User's Guide
Piccolo F280049C controlCARD Information Guide

TEXAS INSTRUMENTS

ABSTRACT

The Piccolo F280049C controlCARD from Texas Instruments (TI) is intended to provide a well-filtered robust design capable of working in most environments. This document describes the hardware details of the F280049C controlCARD and explains the functions, locations of jumpers, and connectors present on the board.

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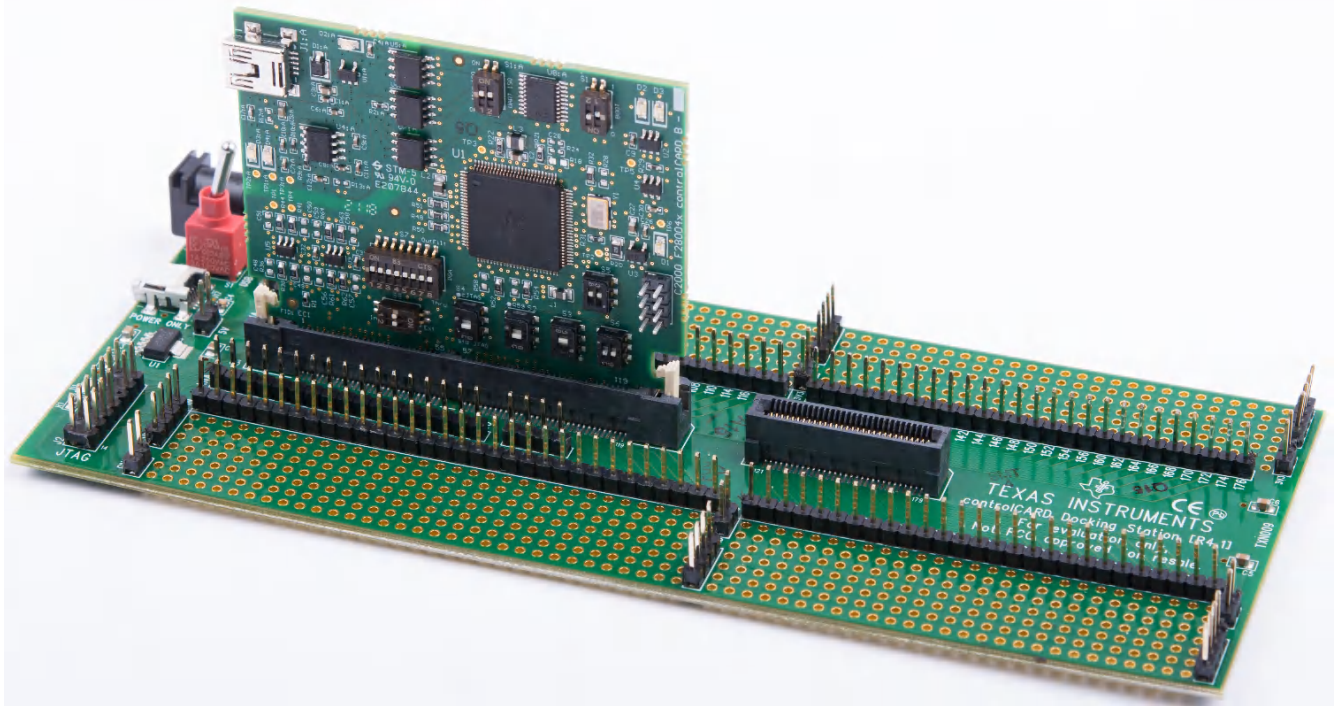
1 Introduction

Figure 1-1. F280049C controlCARD Installed on TMDSHSECDOCK

The Piccolo F280049C controlCARD from Texas Instruments (TI) provides a great way to learn and experiment with the F28004x device family within TI's C2000 family of microcontrollers (MCUs). This controlCARD uses the 120HSEC connector (compatible with the TMDSHSECDOCK docking station) and is intended to provide a well-filtered robust design capable of working in most environments. This document describes the hardware details of the F280049C controlCARD and explains the functions, locations of jumpers, and connectors present on the board.

The Hardware Developer's Kit, which is a full set of files necessary to evaluate and develop with the F280049C 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\TMDSCNCD280049C\Rx_x

> **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 C26:A should be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.

Note

This kit is designed to explore the functionality of the F28004x microcontroller family. The controlCARD can be treated as a good reference design, but 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 final customer system.

This controlCARD can be obtained by ordering one of the products from Table 1-1.

