EVM User's Guide: TPS543021EVM

TPS543021 Step-Down Converter Evaluation Module

Description

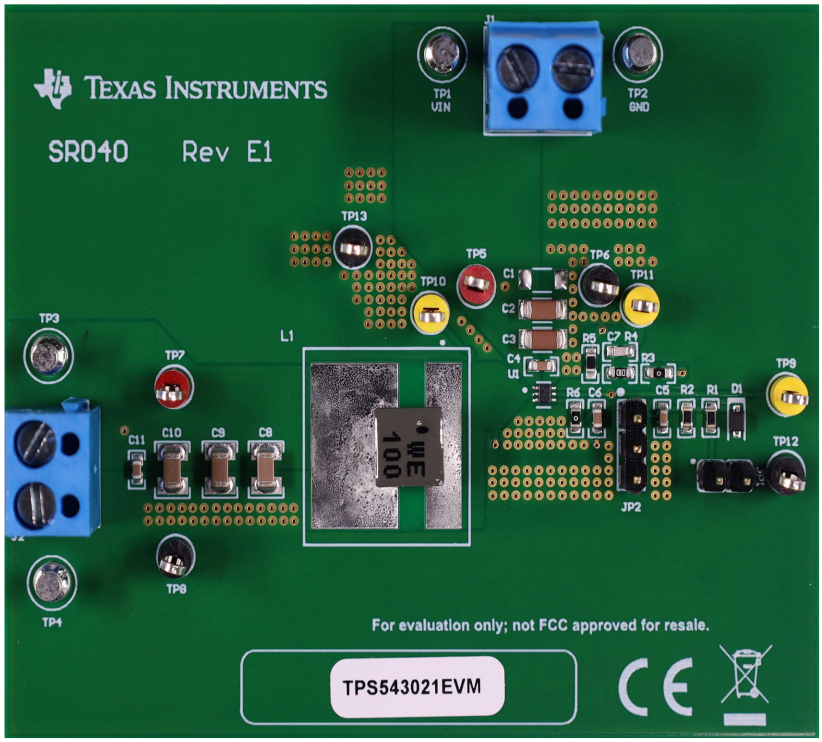
The Texas Instruments TPS543021EVM evaluation module (EVM) helps designers evaluate the operation and performance of the easy-to-use, 3A synchronous step-down converter TPS543021. The TPS543021EVM operates from 6V to 28V input, 24V nominal, and provides a 5V output at 3A. The switching frequency is 400kHz. The EVM also includes AC signal injection terminals for control loop measurements.

Features

- 4.5V to 28V input voltage range
- Adjustable output voltage
- 3A continuous output current capability
- Support low drop out
- Eco-mode at light load

Applications

- 12V, 24V distributed power-bus supply
- Industrial applications
  - Appliances
- Consumer application
  - Audio
  - STB, DTV
  - Printer



TPS543021EVM (Top View)

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1 Evaluation Module Overview

1.1 Introduction

The TPS543021 is a high efficiency, easy-to-use synchronous buck converter. With the wide input voltage range of 4.5V to 28V, the TPS543021 is an excellent choice for systems powered from 5V, 12V, 19V, 24V power bus rails. The device supports up to 3A continuous output current. The device employs fixed frequency peak current control mode for fast transient response and good line and load regulation. The optimized internal loop compensation eliminates the external compensation components over a wide range of output voltage.

This user's guide contains information for the TPS543021 and support documentation for the TPS543021EVM evaluation module. This user's guide includes the performance specifications, schematic and the bill of materials of the TPS543021EVM.

1.2 Kit Contents

- One TPS543021EVM Board
- EVM disclaimer Read Me

1.3 Specification

A summary of the TPS543021EVM performance specifications is provided in Table 1-1. Specifications are given for an input voltage of V_{IN} = 24V and an output voltage of 5V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 1-1. Performance Specifications Summary

Specifications	Test Conditions	MIN	TYP	MAX	Unit
Input voltage range		6	24	28	V
Output voltage set point			5		V
Operating frequency	V_{IN} = 24V, I_O = 3A		400		kHz
Output current range		0		3	A
Output ripple voltage	V_{IN} = 24V, I_O =3A		20		mV_{PP}

1.4 Device Information

Rated input voltage and output current ranges for the evaluation module are given in Table 1-2.

