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 occurred 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

![Block Diagram](image)

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]
**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](image)
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.
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](image)

**Table 1: Current Consumption of SAT0047 Board**

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

![Figure 5: Start-up, no data](image)
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)
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[^5] of the SAT0047 BOM.

SAT High Efficiency Isolated CAN & Profibus Interface Solution - Schematic

![Figure 13: Isolated Power Section](image-url)
Figure 14: Isolated CAN & Profibus Transceivers Section
Layout

Gerber Files

Altium Project Files

![Figure 15: SAT0047 Board Layout](image)

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]

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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.

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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.

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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.

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4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

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