Texas Instruments

A 5-V Input, 1.8-V Output, 6-A Synchronous Buck Converter

User's Guide

April 2006

SLUU246

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1 Introduction

The TPS40041EVM-001 evaluation module (EVM) is a synchronous buck converter providing a fixed 1.8-V output at up to 6 A from a 5-V input bus or 3 A from a 3.3-V input. The EVM is designed to start up from a single supply, so no additional bias voltage is required for start-up. The module uses the TPS40041 Reduced Pin Count Low-Voltage Synchronous Buck Controller.

1.1 Description

TPS40041EVM-001 is designed to use a regulated 5-V (4.5 V to 5.5 V) or 3.3-V (3.0 V to 3.6 V) bus to produce a medium current, regulated 1.8-V output at up to 6 A of load current. TPS40041EVM-001 is designed to demonstrate the TPS40041 in a typical regulated bus to low-voltage application while providing a number of test points to evaluate the performance of the TPS40041 in a given application. The EVM can be modified to support output voltages from 0.9 V to 2.5 V by changing a single set resistor.

1.2 Applications

- Non-isolated medium current point of load and low voltage bus converters.
- Networking equipment
- Telecommunications equipment
- Computer peripherals
- Digital set top box

1.3 Features

- 3.0-V to 5.5-V input range
- 1.8-V fixed output, adjustable with single resistor
- 6-A_{DC} steady state output current (3 A at 3.3-V input)
- 600-kHz switching frequency (fixed by TPS40041)
- Single SO-8 dual MOSFET for both main switch and synchronous rectifier.
- Double sided 2-layer PCB with all components on top side
- Active converter uses less than 1 square inch < 1.0” x 1.0”
- Convenient test points for probing switching waveforms and non-invasive loop response testing

2 TPS40041EVM-001 Electrical Performance Specifications

Table 1. TPS40041EVM-001 Electrical and Performance Specifications

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNITS
Input Characteristics						
Input Voltage Range			3.0		5.5	V
Max Input Current	VIN = 4.5V, IOUT = 6A			2		A
	VIN = 3V, IOUT = 3A			2		
No-Load Input Current	VIN = 5.5V, IOUT = 0A			100		mA
Output Characteristics						
Output Voltage	R6 = 10k R5 = OPEN		1.75	1.80	1.85	V
Output Voltage Regulation	Line Regulation (3.0V<VIN<5.5V, IOUT = 2A)				0.2%	
	Load Regulation (0A<IOUT<6A, VIN = 5V)				0.2%	
Output Voltage Ripple	VIN = 5.5V, IOUT = 6A			10	36	mVpp
Output Load Current	VIN = 4.5 – 5.5V		0		6	A
	VIN = 3.0 – 3.6V		0		3	
Short Circuit Input Current	VIN = 5.5V VOUT = 0V			6		mA
System Characteristics						
Switching Frequency			500	600	700	kHz
Peak Efficiency	VOUT = 1.8V, 1A<IOUT<4Av	VIN = 3.0V		93%		
		VIN = 4.5V		91%		
		VIN = 5.5V		90%		
Full Load Efficiency	VOUT = 1.8V, IOUT = 3A	VIN = 3.0V		91%		
	VOUT = 1.8V, IOUT = 6A	VIN = 4.5V		89%		
		VIN = 5.5V		88%		