Table 1-2. Input Voltage and Output Current Summary

EVM	Input Voltage (V_{IN}) Range	Output Current (I_{OUT}) Range
TPS543021EVM	V_{IN} = 6V to 28V	0A to 3A

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2 Hardware

2.1 Input and Output Connections

The TPS543021EVM is provided with input and output connectors and test points as shown in Table 2-1. Figure 2-1 shows connectors and jumpers placement on the TPS543021EVM board.

A power supply capable of supplying 3A must be connected to J1 through a pair of 20AWG wires. The load must be connected to J2 through a pair of 20-AWG wires. The maximum load current capability is 3A. Wire lengths must be minimized to reduce losses in the wires. Test point TP5 provides a place to monitor the V_{IN} input voltages with TP6 providing a convenient ground reference. TP7 is used to monitor the output voltage with TP8 as the ground reference.

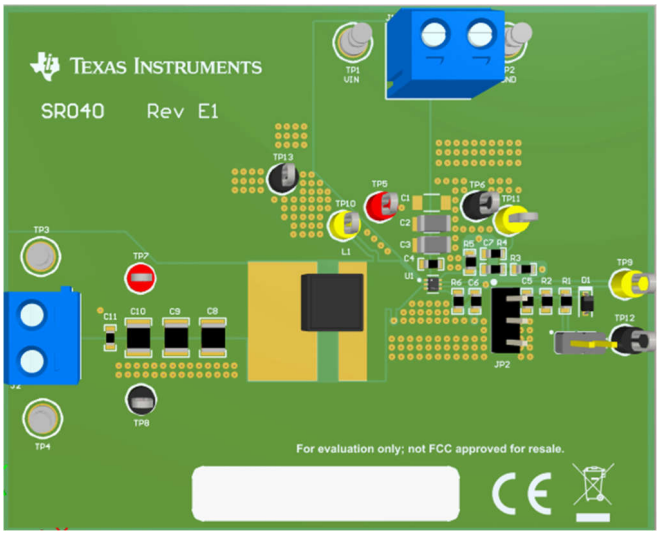

Figure 2-1. TPS543021EVM Connectors and Jumpers Placement

Table 2-1. Connection and Test Points

Reference Designator	Function
J1	V_{IN}
J2	V_{OUT}, 5V at 3A maximum
JP1	V_{IN} divider For programmable system UVLO
JP2	EN control. Short Pin1(scaled Vin) and Pin2(EN) to set system UVLO, Short Pin2(EN) and Pin3(GND) to disable
TP1	V_{IN} positive power point
TP5	V_{IN} positive monitor point
TP7	V_{OUT} positive monitor point
TP3	V_{OUT} positive power point
TP2, TP4	GND power point
TP6, TP8, TP12, TP13	GND monitor point
TP10	Switch node test point
TP9	EN test point
TP11	Test point for loop response measurements

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3 Implementation Results

3.1 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS543021EVM. The section also includes test results typical for the evaluation modules and the following:

- Load transient response
- Start-up
- Shutdown
- Output voltage ripple

3.1.1 Start-Up Procedure

1. The TPS543021 is enabled when EN is floating. Another way to enable the circuit is connecting the JP1 pin1 and pin2, and also connecting JP2 pin2 and pin3.
2. Apply appropriate input voltage to VIN (J1-1) and GND (J1-2).

3.1.2 Load Transient Response

The TPS543021EVM response to load transient is shown in Figure 3-1. The current steps slew rate is set as 0.8A/µs. The total peak-to-peak voltage variation is indicated in the figure with 20MHz scope bandwidth.

