TPS60241EVM-194

170 μVrms Zero-Ripple Switched Cap Buck-Boost Converter for VCO Supply

User's Guide

November 2001

Power Management Products

SLVU057

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 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.

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.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265

EVM IMPORTANT NOTICE

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

This evaluation kit being sold by TI is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not considered by TI to be fit for commercial use. As such, the goods being provided may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety measures typically found in the end product incorporating the goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may not meet the technical requirements of the directive.

Should this evaluation kit not meet the specifications indicated in the EVM User's Guide, the 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. Please be aware that the products received may not be regulatory compliant or agency certified (FCC, UL, CE, etc.). 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 EVM User's Guide and, specifically, the EVM Warnings and Restrictions notice in the EVM User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact the TI application engineer.

Persons handling the product must have electronics training and observe good laboratory practice standards.

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.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 2.7 V to 5.5 V with an output current up to 25 mA.

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.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265

Contents

Figures

Tables

Chapter 1

Introduction

The evaluation module (EVM) for the Texas Instruments (TI) TPS6024x charge pumps helps designers to evaluate these devices.

With this board it is possible to evaluate the performance of the TPS60241. The layout of charge pumps is critical. The suggested layout of the demo board can be used as a reference design to reduce design time.

Topic **Page**

1.1 Basic Operation of the Device

The Texas Instruments TPS6024x 170 µVrms zero ripple switched capacitor buck-boost converters are intended for use with input voltages in the range of:

- 1.8 V to 5.5 V for TPS60240, TPS60242, TPS60243
- 2.7 V to 5.5 V for TPS60241

A push-pull charge pump stage boosts the input voltage to the nominal output voltage, which is 5 V for the TPS60241. The minimum output current is 12 mA. With VIN > 2.95 V the maximum output current is 25 mA. For a functional description, refer to the data sheet.

1.2 Family of Devices

The devices of the TPS6024x family differ only in their output voltage.

Table 1–1. Device List

Device	Input Voltage Range	Output Voltage (Fixed)
TPS60240	1.8 V to 5.5 V	3.3 V
TPS60241	2.7 V to 5.5 V	5 V
TPS60242	1.8 V to 5.5 V	2.7 V
TPS60243	1.8 V to 5.5 V	3 V

Chapter 2

Demo Board Description

This chapter describes the circuit description, EVM layout, schematic, and EVM setup.

Topic **Page**

2.1 Circuit Description and Schematic

For all necessary signals there are single-pin connectors on the board. To operate the board, connect a power source with the appropriate voltage level between VIN and GND.

Some additional GND-pins have been added for your convenience.

C1 to C4 are 1206-size SMD-footprints. These parts are not necessary for operation and have only been added for test purposes. They can be used as test points or to easily increase the value of a capacitor by adding another one in parallel.

