

# TMDSCNCD28P55X controlCARD Information Guide



## Description

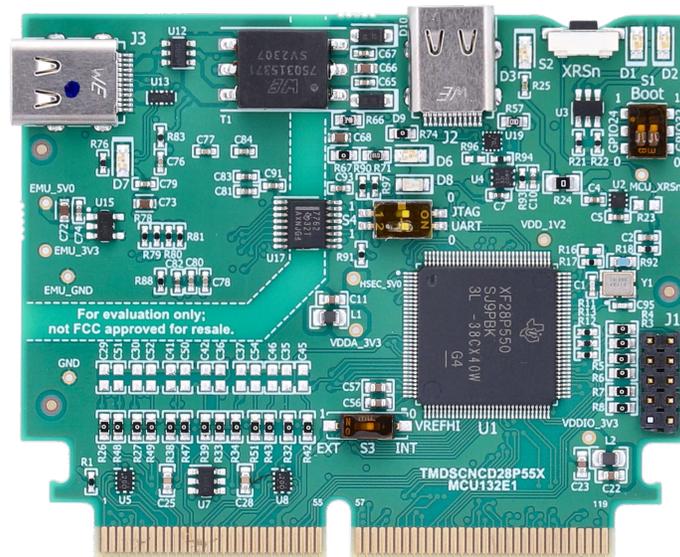
The TMDSCNCD28P55X is a low-cost evaluation and development board for TI C2000™ MCU series of F28P55x devices. The TMDSCNCD28P55X comes with a HSEC180 (180-pin High speed edge connector) and, as a controlCARD, is an excellent choice for initial evaluation and prototyping. For evaluation of TMDSCNCD28P55X, a 180-pin docking station TMDSHSECDOCK is required and can be purchased separately or as a bundled kit.

## Features

- **F28P55X 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 TMDSADAP180TO100 adapter card.
- **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 5V 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 F28P55X is fully isolated from the USB port.
- **Automatic Power Supply Switch** - The controlCARD automatically switches to external 5V power when present.
- **Connectivity** – The controlCARD contains connectors that allow the user to experiment with isolated UART/SCI with the F28P55x 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 5V input supply powers an on-card 3.3V LDO. All MCU inputs are then decoupled using LC filters.
- **ADC Protection/Filtering** – ADC inputs are clamped by protection diodes and noise filters can be easily added.



F28P55x controlCARD

# 1 Evaluation Module Overview

## 1.1 Introduction

The F28P55x ControlCARD (TMDSCNCD28P55X) from Texas Instruments (TI) provides a great way to learn and experiment with the F28P55x devices. The F28P55x 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 capable of working in most environments. This document provides the hardware details of the F28P55x controlCARD and explains the functions, locations of jumpers, and connectors present on the board.

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### Note

This kit is designed to explore the functionality of the F28P55x 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.

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## 1.2 Kit Contents

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 [TMDSCNCD28P55X-Schematic](#)
- Bill of Materials (BOM) [TMDSCNCD28P55X-design files](#)
- Layout PCB files - Designed in Altium [TMDSCNCD28P55X-design files](#)
- Gerber files [TMDSCNCD28P55X-design files](#)
- TMDSCNCD28P55X\_Revx\_120cCARD\_pinout

The Hardware Developer's Kit for the controlCARD can also be found in the [C2000Ware](#) at the following location:

- <install directory>\c2000\C2000Ware\_x\_xx\_xx\_xx\boards\controlCARDs\TMDSCNCD28P55X\Rx\_x

## 1.3 Specification

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

*Nominal Output Voltage: 5 VDC*

*Maximum Output Current: 3A*

*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.

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## 1.4 Device Information

The TMS320F28P55x (F28P55x) is a member of the C2000™ real-time microcontroller family of scalable, ultra-low latency devices designed for efficiency in power electronics, including but not limited to: high power density, high switching frequencies, and supporting the use of GaN and SiC technologies.

There are [applications](#), such as:

- [Motor drives](#)
- [Appliances](#)
- [Hybrid, electric & powertrain systems](#)
- [Solar & EV charging](#)
- [Digital power](#)
- [Body electronics & lighting](#)
- [Test & measurement](#)

The [real-time control subsystem](#) is based on TI's 32-bit C28x DSP core, which provides 150MHz of signal-processing performance for floating- or fixed-point code running from either on-chip flash or SRAM. The C28x CPU is further boosted by the [Floating-Point Unit \(FPU\)](#), [Trigonometric Math Unit \(TMU\)](#), and [VCRC \(Cyclical Redundancy Check\) extended instruction sets](#), speeding up common algorithms key to real-time control systems.