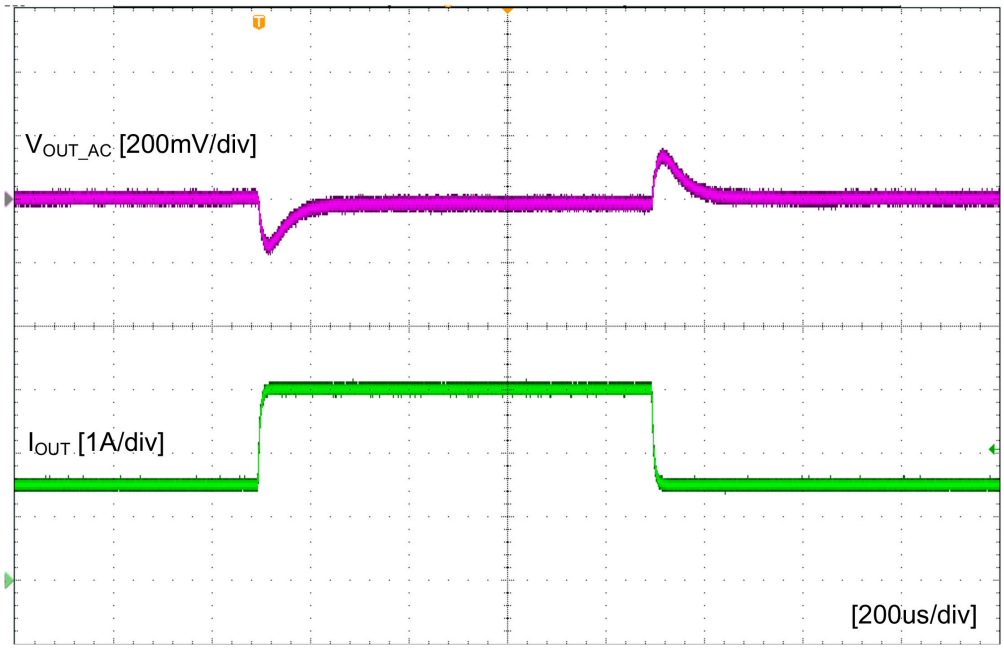

Figure 3-1. TPS543021EVM Load Transient Response, 1.5A to 3A Load Step

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3.1.3 Start-Up

Figure 3-2 shows the TPS543021EVM start-up waveform relative to V_{IN}. The load is 3A.

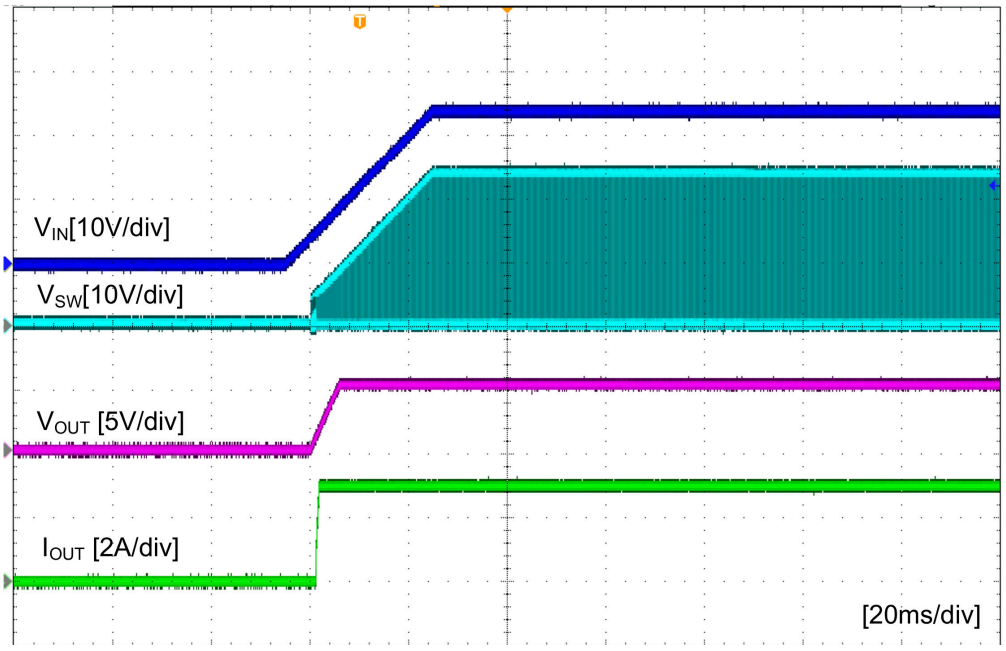

Figure 3-2. TPS543021EVM Start-Up Relative to V_{IN}

3.1.4 Shutdown

Figure 3-3 shows the TPS543021EVM shutdown waveform relative to V_{IN}. The load is 3A.

