

Dual Synchronous Step-Down Fixed Output Controller with 5-V and 3.3-V LDOs

The TPS51225EVM-133 evaluation module (EVM) uses the TPS51225. The TPS51225 is a D-CAP™ mode, dual synchronous step down controller with 5- and 3.3-V low-dropout regulators (LDO). The EVM provides fixed 5- and 3.3-V outputs at up to 10 A each, from a 12-V input bus.

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1 Description

The TPS51225EVM-133 is designed to use a regulated 12-V bus to produce regulated 5- and 3.3-V outputs at up to 10 A each of load current. The EVM demonstrates the TPS51225 as a computing-system power supply. It also provides 5- and 3.3-V LDOs and 14-V voltage-current protection (VCP) for charge pump application.

1.1 Typical Applications

- Notebook Computers, Netbooks, Tablet Computers
- Servers, Telecom motherboards, Embedded Computers

1.2 Features

The TPS51225EVM-133 features:

- 10-A DC steady-state output current for 5- and 3.3-V outputs
- Supports pre-bias output voltage start-up
- S1 for Enable/Disable Output1
- S2 for Enable/Disable Output2
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 1. TPS51225EVM-133 Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS					
Voltage range	V _{in}	8	12	20	V
Maximum input current	V _{in} = 8 V, 5 V _{out} , 1/10A, 3.3 V _{out} , 2/10A		7.3		A
No load input current	V _{in} = 20 V, 5 V _{out} , 1/0A, 3.3 V _{out} , 2/0A with auto-skip mode		1.5		mA
OUTPUT CHARACTERISTICS					
Output voltage V_{OUT1}			5		V
Output voltage regulation	Line regulation(V _{in} = 8–20 V)		0.1%		
	Load regulation(V _{in} = 12 V, V _{out1} /0A–10A with auto-skip mode), V _{output2} : off		0.5%		
Output voltage ripple	V _{in} = 12 V, V _{out1} / 10A , V _{output2} : off		32		mVpp
Output load current	V _{in} = 8–20V	0	8	10	A
Output over current	V _{in} = 12 V		12.9		A
Switching Frequency	V _{in} = 12 V, V _{output1} /10A		300		kHz
Efficiency	V _{in} = 12 V, V _{out1} / 10A, V _{out2} : off		95.69%		
Output voltage V_{out2}			3.3		V
Output voltage regulation	Line regulation(V _{in} = 8–20V)		0.1%		
	Load regulation(V _{in} = 12 V, V _{out} 2/0A–10A with auto-skip mode), V _{output1} : off		0.5%		
Output voltage ripple	V _{in} = 12 V, V _{out2} / 10A , V _{output1} : off		30		mVpp
Output load current	V _{in} = 8–20 V	0	8	10	A
Output over current	V _{in} = 12 V		12.9		A
Switching Frequency	V _{in} = 12 V, V _{output2} /10A		355		kHz
Efficiency	V _{in} = 12 V, V _{out2} at 10 A, V _{out1} : off		94.33%		
Operating temperature			25		°C

4 Test Setup

4.1 Test Equipment

Voltage Source: The input voltage, V_{in} , should be a 0- to 20-V 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 (V_{in}) and TP6 (GND).

V2: V_{out1} at TP2 (V_{out1}) and TP7 (GND).

V3: V_{out2} at TP3 (V_{out2}) and TP8 (GND).

A1: V_{in} input current

Output Load: The output load should be an electronic constant resistance mode load capable of 0 to 15 A dc.

Oscilloscope: A digital or analog oscilloscope can measure the output ripple. Set the oscilloscope for 1-M Ω impedance, 20-MHz Bandwidth, AC coupling, 4 μ s/division horizontal resolution, 50-mV/division vertical resolution. Use test points TP2(V_{out1}), TP3(V_{out2}), TP7(GND), and TP8(GND) for measuring the output ripple voltage by placing the oscilloscope probe tip through TP2/TP3 and holding the ground barrel on TP7/TP8 as shown in Figure 2. Using a leaded ground connection may induce additional noise due to the large ground loop.

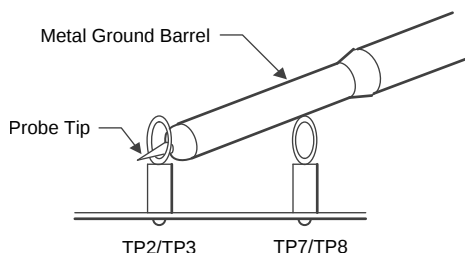


Figure 2. Tip and Barrel Measurement for Vout Ripple

Fan: Some of the components in this EVM may approach temperatures of 60°C during operation. A small fan capable of 200–400 linear feet per minute (LFM) is recommended to reduce component temperatures while the EVM is operating. Do not probe the EVM while the fan is not running.

Recommended Wire Gauge:

1. V_{in} to J1(12-V input):
The recommended wire size is 1x American wire gauge (AWG) #14 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
2. J2, J3 to Load1, Load2:
The minimum recommended wire size is AWG #14, with the total length of wire less than 4 feet (2 feet output, 2 feet return)