3 Schematic

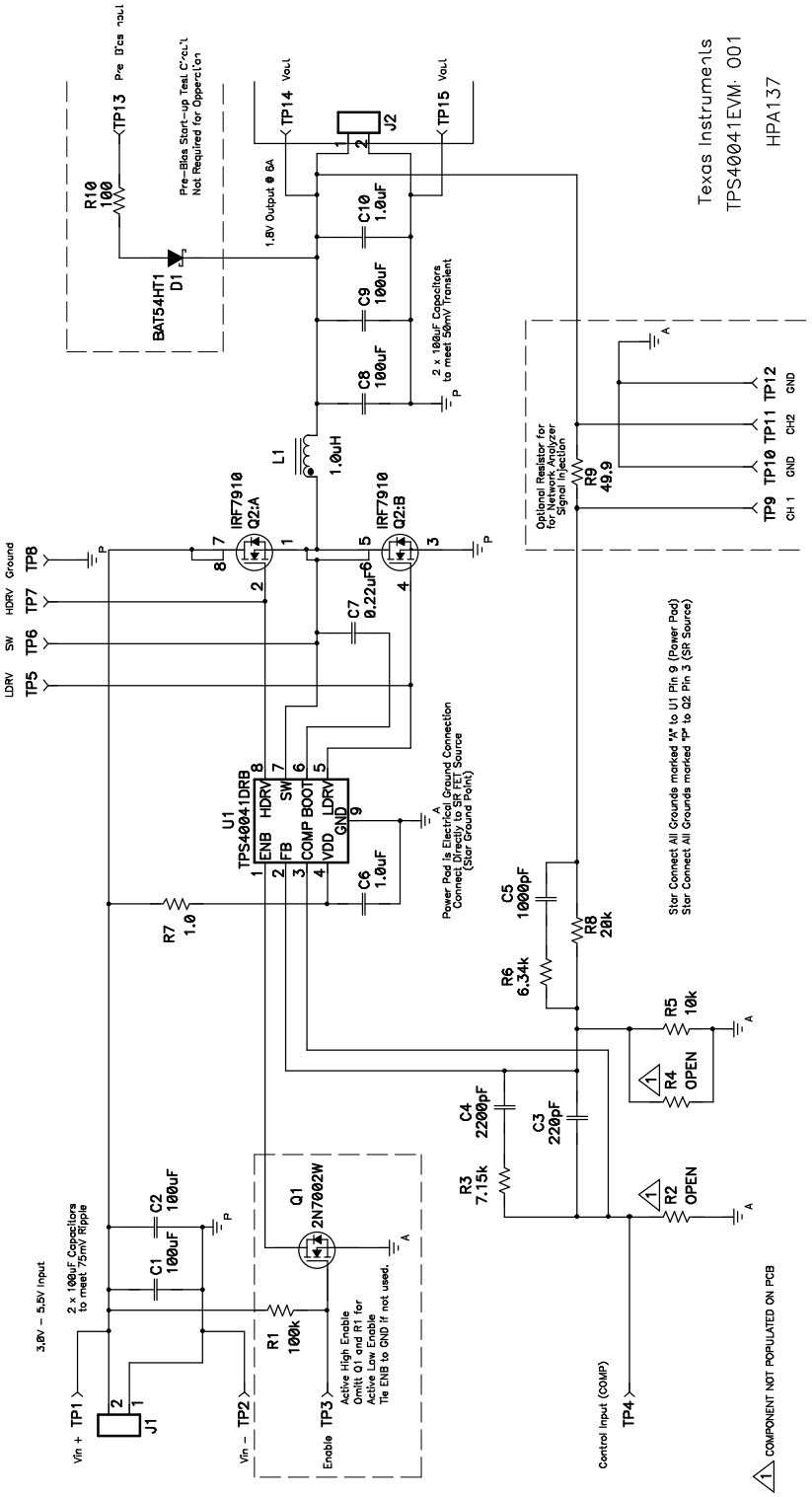

Figure 1. TPS40041EVM-001 Schematic

Note: For reference only, see Table 4 List of Materials for specific values.

3.1 Adjusting Output Voltage (R5)

The regulated output voltage can be adjusted within a limited range by changing the ground resistor in the feedback resistor divider (R5). The output voltage is given by the formula:

$$V_{OUT} \approx V_{REF} \times \frac{R8 + R5}{R5}$$

Where V_{VREF} = 0.600 V and R8 = 20 KΩ

Table 2 contains common values for R1 to generate popular output voltages. TPS40041EVM-001 is stable through these output voltages but the efficiency may suffer as the power stage is optimized for the 1.8-V output.

Table 2. Adjusting V_{OUT} with R5

V_{OUT}	R5
2.5 V	6.34 kΩ
2.25 V	7.32 kΩ
2.0 V	8.66 kΩ
1.8 V	10 kΩ
1.5 V	13.3 kΩ
1.2 V	20 kΩ
1.0 V	30 kΩ
0.9 V	40 kΩ

The values in Table 2 provide less than 1% nominal set-point error in the output voltage. If a tighter nominal value is required, R4 can be used in parallel with R5 to obtain a wider range of resistor values using commonly available E96 resistors.

3.2 Adjusting Short Circuit Protection (R6)

The TPS40041 uses a selectable current limit for short circuit protection. The current limit is selected from three levels by placing a resistor at R6. The TPS40041 compares the voltage drop across the high-side FET (VDD to SW) to an internal reference voltage selected during start-up. The voltage levels are shown in Table 3.

Table 3. Adjusting V_{SCP} with R6

V_{SCP}	R6
105 mV	2.4 kΩ
180 mV	OPEN
300 mV	12 kΩ

The current before declaring short circuit protection can be determined by dividing the $V_{SC}P$ by the $R_{DS(on)}$ of the high-side FET (Q2).

3.3 Enable (TP1 & SW1)

TPS40041EVM-001 provides an active high enable input (TP1) to allow the user to evaluate the TPS40041's enable function. The enable test point uses a 100-kΩ pull-up resistor so TPS40041 turns on if the enable test point is left floating.

4 Test Set Up

4.1 Equipment

4.1.1 Voltage Source

The input voltage source (V_{IN}) should be a 0 V to 6 V variable dc source capable of 5 A_{DC}. Connect V_{IN} to J1 as shown in Figure 3.

4.1.2 Meters

- **A1:** 0 A_{DC} to 5 A_{DC}, ammeter
- **V1:** V_{IN} 0 V to 15 V, voltmeter
- **V2:** V_{OUT} 0 V to 15 V, voltmeter

4.1.3 Loads

- LOAD1

The output load, LOAD1, should be an electronic constant current mode load capable of 0 A_{DC} to 6 A_{DC} at 1.8 V.

4.1.4 Oscilloscope

A digital or analog oscilloscope can be used to measure the ripple voltage on V_{OUT}. The oscilloscope should be set for 1-MΩ impedance, 20-MHz bandwidth, ac coupling, 1-µs/div. horizontal resolution and 10-mV/div. vertical resolution for taking output ripple measurements. TP 14 and TP 15 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP14 and holding the ground barrel to TP15 as shown in Figure 3. For a hands free approach, the loop in TP15 can be cut and opened to cradle the probe barrel. Using a leaded ground connection may induce additional noise due to the large ground loop area.

4.1.5 Recommended Wire Gauge

- V_{IN} to J1

The connection between the source voltage, VIN and J1 of HPA137 can carry as much as 3 A_{DC}. The minimum recommended wire size is AWG #16 with the total length of wire less than 4 feet, 2 feet input, 2 feet return.

- J2 to LOAD1 (power)

The power connection between J2 of HPA137 and LOAD1 can carry as much as 6 A_{DC}. The minimum recommended wire size is 2 x AWG #16, with the total length of wire less than 4 feet, 2 feet output, 2 feet return.

4.1.6 Other

- Fan

This evaluation module includes components that can get hot to the touch, because this EVM is not enclosed to allow probing of circuit nodes, a small fan capable of 200 lfm to 400 lfm is required to reduce component surface temperatures to prevent user injury. The EVM should not be left unattended while powered. The EVM should not be probed while the fan is not running.

4.2 Equipment Setup

Shown in Figure 3 is the basic test set up recommended to evaluate the TPS40041EVM-001. Please note that although the return for J1 and J2 are the same, the connections should remain separate as shown in Figure 2.

4.2.1 Procedure

1. Working at an ESD workstation, make sure that any wrist straps, bootstraps or mats are connected referencing the user to earth ground before power is applied to the EVM. Electrostatic smock and safety glasses should also be worn.
2. Prior to connecting the dc input source, V_{IN}, it is advisable to limit the source current from V_{IN} to 5.0 A maximum. Make sure V_{IN} is initially set to 0 V and connected as shown in Figure 2.
3. Connect the ammeter A1 (0 A to 5 A range) between V_{IN} and J1 as shown in Figure 2.
4. Connect voltmeter V1 to TP1 and TP2 as shown in Figure 2.
5. Connect LOAD1 to J2 as shown in Figure 2. Set LOAD1 to constant current mode to sink 0 A_{DC} before V_{IN} is applied.
6. Connect voltmeter, V2 across TP14 and TP15 as shown in Figure 2.
7. Connect Oscilloscope probe to TP14 and TP15 as shown in Figure 3.
8. Place fan as shown in Figure 2 and turn on, making sure air is flowing across the EVM.