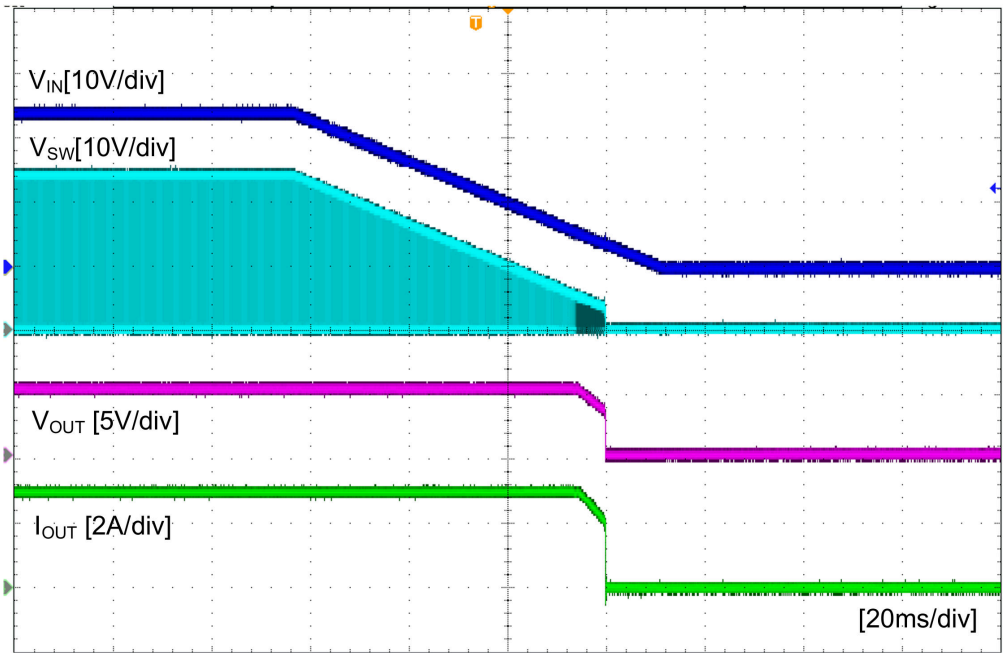

Figure 3-3. TPS543021EVM Shutdown Relative to V_{IN}

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3.1.5 Output Voltage Ripple

The TPS543021EVM output voltage ripple is shown in Figure 3-4, Figure 3-5, Figure 3-6, and Figure 3-7. The output currents are as indicated and all waveforms are tested with 20MHz scope bandwidth.

