EVM User's Guide: TPSM843521EVM

TPSM843521 Step-Down Converter Evaluation Module

Description

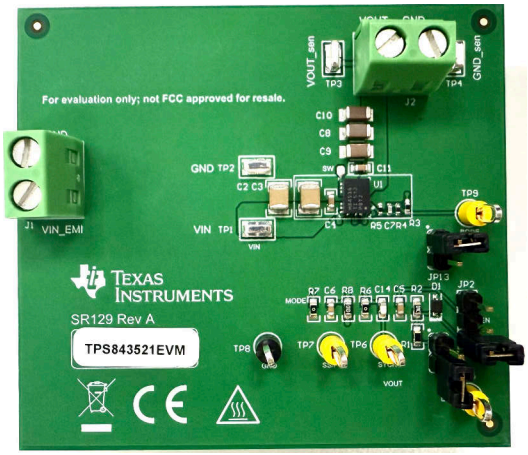
The TPSM843521EVM is a fully assembled and tested circuit for evaluating the TPSM843521 module. The evaluation module is configured to operate from input voltage range of 3.8V to 18V and produce a regulated 5.0V output with up to 5A load current. Most settings of the device can be easily adjusted or set through resistors and jumpers, such as operation mode, soft-start time, and switching frequency.

Features

- 3.8V to 18V input voltage range
- 0.6V to 9V output voltage range
- Support 5A continuous output current
- Selectable Eco-mode and forced continuous conduction modulation (FCCM) mode
- Adjustable switching frequency
- Ease of use

Applications

- Test and measurement
- Motor drive
- Grid Infrastructure
- Medical and healthcare



1 Evaluation Module Overview

1.1 Introduction

The TPSM843521 is a single, PCM control mode, synchronous buck module requiring a very low external component count. The TPSM843521 synchronous buck converter used in the EVM has the following features:

- 3.8V to 18V input voltage range
- 0.6V to 9V output voltage range
- Support 5A continuous output current
- 0.6V±1.0% output voltage accuracy
- Selectable switching frequency of 200kHz and 2200kHz
- Selectable Adjustable Soft-start time/PG function
- Selectable Eco-mode and FCCM under light load operation

This user's guide describes the characteristics, operation, performance, and use of the Texas Instruments TPSM843521 evaluation module (EVM). The TPSM843521 is designed to help users easily evaluate and test the operation and functionality of the TPSM843521. This user's guide includes the following:

- Setup instructions for the hardware
- Printed-circuit board layouts for the EVM
- Schematic diagram
- Bills of material
- Test results for the EVM

1.2 Kit Contents

- TPSM843521EVM Circuit Board
- EVM Disclaimer Read Me
- Prototype EVM Disclaimer Read Me

1.3 Specification

A summary of the TPSM843521EVM performance specifications is provided in Table 1-1. Specifications are given for 24V input voltage and 5.0V output voltage, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 1-1. TPSM843521EVM Performance Specifications Summary

SPECIFICATIONS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IN}	Input voltage		5.5		18	V
V_{OUT}	Output voltage		4.95	5.0	5.05	V
f_{SW}	Operating frequency	V_{IN} = 12V, I_{OUT} = 5A		1000		kHz
I_{OUT}	Output current range		0		5	A

1.4 Device Information

The TPSM843521 evaluation module (EVM) is a single, synchronous buck module providing 5.0V at 5A from a 5.5V to 18V input.

Table 1-2. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE (V_{IN}) RANGE	OUTPUT CURRENT (I_{OUT}) RANGE
TPSM843521EVM	5.5V to 18V	0A to 5A

2 Hardware

2.1 Test Setup and Procedure

2.1.1 EVM Connections

Referencing the EVM connections described in Table 2-1, the recommended test setup to evaluate the TPSM843521 is shown in Figure 2-1. Working at an ESD-protected workstation, make sure that any wrist straps, boot straps, or mats are connected and referencing the user to earth ground before handling the EVM.

