SAT - High Efficiency Isolated CAN & Profibus Interface Solution

Purpose of this Wiki Page

This page explains the High Efficiency Isolated CAN & Profibus Interface Solution TI Design in detail. After reading this guide, a user should better understand the features and usage of this module. The TI Design consists of a board, referred to as SAT0047, which can be mounted onto a Tiva C Launchpad.

EVM Overview

Reference Design Description

The High Efficiency Isolated CAN & Profibus Interface Solution TI Design is intended for use in industrial systems that require isolated power for CAN and/or Profibus transceivers. This TI Design highlights the ability to completely shut off both the power converter and data transceivers with just one GPIO signal from a microcontroller (when dropping into low power modes, for example). This isolated interface solution delivers accurately regulated rails for both primary and secondary power to TI's Profibus and CAN transceivers without costly opto-coupler feedback circuits – making this the simplest, most efficient and flexible isolated interface solution for industrial automation on the market today. Other solutions using transformer drivers are not efficient and do not have the ability to be easily turned off and require additional components to regulated the secondary rail. Lastly, this TI Design has the additional feature of allowing the MCU to wait until power is good before transmitting data or to stop transmitting data if a power fault has occured on the interface.

The Tiva C Series Launch Pad form factor of this TI Design allows easy connection to the LaunchPad board for use of the Tiva C microcontroller in handling the communications protocol to the interface. The combination of the two boards provides a complete, low cost CAN and Profibus communication solution.

Features

High Efficiency Isolated CAN & Profibus Interface Solution TI Design Features

- Enable, Soft-start and Fault functions of TPS55010 provides full MCU control of the power supply rails to the communications interface -- maximizing system power savings
- Adjustable, high switching frequency increases efficiency, decreases solution size and allows avoidance of sensitive frequency bands
- Galvanic insulation technology used in TI's isolated Profibus and CAN Transceivers provide proven reliability and stability over time, temperature and moisture

TI Part Number Features

- **TPS55010**
  - Isolated Fly-Buck Topology
  - Primary Side Feedback
  - 100 kHz to 2000 kHz Switching Frequency
  - Synchronizes to External Clock
  - Adjustable Slow Start
  - Adjustable Input Voltage UVLO
  - Open Drain Fault Output
  - Cycle-by-Cycle Current Limit
  - Thermal Shutdown Protection
  - 3 mm x 3 mm 16 Pin QFN Package
- **ISO1050**
  - Meets the Requirements of ISO11898-2
  - 5000-VRMS Isolation (ISO1050DW)
  - Failsafe Outputs
  - Low Loop Delay: 150ns (Typ), 210ns (Max)
  - 50 kV/μs Typical Transient Immunity
  - Bus-Fault Protection of −27 V to 40 V
  - Driver (TXD) Dominant Time Out Function
  - IEC 60747-5-2 (VDE 0884, Rev. 2) and
  - IEC 61010-1 Approved
  - UL 1577 Double Protection Approved; See Regulatory Information Section
  - IEC 60601-1 (Medical) and CSA Approved
  - 5 KVRMS Reinforced Insulation per TUV; Approved for EN/UL/CSA 60950-1 (ISO1050DW)
  - I/O Voltage Range Supports 3.3V and 5V Microprocessors
  - Typical 25-Year Life at Rated Working Voltage (see Application Report SLLA197 [1])
- **ISO1176**
  - 4000-VPEAK Isolation, 560-Vpeak VIORM
    - UL 1577, IEC 60747-5-2 (VDE 0884, Rev. 2), IEC 61010-1, IEC 60950-1 and CSA Approved
  - Bus-Pin ESD Protection
    - 16 kV HBM Between Bus Pins and GND2
    - 6 kV HBM Between Bus Pins and GND1
  - Meets or Exceeds the Requirements of EN 50170 and TIA/EIA-485
  - Signaling Rates up to 40 Mbps
  - Differential Output Exceeds 2.1 V (54R Load)
  - Low Bus Capacitance − 10 pF (MAX)
  - 50 kV/μs Typical Transient Immunity
  - Failsafe Receiver for Bus Open, Short, Idle
  - 3.3-V Inputs are 5-V Tolerant

Featured Applications

The Platform was designed to demonstrate a simple, efficient and versatile isolated interface solution in the following applications:

- Programmable Logic Control (PLC) Systems
- Industrial Motor Drives
- Human Machine Interface (HMI) Panels
- Industrial Communications Modules

Highlighted Products

The Platform features the following devices:

- TPS55010 - 2.95V To 6V Input, 2W, Isolated DC/DC Converter with Integrated FETS
- ISO1050 - Isolated 5-V CAN Transceiver
- ISO1176 - Isolated PROFIBUS RS-485 Transceiver

