EVM User's Guide: TPS60800EVM-068

TPS60800-Q1 Unregulated Charge Pump Inverter Evaluation Module

Description

The TPS60800-Q1 generates an unregulated negative output voltage from an input voltage ranging from 1.8V to 5.25V with 200mA of maximum load. This EVM facilitates test and evaluation of the functionality of TPS60800-Q1. Only three external 1µF capacitors are required to build a complete DC-DC charge pump inverter. Additional input, output, and flying capacitors can also be added. The device has a variable switching frequency ranging between 500kHz to 750kHz. The device comes in a 6-pin SOT563 package.

Get Started

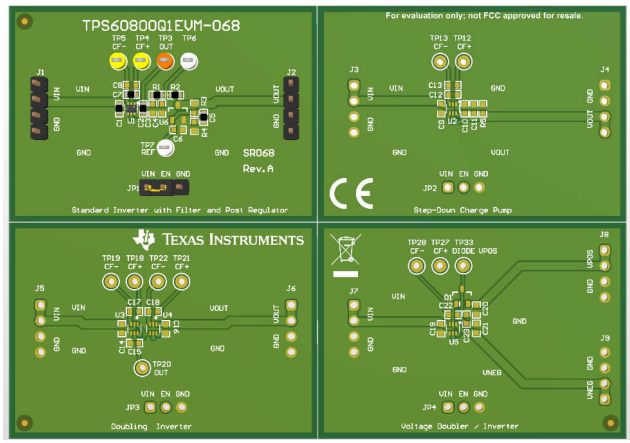
1. Order the EVM on ti.com.
2. Download the *TPS60800-Q1 Unregulated, 200mA, Automotive, Charge Pump Voltage Inverter* data sheet.
3. Use the data sheet for optimizing the BOM and understanding the various configurations provided on the EVM.

Features

- Qualified for automotive applications
- AEC-Q100 test guidance with the following results:
  - Device temperature grade 1: –40°C to +125°C ambient operating temperature range
- Inverts input supply voltage
- Up to 200mA output current
- Only three small 1µf ceramic capacitors needed
- Input voltage range from 1.8V to 5.25V
- Small, 6-pin SOT563 package

Applications

- Automotive infotainment
- Automotive cluster
- LCD bias
- Operational amplifier supply
- Onboard Charger
- Humanoid robot position sensor



TPS60800Q1EVM-068 (Top View)

1 Evaluation Module Overview

1.1 Introduction

This EVM is designed to help the user easily evaluate and test the operation and functionality of the TPS60800-Q1 Unregulated Charge Pump Inverter. The TPS60800Q1EVM-068 EVM is designed to generate a negative output voltage from a positive input between 1.8V and 5.25V with 200mA of maximum load. This user's guide describes the features and how to operate the TPS60800-Q1 unregulated charge pump inverter evaluation module (EVM) in various configurations. The document includes setup instructions for the following:

- Hardware
- A printed-circuit board (PCB) layout
- Schematic diagram
- Bill of materials (BOM)

1.2 Kit Contents

Table 1-1. TPS60800Q1EVM-068 Kit Contents

Item	Description	Quantity
TPS60800Q1EVM-068	PCB	1

1.3 Specification

Table 1-2. Performance Specification Summary

Specification	Test Conditions	Min	Typ	Max	Unit
Input Voltage		1.8	5	5.25	V
Output Voltage			–5		V
Output current	TPS60800Q1EVM-068	0		200	mA

1.4 Device Information

The TPS60800-Q1 generates an unregulated negative output voltage from an input voltage ranging from 1.8V to 5.25V with 200mA of maximum load. This EVM facilitates test and evaluation of the functionality of TPS60800-Q1. Only three external 1µF capacitors are required to build a complete DC-DC charge pump inverter. Additional input, output, and flying capacitors can also be added. The device has a variable switching frequency ranging between 500kHz to 750kHz. The device comes in a 6-pin, SOT563 package.

2 Hardware

2.1 Setup

This section describes how to properly use the TPS60800Q1EVM-068. To operate the EVM, set jumper JP1 to the desired positions per *Jumper Information*. Connect the input supply to J1 and connect the load to J2.

