

# Using the TPS53015EVM-126

## User's Guide



Literature Number: SLUU944  
June 2012

# **Single Synchronous Step-Down Controller for Low-Voltage Power Rails**

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## **1 Introduction**

The TPS53015EVM-126 evaluation module (EVM) presents an easy to use reference design for a typical point-of-load application in a stand-alone module using the TPS53015 controller in cost sensitive applications.

## **2 Description**

The TPS53015EVM-126 provides the user with a convenient way to evaluate the TPS53015 D-CAP2™ mode control in a cost sensitive application. Providing a 1.05-V output at up to 8 A from a loosely regulated 12 V (8 V – 22 V) source, the TPS53015EVM-126 is designed to demonstrate the TPS53015 in a typical point-of-load application while providing a number of test points to evaluate the performance of the TPS53015.

### **2.1 Typical Applications**

- Point-of-Load Regulations in Low-Power Systems for Wide Range of Applications
  - Digital TV Power Supply
  - Network Home Terminals
  - Digital Set Top Box (STB)
  - DVD Player/Recorder
  - Game Consoles and Others

### **2.2 Features**

The TPS53015EVM-126 features:

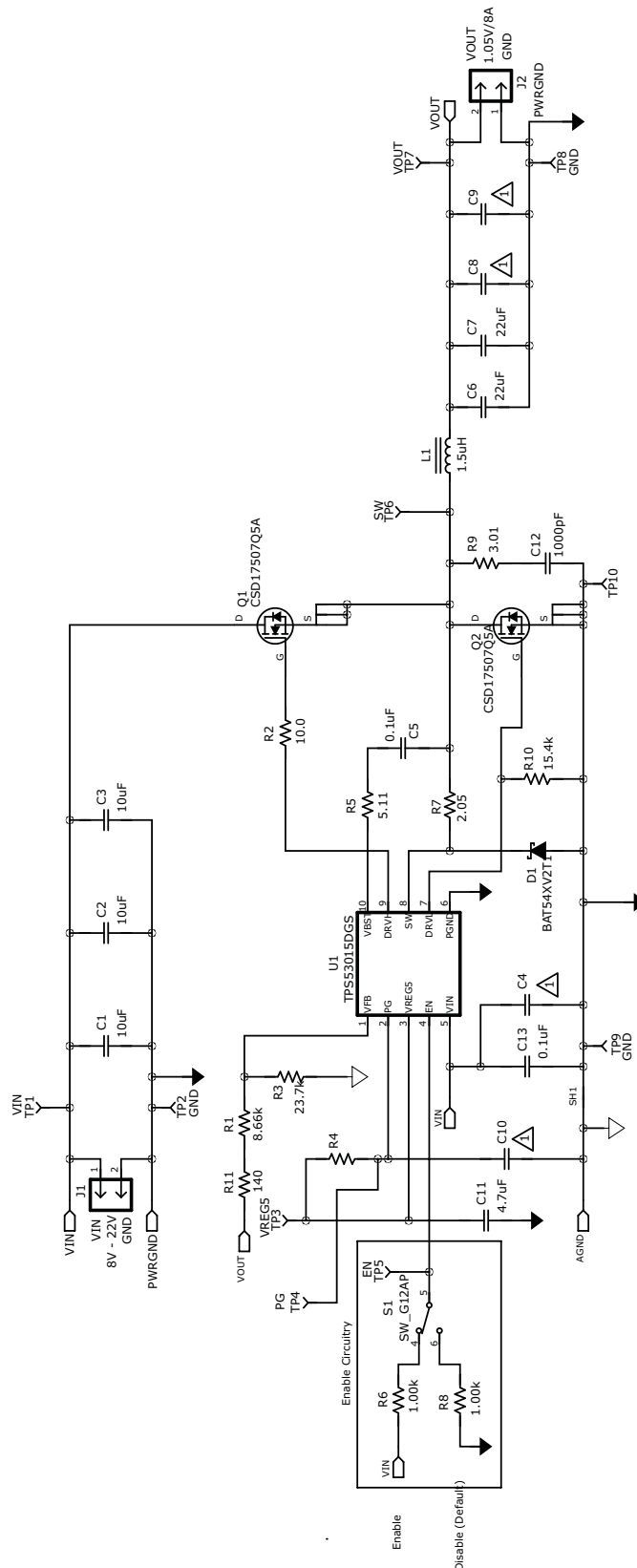
- D-CAP2™ Mode Control
  - Fast Transient Response
  - No External Parts Required For Loop Compensation
  - Compatible with Ceramic Output Capacitors
- Auto-Skip Eco-mode™ for High Efficiency at Light load
- 500-kHz switching frequency
- Power Good Indication
- Non-Sinking Pre-Biased Soft Start
- Cycle-by-Cycle Over-Current Limit
- Over-current, over-voltage, under-voltage and over-temperature protections
- Convenient test points for probing critical waveforms