4.2 Recommended Test Setup

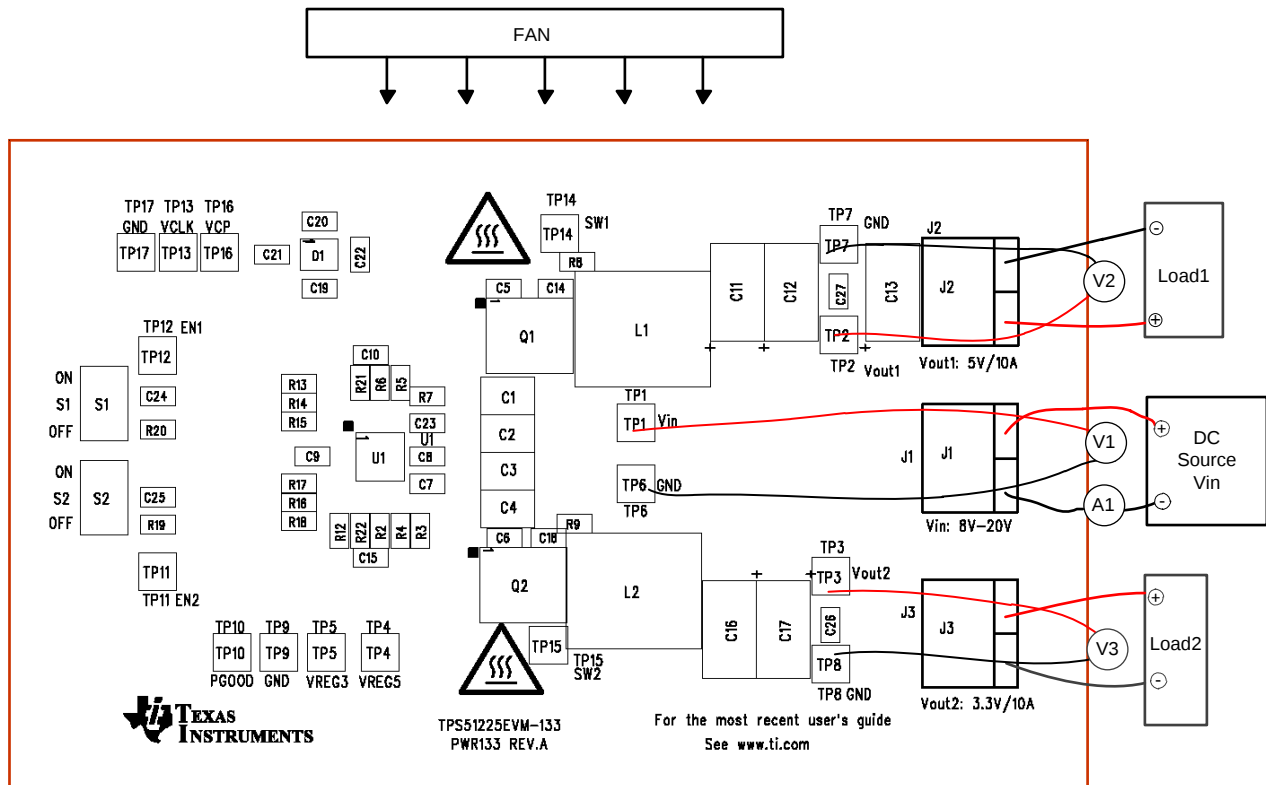


Figure 3. TPS51225EVM-133 Recommended Test Set Up

Figure 3 is the recommended test set up for evaluating the EVM. Working at an ESD workstation, make sure that any wrist straps, bootstraps or mats are connected referencing the user to earth ground before power is applied to the EVM.

Input Connections:

1. Prior to connecting the DC input source, Vin, it is advisable to limit the source current from Vin to 10 A maximum. Make sure Vin is initially set to 0 V and connected as shown in [Figure 3](#).
2. Connect a voltmeter, V1, at TP1(Vin) and TP6(GND) to measure the input voltage.
3. Connect a current meter, A1, to measure the input current.

Output Connections:

1. Connect Load1 to J2 and set Load to constant resistance mode to sink 0 A dc before Vin is applied
2. Connect a voltmeter, V2, at TP2 (Vout1) and TP7 (GND) to measure the output1 voltage.
3. Connect Load2 to J3 and set Load to constant resistance mode to sink 0 A dc before Vin is applied.
4. Connect a voltmeter, V3, at TP3 (Vout2) and TP8 (GND) to measure the output2 voltage.

Other Connections:

Place a fan as shown in [Figure 3](#) and turn it on, making sure air is flowing across the EVM.

5 Configurations

Make all Switcher selections before applying power to the EVM. Configure this EVM per the following:

Enable1 Selection

The EN1 pin can be set by S1.

Default setting: S1 to OFF to disable the Output1

Table 2. EN1 Selection

Switcher set to	SKIPSEL Selection
ON	Enable the Output1
OFF	Disable the Output1

Enable2 Selection

Default setting: S2 to OFF to disable the Output2

Table 3. EN2 Selection

Switcher set to	Enable Selection
ON	Enable the Output2
OFF	Disable the Output2

6 Test Procedure

6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up the EVM as described in [Section 4](#) and [Figure 3](#)
2. Ensure Load1 and Load2 are set to constant resistance mode and to sink 0 Adc
3. Ensure the configuration settings per [Section 5](#)
4. Ensure S1 and S2 are in the OFF position before Vin is applied
5. Increase Vin from 0 V to 12 V. Using V1 to measure input voltage
6. Switch S1 to the ON position to enable the Output1
7. Use V2 to measure Vout1 voltage
8. Vary Load1 from 0–10 Adc, Vout1 should remain in load regulation
9. Vary Vin from 8 V to 20 V, Vout1 should remain in line regulation
10. Switch S1 to the OFF position to disable the Output1
11. Switch S2 to the ON position to enable the Output2
12. Use V3 to measure Vout2 voltage
13. Vary Load2 from 0–10 Adc, Vout2 should remain in load regulation
14. Vary Vin from 8 V to 20 V, Vout2 should remain in line regulation
15. Switch S2 to the OFF position to disable the Output2
16. Decrease Load1 and Load2 to 0 A
17. Decrease Vin to 0 V

6.2 List of Test Points

Table 4. The Functions of Each Test Points

Test Points	Name	Description
TP1	Vin	12-V input
TP2	Vout1	5-V output
TP3	Vout2	3.3-V output
TP4	VREG5	5-V LDO output
TP5	VREG3	3.3-V LDO output
TP6	GND	Ground
TP7	GND	Ground
TP8	GND	Ground
TP9	GND	Ground
TP10	PGOOD	Power Good
TP11	EN2	Enable2
TP12	EN1	Enable1
TP13	VCLK	Clock output for charge pump
TP14	SW1	Switching node of Output1
TP15	SW2	Switching node of Output2
TP16	VCP	14-V charge pump voltage
TP17	GND	Ground

6.3 Equipment Shutdown

1. Shut down Load1 and Load2
2. Shut down Vin
3. Shut down FAN

7 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 20 present typical performance curves for TPS51225EVM-133.

7.1 5-V Efficiency

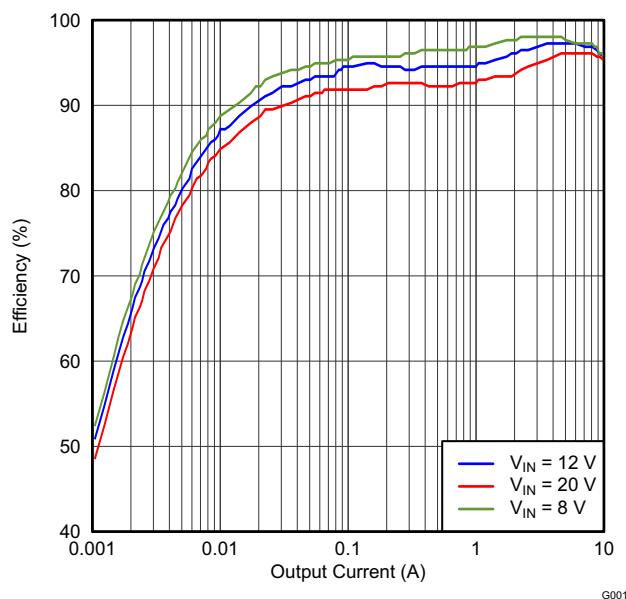


Figure 4. 5-V Efficiency

7.2 5-V Load Regulation

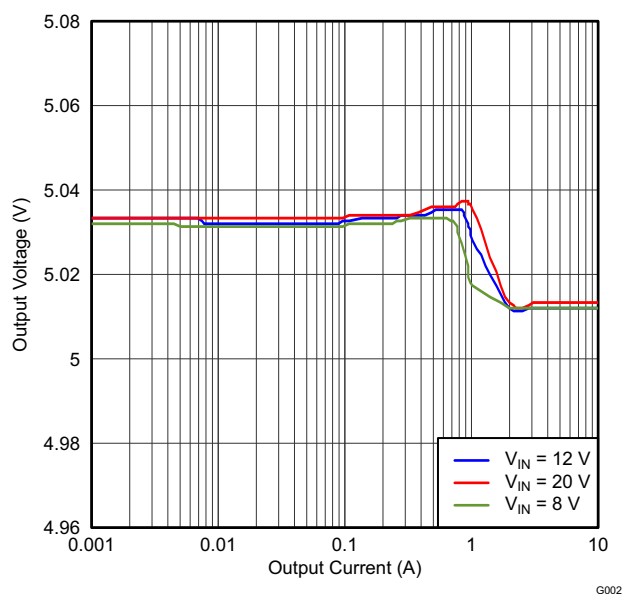


Figure 5. 5-V Load Regulation

7.3 3.3-V Efficiency

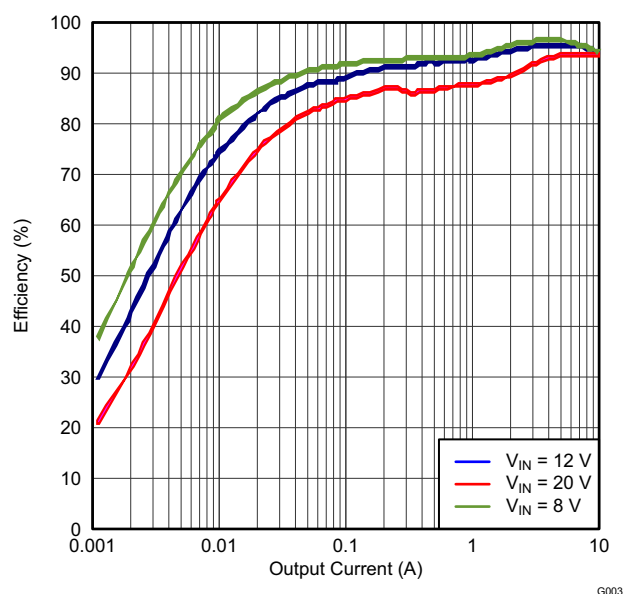


Figure 6. 3.3-V Efficiency

7.4 3.3-V Load Regulation

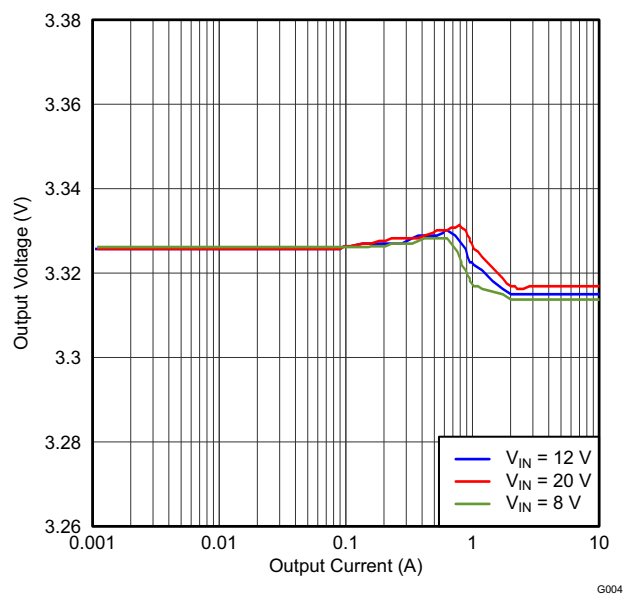


Figure 7. 3.3-V Load Regulation

7.5 Enable Turn on/Turn off

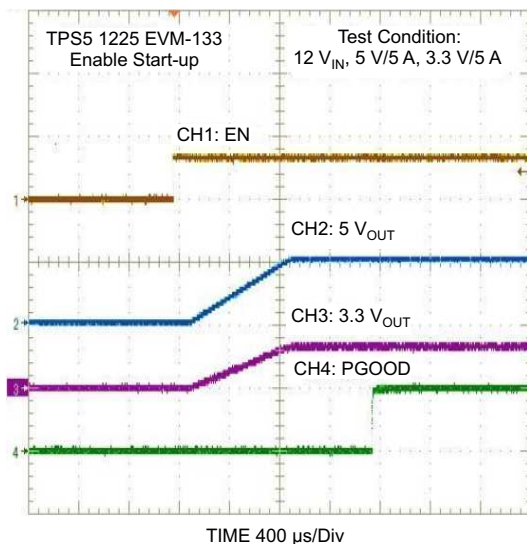


Figure 8. EN1 and EN2 Turn on

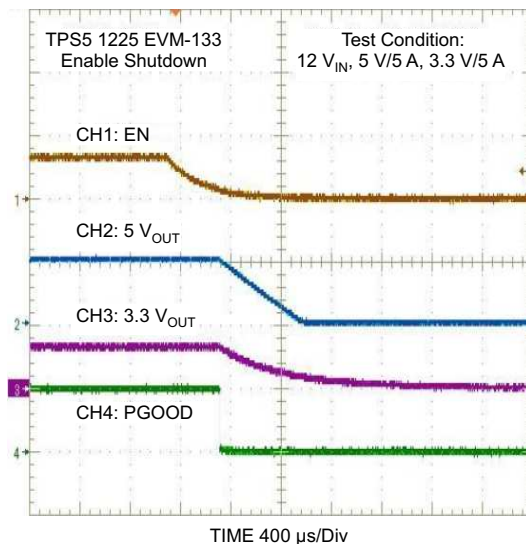


Figure 9. EN1 and EN2 Turn off

7.6 Output Ripple

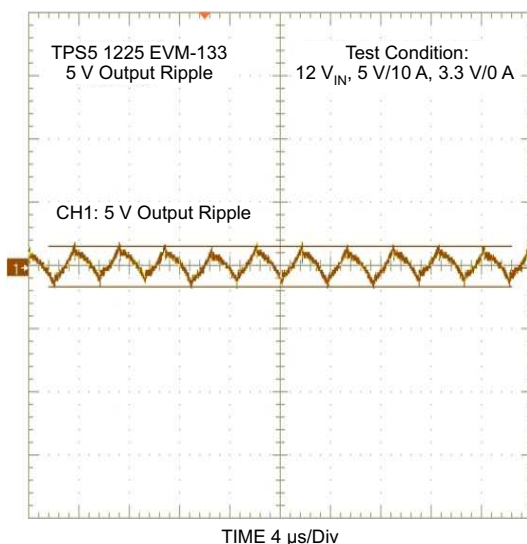


Figure 10. 5-V Output Ripple

