Stellaris® LM4F211 controlCARD Module (MDL-LM4F211CNCD)

User Manual

Literature Number: SPMU294A
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Stellaris® LM4F211 controlCARD Overview

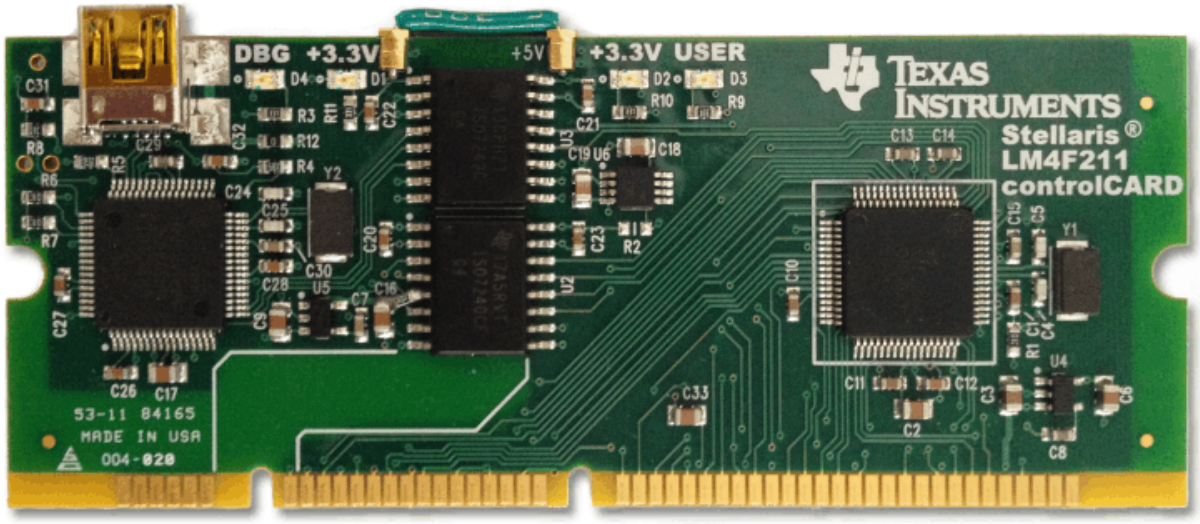
The Stellaris® LM4F211 controlCARD module is a DIMM form-factor evaluation board that can be used as a standalone module or with a range of baseboards to accelerate evaluation and development.

Texas Instruments offers a range of controlCARD baseboards for motor and power-control applications. In most cases, these baseboards are available as complete kits that include a controlCARD module and a baseboard. The Stellaris MDL-LM4F211CNCD module is part of Texas Instruments' controlCARD lineup that includes cards for Stellaris, C2000™, Hercules™, and MSP430™ devices.

Not all controlCARD and baseboards configurations are supported. See the Compatibility Matrix for more information on baseboard options.

The Stellaris LM4F211H5QR microcontroller is an ARM® Cortex™-M4F device with 256 KB Flash and operation at up to 80 MHz. Figure 1-1 shows a photo of the Stellaris MDL-LM4F211CNCD controlCARD module.

Figure 1-1. MDL-LM4F211CNCD controlCARD Module



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1.1 MDL-LM4F211CNCD Kit Contents

The LM4F211 controlCARD module kit comes with the following items:

- MDL-LM4F211CNCD controlCARD module
  - On-board Stellaris In-Circuit Debug Interface (ICDI)
- Cables/Accessories
  - USB-miniB to USB-A plug cable (for debug and serial communication)
  - 1/2-inch (1.27 cm) jumper wires (for bridging power)
- Development Kit CD
  - For the controlCARD module in standalone use:
    - Complete documentation
    - StellarisWare® Peripheral Driver Library and example source code
  - For the controlCARD module when used with a supported baseboard:
    - Source code and binaries
    - Documentation specific to each supported baseboard
    - GUI Microsoft® Windows®-based application
- Tools CD
  - Texas Instruments' Code Composer Studio™ Integrated Development Environment (IDE)
  - Other tool chains

NOTE: The MDL-LM4F211CNCD board may be populated with an LM4F231H5QR microcontroller. This device contains a superset of the features of the LM4F4211H5QR microcontroller. There is no difference in functionality.