Table 1-1. F280049C controlCARD Part Numbers

Part Number	Status	Description
TMDXDOCK280049M	Experimental	XF280049M controlCARD and HSEC docking station bundle
TMDSDOCK280049C	Qualified	F280049C controlCARD and HSEC docking station bundle
TMDSCNCD280049C	Qualified	F280049C controlCARD

2 Errata

Current revision of controlCARD as of June, 2018: PCB rev - B, ASSY rev - none.

2.1 Warnings, Notes, and Errata

Notes for all controlCARDs:

- The docking station is capable of drawing power through the included USB cable. However, when external components are added to the docking station for experimentation, the system may require more power than a standard USB port can provide (5-V and 500-mA). This is especially true when additional circuitry has been added to the docking station. In such cases, an external 5-VDC power supply (2.5-mm inner diameter × 5.5-mm outer diameter) plugged into J1 is recommended. A compatible supply could be the: Phihong PSAC05R-050(P)-R-C2 + Phihong RPBAG.
- The F280049C by default expects GPIO24 and GPIO32 to be the input pins responsible for determining the device boot mode at power up; the external pull directions for GPIO24 and GPIO32 are configured with S1 (see Table 5-2). If desired, the GPIO pins used for boot mode selection can be modified by programming the OTP in the device. Refer to the Boot ROM section of the specific device's Technical Reference Manual (TRM) for more information.
- The controlCARD included with TMDXDOCK280049M uses prototype silicon XF280049M. XF280049M is a prototype variant only, and is not offered in production. It has the same functionality and configuration as the qualified variant F280049C.

3 Getting Familiar With the controlCARD

3.1 F280049C controlCARD Features

- **Piccolo F280049C Microcontroller** – High performance C2000 microcontroller on the controlCARD.
- **120pin HSEC8 Edge Card Interface** – Allows for compatibility with all of C2000's 120- or 180-pin controlCARD-based application kits and TMDSHSECDOCK. Compatibility with 100-pin DIMM controlCARDs can be accomplished using the TMDSADAP180TO100 adapter card (sold separately).
- **Built-in Isolated JTAG Emulation** – An XDS100v2 emulator provides a convenient interface to Code Composer Studio without additional hardware. Flipping a switch allows an external JTAG emulator to be used. This external emulator may use standard 4-pin JTAG or 2-pin cJTAG.
- **Key Signal Breakout** – Most GPIO, ADC, and other key signals routed to hard gold connector fingers.
- **Robust Power Supply Filtering** – Single 5-VDC supply provides power to onboard 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 several ADC input pins.

3.2 F28004x Device Description

For a complete description of the F28004x devices, see Section 1.3 of the *TMS320F28004x Piccolo™ Microcontrollers* data sheet (SPRS945).

3.3 Assumed Operating Conditions

This kit is assumed to run at standard room conditions. The EVM should run at approximately Standard Ambient Temperature and Pressure (SATP) with moderate-to-low humidity.

3.4 Using the controlCARD

For the controlCARD to work, the controlCARD MCU must be powered. This is usually done by inputting 5-VDC through the HSEC connector through an accompanying baseboard. For example, if using a TMDSHSECDOCK docking station baseboard, 5-VDC should be input into the docking station's J1 or J17, then S1 must be toggled to the appropriate position.

Based on the way that the controlCARD is used, additional hardware settings may be necessary, as shown in Table 3-1.

<table>
<tr><td align="center">**WARNING**</td></tr>
<tr><td>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 C26:A should be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.</td></tr>
</table>

Table 3-1. Getting Started Reference

Component	Debug Using CCS and the on-card XDS100v2 Emulator	Debug Using CCS and an External Emulator Through the Baseboard	Standalone (Boot From FLASH or Other Boot Mode)
S1:A (controlCARD)	Left (Switch 1): Up (ON)	Left (Switch 1): Down (OFF)	Left (Switch 1): Down (OFF)
J1:A (controlCARD)	Connect a mini USB cable between J1:A and the computer. In CCS, use this target configuration: TMS320F280049C device with an XDS100v2 emulator.	—	—
S1 (controlCARD)	Left (Switch 2): Down (ON) Right (Switch 1): Up (OFF) Putting the C2000 device into Wait Mode can reduce the risk of connectivity issues.	Left (Switch 2): Down (ON) Right (Switch 1): Up (OFF) Putting the C2000 device into Wait Mode can reduce the risk of connectivity issues.	Set S1 as desired (See Table 5-2 for supported settings)

Table 3-1. Getting Started Reference (continued)

Component	Debug Using CCS and the on-card XDS100v2 Emulator	Debug Using CCS and an External Emulator Through the Baseboard	Standalone (Boot From FLASH or Other Boot Mode)
Baseboard's JTAG connector (J2 on the TMDSHSECDOCK Docking Station baseboard)	—	Connect an external emulator and appropriately configure the CCS target configuration.	—

