

High Performance 8-A Single Synchronous Step-Down Converter Using the TPS53513EVM- PWR587

User's Guide



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1 Introduction

The TPS53513EVM-PWR587 evaluation module (EVM) uses the TPS53513 device. The TPS53513 device is a D-CAP3™-mode, 8-A synchronous buck converter with integrated MOSFETs. The device provides a fixed 1.2-V output at up to 8 A from a 12-V input bus.

2 Description

The TPS53513EVM-PWR587 is designed to use a regulated 12-V bus to produce a regulated 1.2-V output at up to 8 A of load current. The TPS53513EVM-PWR587 is designed to demonstrate the TPS53513 device in a typical low voltage application while providing a number of test points to evaluate the performance of the TPS53513 device.

2.1 Typical Applications

- Server and Storage
- Workstations and Desktops
- Telecommunication Infrastructure

2.2 Features

The TPS53513EVM- PWR587 features:

- 8-A DC Steady-State Output Current
- Support pre-bias output voltage start-up
- J2 for enable function
- J5 for auto-skip and forced CCM selection
- J7 for extra 5-V input for further power saving purpose
- Convenient test points for probing critical waveforms

Electrical Performance Specifications

TPS53513EVM-PWR587 Electrical Performance Specifications⁽¹⁾

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristic					
Voltage range	V_{IN}	5	12	18	V
Maximum input current	$V_{IN} = 5\text{ V}$, $I_O = 8\text{ A}$		2.5		A
No load input current	$V_{IN} = 12\text{ V}$, $I_O = 0\text{ A}$ with auto skip mode		1		mA
Output Characteristics					
Output voltage	V_{OUT}		1.2		V
Output voltage regulation	Line regulation, $V_{IN} = 5\text{ V} - 14\text{ V}$ with FCCM		0.2%		
	Load regulation, $V_{IN} = 12\text{ V}$, $I_O = 0\text{ A} - 8\text{ A}$ with FCCM		0.5%		
Output voltage ripple	($V_{IN} = 12\text{ V}$, $I_O = 8\text{ A}$ with FCCM)		10		mV _{PP}
Output load current		0		8	A
Output over current			11		
Soft-start			1		mS
Systems Characteristics					
Switching frequency			1000		kHz
Peak efficiency	$V_{IN} = 12\text{ V}$, $1.2\text{ V} / 4\text{ A}$		88.5%		
Full load efficiency	$V_{IN} = 12\text{ V}$, $1.2\text{ V} / 8\text{ A}$		86.9%		
Operating temperature			25		°C

⁽¹⁾ Jumpers set to default locations, See the [Configurations](#) section of this user's guide