1.2 Compatibility Matrix

Table 1-1 shows which baseboards are compatible with the MDL-LM4F211CNCD controlCARD module.

Table 1-1. Compatibility Matrix

Baseboard	Description	Electrical Compatibility?	Supported with Software?	Complete Kit Available?
DRV8312	3-Phase, 6.5-A BLDC motor driver	Yes	Yes	DK-LM4F-DRV8312
DRV8301	3-Phase BLDC motor pre-driver	Yes	No	No

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1.3 Using the LM4F211 controlCARD Module

To start using the controlCARD module as a standalone module, see the MDL-LM4F211CNCD *Read Me First* document (included on the CD).

To start using the controlCARD module in conjunction with a Texas Instruments' controlCARD baseboard, see the *Read Me First* document specific to that platform.

1.3.1 Features

The Stellaris MDL-LM4F211CNCD controlCARD module includes the following features:

- LM4F211H5QR Stellaris microcontroller
  - 32-bit ARM Cortex-M4 floating point core
  - 80 MHz max speed
  - 256 KB Flash, 32 KB RAM
- DIMM form-factor
- GPIO signals available on DIMM edge-connector
- User LED
- Debug
  - Stellaris In-Circuit Debug Interface (ICDI)
  - Isolated to 300 V working voltage using Texas' Instruments' digital isolators

1.3.2 Board Dimensions

The MDL-LM4F211CNCD board measures 3.55 in x 1.40 in (9.02 cm x 3.556 cm). See the Component Locations section for more details.

Schematics

Complete schematics for the MDL-LM4F211CNCD are appended to this document.

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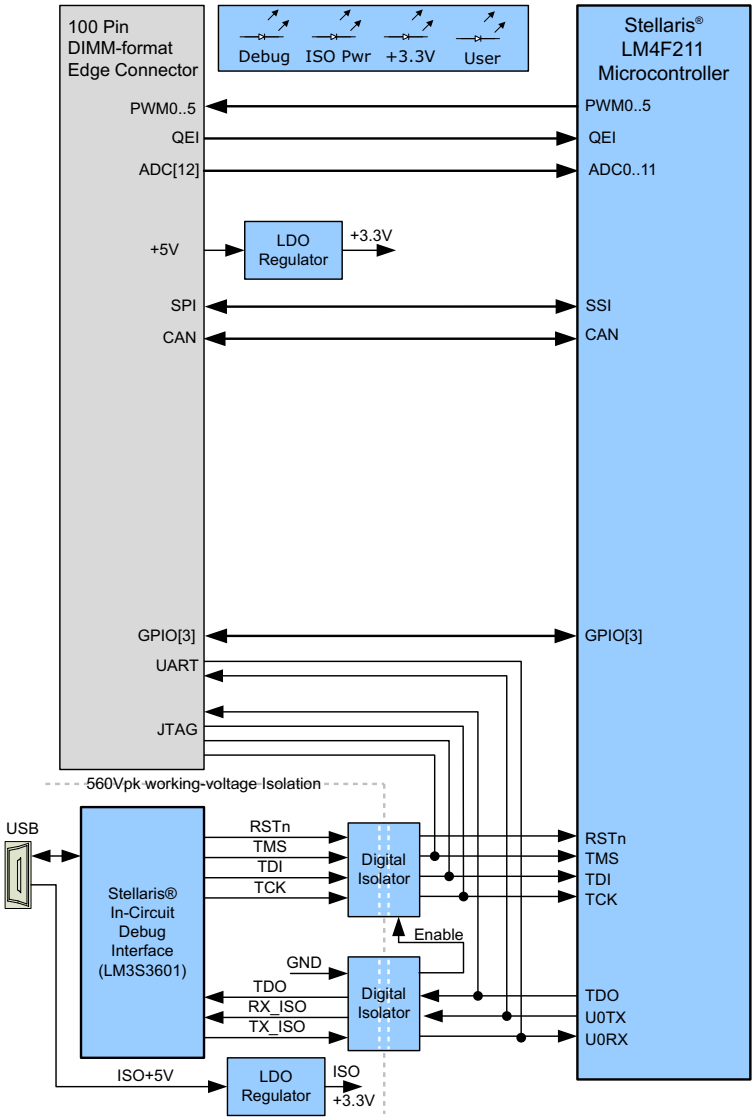
In addition to an LM4F211H5QR microcontroller, the controlCARD module includes some simple multiplexing logic and an integrated Stellaris in-circuit debug interface (ICDI). This chapter describes how the hardware interfaces to the microcontroller.

