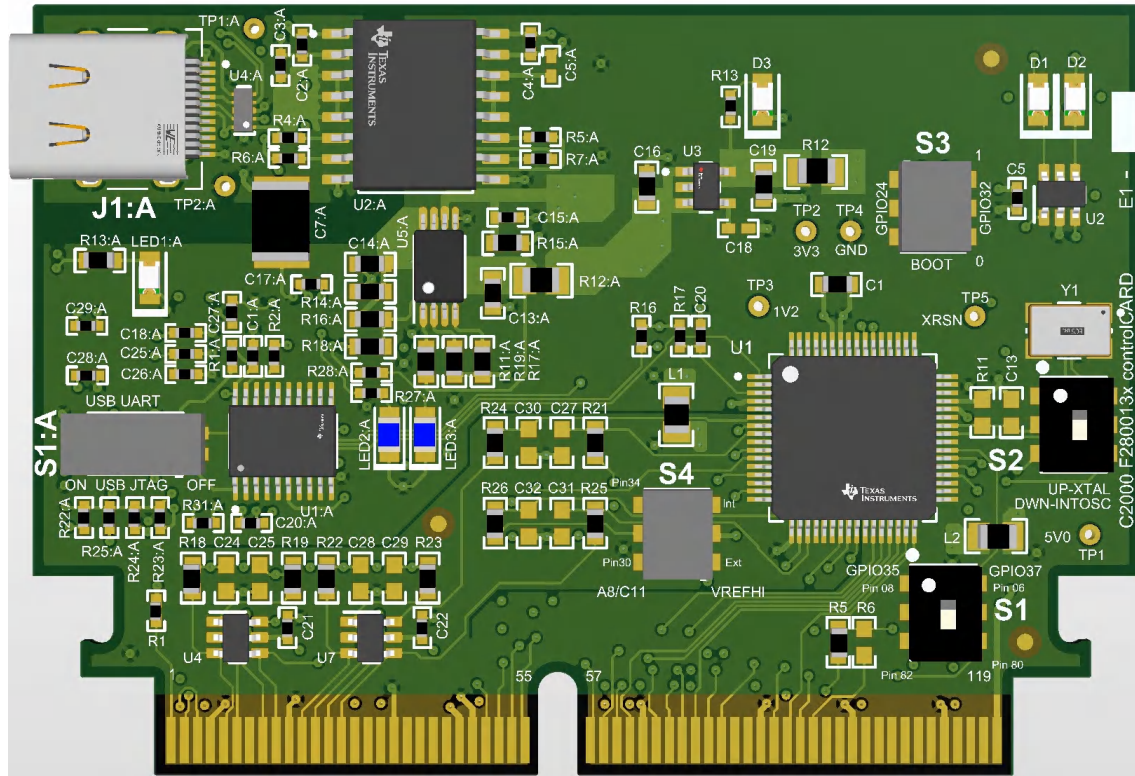


Figure 1-1. F2800137 controlCARD

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\TMDSCNCD2800137\Rx_x

Note

This kit is designed to explore the functionality of the F280013x microcontroller. The controlCARD can be treated as a good reference design; it 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 provides power to the F2800137 device; no additional hardware is required. Optionally, an external 5 V supply can be provided to power the F2800137 device. For a detailed explanation of the hardware configuration, see [Section 4.4](#).

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 should not be touched. Furthermore, the capacitor C7:A should 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 will illuminate.

2.2 Configuration 2: External 5 V Supply

1. Insert the TMDSCNCD2800137 controlCARD into a TMDSHSECDOCK, or other compatible docking station.
2. Connect a USB-B "mini" connector 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.

Note

The TMDSCNCD2800137 controlCARD automatically switches to the external 5 V supply when present. No additional configuration is required.

3 Errata

3.1 Warnings, Notes, and Errata

External power supply is needed when power requirements exceed USB limits

The F2800137 evaluation kit ships with a USB cable and is designed to be powered by way of 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 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 supply such as:

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

5-V power supply instability can lead to device resets

The 5-V rail on the TMDSCNCD280039C 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.