Description

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Schematic

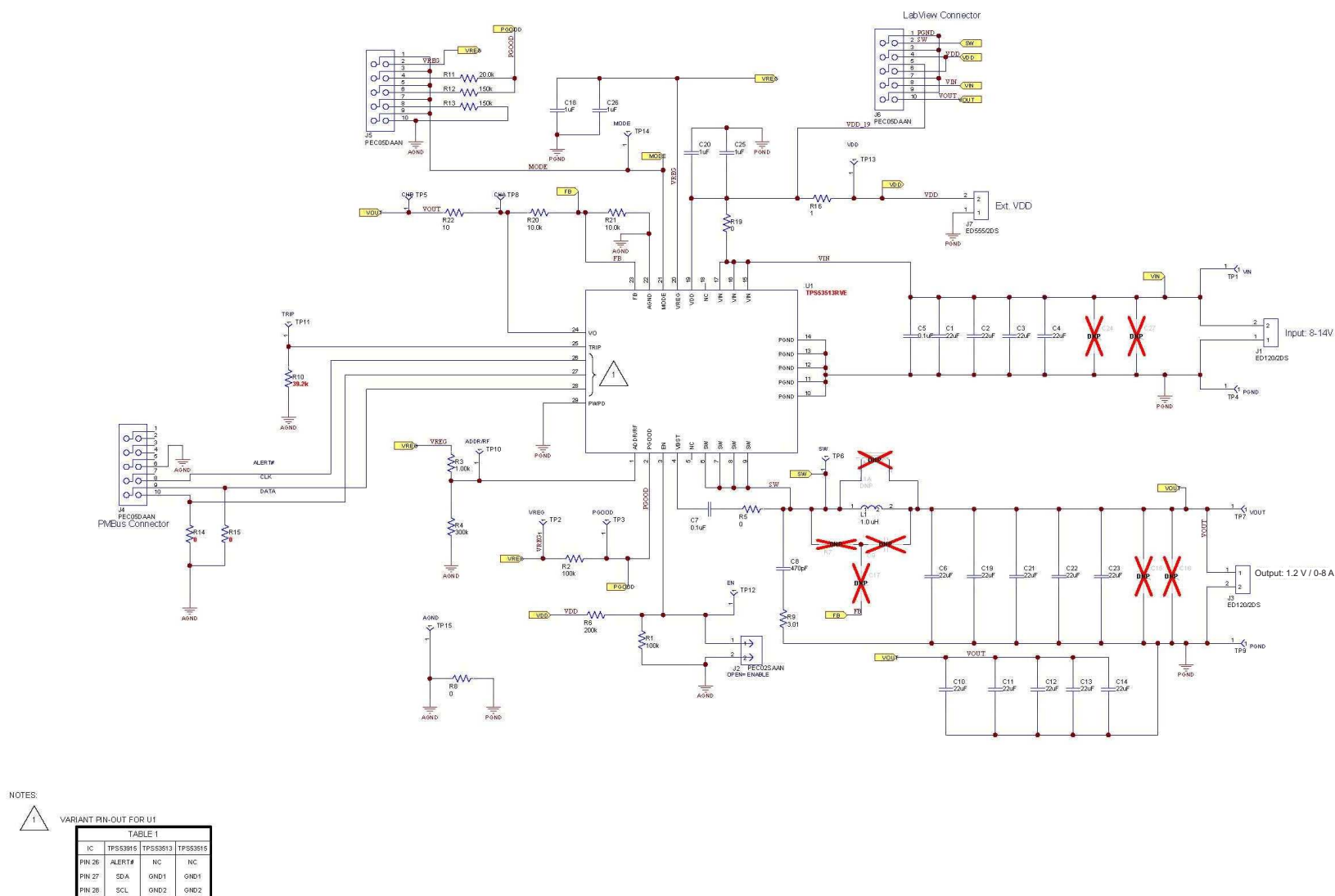


Figure 1. TPS53513EVM-PWR587 Schematic

3 Test Setup

Test Equipment

Voltage Source: The input voltage source V_{IN} must be a 0-14V variable DC source capable of supplying 10 A_{dc}. Connect V_{IN} to J1 as shown in [Figure 3](#).

Multimeters:

- **V1:** V_{IN} at TP1 (VIN) and TP4 (GND)
- **V2:** V_{OUT} at TP7 (VOUT) and TP9 (GND)

Output Load: The output load must be an electronic constant resistance mode load capable of 15-A_{DC} at 1.2 V.

Oscilloscope: A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope should be set for 1-M Ω impedance, 20-MHz bandwidth, AC coupling, 1- μ s/div. horizontal resolution, 20-mV/div. vertical resolution. Test points TP7 and TP9 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP7 and holding the ground barrel on TP9 as shown in [Figure 2](#). Using a leaded ground connection may induce additional noise due to the large ground loop.

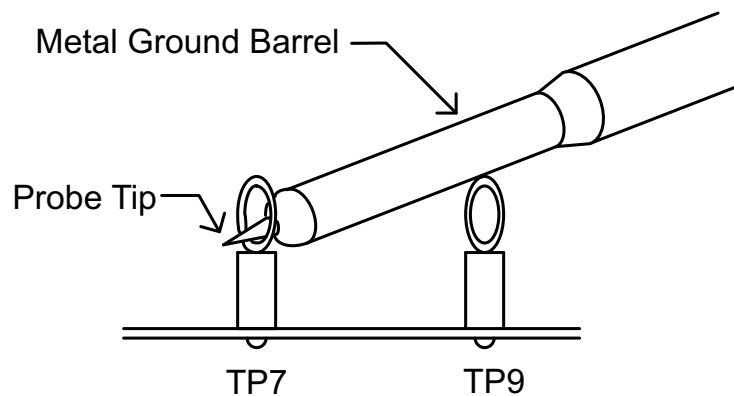


Figure 2. Tip and Barrel Measurement for V_{OUT} Ripple

Recommended Wire Gauge:

- **VIN to J1 (12V input):** The recommended wire size is 1x AWG #14 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
- **J3 to LOAD:** The minimum recommended wire size is 2x AWG #14, with the total length of wire less than 4 feet (2 feet output, 2 feet return).