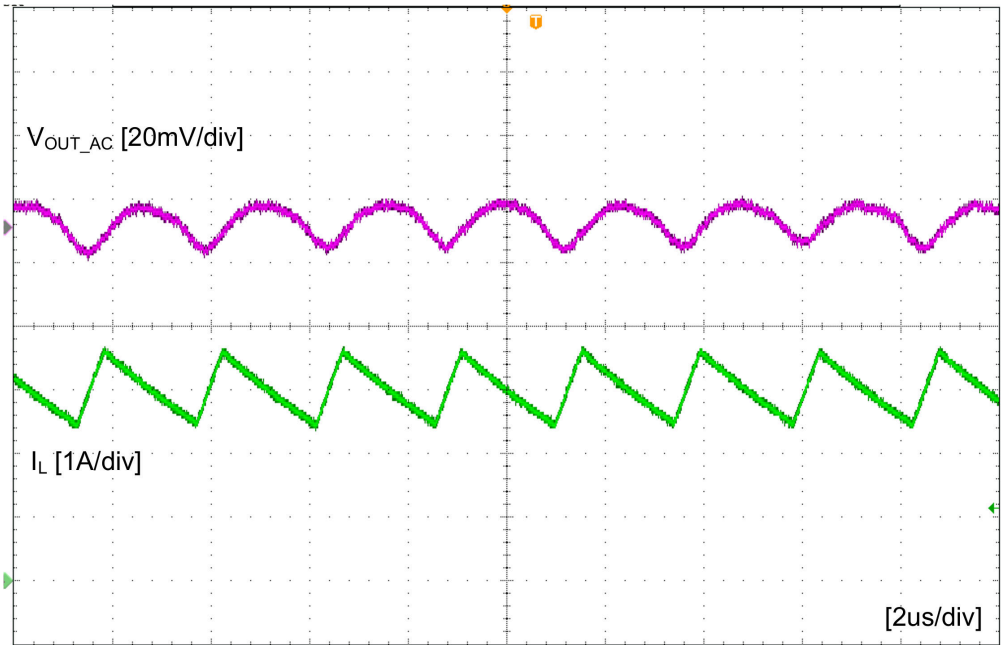

Figure 3-4. TPS543021EVM Output Voltage Ripple, I_{OUT} = 3A

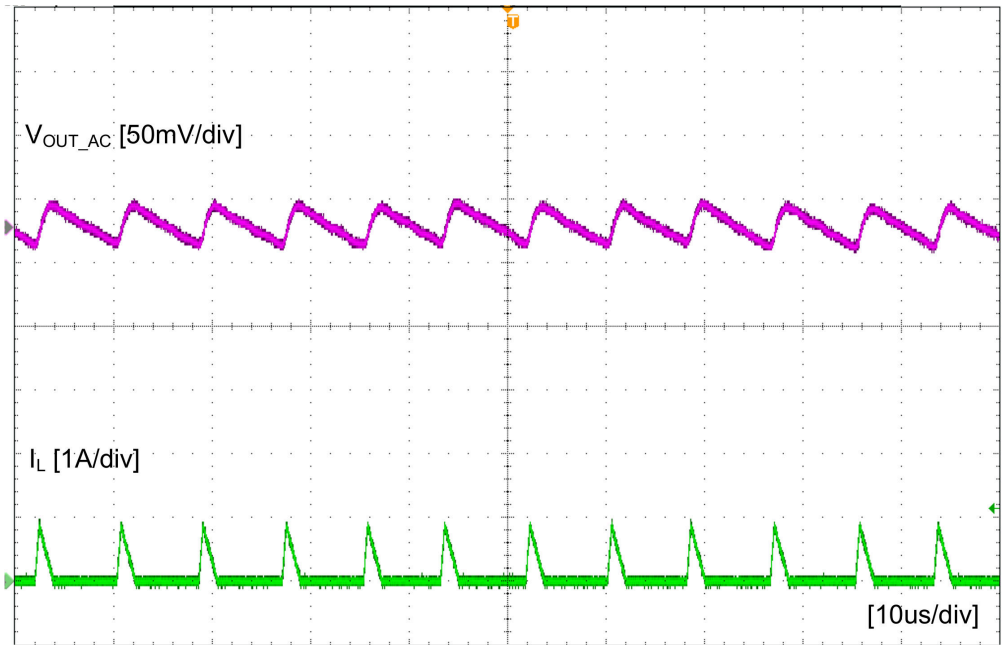

Figure 3-5. TPS543021EVM Output Voltage Ripple, I_{OUT} = 0.1A

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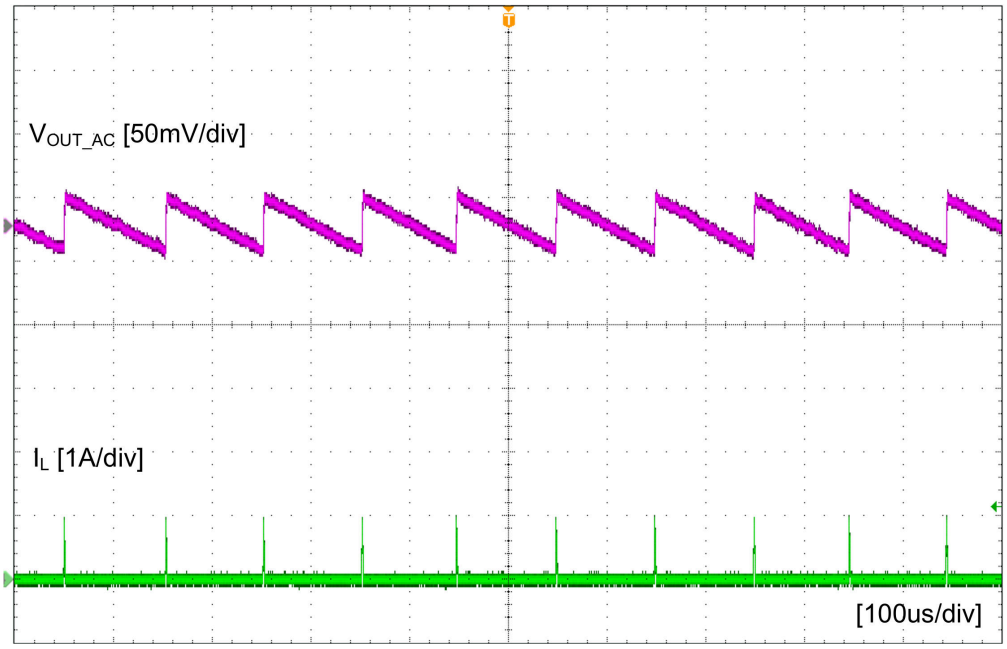

