TEXAS INSTRUMENTS

TPS6050xEVM-193

Step-Down Charge Pump

User's Guide

March 2002

Power Management Products

SLVU058

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 1.8 V and 6.5 V and the output voltage range of 0.8 V and 3.3 V at an output current up to 250 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.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 85°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

Contents

Figures

Tables

Chapter 1

Introduction

The Texas Instruments TPS6050x charge pumps are regulated step-down converters. The TPS60500 has an adjustable output voltage in the range of 0.8 V to 3.3 V, whereas the TPS60501, TPS60502, and TPS60503 have a fixed output voltage of 3.3 V, 1.8 V, or 1.5 V. The devices work from an input voltage in the range of 1.8 V to 6.5 V. The input voltage has to be at least 1 V higher than the output voltage. The maximum output current is 250 mA.

Topic **Page**

1.1 TPS6050x EVM

The evaluation module (EVM) for the new Texas Instruments (TI) charge pump devices, TPS60500 to TPS60503, helps designers to evaluate these devices.

With these EVMs it is possible to evaluate all different modes of the devices, as well as their performance. Only a dc voltage source is needed to operate the EVM.

The layout of charge pumps is critical, similar to the layout of inductive dc/dc converters. The suggested layout of the EVM board can be used as a reference to reduce design time.

1.2 Basic Operation of the Device

The TPS6050x devices consist of a multimode step-down power stage that automatically selects the conversion mode. Depending on the input to output voltage ratio, the conversion ratio is 1 (LDO mode), 0.66, 0.5, or 0.33. The implementation of different conversion modes improves efficiency.

For a description of the different operation modes and a functional description, refer to the data sheet.

Chapter 2

EVM Description

This chapter describes the schematics, EVM layout, and EVM setup.

Topic **Page**

2.1 Schematic of the EVM

To operate the board, connect a power source with the appropriate voltage level between V_{IN} and GND. Connect a jumper between EN and GND to enable the device. Remove the jumper to disable the device. In this state the supply current of the IC decreases to 0.05 μA. When the device is disabled, the PG output is pulled low.

The output voltage is set to 1.5 V by the resistor divider R3 and R4.

Figure 2–1. Schematic

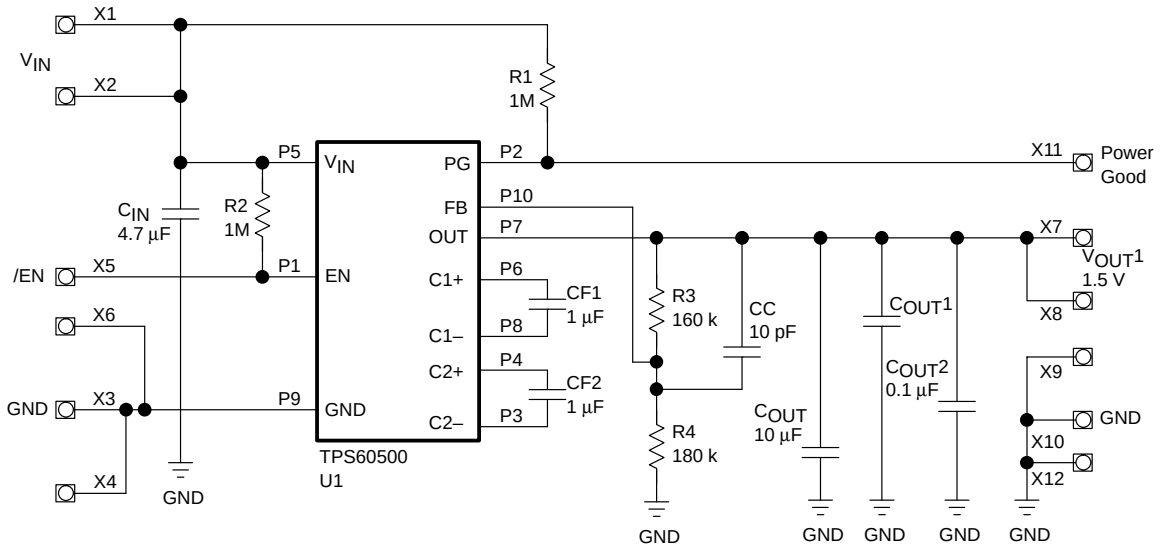


Table 2–1. Bill of Material

Ref	Part Count	PN	Description	Manufacturer	Size
CF1, CF2	2	LMK212BJ105KG	Capacitor, ceramic, 1 μF, 10 V, X7R	Taiyo Yuden	0805
Cin	1	LMK316BJ475KL	Capacitor, ceramic, 4.7 μF, 10 V, X7R	Taiyo Yuden	1206
Cout	1	C2012X5R0J106M	Capacitor, ceramic, 10 μF, 6.3 V, X5R	TDK	0805
Cout1	0		Not populated		
Cout2	1		Capacitor, ceramic, 100 nF, 50 V, X7R		0805
CC			10 pF		0805
R1, R2	2	E12–Series	Resistor, 1 MΩ		0805
R3	1	E12–Series	Resistor, 160 kΩ		0805
R4	1	E12–Series	Resistor, 180 kΩ		0805
U1	1	TPS60500DGS	Charge pump	TI	MSOP–10 (DGS)
X1–X4 X7–X10	2	AMP Modu II 826629–4	Male header, 4-pin, 2,54 mm	AMP	
X5–X6 X11–X12	2	AMP Modu II 826629–2	Male header, 2-pin, 2,54 mm	AMP	
	1	SLVP193	PCB	TI / BVR	43,4 x 32,9 mm
	1		Jumper for ENABLE		

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 43,4 x 33,0 mm^2 that is 1432 mm^2, which is much larger than required for the IC and its capacitors.

