

# Delfino TMS320F28377D controlCARD R1.1 Information Guide

Version 1.5 – March 2015

C2000 Systems and Applications Team



*Fig 1: TMSDOCK28377D Experimenter's Kit*

## 1 Introduction

The Delfino F28377D controlCARD (TMDSCNCD28377D) from Texas Instruments (TI) provides a great way to learn and experiment with the F2837x device family within TI's C2000 family of microcontrollers (MCUs). This 180-pin controlCARD is intended to provide a well-filtered robust design which is capable of working in most environments. This document goes over the hardware details of the F28377D controlCARD and explains the functions, locations of jumpers, and connectors present on the board.

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

- Schematics – Designed in Mentor PADS Logic
- Bill of Materials (BOM)
- Layout PCB files – Designed in Mentor Layout
- Gerber files

NOTE: this kit is designed to explore the functionality of the F2837x microcontroller. Even though 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 final customer's system.

## 2 Errata

Current revision of controlCARD as of 9-May-2014: PCB R1.1, ASSY rev A (R1.1a)

### 2.1 Warnings/Notes/Errata –

Notes for all controlCARDs:

1. The F28377D controlCARD supports USB host/device connectivity. However, the micro-USB port, J8, is not isolated from the board ground. Care should be taken when this controlCARD is being used in a high power application and this USB port is also being used. Note that external USB isolation buffers may be required for these types of applications.
2. The F28377D Experimenter's Kit ships with a USB cable and is designed to be powered via USB. However, in extreme cases the board/controlCARD may require more power than the 5V @ 500mA a computer's USB port can provide (<0.01% of use cases). This is especially true when additional circuitry has been added to the Docking Station.

In such cases, it is recommended to use an external 5V power supply (2.5mm inner diameter x 5.5mm outer diameter) and plug it into J1. A compatible supply could be the: Phihong *PSAC05R-050(P)-R-C2* + Phihong *RPBAG*

3. In Boot-from-SCI mode, the MCU will by default expect GPIO84 and GPIO85 to be the IO pins responsible for sending the program to the device. These GPIOs are different from the GPIOs which connect to the isolated USB-to-serial interface via the FTDI chip (which use GPIO28 & GPIO29). To use GPIO28 & 29 instead:
  - a. Change the boot mode to Get Mode and then, in your main flashed code, you can decide to call the bootloader for SCIBoot IOOption2 (in the bootROM) always or based on whatever is desired.
  - b. Change the boot mode to Get Mode and configure the OTP such that SCIBoot IOOption2 is called. This is really only an option if you always want to boot from SCI or Parallel GPIO because you'll be overwriting your ability to boot from Flash.
  - c. With an emulator connected (TRSTn = 1), registers can be set such that SCIBoot's IOOption2 boot mode is called.

See the TRM of your specific device for more information.

## 2.2 Warnings about Specific controlCARD revisions –

Warnings about R1.0a revision controlCARDs:

1. Among many other changes made, the pinout of the R1.1 F28377D controlCARD is different from the pinout of the pre-release R1.0a controlCARDs. Please refer to the kit documentation and schematics when porting code.

Warnings about R1.1 and earlier controlCARDs:

1. The F28377D MCU is not 5V tolerant. Because of this some additional protection is needed between the USB port J8 and the MCU. In particular, resistor R72 should change from 0R0 to 100K and resistor R74 should change from 0R0 to 10K. This will effectively limit the voltage/current received by the MCU pin. This issue was fixed in R1.1a and later revision controlCARDs.
2. If used, the crystal X1 should be acceptable in most applications. However, it may fail under some worst case conditions. To guarantee proper operation, please see the F28377x Silicon Errata guide. This issue was fixed in R1.1a and later revision controlCARDs.
3. Several name changes were made to pins on the device and are now reflected in R1.1a controlCARD documentation. No functionality was affected.

Warnings about R1.1a and earlier controlCARDs:

1. The circuitry used to drive the C2000 MCU's voltage references is not ideal. Instead, we recommend that users use the voltage reference driving circuitry found in F2837xD\_VREFHI\_12bitDrivingCkt.pdf or in F2837xD\_VREFHI\_16bitDrivingCkt.jpg which can both be found in the same directory as this document.

