Using the TPS51219EVM-630 High-Performance, Single, Synchronous, Step-Down Controller for Notebook Power Supply

The TPS51219EVM evaluation module (EVM) uses the TPS51219. The TPS51219 is a small-size, single buck controller with adaptive on-time D-CAP2™ providing 1.05-V output at up to 20 A from input voltage ranging 8 V to 20 V.

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1 Description

The TPS51219EVM evaluation module (EVM) is designed to use a regulated voltage ranging 8 V to 20 V to produce 1.05-V output at up to 20 A of load current. The TPS51219EVM demonstrates the TPS51219 in a typical low-voltage application with D-CAP2™ mode operation. The EVM also provides test points to evaluate the performance of the TPS51219.

1.1 Typical Applications

- Notebook computers
- I/O supplies
- System power supplies

1.2 Features

The TPS51219EVM features:

- D-CAP2™-mode operation with low-ESR output capacitance
- 2% tolerance 1.05-V output voltage
- 20-Adc, steady-state output current
- Support prebias output voltage start-up
- 500-kHz switching frequency
- SW1 for enable function
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 1. TPS51219EVM-630-001 Electrical Performance Specifications

Parameter	Test Conditions	Min	Typ	Max	Unit
Input Characteristics					
Voltage range	VIN voltage	8	12	20	V
Maximum input current	VIN = 8 V, IOUT = 20 A		3		A
No load input current	VIN = 8 V, IOUT = 0 A		0.2		mA
Voltage range	V5IN voltage	4.5	5	5.5	V
Maximum input current	V5IN = 5 V, VIN = 12 V, IOUT = 20 A		20		mA
No load input current	V5IN = 5 V, VIN = 12 V, IOUT = 0 A		0.5		mA
Output Characteristics					
Output voltage, VOUT	VIN = 12 V, IOUT = 10 A		1.05		V
Output load current, IOUT			20		A
Output voltage regulation	Line Regulation: VIN = 8 V to 20 V, VOUT = 1.05 V, IOUT = 20 A		0.2%		
	Load Regulation: VIN= 12 V, VOUT = 1.05 V, IOUT = 1 mA to 20 A		0.2%		
Output voltage ripple	At VIN = 12 V, VOUT = 1.05 V, IOUT = 20 A		15		mVpp
Output over current			27		A
System Characteristics					
Switching frequency	VIN = 8 V, VOUT = 1.05 V, IOUT = 10 A		500		kHz
Peak efficiency	VIN = 12 V, VOUT = 1.05 V		89.3%		
Full load efficiency	VIN = 12 V, VOUT = 1.05 V, IOUT = 20 A		85.4%		
Operating temperature			25		°C