2.1 Block Diagram

Figure 2-1 shows the controlCARD module block diagram.

Figure 2-1. Block Diagram



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2.2 Functional Description

This section provides a detailed description of the LM4F211 controlCARD module hardware.

2.2.1 Microcontroller and Interfaces (Schematic Page 1)

LM4F211H5QR Microcontroller

The Stellaris LM4F211H5QR microcontroller is an ARM Cortex-M4-based microcontroller with 256-KB flash memory, 32-KB SRAM, 80-MHz operation, motion control PWMs, controller area network (CAN), and a wide range of other peripherals. See the LM4F211H5QR microcontroller data sheet for complete device details.

The LM4F211H5QR microcontroller is factory-programmed with a simple quickstart demo program. The quickstart program resides in on-chip Flash memory and runs each time power is applied, unless the quickstart has been replaced with a user program.

DIMM Edge Connector

Most of the Stellaris microcontroller GPIO signals are routed to the DIMM-style edge connector.

The controlCARD module is compatible with standard DIMM sockets, such as Molex part number 87630-1001.

User LED

The board also has a green user LED connected to GPIO PG5.

Signal Multiplexing

The DRV8312 and DRV8301 baseboards have Hall inputs on different DIMM pins. U11 multiplexes these signals under the control of GPIO PB6.

An analog switch (U12) under the control of PB4 selects between bus current (I-total) and Phase B current (IB-FB). See the associated ZIP file with a spreadsheet that details the signals for the module (available for download from the MDL-LM4F211CNCD tool folder on the TI website; click on the *Technical Documents* link).

Reset

The $\overline{\text{RESET}}$ signal into the LM4F211H5QR microcontroller connects to an R-C network (R1/C1) and to the ICDI circuit for a debugger-controlled reset. A voltage supervisor (U8) monitors the +5-V rail to ensure that the microcontroller is held in reset well before the +3.3-V supply rail moves below the –10% limit.

External reset is asserted (active low) under any one of these conditions:

- Power-on reset
- By the ICDI circuit when instructed by the debugger (this capability is optional, and may not be supported by all debuggers).
- By the +5-V voltage supervisor if the rail drops below +4.38 V.

Power Supplies

The controlCARD module is typically powered by the baseboards via the DIMM edge connector. When used as a standalone module, without a baseboard, install wire jumpers to support USB-powered operation.

WARNING

Do not install the wire power links if the controlCARD module is installed in a baseboard. Damage to the board may result. In high-voltage applications, the power supplies must remain electrically isolated for personal safety.

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2.2.2 Debug Interface, Virtual COM Port, and Isolators (Schematic Page 2)

Stellaris In-Circuit Debug Interface (ICDI) and Virtual COM Port

The MDL-LM4F211CNCD controlCARD module includes an onboard Stellaris In-Circuit Debug Interface (ICDI). The Stellaris ICDI allows for the programming and debug of the LM4F211H5QR microcontroller using LM Flash and/or any of the supported tool chains.

