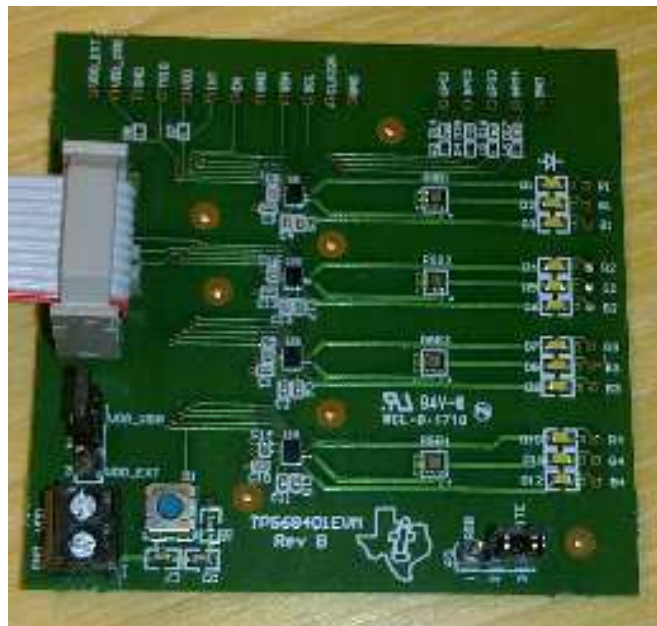# TPS68401EVM User's Guide

The TPS68401EVM is an evaluation board to assist in evaluating the TPS68401 IC as a multifunction LED driver.

The TPS68401 device is an advanced lighting management unit for handheld devices. It has three independent channels optimized for driving RGB LEDs. The built-in fractional charge pump boosts the input voltage to power the LEDs at low input voltage. Channel one can optionally be supplied directly from the battery voltage to reduce power consumption and improve efficiency.

At the heart of the device is a programmable state machine which executes a lighting program consisting of up to 16 instructions per channel. Once the program is loaded through the I²C™ interface the device is fully independent from the main processor resulting in significant system-level power savings. The device can issue an interrupt to the main processor via the INT pin. The TRIG I/O allows synchronization between multiple devices. A general-purpose output pin is provided which is addressable through the serial interface. In addition, the INT pin can also be configured as general-purpose output.

Figure 1. TPS68401EVM

The following related documents are available for download through the Texas Instruments web site (http://www.ti.com) or via the links below.

Table 1. EVM Related Data Sheets

DEVICE	LITERATURE NUMBER
TPS68401	SLVSA68
USB-TO-GPIO	SLLU093

Contents

List of Figures

1 INTRODUCTION

1.1 Description

The Texas Instruments TPS68401 evaluation module (EVM) helps designers to evaluate TPS68401 advanced lighting management unit for handheld devices. These devices have three independent channels optimized for driving RGB LEDs. The built-in fractional charge pump boosts the input voltage to power the LEDs at low input voltage. Channel one can optionally be supplied directly from the battery voltage to reduce power consumption and improve efficiency.

At the heart of the device is a programmable state machine which executes a lighting program consisting of up to 16 instructions per channel. Once the program is loaded through the I^2C interface the device is fully independent from the main processor resulting in significant system-level power savings. The device can issue an interrupt to the main processor via the INT pin.

The TRIG I/O allows synchronization between multiple devices. A general-purpose output pin is provided which is addressable through the serial interface. In addition, the INT pin can also be configured as general-purpose output.

The EVM contains four independent TPS68401 devices that can be programmed and controlled trough a GUI.

1.2 Applications

- LED control for portable applications
- Accent lighting (mood, personalization, etc.)
- Function indication (charge, messages, etc.)
- Keypad illumination/backlight (white or RGB)
- Display backlight

1.3 Features

- Multifunction LED driver with three independent channels
- Integrated high efficiency 1x/1.5x charge pump with automatic or manual gain change
- 3 x 25.5-mA total output current
- Three independent program execution engines (3 x 16 instructions)
- 8-bit PWM with exponential control option
- 8-bit current DAC control
- 200-nA typical shutdown current
- Automatic power-save mode
- Autonomous operation without external control
- Trigger I/O for synchronizing multiple devices
- One or two general purpose output controlled via serial interface
- I^2C interface
- Operating Temperature Range: -30ºC to 85ºC
- 20-ball WLCSP package with 0.4-mm pitch

2   SYSTEM OVERVIEW

The system block diagram is shown below.
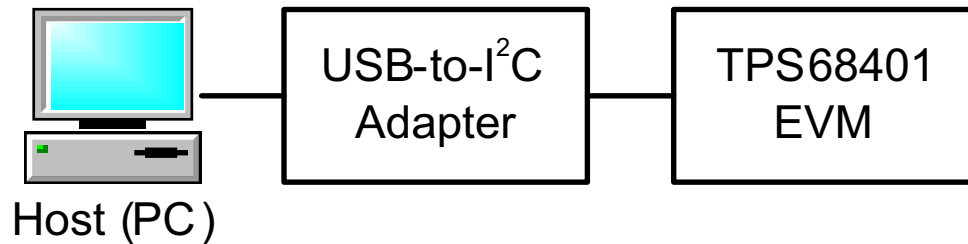

Figure 2. System Block Diagram

The system consists of the following components:

Host (PC)— A Windows® personal computer (PC) – used to configure and monitor the TPS68401EVM. The GUI operates on the host. For the GUI to execute properly, the host needs to have the correct LabViewTM RunTimeTM version. If the host doesn't have the correct RunTimeTM version it will be prompted during GUI installation. More information in GUI installation section.