The total space required for the IC and the capacitors on the EVM is only about 17 mm x 11 mm = 181 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.

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 2–2. Layout of the EVM

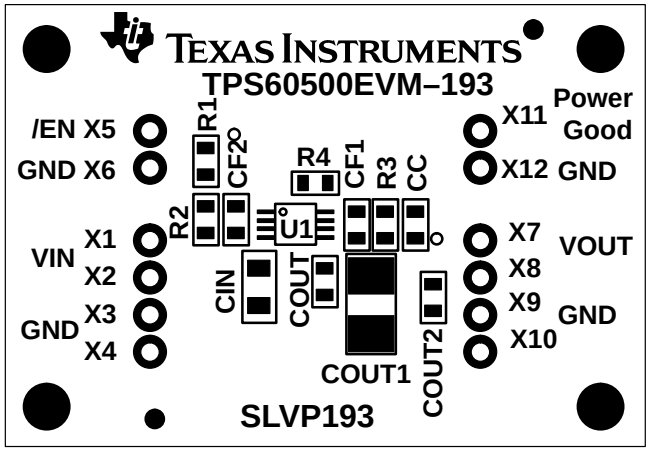


Figure 2–3. Top Layer (Size 1:1)

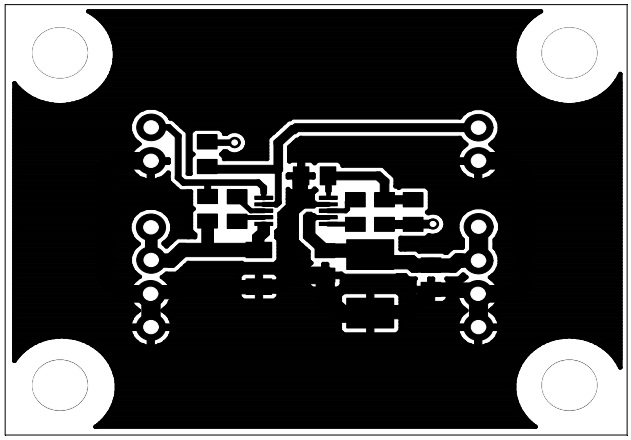
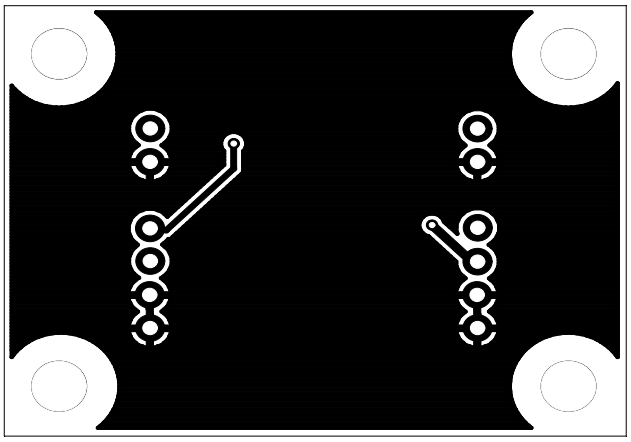


Figure 2–4. Bottom Layer (Mirrored, size 1:1)



2.3 Setup of the EVM

For proper operation of the EVM, follow these steps:

1) Connect a load to the output (between GND and OUT).
   RLOAD ≥6 Ω at Vout = 1.5 V

2) Connect a signal source (or a battery pack) with the appropriate voltage between the input (In) and ground (GND):
   Vin = 2.4 V to 6.5 V for an output voltage of 1.5 V at Iout=150 mA
   Vin = 3.0 V to 6.5 V for an output voltage of 1.5 V at Iout=250 mA

3) Increase Cout to ≥22 µF for an output current >150 mA.

Chapter 3

Capacitor Selection

For 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 4.7 μF at Iout ≤ 50 mA and 10 μF at Iout > 50 mA. For Iout >150 mA an output capacitor of 22 μF or larger is required. This value is necessary to assure a stable operation of the system. With lower flying capacitors than 1 μF the maximum output power decreases.

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, use a ceramic capacitor at the input and output. Tantalum capacitors are not able to filter these spikes because their equivalent series resistance (ESR) is too high. The input capacitor must be placed as close as possible between the input pin (Vin) and GND. An X5R or X7R ceramic capacitor is recommended for the input capacitor.