The debug interface incorporates Texas Instruments' digital isolators (ISO7240M and ISO7242M) for safety isolation between the ICDI and the Stellaris microcontroller. Due to the presence of the unidirectional isolators, only JTAG debugging and programming is supported. Serial Wire Debug (SWD) and Serial Wire Trace (SWT) are not supported.

Virtual COM Port

When plugged in to a PC, the device enumerates as a debugger and a virtual COM port. The COM port is connected to the following pins on the microcontroller as shown in Table 2-1.

Table 2-1. COM Port Pin Connections

GPIO Pin	Pin Functions	Virtual COM Port
PA0	U0RX	TXD
PA1	U0TX	RXD

The UART signals are also electrically isolated.

Electrical Isolation

The PCB layout incorporates IEC standard reinforced isolation for over-voltage category II and pollution degree 2. Creepage and clearance distances are 6.4 mm. The digital isolators limit the working voltage to 560 Vpk, which is sufficient for most 115 Vrms and 230 Vrms line-powered designs.

CAUTION

If using the controlCARD as a module in a new design, refer to the safety regulations that apply to that product and its environment to determine the safe working voltage.

The integrated isolation feature allows the Stellaris microcontroller to operate at the same common-mode voltage as the baseboards which simplifies circuit design in high-voltage motor control designs. Firmware programming, debugging, and serial communication is supported using the isolated, low-voltage debug interface. Figure 2-2 shows controlCARD module isolation.

WARNING

When installed in a high-voltage power board, the microcontroller and non-isolated circuitry may be at high voltage. Read and understand the safety warnings included in the power board documentation before using the controlCARD module in a high-voltage application.

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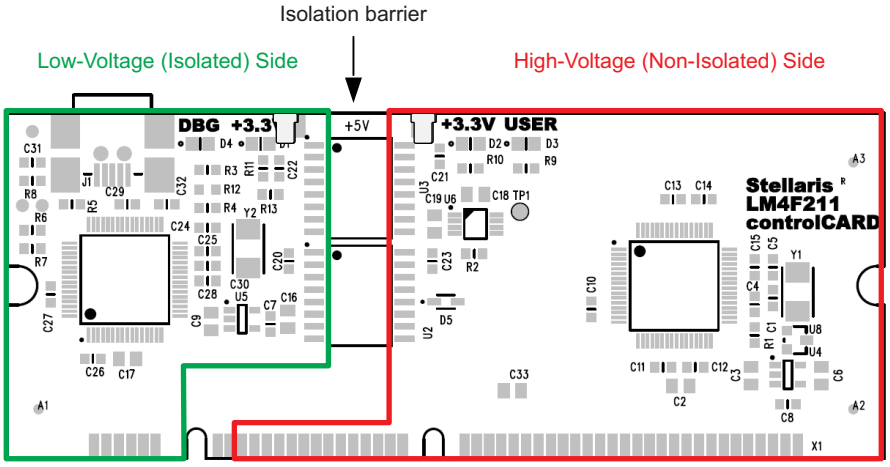
Figure 2-2. controlCARD Module Isolation



NOTE: Non-isolated means that these circuits will be at the same voltage potential as the baseboard.

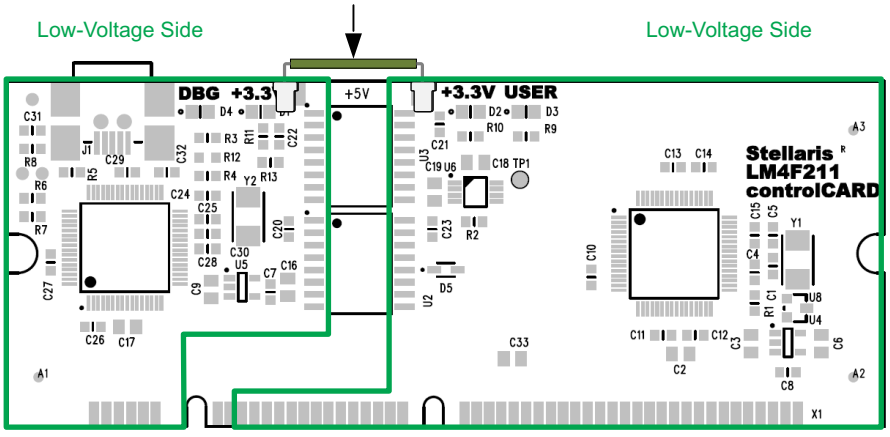
The controlCARD module may be used without a baseboard. In order to power the non-isolated circuitry, power must be bridged across the isolation barrier as shown in Figure 2-3.