### 3 Electrical Performance Specifications

**Table 1. TPS53015EVM-126 Electrical Performance Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>Input Characteristics</b>					
Voltage range	VIN	8.0	12	22	V
Maximum input current	VIN = 12 V, IOOUT = 8 A		0.9		A
No load input current	VIN = 12 V, IOOUT = 0 A		0.6		mA
<b>Output Characteristics</b>					
Output voltage			1.05		V
Output voltage regulation	Setpoint accuracy (VIN = 12 V, IOOUT = 8 A)	-2%		2%	
	Line regulation (VIN = 8.0 V – 22 V, IOOUT = 8 A)		1%		
	Load regulation (VIN = 12 V, IOOUT = 0 A – 8 A)		1.5%		
Output voltage ripple	VIN = 12 V, IOOUT = 8 A		20		mVpp
Output load current		0		8.0	A
Over current limit	VIN = 12 V		11		
<b>Systems Characteristics</b>					
Switching frequency			500		kHz
Peak efficiency	VIN = 12 V, IOOUT = 3.2 A		86.5%		
Full load efficiency	VIN = 12 V, IOOUT = 8.0 A		81.4%		
Operating temperature			25		°C

4 Schematic



Notes: NOT POPULATED

Figure 1. TPS53015EVM-126 Schematic

## 5 Test Setup

### 5.1 Test Equipment

#### Voltage Source:

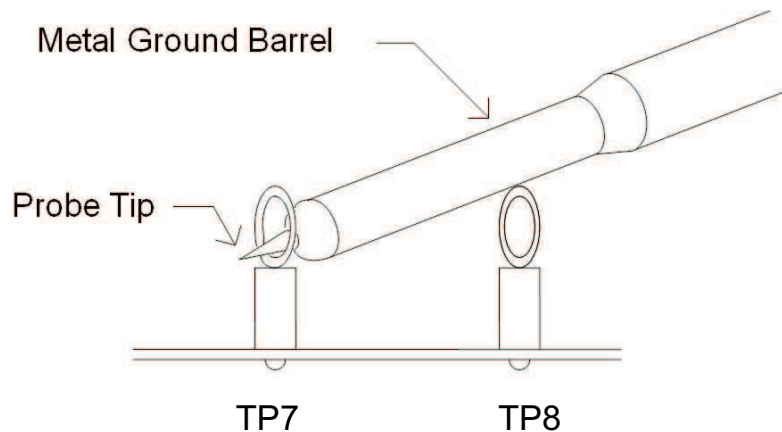
- **VIN:** The input voltage source VIN should be a 0-V to 30-V variable DC source capable of supplying 2 A<sub>DC</sub>. Connect VIN to J1 as shown in [Figure 3](#).

#### Multimeters:

- **V1:** VIN at TP1 (VIN) and TP2 (GND), 0-V to 30-V voltmeter.
- **V2:** VOUT at TP7 (VOUT) and TP8 (GND).
- **A1:** VIN input current, 0 A<sub>DC</sub> to 2 A<sub>DC</sub> Ammeter.

**Output Load:** The output load should be an electronic constant resistance mode load capable of 0 A<sub>DC</sub> to 8 A<sub>DC</sub> at 1.05 V.

**Oscilloscope:** A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope should be set for 1-MΩ impedance, 20-MHz bandwidth, AC coupling, 1-μs/division horizontal resolution, 50-mV/division vertical resolution. Test points TP7 and TP8 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP7 and holding the ground barrel on 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 85°C during operation. A small fan capable of 200 LFM to 400 LFM is recommended to reduce component temperatures while the EVM is operating. The EVM should not be probed while the fan is not running.

#### Recommended Wire Gauge:

- **VIN to J1:** The recommended wire size is 1x AWG #16 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
- **J2 to LOAD:** The minimum recommended wire size is 1x AWG #16, with the total length of wire less than 4 feet (2 feet output, 2 feet return)

## 5.2 Recommended Test Setup

Figure 3 is the recommended test set up to evaluate the TPS53015EVM-126. 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.