Figure 2–1. Typical Application Circuit Schematic

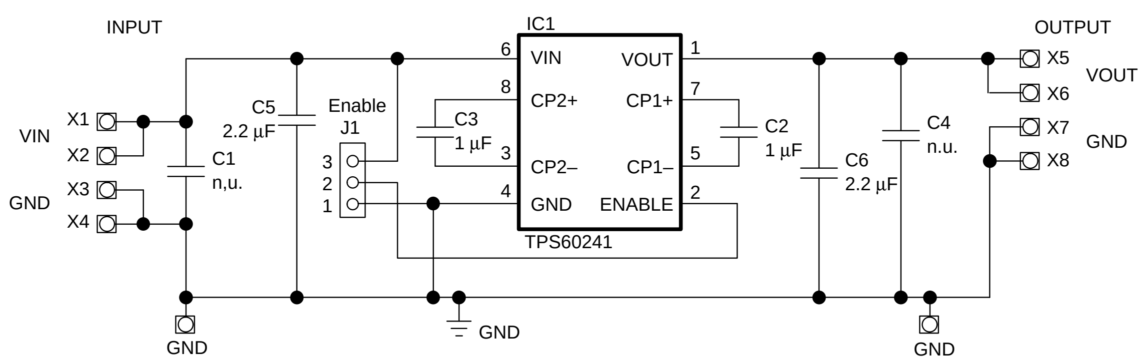


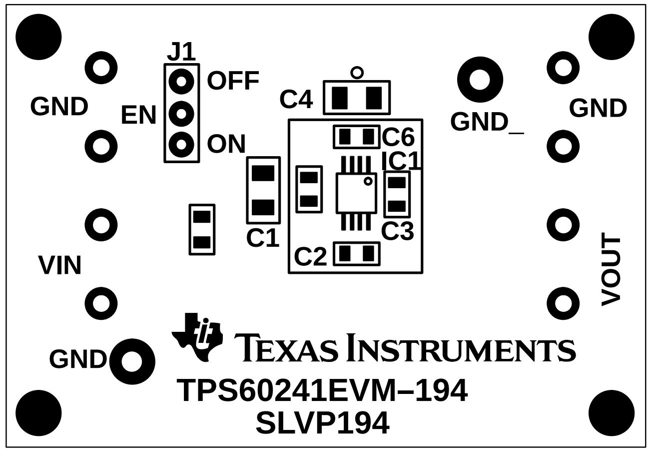
Table 2–1. Bill of Materials

Reference	Part	Description
X1 to X8	MC S1-B	Connector
J1	Jumper	Enable
IC1	TPS60241DGK	Buck-boost converter
C5	2.2 µF/10 V; X7R ceramic capacitor size 0805	Input capacitor
C2, C3	1 µF/10 V; X7R ceramic capacitor size 0805	Flying capacitor
C6	2.2 µF/10 V; X7R ceramic capacitor size 0805	Output capacitor
C1, C4	Additional footprints for input- and output-capacitor; size 1206	

2.2 Layout of the EVM

Figure 2–2 shows the placement of the components of the EVM. Components are only placed on the top layer of the board. The size of the EVM is 51.0 × 35.5 mm^2 that is 1810 mm^2, which is much larger than required for the IC and its capacitors.

Figure 2–2. Placement



The total space required for the IC and the capacitors on the EVM is only about 10 mm × 12 mm = 120 mm^2. The capacitors are not optimized for space. They are optimized for performance. It is possible to use smaller capacitors to optimize the layout for minimum board space. On the EVM, it is also possible to solder some other capacitors because 1206-size pads have ben added in parallel to C_{IN} and C_{OUT}.

The signal on the bottom is the ground signal (GND). For good performance, the entire bottom layer is one GND plane, only interrupted by some vias. Figure 2–3 and Figure 2–4 show the layout of the board.

Figure 2–3. Top Layer

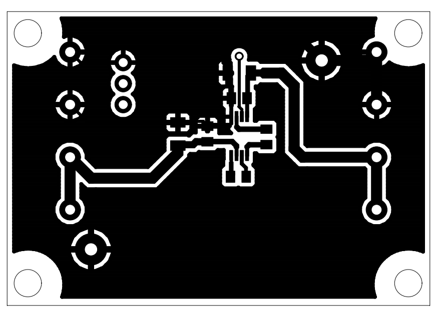
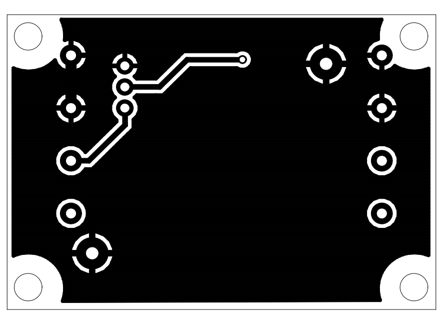


Figure 2–4. Bottom Layer



2.3 Setup of the EVM

For proper operation of the EVM, follow these steps:

1) Connect a load to the output (between VOUT and GND) with minimum
   R = 417 Ω, for VIN = 2.7 V to 5.5 V
   R = 200 Ω, for VIN = 2.95 V to 5.5 V

2) Connect a voltage source (or a battery pack) with the appropriate voltage between the input (VIN) and ground (GND): 2.7 V to 5.5 V.

3) Enable the device by setting Jumper J1 in the ON position

Chapter 3

Capacitor Selection

For the maximum output current and best performance, capacitors placed on the EVM are recommended. For lower currents or higher allowed output voltage ripple, other capacitors can also be used. *It is recommended that the output capacitor has a minimum value of 0.22 μF.* This value is necessary to assure a stable operation of the system. However, output ripple and noise are going to be much larger with such a low output capacitor. With lower flying capacitors then 1 μF the maximum output power will decrease.

The best performance of the charge pumps can be seen with ceramic capacitors. To reduce the spikes during turnover from the transfer phase (charging of the output capacitor) of one charge pump to that of the other one, a ceramic capacitor is recommended at the input and output. Tantalum capacitors are not able to filter these spikes because their equivalent series resistance (ESR) is too high. When using tantalum capacitors as input or output capacitors connect a ceramic capacitor in parallel to reduce voltage spikes.