WARNING

Do not install the controlCARD module in a baseboard if the jumpers are installed. The isolation barrier is compromised and an electric shock hazard exists. Power-supply contention may also damage the controlCARD module or the baseboard.

Figure 2-3. Using controlCARD without a Baseboard

To bridge power, install 0.5" wire power-jumpers into J2 and J3 (both sides of PCB). Ensure that wires do not short to other components.



WARNING: Do not install controlCARD in a baseboard when wire power-jumpers are installed!

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Software Development

This chapter provides general information on software development as well as instructions for Flash memory programming.

3.1 Software Description

The CD supplied with the controlCARD module includes the StellarisWare® Peripheral Driver Library which contains a rich set of functions for developing software for the Stellaris microcontroller and its on-chip peripherals.

The software includes a set of example applications that utilize the StellarisWare® Peripheral Driver Library. These applications demonstrate the capabilities of the LM4F211H5QR microcontroller, as well as providing a starting point for developing user applications.

Source Code

The complete source code is included on the controlCARD Development Kit CD. See the quickstart guide for the respective toolchain to get information on how to install the source code and toolchain. The source code and binary files are installed in the StellarisWare tree.

Tool Options

The source code installation includes directories containing projects and/or makefiles for the following toolchains:

- Keil ARM RealView® Microcontroller Development System
- IAR Embedded Workbench for ARM
- Sourcery CodeBench™
- Code Red Technology Red Suite
- Generic Gnu C compiler
- Texas Instruments' Code Composer Studio IDE

Baseboards from Texas Instruments may not support all toolchain options.

Evaluation versions of these tools may be downloaded from www.ti.com/stellaris. Due to code size restrictions, the evaluation tools may not build all example programs. A full license is necessary to re-build or debug all examples.

Instructions for installing and using each of the evaluation tools can be found in each toolchain quick-start guide (for example, Quickstart-Keil, Quickstart-IAR) which are available for download from the evaluation kit section of our web site at www.ti.com/stellaris.

For detailed information on using the tools, see the documentation included in the toolchain installation or visit the website of the tool supplier.

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3.2 Programming the MDL-LM4F211CNCD controlCARD Module

The MDL-LM4F211CNCD software package includes pre-built binaries for each of the example applications. If you installed StellarisWare to the default installation path (C:\StellarisWare), you can find the example applications in *C:\StellarisWare\boards\mdl-lm4f211cncd*. The onboard Stellaris ICDI is used along with the Stellaris LM Flash Programmer tool to program applications on the MDL-LM4F211CNCD board.

Follow these procedures to program example applications into the MDL-LM4F211CNCD evaluation board using the Stellaris ICDI:

1. Install LM Flash Programmer on a Windows-based PC.
2. Connect the USB cable A-plug to an available port on the PC and the miniB-plug to the board.
3. Verify that both power LEDs are lit. LED D2 indicates the status of the non-isolated microcontroller power and LED D1 indicates the status of the isolated USB power.
4. Run LM Flash Programmer.
5. In the Configuration tab, use the Quick Set control to select *LM4F232 Evaluation Board*. Move to the Program tab and click the **Browse** button. Navigate to the example applications directory (the default location is *C:\StellarisWare\boards\MDL-LM4F211CNCD*).
6. Each example application has its own directory. Navigate to the example directory that you want to load and then into the directory which contains the binary (*.bin) files. Select the binary file and click *Open*.
7. Set the *Erase Method* to *Erase Necessary Pages*, check the **Verify After Program** box, and check *Reset MCU After Program*.
8. Next, click the **Program** button to start the Erase, Download and Verify process. The DEBUG ACTIVE LED (D1) on the board turns on at this time.
9. Program execution starts once the Verify process is complete.

