TEXAS INSTRUMENTS

TPS6021x Evaluation Module

Regulated 3.3-V, 100-mA Charge Pump With UltraLow Operating Current

User's Guide

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Power Management Products

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About This Manual

This user's guide describes the evaluation module (EVM) TPS60210EVM-167. This EVM helps to evaluate the performance of the regulated low-ripple charge pump dc/dc converter TPS60210. The EVM has the dimension of a 14-pin dual inline package and the board is a single-layer board. The board design is optimized for performance and space.

The user's guide also documents the necessary changes to use the board for the other devices of the TPS6021x family.

How to Use This Manual

For more information about the EVM, please read Chapter 1, Description of the EVM. Chapter 2 includes the Physical Data and the Setup of the EVM.

Related Documentation From Texas Instruments

Data sheet of TPS60210/TPS60211/TPS60212/TPS60213 (literature number SLVS296)

Erich Bayer, Alexander Müller, Hans Schmeller, and Günter Sporer: Charge Pump Technology Optimized for Battery-Operated Systems, EE-Times Special Seminar Series, Analog & Mixed Signal Technology, Oct. 99

Brigitte Kormann: TPS6014x Charge Pump Evaluation Module Design Guide (literature number SLVU023)

Brigitte Kormann: TPS6010x/TPS6011x Charge Pump Application Report (literature number SLVA070)

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Chapter 1

Description of the EVM

The Texas Instruments TPS60210 charge pump is a regulated voltage doubler. The TPS60210 delivers 3.3-V output voltage (V_O) from a 1.8-V to 3.6-V input voltage (V_I). The output current (I_O) is 100 mA minimum, for an input voltage (V_I) of 2.0 V or higher.

For output currents below 2 mA, the device can be operated in the snooze mode ($\overline{\text{SNOOZE}}$ = 0). This is an operating mode, where the quiescent current is drastically reduced. In this mode, V_O is regulated to 3.3 V ±6%. The low quiescent current is achieved by disabling most of the internal circuitry as long as V_O is high enough. When V_O decreases, the device operates for a short period of time in normal mode, to boost V_O. The internal circuitry is then disabled again. This reduces the quiescent current to a typical value of only 2 µA. If the device is programmed to operate in snooze mode and the I_O increases above 2 mA, the device enters the startup mode to increase V_O.

Additionally, the TPS60210 has a low battery detector (LBI input and LBO output). The trip voltage of the LBI input is typically 1.18 V. The TPS60210 can be programmed with an external resistive divider to the specific trip voltage for the application. On the EVM, the resistive divider on the LBI input is connected to V_I and the trip voltage is set to 2.0 V, typically. The LBO output is an open-drain output and is in a high-impedance state as long as the voltage at LBI is above the trip voltage. A 1-MΩ pullup resistor to V_O is added on the EVM to get a defined high signal as long as the voltage at LBI is above the trip voltage.

For simple evaluation, a 1-MΩ resistor between V_I and the $\overline{\text{SNOOZE}}$ pin is added to operate the TPS60210 in normal mode.

A minimum of four external capacitors for a push-pull voltage doubler charge pump are required. The EVM is built with these four capacitors. For evaluation, it is possible to use other capacitor values like those given in the application section of the TPS6021x data sheet (literature number SLVS296). The capacitors on the EVM are ceramic capacitors. The ESR of all other capacitor types is too high to get good performance.

The TPS60210 EVMs can also be used to evaluate the other devices of this family (TPS60211, TPS60212, and TPS60213). For that purpose, replace the integrated circuit. For the TPS60211 and TPS60213, the LBI resistors should be removed and LBI connected to GND. The LBO pullup resistor works as power good (PG) pullup, and the LBO pad gives the PG signal.

Free samples of the other parts of the TPS6021x family can be ordered from http://www.ti.com. Use the *SC Part Number Search* to go to the product folder of the specific device.

Chapter 2

Physical Data and Setup of the EVM

This section shows the schematic, the layout, and setup of the EVM. The layout of a charge pump circuit is critical; therefore, the given layout can be used as a reference and helps to reduce design and evaluation time.

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2.1 Schematic of the EVM

Figure 2–1 shows the schematic of the EVM. For this EVM, only ceramic capacitors with X5R or X7R material are used.