The F280049C controlCARD to docking station signal mapping can be found in the C2000Ware controlCARD product directory at \ti\c2000\C2000Ware_XXXX\boards\controlCARDs:

- **TMDSCNCD28004x_RevA_120cCARD_pinout.pdf** -- F280049C signal mapping on the default HSEC docking station
- **TMDSCNCD28004x_RevA_100DIM_map.pdf** -- F280049C signal mapping on the legacy DIM100 docking station if using TMDSADAP180TO100 adapter card

Hardware support files for the F280049C controlCARD and docking station can also be found in the C2000Ware product directories:

- F280049C controlCARD: \ti\c2000\C2000Ware_XXXX\boards\controlCARDs
- Docking station: \ti\c2000\C2000Ware_XXXX\boards\ExperimenterKits

3.5 Software Development

Code Composer Studio (CCS) is the recommended integrated development environment (IDE) for developing and debugging software for the C2000 series of MCUs. CCS is free to download and use with the controlCARD.

For users new to C2000's F28004x 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.

Note

For users of TMDXDOCK280049M

TMS320F280049M is a discontinued part number that is not supported on new installations of CCS. Use the functionally equivalent TMS320F280049C part number when creating a new target configuration for TMDXDOCK280049M on new installations of CCS.

C2000Ware contains a full suite of example software designed to work with the F280049C controlCARD. This software package includes many example projects which 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 programming examples are located at: \ti\c2000\C2000Ware_XXXX\device_support\f28004x\examples
- Driverlib programming examples are located at: \ti\c2000\C2000Ware_XXXX\driverlib\f28004x\examples

4 Special Notes

4.1 XDS100v2 Emulator and SCI/UART Connectivity

The F280049C controlCARD provides on-board emulation and USB-to-UART adapter functionality. This allows for a convenient method to debug and demo the F280049C MCU.

The FTDI chip, its support circuitry, and associated isolation 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).

Each F280049C controlCARD's XDS100v2 is programmed with a fixed serial number. If a debug session must involve two or more F280049C controlCARDs, each controlCARDs must have a unique serial number, and some must be reprogrammed, see: https://software-dl.ti.com/ccs/esd/documents/xdsdebugprobes/emu_xds100.html (under Additional Information).

The configuration of the switches on S1:A (shown in Figure 4-1) determine whether the onboard emulator is active, whether an external emulator can be used, or whether the device will boot from FLASH/peripherals.
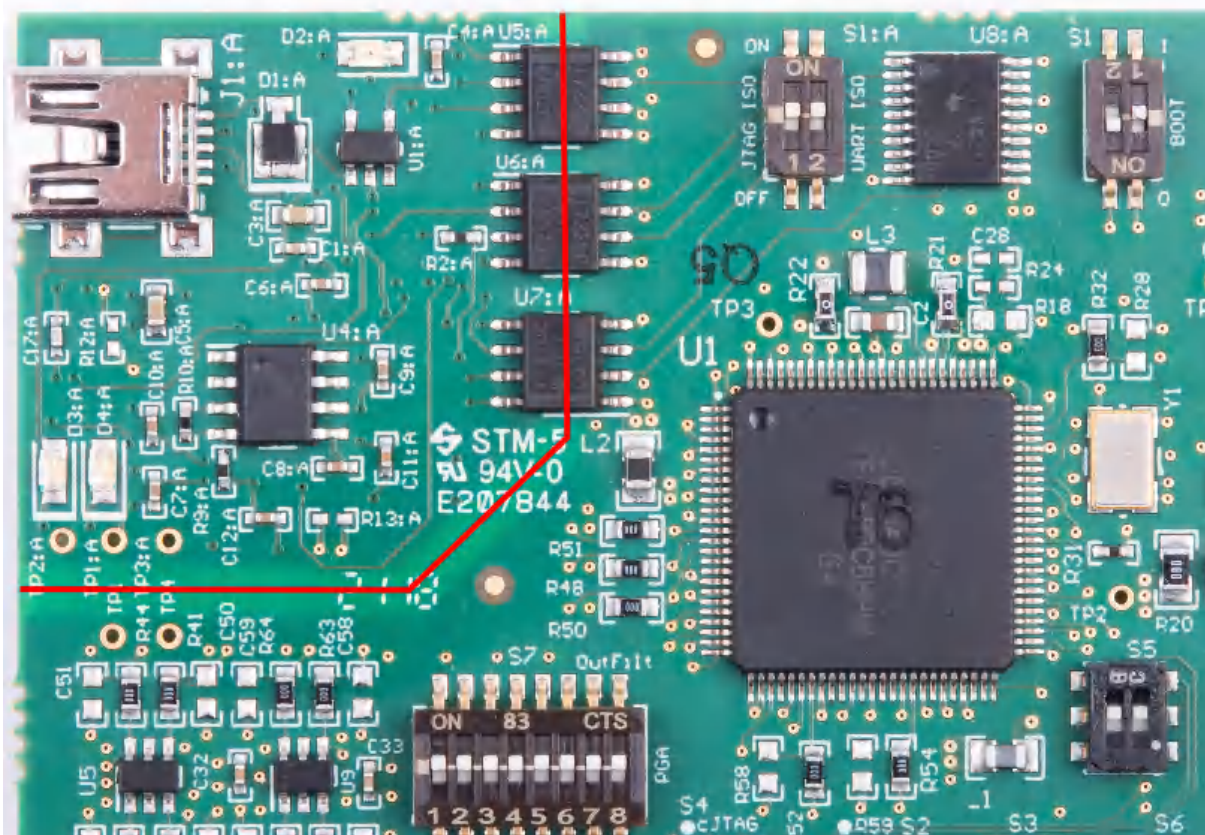