3.2 Warnings About Specific controlCARD Revisions

Table 3-1. MCU102A

| Issue | Description |
|--------------------------------------------------------|-----------------------------------------------------------------|
| 5-V power supply instability can lead to device resets | See Section 3.1 about power supply instability. |

Table 3-2. MCU102E1

| 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. |
| 5-V power supply instability can lead to device resets | See Section 3.1 about power supply instability. |
| EVM for software development only | This EVM is for software development only and is meant to be used only with the TMDSHSECDOCK. |

4 Getting Familiar with the controlCARD

4.1 F2800137 controlCARD Features

- **F2800137 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 TMDADAP180TO100 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 F2800137 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 F280013x 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.

4.3 Power Supply Requirements

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

4.3.1 External Power Supply or Accessory Requirements

Nominal Output Voltage: 5 VDC

Maximum Output Current: 3 A

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.

4.4 Using the controlCARD

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

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 can not be touched. Furthermore, the capacitor C7:A can be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.

Table 4-1. Emulator Switch Selections

| | Debug Using CCS IDE and the On-Card XDS110 Emulator | Debug Using CCS IDE and an External Emulator via the Baseboard | Standalone (Boot from Flash or Other Boot Mode) |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S1:A | Position 1: ON (left, default) | Position 1: OFF (right) | Position 1: OFF (right) |
| J1:A | Connect a USB-C cable between J1:A and your computer. In CCS IDE, use this target configuration: TMS320F2800137 device with an XDS110 emulator. | --- | --- |
| S1 | Setup S1 as desired. DOWN (default) - Disconnects GPIO35/TDI and GPIO37/TDO from the embedded XDS110 emulator; 2-pin cJTAG mode must be used UP - Connects GPIO35/TDI and GPIO37/TDO to the embedded XDS110 emulator; 4-pin JTAG mode can be used | Setup S1 as desired. DOWN (default) - Disconnects GPIO35/TDI and GPIO37/TDO from the external emulator; 2-pin cJTAG mode must be used UP - Connects GPIO35/TDI and GPIO37/TDO to the external emulator; 4-pin JTAG mode can be used | DOWN (default) |
| S2 | Setup S2 as desired. Up - Enables connection to the external XTAL (Y1). Down (default) - Disables connection to the external XTAL (Y1); on-chip INTOSC must be used. | Setup S2 as desired. Up - Enables connection to the external XTAL (Y1). Down (default) - Disables connection to the external XTAL (Y1); on-chip INTOSC must be used. | Setup S2 as desired. Up - Enables connection to the external XTAL (Y1). Down (default) - Disables connection to the external XTAL (Y1); on-chip INTOSC must be used. |
| S3 | Position 1: up- Logic 1 Position 2: down- Logic 0 Putting the C2000 device into WaitMode can reduce the risk of connectivity issues. | Position 1: down- Logic 1 Position 2: up- Logic 0 Putting the C2000 device into Wait Mode can reduce the risk of connectivity issues. | Set S3 as desired |
| Baseboard's JTAG connector (J2 on Docking Station) | --- | Connect an external emulator. | --- |

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

The following PDF documents are provided as part of [C2000Ware](#), to describe where each of the F280013x MCU pins appear on the controlCARD connector/docking station:

- **TMDSNCND2800137_120cCARD_map**– Describes where each MCU pin goes on the HSEC controlCARD connector or the 120/180-pin controlCARD docking station.
- **TMDSNCND2800137_100DIM_map** – Describes where each MCU pin goes to on the DIM100 controlCARD connector or the DIM100 docking station. This assumes that the TMSADAP180TO100 adapter card is used.

More information on the controlCARD docking station can be found at the following location:

- <install directory>\c2000\C2000Ware_x_xx_xx_xx\boards\controlCARDs\TMDSNCND2800137\Rx_x

4.5 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 are available at training.ti.com.

[C2000Ware](#) contains a full suite of example software designed to work with the F280013x 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: `\\ti\c2000\C2000Ware_XXXX\device_support\F280013x\examples`
- Driverlib programming examples are located at: `\\ti\c2000\C2000Ware_XXXX\driverlib\F280013x\examples`

For users new to C2000's F280013x series of devices and CCS, 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 F2800137 controlCARD provides emulation and USB-to-UART adapter functionality on the controlCARD. This allows for a convenient method to debug and demonstrate the F280013x MCU.