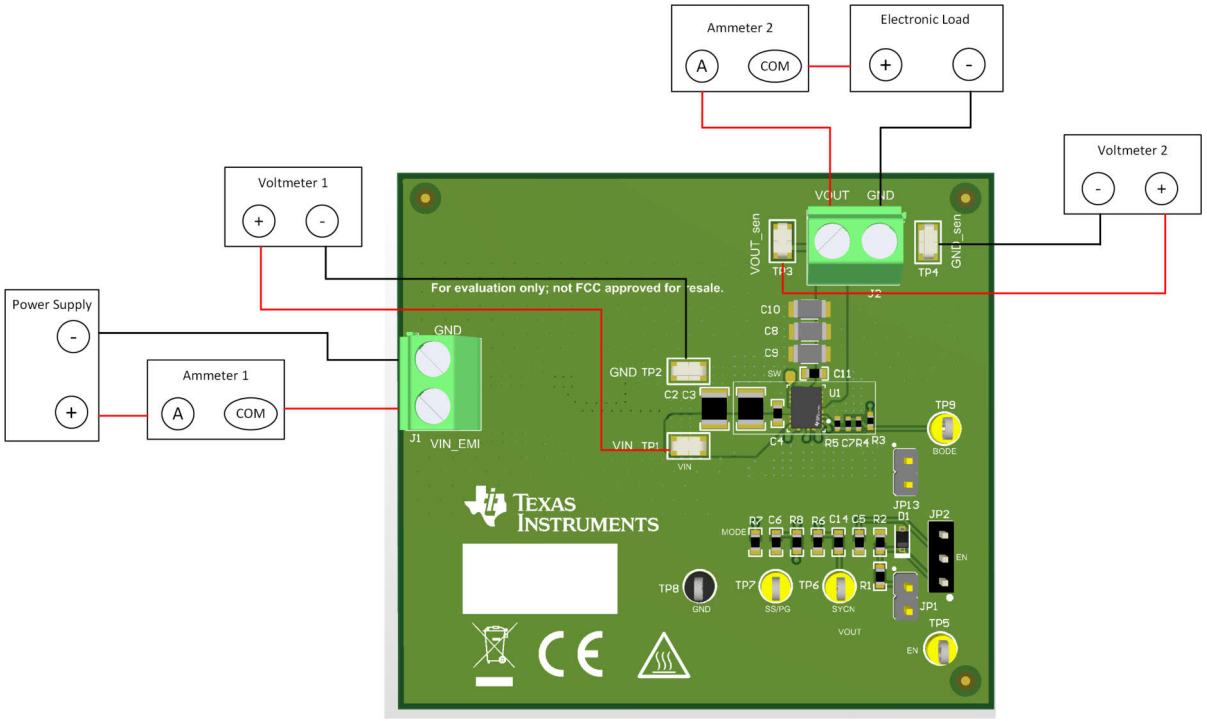


Figure 2-1. EVM Test Setup

Table 2-1. EVM Power Connections

LABEL	DESCRIPTION
VIN_EMI (J1)	Positive input voltage power and sense connection
GND (J1)	Negative input voltage power and sense connection
VOUT (J2)	Positive output voltage power and sense connection
GND (J2)	Negative output voltage power and sense connection

Table 2-2. EVM Signal Connections

LABEL	DESCRIPTION
VIN_(TP1)	Measure input voltage
VOUT_sen(TP3)	Measure output voltage
GND(TP8)	Ground of the converter
SS/PG (TP7)	Soft-start function or Power-Good function depending on the mode selection
BODE(TP9)	Mode selection pin
EN (TP5)	EN indicator of converter
SYNC (TP6)	SYNC clock injection
Header (JP1 and JP2)	Leaving JP1 and JP2 open enables the converter. Connection (PIN-1 to PIN-2) of JP1 and (PIN-2 to PIN-3) of JP2 can set system UVLO voltage with an external resistor divider R1 and R2. Connection (PIN-1 to PIN-2) of JP1 and (PIN-1 to PIN-2) of JP2 can disable the converter.
Header (JP13)	When Power-Good mode is selected, connection (PIN-1 to PIN-2) of JP13.

2.1.2 Test Equipment

Voltage Source: use an input voltage source capable of supplying 0V to 18V and 5A.