3 Schematic

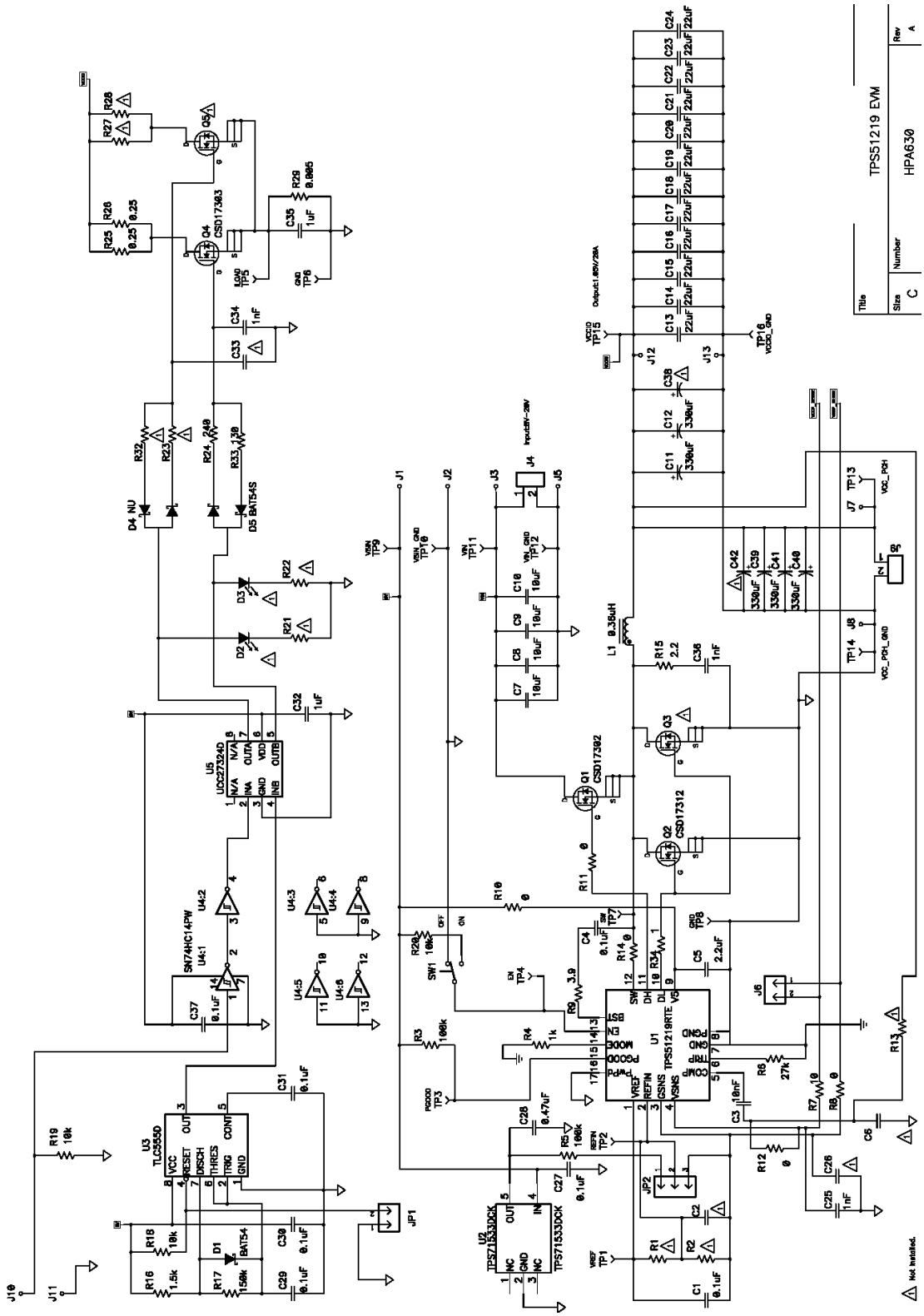

Figure 1. TPS51219EVM-630 Schematic, Sheet 1 of 2

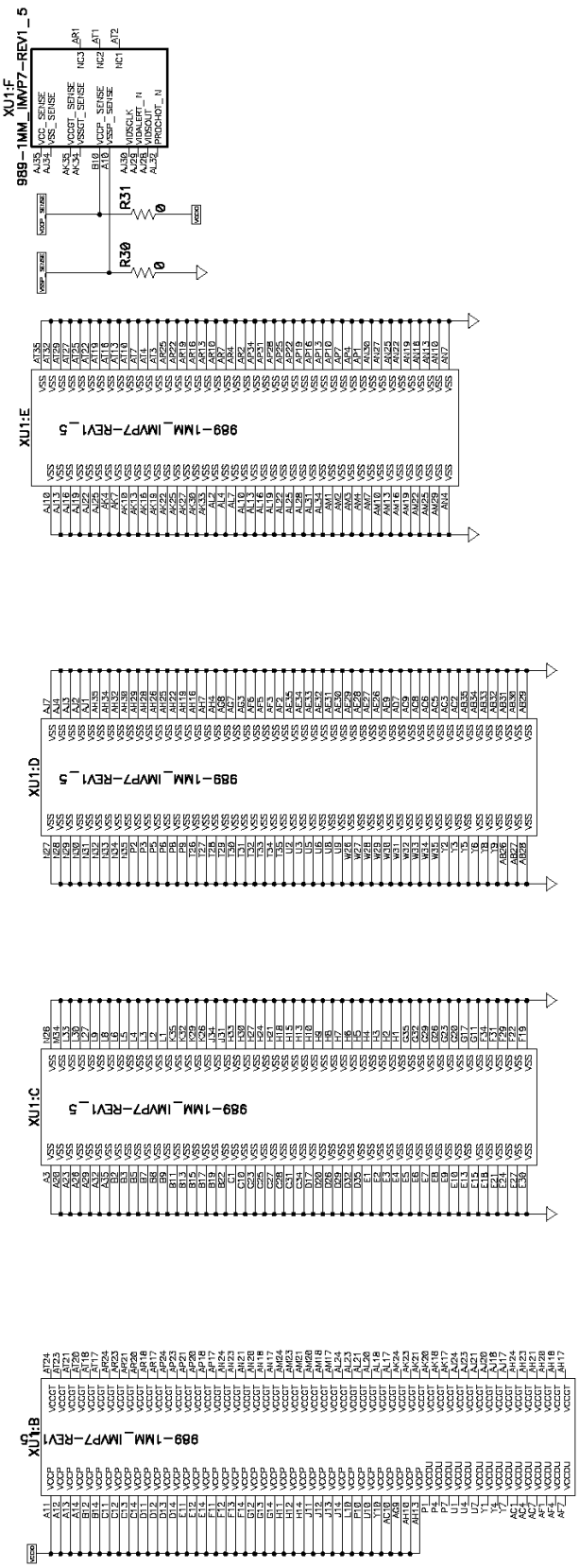

Figure 2. TPS51219EVM-630 Schematic, Sheet 2 of 2

4 Test Setup

4.1 Test Equipment

Voltage Source VIN: The input voltage source VIN must be a 0-V to 20-V variable DC source capable of supplying 10 Adc. Connect VIN to J4 as shown in Figure 4.

Voltage Source V5IN: The input voltage source V5IN must be a 0-V to 5-V variable DC source capable of supplying 1 Adc. Connect V5IN to J1 as shown in Figure 4.

Multimeters:

V1: VIN at TP11 (VIN) and TP12 (VIN_GND)
V2: V5IN at TP10 (V5IN) and TP9 (V5IN_GND)
V3: VSNS at J6-2 and GSNS at J6-1
A1: VIN input current
A2: V5IN input current

Output Load: The output load must be an electronic constant-resistance mode load capable of 0-Adc to 30-Adc at 1.05 V.

Oscilloscope: A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope must be set for 1-MΩ impedance, 20-MHz bandwidth, ac coupling, 1-µs/division horizontal resolution, 20-mV/division vertical resolution. Test point J6 can be used to measure the differential output ripple voltage, using a passive probe with the shortest leaded ground clip. For switch node voltage measurement, TP7 and TP8 can be used by placing the passive probe tip through TP7 and holding the ground barrel TP8 as shown in Figure 3. In this case, using a leaded ground connection may induce additional noise due to the large ground loop.

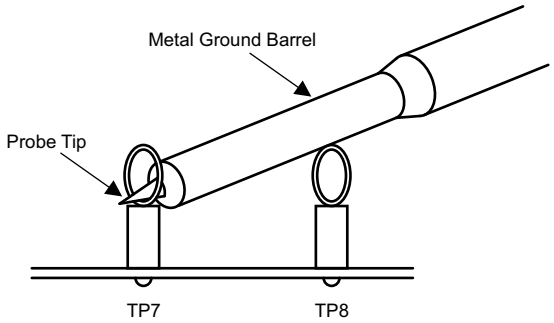

Figure 3. Tip and Barrel Measurement for Switch Node Voltage

Fan: Some of the components in this EVM may get hot, approaching temperatures of 60°C during operation. A small fan capable of 200-400 LFM is recommended to reduce component temperatures while the EVM is operating. The EVM must not be probed when the fan is not running.

Recommended Wire Gauge:

1. VIN to J4 (8-V to 20-V input)
   The recommended wire size is 1x AWG 14 per input connection, with the total length of wire less than 4 feet (2-foot input, 2-foot return).
2. V5IN to J1 (5-V input)
   The recommended wire size is 1x AWG 18 per input connection, with the total length of wire less than 4 feet (2-foot input, 2-foot return).
3. J12 to LOAD
   The minimum recommended wire size is 2x AWG 14, with the total length of wire less than 4 feet (2-foot input, 2-foot return).