Figure 4-1. XDS100v2 Emulation Circuitry and Isolation Circuitry is Denoted by :A

4.2 cJTAG Usage

The F280049C MCU supports the cJTAG 2-pin debugging interface, but the onboard XDS100v2 emulator does not. To experiment with cJTAG, an external emulator must be connected through the baseboard. To enable cJTAG:

1. Connect an external emulator to the controlCARD's baseboard.
2. Change S4 to the cJTAG position (switch flipped up).
3. If cJTAG is used, the F280049C MCU will have two additional GPIOs which can be used by the application. Configure S2 and S3, as desired, to control which controlCARD fingers or pins the newly available GPIOs are connected to.

4.3 Evaluation of the Programmable Gain Amplifier (PGA)

When evaluating the PGA, the PGA_GND pin must be driven to the ground reference of the PGA_IN signal. The PGA_GND signal may be provided using differential signaling through the HSEC fingers for improved noise immunity, or the PGA_GND pin may be tied to the GND reference of the controlCARD through a 0-Ω resistor (R55 in Figure 4-2) for simplicity.
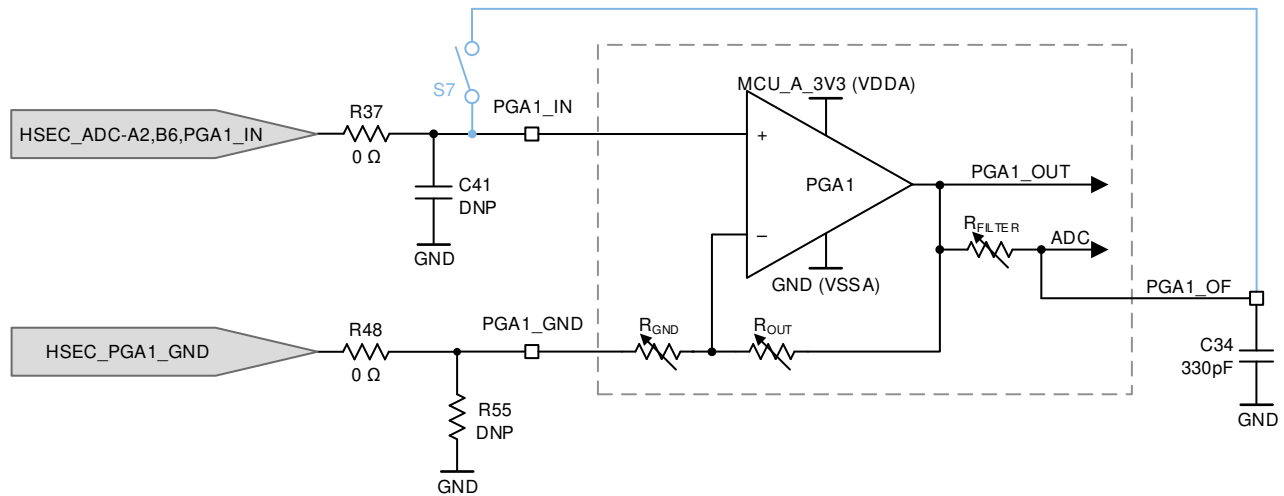

Figure 4-2. PGA With S7 Open (Output Filter Usable)