Multimeters:

- **Voltmeter 1:** input voltage at VIN(TP1) to GND(TP2). Set the voltmeter to an input impedance of 100MΩ.
- **Voltmeter 2:** output voltage at VOUT_SNS(TP3) to GND_SNS(TP4). Set the voltmeter to an input impedance of 100MΩ.
- **Ammeter 1:** input current. Set the ammeter to 1-second aperture time.
- **Ammeter 2:** output current. Set the ammeter to 1-second aperture time.

Electronic Load: the load must be an electronic constant-resistance (CR) or constant-current (CC) mode load capable of 0A to 5A at 5.0V. For a no-load input current measurement, disconnect the electronic load as the load can draw a small residual current.

Oscilloscope: with the scope set to 20MHz bandwidth and AC coupling, measure the output voltage ripple directly across an output capacitor with a short ground lead normally provided with the scope probe. Place the oscilloscope probe tip on the positive terminal of the output capacitor, holding the ground barrel of the probe through the ground lead to the negative terminal of the capacitor. The switching waveforms can be tested by a probe tip click to copper of SW node. TI does not recommend using a long-leaded ground connection because this can induce additional noise given a large ground loop. To measure other waveforms, adjust the oscilloscope as needed.

Safety: always use caution when touching any circuits that can be live or energized.

2.1.3 Recommended Test Setup

2.1.3.1 Input Connections

1. Prior to connecting the DC input source, set the current limit of the input supply to 0.1A maximum. Make sure the input source is initially set to 0V and connected to the VIN_EMI and GND of J1 as shown in Figure 2-1.
2. Connect voltmeter 1 at VIN and GND test points to measure the input voltage.
3. Connect ammeter 1 to measure the input current and set to at least 1-second aperture time.

2.1.3.2 Output connections

1. Connect electronic load to VOUT and GND of J2 connection. Set the load to constant-resistance mode or constant-current mode at 0A before applying input voltage.
2. Connect voltmeter 2 at VOUT_SNS and GND_SNS test points to measure the output voltage.
3. Connect ammeter 2 to measure the output current.

2.1.4 Test Procedure

2.1.4.1 Line and Load Regulation, Efficiency

1. Set up the EVM as previously described.
2. Set the load to constant resistance or constant current mode and to sink 0A.
3. Increase input source from 0V to 18V; use voltmeter 1 to measure the input voltage.
4. Increase the current limit of the input supply to 5A.
5. Using voltmeter 2 to measure the output voltage, V_{OUT}, vary the load current from 0A to 5A; V_{OUT} must remain within the load regulation specification.
6. Set the load current to 2.5A (50% rated load) and vary the input source voltage from 5.5V to 18V; V_{OUT} must remain within the line regulation specification.
7. Decrease load to 0A. Decrease input source voltage to 0V.

3 Hardware Design Files

3.1 Schematic

The following figure shows the schematic for the TPSM843521EVM.