4.2.2 Diagram

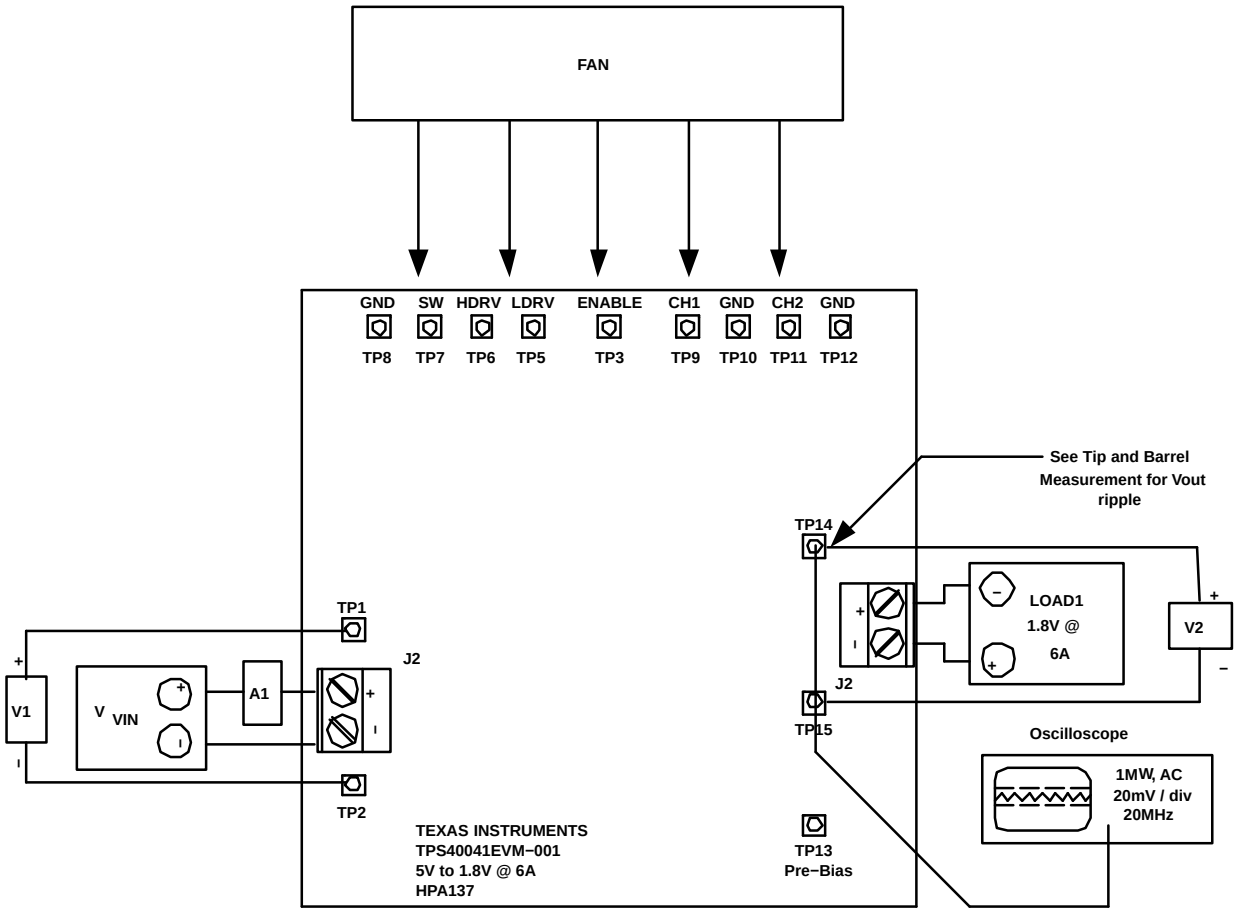

Figure 2. TPS40041EVM-001 Recommended Test Set-Up

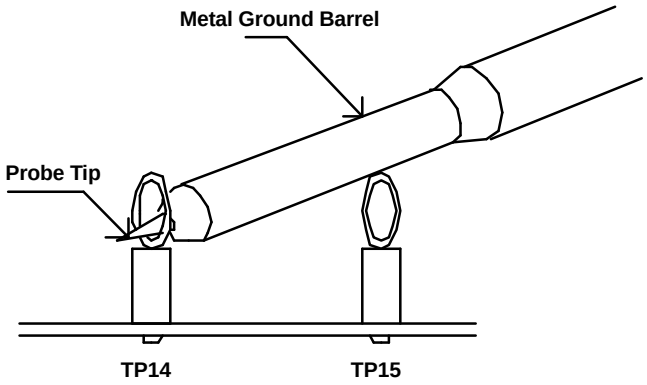

Figure 3. Output Ripple Measurement - Tip and Barrel using TP9 and TP10

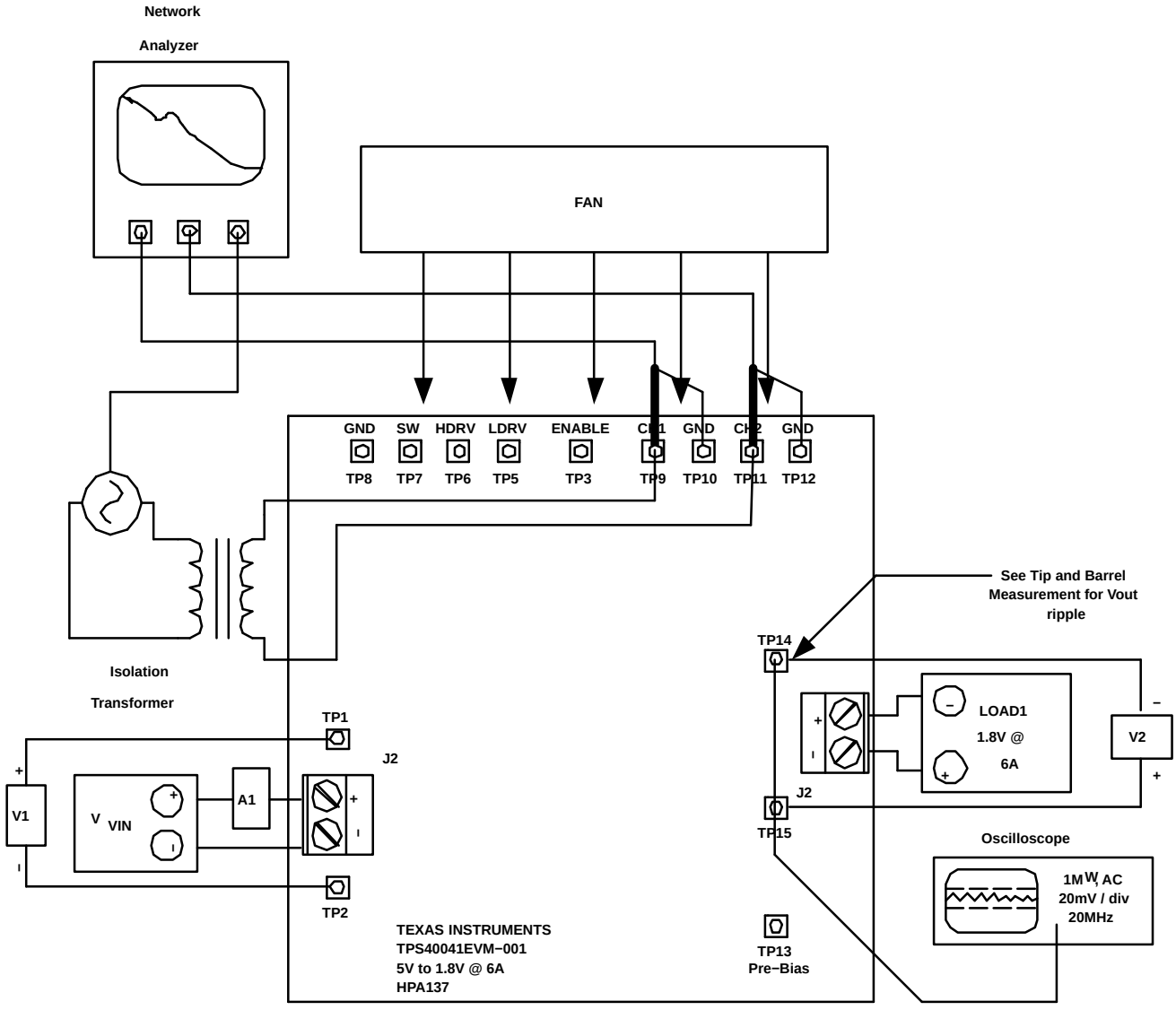

Figure 4. Control Loop Measurement Setup

4.3 Start-Up / Shut-Down Procedure

1. Increase V_{IN} from 0 V_{DC} to 5 V_{DC}.
2. Vary LOAD1 from 0 V_{DC} to 6 V_{DC}.
3. Vary V_{IN} from 3.0 V_{DC} to 5.5 V_{DC}.
4. Decrease LOAD1 to 0 A.

4.4 Control Loop Gain and Phase Measurement Procedure

1. Connect 1-kHz to 1-MHz isolation transformer to TP9 and TP11 as show in Figure 4.
2. Connect input signal amplitude measurement Probe (Channel A) to TP9 as shown in Figure 4.
3. Connect output signal amplitude measurement probe (Channel B) to TP11 as shown in Figure 4.
4. Connect ground lead of Channel A and Channel B to TP10 & TP12 as shown in Figure 4.
5. Inject 25 mV or less signal across R7 through isolation transformer.
6. Sweep frequency from 1 kHz to 1 MHz with 10 Hz or lower post filter.