Note that the MSP432 chip, its 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 GPIO 19 for EPWM6, while others require these GPIO to be utilized as a precision clock input source. To accommodate both of these systems a switch (S2) has been added to the design. This methodology should not be used in a final system as it increases EMI emissions and creates robustness susceptibilities. It is up to the system designer to 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 F2800137 on-chip ADCs there are some useful guideline to follow to realize the performance numbers listed in the device-specific data sheet. 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, the 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 F2800137 MCU as well.

On-board resistors and capacitors: By default all inline resistors to the ADC pins are a simple 0-Ω 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) are to be populated based on the voltage source's characteristics. Referring to the ADC Input Model, the ADC input has its 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, you 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/°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 is only 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 F2800137. This does also 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 it samples the input. Ideally an input to an ADC would have 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 may 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 F2800137 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 via SMA for best noise immunity. For the local RC network, 30-Ω 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, 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 can not be touched. Furthermore, the capacitor C7:A can be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.

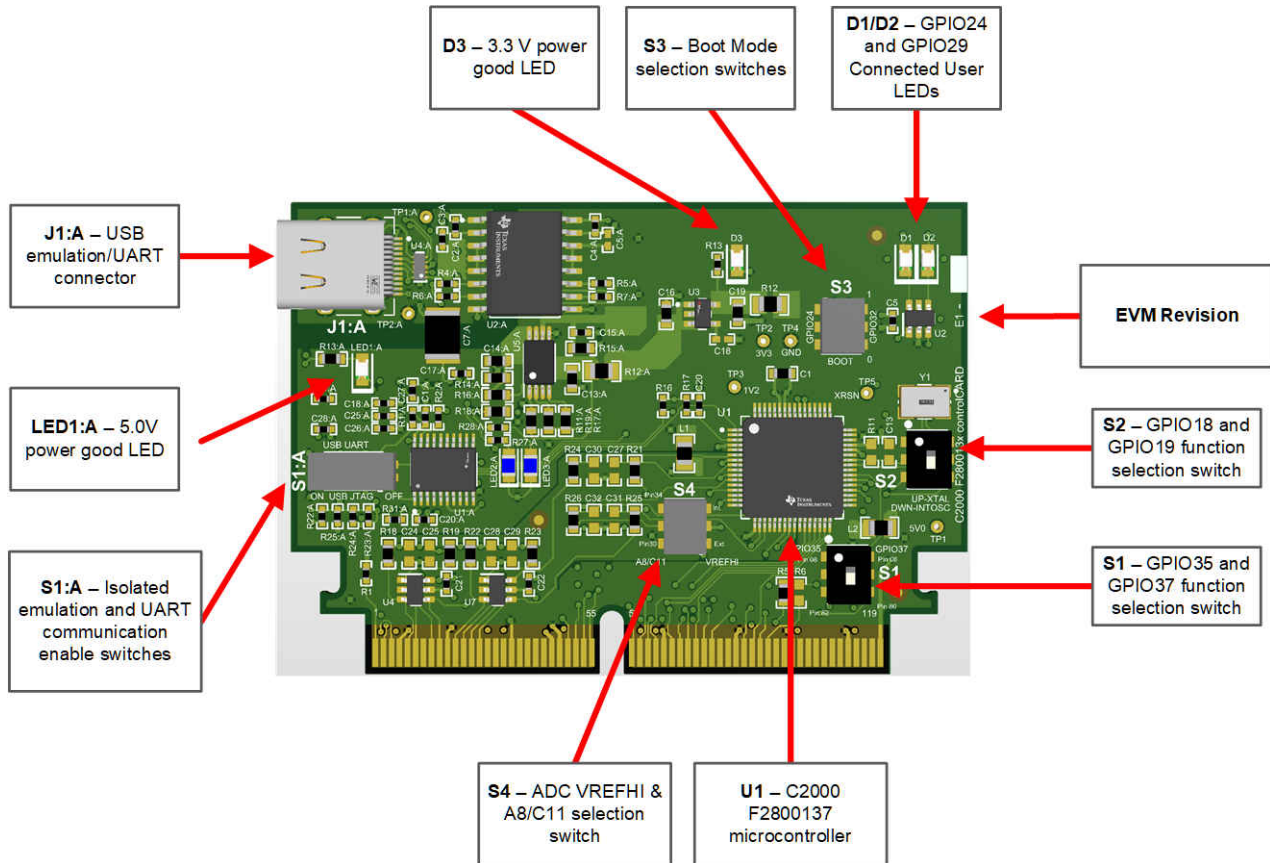


Figure 6-1. Key Components on the controlCARD - Front

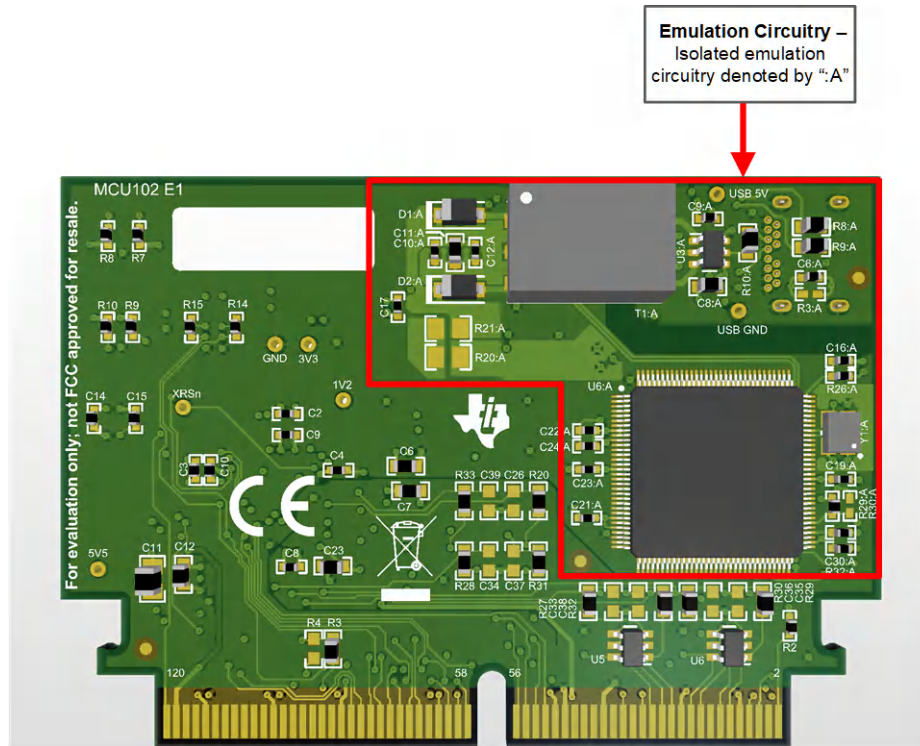


Figure 6-2. Key Components on the controlCARD - Back

Table 6-1. Hardware Connections

| Connectors | |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| J1:A | Emulation/UART connector/Power - USB-C connector used to provide XDS110 emulation and USB-to- UART (SCI) communication through MSP432 logic. S1:A determines which connections are enabled to the MCU. The USB-C connector also provides power on the controlCARD. |
| LEDs | |
| LED1:A | Turns on (red) when 5 V is supplied to the controlCARD (5 V can be supplied either through the USB-C connector or externally through the HSEC connector) |
| LED2:A/LED3:A | JTAG/UART RX/TX toggle indicator (blue) |
| D1 | Controlled by GPIO–24 with negative logic (red) |
| D2 | Controlled by GPIO–39 with negative logic (red) |
| D3 | Turns on (green) when 3.3 V is supplied to the controlCARD from the on-board LDO (U3) |
| Resistors and Capacitors | |
| R18-R33 | ADC RC input filter resistors: Series resistors which can be used to create an RC filter on the ADC's input. |
| C24-C39 | ADC RC input filter capacitors: Optional capacitors, not populated by default, for the ADC input's RC filters. |
| R11 and C13 | External precision resistor. Optional external precision resistor (ExtR), no populated by default, to achieve better accuracy with INTOSC2. Refer to the F280013x data sheet for more information on the ExtR feature. |