Recommended Test Setup

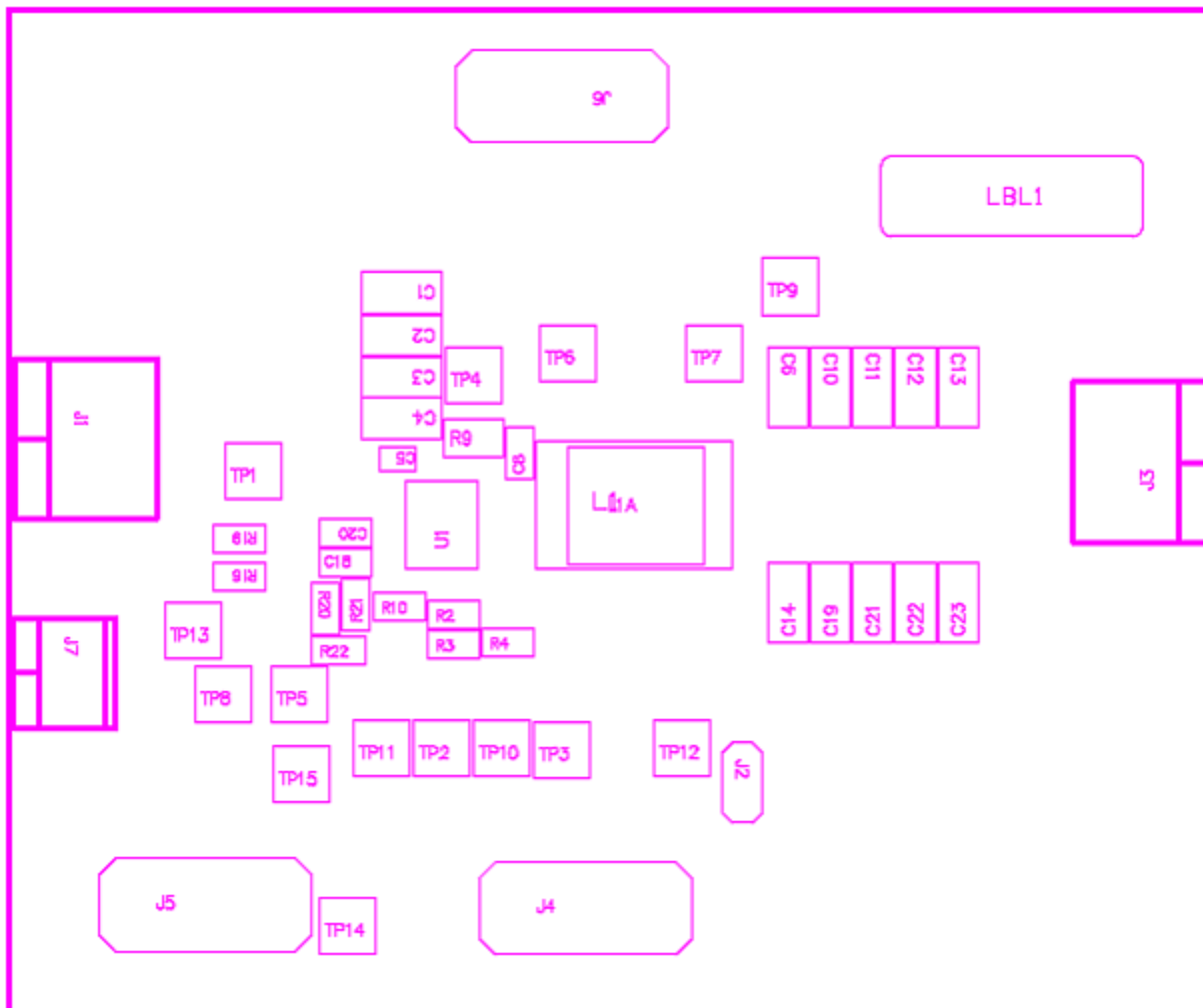


Figure 3. TPS53513EVM-587 Top Layer for Test Set Up

Input Connections

1. Prior to connecting the DC input source (V_{IN}), it is advisable to limit the source current from V_{IN} to 10 A maximum. Make sure V_{IN} is initially set to 0 V and connected as shown in [Figure 3](#).
2. Connect a voltmeter V1 at TP1 (V_{IN}) and TP2 (GND) to measure the input voltage.

Output Connections

1. Connect Load to J3 and set load to constant resistance mode to sink 0 A_{DC} before V_{IN} is applied.
2. Connect a voltmeter V2 at TP7 (V_{OUT}) and TP9 (GND) to measure the output voltage.

4 Configurations

All Jumper selections should be made prior to applying power to the EVM. User can configure this EVM per following configurations.

Switching Frequency Selection

Switching Frequency can be changed according to [Table 1](#).

Default setting: 1 MHz.