The S7 switch bank provides the flexibility to either use the PGA output filter pin (PGAn_OF) for filtering (S7 open in Figure 4-2) or for sampling the PGA input voltage directly by bypassing the internal PGA (S7 closed in Figure 4-3).
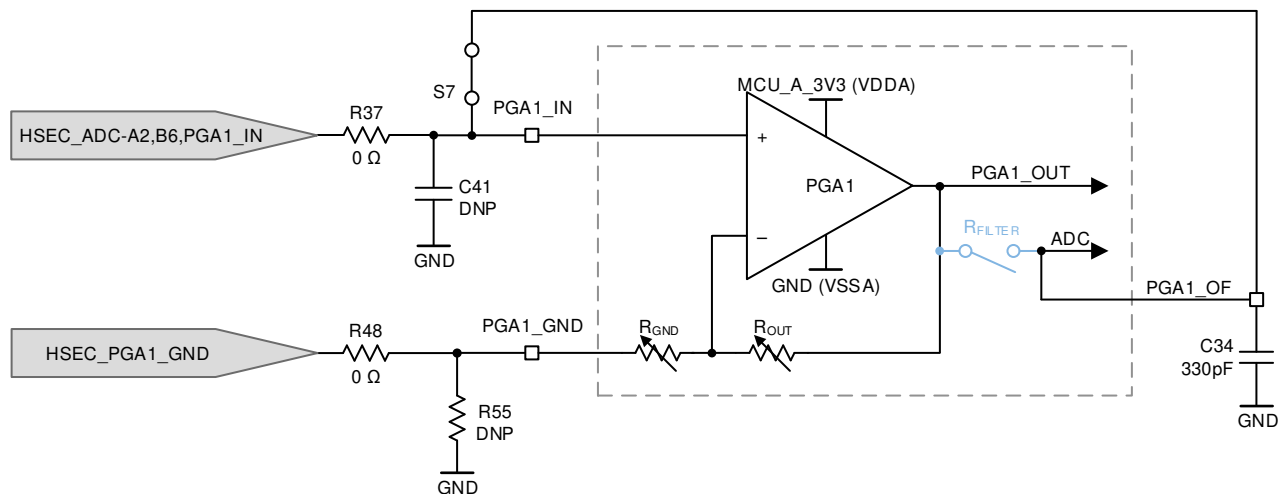

Figure 4-3. PGA With S7 Closed (Output Filter Not Usable)

Note

The S7 closed implementation for PGA6 is different from the other PGAs. Instead of shorting PGA6_OF and PGA6_IN, the PGA6_OF signal may be accessed from the HSEC connector independently of the PGA6_IN signal.

Note

The PGA R$_{FILTER}$ resistor should never be enabled while the S7 switch is closed. Prolonged exposure to contention between the PGA_IN and PGA_OF pins may result in permanent damage to the internal R$_{FILTER}$ resistor.

4.4 Evaluation of the Analog-to-Digital Converters (ADCs)

When using the F280049C on-chip ADCs there are some useful guideline to follow to realize the performance numbers listed in the datasheet. This is especially true for the AC parameters such as: SNR, THD, and SINAD. Furthermore, it can also be shown that there is a direct correlation between the SNR of the ADC result and the spread of ADC codes seen for a DC input; as such these tips will improve the range and standard deviation of a DC input as well. Finally, while topics addressed will be with respect to the controlCARD, they are applicable to other implementations using the F280049C MCU as well.

On-board resistors and capacitors: By default (Figure 4-4) 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) will need 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 we can optimize the input circuit to assist with settling time and/or filtering the input signal. Finally, it is recommended in general to use Negative-Positive 0 PPM/°C (NP0/C0G) capacitors as these have better stability over temperature and across input frequencies than other types of capacitors.
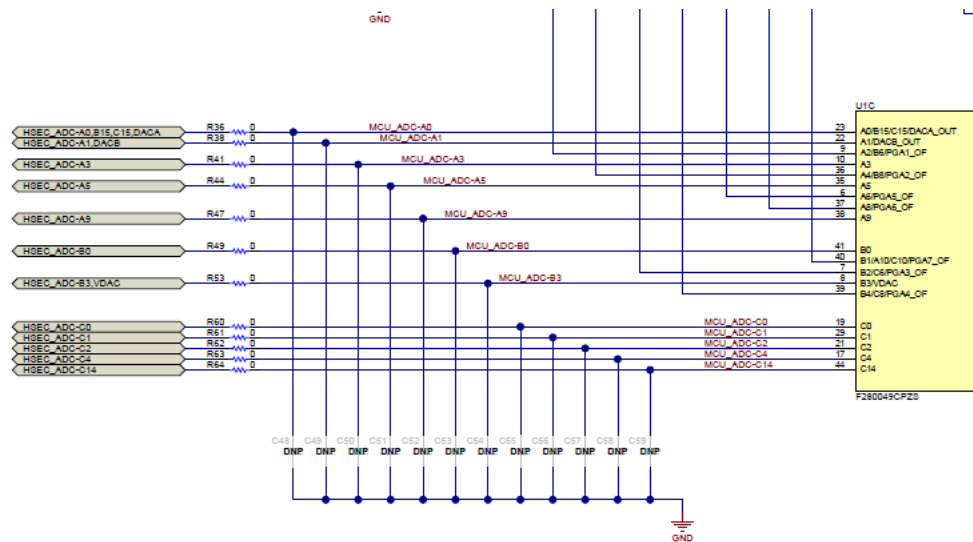