2.2 Header Information

J1, Pin 1 and 2– VIN: positive input voltage connection from the input supply for the EVM

J1, Pin 3 and 4– GND: input return connection from the input supply for the EVM

J2, Pin 1 and 2– VOUT: positive output voltage connection

J2, Pin 3 and 4– GND: output return connection

2.3 Jumper Information

JP1 – EN: EN pin jumper. Place the supplied jumper across VIN and EN to turn on the IC. Place the jumper across GND and EN to turn off the IC.

2.4 Test Points

TP3 - output voltage measurement point.

TP4 - Cfly positive terminal measurement point

TP5 - Cfly negative terminal measurement point

TP6 - output voltage measurement point

TP7 - output voltage measurement point if filter and post regulator is used

3 Implementation Results

3.1 TPS60800Q1EVM-068 Evaluation Board

The layout of a charge pump is very critical. The suggested layout of the evaluation board can be used as a reference to reduce design time. The evaluation board is split into four sections. Each section contains a different application circuit for the device.

- Simple inverter or inverter with filter and post regulator (for example, for LCD bias)
- Doubling inverter (VOUT = –2 VIN)
- Combined doubler, inverter (VOUT1 = –VIN; VOUT2 = 2 VIN)
- Step-down charge pump (VOUT = 0.5 VIN)

Standard Inverter With Filter and Post Regulator

The following schematic shows the standard inverter with filter and post regulator application. TPS60800-Q1 charge pump is used to generate a negative output voltage, which is filtered using R1, R2, and C4. The output is stabilized by a TLV431 shunt regulator. Resistors R3 and R4 are used to adjust the output voltage. The negative output voltage V_O is determined by the resistor network R4/R3 as follows:

$$V_O = –(1 + R4 / R3) \times V_{ref} – R4 \times I_{(ref)}$$

where: V_{ref} is typically 1.24V. $I_{(ref)}$ is the reference input current, which is typically about 0.15µA. The resistors R1 and R2 must provide a cathode current $|I_{(KA,min)}| \geq 0.08$mA to the TLV431 at minimum V_I. Refer to the *TLV431x Low-Voltage Adjustable Precision Shunt Regulator* data sheet for further information. Capacitors C3, C6, and C8 are not used in this application. Capacitors C3, C6, and C8 can be added if needed.

For further information, refer to the *TPS60800-Q1 Unregulated, 200mA, Automotive, Charge Pump Voltage Inverter* data sheet.

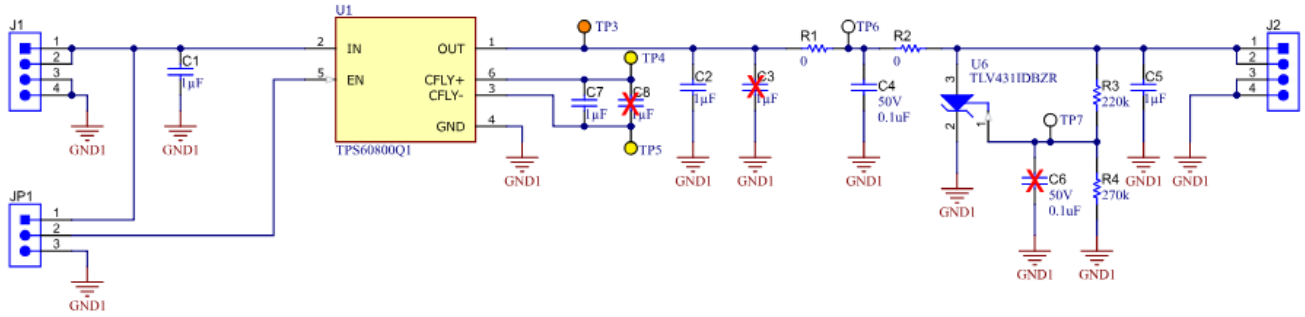


Figure 3-1. Standard Inverter With Filter and Post Regulator

Voltage Doubler, Inverter

The following schematic shows the TPS60800-Q1 in a dual output application. The no load output voltage of V_{POS} is twice the input voltage. When loaded, the output voltage decreases due to the forward voltage of D1 and D2. Schottky diodes can also be used. This action increases the output voltage under load. V_{NEG} is the inverting output with $V_{NEG} = –V_{IN}$. Input current is about two times the output current at V_{POS} plus the output current at V_{NEG}.