Figure 3-6. TPS543021EVM Output Voltage Ripple, I_{OUT} = 0.01A

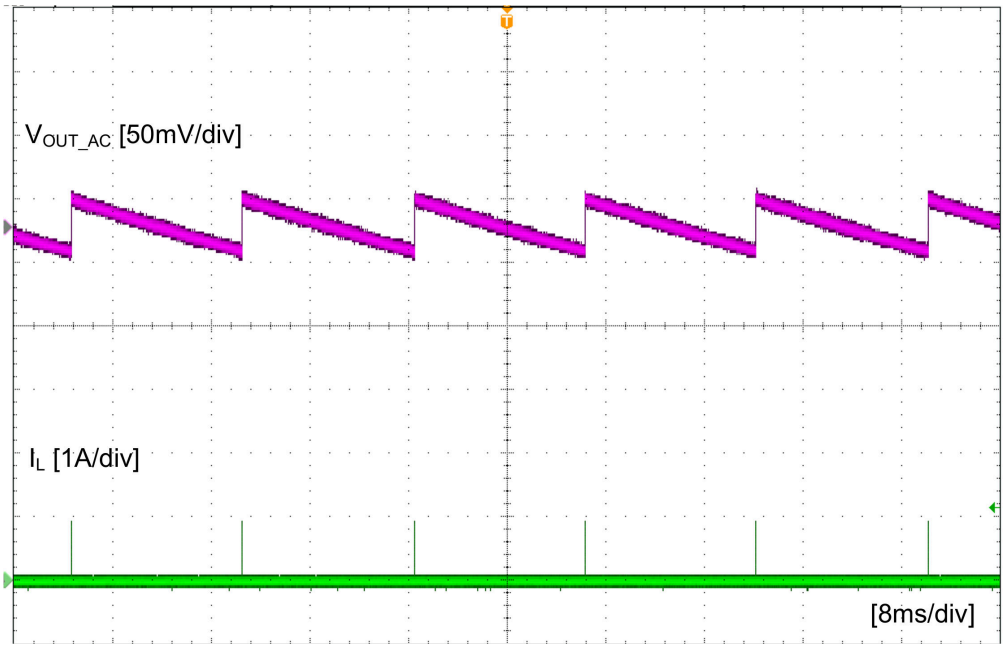

Figure 3-7. TPS543021EVM Output Voltage Ripple, I_{OUT} = 0A

3.2 Output Voltage Setpoint

The output voltage of the EVM can be selected by changing the value of resistor R_4 (R_{FBT}) and R_5 (R_{FBB}). TI recommends using 1% tolerance or better divider resistors. Start with a 100kΩ for R_4 (R_{FBT}) and use Equation 1 to calculate R_5 (R_{FBB}). To improve efficiency at light loads, consider using larger value resistors. If the values are too high, the regulator is more susceptible to noise and voltage errors from the FB input current are noticeable.

$$R_4 = \frac{R_5 \times (V_{out} - 0.596\,V)}{0.596\,V} \quad (1)$$

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4 Hardware Design Files

4.1 Schematic

Figure 4-1 is the schematic for the TPS543021EVM.