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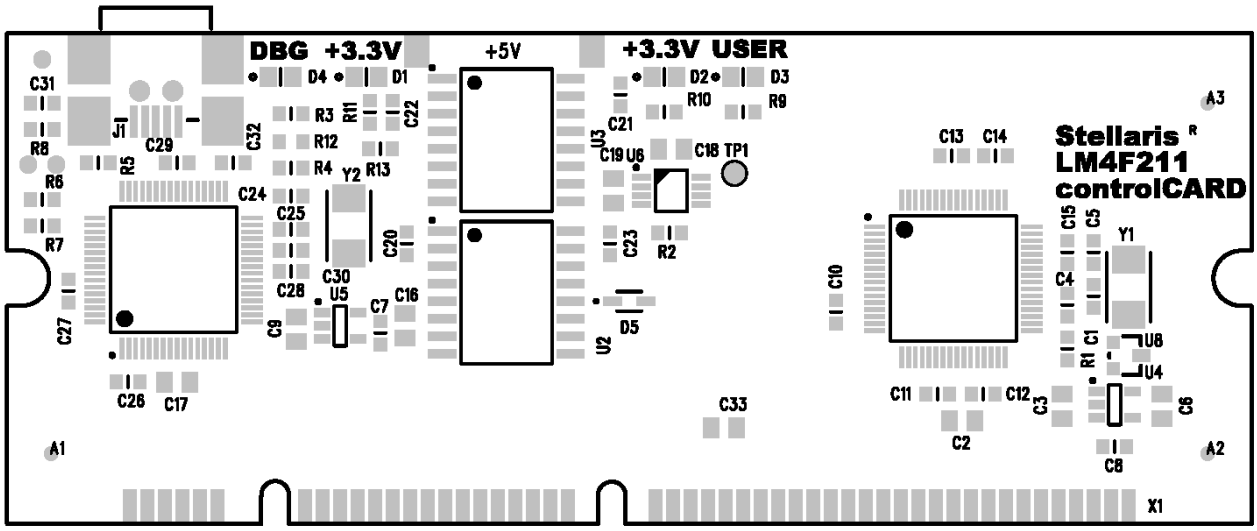
PCB Layout and References

4.1 Component Locations

Figure 4-1 shows the plot of the top-side component locations.

Figure 4-1. Top-Side Component Location



4.2 References

In addition to this document, the following references are included on the Stellaris controlCARD Development Kit CD and are also available for download from the TI website at www.ti.com:

- Stellaris Development and Evaluation Kits for Code Composer Studio Quickstart Guide
- Stellaris LM4F211H5QR Microcontroller Data Sheet (literature number SPMS323)
- StellarisWare Driver Library User's Manual, publication SW-DRL-UG (literature number SPMU019)
- Associated ZIP file with a spreadsheet that summarizes the signals for the MDL-LM4F211CNCD (literature number SPMU294)

Information on development tool being used:

- Texas Instruments' Code Composer Studio IDE website: www.ti.com/ccs

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Schematics

The following schematics for the LM4F211 controlCARD module are appended to this document:

- Stellaris Contents (sheet 1)
- Debug Interface, Virtual COM Port, and Isolators (sheet 2)