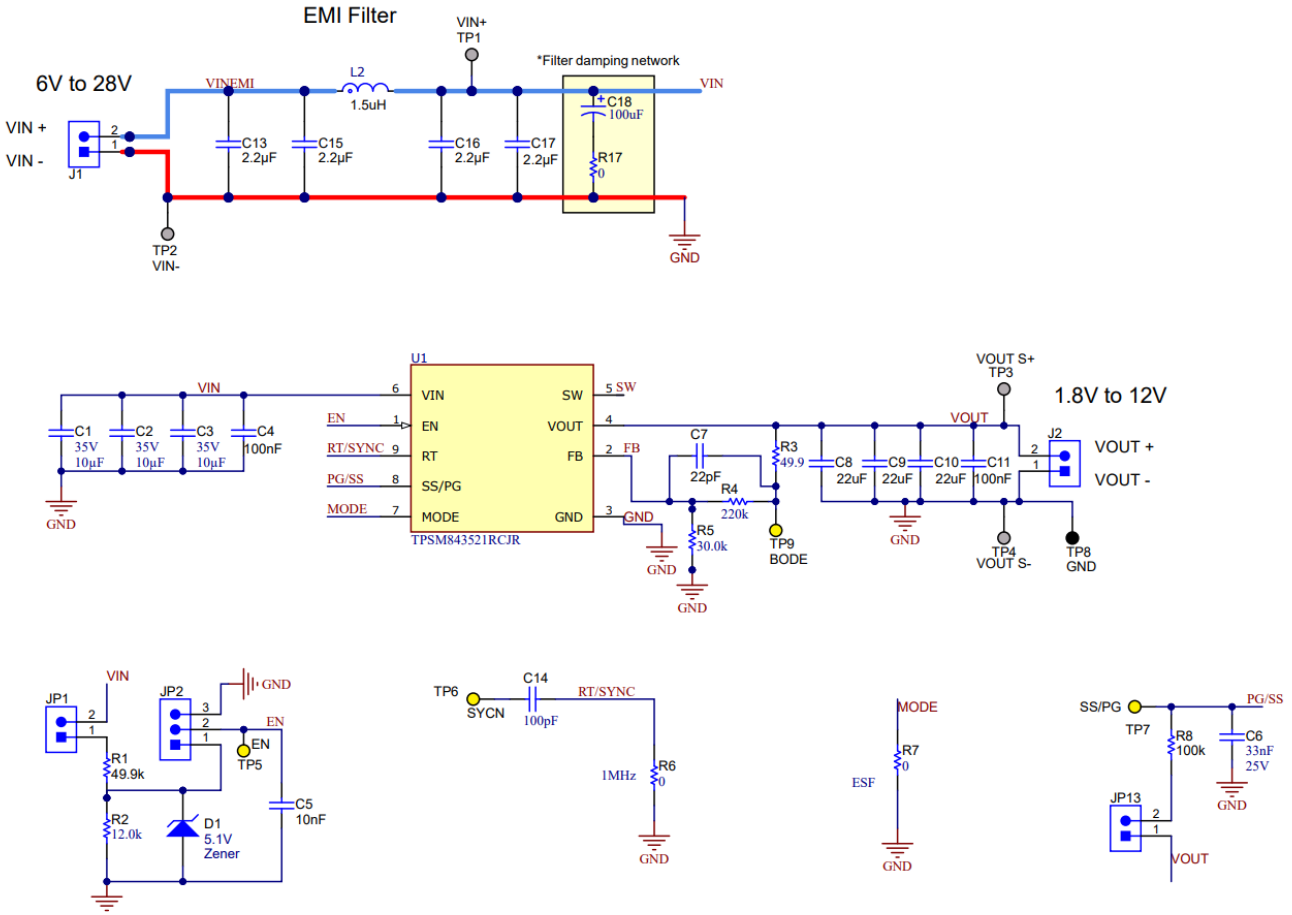


Figure 3-1. TPSM843521EVM Schematic Diagram

The default operating frequency of TPSM843521EVM is 1000kHz, and default mode is ECO external soft start and spread spectrum. If another frequency or mode is needed, then refer to the related description of RT and Mode in the *TPSM843521 3.8V to 18V, 5A, Synchronous Buck Power Module With User Selectable Mode* data sheet.

3.2 PCB Layout

Figure 3-2 through Figure 3-5 show the design of the TPSM843521EVM using a four-layer PCB with 2oz copper thickness.

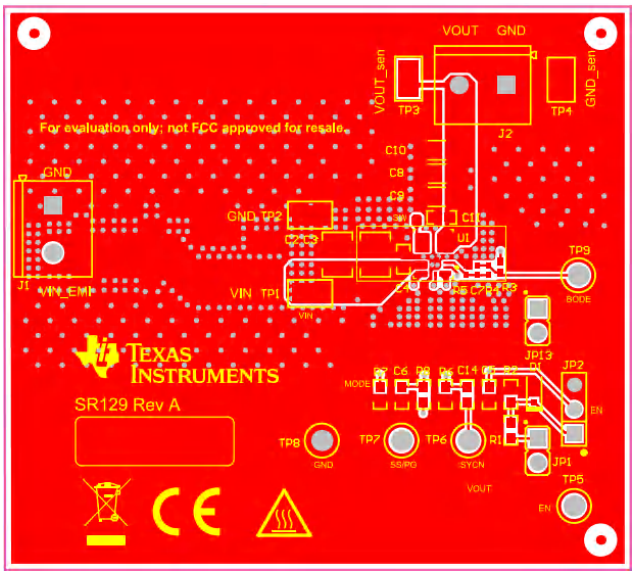


Figure 3-2. Top Copper (Top View)