4.2 Recommended Test Setup

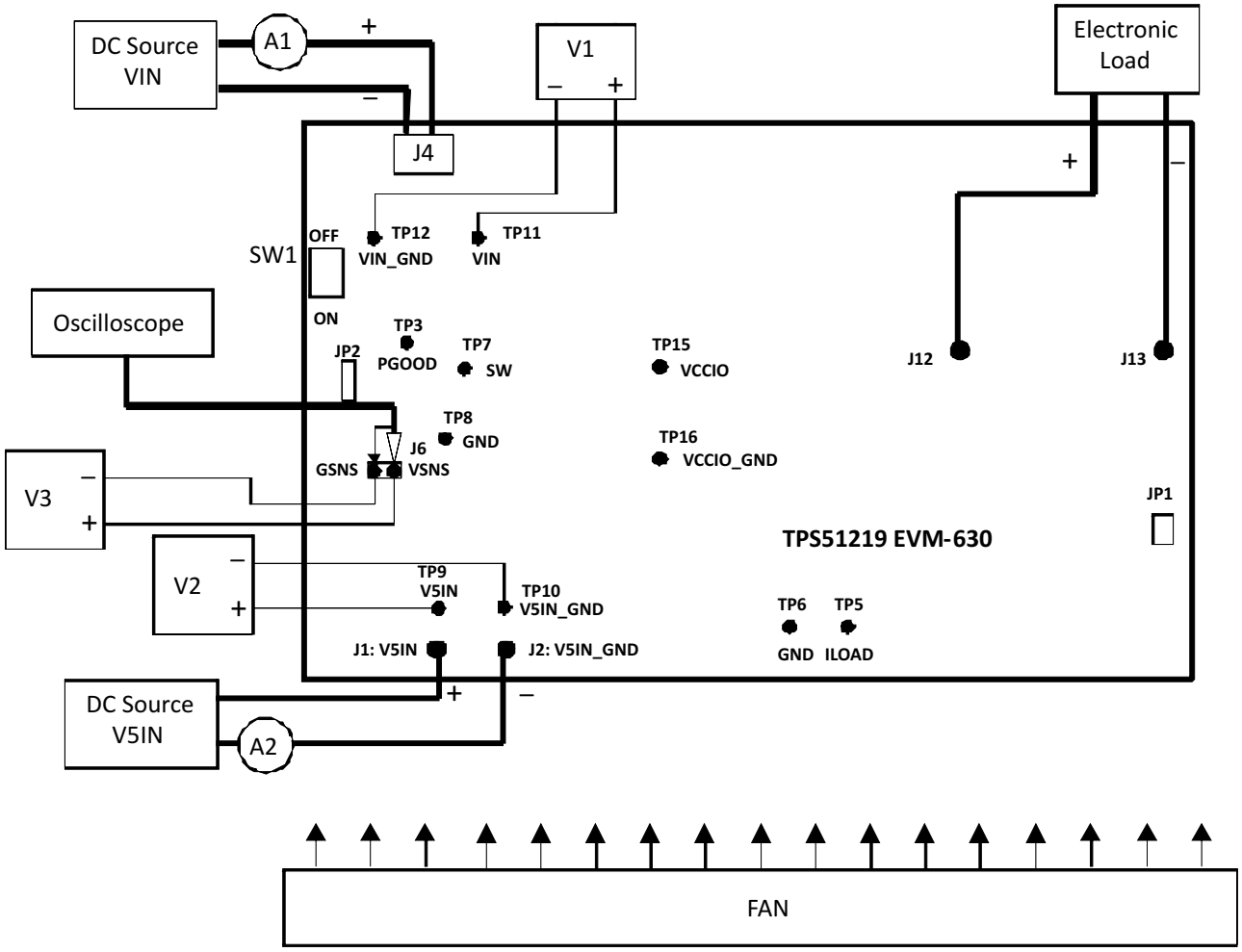

Figure 4. TPS51219EVM-630 Recommended Test Setup

Figure 4 is the recommended test setup to evaluate the TPS51219EVM. Working at an ESD workstation, ensure 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 source VIN, it is advisable to limit the source current from VIN to 10 A maximum. Ensure that VIN is initially set to 0 V and connected as shown in Figure 4.
2. Prior to connecting the DC source V5IN, it is advisable to limit the source current from V5IN to 1 A maximum. Ensure that V5IN is initially set to 0 V and connected as shown in Figure 4.
3. Connect a voltmeter V1 at TP11 (VIN) and TP12 (VIN_GND) to measure VIN voltage, V2 at TP9 (V5IN) and TP10 (V5IN_GND) to measure V5IN voltage as shown in Figure 4.
4. Connect a current meter A1 between DC source VIN and J4 to measure the input current.
5. Connect a voltmeter V2 between DC source V5IN and J1 to measure the 5-V input current.

Output Connections:

1. Connect the load to J12 and J13, and set load to constant resistance mode to sink 0-Adc before VIN and V5IN are applied.
2. Connect a voltmeter V3 at J6-2 (VSNS) and J6-1 (GSNS) to measure the output voltage.

Other Connections:
Place a fan as shown in Figure 4 and turn it on, ensuring that air is flowing across the EVM.

5 Test Procedure

5.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Ensure the load is set to constant resistance mode and to sink 0 Adc.
2. Ensure SW1 on the EVM is at OFF position before VIN and V5IN are applied.
3. Increase VIN from 0 V to 8 V. Use V1 to measure input voltage.
4. Increase V5IN from 0 V to 5 V. Use V2 to measure input voltage.
5. Turn SW1 to ON position to enable the controller.
6. Vary the load from 0 Adc to 20 Adc; VOUT must remain in load regulation.
7. Vary VIN from 8 V to 20 V; VOUT must remain in line regulation.
8. Decrease the load to 0 A.
9. Turn SW1 to OFF position to disable the controller.
10. Decrease V5IN to 0 V.
11. Decrease VIN to 0 V.

5.2 List of Test Points

Table 2. Functions of Each Test Point

Test Point	Name	Description
TP1	VREF	VREF voltage
TP2	REFIN	REFIN voltage
TP3	PGOOD	Power good
TP4	EN	Output enable
TP5	ILOAD	Built-in dynamic load current
TP6	GND	GND for ILOAD
TP7	SW	Switch node
TP8	GND	GND for SW
TP9	V5IN	5V supply
TP10	V5IN_GND	GND for 5-V supply
TP11	VIN	VIN supply
TP12	VIN_GND	GND for VIN supply
TP13	VCC_PCH	Output for VCC_PCH
TP14	VCC_PCH_GND	GND for VCC_PCH
TP15	VCCIO	VCCIO
TP16	VCCIO_GND	GND for VCCIO
J6-1	GSNS	Differential sensing (low)
J6-2	VSNS	Differential sensing (high)

5.3 Equipment Shutdown

1. Shut down the load.
2. Shut down V5IN and VIN.
3. Shut down the fan.

6 Performance Data and Typical Characteristic Curves

Figure 5 through Figure 13 present typical performance curves for TPS51219EVM-630.

6.1 Efficiency

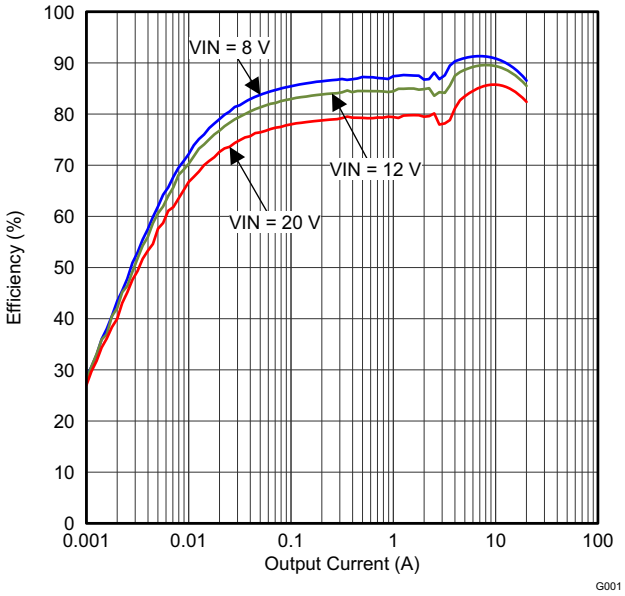

Figure 5. TPS51219EVM-630 Efficiency

6.2 Load Regulation

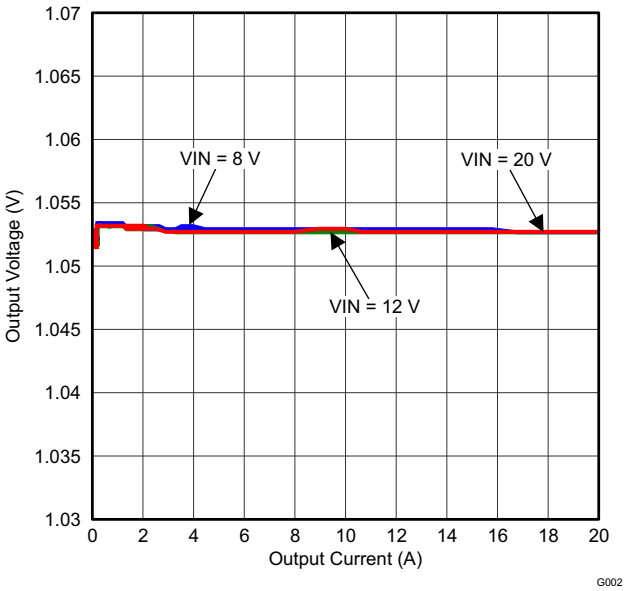

Figure 6. TPS51219EVM-630 Load Regulation

6.3 Line Regulation

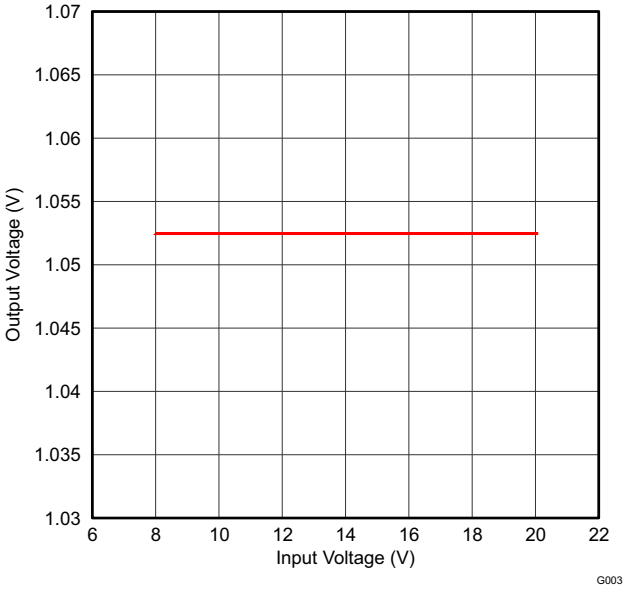

Figure 7. TPS51219EVM-630 Line Regulation

6.4 Load Transient

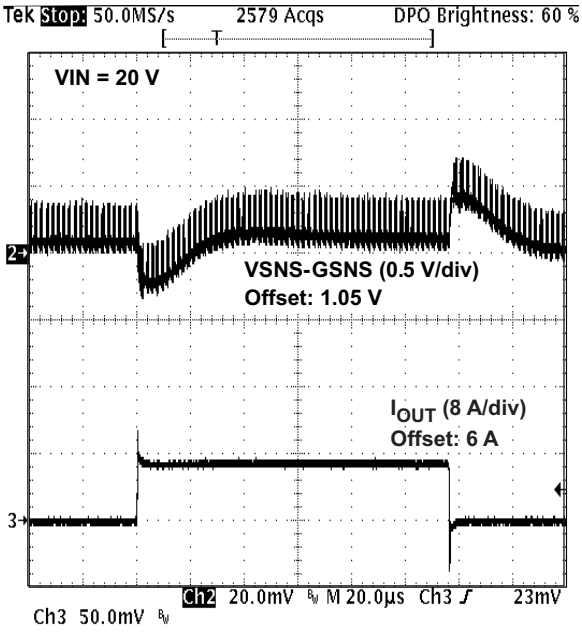

Figure 8. TPS51219EVM-630 Load Transient (V_{OUT}=1.05 V)