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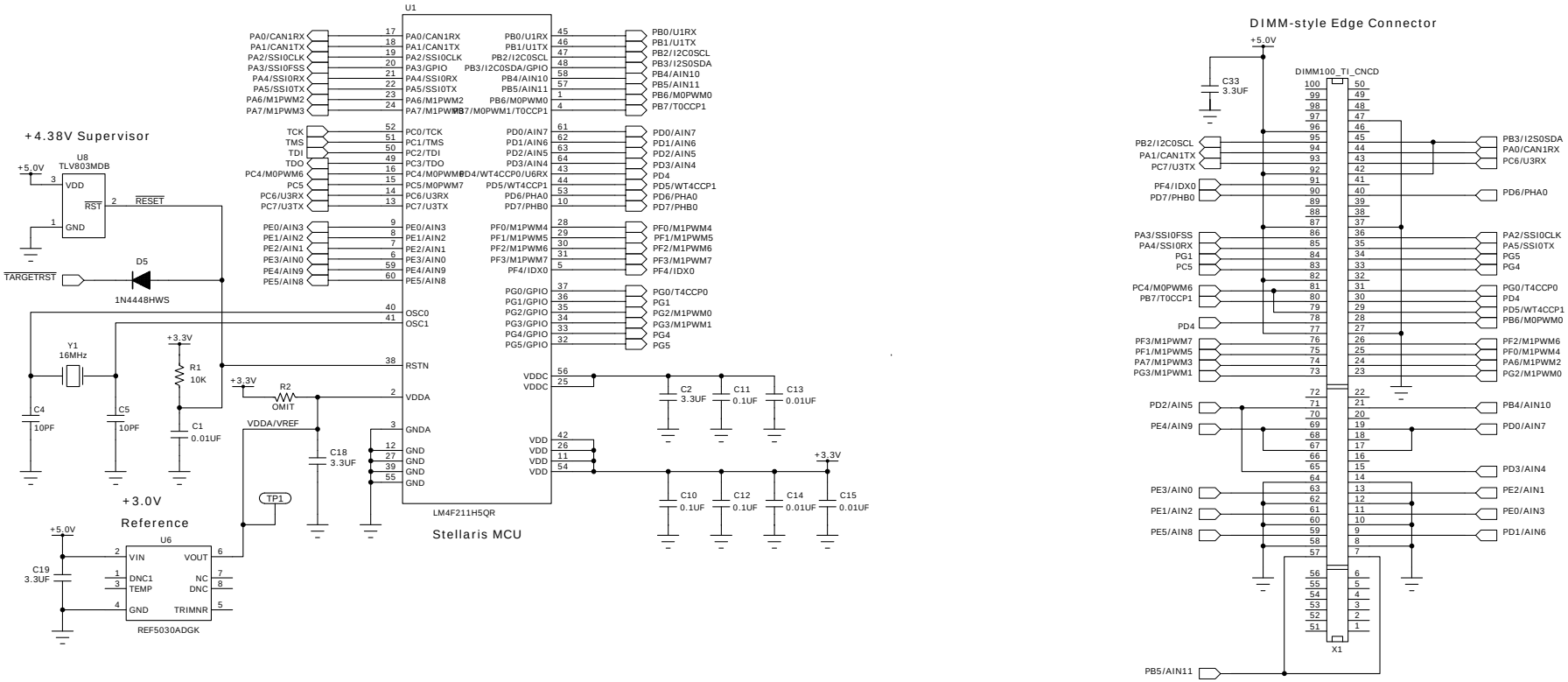

DESIGNER: JAG	REVISION: A	DATE: 4/20/2012
PROJECT: Control Card LM4F211		
DESCRIPTION: STELLARIS LM4F211 CONTROLCARD WITH LM4F211H5QR MCU		
FILENAME: MDL-LM4F211CNCD Rev A.sch		