Figure 4-4. Partial Schematic Showing Default R and C values

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 will only be 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 would mean that ideally the analog input should 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 F280049C. 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

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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 was used to validate the ADC performance on the F280049C 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 4-5) on the controlCARD docking station to receive the signal via SMA for best noise immunity. For the local RC network 30-Ω resistors and 300pF capacitors were used. Using this setup the ADC parameters were observed to be consistent with the numbers in the datasheet.

Figure 4-5. Female SMA Connector

4.5 Evaluation of the Internal DC/DC Converter

The controlCARD, by default, assumes the F280049C internal VREG will be used to generate the 1.2-V power supply required by the MCU. The controlCARD enables the user to use the internal DC/DC converter capabilities, with some soldering.

To enable the internal DC/DC converter:
- R18 and R19 must be unpopulated.
- R21 and R22 must be populated with a 0-Ω resistor.
- C19 must be populated with a 2.2-µF X5R/X7R capacitor.
- C20 and C21 must each be populated with a 10-µF X5R/X7R capacitor.

Functionally, the F280049C powers up the 1.2-V power rail using the internal VREG, then requires software to change from the VREG to the DC/DC. See the F28004x Technical Reference Manual for more details.

5 Hardware References

Table 5-1 shows the various connections available on the board. Figure 5-1 illustrates the location of many of these components on the board.

> **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 C26:A should be removed to minimize the possibility of leakage current flowing across the isolation barrier of the controlCARD.
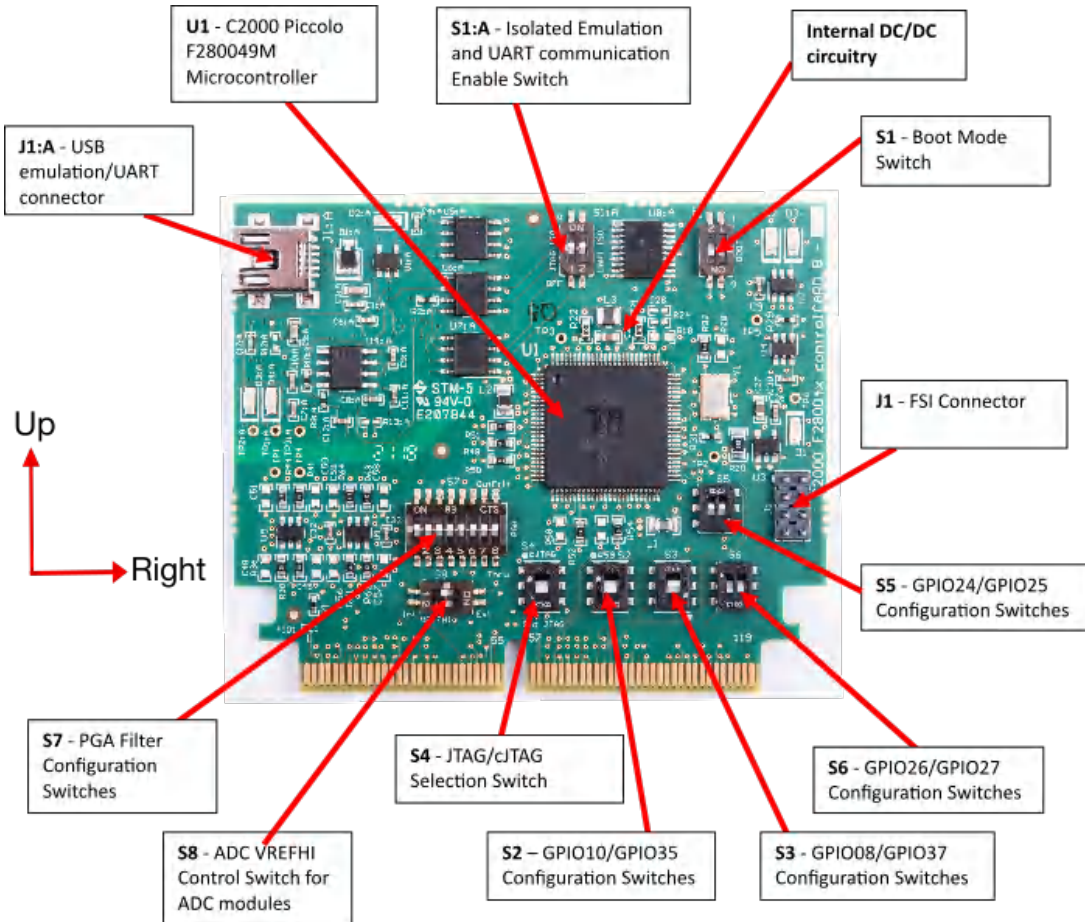

Figure 5-1. Key Components on the controlCARD

Table 5-1. Hardware References

Connectors	
J1:A	Emulation/UART connector - USB mini A connector used to provide XDS100v2 emulation and USB-to-UART(SCI) communication through FTDI logic. S1:A determines which connections are enabled to the MCU.
Jumpers	
J1	FSI Connector - Gives an ability to connect FSI signals from the F280049C to another board.
LEDs	
D1	Turns on when the controlCARD is powered ON (green)
D2	Controlled by GPIO-31 with negative logic (red)
D3	Controlled by GPIO-34 with negative logic (red)
D2:A	Turns on when ISO JTAG logic is powered on (green)
D3:A	JTAG/UART RX toggle indicator (blue)
D4:A	JTAG/UART TX toggle indicator (blue)
Resistors and Capacitors (default setting in BOLD)	
R18, R19, R21, R22	GPIO22/23 configuration resistors These resistors allow the user to choose whether GPIO22/23 is used as GPIO (and go to the baseboard) or whether they will be used in conjunction with the F280049C MCU's internal DC/DC capability: • **R18,R19 populated with 0-Ω resistors and R21,R22 unpopulated** – GPIO22 and GPIO23 are used as GPIO and go to the baseboard through EC1. The internal DC/DC cannot be used. • R18,R19 unpopulated and R21,R22 populated with 0-Ω resistors – Internal DC/DC can be used to generate the 1.2-V VDD power rail. GPIO22 and GPIO23 are used as VFBSW and VSW, respectively. The internal DC/DC can be used.
C19, C20, C21	These capacitors should be populated when the F280049C's internal DC/DC capability is used. C19 should be populated with a 2.2-µF capacitor. C20 and C21 should each be populated with a 10-µF capacitor.
R24, C28	R24 and C28 create an optional snubber circuit, which can be used if the DC/DC is used.
R36-R47,R49,R53, R60-R64, C41-C47, and C48-C59	Optional RC input filter for all ADC/PGA inputs
C34-C40	PGA filter capacitor when PGA filtering is used
R55-R59	PGA-GND configuration resistors
R48,R50-R52,R54	These resistors control whether the negative input (PGAGND) for each PGA are grounded locally or whether they should be grounded through pins on the HSEC connector (for use in Kelvin grounding). By default, **resistors R55-R59 are not populated and R48, R50-R52, R54 are populated**. Because of this, all the PGAs are, by default, expected to be referenced to ground by the baseboard. If, for example, R55 was populated and R48 was unpopulated, then PGA1's PGAGND would be grounded on the controlCARD.
Switches (default position in BOLD)	
S1 (Installed with 180 degree rotation)	Boot Mode Selection Switch See Table 5-2 for a list of selectable boot modes. See the device datasheet and TRM for more information about device boot behavior. Left (Switch 2) – GPIO24 Configuration Switch: • **In the up position** – GPIO24 is pulled high • In the down position – GPIO24 is pulled low Right (Switch 1) – GPIO32 Configuration Switch: • **In the up position** – GPIO32 is pulled high • In the down position – GPIO32 is pulled low
S2	GPIO10/GPIO35 Configuration Switches • In the up position – GPIO10 goes to pin 60 of the HSEC connector. If S4's switch 1 is in the up position, GPIO35 goes to pin 85 of the HSEC connector. • **In the down position** – GPIO10 goes to pin 85 of the HSEC connector. If S4's switch 1 is in the up position, GPIO35 goes to pin 60 of the HSEC connector.

Table 5-1. Hardware References (continued)

S3 (Installed with 180 degree rotation)	GPIO08/GPIO37 Configuration Switches • **In the up position** – GPIO08 goes to pin 87 of the HSEC connector. If S4's switch 2 is in the up position, GPIO37 goes to pin 58 of the HSEC connector. • In the down position – GPIO08 goes to pin 58 of the HSEC connector. If S4's switch 2 is in the up position, GPIO37 goes to pin 87 of the HSEC connector.
S4	JTAG/cJTAG Selection Switch • In the up position – 2-pin cJTAG mode is expected to be used. GPIO35 and GPIO37 go to the baseboard based on the settings of S2 and S3, respectively. • **In the down position** – 4-pin standard JTAG is expected to be used. GPIO35 and GPIO37 are used to support JTAG functionality. The on-card XDS100v2 emulator requires 4-pin JTAG to be used.
S5 (Installed with 180 degree rotation)	GPIO24/GPIO25 Configuration Switches Left (Switch 2) – GPIO25 Configuration Switch: • **In the up position** – GPIO25 goes to pin 77 of the HSEC connector. • In the down position – GPIO25 goes to pin 102 of the HSEC connector. Right (Switch 1) – GPIO24 Configuration Switch: • **In the up position** – GPIO24 goes to pin 75 of the HSEC connector. • In the down position – GPIO24 goes to pin 100 of the HSEC connector.
S6	GPIO26/GPIO27 Configuration Switches Left (Switch 1) – GPIO26 Configuration Switch: • In the up position – GPIO26 goes to pin 107 of the HSEC connector. • **In the down position** – GPIO26 goes to pin 79 of the HSEC connector. Right (Switch 2) – GPIO27 Configuration Switch: • In the up position – GPIO27 goes to pin 109 of the HSEC connector. • **In the down position** – GPIO27 goes to pin 81 of the HSEC connector.
S7	PGA Filter Configuration Switches From the left, the switches control whether PGA1-PGA7's outputs, respectively, are filtered. The eighth switch of S7 is not used. Each switch: • **In the up position** – an HSEC pin is connected to the respective PGA+ input pin, and is now also tied to an additional ADC input pin. In software, PGA output filtering, for the respective PGA, functionality should NOT be used. • In the down position – an HSEC pin only goes to the PGA+ input pin. PGA output filtering, for the respective PGA, may be used. The up position for S7's switch 6 (PGA6) is implemented differently from the other PGAs. PGA6_OF may be accessed through the HSEC connector independently of PGA6_IN, whereas the other PGAs will have their respective PGAn_OF and PGAn_IN signals shorted together.
S8 (Installed with 90 degree rotation)	ADC VREFHI Control Switch for ADC modules Top (Switch 1) – VREFHI Control Switch for ADC module A: • **In the left position** – ADC-A should be configured to use the internal voltage reference. • In the right position – ADC-A is configured to use an external voltage reference, which should be connected to pin 45 of the HSEC connector. Bottom (Switch 2) – VREFHI Control Switch for ADC module B and module C: • **In the left position** – ADC-B and ADC-C should be configured to use the internal voltage reference. • In the right position – ADC-B and ADC-C are configured to use an external voltage reference, which should be connected to pin 45 of the HSEC connector.

Table 5-1. Hardware References (continued)

S1:A	Isolated emulation and UART communication enable switches

Isolated emulation and UART communication enable switches
Left (Switch 1) – JTAG Enable:
- **Up (on)** – All signals between the XDS100v2 emulation logic and the MCU are connected. This setting is valid when the MCU is being debugged or programmed through the on-card XDS100v2 emulator.
- Down (off) – The XDS100v2 emulation logic will NOT be 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.

Right (Switch 2) – ISO UART communication enable:
- **Up (on)** – The C2000 MCU's GPIO-28 (and pin76 of the 180pin controlCARD connector) are coupled to the FTDI's USB-to-Serial adapter. This allows UART communication to a computer through the FTDI chip. However, in this position, GPIO-28 is forced high by the FTDI chip. Functionality of pin76 on the connector is limited.
- Down (off) – The C2000 MCU will NOT be connected to the FTDI USB-to-Serial adapter. Pin76 of the 180pin controlCARD connector is directly connected to GPIO-28.

Table 5-2. Boot Mode Switch (S1) Positions

Mode #	GPIO-24 (Left, Switch 2)	GPIO-32 (Right, Switch 1)	Boot from
00	0 (Down)	0 (Down)	Parallel I/O
01	0 (Down)	1 (Up)	Boot from SCI / Wait Mode
02	1 (Up)	0 (Down)	Boot from CAN
03	1 (Up)	1 (Up)	Boot from FLASH

6 Revision History

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

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

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

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

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

3   *Regulatory Notices:*

3.1   *United States*

3.1.1   *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2   *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2   *Canada*

3.2.1   *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/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２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/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, INDEMITY 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.

IMPORTANT NOTICE AND DISCLAIMER