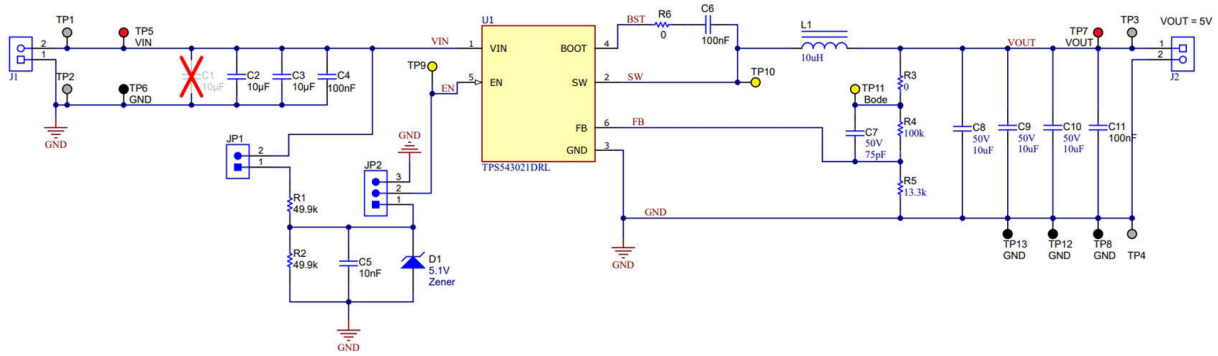

Figure 4-1. TPS542021EVM Schematic Diagram

4.2 Layout

Figure 4-2, Figure 4-3, and Figure 4-4 show the board layout for the TPS543021EVM. The top layer contains the main power traces for VIN, VOUT, and ground. Connections for the pins of the TPS543021 and a large area filled with ground are also on the top layer. Most of the signal traces are also located on the top side. The input decoupling capacitors C2, C3, and C4 are located as close to the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with the signal ground copper fill and the feedback trace from the point of regulation to the top of the resistor divider network. Both the top layer and bottom layer use 2-oz copper thickness.

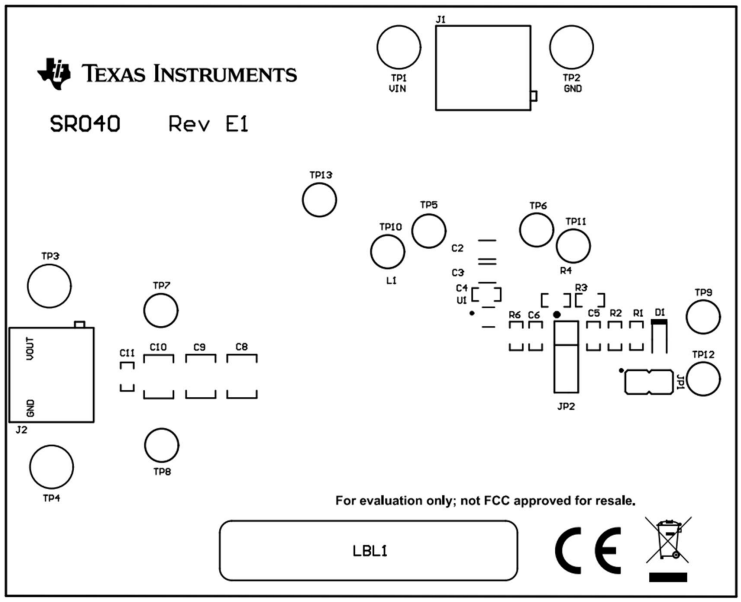

Figure 4-2. TPS543021EVM Top Assembly

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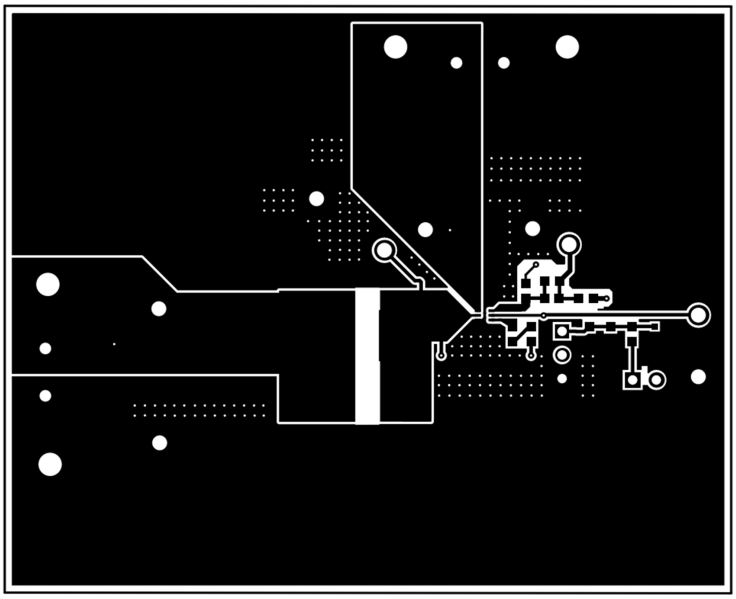