## 3 Getting Familiar with the controlCARD

### 3.1 F28377D controlCARD Features

- **Delfino F28377D Microcontroller** – High performance C2000 microcontroller is located on the controlCARD.
- **180pin HSEC8 Edge Card Interface** – Allows for compatibility with all of C2000's 180pin controlCARD based application kits and controlCARDs. Compatibility with 100pin controlCARDs can be accomplished using the TMD SADAP180TO100 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.
- **Connectivity** – The controlCARD contains connectors that allow the user to experiment with USB, a microSD card, and isolated UART/SCI with the F2837x MCU.
- **Key Signal Breakout** – Most GPIO, 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 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 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.

### 3.3 Using the controlCARD

In order for the controlCARD to work, the controlCARD's MCU must be powered. This is most often done by inputting 5V through the HSEC connector via an accompanying baseboard. For example, if using a Docking Station baseboard, 5VDC should be input into the Docking Station's J1 or J17 and then SW1 will need to be toggled to the appropriate position.

Optionally, the MCU could also be powered via the micro-USB connector on the controlCARD.

Based on the way that the controlCARD will be used, additional hardware settings will be necessary. See the table below:

	<b>Debug using CCS and the on-card xds100v2 emulator</b>	<b>Debug using CCS and an external emulator via the baseboard</b>	<b>Standalone (Boot from FLASH or other boot mode)</b>
<b>A:SW1 (controlCARD)</b>	Position 1: ON (up)	Position 1: OFF (down)	Position 1: OFF (down)
<b>A:J1 (controlCARD)</b>	Connect a mini USB cable between A:J1 and your computer.  In CCS, use this target configuration: TMS320F28377D device with an xds100v2 emulator.	---	---
<b>SW1 (controlCARD)</b>	Position 1: OFF (up) Position 2: ON (down)  Putting the C2000 device into Wait Mode can reduce the risk of connectivity issues.	Position 1: OFF (up) Position 2: ON (down)  Putting the C2000 device into Wait Mode can reduce the risk of connectivity issues.	Set SW1 as desired
<b>Baseboard's JTAG connector (J2 on the Docking Station baseboard)</b>	---	Connect an external emulator.	---

*Table 1: Getting Started Reference*

Code Composer Studio (CCS) is an Integrated Development Environment (IDE) used to debug and develop software for the C2000 series of MCUs. It can be downloaded from the following link: [http://processors.wiki.ti.com/index.php/Download\\_CCS](http://processors.wiki.ti.com/index.php/Download_CCS)

For users new to C2000's F28x7x series of devices and CCS, TI's Technical Training Organization provides several workshops (online and in-person) that may be helpful:

[http://processors.wiki.ti.com/index.php/C2000\\_32-bit\\_Real-Time\\_MCU\\_Training](http://processors.wiki.ti.com/index.php/C2000_32-bit_Real-Time_MCU_Training)

[http://processors.wiki.ti.com/index.php/Hands-On\\_Training\\_for\\_TI\\_Embedded\\_Processors](http://processors.wiki.ti.com/index.php/Hands-On_Training_for_TI_Embedded_Processors)

The following PDF documents are provided to describe where each of the F2837x MCU's pins will appear on the controlCARD connector/Docking Station:

**TMDSCNCD28377D\_180cCARD\_pinout\_R1\_1** – tells where each MCU pin will go on the HSEC controlCARD connector or the 120/180-pin controlCARD Docking Station.

**TMDSCNCD28377D\_100DIMmap\_R1\_1** – tells where each MCU pin will go to on the DIM100 controlCARD connector or the DIM100 Docking Station. This assumes that the TMDADAP180TO100 adapter card is used.

More information on the controlCARD/Docking Station can be found at the following locations:

\C2000Ware\_X\_XX\_XX\_XX\boards\controlCARDs\TMDSCNCD28377D\

\C2000Ware\_X\_XX\_XX\_XX\boards\ExperimenterKits\

DockingStation\_HSEC\_120or180pin\

### 3.4 Experimentation Software

All key examples for the F28377D MCU can be found within C2000Ware at:

\C2000Ware\_X\_XX\_XX\_XX\device\_support\f2837xd\

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

## 4 Special Notes on Connectivity

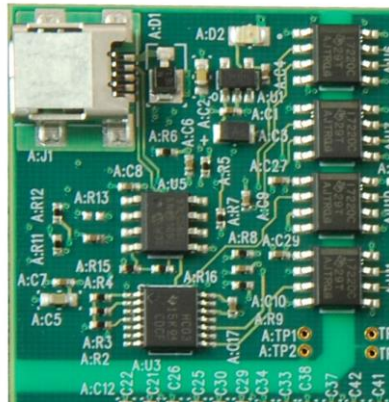
### 4.1 xds100v2 Emulator and SCI/UART Connectivity

The F28377D controlCARD provides emulation and USB-to-UART adapter functionality on the controlCARD. This allows for a convenient method to debug and demo the F2837x MCU.