USB-to-I^{2}C Adapter— TPS68401EVM uses the I^{2}C interface for communication with the host. The TI-supplied USB-to-I^{2}C adapter does the appropriate conversion so the host can use the USB interface for communication. USB-to-I^{2}C adapter has a 3.3-V supply rail which is used to supply the EVM so no external power supply is needed.

TPS68401EVM— EVM board that houses the TPS68401 and peripheral components.

The evaluation module is designed to provide access to the features of the TPS65281. Some modifications can be made to this module to test performance at different input and output voltages, current and switching frequency. Please contact TI Field Applications Group for advice on these matters.
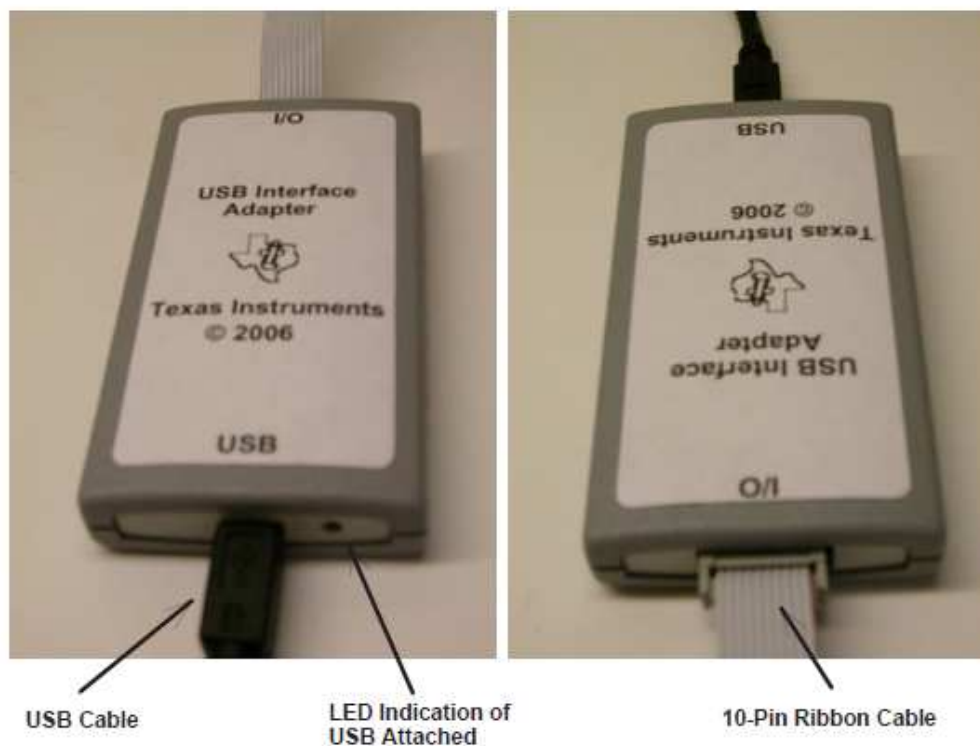
Figure 3. USB-to-GPIO Adapter

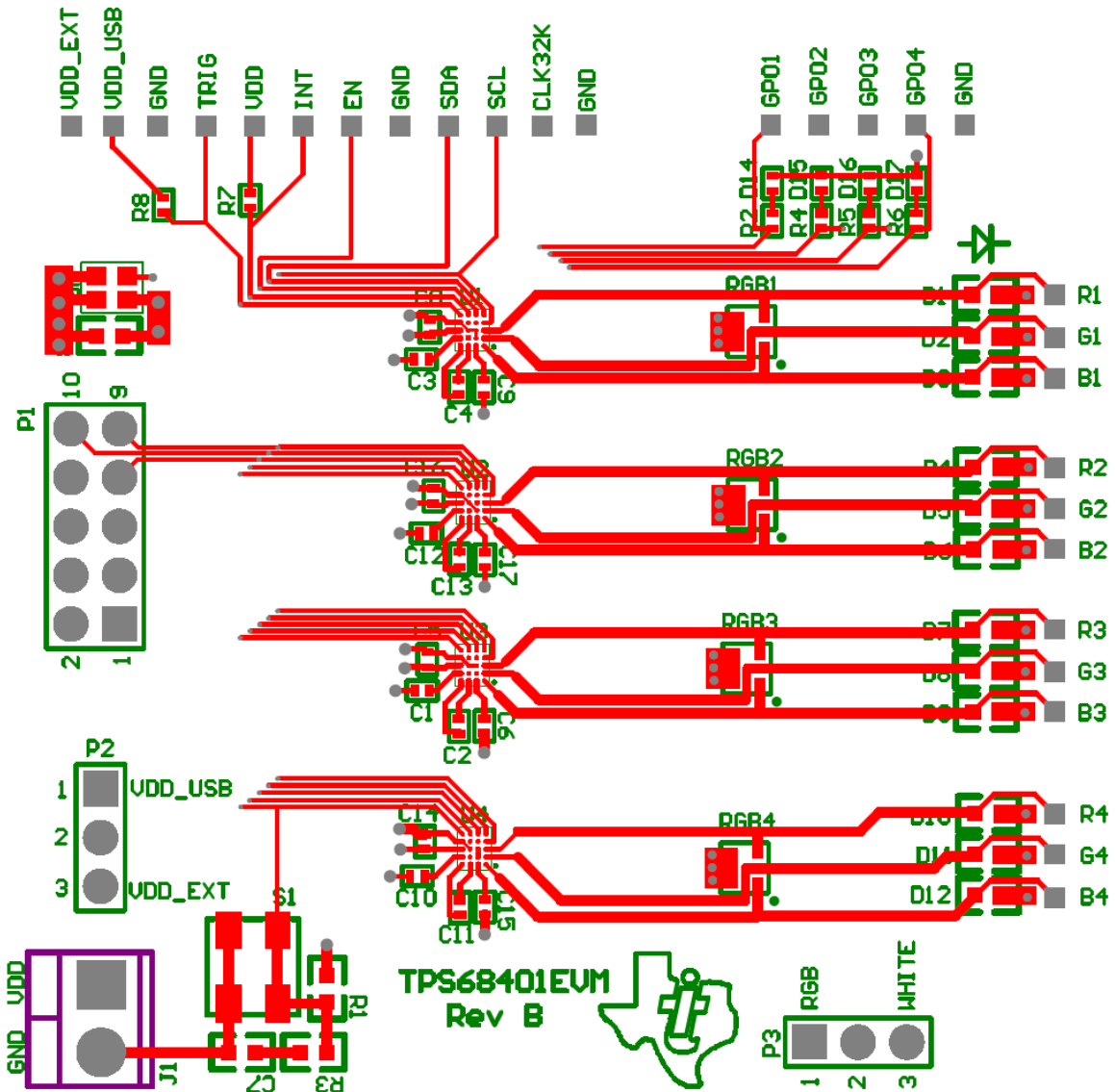*Submit Documentation Feedback*

3   BOARD LAYOUT

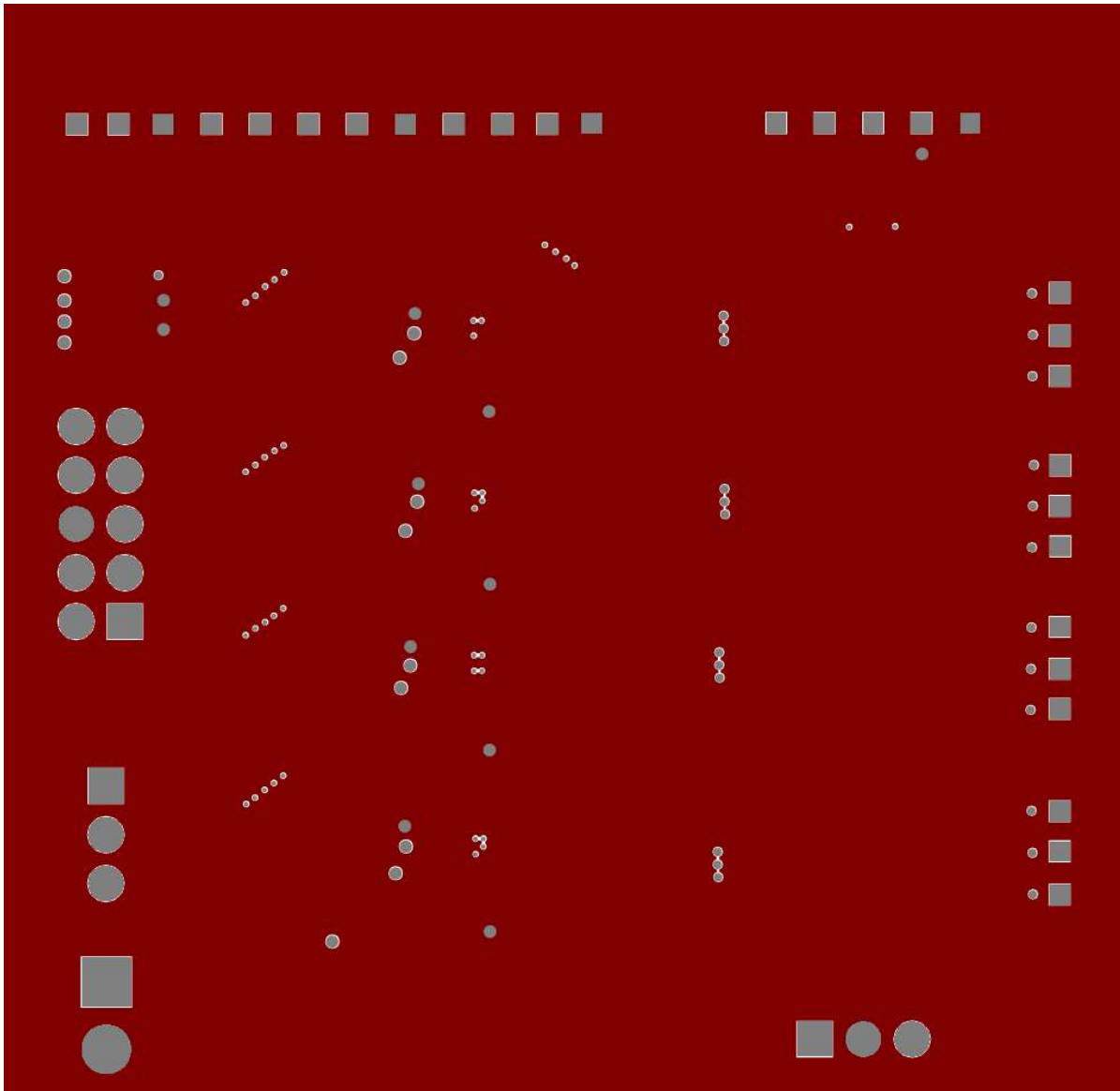**Figure 4. TPS68401EVM Board Layer 1 (SIGNAL)**

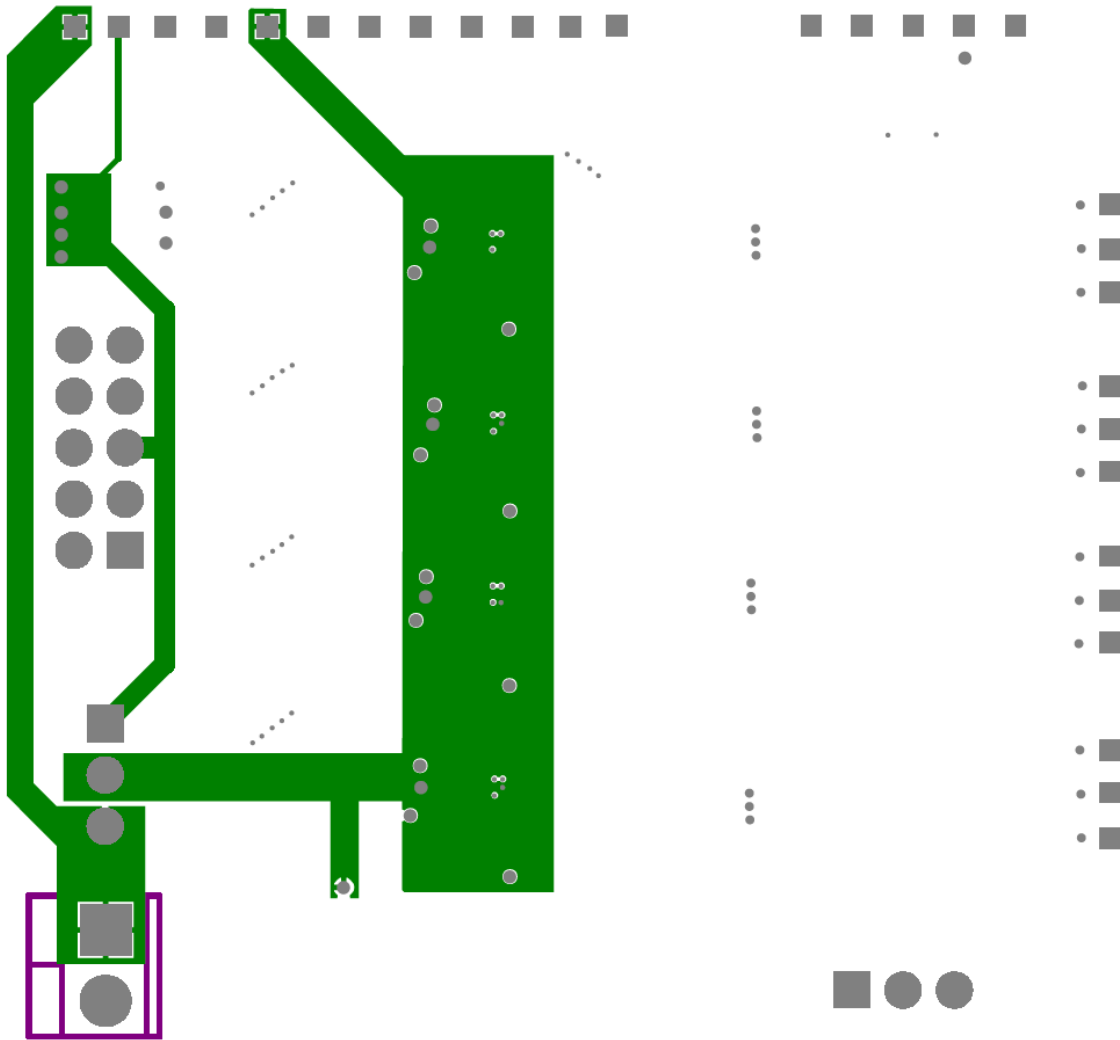**Figure 5. TPS68401EVM Board Layer 2 (GND)**

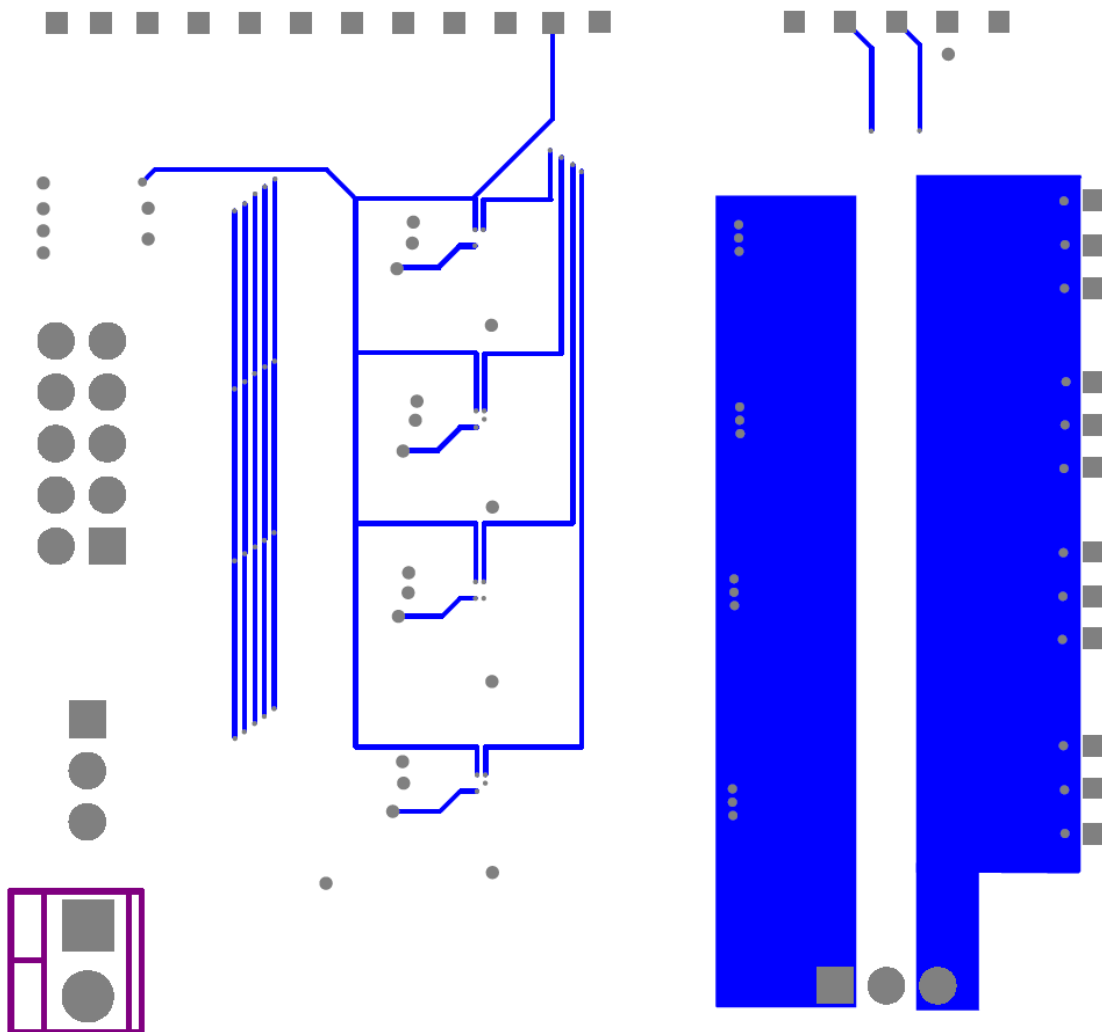**Figure 6. TPS68401EVM Board Layer 3 (POWER)**

Figure 7. TPS68401EVM Board Layer 4 (SIGNAL)

4   HARDWARE OVERVIEW

The TPS68401EVM allows evaluation of the TPS68401 Advanced Lighting Management Unit for handheld devices. TPS68401 has three independent channels optimized for driving RGB LEDs. The built-in fractional charge pump boosts the input voltage to power the LEDs at low input voltage. At the heart of the device is a programmable state machine which executes a lighting program consisting of up to 16 instructions per channel. Once the program is loaded through the I^2C interface the device is fully independent from the main processor resulting in significant system-level power savings. The TRIG I/O allows synchronization between multiple devices.

The TPS68401EVM can be configured and monitored through a Windows GUI application running on a PC. The GUI communicates with the TPS68401EVM through the USB Interface Adapter (included with EVM kit), which acts as an I^2C master for the board. TPS68401EVM has four TPS68401 devices and those can be separately programmed through the GUI.

The TPS68401EVM provides the following functionality:

- Programming of the four different TPS68401 devices (all four devices have different I^2C addresses which can be selected from the GUI).
- Driving either RGB or white LED's (see jumper setting).
- 32-kHz oscillator on board is used as an external clock the TPS68401 devices on board.
- Trigger button to enable synchronous program execution between several devices.
- Indicator LEDs for all four general purpose outputs (GPOs).
- Standard 400-kHz I^2C communication via I^2C connector to USB adapter for connection to a PC.
- Board can be supplied through the 3.3 V from the USB adapter or from an external power source (see jumper setting).

4.1   Connectors

The TPS68401EVM has connectors for power and I^2C communications. J1 provides a possibility to power EVM from an external power supply (between 2.7 V and 5.5 V). USB adapter Interface Adapter has 3.3-V power output that can be used to power the board so there is no need for external power source.

P1 header provides the I^2C communication interface to the TPS68401EVM. The USB Interface Adapter includes a ribbon cable that can be connected to P1. The adapter is connected to a Windows-based PC.

CAUTION
When using an external power supply for the TPS68401EVM, the recommended supply range for TPS68401 is from 2.7 V to 5.5 V.
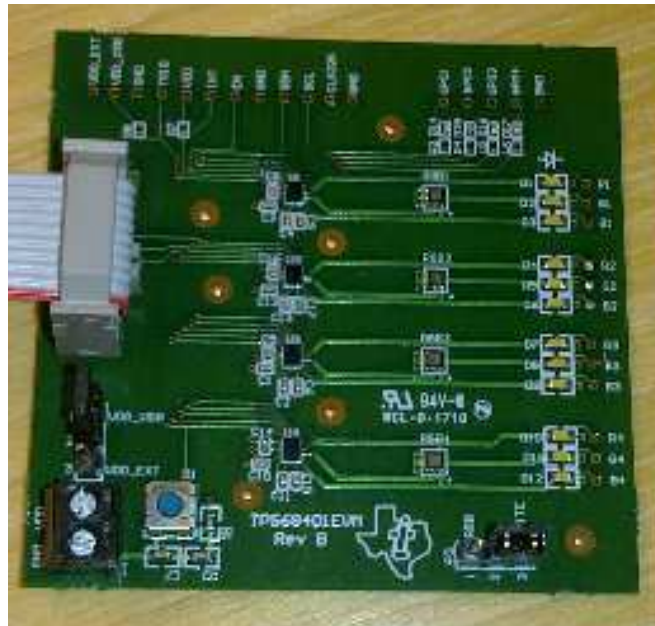
Connecting the ribbon cable to TPS68401EVM pin one is marked on the EVM and with the red stripe in the ribbon cable.

Figure 8. Ribbon Cable Connection

4.2   Jumpers

The TPS68401EVM operation can be configured using jumpers:

- Board power from external supply or USB Interface Adapter
- Driving RGB or white LEDs

Table 2. TPS68401EVM Jumpers

NO.	FUNCTION	DEFAULT SETTING
P2	Board power supply selection. Connect to pins 1-2 when using 3.3 V from the USB Interface Adapter and pins 2-3 if external power supply is used.	Pins 1-2 (Power from USB Interface Adapter)
P3	RGB or white LEDs are connected. Connect to pins 1-2 if RGB LEDs are used and 2-3 when using white LEDs. If using U4 to generate PWM signals for other devices through P5 connector pin 2-3 need to be connected.	Pins 1-2 (RGB LEDs connected)

4.3   Test points

The TPS68401EVM provides test points that can be used for evaluation. Important voltages can be monitored with a meter through the use of the test points.

4.4   EVM Operation

The TPS68401EVM operates from either USB Interface Adapter (through P1) or External Power Supply (through J1). Jumper P2 can be used to select the power source.

1. Connect the USB Interface Adapter to the TPS68401EVM P1 connector using the ribbon cable provided.
2. Plug the appropriate end of the USB cable into the adapter and the other end into your PC.

> **NOTE:** If using an external power supply connect jumper's pins 2-3 and use J1 to connect the power supply.

5   SOFTWARE

The TPS68401EVM comes with a Windows application that can be used to configure and monitor the EVM. The GUI can be used to configure all available options of the EVM such as programming and current settings.

The following section explains the procedure for installing the graphical user interface (GUI) onto a Windows based PC. A USB interface adapter is required to connect the EVM to a PC and should be provided with the EVM.

Additional interfaces can be ordered through http://focus.ti.com/docs/toolsw/folders/print/usb-to-gpio.html

5.1   Software Installation Instructions

To install the EVM software follow the steps outlined:

1. Double-click on the setup.exe file in the \Installer\Volume\ directory.
2. Follow the prompts to finish the installation.
3. At the end of the installation, a reboot of your computer may be required.
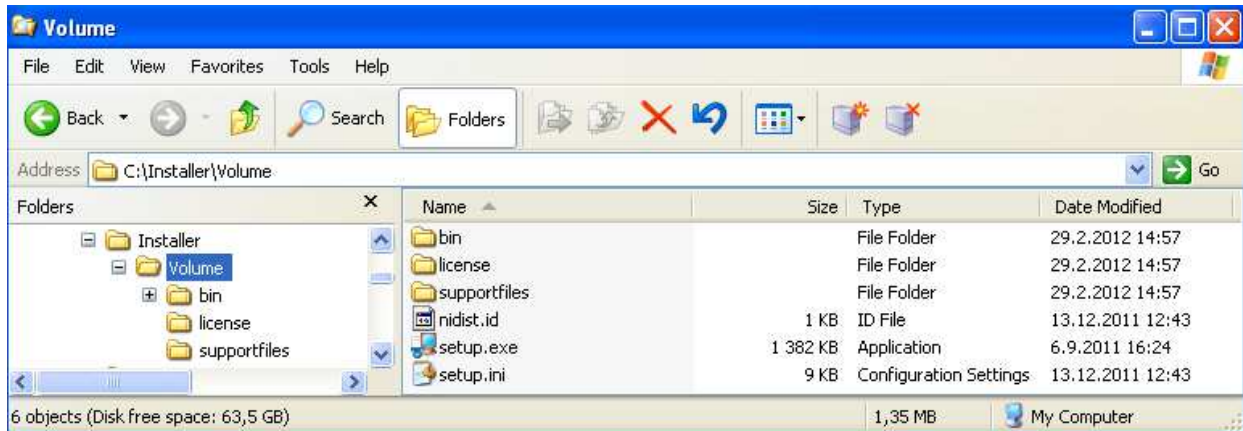
Figure 9. setup.exe. File Location

I^2C read/write commands may be made using the provided software. A dark grey block means the bit is high. A white block means the bit is low. A write may be performed simply by clicking on an individual bit or an entire register may be written by using the write command on the left side of the GUI.

Figure 10. TPS68401EVM GUI Main

Figure 11. TPS68401EVM GUI Basic

6   SCHEMATIC AND BILL OF MATERIALS
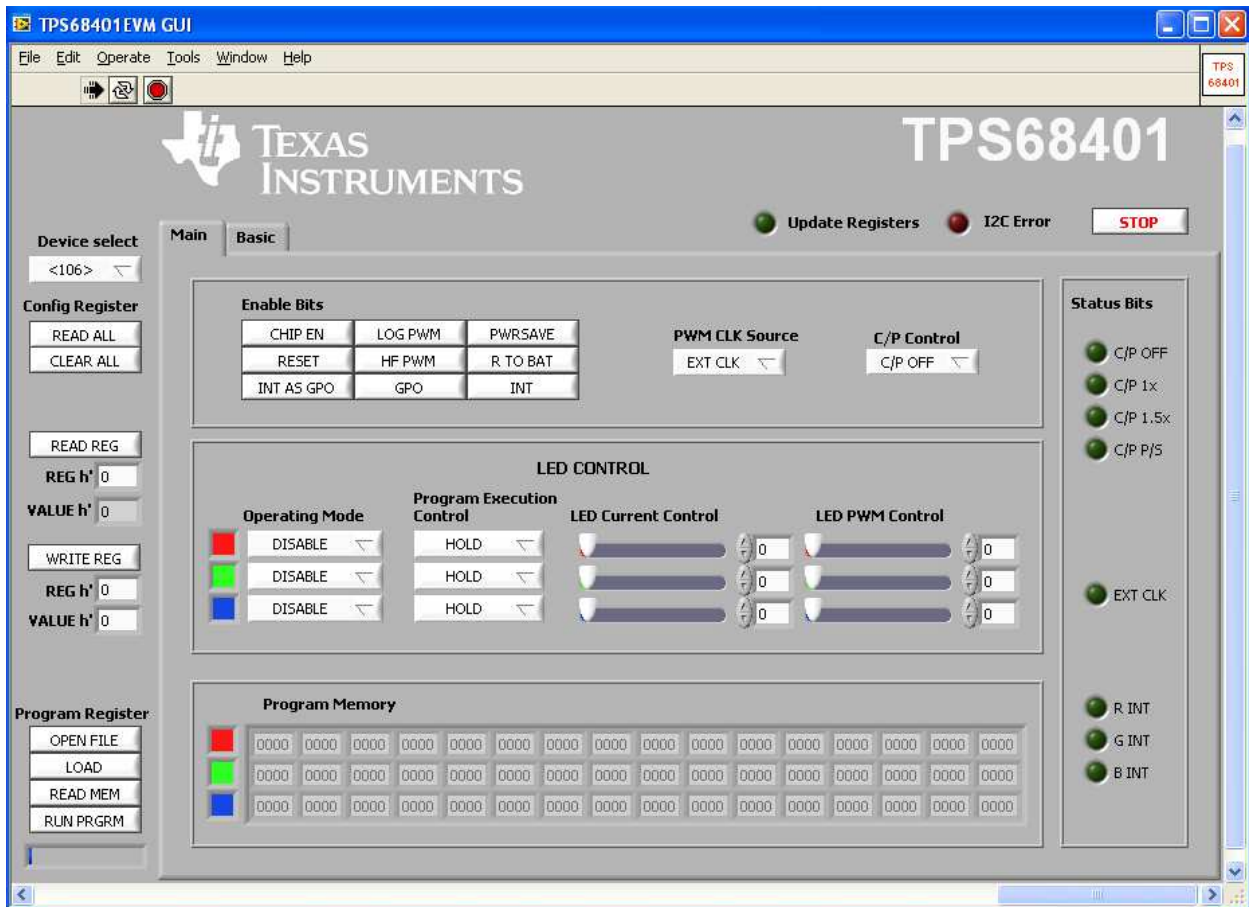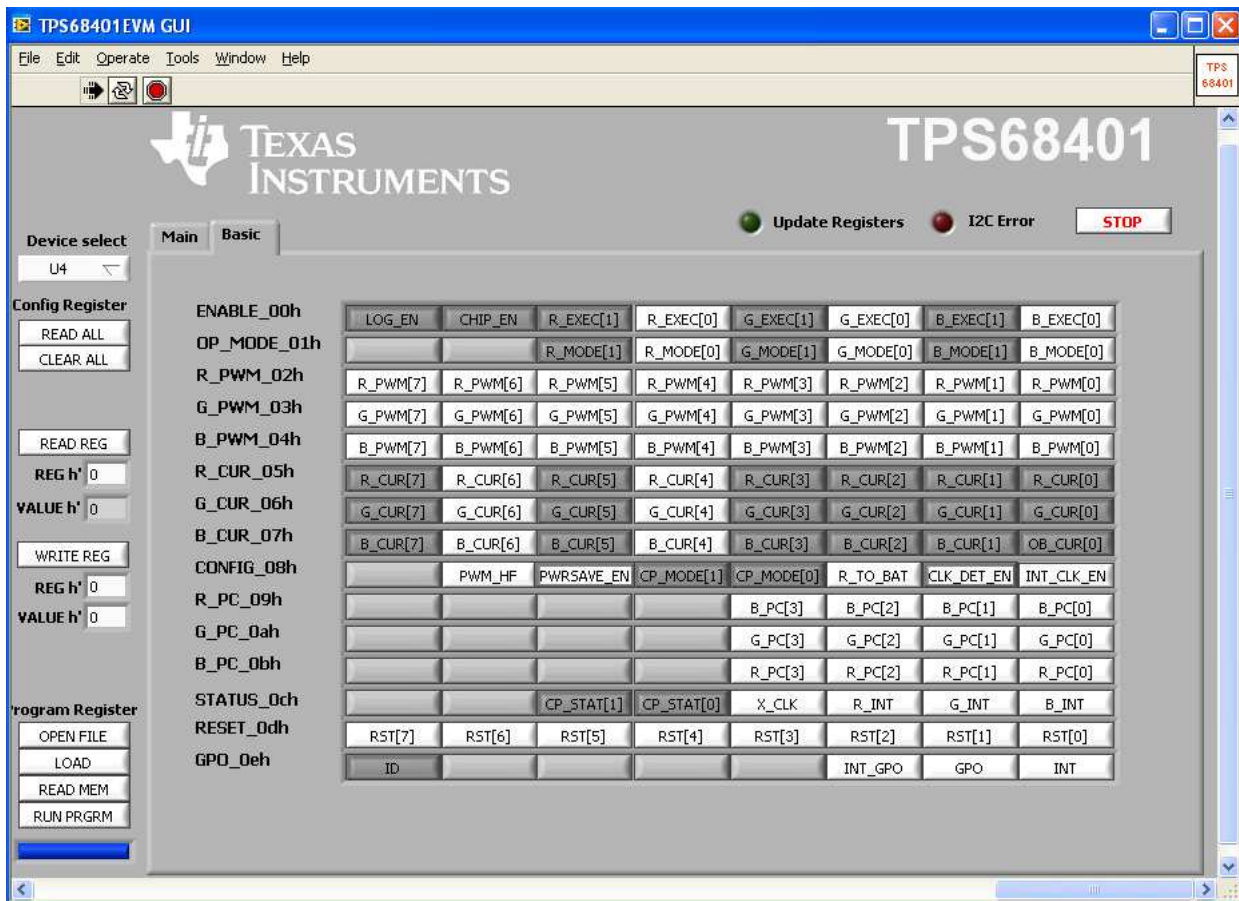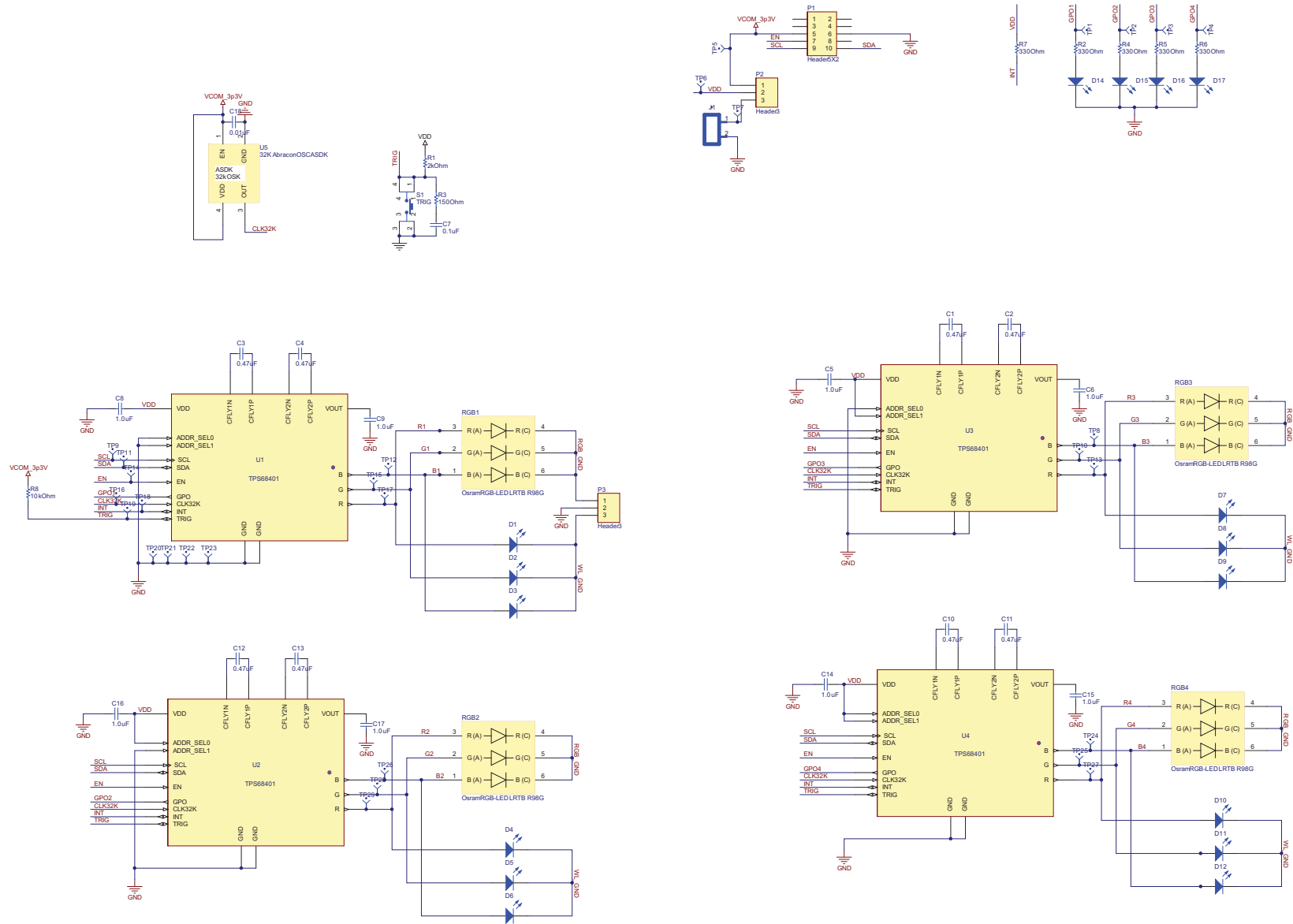
The following pages contain the TPS68401EVM board schematic and bill of materials.

Table 3. TPS68401EVM Bill of Materials

Item No.	Qty	Designator	Value	Size	Manufacturer	Part No.	Description
1	8	C1, C2, C3, C4, C10, C11, C12, C13	0.47uF	402	Panasonic	ECJ0EB0J474K	Capacitor, Ceramic, 10V, X5R
2	8	C5, C6, C8, C9, C14, C15, C16, C17	1.0uF	402	Panasonic	ECJ0EB1A105M	Capacitor, Ceramic, 10V, X5R
3	1	C7	0.1uF	603			
4	1	C18	0.01uF	603			
5	12	D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12		603	Osram	LW Q38G	White LED
6	4	D14, D15, D16, D17		402	Lumex	SML-LX0402SIC	Indicator LED
7	1	J1		2 x 3.5mm	On Shore	ED555/2DS	Terminal Block
8	1	P1			Sullins	PBC05DAAN	Header, 2x5, 0.1mil
9	1	P2, P3			Sullins	PBC03SAAN	Header, 1x3, 0.1mil
10	1	R1	2k	603			Resistor, Chip, 1/10W
11	5	R2, R4, R5, R6, R7	330	403			Resistor, Chip, 1/10W
12	1	R3	150	603			Resistor, Chip, 1/10W
13	1	R8	10k	402			Resistor, Chip, 1/10W
14	4	RGB1, RGB2, RGB3, RGB4		1.6x1.6mm	Osram	LRTB R98G	RGB chip LED
15	1	S1		5 x 5mm		7914J-1-000E	Sealed Key Switch
16	1	U5			Abracon	ASDK-32.768KHZ-LRT	32k Oscillator
17	4	U1, U2, U3, U4			TI	TPS68401	IC, Multifunction LED Driver

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.

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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 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.

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

http://www.tij.co.jp

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http://www.tij.co.jp

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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