The CLA allows significant offloading of common tasks from the main C28x CPU. The CLA is an independent 32-bit floating-point math accelerator that executes in parallel with the CPU. Additionally, the CLA has dedicated memory resources and can directly access the key peripherals that are required in a typical control system. Support of a subset of ANSI C is standard, as are key features like hardware breakpoints and hardware task-switching.

The F28P55x supports up to 1088KB of flash memory divided into four 256KB banks plus one 64KB bank, which enable programming one bank and execution in another bank in parallel. Up to 133KB of on-chip SRAM is also available to supplement the flash memory.

The Live Firmware Update hardware enhancements on F28P55x allow fast context switching from the old firmware to the new firmware to minimize application downtime when updating the device firmware.

High-performance analog blocks are integrated on the F28P55x real-time microcontroller (MCU) and are closely coupled with the processing and PWM units to provide the best real-time signal chain performance. Twenty-four PWM channels, all supporting frequency-independent resolution modes, enable control of various power stages from a 3-phase inverter to power factor correction and advanced multilevel power topologies.

The inclusion of the Configurable Logic Block (CLB) allows the user to add [custom logic](#) and potentially [integrate FPGA-like functions](#) into the C2000 real-time MCU.

Interfacing is supported through various industry-standard communication ports (such as SPI, SCI, I2C, PMBus, LIN, and CAN FD) and offers [multiple pin-muxing options](#) for the best signal placement.

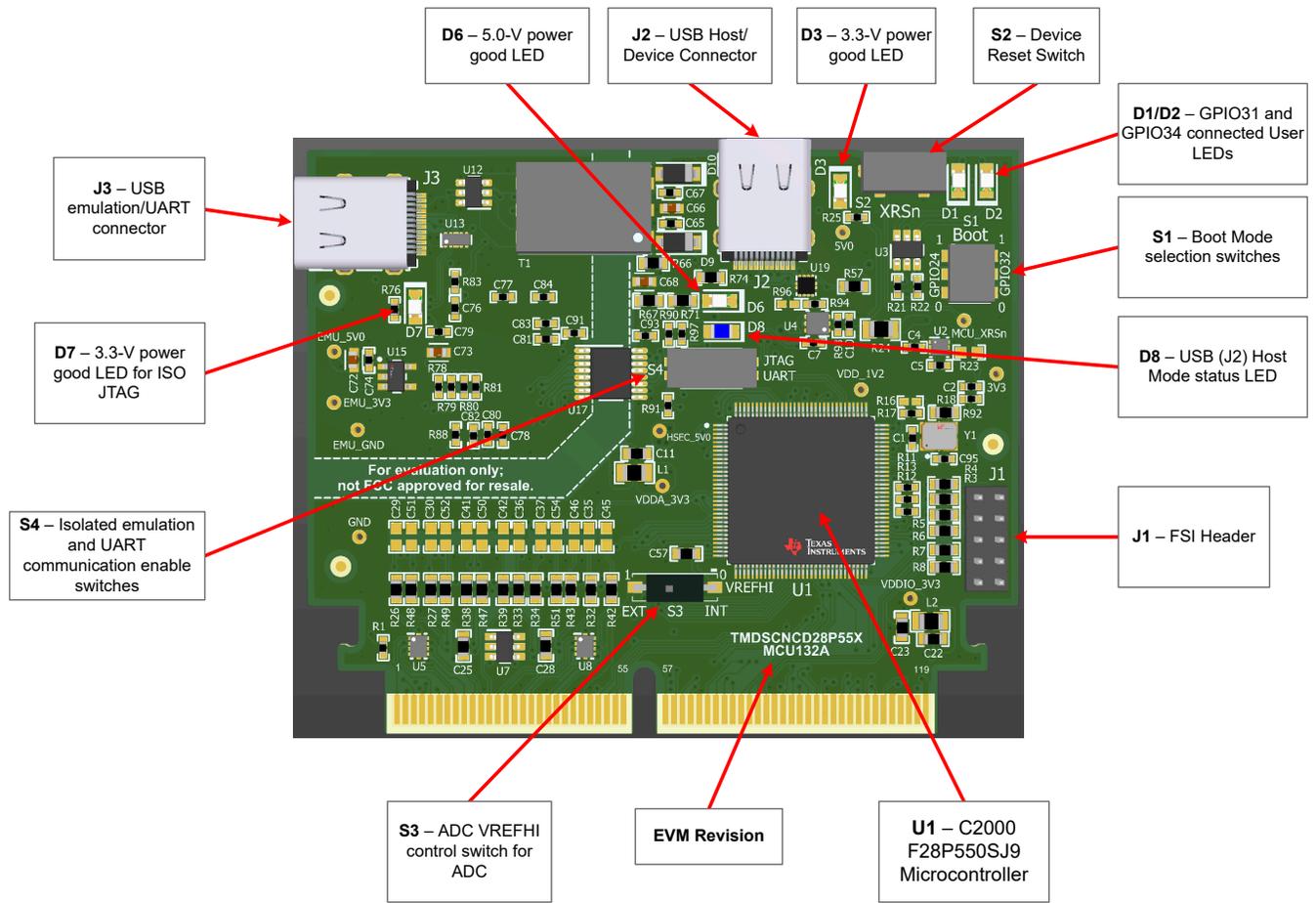
Want to learn more about features that make C2000 Real-Time MCUs the right choice for your real-time control system? Check out [The Essential Guide for Developing With C2000™ Real-Time Microcontrollers](#) and visit the [C2000™ real-time control MCUs](#) page.