Block Diagram

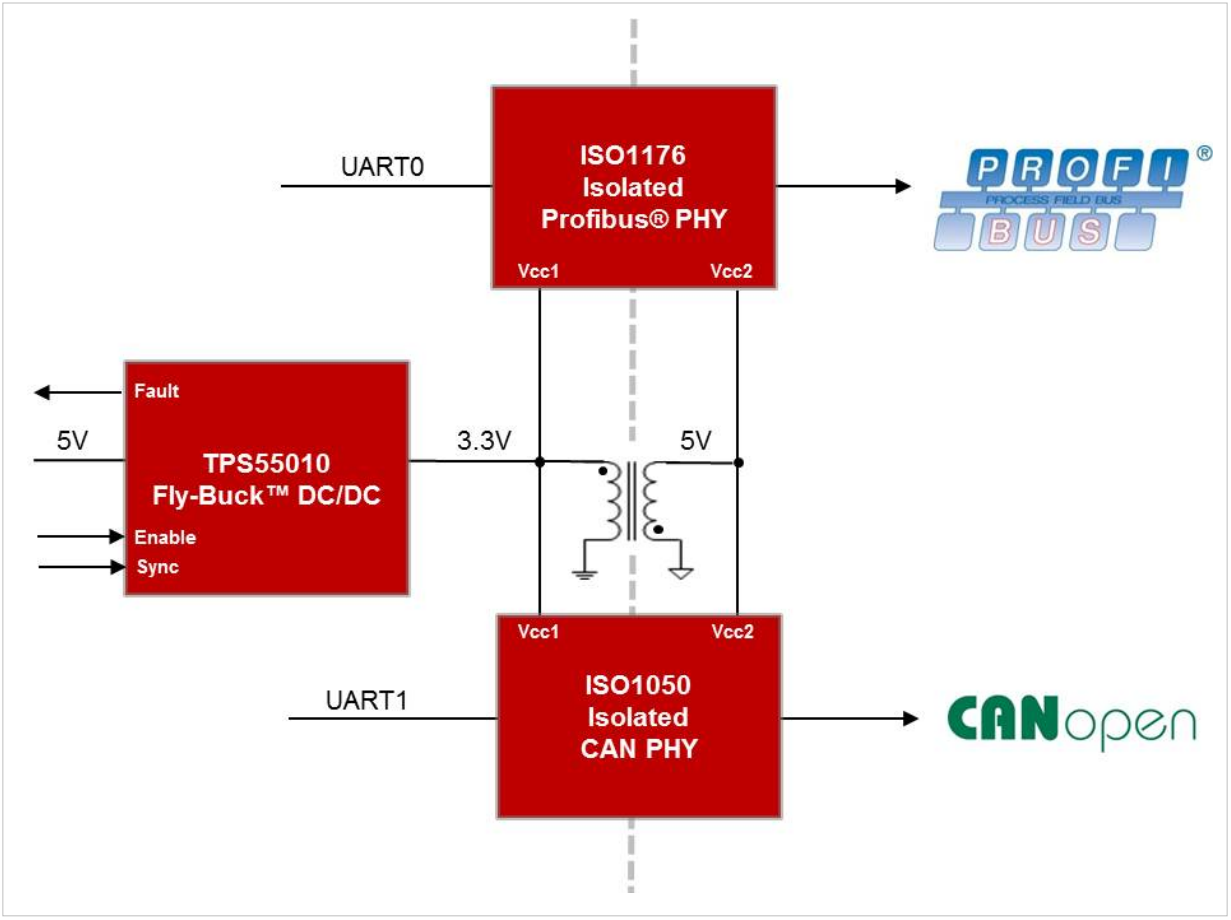

Figure 1: High Efficiency Isolated CAN & Profibus Interface Solution Block Diagram

EVM Wiki

The most up-to-date information on this Reference Design can be found at the SAT - High Efficiency Isolated CAN & Profibus Interface Solution Wiki Page [2]

EVM Landing Page

This module is currently not available for order.

Hardware Description

Getting Started: What's Needed

- SAT0047 Board
- Tiva C LaunchPad [3]