Table 1. Switching Frequency

Switching Frequency (f _{sw})(kHz)	Resistor Divider Ratio (R _{DR})	Example RF Frequency Combinations	
		R _{RF_H} (kΩ)	R _{RF_L} (kΩ)
1000	> 0.557	1	300
850	0.461	180	154
750	0.375	200	120
600	0.297	249	105
500	0.229	240	71.5
400	0.16	249	47.5
300	0.096	255	27
250	< 0.041	270	11.5

For different switching frequency settings, change R3 and R4 according to [Table 1](#).

Mode Selection

The MODE can be set by J5.

Default setting: FCCM.

MODE Selection

Jumpers Set To:	MODE Selection
1-2 pin shorted	FCCM with 2x RC time constant
3-4 pin shorted	Forced CCM⁽¹⁾ with 1x RC time constant
5-6 pin shorted	Forced CCM ⁽¹⁾ with 2x RC time constant
7-8 pin shorted	Auto-Skip Mode with 2x RC time constant
9-10 pin shorted	Auto-Skip Mode with 1x RC time constant

⁽¹⁾ Device goes into FCCM after PGood becomes high

VDD pin Supply Selection

The controller can be enabled and disabled by J7.

Default setting: VDD pin connected to VIN pins through R19.

The Controller can be Enabled and Disabled by J7⁽¹⁾

Set On Connection	Enable Selection
R19 = 0 Ω	VDD pin connected to VIN pins
R19 = Open	VDD pin disconnected to VIN pins

⁽¹⁾ J7 requires the proper input voltage for power up. The VDD pin input voltage range is from 4.5 V to 25 V.

Test Procedure

Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in the [Test Setup](#) section and [Figure 3](#).
2. Ensure Load is set to constant resistance mode and to sink 0 A_{DC}.
3. Ensure all jumpers set per the [Configurations](#) section.
4. Ensure the jumper provided in the EVM shorts on J2 before V_{IN} is applied.
5. Increase V_{IN} from 0 V to 12 V. Using V1 to measure input voltage.
6. Remove the jumper on J2 to enable the controller.
7. Use V2 to measure V_{OUT} voltage
8. Vary load from 0 A_{DC} to 10 A_{DC}, V_{OUT} must remain in load regulation.
9. Vary V_{IN} from 8 V to 14 V, V_{OUT} must remain in line regulation.
10. Put the jumper on J2 to disable the converter.
11. Decrease load to 0 A.
12. Decrease V_{IN} to 0 V.

Control Loop Gain and Phase Measurement Procedure

TPS53513EVM-PWR587 contains a 10-Ω series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in the [Test Setup](#) section and [Figure 3](#).
2. Connect isolation transformer to test points marked TP5 and TP8.
3. Connect input signal amplitude measurement probe (channel A) to TP10. Connect output signal amplitude measurement probe (channel B) to TP11.
4. Connect ground lead of channel A and channel B to TP15.
5. Inject around 20-mV or less signal through the isolation transformer.
6. Sweep the frequency from 100 Hz to 1 MHz with 10 Hz or lower post filter. The control loop gain and phase margin can be measured.
7. Disconnect isolation transformer from bode plot test points before making other measurements (Signal injection into feedback may interfere with accuracy of other measurements).

List of Test Points

Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1	VIN	Converter input supply voltage
TP2	VREG	LDO voltage
TP3	PGood	Power good output
TP4	PGND	Power ground
TP5	CHB	Input B for loop injection
TP6	SW	Switching node
TP7	VOUT	V _{OUT} terminal +
TP8	CHA	Input A for loop injection
TP9	PGND	Power ground
TP10	RF	RF pin
TP11	TRIP	TRIP pin
TP12	EN	Enable pin
TP13	VDD	VDD pin
TP14	MODE	Mode pin
TP15	AGND	Analog ground

Equipment Shutdown

1. Shut down load
2. Shut down V_{IN}

The following figures ([Figure 4](#) through [Figure 11](#)) show the design of the TPS53513EVM-PWR587 printed circuit board. The EVM has been designed using 4 Layers, 2-oz copper circuit board.