7. Control loop gain can be measured by: $20 \times \log\left(\frac{\text{ChannelB}}{\text{ChannelA}}\right)$
8. Control loop phase is measured by the phase difference between Channel A and Channel B.
9. Disconnect isolation transformer from TP9 and TP11 before making other measurements, signal Injection into feedback may interfere with accuracy of other measurements.

4.5 Equipment Shutdown

1. Shut down oscilloscope
2. Shut down LOAD1
3. Shut down V_{IN}
4. Shut down FAN

5 TPS40041EVM Typical Performance Data and Characteristic Curves

Figure 5 through Figure 9 present typical performance curves for the TPS40041EVM-001. Since actual performance data can be affected by measurement techniques and environmental variables, these curves are presented for reference and may differ from actual field measurements.

5.1 Efficiency

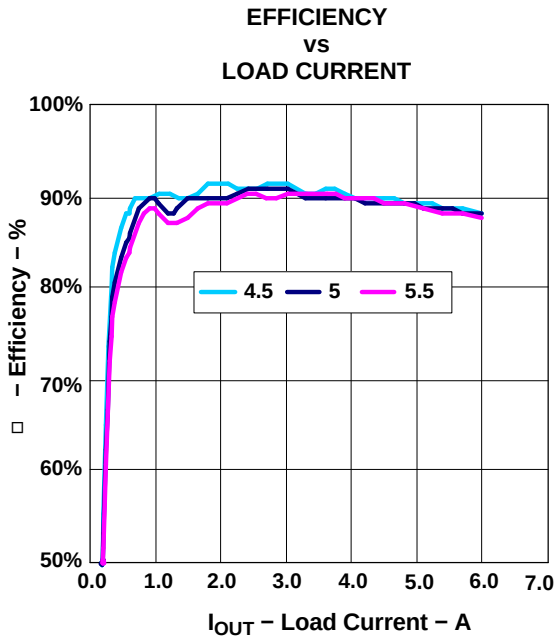

Figure 5. TPS40041EVM-001 Efficiency V_{IN} = 4.5 V to 5.5 V, V_{OUT} = 1.8 V, I_{OUT} = 0 A to 6 A

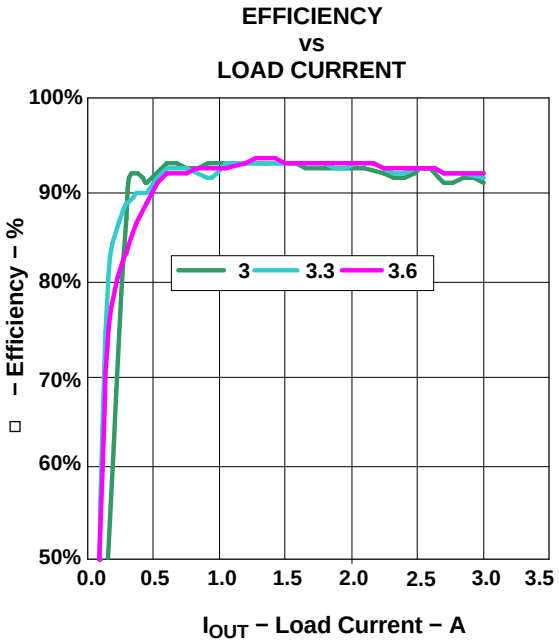

Figure 6. TPS40041EVM-001 Efficiency V_{IN} = 3.0 V to 3.6 V, V_{OUT} = 1.8 V, I_{OUT} = 0 A to 3 A