6.5 Output Ripple

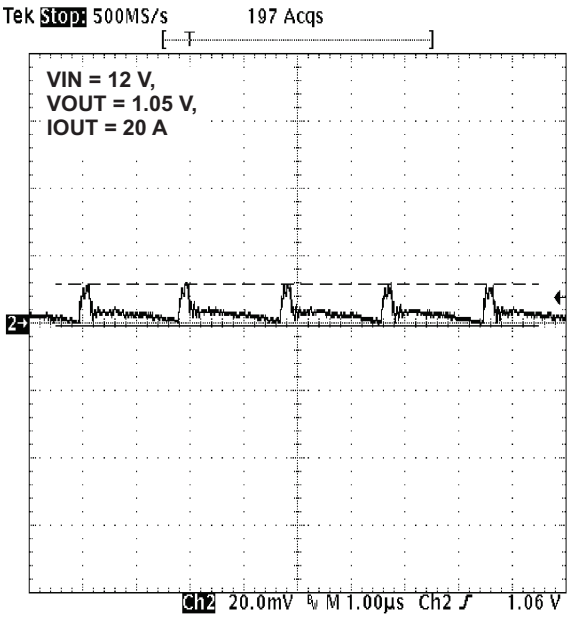

Figure 9. Output Ripple

6.6 Switch Node Voltage

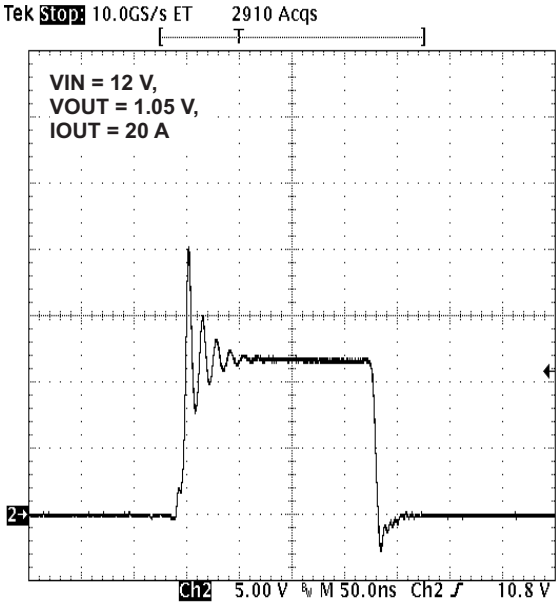

Figure 10. Switching Node Waveform

6.7 Turnon/Turnoff Waveform

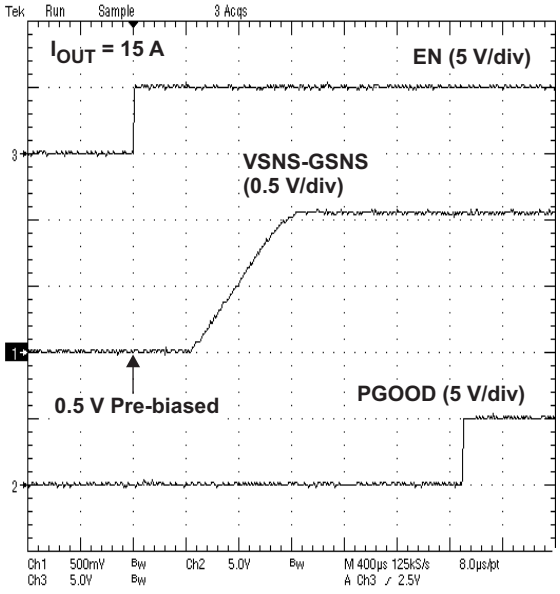

Figure 11. Enable Turnon

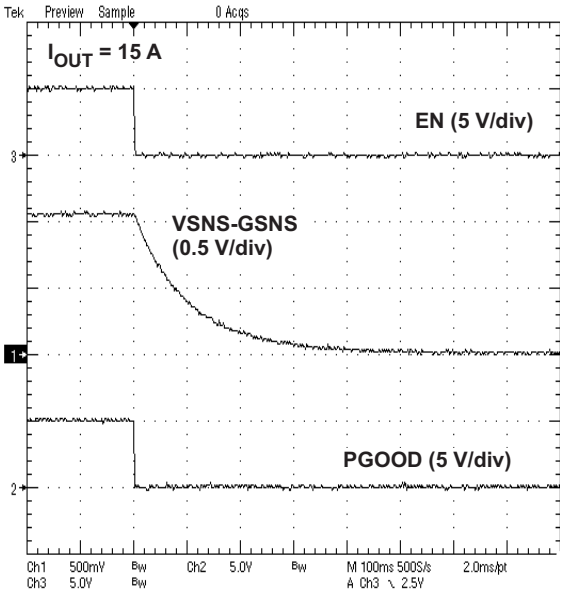

Figure 12. Enable Turnoff

6.8 Output 0.5-V Prebias Turnon Waveform

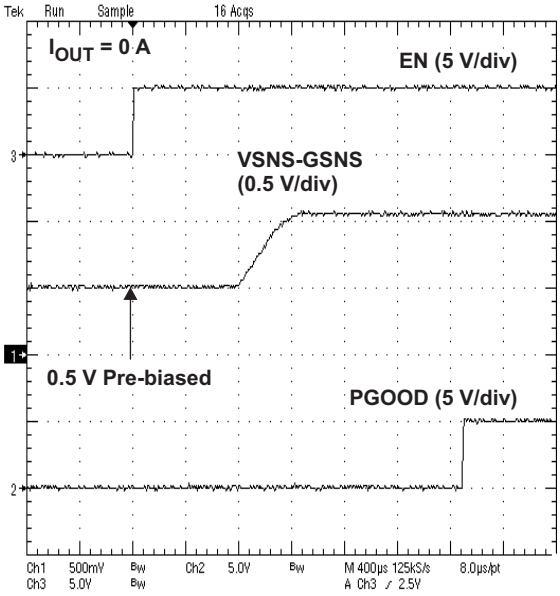

Figure 13. Output 0.5-V Prebias Turnon Waveform

7 EVM Assembly Drawing and PCB Layout

The following figures (Figure 15 through Figure 19) show the design of the TPS51219EVM-630 printed-circuit board (PCB). The EVM has been designed using four-layer, 2-oz copper circuit board.