Note that 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 (ie A:R2 for resistor 2 in Macro A).

Each F28377D controlCARD's xds100v2 is programmed with a fixed serial number. If a debug session needs to involve 2 or more F28377D controlCARD, each controlCARDs will need have a unique serial number and some will need to be reprogrammed. See: <http://processors.wiki.ti.com/index.php/XDS100#Q: Can I change the serial number on my XDS100v2.3F>

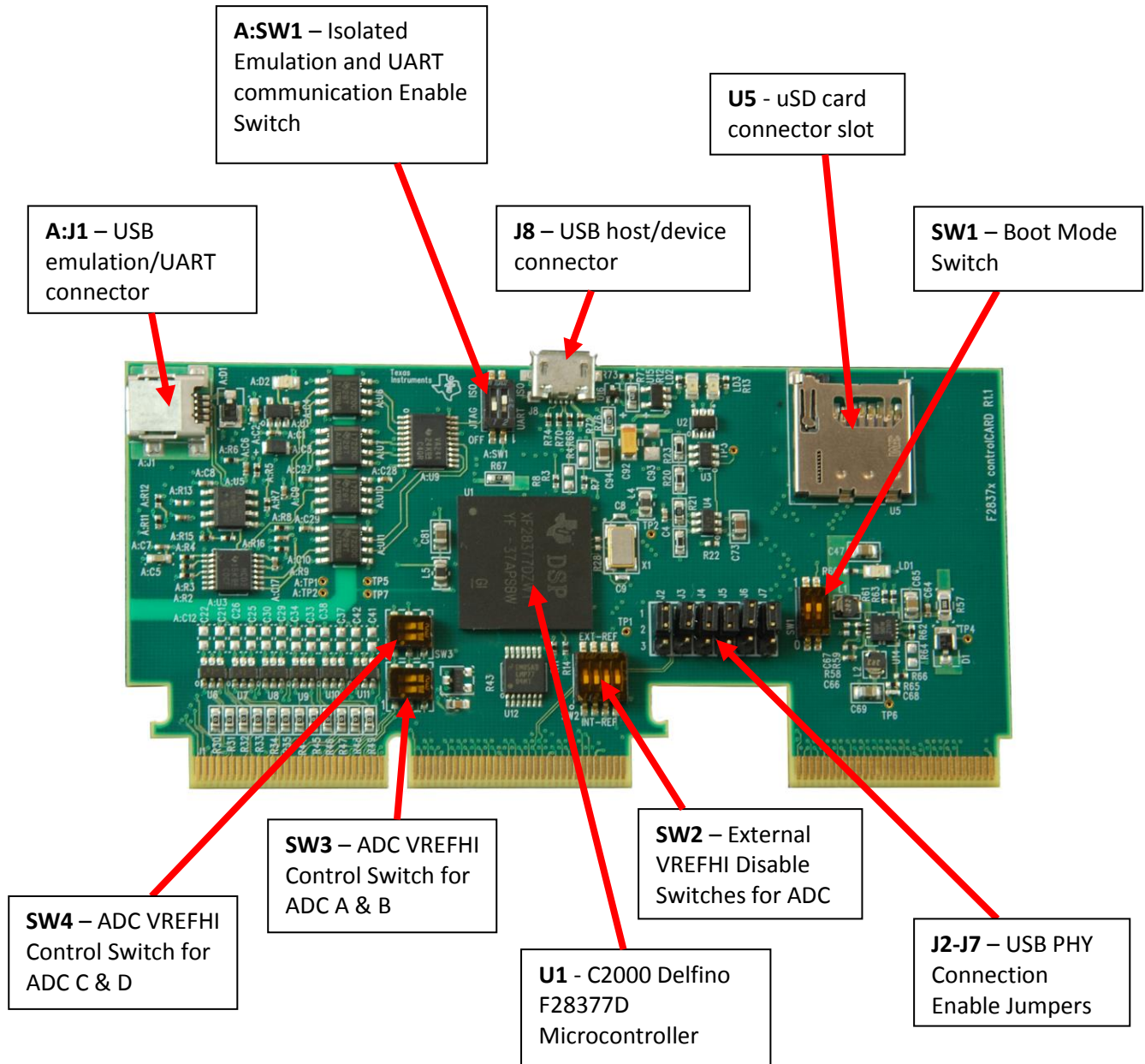
The configuration of the switches on A:SW1 determine whether the on-board emulator is active, whether an external emulator can be used, or whether the device will boot from FLASH/peripherals. See Table 2.