Figure 2–1. Schematic of the EVM

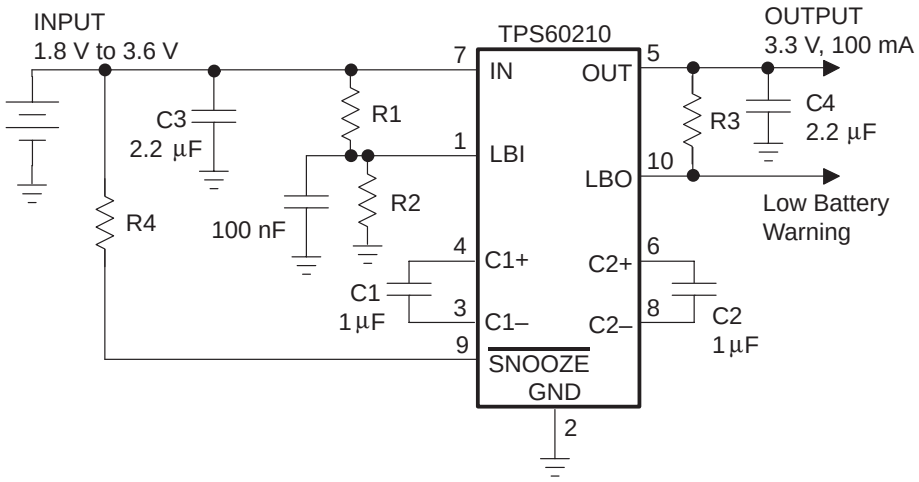


Table 2–1. Bill of Material for the TPS60210 EVM

Component	Value	Part Number	Manufacturer	Description
C1, C2	1 µF, 10 V, 0805	LMK212BJ105KG–T	Taiyo Yuden	Flying capacitors
C3, C4	2.2 µF, 16 V, 1206	EMK316BJ225KL–T	Taiyo Yuden	Input and output capacitors
C5	100 nF			Filter capacitor for the LBI input signal
IC1		TPS60210	Texas Instruments	
R1	402 kΩ	E96-Series		LBI input voltage adjustment
R2	576 kΩ	E96-Series		LBI input voltage adjustment
R3	1 MΩ			Pullup for the open drain output LBO
R4	1 MΩ			Pullup for the $\overline{\text{SNOOZE}}$ input

Table 2–1 contains the bill of material of the TPS60210EVM-167. The following paragraph describes the use of some of the parts.

R1 and R2 adjust the input voltage of the LBI input for low battery detection. The resistive divider on the EVM is connected to V_I. For the given resistor values, the LBO signal will go active (low) if V_I is below 2.0 V. The divided input voltage is compared to the internal reference voltage of 1.18 V. C5 works as a filter capacitor for the LBI input voltage. This capacitor is recommended if line or load transients occur. At the switching point of the LBI comparator, noise may trigger the LBI, and this may lead to oscillations at the LBO pin. The LBO output is an open-drain output and requires an external pullup resistor (R3). For R3, a value between 100 kΩ and 1 MΩ is recommended. If your application does not require low battery detection, these four parts can be omitted. In this case, connect the LBI-pin to ground.

R4 is the pullup resistor for the $\overline{\text{SNOOZE}}$ pin, therefore, the device operates in normal mode. Applying a logic low level to the $\overline{\text{SNOOZE}}$ input, programs the device in snooze mode.

Note:

When the device is in snooze mode, be aware that the LBI and $\overline{\text{SNOOZE}}$ resistors (R1, R2, and R4) draw more current than the device itself. For measuring the low quiescent current in this mode, these three resistors must be removed.

For operation with the internal oscillator, connect the $\overline{\text{SNOOZE}}$ signal to either the input voltage (like on the EVM) or a logic high level respectively, or to a low-level for operation in snooze mode. The device can also be synchronized with an external oscillator signal. For synchronization to an external oscillator signal, the $\overline{\text{SNOOZE}}$ pin must be connected to this signal. When the internal logic detects an external clock signal, the device is synchronized to this clock and the internal clock is turned off. For the appropriate frequency and levels, please refer to the TPS6021x data sheet (literature number SLVS296).

2.2 Layout of the EVM

Figure 2–2 and Figure 2–3 show the placement of the components and the layout of the EVM. The components and all signals are exclusively placed on the top layer of the PC board. Figure 2–4 shows the actual size of the board.