5.2 Line and Load Regulation

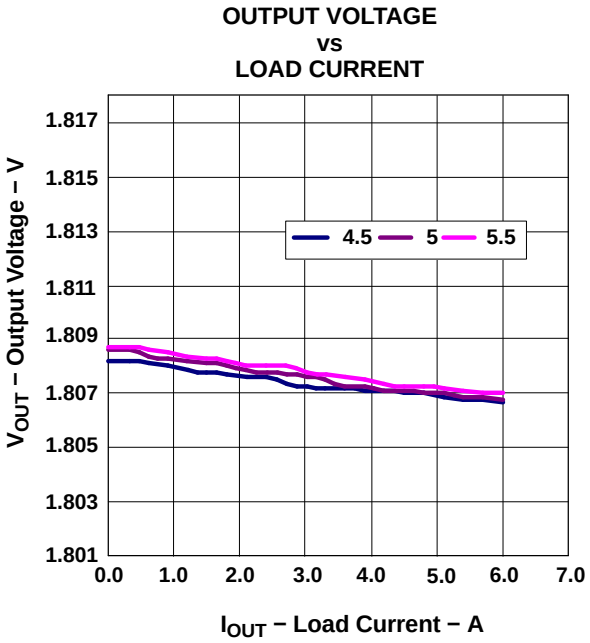

Figure 7. TPS40041EVM-001 Line and Load Regulation V_{IN} = 4.5 V to 5.5 V, V_{OUT} = 1.8 V, I_{OUT} = 0 A to 6 A

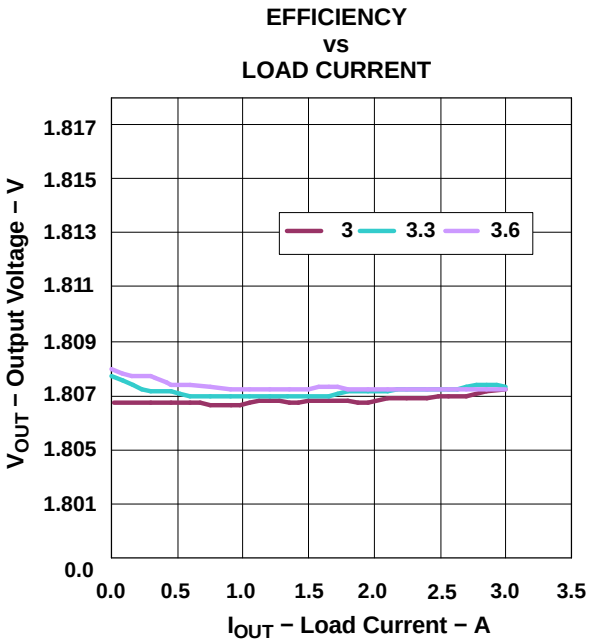

Figure 8. TPS40041EVM-001 Line and Load Regulation V_{IN} = 3.0 V to 3.6 V, V_{OUT} = 1.8 V, I_{OUT} = 0 A to 3 A

5.3 Output Voltage Ripple

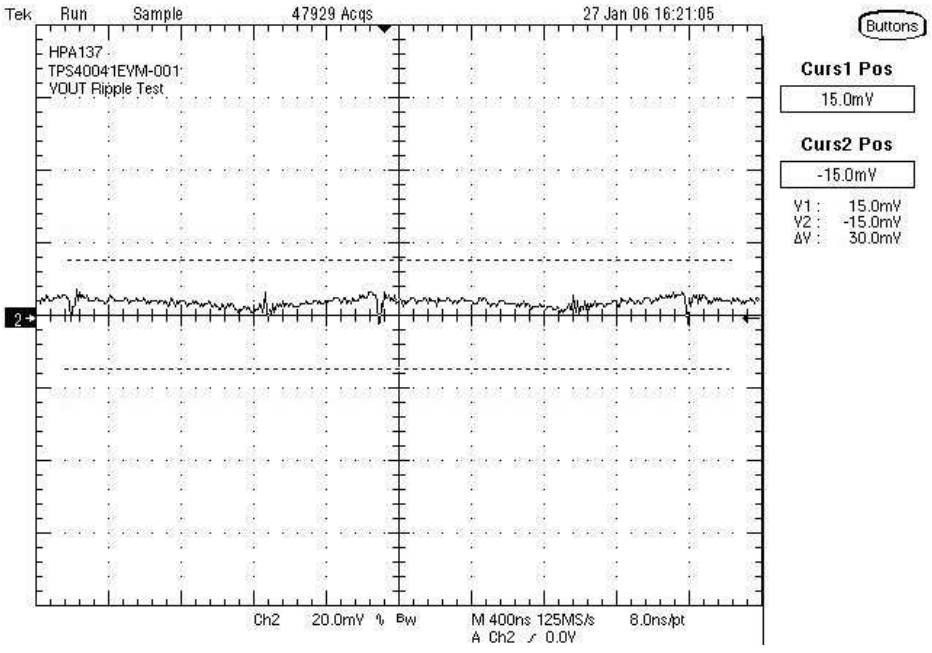

Figure 9. TPS40041EVM-001 Output Voltage Ripple, V_{IN} = 5.5V, I_{OUT} = 6 A

6 EVM Assembly Drawings and Layout

The following figures, Figure 10 through Figure 13, show the design of the TPS40041EVM-001 printed circuit board. The EVM has been designed using a double sided, 2-oz copper-clad circuit board 2.5” x 2.4” with all components in a 1” x 1” active area on the top side to allow the user to easily view, probe and evaluate the TPS40041 control device in a practical application. Moving components to both sides of the PCB or using additional internal layers can offer additional size reduction for space constrained systems.

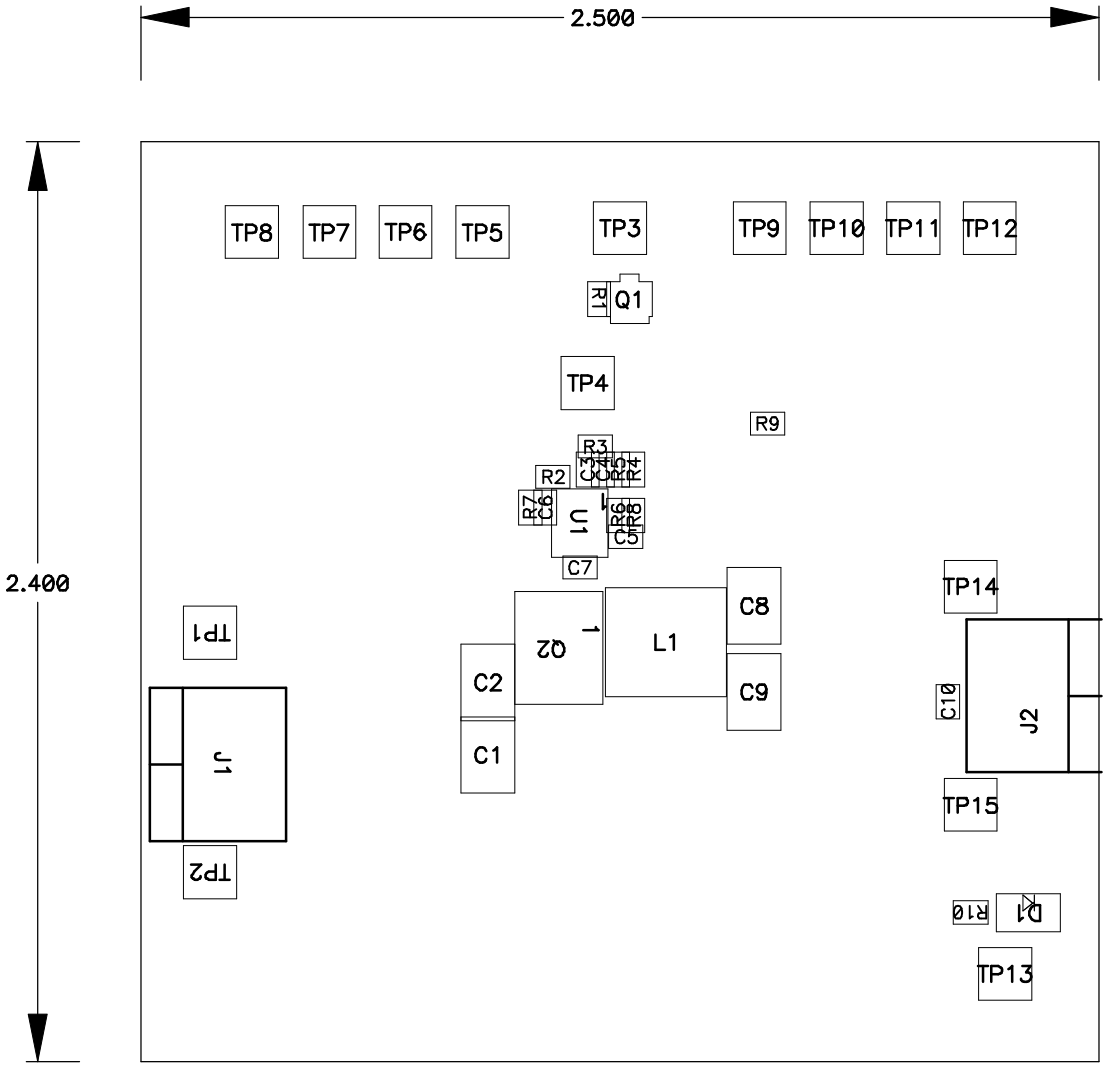

Figure 10. TPS40041EVM-001 Component Placement, Top View

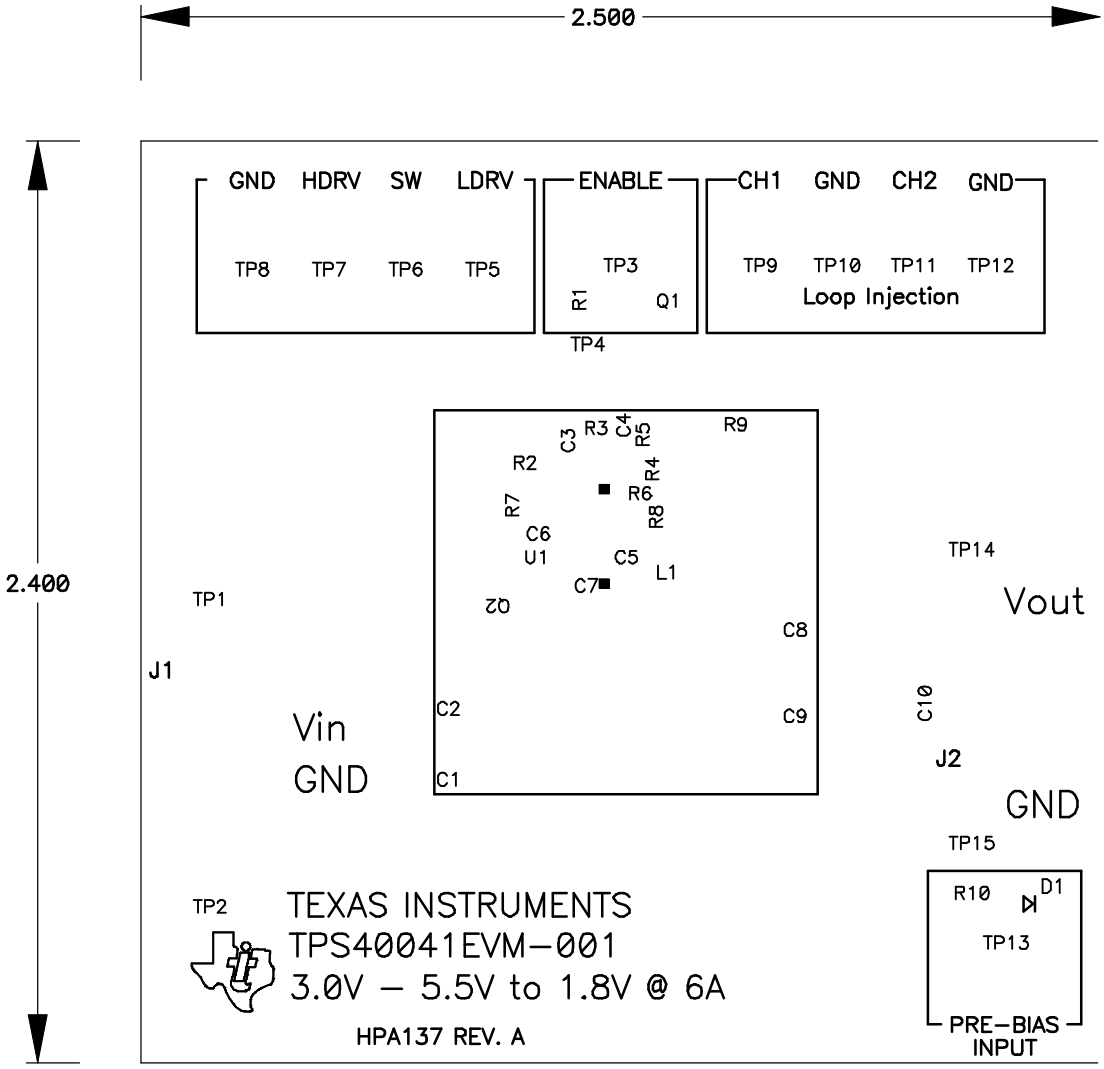

Figure 11. TPS40041EVM-001 Silkscreen, Top View

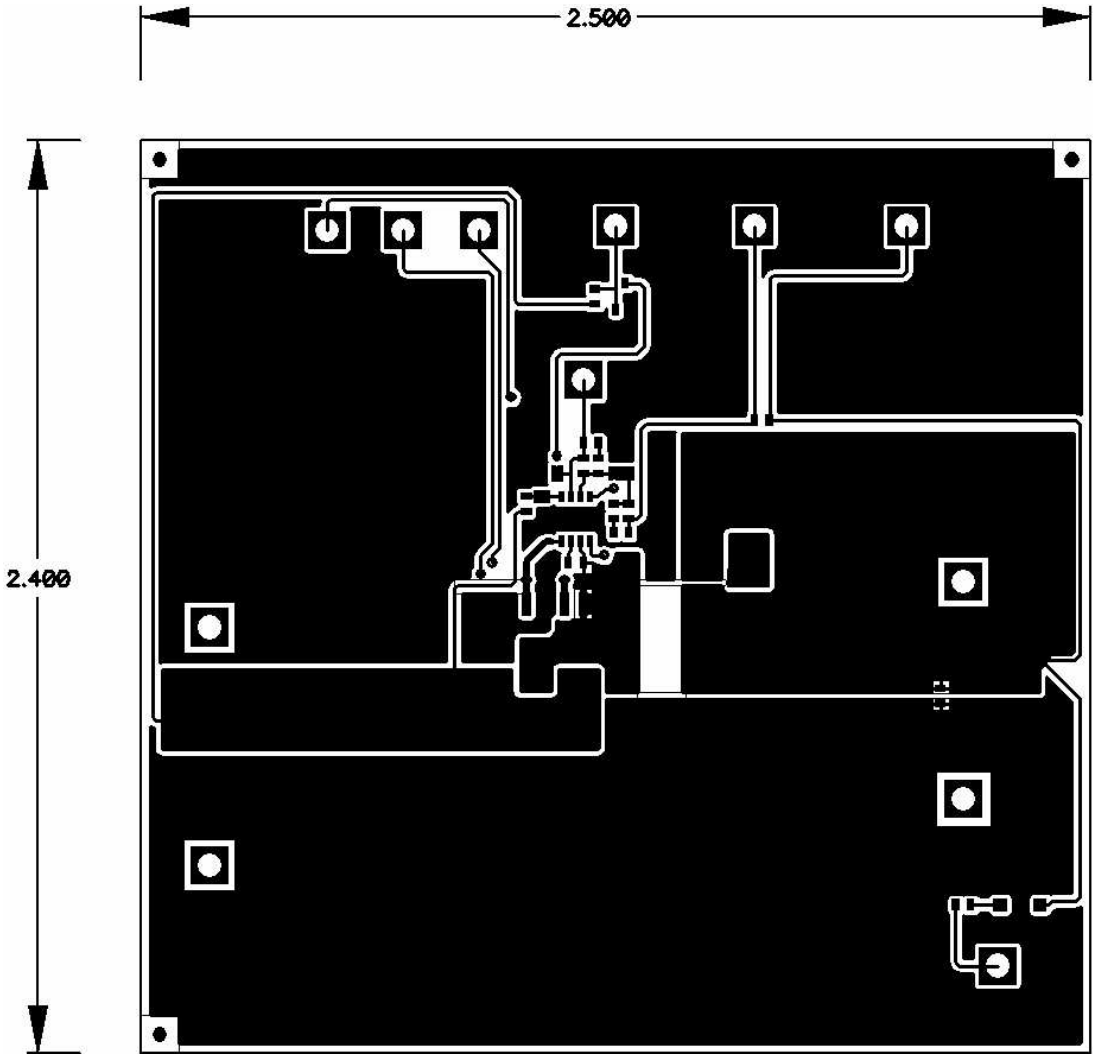

Figure 12. TPS40041EVM-001 Top Copper, Top View

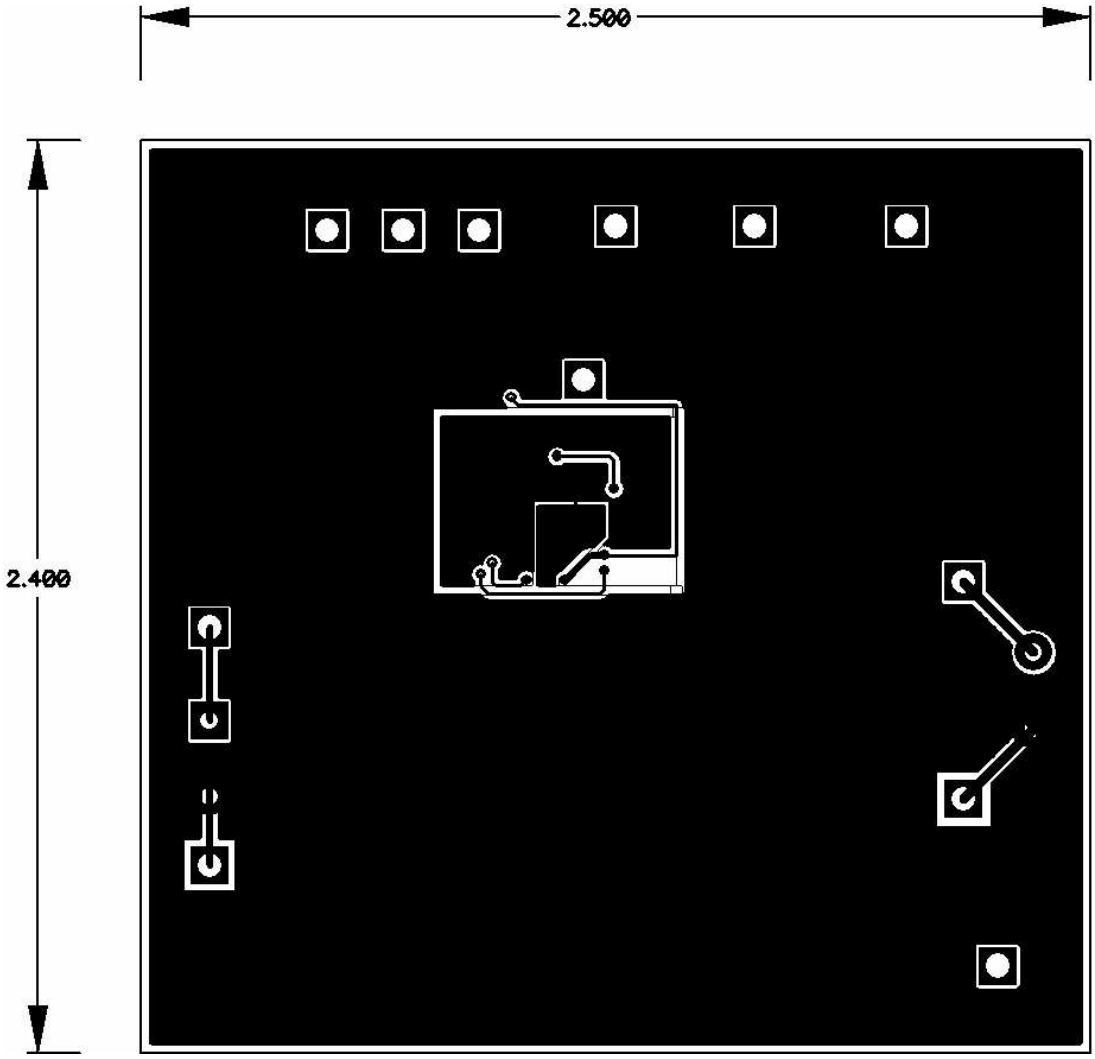

Figure 13. TPS40041EVM-001 Bottom Copper, X-Ray View from Top

7 LIST OF MATERIALS

Table 4 lists the EVM components as configured according to the schematic shown in Figure 1.

Table 4. TPS40041EVM-001 List of Materials

REF	COUNT	DESCRIPTION	MANUFACTURER	PART NUMBER
C1, C2, C8, C9	4	Capacitor, ceramic, 6.3 V, X5R, 20%, 100 µF, 1210	TDK	C3225X5R0J107M
C3	1	Capacitor, ceramic, 50 V, X7R, 20%, 220 pF, 0402	TDK	C1005X7R1H221M
C4	1	Capacitor, ceramic, 50 V, X7R, 20%, 2200 pF, 0402	TDK	C1005X7R1H222M
C5	1	Capacitor, ceramic, 50 V, X7R, 20%, 1000 pF, 0402	TDK	C1005X7R1H102M