| Switches | |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S1:A | <p>Isolated emulation and UART communication enable switches:</p> <p>S1:A Position 1 – USB JTAG Enable:</p> <ul style="list-style-type: none"> ON – All 4 JTAG signals from the 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 via the on-card XDS110 emulator in cJTAG mode. To enable full JTAG mode, S1 must be additionally configured. OFF – The 4 JTAG signals from the 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. <p>S1:A Position 2 – USB UART communication enable:</p> <ul style="list-style-type: none"> ON – The C2000 MCU GPIO-28 and GPIO-29 are connected to the MSP432 on the XDS110. This allows UART communication to a computer COM port. However, in this position, GPIO-28 and GPIO-29 are reserved for COM port use. The corresponding pins on the 180-pin controlCARD connector cannot be used for another function. OFF – The C2000 MCU GPIO-28 and GPIO-29 are NOT connected to the MSP432 on the XDS110. The corresponding pins on the 180-pin controlCARD connector can be used for another function. |
| S1 | <p>GPIO35/TDI and GPIO37/TDO Function Switch: This switch selects the function of the GPIO35 and GPIO37 pins</p> <ul style="list-style-type: none"> Upward position - 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. Downward position - GPIO35 and GPIO37 are connected to HSEC pins 80 and 82, respectively. This setting is valid when using these pins as GPIO. |
| S2 | <p>PWM6 or external crystal selection switch: This switch enables the use of PWM6 or an external crystal. This methodology was required to support the full range of TI's baseboards and is not recommended in a production system. For full details, see Section 5.2.</p> |
| S3 | <p>Boot Mode Switch: Controls the Boot Options of the F280013x device, see the Table 6-2. For a full description, see the device-specific data sheet.</p> |
| S4 | <p>Analog Configuration Switch: This switch selects the source for VREFHI and the routing of the A8/C11 ADC channel.</p> <p>S4 Position 1 (left switch) – ADC channel A8/C11 HSEC pin selection</p> <ul style="list-style-type: none"> Upward position – Channel A8/C11 goes to HSEC pin 34 Downward Position – Channel A8/C11 goes to HSEC pin 30 <p>Position 2 (right switch) - ADC voltage reference selection.</p> <ul style="list-style-type: none"> Upward position – Internal voltage reference Downward Position – External voltage reference <p>Note that additional software configuration is required to enable the ADC internal or external voltage reference.</p> |

| Test Points | |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| TP1:A | USB 5.0 V input: This is the 5 V supply from the USB-C connector. |
| TP2:A | USB GND input: This GND from the USB-C connector. |
| TP1 | HSEC 5.0 V input: 5.0 V input provided to the controlCARD. |
| TP2 | Unfiltered 3.3 V: Provides power to the F280013x device. |
| TP3 | MCU 1.2 V: VDD 'core supply' to the F280013x device. Note that this controlCARD has been designed to use the internal voltage regulator. |
| TP4 | Device Ground |
| TP5 | XRSn of F280013x device: Connected to the XRSn pin of the F280013x 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. S3, Bootmode Selection Table

| Mode | Switch Position 1 (left switch, GPIO-24) | Switch Position 2 (right switch, GPIO-32) | Boot From |
|------|------------------------------------------|-------------------------------------------|---------------|
| 00 | 0 (down) | 0 (down) | Parallel I/O |
| 01 | 1 (up) | 0 (down) | SCI/Wait Boot |
| 02 | 0 (down) | 1 (up) | CAN |
| 03 | 1 (up) | 1 (up) | Flash/USB |

7 Revision History

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

Changes from November 1, 2021 to October 20, 2022 (from Revision A (November 2021) to Revision B (October 2022))

| | Page |
|----------------------------------------------------------------|-------------|
| • Added Warning in Section 2 | 3 |
| • Deleted paragraph in Section 3 | 4 |
| • Changed Section 3.1 | 4 |
| • Added Table 3-1 | 4 |
| • Changed Table 3-2 | 4 |
| • Added Section 4.3 | 5 |
| • Added Section 4.3.1 | 5 |
| • Deleted first paragraph in Section 4.4 | 5 |
| • Added Warning in Section 4.4 | 5 |
| • Changed Table 4-1 | 5 |
| • Added Warning in Section 6 | 9 |

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductor products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 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.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 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.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・インスツルメンツ株式会社
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/lstds/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。http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated