

## **TPS7A4001EVM-709**

This User's Guide describes operational use of the TPS7A4001EVM-709 Evaluation Module (EVM) as a reference design for engineering demonstration and evaluation of the TPS7A4001, low dropout linear regulator (LDO). Included in this user's guide are setup instructions, a schematic diagram, layout and thermal guidelines, a bill of materials, and test results.

### **Contents**

|   |                                                     |   |
|---|-----------------------------------------------------|---|
| 1 | Introduction .....                                  | 1 |
| 2 | Setup .....                                         | 2 |
| 3 | Operation .....                                     | 2 |
| 4 | Test Results .....                                  | 3 |
| 5 | Thermal Guidelines and Layout Recommendations ..... | 4 |
| 6 | Board Layout .....                                  | 5 |
| 7 | Schematic and Bill of Materials .....               | 7 |

### **List of Figures**

|   |                                                                                                                                 |   |
|---|---------------------------------------------------------------------------------------------------------------------------------|---|
| 1 | Turnon Sequence: C1 EN - Turnon to 4.5V, C4 VOUT – 5V Turnon Ramp Characteristic.....                                           | 3 |
| 2 | Step Load and Output Voltage Transient Response: C1 – Full Load Current Step, C2 VOUT – Output Voltage Transient Response ..... | 3 |
| 3 | Assembly Layer .....                                                                                                            | 5 |
| 4 | Top Layer Routing .....                                                                                                         | 5 |
| 5 | Bottom Layer Routing .....                                                                                                      | 6 |
| 6 | Schematic.....                                                                                                                  | 7 |

### **List of Tables**

|   |                                                                         |   |
|---|-------------------------------------------------------------------------|---|
| 1 | Thermal Resistance, $\theta_{JA}$ , and Maximum Power Dissipation ..... | 4 |
| 2 | TPS7A4100EVM-709 Bill of Materials .....                                | 8 |

## **1 Introduction**

The Texas Instruments TPS7A4001EVM-709 EVM helps design engineers to evaluate the operation and performance of the TPS7A4001 linear regulator for possible use in their own circuit application. This particular EVM configuration contains a single linear regulator with internal thermal and current limit shutdowns, and enable (disable) circuitry in a 3mm x 5mm, MSOP-8, thermally enhanced PowerPad™ package. The regulator, including external components, is capable of delivering up to 50mA to the load, depending on the input-output power dissipation, at an operating input voltage of up to 100V. The EVM output voltage is adjustable by an external resistor divider from 1.2V to 35V, but this is limited by the working voltage of the output capacitor. The LDO supports output voltages to 90V. The resistor divider is preset to provide VOUT equal to 5V.

## 2 Setup

This section describes the jumpers and connectors on the EVM as well as how to properly connect, setup and use the TPS7A4001EVM.

### 2.1 Input/Output Connector and Jumper Descriptions

- **J1-EN:** Output enable. To enable the output, connect a jumper to short ON (pin 1) to EN (center pin 2). To disable the output, connect a jumper to short EN (pin 2) to OFF (pin 3).
- **J2 – VIN:** Input power supply voltage connector. The positive input lead and ground return lead from the input power supply should be twisted and kept as short as possible to minimize EMI transmission. Additional bulk capacitance should be added between J2 and J4 if the supply leads are greater than six inches. For example, an additional 47μF electrolytic capacitor connected from J2 to ground can improve the transient response of the TPS7A4001 while eliminating unwanted ringing on the input due to long wire connections
- **J4 – GND:** Ground-return connector for the input power supply
- **J3 – VOUT:** Regulated output voltage connector.
- **J5 – GND:** Output ground-return connector.

### 2.2 Soldering Guidelines

Any solder re-work to modify the EVM for the purpose of repair or other application reasons must be performed using a hot-air system to avoid damaging the integrated circuit IC especially.

### 2.3 Equipment Interconnect

- Turn off the input power supply after verifying that its output voltage is set to the desired supply voltage (less than 100V) and the current limit is set to approximately 100mA. Connect the positive voltage lead from input power supply to VIN, at the J2 connector of the EVM. Connect the ground lead from the input power supply to GND at the J4 connector of the EVM.
- Connect a 0-50mA load (ILoad) between VOUT, at the J3 connector, and the GND, at the J4 connector.
- Disable the output by connecting a jumper at J1 to short the EN (pin 2) to the OFF (pin 3).

## 3 Operation

- Turn on the input power supply. Verify that the output voltage is near 0.V.
- Enable the output by reconnecting the jumper on J1 to short the EN (pin 2) to the ON (pin 1).
- Vary the load current and VIN voltage as necessary for test purposes. Note that at room temperature (25°C) the power dissipation ( $P_{disp}$ ) across the TPS7A4001.

$$P_{disp} = (VIN - VOUT) \times I_{Load} \quad (1)$$

## 4 Test Results

This section provides typical performance waveforms for the TPS7A4001EVM-709 characteristic of this EVM design.

### 4.1 Turnon Characteristics

Figure 1 shows the turn-on characteristic where VIN is pre-set to 9V, the output load is set to 50mA, and the regulator is enabled by a 4.5V step voltage (C1, gold) applied to EN (J1, pin 2). The VOUT softstart (C4, green) shows a rise time indicative of the R1 and C2 values selected.

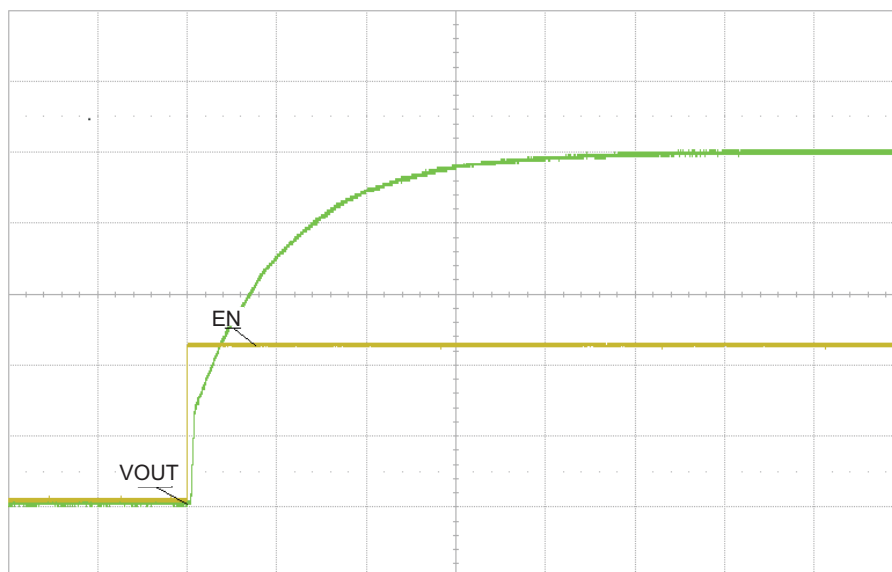


Figure 1. Turnon Sequence: C1 EN - Turnon to 4.5V, C4 VOUT – 5V Turnon Ramp Characteristic

### 4.2 Output Load Transition

Figure 2 shows the VOUT transient response (C2, red) for a full load step transition from 0mA to 50mA (C1, gold).

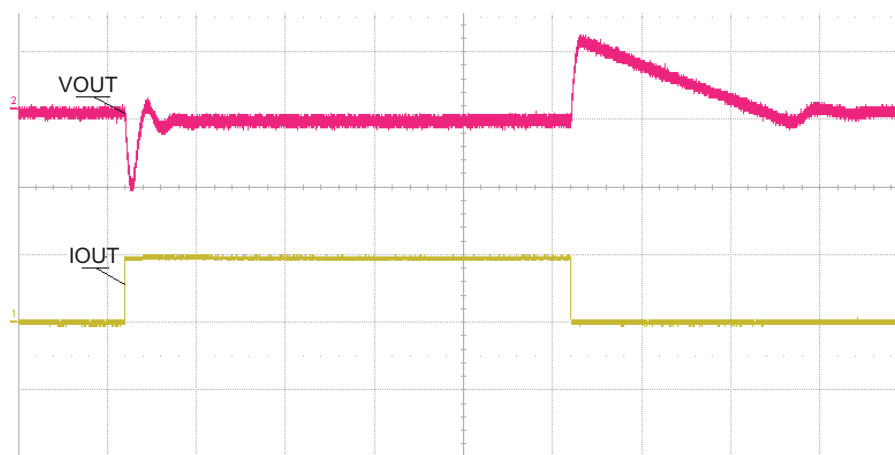


Figure 2. Step Load and Output Voltage Transient Response: C1 – Full Load Current Step, C2 VOUT – Output Voltage Transient Response

## 5 Thermal Guidelines and Layout Recommendations

Thermal management is a key component of design of any power converter and is especially important when the power dissipation in the LDO is high. Use the following formula to approximate the maximum power dissipation for the particular ambient temperature:

$$T_J = T_A + P_d \times \theta_{JA} \quad (2)$$

where:

$T_J$  is the junction temperature

$T_A$  is the ambient temperature

$P_d$  is the power dissipation in the device (Watts)

$\theta_{JA}$  is the thermal resistance from junction to ambient.

All temperatures are in degrees Celcius. The maximum silicon junction temperature,  $T_J$ , must not be allowed to exceed 125°C. The layout design must use copper trace and plane areas with care, as thermal sinks. Do not to allow  $T_J$  to exceed the absolute maximum rating under all temperature conditions and voltage conditions across the part.

The layout should consider carefully the thermal design of the PCB for optimal performance over temperature. For this EVM, [Figure 5](#) shows that the DQN package footprint employs a thermal pad for further cooling the part. The thermal pad contains a single 6.mil thermal via connection to the bottom side copper ground plane as well as a direct connection to the top side surface copper over the ground pad/pin for IC. The PCB is a two layer board with 2.oz. copper on top and bottom layers. The DQN package drawing can be found at the Texas Instruments web site in the product folder for the [TPS707](#) LDO.

Table 1 repeats information from the Dissipation Ratings Table of the TPS7A4001 data sheet for comparison with the thermal resistance,  $\theta_{JA}$ , calculated for this EVM layout to show the variation in thermal resistances for given copper areas. The High-K value is determined using a standard JEDEC high-k (2s2p) board having dimensions of 3-inch x 3-inch with 1-ounce internal power and ground planes and 2-ounce copper traces on top and bottom of the board.

**Table 1. Thermal Resistance,  $\theta_{JA}$  , and Maximum Power Dissipation**

| Board            | Package | $\theta_{JA}$ | Max Dissipation without Derating<br>( $T_A = 25^\circ\text{C}$ ) | Max Dissipation without Derating<br>( $T_A = 70^\circ\text{C}$ ) |
|------------------|---------|---------------|------------------------------------------------------------------|------------------------------------------------------------------|
| High-K           | DGN     | 55.1°C/W      | 1.83W                                                            | 1.08W                                                            |
| TPS7A4001EVM-709 | DGN     | 49.0°C/W      | 2.04W                                                            | 1.12W                                                            |

The thermal resistance for the TPS7A4001EVM-709,  $\theta_{JA}$ , is the measured value for this particular layout scheme. The maximum power dissipation is proportional to the volume of copper volume connected to the package.

## 6 Board Layout

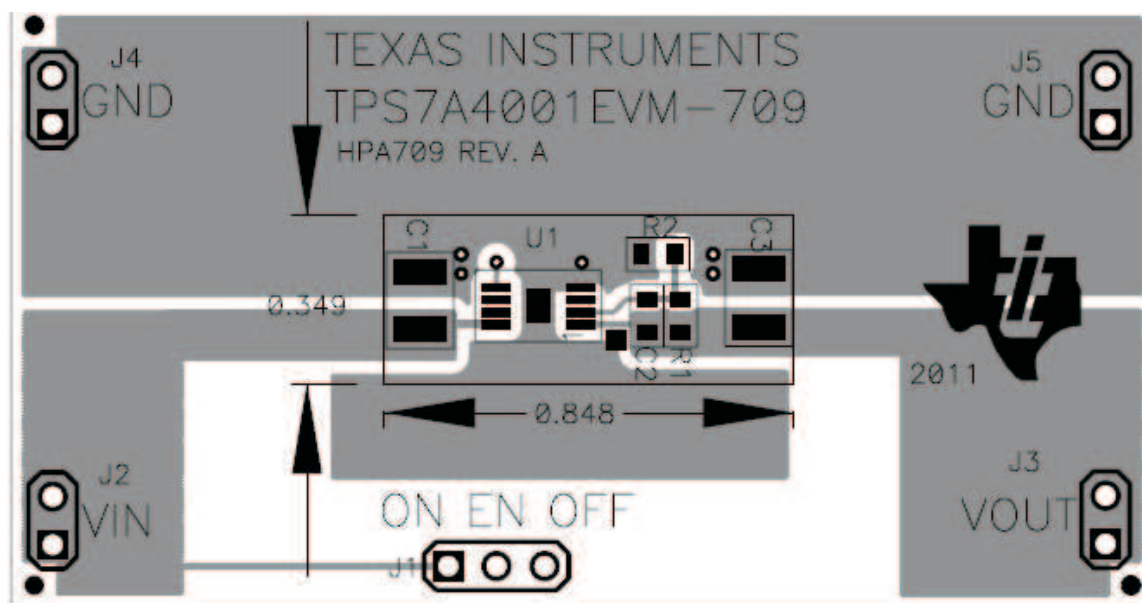


Figure 3. Assembly Layer

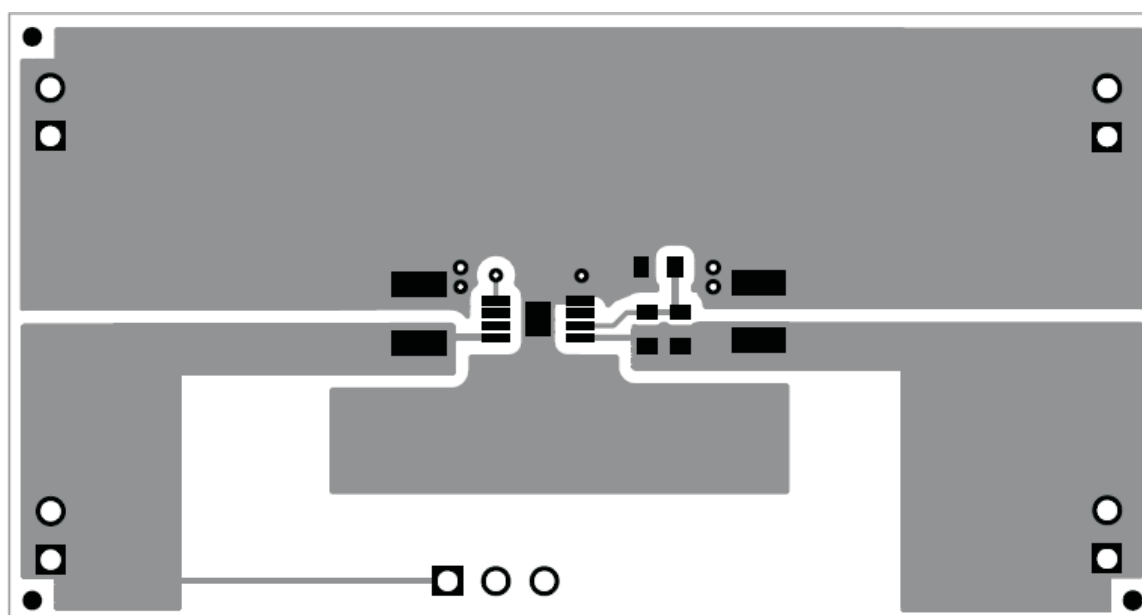
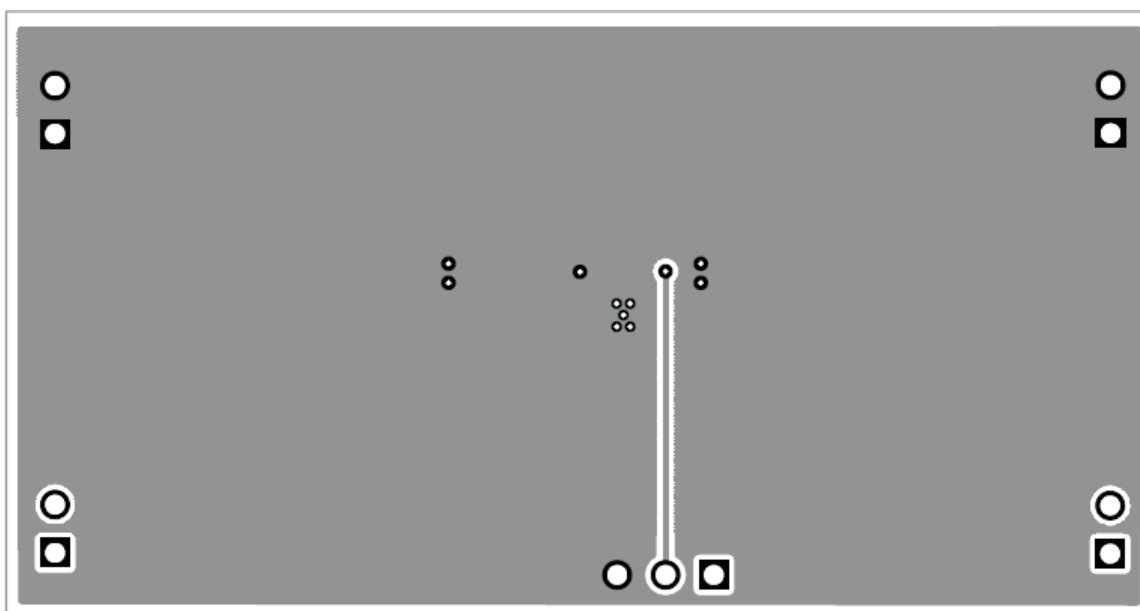
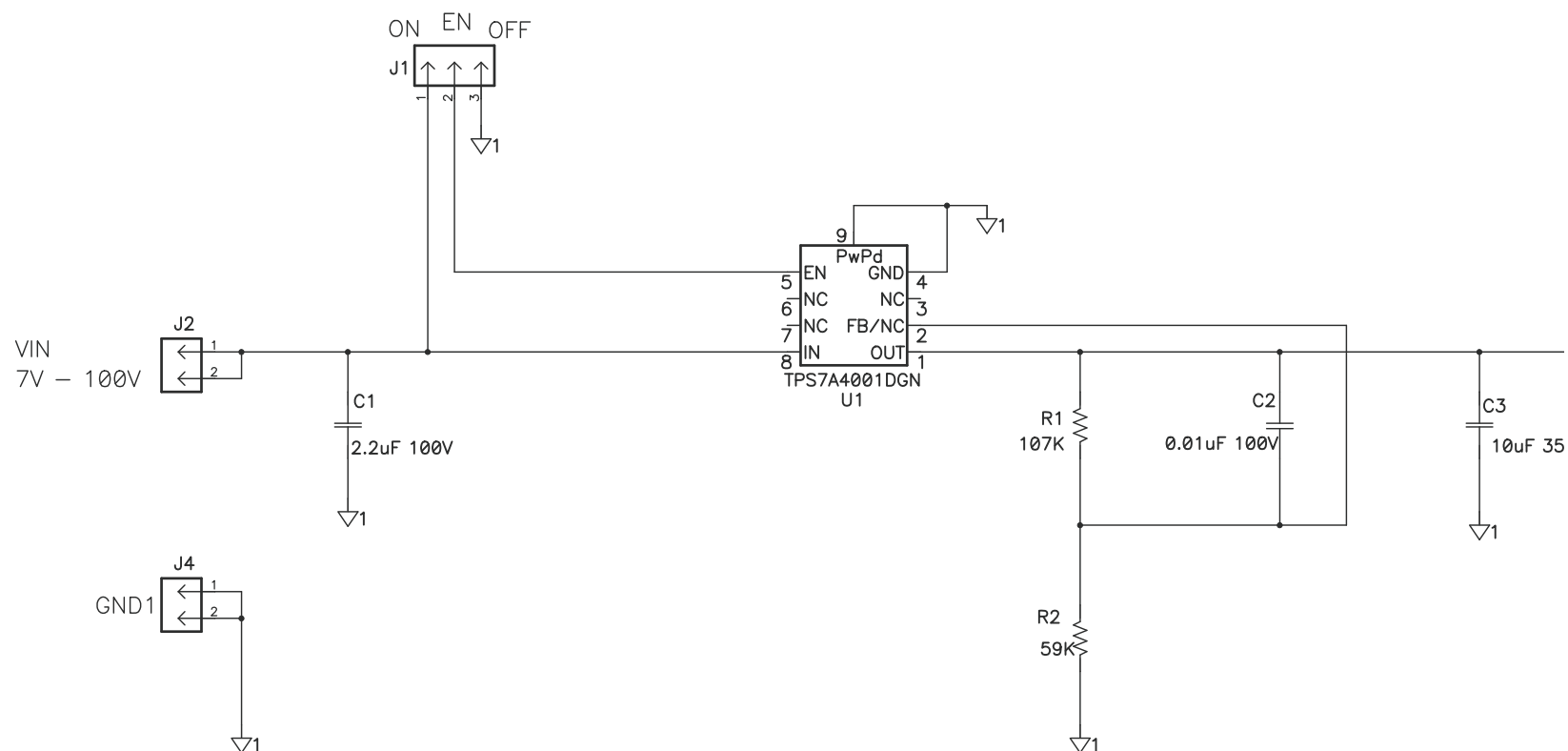


Figure 4. Top Layer Routing



**Figure 5. Bottom Layer Routing**

## 7 Schematic and Bill of Materials



**Figure 6. Schematic**

**Table 2. TPS7A4100EVM-709 Bill of Materials**

| COUNT                                                                                                                                                                                                                                                                                                                                                                                                   | RefDes         | Value        | Description                                        | Size           | Part Number  | MFR     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------|----------------------------------------------------|----------------|--------------|---------|
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | C1             | 2.2 uF       | Capacitor, Ceramic, 100V, X7R, 10%                 | 1210           | STD          | STD     |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | C2             | 0.01uF       | Capacitor, Ceramic, Low Inductance, 100V, X7R, 20% | 0603           | STD          | STD     |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | C3             | 10.0 uF      | Capacitor, Ceramic, 35V, X7R, 10%                  | 1210           | STD          | STD     |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | J1             | PEC03SAAN    | Header, Male 3-pin, 100mil spacing                 | 0.100 inch x 3 | PEC03SAAN    | Sullins |
| 4                                                                                                                                                                                                                                                                                                                                                                                                       | J2, J3, J4, J5 | PEC02SAAN    | Header, Male 2-pin, 100mil spacing                 | 0.100 inch x 2 | PEC02SAAN    | Sullins |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | R1             | 107K         | Resistor, Chip, 1/16W, 1%                          | 0603           | STD          | STD     |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | R2             | 59K          | Resistor, Chip, 1/16W, 1%                          | 0603           | STD          | STD     |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | U1             | TPS7A4001DGN | IC, 120 V Input Voltage, 50 mA                     | DGN            | TPS7A4001DGN | TI      |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | --             | --           | PCB, 1.260In x 2.370 In x 0.062 In                 | --             | HPA709       | Any     |
| 1                                                                                                                                                                                                                                                                                                                                                                                                       | --             | --           | Shunt, 100-mil, Black                              | 0.100 inch     | 929950-00    | 3M      |
| Notes:<br>1. These assemblies are ESD sensitive, ESD precautions shall be observed.<br>2. These assemblies must be clean and free from flux and all contaminants.<br>3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.<br>4. Ref designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components. |                |              |                                                    |                |              |         |

## Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit 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. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

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 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.**

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. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

**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.**

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.**

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 contact the TI application engineer or visit [www.ti.com/esh](http://www.ti.com/esh).

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.

## FCC Warning

This evaluation board/kit 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 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments 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.

## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 7V to 100V and the output voltage range of not to exceed 90V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 160°C. The EVM is designed to operate properly with certain components above 160°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for 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, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

|                             |                                                                    |
|-----------------------------|--------------------------------------------------------------------|
| Audio                       | <a href="http://www.ti.com/audio">www.ti.com/audio</a>             |
| Amplifiers                  | <a href="http://amplifier.ti.com">amplifier.ti.com</a>             |
| Data Converters             | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>     |
| DLP® Products               | <a href="http://www.dlp.com">www.dlp.com</a>                       |
| DSP                         | <a href="http://dsp.ti.com">dsp.ti.com</a>                         |
| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
| Logic                       | <a href="http://logic.ti.com">logic.ti.com</a>                     |
| Power Mgmt                  | <a href="http://power.ti.com">power.ti.com</a>                     |
| Microcontrollers            | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a> |
| RFID                        | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>               |
| RF/IF and ZigBee® Solutions | <a href="http://www.ti.com/lprf">www.ti.com/lprf</a>               |

### Applications

|                               |                                                                                          |
|-------------------------------|------------------------------------------------------------------------------------------|
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
| Transportation and Automotive | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Video and Imaging             | <a href="http://www.ti.com/video">www.ti.com/video</a>                                   |
| Wireless                      | <a href="http://www.ti.com/wireless-apps">www.ti.com/wireless-apps</a>                   |

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated