TPS4333xEVM

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PowerPAD is a trademark of Texas Instruments.

1 Introduction

The Texas Instruments TPS4333xEVM evaluation module (EVM) helps designers evaluate the operation and performance of the TPS4333x family of Switch Mode Power Supplies – Multiple-output voltage regulator.

The EVM contains one DC / DC converter (see Table 1).

Table 1. Device and Package Configurations

Converter	IC	Package
U1	TPS43330QDAPQ1	DAP-38
	TPS43332QDAPQ1	
	TPS43335QDAPQ1	
	TPS43336QDAPQ1	

2 Setup

This section describes the jumpers and connectors on the EVM as well and how to properly connect, set up and use the TPS4333xEVM.

2.1 Input/Output Connector Description

J1 – Input is the protected power input terminal for the converter with a voltage range from 2V-40V (Boost enabled) or 4V-40V (Boost disabled). The terminal block provides a power (V_{bat}) and ground (GND) connection to allow the user to attach the EVM to a cable. harness. The power path provides a series Schottky diode for reverse battery protection.

J2 – VOUTA is the output terminal for the TPS4333x buck controller A. The terminal block provides a power (VOUTA) and ground (GND) connection.

J3 – VOUTB is the output terminal for the TPS4333x buck controller B. The terminal block provides a power (VOUTB) and ground (GND) connection.

JP1 – DIV is the jumper used to select the output voltage for the boost pre-regulator stage. The boost output is 7V when DIV is low, 10V when DIV floating and 11V when DIV is pulled high.

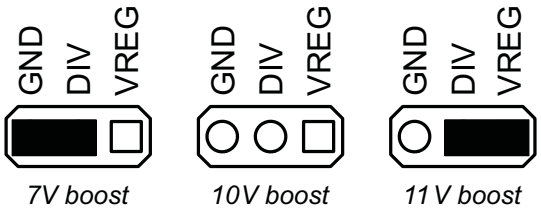

Figure 1. DIV Jumper Settings

JP2 – ENA is the jumper used to enable buck controller A. The controller will be enabled when the ENA is high and disabled when low.

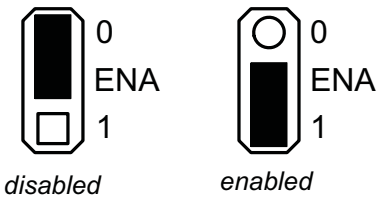

Figure 2. ENA Jumper Settings

JP3 – ENB is the jumper used to enable buck controller B. The controller will be enabled when the ENB is high and disabled when low.

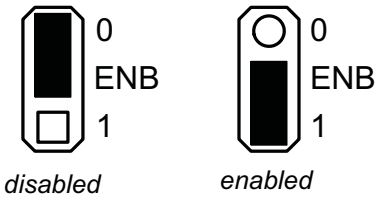

Figure 3. ENB Jumper Settings

JP3 – ENC is the jumper used to enable the boost pre-regulator. The converter will be enabled when the ENC is high and disabled when low.

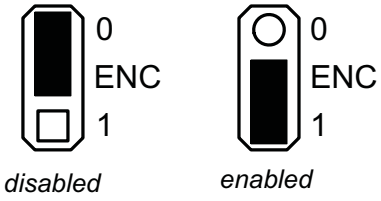

Figure 4. ENC Jumper Settings

JP4 – SYNC is the external clock input for switching frequency synchronization of the buck converters and to enable Low Power Mode (LPM). The external clock source can be attached to the center pin of JP4. A high logic level on this pin ensures forced continuous mode operation of the buck controllers and inhibits transition to low power mode. An open or low allows discontinuous mode operation, and entry into low power mode at light loads. On the TPS43332 and TPS43336, a high level enables frequency-hopping spread spectrum while an open or a low level disables the spectrum.

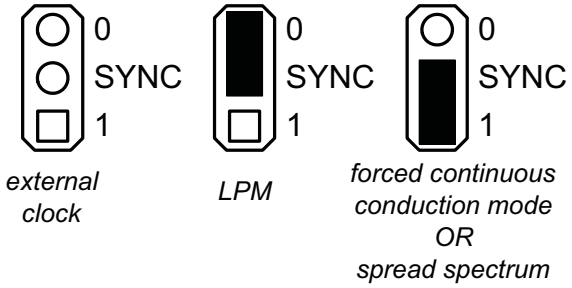

Figure 5. SYNC Jumper Setting

JP5 – RT is the jumper used to choose the switching frequency of the Buck controllers. The operating frequency can be set to 240 KHz, 400 KHz or 600 KHz.

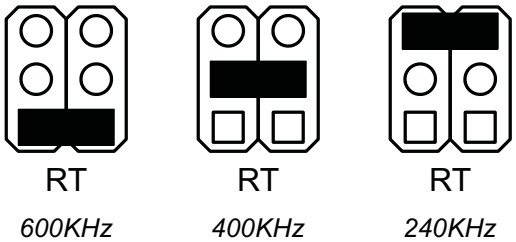

Figure 6. RT Jumper Setting

JP6 – EXTSUP is the jumper used to choose one of the Buck output voltages (VOUTA or VOUTB) to provide the internal voltage VREG. If no jumper is plugged, VREG is generated from the input voltage.

VOUTA selected *VOUTB selected*

Figure 7. EXTSUP Jumper Setting

Test Points

• DLYAB	Power Good Delay for Buck Controller A and B
• DS	Drain-Source Current Sense for Boost FET
• GND (x4)	Ground
• PGA	Power Good for Buck Controller A
• PGB	Power Good for Buck Controller B
• PHA	Buck Controller A phase pin
• PHB	Buck Controller B phase pin
• SSA	Soft Start for Buck Controller A
• SSB	Soft Start for Buck Controller B
• VBAT	Power Input before the boost regulator stage
• VIN	Power Input after the boost regulator stage
• VOUTA	Buck Controller A output
• VOUTB	Buck Controller B output

2.2 Setup

The input voltage range for the converter is 2 V to 40 V. A load should be applied to the output terminal for proper operation.

2.3 Operation

For proper operation of the TPS43330, DIV, ENA, ENB, ENC, EXTSUP, JP5 (OSC) and SYNC jumpers should be properly configured. The recommended setting, using the switch and shorting blocks.

DIV	VREG
ENA	enabled
ENB	enabled
ENC	enabled
EXTSUP	A
RT	400KHz
SYNC	LPM

In this configuration, the regulators will turn on when power is applied. DIV selects the output voltage for the Boost pre-regulator stage. ENA, ENB and ENC turn the regulators on or off, disabled or enabled. EXTSUP selects the power supply source for the gate drive. RT sets the switching frequency for the regulators to approximately 240KHz, 400KHz or 600KHz. SYNC enabled LPM or forced continuous conduction mode and is the external clock input for switching frequency synchronization of the buck converters. SYNC will disable spread spectrum operation on the TPS43332 and TPS43336 when set low or left open. The device can be setup to run in low power mode, to reduce the quiescent operating current, by connecting the Sync test point to ground. Low power mode will allow the device to switch into a PFM mode of operation if the load current demand is low. It will automatically switch back to PWM mode as the load current increases.

Regulator	Output Voltage	Maximum Output Current
Buck Controller A:	5 V	2A
Buck Controller B:	3.3 V	4A

If jitter is observed on the phase signal of the regulator, then noise may be entering the feedback interface and a capacitive filter may be required. The EVM provides a footprint across the low-side feedback resistors to add these capacitors, if needed. A capacitor has been added across the low-side resistor on the EVM. Typically 47pF to 100pF is sufficient to filter any noise issues.

3 Board Layout

Figure 8, through Figure 11 show the board layout for the TPS43330EVM PWB.

The TPS43330 controller offers high efficiency, but does dissipate power. The PowerPAD™ package offers an exposed thermal pad to enhance thermal performance. This must be soldered to the copper landing on the PCB for optimal performance. The PCB provides 2 oz copper planes on the top and bottom to dissipate heat

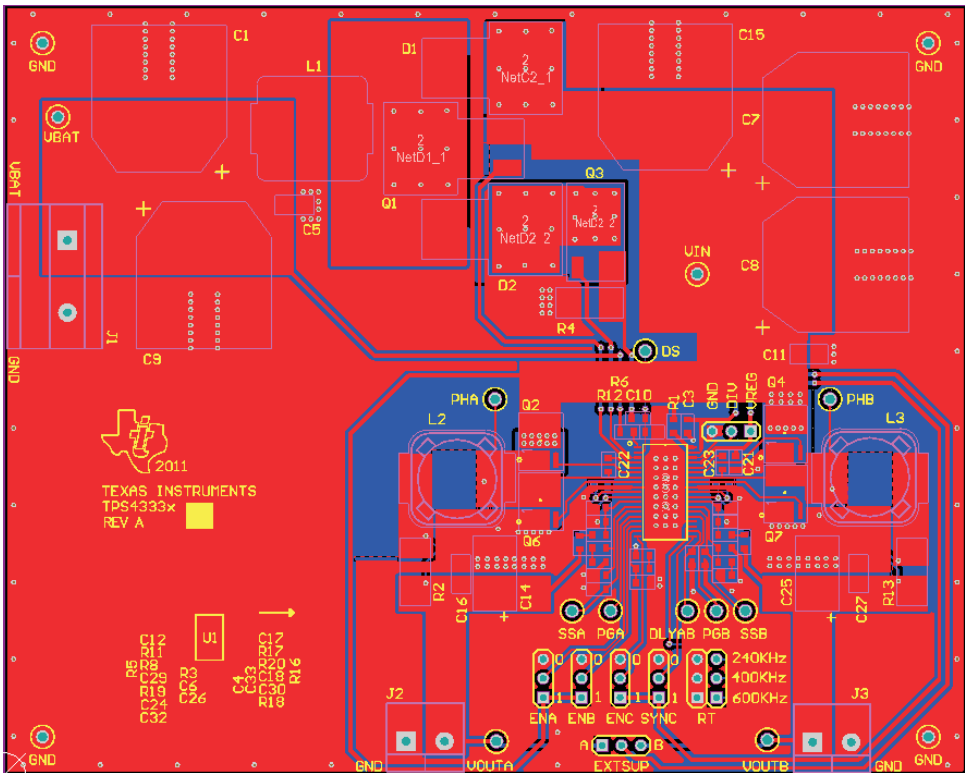

Figure 8. Top Assembly Layer

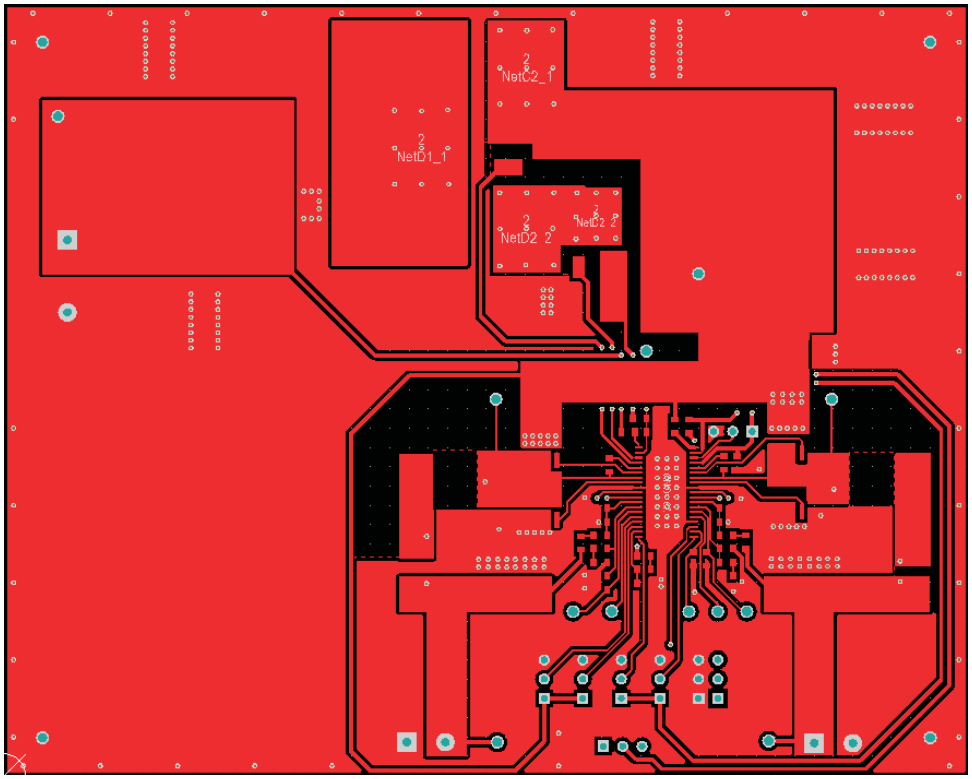

Figure 9. Top Layer Routing

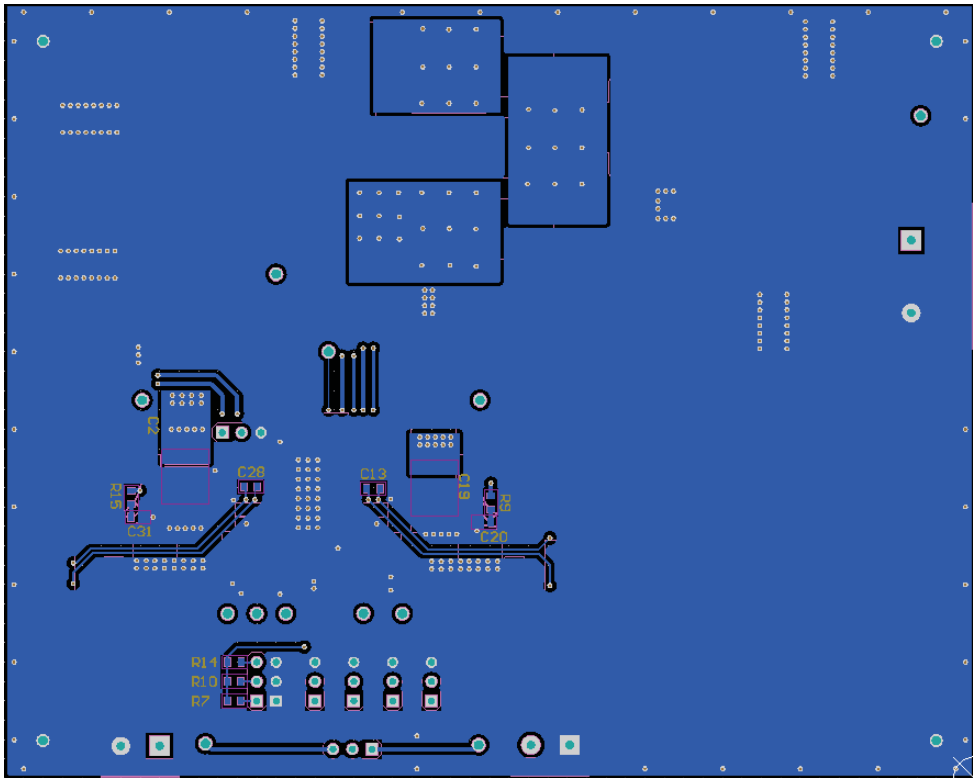

Figure 10. Bottom Assembly Layer

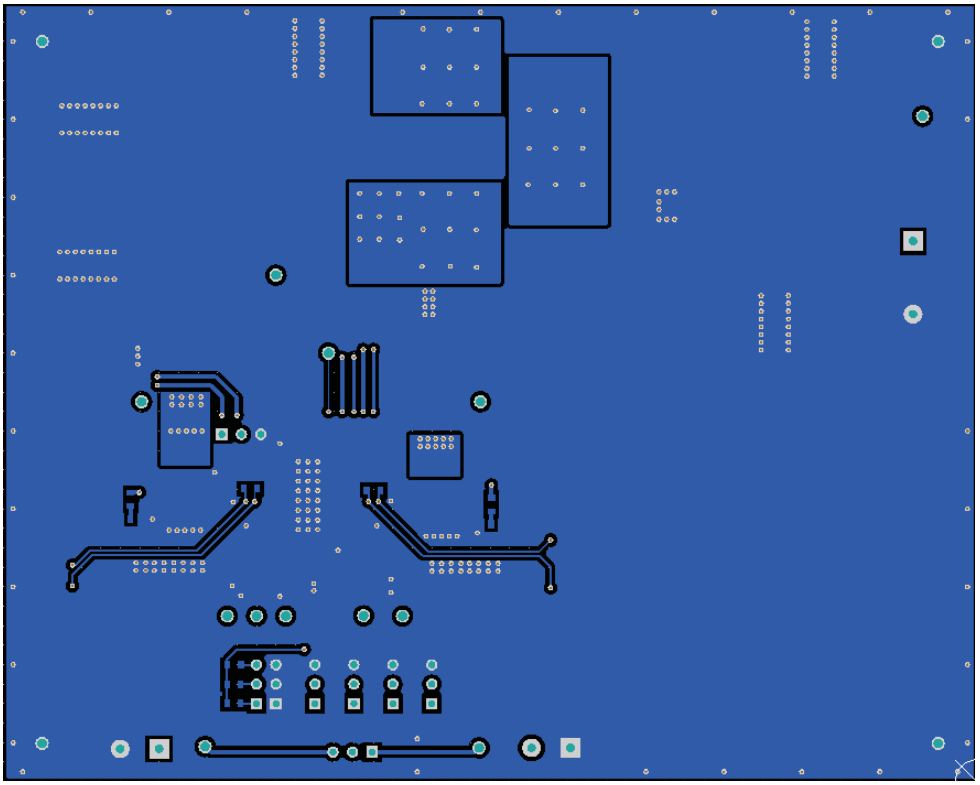

Figure 11. Bottom Layer Routing

4 Schematic and Bill of Materials

4.1 Schematic

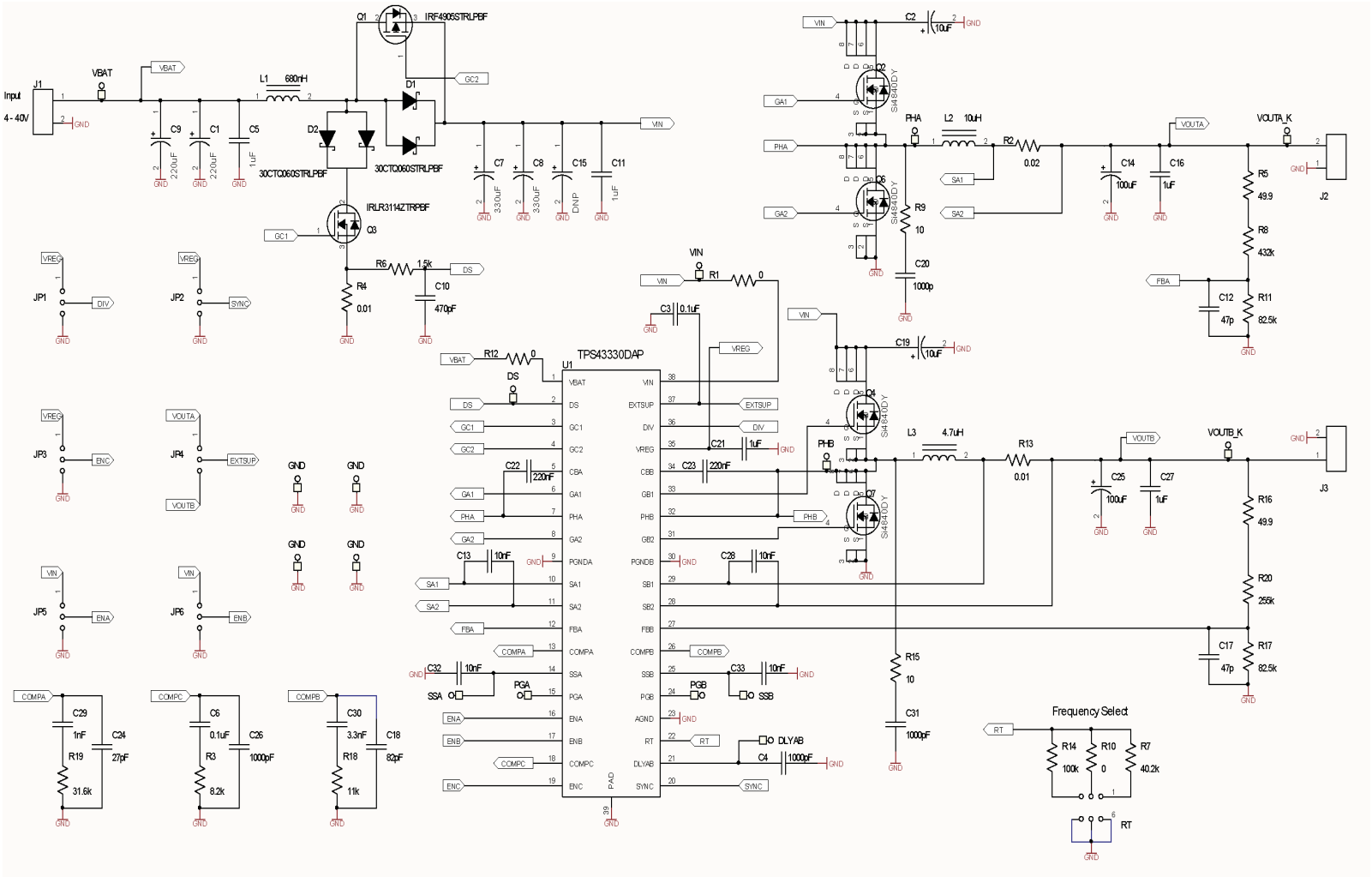

Figure 12. TPS4333xEVM Schematic

4.2 Bill of Materials

Table 2. TPS4333xEVM Bill of Materials

COUNT	REF DES	DESCRIPTION	SIZE	MFR	PART NUMBER
2	C1, C9	Capacitor, electrolytic, 220uF, 50V, 20%	G	Panasonic	EEE-FK1H221P
2	C2, C19	Capacitor, ceramic, 10uF, 50V, 10%	2220	TDK	C5750X7R1H106M
2	C3, C6	Capacitor, ceramic, 0.1uF, 50V, 10%	603	Std	Std
5	C4, C20, C26, C29, C31	Capacitor, ceramic, 1000pF, 50V, 10%	603	Std	Std
2	C5, C11	Capacitor, ceramic, 1uF, 100V, 10%	1206	Std	Std
2	C7, C8	Capacitor, electrolytic, 330uF, 50V, 20%	H13	Panasonic	EEV-FK1H331Q
1	C10	Capacitor, ceramic, 470pF, 50V, 10%	603	Std	Std
2	C12, C17	Capacitor, ceramic, 47pF, 50V, 10%	603	Std	Std
4	C13, C28, C32, C33	Capacitor, ceramic, 0.01uF, 50V, 10%	603	Std	Std
2	C14, C25	Capacitor, tantalum, 100uF, 16V, 10%	7343	AVX	TPSD107K016R0060
1	C15	Do not populate			
3	C16, C21, C27	Capacitor, ceramic, 1uF, 16V, 10%	603	Std	Std
1	C18	Capacitor, ceramic, 82pF, 50V, 10%	603	Std	Std
2	C22, C23	Capacitor, ceramic, 220nF, 50V, 10%	603	Std	Std
1	C24	Capacitor, ceramic, 27pF, 50V, 10%	603	Std	Std
1	C30	Capacitor, ceramic, 3.3nF, 50V, 10%	603	Std	Std
2	D1, D2	Diode, Schottky, 15A, 60V	D2PAK	Vishay	30CTQ060STRLPBF
1	J1	Terminal block, 2-pin, 25A	9.52MM	OST	OSTT7022150
2	J2, J3	Terminal block, 2-pin, 15A	2 x 5.1mm	OST	OSTTA024163
6	JP1, JP2, JP3, JP4, JP5, JP6	Header, 3-pin, 100-mil spacing	0.100 x 3	Sullins	PEC03SAAN
1	RT	Header, 6-pin, 100-mil spacing	0.100 x 3	Sullins	PEC06DAAN
7	JP1, JP2, JP3, JP4, JP5, JP6, RT	Connector jumper, shorting, 100-mil spacing	0.1	Sullins	SPC02SYAN
1	L1	Inductor, SMT, 0.68uH, 28A	13.2mm x 12.9mm	Vishay	IHLP5050CEERR68M01
1	L2	Inductor, SMT, 10-uH, 6.04A	12.3mm x 12.3mm	Coilcraft	MSS1278T-103ML
1	L3	Inductor, SMT, 4.7-uH, 4.3A	12.3mm x 12.3mm	Coilcraft	MSS1278T-472ML
1	Q1	MOSFET P-CH 55V 42A	D2PAK	IR	IRF4905STRLPBF
4	Q2, Q4, Q6, Q7	MOSFET, n-channel	SOIC	Vishay	SI4840DY
1	Q3	MOSFET, n-channel	DPAK	IR	IRLR3114ZTRPBF
3	R1, R10, R12	Resistor, chip, 0-ohms, 1/16W, 5%	603	Std	Std

Table 2. TPS4333xEVM Bill of Materials (continued)

COUNT	REF DES	DESCRIPTION	SIZE	MFR	PART NUMBER
1	R2	Resistor, chip, 0.02-ohm, 2W	2512	Stackpole	CSRN2512FK20L0
1	R3	Resistor, chip, 8.2-kohms, 1/16W, 1%	603	Std	Std
2	R4, R13	Resistor, chip, 0.01-ohm, 2W	2512	Stackpole	CSRN2512FK10L0
2	R5, R16	Resistor, chip, 49.9-ohms, 1/16W, 1%	603	Std	Std
1	R6	Resistor, chip, 1.5-kohms, 1/16W, 1%	603	Std	Std
1	R7	Resistor, chip, 40.2-kohms, 1/16W, 1%	603	Std	Std
1	R8	Resistor, chip, 432-kohms, 1/16W, 1%	603	Std	Std
2	R9, R15	Resistor, chip, 10-ohms, 1/16W, 1%	603	Std	Std
2	R11, R17	Resistor, chip, 82.5-kohms, 1/16W, 1%	603	Std	Std
1	R14	Resistor, chip, 100-kohms, 1/16W, 1%	603	Std	Std
1	R18	Resistor, chip, 11-kohms, 1/16W, 1%	603	Std	Std
1	R19	Resistor, chip, 31.6-kohms, 1/16W, 1%	603	Std	Std
1	R20	Resistor, chip, 255-kohms, 1/16W, 1%	603	Std	Std
16	DLYAB, DS, GND (x4), PGA, PGB, PHA, PHB, SSA, SSB, VBAT, VIN, VOUTA_K, VOUTB_K	Test point, 52-mil	0.052	Std	Std
1	U1	IC, TPS43330DAPRQ1 or TPS43332DAPRQ1 or TPS43335DAPRQ1 or TPS43336DAPRQ1		TI	TPS43330-Q1or TPS43332-Q1 or TPS43335-Q1 or TPS43336-Q1
	-	PCB, 5-inch x 4-inch x 0.062		Any	TPS4333X, REV A

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 2 V to 40 V (Boost enabled) or 4V to 40 V (Boost disabled) and the output voltage range of 9 V to 11 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 85°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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3.1 *United States*

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

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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。

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。

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:*

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.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

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

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

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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