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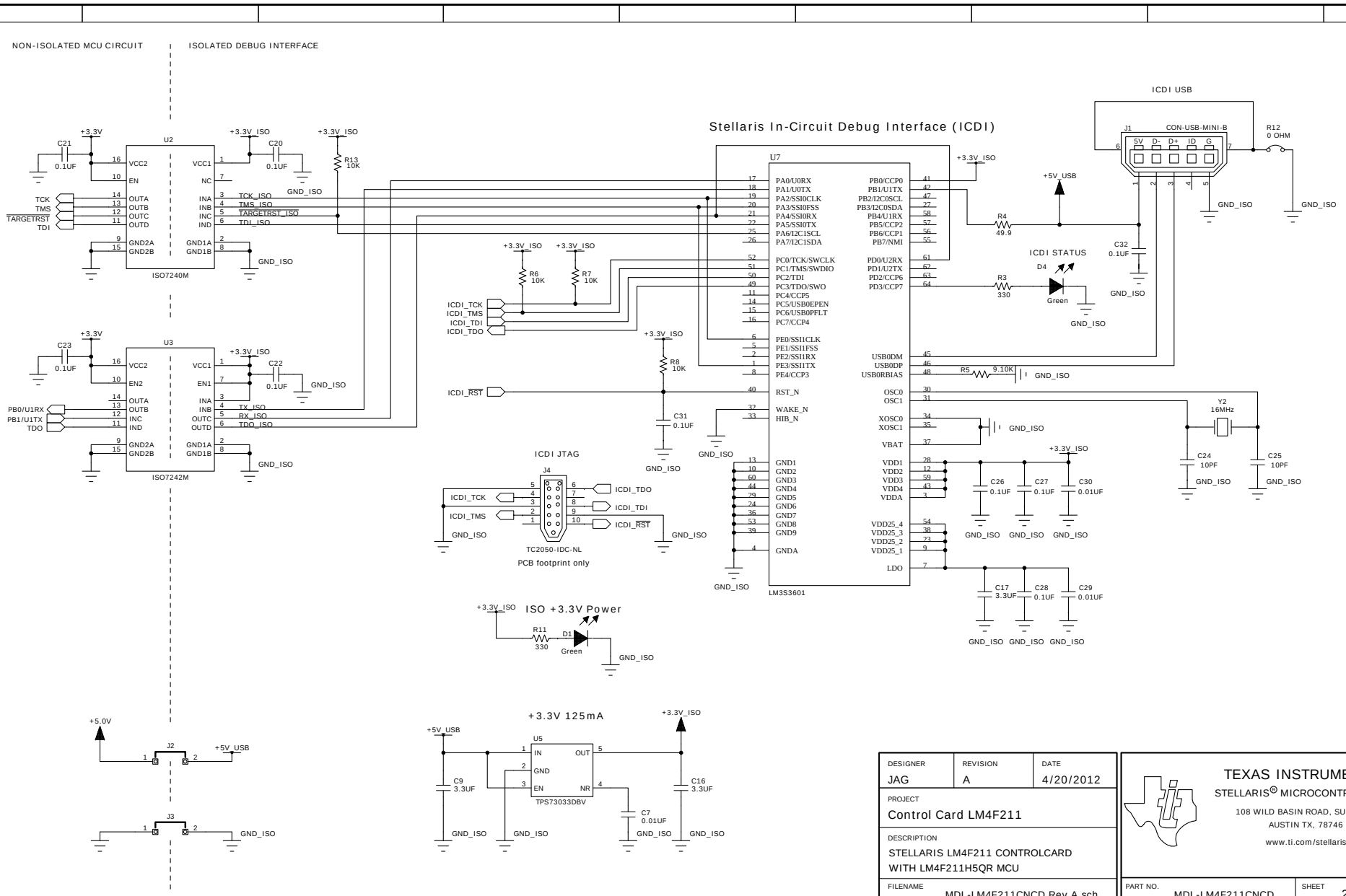
PART NO.: MDL-LM4F211CNCD	SHEET: 1 OF 2



DESIGNER	REVISION	DATE
JAG	A	4/20/2012

PROJECT
Control Card LM4F211

DESCRIPTION
STELLARIS LM4F211 CONTROLCARD
WITH LM4F211H5QR MCU

FILENAME
MDL-LM4F211CNCD Rev A.sch

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PART NO.	SHEET
MDL-LM4F211CNCD	2 OF 2

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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

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.

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 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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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