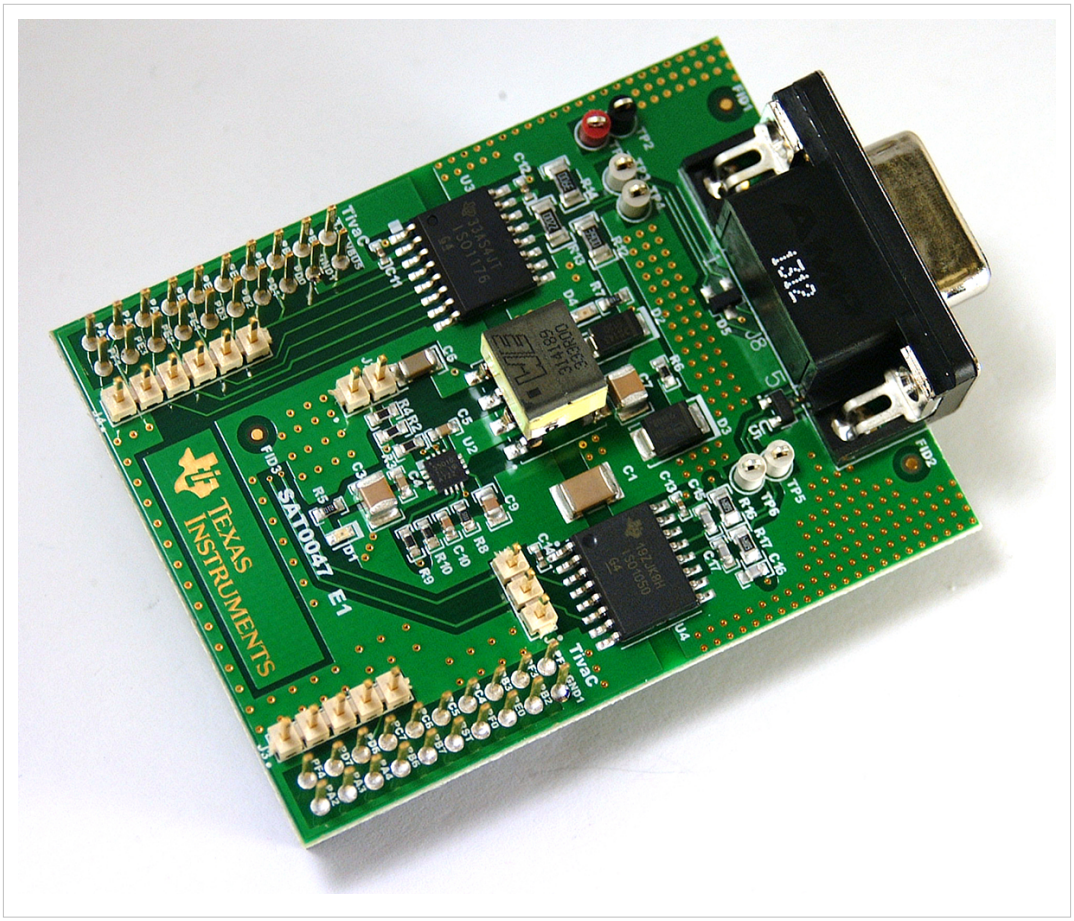

Figure 2: High Efficiency Isolated CAN & Profibus Interface Solution Board

Easy Steps to *GetGoing*

Typical configuration of the module is as follows:

- If the High Efficiency Isolated CAN & Profibus Interface Solution will be evaluated in conjunction with the Tiva C LaunchPad, mate the SAT0047 board on top of the LaunchPad, ensuring that the pin labels match up.