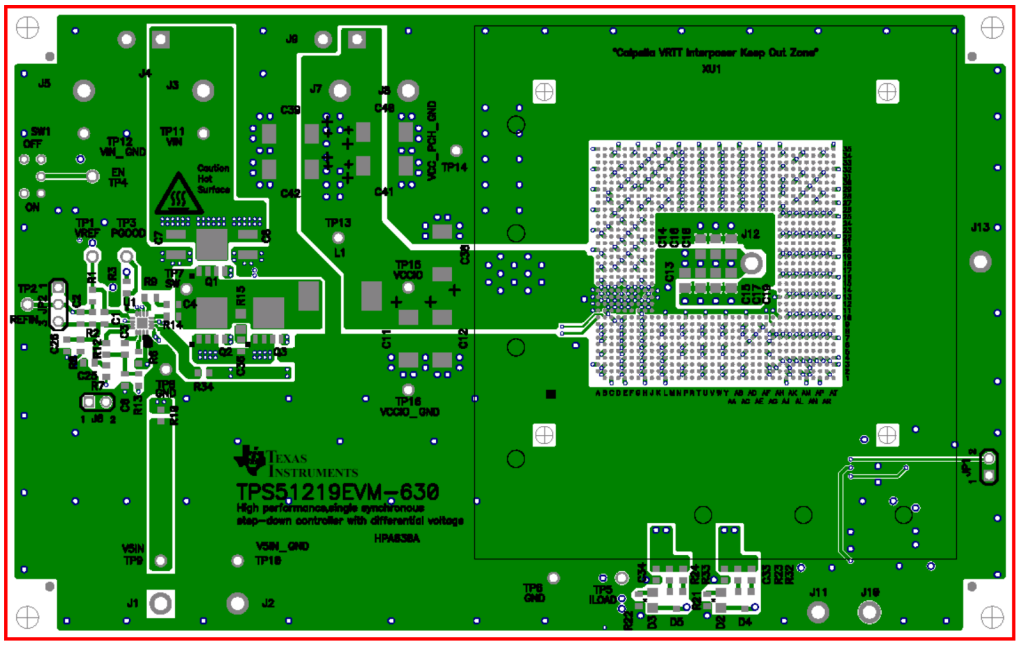

Figure 14. TPS51219EVM-630 Top Layer Assembly Drawing (Top View)

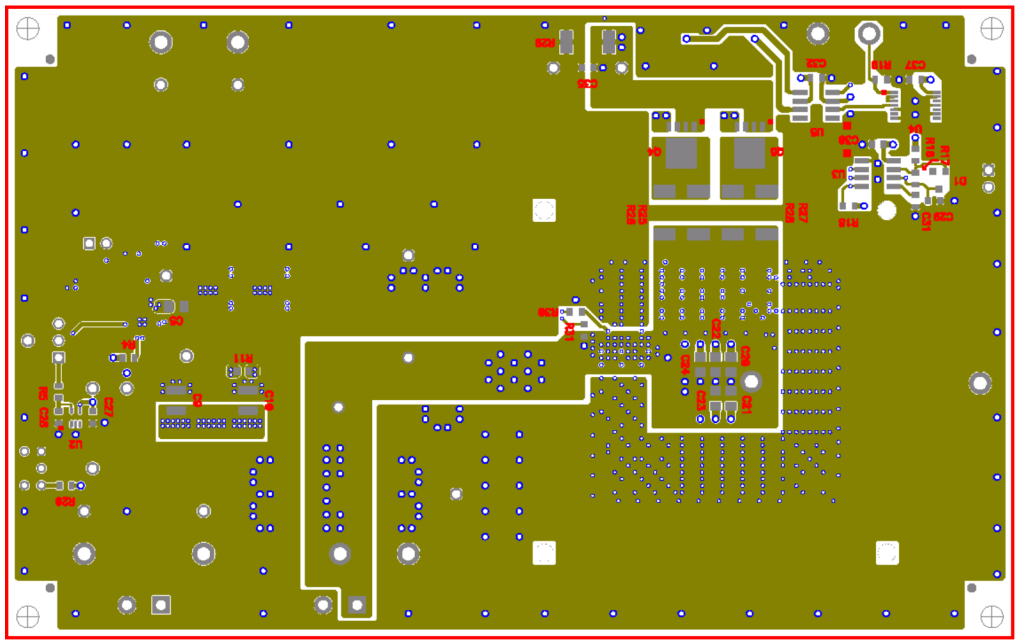

Figure 15. TPS51219EVM-630 Bottom Layer Assembly Drawing (Bottom View)

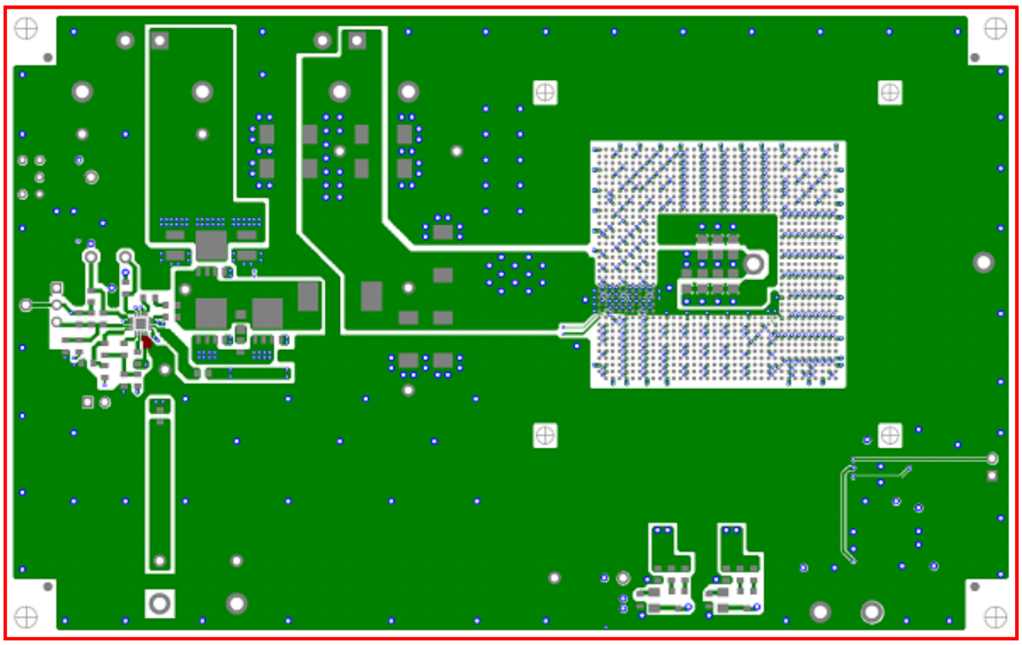

Figure 16. TPS51219EVM-630 Top Copper Layer (Top View)

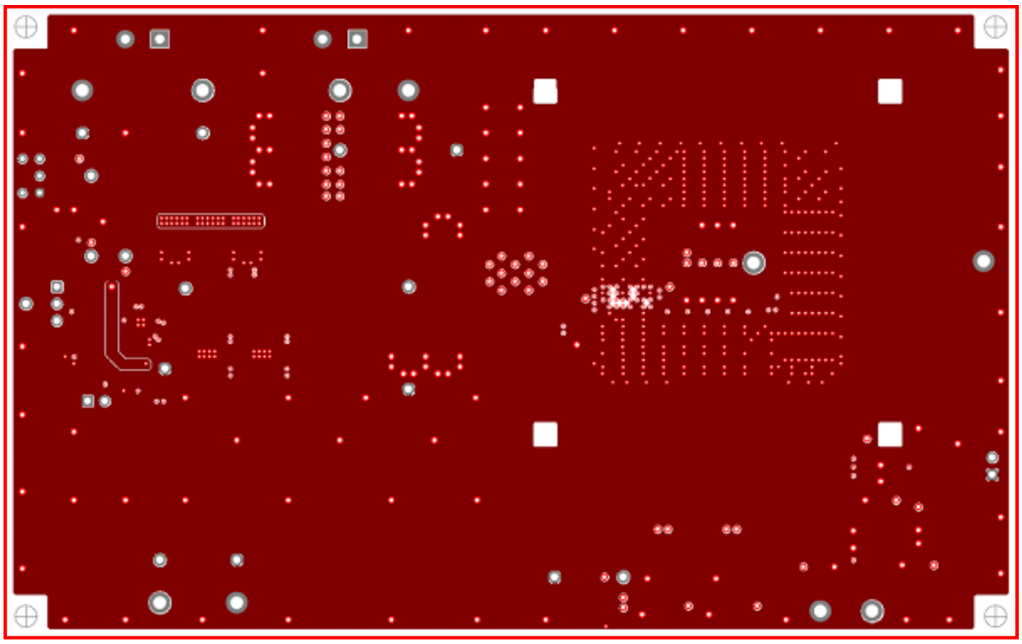

Figure 17. TPS51219EVM-630 Internal Layer 1 (Top View)

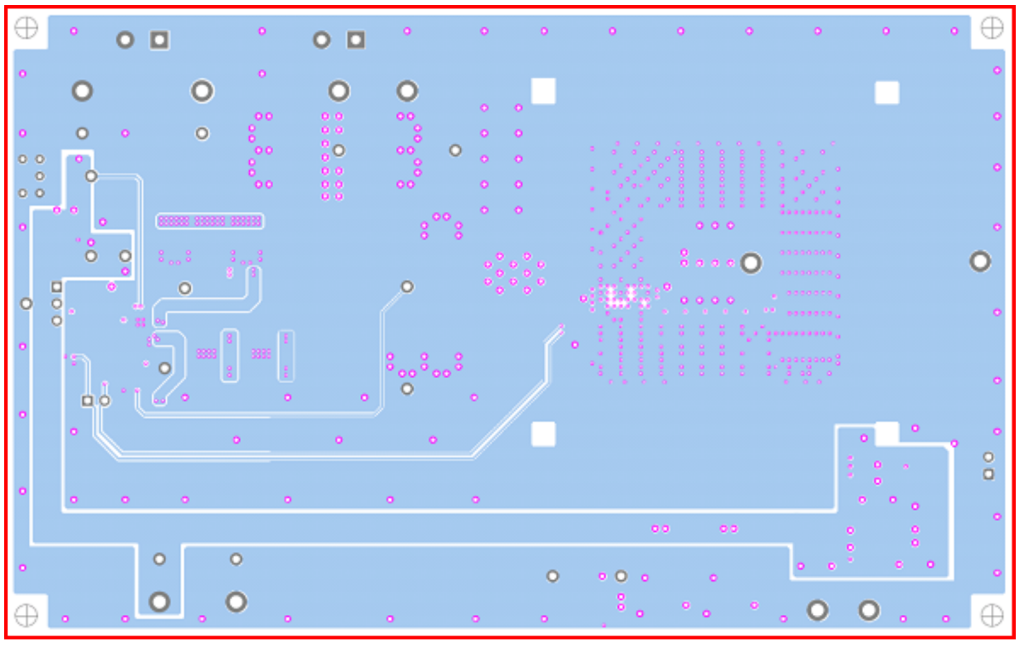

Figure 18. TPS51219EVM-630 Internal Layer 2 (Top View)

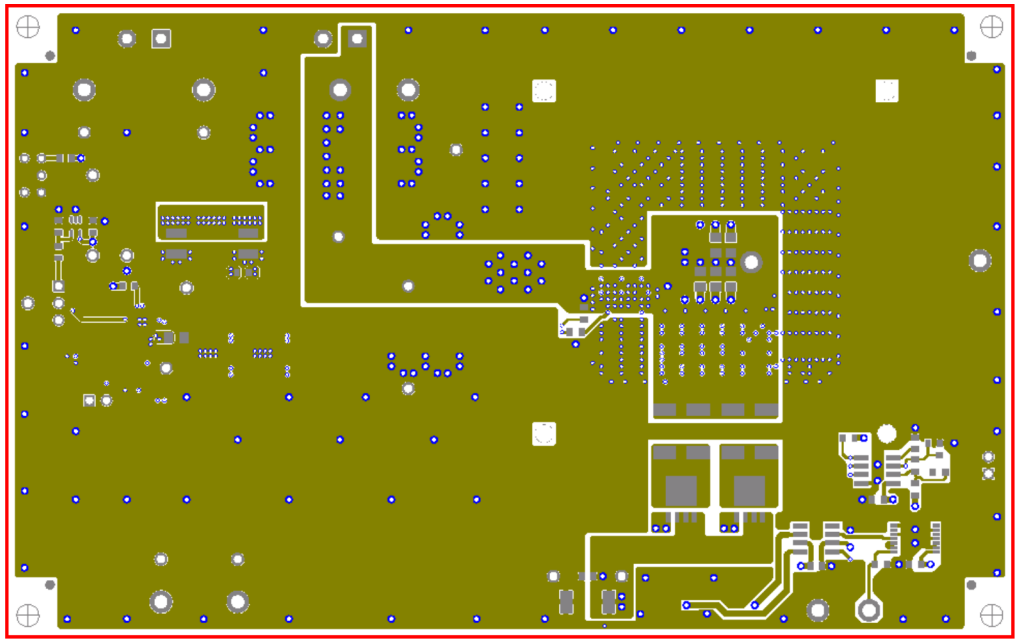

Figure 19. TPS51219EVM-630 Bottom Copper Layer (Top View)

8 Bill of Materials

Table 3. EVM Components List According to Schematic Shown in Figure 1

QTY	REFDES	VALUE	DESCRIPTION	PART NUMBER	MFR
7	C1, C4, C27, C29, C30, C31, C37	0.1 µF	Capacitor, Ceramic, 50 V, X5R, 10%	STD	STD
1	C3	10 nF	Capacitor, Ceramic, 50 V, X5R, 10%	STD	STD
1	C5	2.2 µF	Capacitor, Ceramic, 10 V, X5R, 10%	GRM188R61A225KE34	muRata
4	C7, C8, C9, C10	10 µF	Capacitor, Ceramic, 25 V, X5R, 20%	TMK325BJ106MM-T	Taiyo Yuden
5	C11, C12, C39, C40, C41	330 µF	Capacitor, Aluminum, 2 V, 6 mΩ, 20%	EEFSX0D331XE	Panasonic
12	C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24	22 µF	Capacitor, Ceramic, 6.3 V, X5R, 10%	JMK212BJ226MG-T	Taiyo Yuden
1	C28	0.47 µF	Capacitor, Ceramic, 50 V, X5R, 10%	STD	STD
2	C32, C35	1 µF	Capacitor, Ceramic, 10 V, X5R, 10%	C1608X5R1A105K	TDK
3	C25, C34, C36	1 nF	Capacitor, Ceramic, 50 V, CH, 10%	STD	STD
0	C2, C6, C26, C33, C38, C42	NU			
1	D1	BAT54	Diode, Schottky, 200 mA, 30 V	BAT54	STD
0	D2, D3, D4	NU			
1	D5	BAT54S	Diode, Dual Schottky, 200 mA, 30 V	BAT54S	STD
1	L1	0.36 µH	Inductor, Power Choke SMT, 30 A, 1.05 mΩ	MPCG1040LR36	NEC Tokin
1	Q1	CSD17302Q5A	MOSFET, NChan, 30 V, 87 A, 7.3 mΩ	CSD17302Q5A	TI
1	Q2	CSD17312Q5	MOSFET, NChan, 30 V, 100 A, 1.4 mΩ	CSD17312Q5	TI
1	Q4	CSD17303Q5	MOSFET, NChan, 30 V, 100 A, 2 mΩ	CSD17303Q5	TI
0	Q3, Q5	NU			
2	R3, R5	100 kΩ	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R4	1 kΩ	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R6	27 kΩ	Resistor, Chip, 1/16 W, 1%	STD	STD
7	R8, R10, R11, R12, R14, R30, R31	0 Ω	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R9	3.9 Ω	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R15	2.2 Ω	Resistor, Chip, 1/10 W, 1%	STD	STD
1	R16	1.5 kΩ	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R17	150 kΩ	Resistor, Chip, 1/16 W, 1%	STD	STD
3	R18, R19, R20	10 kΩ	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R24	240 Ω	Resistor, Chip, 1/16 W, 1%	STD	STD
2	R25, R26	0.25 Ω	Resistor, Chip, 1 W, 1%	WSL2512R2500FEA	Vishay
1	R29	0.005 Ω	Resistor, Chip, 1 W, 1%	ERJM1WSF5M0U	Panasonic
1	R7	10 Ω	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R33	130 Ω	Resistor, Chip, 1/16 W, 1%	STD	STD
1	R34	1 Ω	Resistor, Chip, 1/16 W, 1%	STD	STD
0	R1, R2, R13, R21, R22, R23, R27, R28, R32	NU			
1	SW1	G12AP	Switch, ON-ON Mini Toggle	G12AP	Nikkai
1	U1	TPS51219RTE	IC, High Performance, Single Synchronous Step-Down Controller	TPS51219RTE	TI
1	U2	TPS71533DCK	IC, Regulator, LDO, 50 mA, 24 V	TPS71533DCK	TI
1	U3	TLC555CD	IC, Timer, Low-Power CMOS	TLC555D	TI
1	U4	SN74HC14PW	IC, HEX Schmitt Trigger Inverters.	SN74HC14PW	TI
1	U5	UCC27324D	IC, Dual 4 A High Speed MOSFET Driver	UCC27324D	TI

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

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

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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 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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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。
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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。

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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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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

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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.

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Concernant les EVMs avec appareils radio

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Concernant les EVMs avec antennes détachables

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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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日本テキサス・インスツルメンツ株式会社
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http://www.tij.co.jp

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.
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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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IMPORTANT NOTICE

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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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TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

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Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

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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