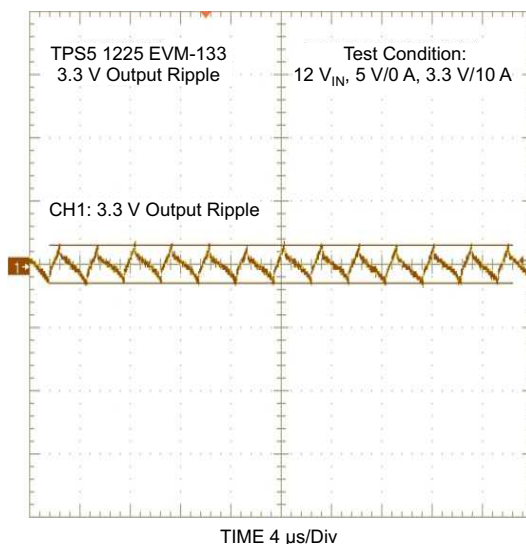


Figure 11. 3.3-V Output Ripple

7.7 Switching Node

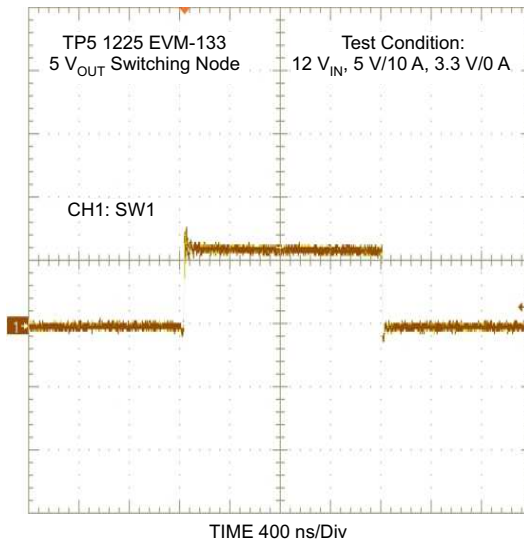


Figure 12. 5-V Switching Node

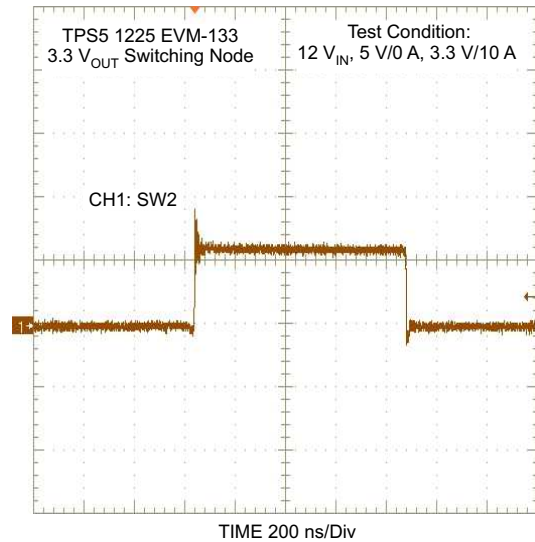


Figure 13. 3.3-V Switching Node

7.8 5-V Output Transient with Auto-skip Mode

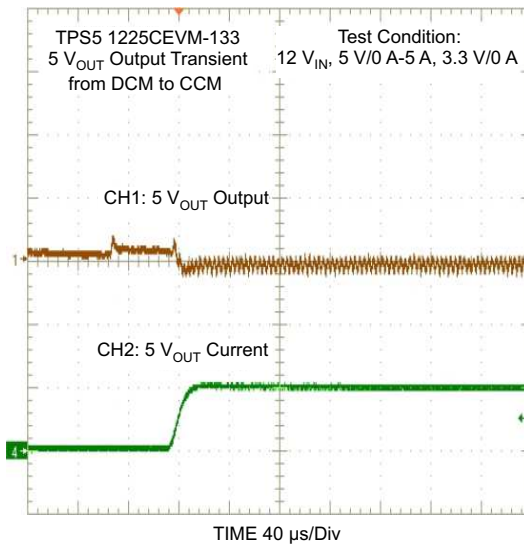


Figure 14. 5-V Output Transient from DCM to CCM

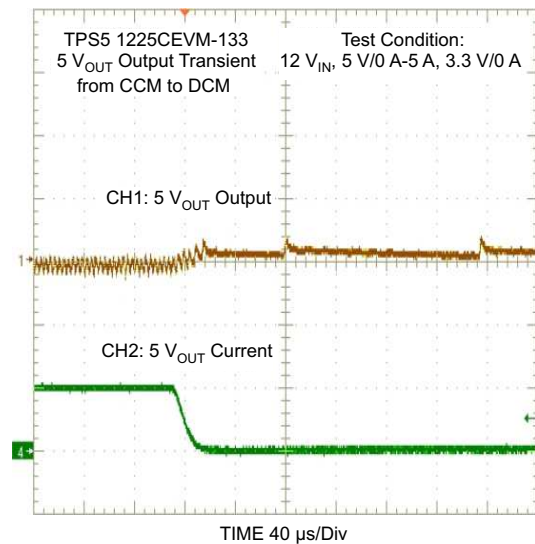


Figure 15. 5-V Output Transient from CCM to DCM

7.9 3.3-V Output Transient with Auto-skip Mode

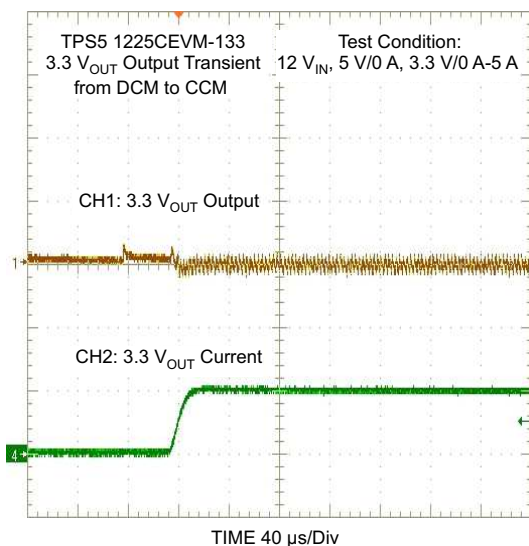


Figure 16. 3.3-V Output Transient from DCM to CCM

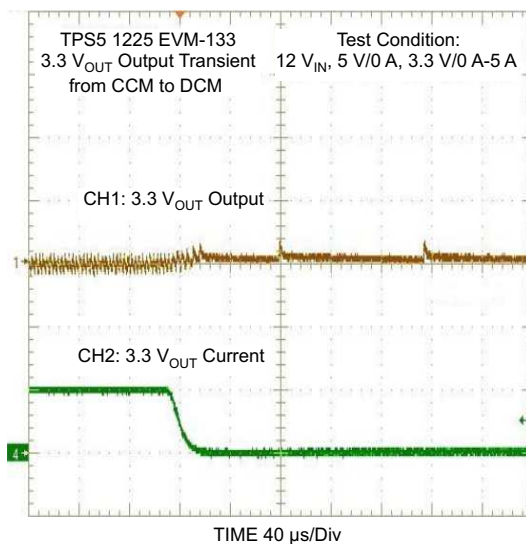


Figure 17. 3.3-V Output Transient from CCM to DCM

7.10 Output Prebias Turn on

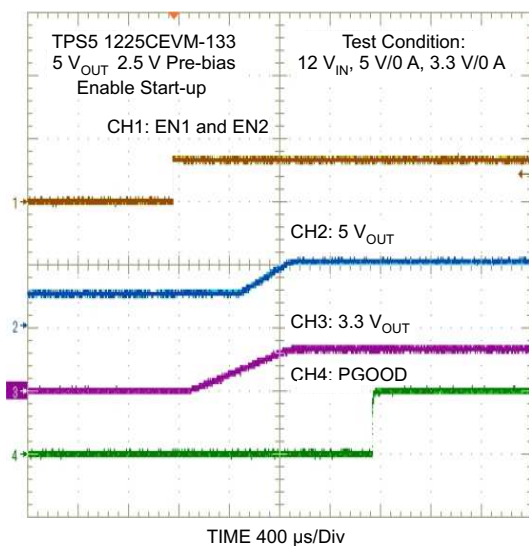


Figure 18. 5-V Output, 2.5-V Prebias Start up

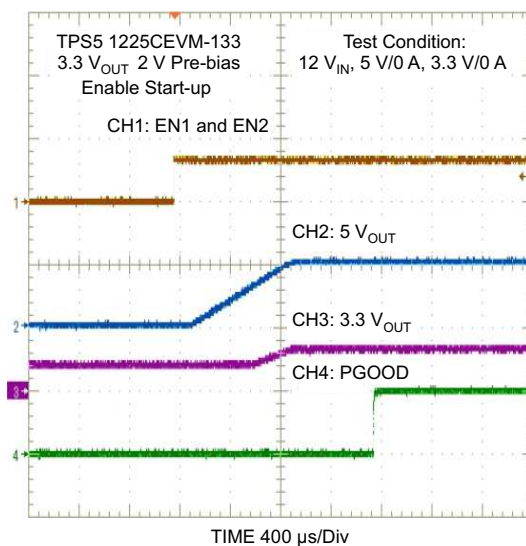


Figure 19. 3.3-V Output, 2-V Prebias Start up

7.11 Thermal Image

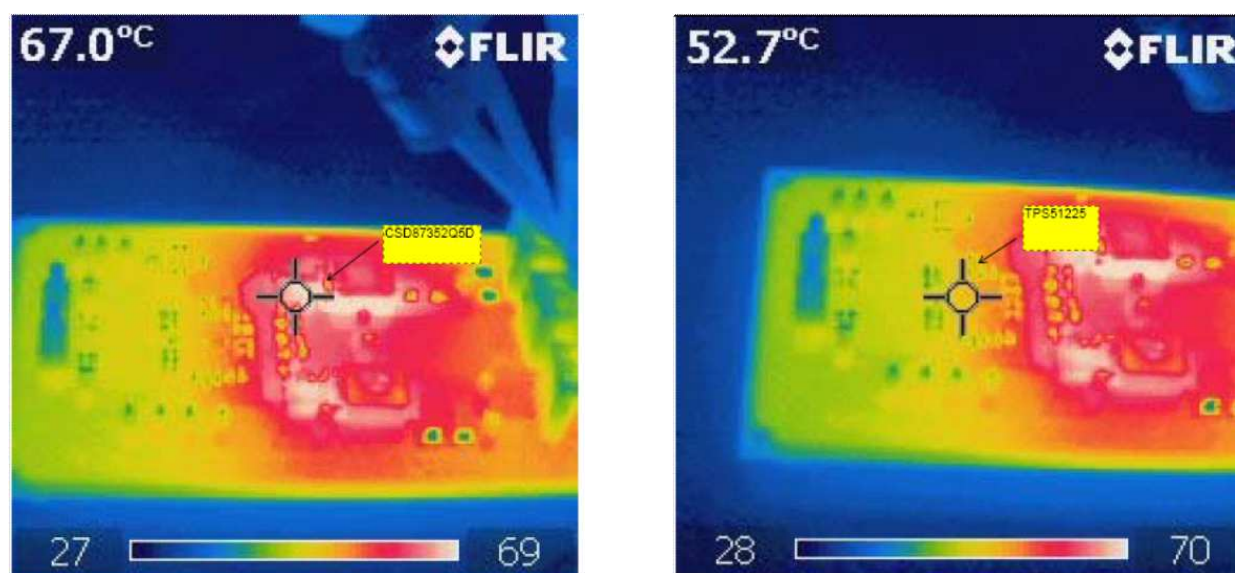


Figure 20. Top Board at 12 Vin, 5 V/10 A, 3.3 V/10 A, 25°C Ambient without Airflow

8 EVM Assembly Drawing and PCB Layout

The following figures (Figure 21 through Figure 26) show the design of the TPS51225EVM-133 printed circuit board. The EVM has been designed using 4 Layers, 2 oz copper circuit board.

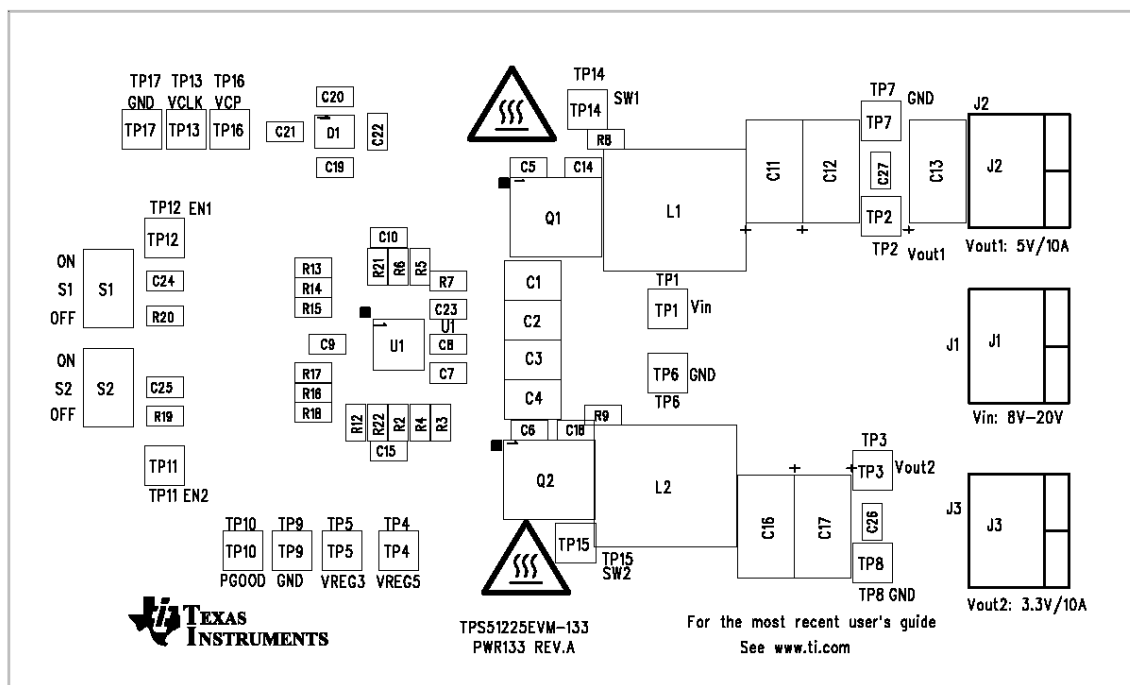


Figure 21. TPS51225EVM-133 Top Layer Assembly Drawing

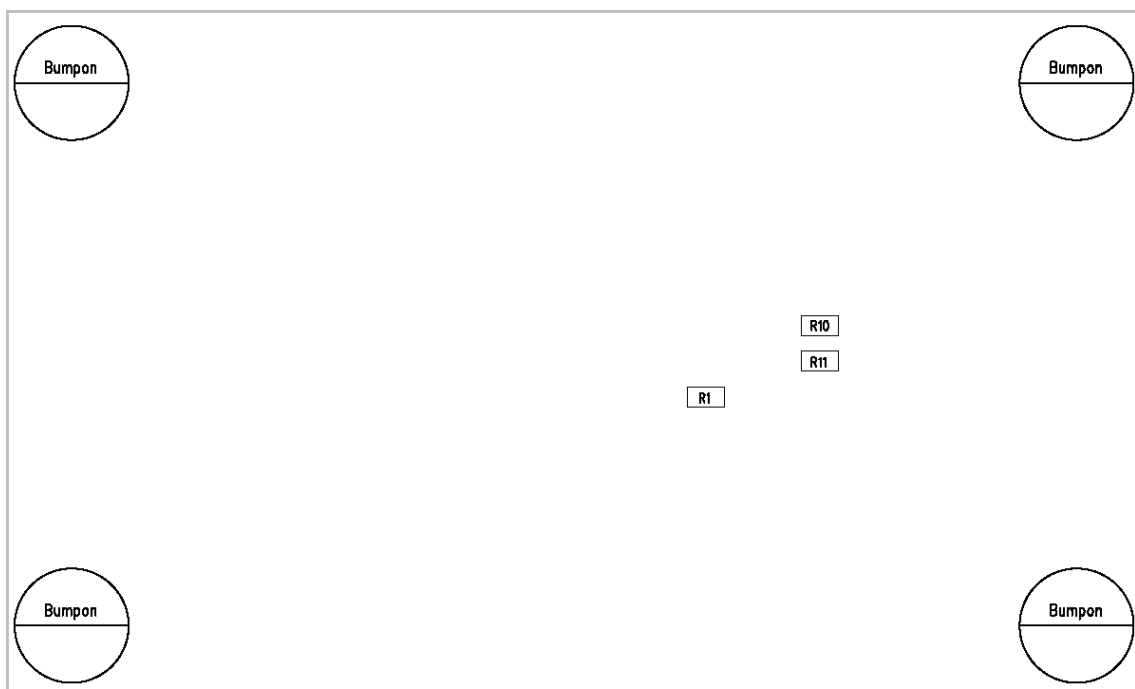


Figure 22. TPS51225EVM-133 Bottom Assembly Drawing

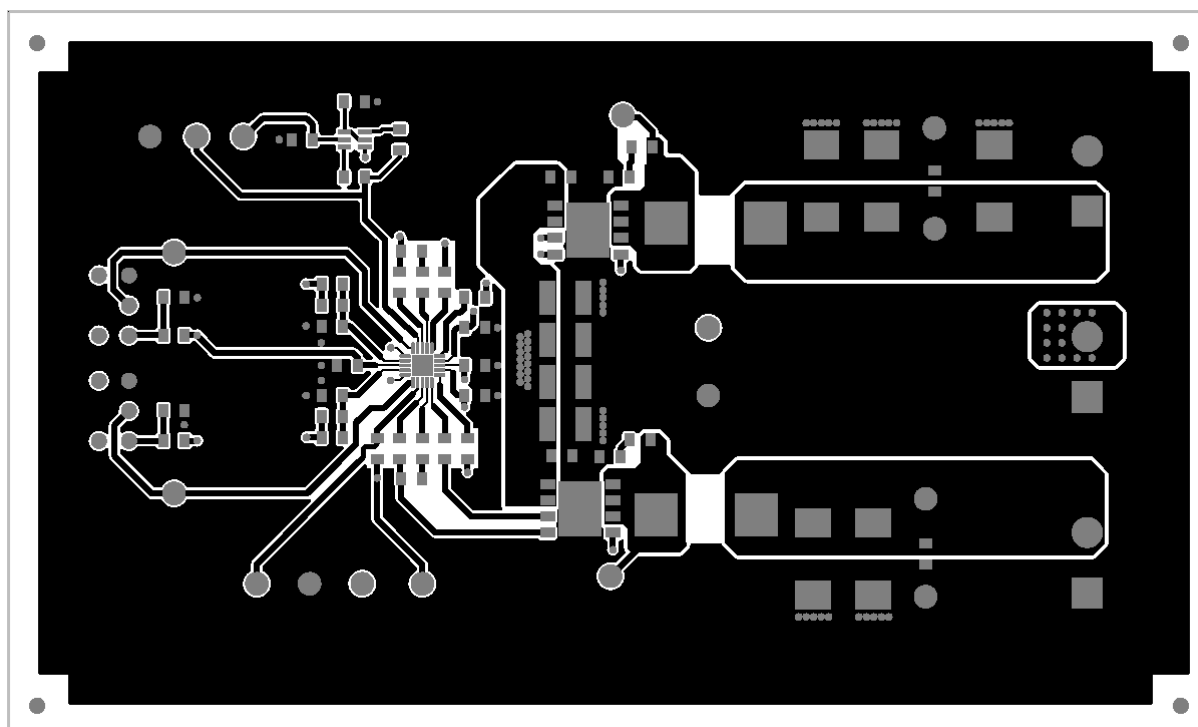


Figure 23. TPS51225EVM-133 Top Copper

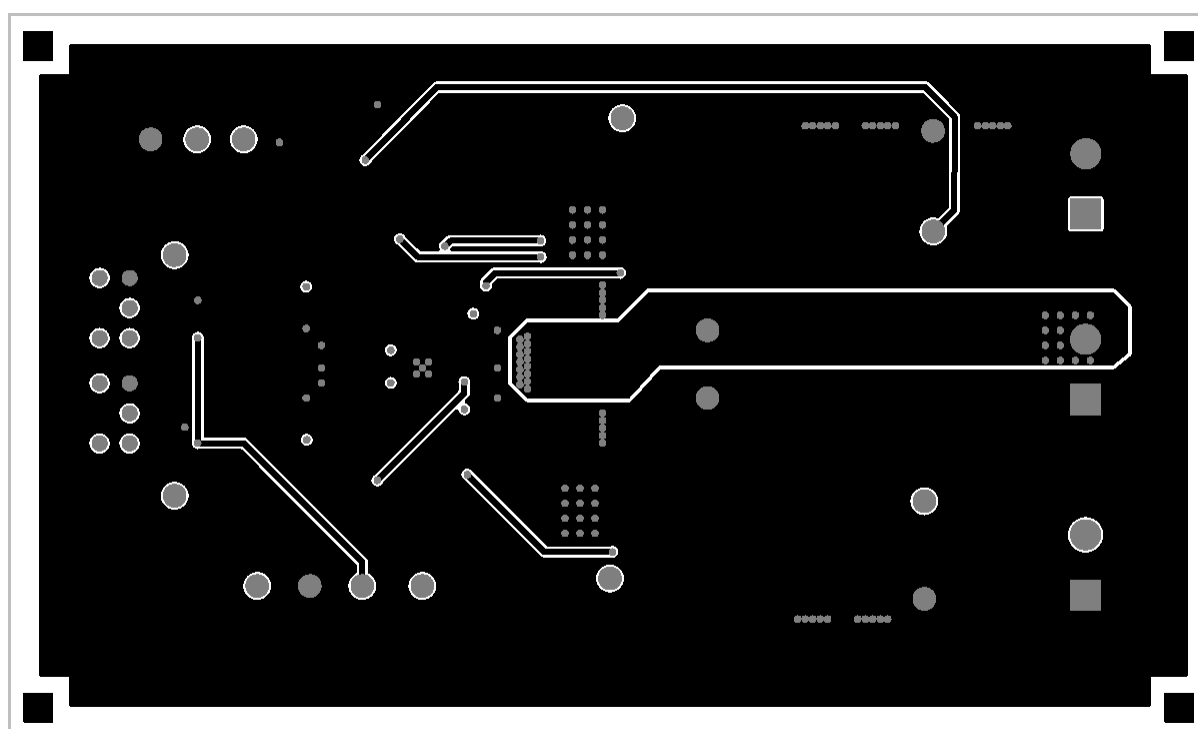


Figure 24. TPS51225EVM-133 Layer 2 Copper

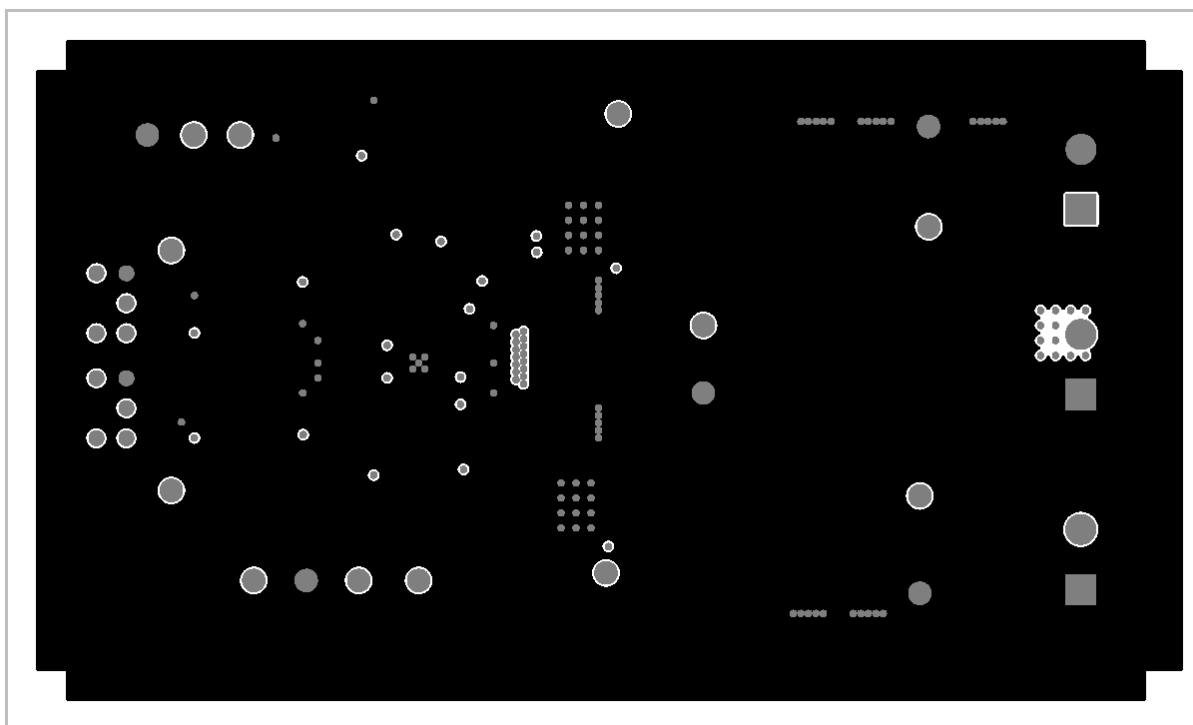


Figure 25. TPS51225EVM-133 Layer 3 Copper

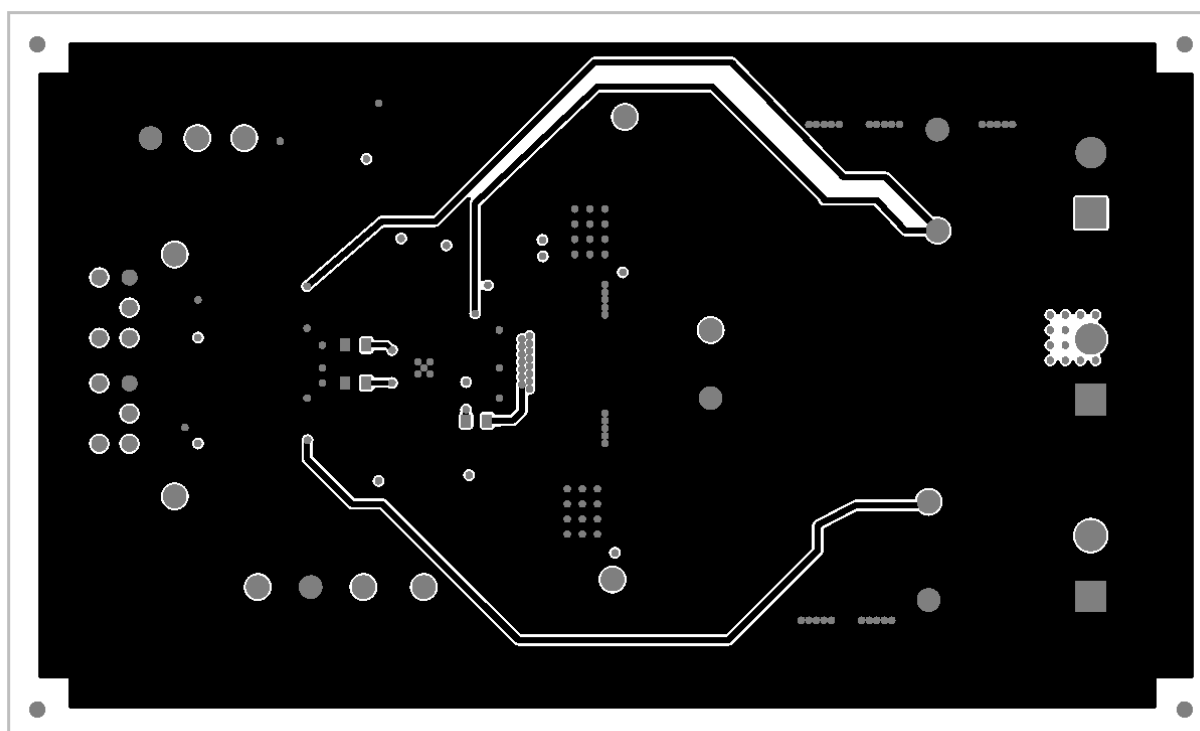


Figure 26. TPS51225EVM-133 Layer 4 Copper

9 Bill of Materials

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

Table 5. EVM Components List

Qty	RefDes	Description	MFR	Part Number
4	C1, C2, C3, C4	Capacitor, ceramic, 22 μ F, 25 V, X5R, 20%, 1210	Murata	GRM32ER61C226KE20L
6	C10, C15, C19, C20, C21, C22	Capacitor, ceramic, 0.1 μ F, 50 V, X7R, 10%, 0603	STD	STD
4	C5, C6, C26, C27	Capacitor, ceramic, 0.01 μ F, 50 V, X7R, 10%, 0603	STD	STD
3	C7, C8, C9	Capacitor, ceramic, 1 μ F, 10 V, X7R, 10%, 0603	STD	STD
2	C11, C12	Capacitor, POS, 330 μ F, 6.3 VDC, 18 m Ω , 20%, 7343	Sanyo	6TPE330MIL
2	C16, C17	Capacitor, POS, 470 μ F, 4 VDC, 18 m Ω , 20%, 7343	Sanyo	4TPE470MIL
1	D1	Diode, Schottky barrier array, 70 mA, 40 V, SOT363	BAS40DW-04	Diodes
1	L1	Inductor, SMT, 3.3 μ H, 12.3 A, 9.2 m Ω , 11.2 mm $\times$ 10.0 mm	Toko	FDVE1040-H-3R3M
1	L2	Inductor, SMT, 2.2 μ H, 14.2 A, 6.1m Ω , 11.2 mm $\times$ 10.0 mm	Toko	FDVE1040-H-2R2M
2	Q1, Q2	MOSFET, Dual N-Chan, 30 V, 25 A, QFN-8 POWER	TI	CSD87352Q5D
9	R1, R3, R4, R5, R7, R19, R20, R21, R22	Resistor, chip, 0 Ω , 1/16W, 1%, 0603	STD	STD
2	R10, R11	Resistor, chip, 30.1 k Ω , 1/16W, 1%, 0603	STD	STD
1	R18	Resistor, chip, 51.1 k Ω , 1/16W, 1%, 0603	STD	STD
1	R12	Resistor, chip, 100 k Ω , 1/16W, 1%, 0603	STD	STD
1	R14	Resistor, chip, 15.0 k Ω , 1/16W, 1%, 0603	STD	STD
2	R15, R17	Resistor, chip, 10.0 k Ω , 1/16W, 1%, 0603	STD	STD
1	R16	Resistor, chip, 7.50 k Ω , 1/16W, 1%, 0603	STD	STD
1	R6	Resistor, chip, 2.21 Ω , 1/16W, 1%, 0603	STD	STD
1	R2	Resistor, chip, 4.02 Ω , 1/16W, 1%, 0603	STD	STD
1	U1	IC, Dual Synchronous Step-Down Controller with 5-V/3.3-V LDOs for Notebook System Power DFN-20	TI	TPS51225RUK

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.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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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 this Product 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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2. 実験局の免許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. 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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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.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

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

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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. 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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TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

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