*Fig2: xds100v2 Emulation circuitry and isolation circuitry is denoted by A:*

## 5 Hardware References

On the following pages, Table 2 shows the various connections available on the board. Fig 3, below, illustrates the location of many of these components on the board:



*Fig3: Key components on the controlCARD*



Connectors	
<b>A:J1</b>	Emulation/UART connector - USB mini A connector used to provide xds100v2 emulation and USB-to-UART(SCI) communication through FTDI logic. A:SW1 determines which connections are enabled to the MCU.
<b>U5</b>	SD Micro card slot – connects to MCU via SPI
<b>J8</b>	USB connector – USB micro AB connector supports USB 2.0 host/device
Jumpers	
<b>J2-J7</b>	<p>USB PHY connection enable/disable jumpers –</p> <ul style="list-style-type: none"> <li><b>All jumpers up</b> – The MCU will be connected to the USB PHY on the controlCARD via GPIOs 42, 43, 46, 47, 120, and 121.</li> <li>All jumpers down – The MCU will not connect to the USB PHY and all signals will instead go through the 180pin controlCARD connector.</li> </ul>
LEDs	
<b>LD1</b>	Turns on when the controlCARD is powered ON (green)
<b>LD2</b>	Controlled by GPIO-31 with negative logic (red)
<b>LD3</b>	Controlled by GPIO-34 with negative logic (red)
<b>A:D2</b>	Turns on when ISO JTAG logic is powered on (green)
<b>A:D3</b>	JTAG/UART RX toggle indicator (blue)
<b>A:D4</b>	JTAG/UART TX toggle indicator (blue)
Resistors and Capacitors	
<b>R42, R43</b>	<p>Alternate Reference Configuration Resistors:</p> <p>These resistors allow the user to choose whether the alternate reference for the ADCs will be given by:</p> <ul style="list-style-type: none"> <li>If R42 is populated &amp; R43 is unpopulated - A precision 3.0V reference</li> <li>If R42 is unpopulated &amp; R43 is populated - The reference will be given by pin 45 of the HSEC controlCARD connector. This will presumably allow the baseboard to provide the desired voltage reference.</li> </ul>
<b>R30-R41, R44-R55 and C19-C42</b>	Optional RC input filter for all ADC inputs

## Switches (default position in **BOLD**)

<b>SW1</b>	<p>Boot Mode Switch: Controls the Boot Options of the F2837x device. See the device datasheet for more information. (0 is down, 1 is up)</p> <table><tr><th>Mode #</th><th>Switch Position 1 (GPIO-72)</th><th>Switch Position 2 (GPIO-84)</th><th>Boot from</th></tr><tr><td>00</td><td>0</td><td>0</td><td>Parallel I/O</td></tr><tr><td>01</td><td>0</td><td>1</td><td>Boot from SCI</td></tr><tr><td>02</td><td>1</td><td>0</td><td>Wait Boot Mode</td></tr><tr><td><b>03</b></td><td><b>1</b></td><td><b>1</b></td><td><b>Get Mode (Flash by default)</b></td></tr></table>	Mode #	Switch Position 1 (GPIO-72)	Switch Position 2 (GPIO-84)	Boot from	00	0	0	Parallel I/O	01	0	1	Boot from SCI	02	1	0	Wait Boot Mode	<b>03</b>	<b>1</b>	<b>1</b>	<b>Get Mode (Flash by default)</b>
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01	0	1	Boot from SCI																		
02	1	0	Wait Boot Mode																		
<b>03</b>	<b>1</b>	<b>1</b>	<b>Get Mode (Flash by default)</b>																		
<b>SW2</b>	<p>External VREFHI Disable Switches for ADC:</p> <p>This switch determines which ADC voltage reference (VREFHI) inputs will be connected to external references.</p> <p>Each Switch (leftmost switch is for ADC-A, rightmost is for ADC-D, etc):</p> <ul style="list-style-type: none"><li>In the down position, the external reference to the ADC will be disabled. This configuration should not be used.</li><li><b>In the up position</b>, the respective ADC will be configured to use an external voltage reference chosen by SW3 or SW4.</li></ul>																				
<b>SW3</b>	<p>ADC VREFHI Control Switch for ADC modules A &amp; B:</p> <p>Switch 1 (lower switch) – VREFHI Control Switch for ADC module A:</p> <ul style="list-style-type: none"><li>In the left position – If ADC-A is configured to use an external reference via SW2, the ADC will be referenced to the alternate reference chosen by R42/R43 (see above).</li><li><b>In the right position</b> – If ADC-A is configured to use an external reference via SW2, the ADC will be referenced to a precise 3.3V reference located on the controlCARD.</li></ul> <p>Switch 2 (upper switch) – VREFHI Control Switch for ADC module B:</p> <ul style="list-style-type: none"><li>In the left position – If ADC-B is configured to use an external reference via SW2, the ADC will be referenced to the alternate reference chosen by R42/R43 (see above).</li><li><b>In the right position</b> – If ADC-B is configured to use an external reference via SW2, the ADC will be referenced to a precise 3.3V reference located on the controlCARD.</li></ul>																				