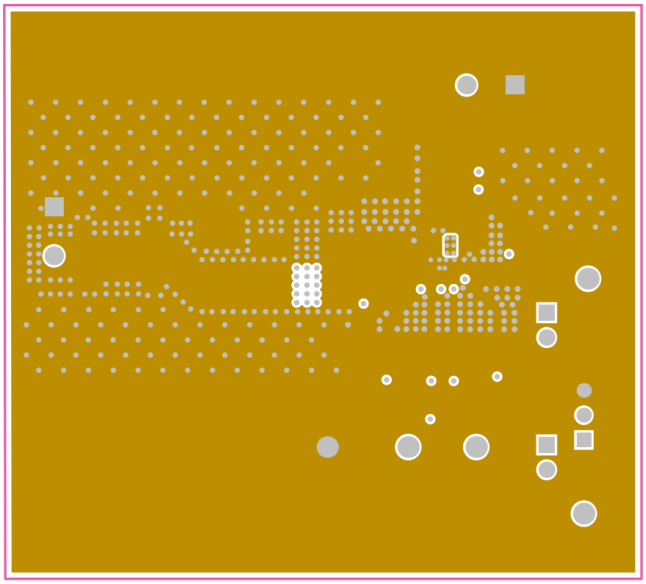


Figure 3-3. Layer 2 Copper (Top View)

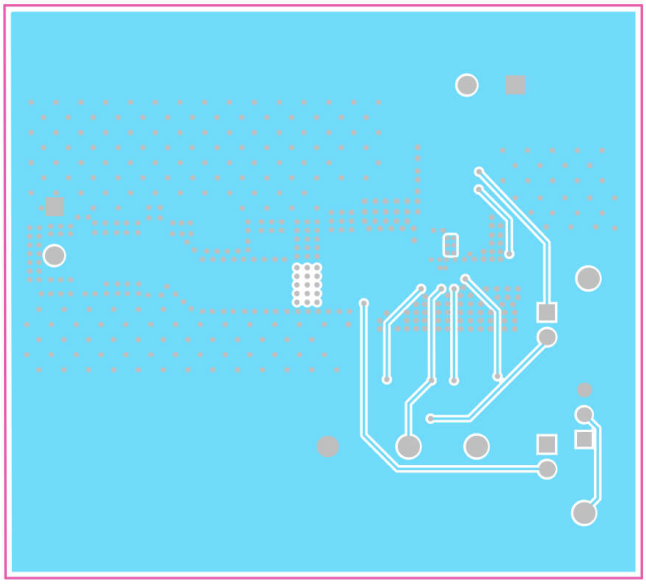


Figure 3-4. Layer 3 Copper (Top View)

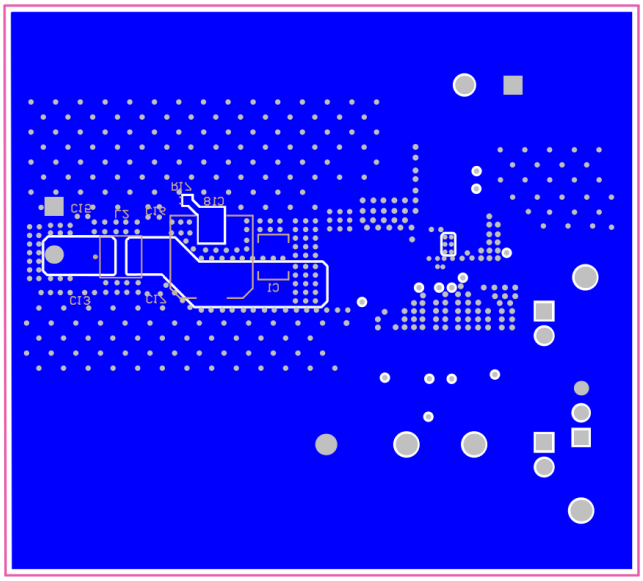


Figure 3-5. Bottom Copper (Top View)

3.3 Bill of Materials

The following table shows the TPSM843521EVM bill of materials.