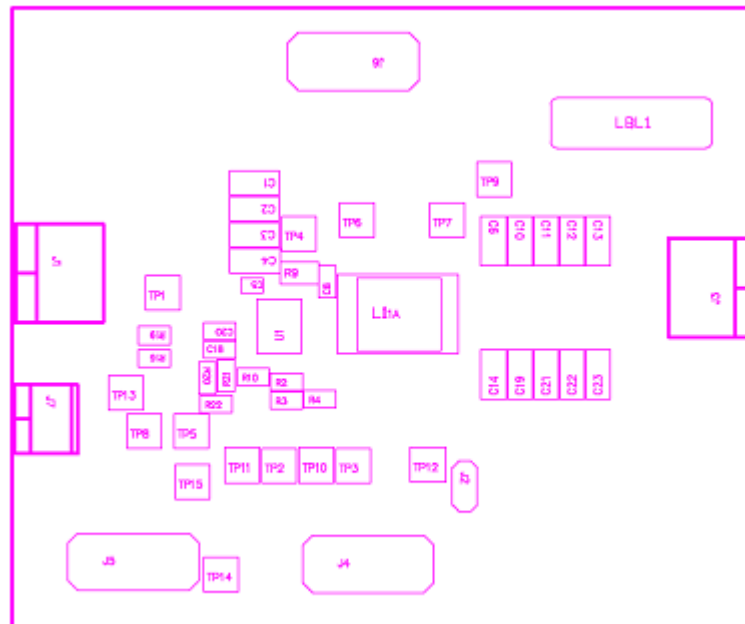


Figure 4. TPS53513EVM-587 Top Layer Assembly Drawing

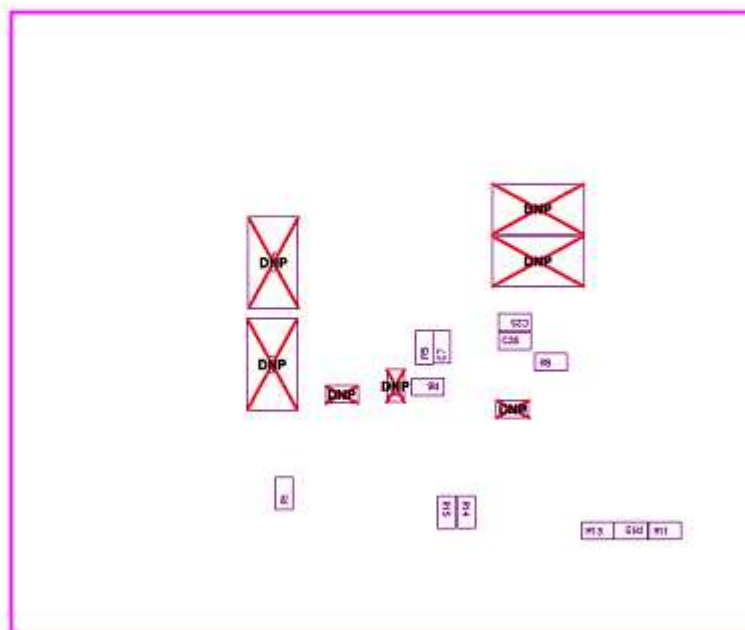


Figure 5. TPS53513EVM-587 Bottom Assembly Drawing

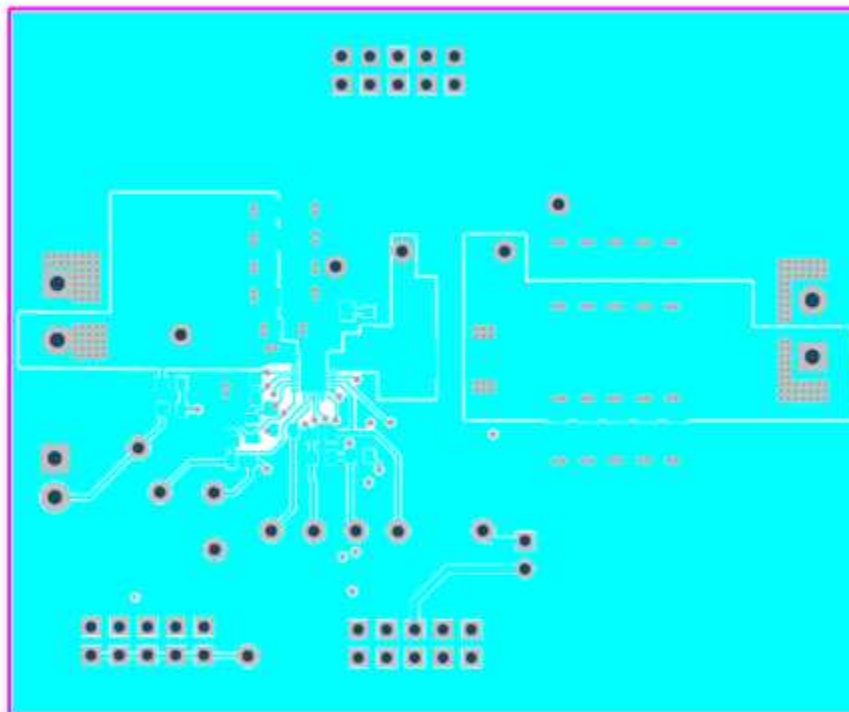


Figure 6. TPS53513EVM-587 Top Copper