The [Getting Started With C2000™ Real-Time Control Microcontrollers \(MCUs\) Getting Started Guide](#) covers all aspects of development with C2000 devices from hardware to support resources. In addition to key reference documents, each section provides relevant links and resources to further expand on the information covered.

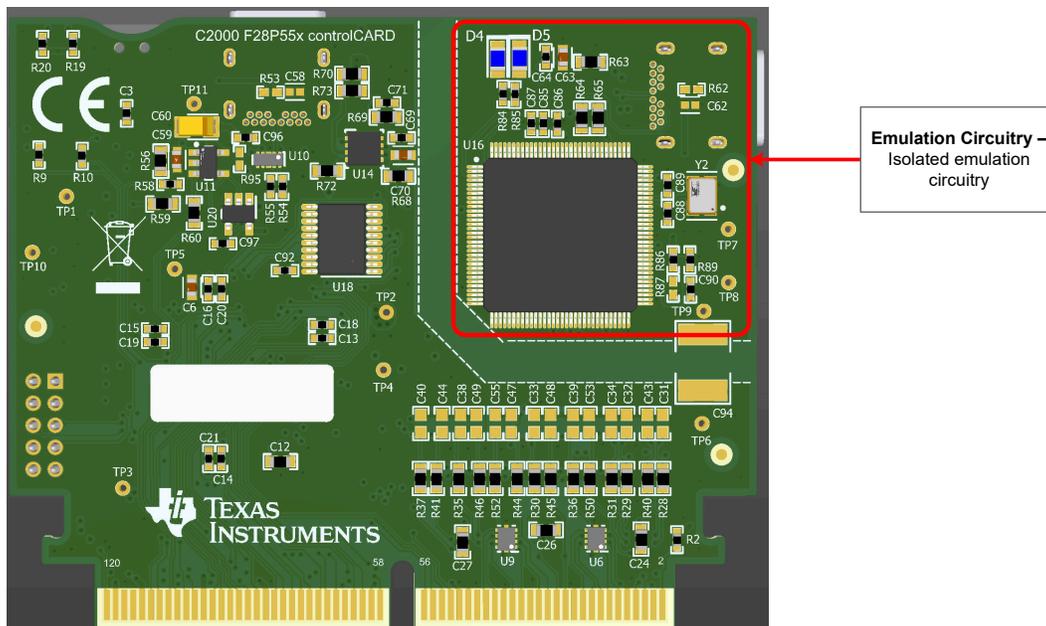
For additional information, refer to the TMS320F28P55x data sheet ([SPRSP85](#)).

## 2 Hardware

### 2.1 Hardware References



**Figure 2-1. Key Components on the controlCARD - Front**



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

**Table 2-1. Hardware Connections**

Connectors	
<b>J1</b>	FSI Header
<b>J2</b>	Type C USB Connector - Data Peripheral to MCU. This connector supports DRP for dynamic switching between host mode (DFP) and device mode (UFP).
<b>J3</b>	Emulation/UART connector/Power - USB-C connector used to provide XDS110 emulation and USB-to-UART (SCI) communication through MSP432 logic. S4 determines which connections are enabled to the MCU. The USB-C connector also provides power on the controlCARD.