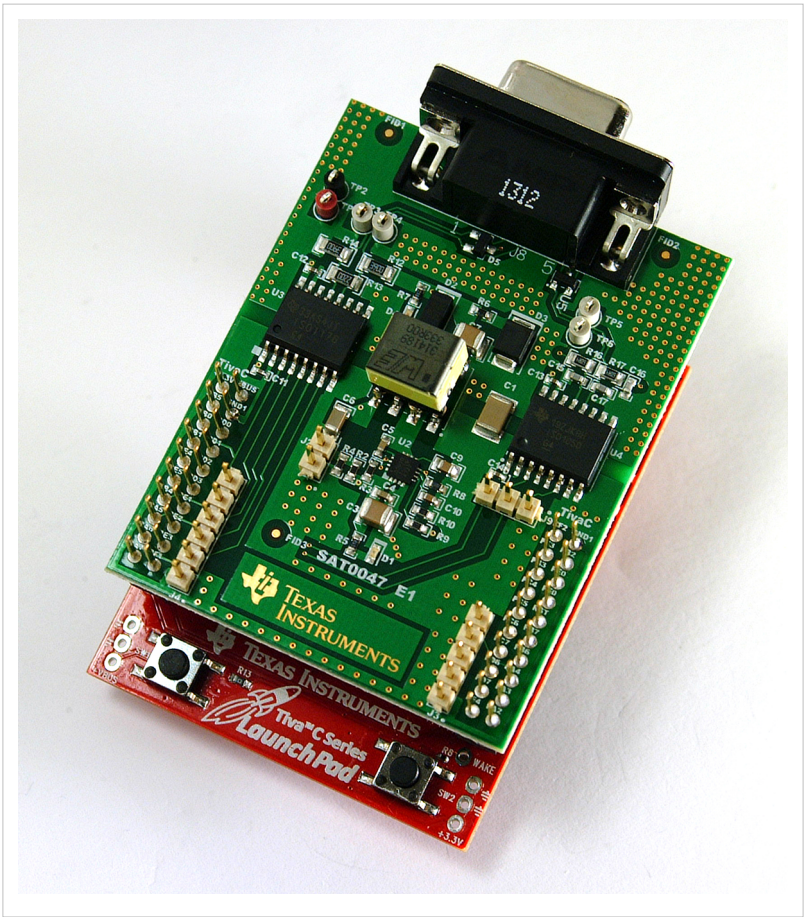

Figure 3: SAT0047 Board mated to Tiva C LaunchPad

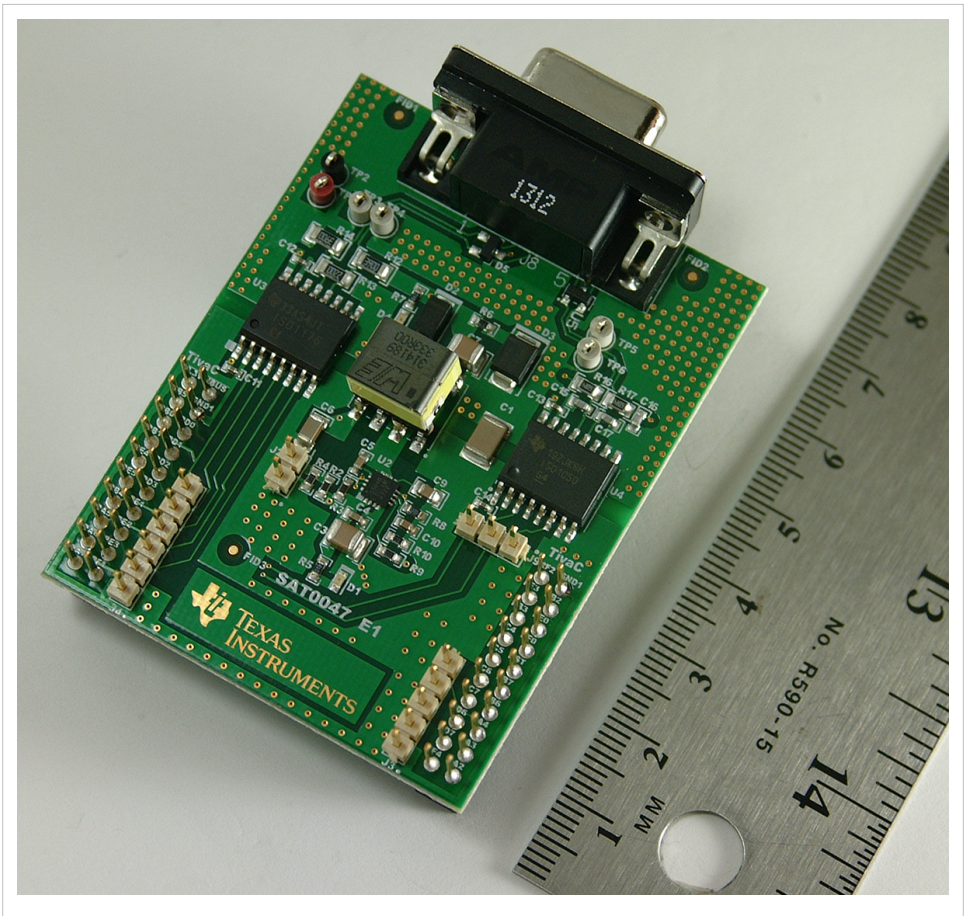

Figure 4: SAT0047 Board shown to scale

Functional Test Information

The High Efficiency Isolated CAN & Profibus Interface Solution was tested under several different test conditions. The TPS55010 has an EN pin, which allows a user to completely disable the power converter. The system can be configured to set the EN pin disabled or enabled. In addition, the CAN transceiver (ISO1050) can be run with a 1 Mbps, 50% duty cycle signal, which will represent an average, high-speed CAN signal. For testing purposes, a 37 kbps signal with 11 dominant (low) bits followed by 1 recessive (high) bit was used to simulate the absolute worst-case power consumption of the ISO1050 device. In real CAN systems, this signal sequence is unlikely to occur. The Profibus transceiver (ISO1176) was tested with a 12 Mbps, 50% duty cycle data stream. The LED currents due to D1 & D4 were subtracted from the total currents given in Table 1, below.

Test Condition	3.3V Rail (V)	5V_ISO Rail (V)	$I_{SAT0047}$ (mA)
EN disabled, CAN (no data), Profibus (no data)	0	0	0.15
EN enabled, CAN (no data), Profibus (no data)	3.338	4.986	43.29
ISO1176T Small EVM, Profibus only (no data)	**3.188**	**5.015**	**44.30**
EN enabled, CAN (1 Mbps, 50% duty cycle), Profibus (no data)	3.338	4.935	56.48
EN enabled, CAN (37 kbps, 11 bits low, 1 bit high), Profibus (no data)	3.338	4.885	69.30
EN enabled, CAN (no data), Profibus (12 Mbps)	3.338	4.807	89.37
ISO1176T Small EVM, Profibus only (12 Mbps)	**3.073**	**5.011**	**88.66**
EN enabled, CAN (1 Mbps, 50% duty cycle), Profibus (12 Mbps)	3.338	4.766	102.15
EN enabled, CAN (37 kbps, 11 bits low, 1 bit high), Profibus (12 Mbps)	3.338	4.705	113.50

Table 1: Current Consumption of SAT0047 Board

As seen in Table 1 above, one of the benefits of the High Efficiency Isolated CAN & Profibus Interface Solution is the ability to disable the entire system via one GPIO pin. When pulling the EN pin on the TPS55010 low, the current consumption drops to 150µA. If the EN pin was not available as a system feature, the current consumption would be 43.29mA. Therefore, the High Efficiency Isolated CAN & Profibus Interface Solution has the ability to save approximately 215mW when the data transceivers are idling.

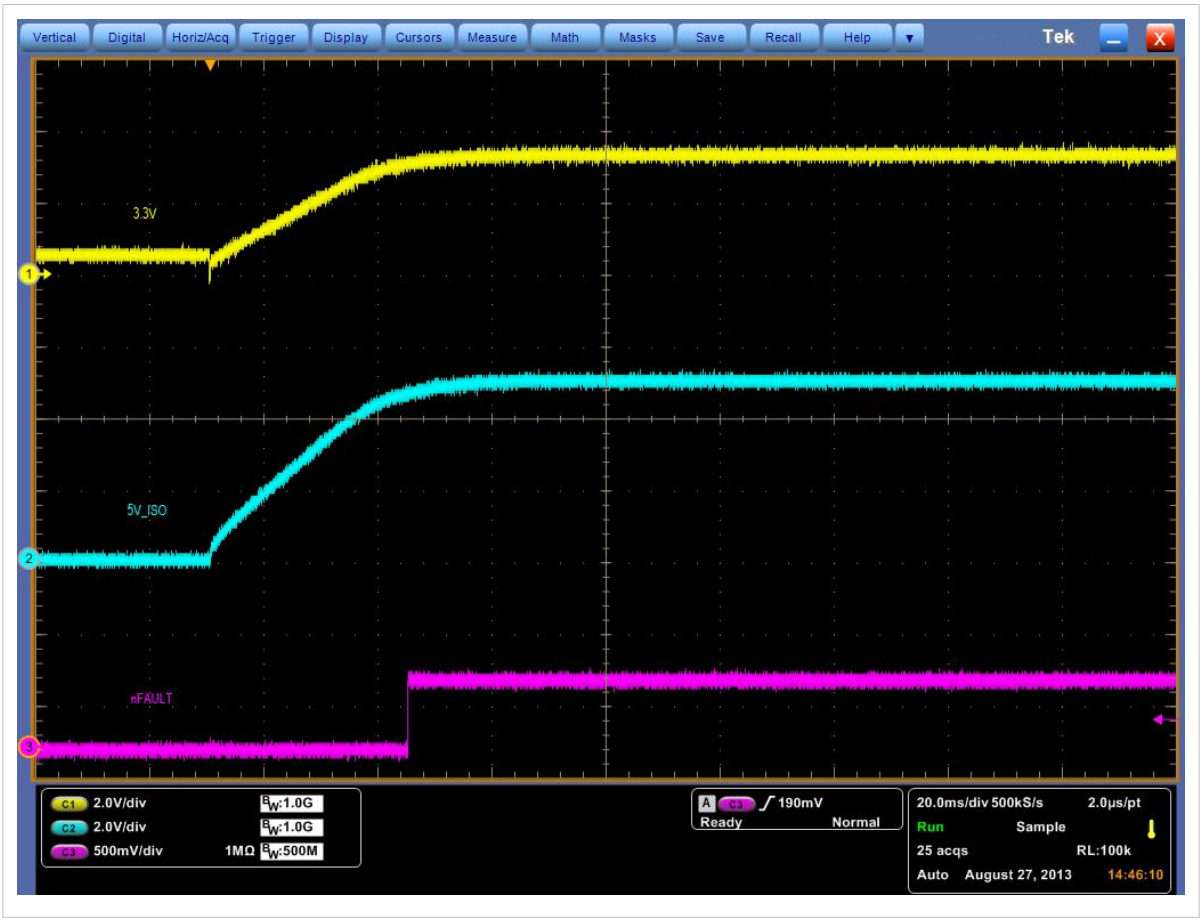

Figure 5: Start-up, no data

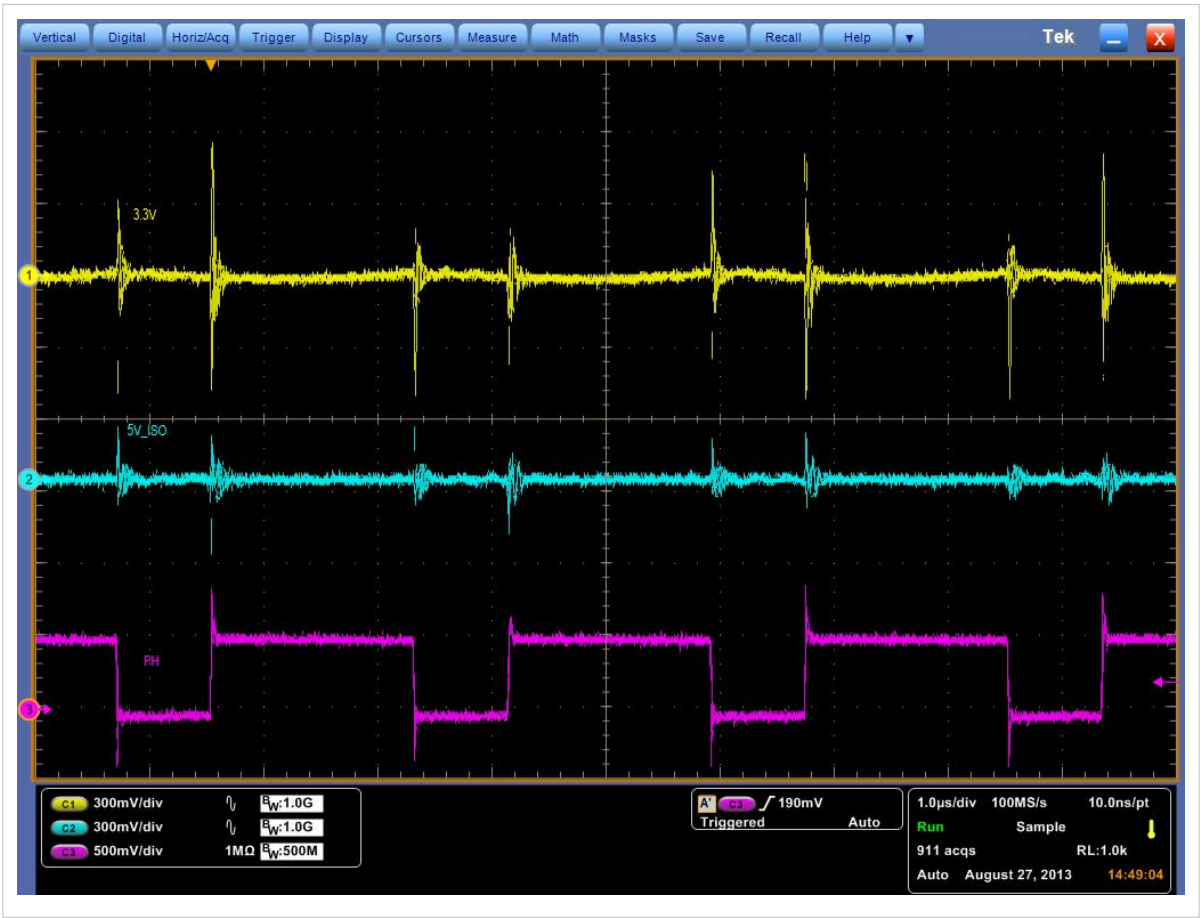

Figure 6: Output Ripple and PH node with EN enabled, no data

Figure 7: Output Ripple and PH node with EN enabled, CAN (1 Mbps, 50% duty cycle)

Figure 8: Output Ripple and PH node with EN enabled, CAN (37 kbps, 11 bits low, 1 bit high)

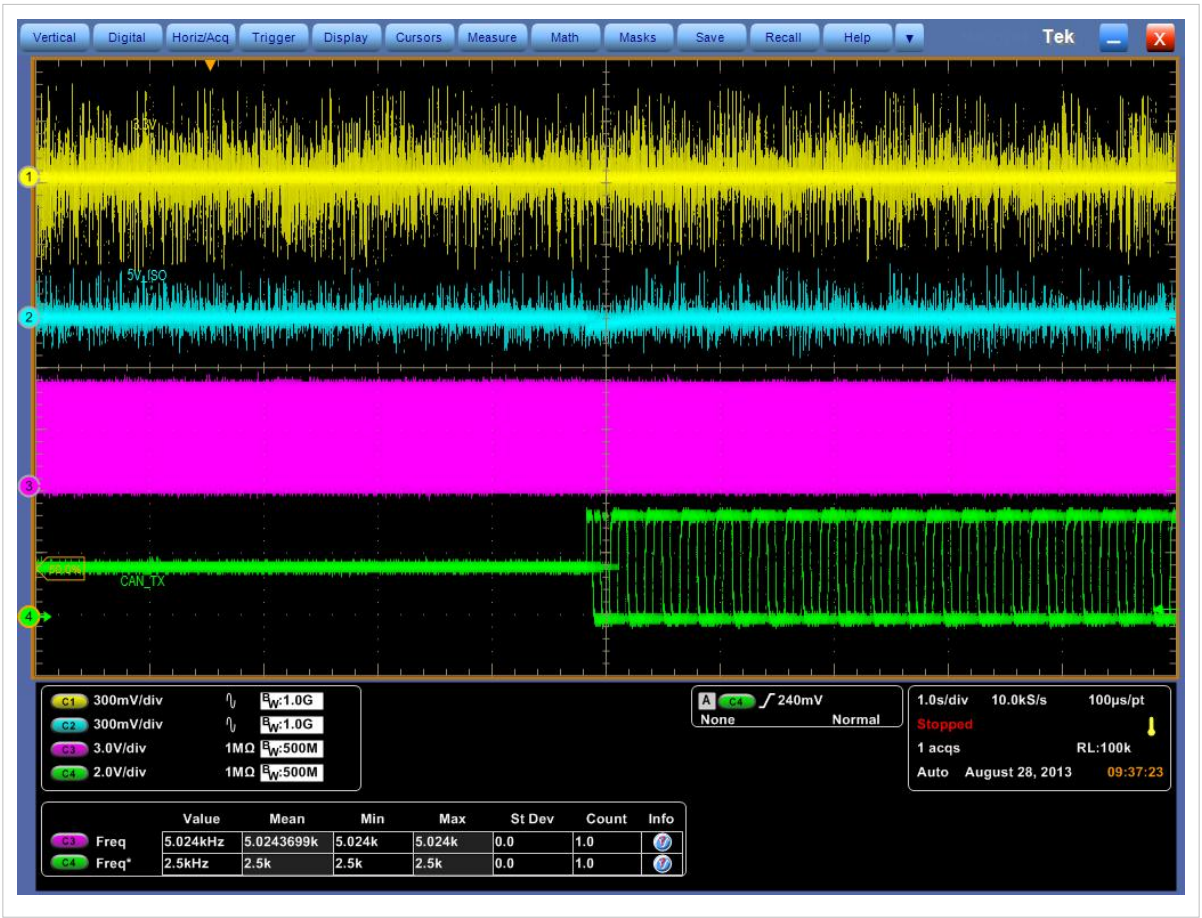

Figure 9: Start-up, EN enabled, CAN (1 Mbps, 50% duty cycle)

Figure 10: Output Ripple and PH node with EN enabled, Profibus (12 Mbps)

Figure 11: Output Ripple and PH node with EN enabled, Profibus (12 Mbps), CAN (1 Mbps, 50% duty cycle)

Figure 12: Output Ripple and PH node with EN enabled, Profibus (12 Mbps), CAN (37 kbps, 11 bits low, 1 bit high)

Lessons Learned

Design Errors

- The original design was found to have a start-up glitch due to noise pickup on the RT/CLK pin of TPS55010. To solve this problem, the following steps were taken:
  - R8 default value is changed to 243kOhm (changes TPS55010 switching frequency to ~400kHz; no other components need to be altered)
  - Optionally, the RT/CLK pin can be driven directly from Tiva C LaunchPad to choose a different switching frequency

Design Optimizations

- Currently none

Schematics and BOM

Download a PDF [4] of the SAT0047 schematic.

Download a PDF [5] of the SAT0047 BOM.

SAT High Efficiency Isolated CAN & Profibus Interface Solution - Schematic

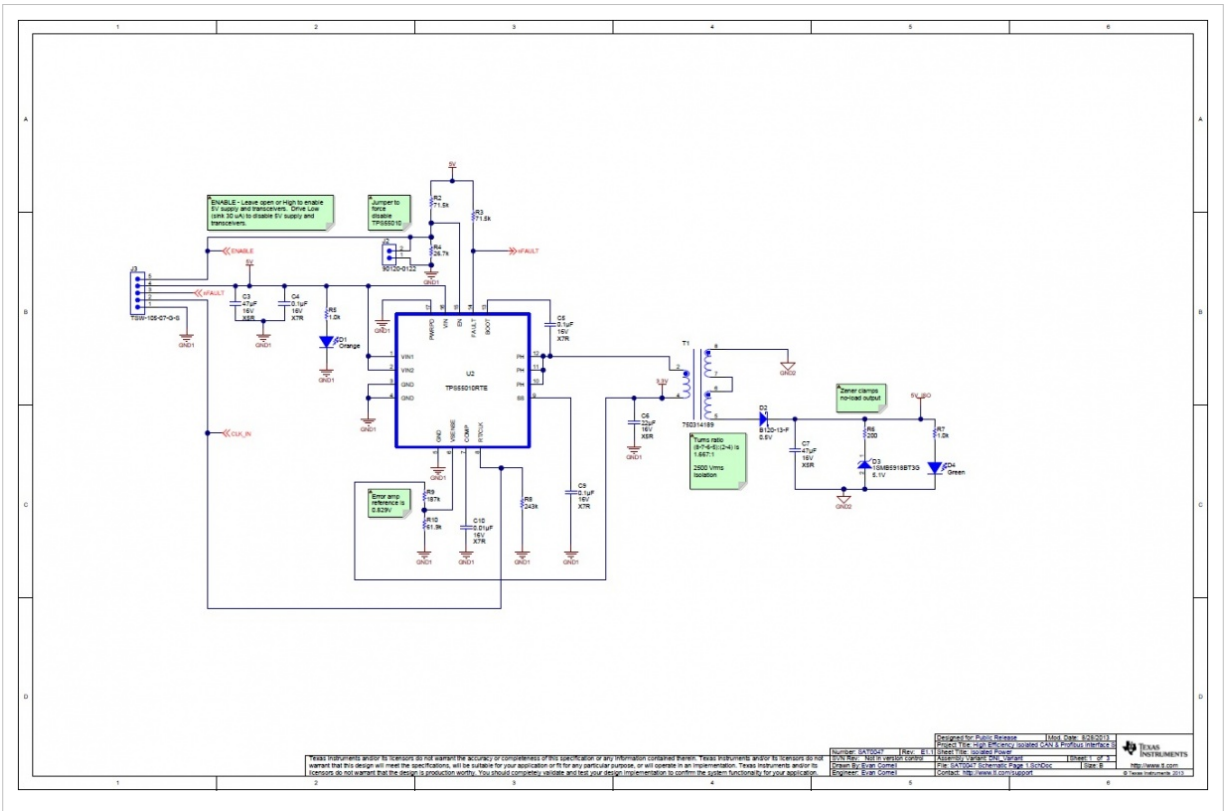

Figure 13: Isolated Power Section

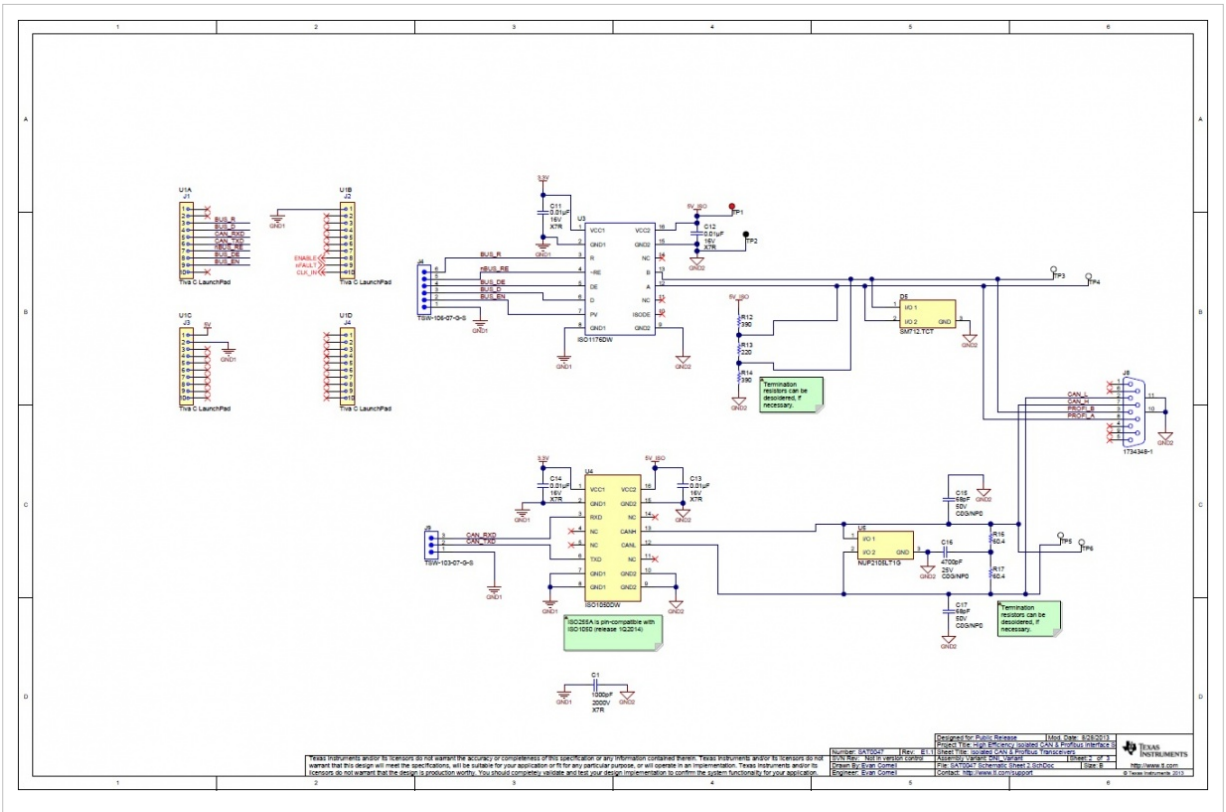

Figure 14: Isolated CAN & Profibus Transceivers Section

Layout

Gerber Files

Download a zip [6] of SAT0047 - High Efficiency Isolated CAN & Profibus Interface Solution Board Gerber Files.

Altium Project Files

Download a zip [7] of SAT0047 - High Efficiency Isolated CAN & Profibus Interface Solution Altium Files.

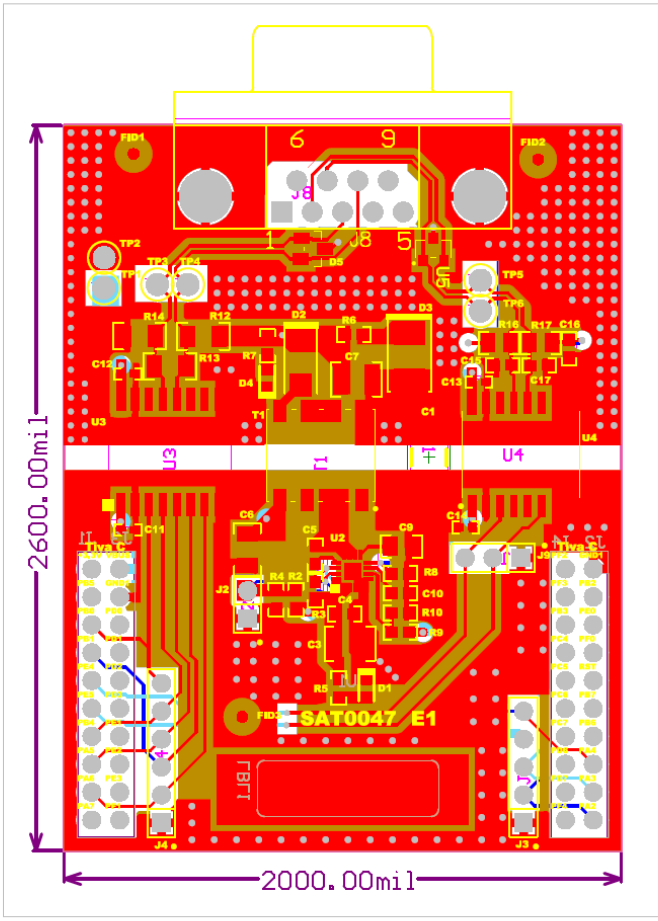

Figure 15: SAT0047 Board Layout

FCC Report

This platform does not incorporate intentional radiators

Precautions and Certifications

ESD Precautions

The following guidelines should be followed in order to avoid ESD damage to the board components:

- Any person handling boards must be grounded either with a wrist strap or ESD protective footwear, used in conjunction with a conductive or static-dissipative floor or floor mat.
- The work surface where boards are placed for handing, processing, testing, etc., must be made of static-dissipative material and be grounded to ESD ground.

- All insulator materials either must be removed from the work area or they must be neutralized with an ionizer. Static-generating clothes should be covered with an ESD-protective smock.
- When boards are being stored, transferred between operations or workstations, or shipped, they must be maintained in a Faraday-shield container whose inside surface (touching the boards) is static dissipative.

Certifications

Eco-Info & Lead-Free Home [8]

RoHS Compliant Solutions [9]

Statement on Registration, Evaluation, Authorization of Chemicals (REACh) [10]

Important Notices

Evaluation Board/Kit/Module (EVM) Additional Terms

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/ kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

Regulatory Compliance Information

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs not subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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 is 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.

Texas Instruments Japan Limited (address) 24-1, Nishi-Shinjuku 6 chome, Shinjukku-ku, Tokyo, 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.

References

[1] http://www.ti.com/lit/pdf/SLLA197
[2] http://processors.wiki.ti.com/index.php/SAT_-_High_Efficiency_Isolated_CAN_%26_Profibus_Interface_Solution
[3] http://www.ti.com/tool/ek-tm4c123gxl
[4] http://processors.wiki.ti.com/index.php/File:SAT0047_Rev_E1.pdf
[5] http://processors.wiki.ti.com/index.php/File:SAT0047_BOM_Rev_E1.pdf
[6] http://processors.wiki.ti.com/index.php/File:SAT0047_Rev_E1(Gerbers).zip
[7] http://processors.wiki.ti.com/index.php/File:SAT0047_Rev_E1.zip
[8] http://focus.ti.com/quality/docs/gencontent.tsp?templateId=5909&navigationId=11208&contentId=5026
[9] http://focus.ti.com/quality/docs/gencontent.tsp?templateId=5909&navigationId=11219&contentId=5057
[10] http://focus.ti.com/en/download/qlty/TI_REACH_Statement.pdf

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