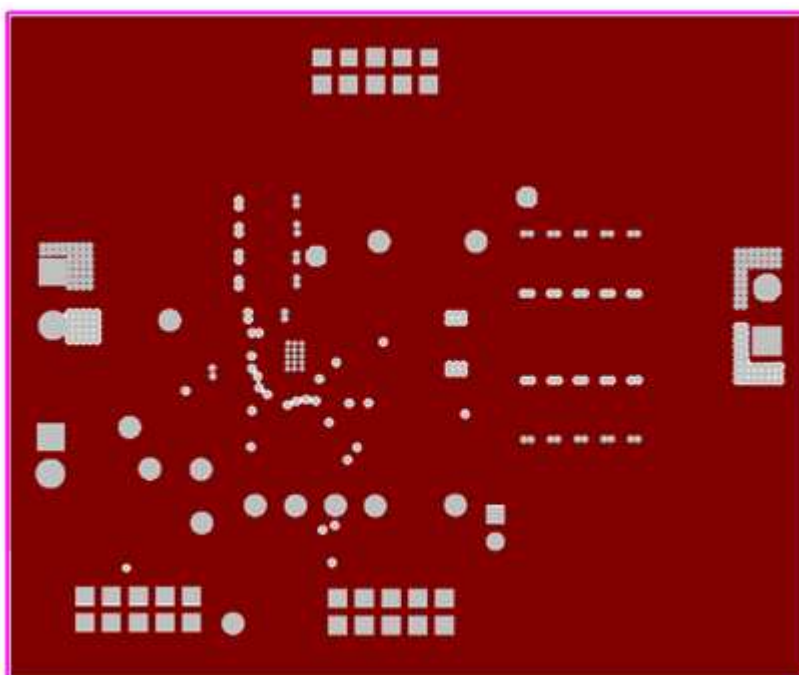


Figure 7. TPS53513EVM-587 Layer 2 Copper

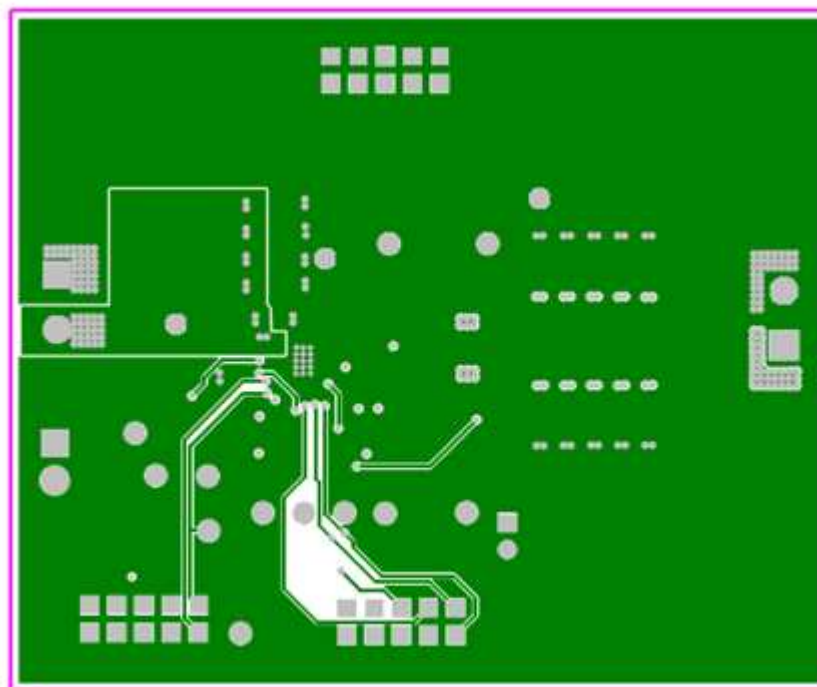


Figure 8. TPS53513EVM-587 Layer 3 Copper

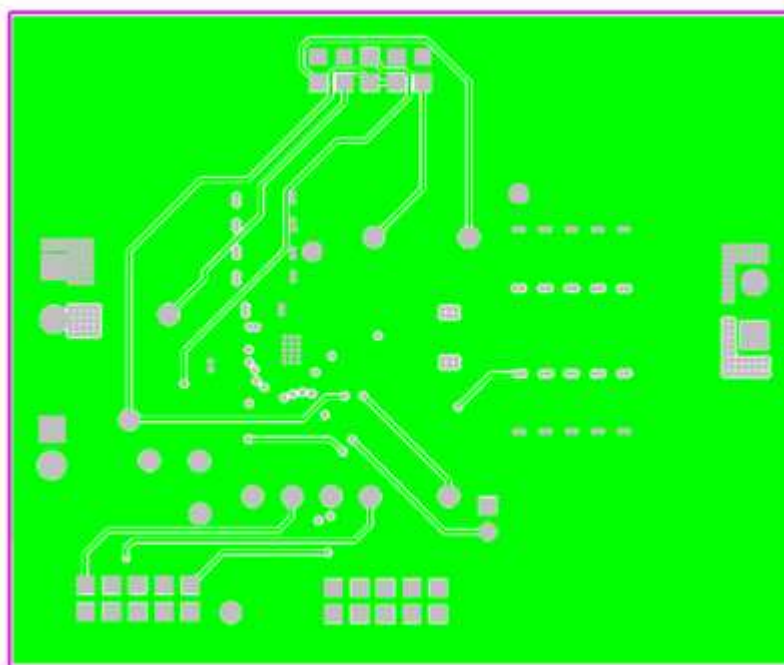


Figure 9. TPS53513EVM-587 Layer 4 Copper

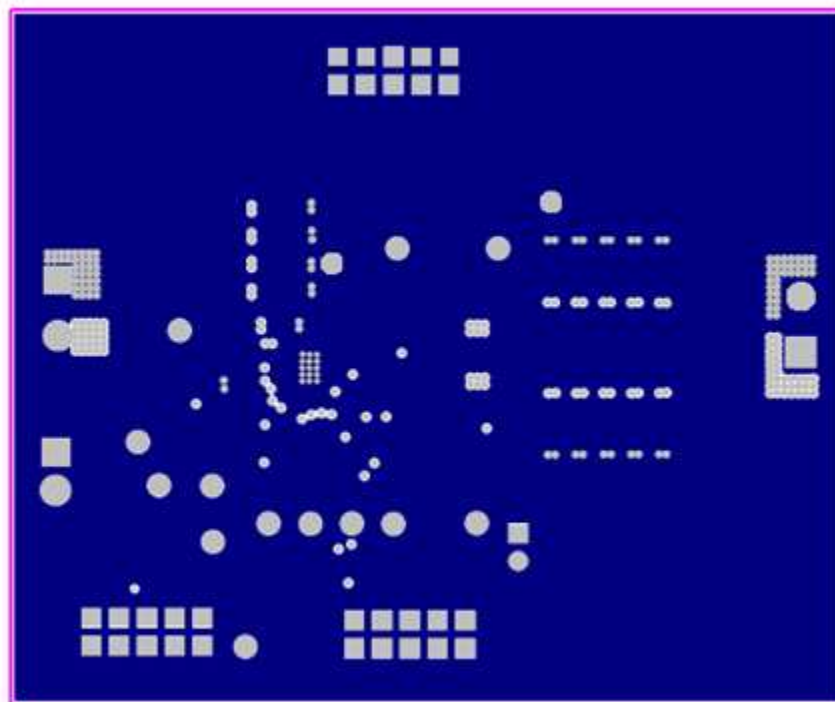


Figure 10. TPS53513EVM-587 Layer 5 Copper

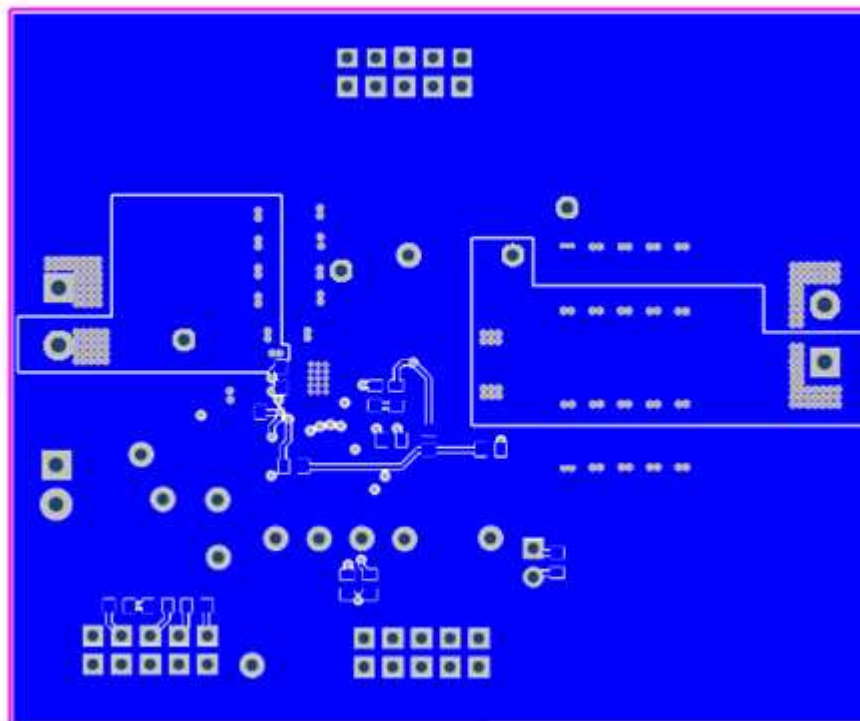


Figure 11. TPS53513EVM-587 Bottom Layer Copper

List of Materials

The EVM components list according to the schematic shown in [Figure 1](#)

TPS53313EVM-078 List of Materials

Designator	Qty.	Value	Description	Package Ref.	Part Number	Manufacturer
C1, C2, C3, C4	4	22uF	Capacitor, Ceramic, 25V, X5R, 10%	1206	GRM31CR61E226KE15L	Murata
C5	1	0.1uF	CAP CER 0.1UF 25V 10% X5R 0402	0402	GRM155R61E104KA87D	Murata
C6, C10, C11, C12, C13, C14, C19, C21, C22, C23	10	22uF	Capacitor, Ceramic, 6.3V, X5R, 20%	1206	GRM31CR60J226KE19L	Murata
C7	1	0.1uF	CAP CER 0.1UF 50V 10% X7R 0603	0603	GRM188R71H104KA93D	Murata
C8	1	470pF	CAP CER 470PF 50V 10% X7R 0603	0603	GRM188R71H471KA01D	Murata
C9, C17	0	Open	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
C15, C16, C24, C27	0	Open	Capacitor, POSCAP, SMT, 2.5V, 330uF, 8 mohm	7343(D)	2R5TPE330M9 or 6TPE330MIL	Sanyo
C18, C20, C25, C26	4	1uF	CAP CER 1UF 16V 10% X7R 0603	0603	GRM188R71C105KA12J	Murata
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
J1, J3	2	ED120/2DS	Terminal Block, 2-pin, 15-A, 5.1mm	0.40 x 0.35 inch	ED120/2DS	OST
J2	1	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
J4, J5, J6	3	PEC05DAAN	Header, Male 2x5-pin, 100mil spacing	0.100 inch x 5 X 2	PEC05DAAN	Sullins
J7	1	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	ED555/2DS	OST
L1	1	1.0 uH	Inductor, Power Chokes SMD	6.6x7.1 mm	PIMB065T-1R0MS	Cyntec
L1A	0	DNP	Inductor, High Fq Power, ±15%	0.283 x 0.433 inch	69P987xN	Vitec
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
R1, R2	2	100k	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R3	1	1.00k	RES, 1.00k ohm, 1%, 0.1W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R4	1	300k	RES, 300k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07300KL	Yageo America
R5, R8, R14, R15, R19	5	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R6	1	200k	RES, 200k ohm, 1%, 0.1W, 0603	0603	CRCW0603200KFKEA	Vishay-Dale
R7	0	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
R9	1	3.01	RES, 3.01 ohm, 1%, 0.125W, 0805	0805	CRCW08053R01FKEA	Vishay-Dale
R10	1	39.2k	RES, 39.2k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0739K2L	Yageo America
R11	1	20.0k	RES, 20.0k ohm, 1%, 0.1W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale
R12, R13	2	150k	RES, 150k ohm, 1%, 0.1W, 0603	0603	CRCW0603150KFKEA	Vishay-Dale
R16	1	1	RES, 1.00 ohm, 1%, 0.1W, 0603	0603	CRCW06031R00FKEA	Vishay-Dale
R20, R21	2	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R22	1	10	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
TP1, TP2, TP3, TP5, TP6, TP7, TP8, TP10, TP11, TP12, TP13, TP14, TP15	13	5000	Test Point, Red, Thru Hole Color Keyed	0.100 x 0.100 inch	5000	Keystone

TPS53313EVM-078 List of Materials (continued)

Designator	Qty.	Value	Description	Package Ref.	Part Number	Manufacturer
TP4, TP9	2	5001	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
U1	1	TPS53513RVE	IC, High Performance, 8-A Single Sync. Step-Down Converter.		TPS53513RVE	

Revision History

Changes from A Revision (December 2013) to B Revision Page

- Changed the test points in the *Tip and Barrel Measurement for VOUT Ripple* image from TPS5 and TPS7 to TPS7 and TPS9 (respectively from left to right) 5

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Revision History

Changes from Original (October 2013) to A Revision Page

- Changed output range from 1.2 V / 0-6 A to 1.2 V / 0-8 A in the schematic 4

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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3. 技術基準適合証明を取得後ご使用いただく。

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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