For further information, refer to the *TPS60800-Q1 Unregulated, 200mA, Automotive, Charge Pump Voltage Inverter* data sheet.

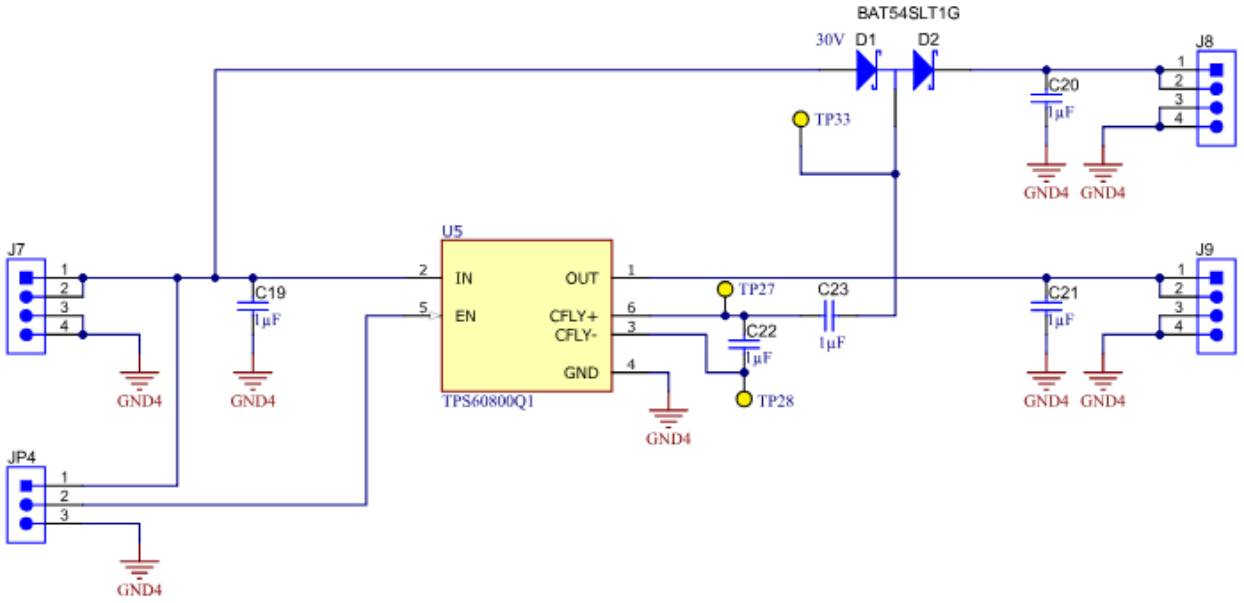


Figure 3-2. Voltage Doubler/Inverter

Doubling Inverter

The following schematic shows the configuration of two TPS60800-Q1 devices connected in series to convert a input voltage in the range of 1.8V to 5V to an output voltage in the range of –3.6V to –10V. Capacitors C14, C15, C17, and C18 must have a voltage rating according to the input voltage, the output capacitor must have a voltage rating of at least twice the input voltage.

For further information, refer to the *TPS60800-Q1 Unregulated, 200mA, Automotive, Charge Pump Voltage Inverter* data sheet.

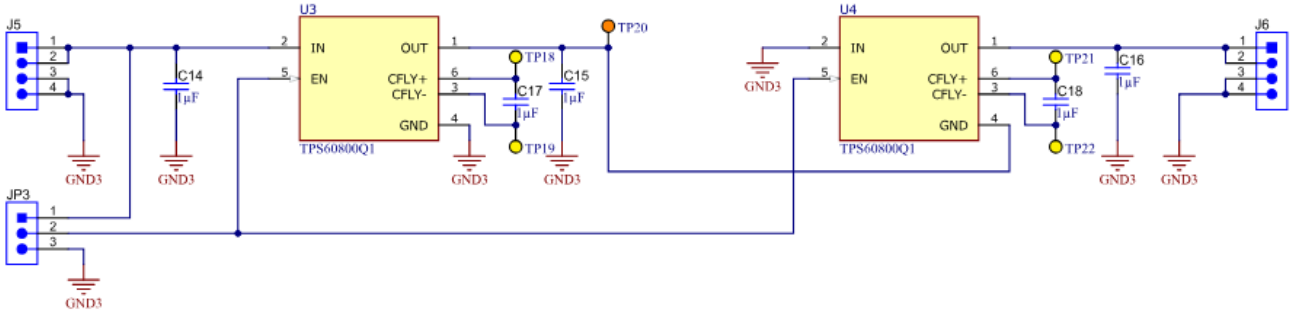


Figure 3-3. Doubling Inverter

Step-Down Charge Pump

TPS60800-Q1 can also be used to step down the input voltage by a factor of two. The following schematic shows this configuration. The output current is twice the input current. To operate an inverter in a step-down configuration, simply exchange the GND and the OUT pin of the inverter. The output resistance is typically 5Ω for a 5V to 2.5V conversion.