Table 3-1. Bill of Materials

DESIGNATOR	QTY	DESCRIPTION	PART NUMBER	MANUFACTURER
!PCB1	1	Printed Circuit Board	SR023	Any
C1, C2, C3	3	CAP, CERM, 10µF, 35V,+/- 10%, X7R, 1210	GRM32ER7YA106KA12K	MuRata
C4, C11	2	CAP, CERM, 0.1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	C0603C104K5RACAUTO	Kemet
C5	4	CAP, CERM, 0.01uF, 50V, +/- 5%, X7R, 0603	C0603C103J5RACTU	Kemet
C6	1	CAP, CERM, 0.033uF, 25V, +/- 5%, X7R, 0603	C0603C333J3RACTU	Kemet
C8,C9	1	CAP, CERM, 22uF, 35V, +/- 20%, X5R, 1206	C3216X5R1V226M160AC	TDK
C13, C15, C16, C17	4	CAP, CERM, 2.2uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J3X7R1H225K125AB	TDK
C14	1	CAP, CERM, 100pF, 50V,+/- 1%, C0G/NP0, 0603	C0603C101F5GACTU	Kemet
C18	1	CAP, AL, 100uF, 50V, +/- 20%, 0.34 ohm, SMD	UUD1H101MNL1GS	Nichicon
D1	1	Diode, Zener, 5.1V, 200 mW, SOD-323	MMSZ5231BS-7-F	Diodes Inc.
FID1, FID2, FID3	3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
J1, J2	2	TERM BLOCK 2POS 5mm, TH	1729018	Phoenix Contact
JP1, JP13	2	Header, 100mil, 2x1, Gold, TH	PBC02SAAN	Sullins Connector Solutions
JP2	1	Header, 100mil, 3x1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
L2	1	Shielded Power Inductors 1.5µH 10.2A 10.5mOhm Max Nonstandard	XGL4030-152MEC	Coilcraft
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R1	1	RES, 49.9 k, 1%, 0.1 W, 0603	RC0603FR-0749K9L	Yageo
R2	1	RES, 12k, 1%, 0.1 W, 0603	RC0603FR-0712KL	Yageo
R3	1	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040249R9FKED	Vishay-Dale
R4	1	RES, 220 k, 1%, 0.0625 W, 0402	RC0402FR-07220KL	Yageo America
R5	1	RES, 30.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040230K0FKED	Vishay-Dale
R6,R7	1	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R8	1	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RC0603FR-07100KL	Yageo
R17	1	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
SH-JP1, SH-JP2, SH-JP3	3	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4	4	Test Point, Miniature, SMT	5019	Keystone
TP5, TP6, TP7, TP9	4	Test Point, Multipurpose, Yellow, TH	5014	Keystone
TP8	1	Test Point, Multipurpose, Black, TH	5011	Keystone
U1	1	3.8V to 18V Input, 5A, 200kHz-2.2MHz, Power module with HotRod QFN package	TPSM843521	Texas Instruments
C7	0	CAP, CERM, 22pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2NP01H220J050BA	TDK
C10	0	CAP, CERM, 22uF, 35V, +/- 20%, X5R, 1206	C3216X5R1V226M160AC	TDK

4 Compliance Information

4.1 Compliance and Certifications

TPSM843521EVM EU Declaration of Conformity (DoC) certificate

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 Related Documentation

For related documentation, see the following:

Texas Instruments, *TPSM843521 3.8V to 18V, 5A, Synchronous Buck Power Module With User Selectable Mode* data sheet

STANDARD TERMS FOR EVALUATION MODULES

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.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。

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上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

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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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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:*

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