<b>SW4</b>	<p>ADC VREFHI Control Switch for ADC modules C &amp; D:</p> <p>Switch 1 (lower switch) – VREFHI Control Switch for ADC module C:</p> <ul style="list-style-type: none"> <li>• In the left position – If ADC-C is configured to use an external reference via SW2, the ADC will be referenced to the alternate reference chosen by R42/R43 (see above).</li> <li>• <b>In the right position</b> – If ADC-C is configured to use an external reference via SW2, the ADC will be referenced to a precise 3.3V reference located on the controlCARD.</li> </ul> <p>Switch 2 (upper switch) – VREFHI Control Switch for ADC module D:</p> <ul style="list-style-type: none"> <li>• In the left position – If ADC-D is configured to use an external reference via SW2, the ADC will be referenced to the alternate reference chosen by R42/R43 (see above).</li> <li>• <b>In the right position</b> – If ADC-D is configured to use an external reference via SW2, the ADC will be referenced to a precise 3.3V reference located on the controlCARD.</li> </ul>
<b>A:SW1</b>	<p>Isolated emulation &amp; UART communication enables:</p> <p>Switch Position 1 – JTAG Enable:</p> <ul style="list-style-type: none"> <li>• <b>ON</b> – All signals between the xds100v2 emulation logic and the MCU will be connected. This setting is valid when the MCU is being debugged or programmed via the on-card xds100v2 emulator.</li> <li>• <b>OFF</b> – The xds100v2 emulation logic will <b>NOT</b> be connected to the MCU. This setting is valid when the device will boot from FLASH, boot from a peripheral directly, or when an external JTAG emulator will be used.</li> </ul> <p>Switch Position 2 – ISO UART communication enable:</p> <ul style="list-style-type: none"> <li>• <b>ON</b> – The C2000 MCU's GPIO-28 (and pin76 of the 180pin controlCARD connector) will be coupled to the FTDI's USB-to-Serial adapter. This allows UART communication to a computer via the FTDI chip. However, in this position, GPIO-28 will be forced high by the FTDI chip. Functionality of pin76 of the connector will be limited.</li> <li>• <b>OFF</b> – The C2000 MCU will <b>NOT</b> be connected to the FTDI USB-to-Serial adapter. Pin76 of the 180pin controlCARD connector will be directly connected to GPIO-28.</li> </ul>

*Table 2: Hardware References*

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### **U.S. Federal Communications Commission Compliance**

#### **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 could void the user's authority to operate the equipment.

#### **FCC Interference Statement for Class A EVM devices**

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 its own expense.

#### **FCC Interference Statement for Class B EVM devices**

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.

### **Industry Canada Compliance (English)**

#### **For EVMs Annotated as IC – INDUSTRY CANADA Compliant:**

This Class A or B digital apparatus complies with Canadian ICES-003.

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

#### **Concerning EVMs Including Radio Transmitters**

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

#### **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.

### **Canada Industry Canada Compliance (French)**

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

#### **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.

#### **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

requis pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

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## **Important Notice for Users of EVMs Considered “Radio Frequency Products” in Japan**

**EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.**

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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本開発キットは技術基準適合証明を受けておりません。本製品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。

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