For further information, refer to the *TPS60800-Q1 Unregulated, 200mA, Automotive, Charge Pump Voltage Inverter* data sheet.

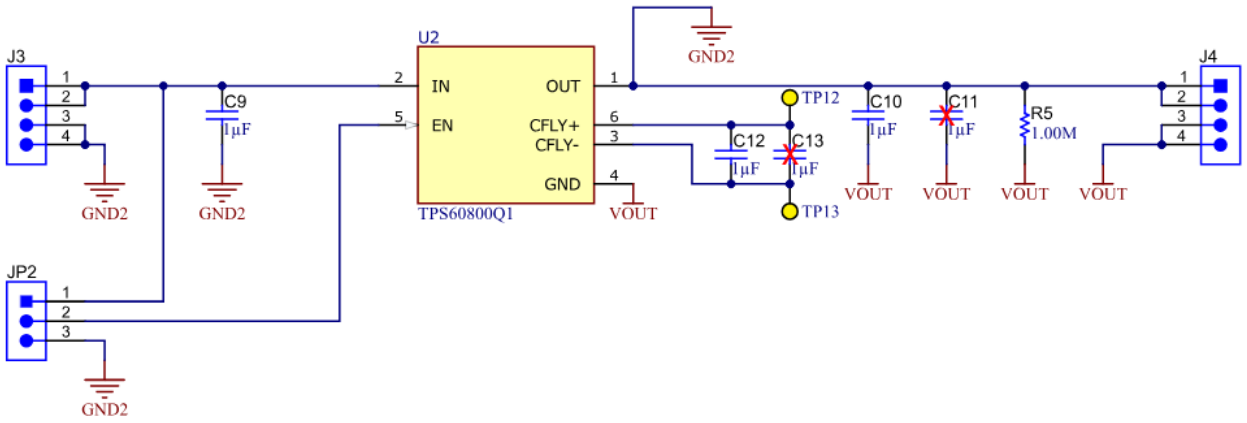


Figure 3-4. Step-Down Charge Pump

4 Hardware Design Files

4.1 Schematics

The following schematic illustrates the simple inverter configuration without filter and post regulator. The additional filter and post regulator can be added if needed.

For the schematics of other application circuits provided on the EVM, please refer to the respective sections in this document.

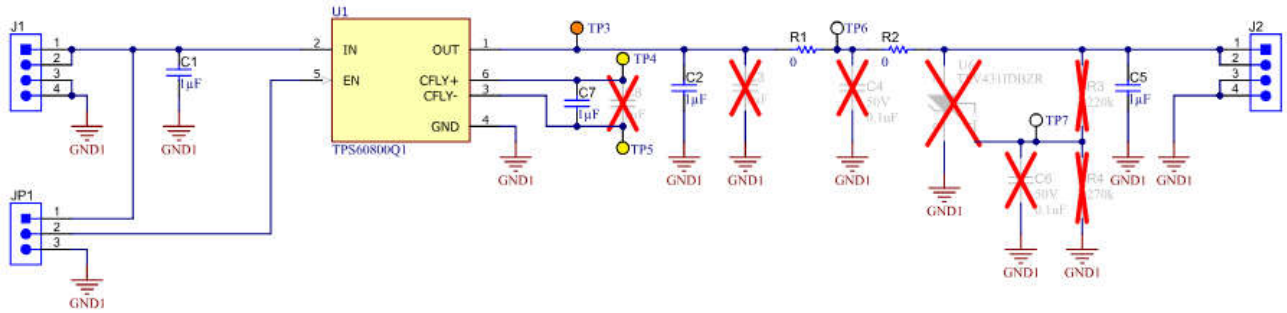


Figure 4-1. Standard Inverter

4.2 PCB Layout of the EVM

This section provides the board layout of the TPS60800-Q1 EVM with all four configurations. This layout is a 2 layer PCB.