C6, C10	2	Capacitor, ceramic, 6.3 V, X5R, 20%, 1.0 µF, 0402	TDK	C1005X5R0J105M
C7	1	Capacitor, ceramic, 6.3 V, X5R, 20%, 0.22 µF, 0402	TDK	C1005X5R0J224M
D1	1	Diode, schottky, 200 mA, 30 V, SOD323	On Semi	BAT54HT1
J1, J2	2	Terminal block, 2 pin, 15 A, 5.1 mm 0.40 x 0.35 inch	OST	ED1609
L1	1	Inductor, SMT, 1.0 µH, 12 A, 6.6 mΩ, 1.0 µH, 0.268 x 0.268 inch	Pulse	PG0083.102
Q1	1	MOSFET, N-channel, VDS 60 V, RDS 2 Ω, ID 115 mA SOT-323 (SC-70)	Diodes Inc	2N7002W-7
Q2	1	MOSFET, dual N-channel, 12 V, 10 A, 15 mΩ SO8	IR	IRF7910
R1	1	Resistor, chip, 100 kΩ, 1/16 W, 1% 0402	Std	Std
R10	1	Resistor, chip, 100 Ω, 1/16 W, 1% 0402	Std	Std
R2, R4	0	Resistor, chip, 1/16 W, OPEN, 0402	Std	Std
R3	1	Resistor, chip, 7.15 kΩ, 1/16 W, 1% 0402	Std	Std
R5	1	Resistor, chip, 10.0 kΩ, 1/16 W, 1% 0402	Std	Std
R6	1	Resistor, chip, 6.34 kΩ, 1/16 W, 1% 0402	Std	Std
R7	1	Resistor, chip, 1 Ω, 1/16 W, 1% 0402	Std	Std
R8	1	Resistor, chip, 20 kΩ, 1/16 W, 1% 0402	Std	Std
R9	1	Resistor, chip, 49.9 Ω, 1/16 W, 1% 0402	Std	Std
TP1, TP14	2	Test point, red, thru hole 0.125 x 0.125		5010
TP2, TP8, TP10, TP12, TP15	5	Test point, black, thru hole 0.125 x 0.125		5011
TP3, TP4, TP5, TP6, TP7, TP9, TP11, TP13	8	Test point, white, thru hole 0.125 x 0.125		5012
U1*	1	TPS40041DRB, Low Voltage DC/DC Synchronous Buck Controller, QFN-8P	TI	TPS40041DRB

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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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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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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3.4 *European Union*

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.

4 *EVM Use Restrictions and Warnings:*

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.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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