Figure 4-3. TPS543021EVM Top Layer

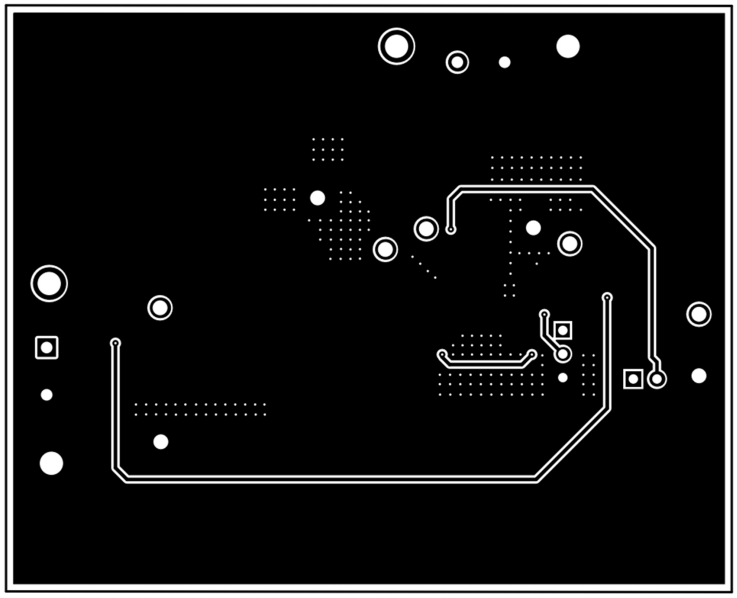

Figure 4-4. TPS543021EVM Bottom Layer

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4.3 Bill of Materials

Table 4-1. Bill of Materials

Des	Qty	Description	Part Number	Manufacturer
!PCB1	1	Printed Circuit Board	SR040	Any
C2, C3	2	CAP, CERM, 10µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	CGA5L1X7R1H106K160AC	TDK
C4, C6, C11	3	CAP, CERM, 0.1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	C0603C104K5RACAUTO	Kemet
C5	1	CAP, CERM, 0.01uF, 50V, +/- 5%, X7R, 0603	C0603C103J5RACTU	Kemet
C7	1	CAP, CERM, 75pF, 50V, +/- 5%, C0G/NP0, 0603	GRM1885C1H750JA01D	MuRata
C8, C9, C10	3	CAP, CERM, 10uF, 50V, +/- 10%, X6S, 1206	GRM31CD71H106KE11L	MuRata
D1	1	Diode, Zener, 5.1V, 200mW, SOD-323	MMSZ5231BS-7-F	Diodes Inc.
J1, J2	2	Terminal Block, 5.08mm, 2x1, Brass, TH	ED120/2DS	On-Shore Technology
JP1	1	Header, 100mil, 2x1, Gold, TH	PBC02SAAN	Sullins Connector Solutions
JP2	1	Header, 100mil, 3x1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
L1	1	Inductor, Shielded, Hyperflux, 10 µH, 5A, 0.02915ohm, SMD	74439346100	Wurth Elektronik
LBL1	1	Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	THT-13-457-10	Brady
R1, R2	2	RES, 49.9k, 1%, 0.1W, 0603	RC0603FR-0749K9L	Yageo
R3	1	RES, 0, 1%, 0.1W, 0603	ERJ-3GEY0R00V	Vishay-Dale
R4	1	RES, 100k, 1%, 0.1W, 0603	CRCW0603100KFKEA	Vishay-Dale
R5	1	RES, 13.3k, 1%, 0.1W, 0603	CRCW060313K3FKEA	Vishay-Dale
R6	1	RES, 0ohm, 5%, 0.1W, 0603	ERJ-3GEY0R00V	Panasonic
TP1, TP2, TP3, TP4	4	Terminal, Turret, TH, Double	1502-2	Keystone
TP5, TP7	2	Test Point, Multipurpose, Red, TH	5010	Keystone
TP6, TP8, TP12, TP13	4	Test Point, Multipurpose, Black, TH	5011	Keystone
TP9, TP10, TP11	3	Test Point, Multipurpose, Yellow, TH	5014	Keystone
U1	1	4.5V to 28V Input, 3A, 400kHz Synchronous Buck Converter	TPS543021DRLR	Texas Instruments

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 References

1. Texas Instruments, *TPS543021, 4.5V to 28V Input, 3A, 400kHz, Synchronous Buck Converter*, data sheet

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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

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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 *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.

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