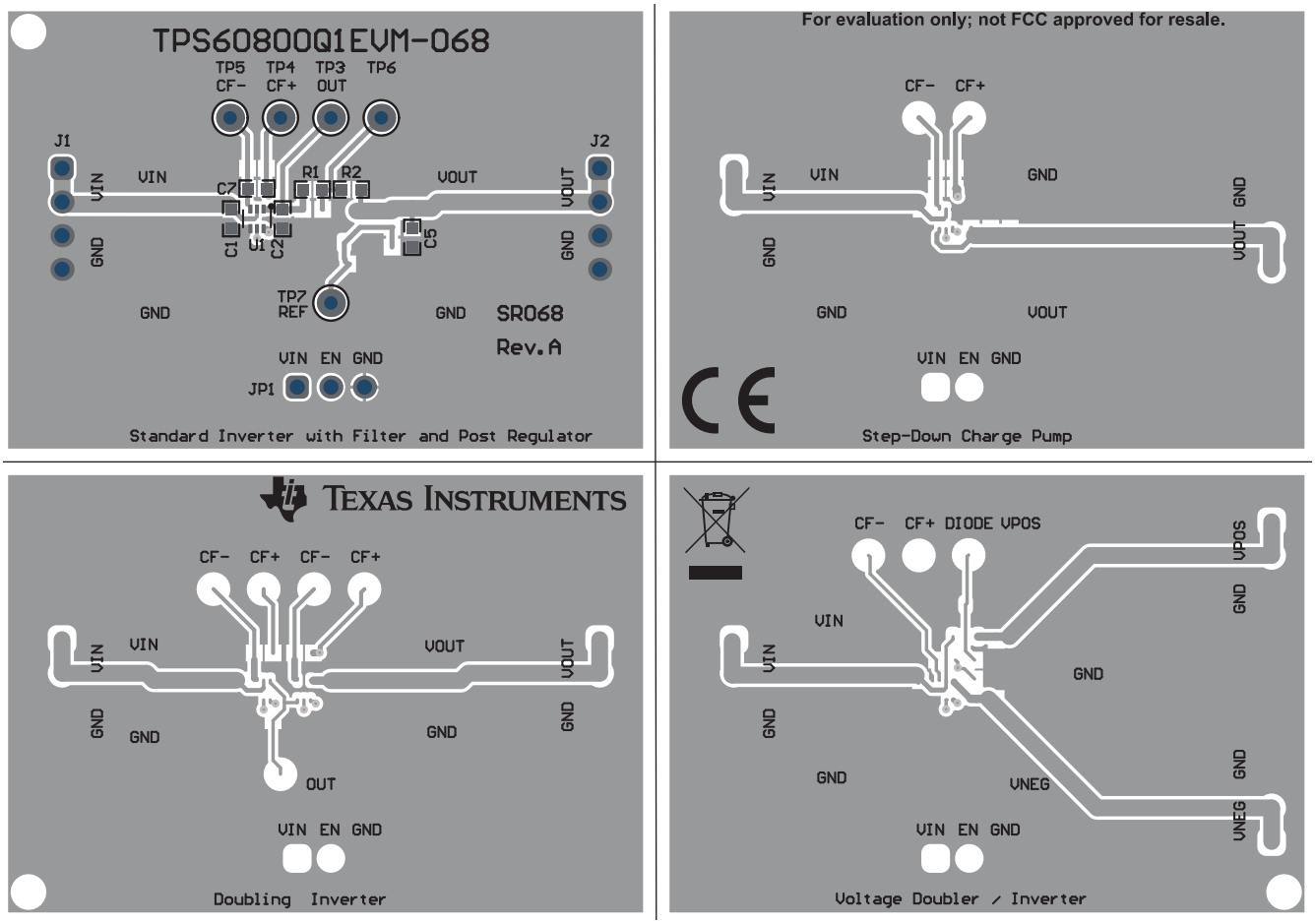


Figure 4-2. Top View

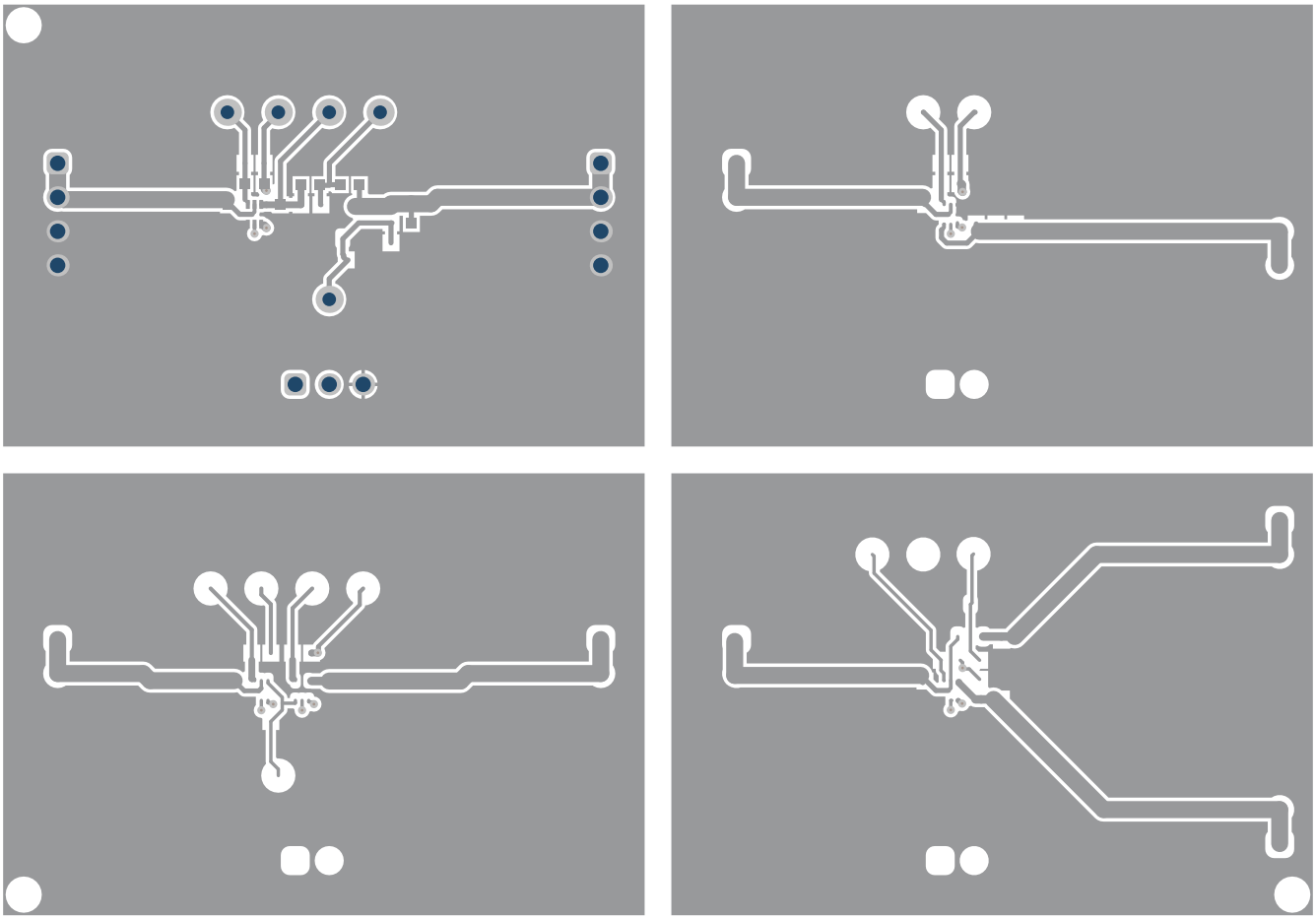


Figure 4-3. Top Layer

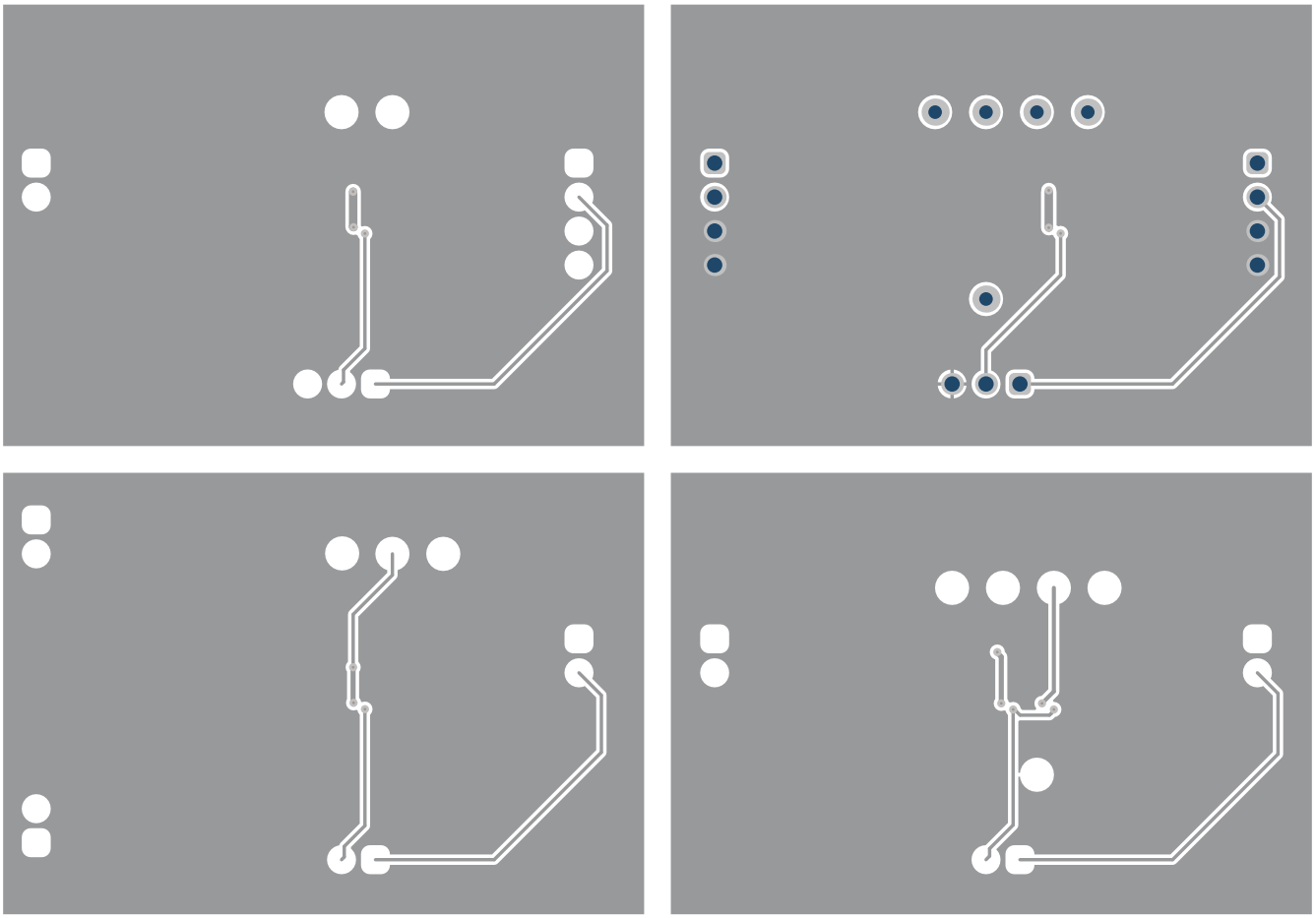


Figure 4-4. Bottom Layer

4.3 Bill of Materials (BOM)

The table below lists the bill of materials needed for this EVM in the simple inverter configuration without filter and post regulator.

Table 4-1. TPS60800Q1EVM-068 Bill of Materials

Quantity TPS60800Q1EVM-068	Ref Des	Value	Description	Size	Part Number	MFR
4	C1, C2, C5, C7	1uF	Capacitor, Ceramic, 25V, X7R, AEC-Q200, ±10%	0603	GCM188R71E105KA64D	MuRata
2	R1, R2	0	Resistor, Chip, 0.1W, 1%	0603	Std	Std
1	U1	TPS60800QDRLRQ1	200mA unregulated charge pump voltage inverter	1.6mm × 1.6mm	TPS60800QDRLRQ1	Texas Instruments

5 Additional Information

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *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

NOTE: 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

NOTE: 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.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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.

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.

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.

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs 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 EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should 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 also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure 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. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

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5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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