Figure 2–2. Placement of the Components

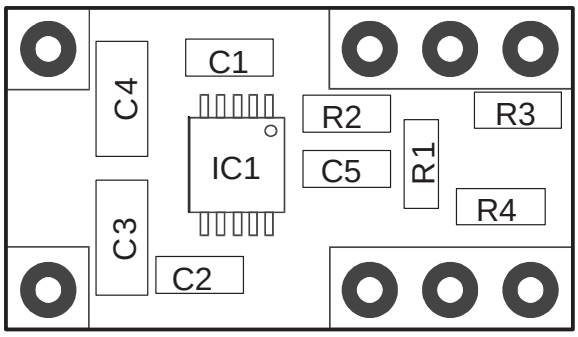


Figure 2–3. Single Layer of the EVM

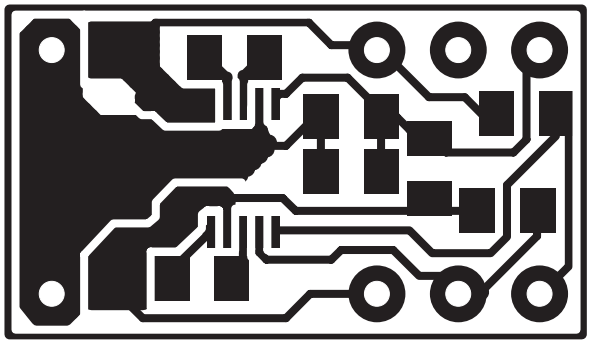


Figure 2–4. Actual Size of the EVM, 17,9 mm × 10,2 mm

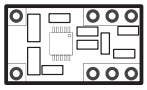


Table 2–1 contains the values and description of the five capacitors and the four resistors that are placed on the EVM.

The EVM is built to fit into a 14-pin dual in-line socket. However, not all 14 pins are used. Only pins 1 to 3, 7, 8, and 12 to 14 of a dual in-line socket are used. Table 2–2 shows the correlation between the dual in-line pin number and the connected signal of the device on the board.

Table 2–2. Pin Assignment of the Board to a 14-Pin Dual-In-Line Socket

Socket Pin Number	Connected Signal
1	LBI
2	Not connected
3	OUT
7, 8	GND
12	IN
13	$\overline{\text{SNOOZE}}$
14	LBO

2.3 Setup of the EVM

Follow these steps for proper operation of the EVM:

1) Connect a load to the output (between GND and OUT).
   > 33 Ω or 0 mA to 100 mA for 2.0 V ≤ V_I ≤ 3.6 V
   > 66 Ω or 0 mA to 50 mA for 1.8 V ≤ V_I < 2 V
   > 132 Ω or 0 mA to 25 mA for 1.6 V ≤ V_I ≤ 1.8 V

Note:

Start up only with resistive load, not with a current sink.

2) Connect a dc power supply (or a battery pack) with an appropriate voltage between input (IN), and ground (GND).
   1.6 V ≤ V_I ≤ 3.6 V

2.4 Evaluation Information

Due to the pullup resistor R4 at $\overline{\text{SNOOZE}}$ of the EVM, the TPS60210 is enabled by default. To operate the device in snooze mode, drive the $\overline{\text{SNOOZE}}$ pin of the EVM to ground.

By connecting a clock signal between 400 kHz and 800 kHz to the $\overline{\text{SNOOZE}}$ pin of the board, the device can be synchronized to an external clock. To get the proper duty cycle and levels, please refer to the TPS6021x data sheet (literature number SLVS296). In synchronization, snooze mode can not be used.

For testing the functionality of the low battery detector (transition on LBO), reduce the input voltage below 2 V and a transition from high-to-low at LBO will occur. Trip voltages other than 2 V, can be adjusted by replacing the LBI resistive divider with the appropriate resistors. For the correct resistor values for different trip voltages, please refer to the TPS6021x data sheet (literature number SLVS296).

It is also possible to evaluate several different capacitors on the EVM. A capacitor selection list with the measured output ripple voltage can be found in the TPS6021x data sheet (literature number SLVS296).

Note:

Do not use the device for long periods of time at the maximum input voltage, maximum output current, and maximum ambient temperature. The dissipated power could heat up the device and may destroy it. This is not a problem in battery driven systems. For more details refer to the application part in the TPS6021x data sheet (literature number SLVS296).