**Table 2-2. LEDs**

LEDs	
<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 (U4).
<b>D4/D5</b>	LEDs controlled by XDS110.
<b>D6</b>	Turns on (red) when 5V is supplied to the controlCARD (5V can be supplied either through the USB-C connector or externally through the HSEC connector).
<b>D7</b>	Turns on when JTAG logic is powered on (green).
<b>D8</b>	Turns on when USB Data Connector (J2) is operating in host mode (DFP).
<b>D9/D10</b>	Output of onboard transformer.

**Table 2-3. Resistors and Capacitors**

Resistors and Capacitors	
R26-R52	ADC RC input filter resistors: Series resistors which can be used to create an RC filter on the input of the ADC.
C29-C55	ADC RC input filter capacitors: Optional capacitors, not populated by default, for the ADC RC filter of the input.

**Table 2-4. Switches**

Switches	
<b>S1</b>	<b>Boot Mode Switch:</b> Controls the Boot Options of the F28P55x device, see <a href="#">Table 2-6</a> . For a full description, see the device specific data sheet.
<b>S2</b>	<b>Reset switch:</b> Switch connected to the XRSn line of the F28P55x device. Pressing this button pulls the device reset low.
<b>S3</b>	<b>ADC VREFHI Control Switch:</b> <ul style="list-style-type: none"> <li><b>LEFT position</b> - ADCs are configured to use an external voltage reference.</li> <li><b>RIGHT (default) position</b> - ADCs are configured to use an internal voltage reference which can be selected to be 0V to 3.3V or 0V to 2.5V.</li> </ul>
<b>S4</b>	Isolated emulation and UART communication enable switches: <b>S4 Position 1 – USB JTAG Enable:</b> <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 and connected to the MCU. This setting is valid when the MCU is being debugged or programmed using the embedded XDS110 emulator.</li> <li><b>OFF</b> – The 4 JTAG signals from the embedded XDS110 emulation logic are 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> <b>S4 Position 2 – USB UART communication enable:</b> <ul style="list-style-type: none"> <li><b>ON (default)</b>– The C2000 MCU GPIO28 is 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 is NOT connected to the embedded XDS110. The corresponding pins on the 180-pin controlCARD connector can be used for another function.</li> </ul>

**Table 2-5. Test Points**

Test Points	
<b>TP1</b>	<b>XRSn of F28P55X device:</b> Connected to the XRSn pin of the F28P55x device
<b>TP2</b>	<b>HSEC 5.0V input:</b> 5.0V input provided to the controlCARD
<b>TP3</b>	<b>Filtered Digital 3.3V:</b> Provides digital power to the F28P55x device
<b>TP4</b>	<b>Filtered Analog 3.3V:</b> Provides analog power to the F28P55x device
<b>TP5</b>	<b>Filtered 1.2V:</b> VDD <i>core supply</i> to the F28P55x device
<b>TP6</b>	<b>Device Ground</b>
<b>TP7</b>	<b>USB 5.0V input:</b> This is the 5V supply from the USB-C connector
<b>TP8</b>	<b>Unfiltered 3.3V:</b> Provides power to the MSP432 device
<b>TP9</b>	<b>USB GND input:</b> This GND from the USB-C connector
<b>TP10</b>	<b>Unfiltered 3.3V:</b> Output of the 5V to 3.3V LDO which provides 3.3V power to the F28P55x side of the board
<b>TP11</b>	<b>5V input:</b> Output of the power selection switch

**Note**

On the front of the controlCARD, test points are indicated by the signal net name.  
On the back of the controlCARD, test points are indicated by the TP designator number.

**Table 2-6. S3, Bootmode Selection**

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

## 2.2 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 F28P55x device; no additional hardware is required. Optionally, an external 5V supply can be provided to power the F28P55x device. For a detailed explanation of the hardware configuration, see [Section 3.1](#).

### **WARNING**

When the controlCARD is used in a high-voltage setup, the user is responsible 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 C94 must remain unpopulated to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.

### 2.2.1 Configuration 1: Standalone

1. Connect a USB-C cable to J3.
2. Connect the other end of the USB cable to a USB2.0/USB3.x port.
3. LEDs D3, D5, D6 and D7 on the controlCARD illuminate.

### 2.2.2 Configuration 2: External 5V Supply

1. Insert the TMDSCNCD28P55X 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 5V supply.
4. LEDs D3 and D6 on the controlCARD illuminate.

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### **Note**

TMDSCNCD28P55X controlCARD automatically switches to the external 5V supply when present. No additional configuration is required.

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## 2.3 Errata

### 2.3.1 Warnings, Notes, and Errata

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

The F28P55X Experimenter's Kit ships with a USB cable and is designed to be powered via USB. However, in extreme cases, the board/controlCARD can require more power than the 5V at 500mA (USB 3.0 - 900mA) that a computer USB port can provide. This is especially true when additional circuitry has been added to the docking station. In such cases, TI recommends to use an external 5V power supply (2.5mm inner diameter x 5.5mm outer diameter) and plug into J1. A compatible supply such as:

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

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

The 5V rail on the TMDSCNCD28P55X 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 5V input power source for the controlCARD without the need for user configuration.

A loss of power or glitching on the baseboard 5V 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 0V or 5V during code execution.

See [SPRZ545](#) for more information.

### 2.3.2 Warnings About Specific controlCARD Revisions

**Table 2-7. MCU132A**

Issue	Description
PGA2_INM inaccessible on TMDSHSECDOCK	On MCU132A, pin 28 (A5, B12, C2, PGA2_INM) is pinned out to pin 19 on the TMDSHSECDOCK. However, on the docking station, this pin is tied to board GND.

**Table 2-8. MCU132E1**

Issue	Description
PGA2_INM inaccessible on TMDSHSECDOCK	On MCU132E1, pin 28 (A5, B12, C2, PGA2_INM) is pinned out to pin 19 on the TMDSHSECDOCK. However, on the docking station, this pin is tied to board GND.
No test point for output of 5V Power Supply Switch	On MCU132E1, there is no test point (TP) to monitor the output of the 5V power supply switch.

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

When using the F28P55X 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, 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 F28P55x MCU as well.

**On-board resistors and capacitors:** By default all inline resistors to the ADC pins are a simple 0Ω 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 the 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 filtering the input signal. Finally, TI recommends to use Negative-Positive 0PPM/°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), the translation only is as precise as the input provided to the ADC. The recommended method 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 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. For this reason, typical voltage supplies are not the best choice to show the performance of a higher bit ADC, such as the one on the F28P55x. Many times the supply in question is providing the main voltage to power the MCU; 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. 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 method to isolate the source impedance from the ADC sampling network is to place an operational amplifier in the signal path. Placing an operational amplifier in the signal path does not only isolate the impedance of the signal from the ADC, but also shields the source 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 F28P55x 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 the output. The outputs are routed through single or dual SMA type connectors; TI highly recommends to place an additional female SMA connector ([Figure 2-3](#)) on the controlCARD docking station to receive the signal by way of SMA for best noise immunity. For the local RC network, 30Ω resistors and 300pF capacitors were used. Using this setup, the ADC parameters were observed to be consistent with the numbers in the device-specific data sheet.



**Figure 2-3. Female SMA Connector**

## 3 Software

### 3.1 Using the controlCARD

For the controlCARD to operate, the controlCARD MCU must be powered. This is done through the USB-C connector J3 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 3-1](#)).

#### Note

MCU is not powered via type-C USB connector J2 on the controlCARD. This USB is to be used only for data-peripheral connection with the C2000 MCU.

**Table 3-1. Emulator Switch Selections**

Switch	Debug using CCS IDE and the on-card XDS110 Emulator (4-pin JTAG mode only)	Debug using CCS IDE and an External Emulator using the Baseboard	Standalone (Boot from FLASH or other Boot Mode)
<b>S4</b>	Position 1: ON (right, <b>default</b> ) to connect the embedded XDS110 emulator to the MCU Position 2: ON (right, <b>default</b> ) to connect the embedded XDS110 UART COM port to the MCU GPIO28 pin.	Position 1: OFF (left) to disconnect the embedded XDS110 emulator from the MCU Position 2: OFF (left) to disconnect the embedded XDS110 UART COM port to the MCU GPIO28 pin.	Position 1: OFF (left) Position 2: OFF (left)
<b>J3</b>	Connect a USB-C cable between J3 and your computer In CCS, use this target configuration: TMS320F28P550SJ9 device with an XDS110 emulator, 4-pin JTAG mode only.	---	---
<b>S1</b>	Position 1 (GPIO24): down-Logic 0 Position 2 (GPIO32): up- Logic 1 Putting the C2000 device into Wait Mode can reduce risk of connectivity issues	Position 1 (GPIO24): down-Logic 0 Position 2 (GPIO32): up- Logic 1 Putting the C2000 device into Wait Mode can reduce risk of connectivity issues	Setup S3 as desired
<b>Baseboard JTAG connector (J2 on Docking Station)</b>	---	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. 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 F28P55x MCU pins appears on the controlCARD connector/docking station:

- **TMDSCNCD28P55X\_<rev>\_120cCARD\_pinout** – Indicates where each MCU pin goes on the HSEC controlCARD connector or the 120/180-pin controlCARD docking station.
- **TMDSCNCD28P55X\_<rev>\_100DIM\_map** – Indicates where each MCU pin goes on the DIM100 controlCARD connector or the DIM100 docking station. This assumes that the TMDSDADAP180TO100 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\TMDSCNCD28P55X\Rx\_x.

### 3.2 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](http://training.ti.com).

[C2000Ware](#) contains a full suite of example software designed to work with the F28P55x 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\F28P55x\examples
- Driverlib programming examples are located at:  
<install\_directory>\ti\c2000\C2000Ware\_<rev>\driverlib\F28P55x\examples

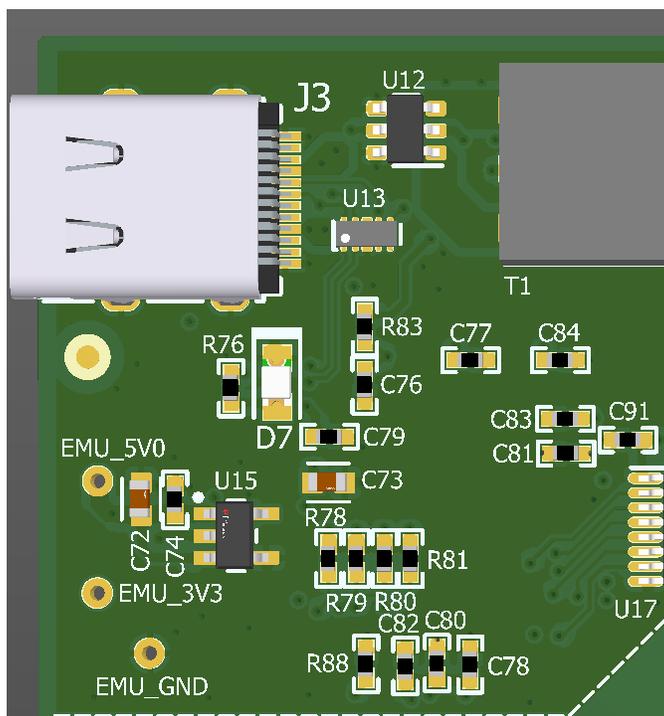
For users new to the F28P55x series of devices and CCS IDE, TI's [C2000 Academy](#) provides several easy-to-follow training modules and hands-on lab exercises to help users get started quickly.

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

The F28P55X controlCARD provides emulation and USB-to-UART adapter functionality on the controlCARD. This allows for a convenient method to debug and demonstrate the F28P55x MCU.

Note that the MSP432 chip, support circuitry, and associated components are placed toward the left section of the controlCARD. (see [Figure 3-1](#)).

The configuration of the switches on S4 determines 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 3-1](#)).



**Figure 3-1. XDS110 Emulation Circuitry and Isolation Circuitry**

## 4 Hardware Design Files

### 4.1 Schematics

The controlCARD's schematic can be found at this link: [TMDSCNCD28P55X-Schematic](#).

### 4.2 PCB Layouts

The layout source files for the TMDSCNCD28P55X are included in the [TMDSCNCD28P55X design files](#) download.

### 4.3 Bill of Materials (BOM)

The BOM for the TMDSCNCD28P55X is included in the [TMDSCNCD28P55X design files](#) download.

## 5 Additional Information

### 5.1 Trademarks

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

## 6 Revision History

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

<b>Changes from Revision * (November 2023) to Revision A (April 2024)</b>	<b>Page</b>
• First public release.....	<b>1</b>

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  - 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](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。

<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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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。

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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](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page)

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#### 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.

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- 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.

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