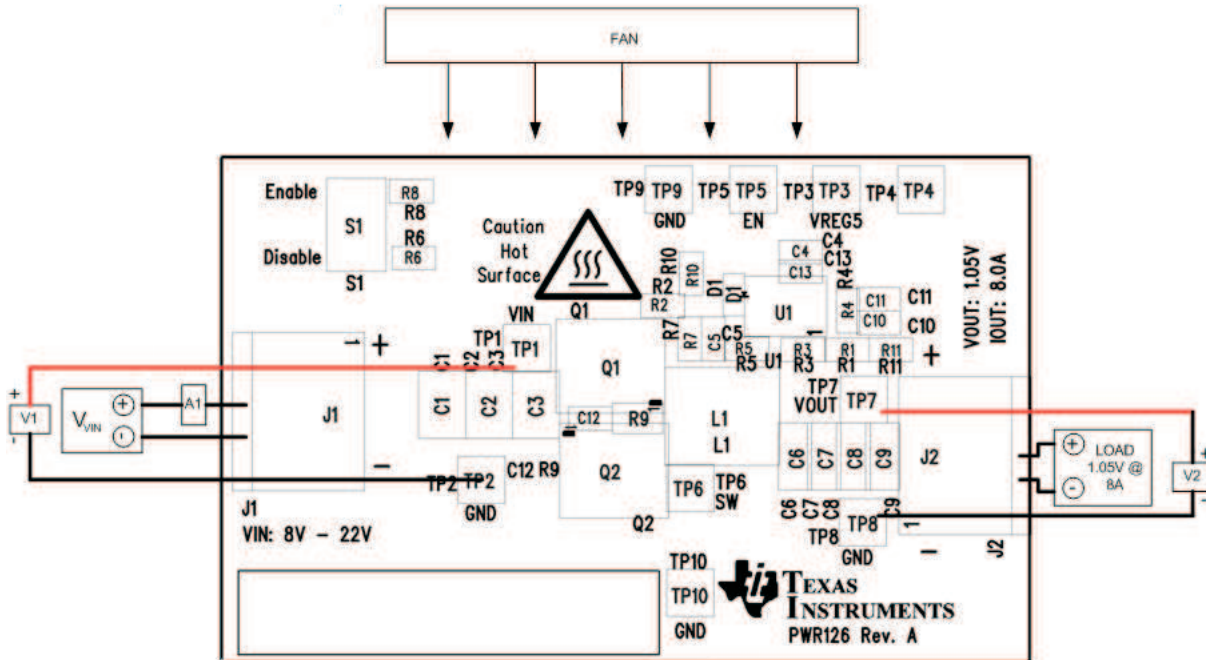


Figure 3. TPS53015EVM-126 Recommended Test Set Up

### Input Connections:

- Prior to connecting the DC input source  $V_{IN}$ , it is advisable to limit the source current from  $V_{IN}$  to 2 A maximum. Make sure  $V_{IN}$  is initially set to 0 V and connected to J2 as shown in Figure 3.
- Connect a current meter A1 between  $V_{IN}$  and J1 to measure the input current.
- Connect a voltmeter V1 at TP1 ( $V_{IN}$ ) and TP2 (GND) to measure the input voltage.

### Output Connections:

- Connect Load to J2 and set load to constant resistance mode to sink 0 A<sub>DC</sub> before  $V_{IN}$  is applied.
- Connect a voltmeter V2 at TP7 (VOUT) and TP8 (GND) to measure the output voltage.

**Other Connections:** Place a fan as shown in Figure 3 and turn on, making sure air is flowing across the EVM.

## 6 Configurations

### 6.1 Enable/Disable Switch S1

The TPS53015EVM-126 is equipped with a switch (S1) to drive the EN pin of the TPS53015. When S1 is in the Enable position, EN is connected to VIN, and the TPS53015 is enabled and generates a regulated 1.05-V output. When S1 is in the Disable position, EN is connected to GND, and the TPS53015 enters a high impedance output state.

**Default setting:** set S1 to the Disabled position to disable the controller

## 7 Test Procedure

### 7.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in [Section 5](#) and [Figure 3](#).
2. Ensure Load is set to constant resistance mode and to sink 0 A<sub>DC</sub>.
3. Ensure the switch S1 is set per [Section 6](#).
4. Increase VIN from 0 V to 12 V. Using V1 to measure VIN voltage.
5. Set the switch S1 to Enable position to enable the controller.
6. Use V2 to measure VOUT voltage, A1 to measure VIN current.
7. Vary load from 0-8 A<sub>DC</sub>, VOUT should remain in load regulation.
8. Vary VIN from 8.0 V to 22 V, VOUT should remain in line regulation.
9. Set the switch S1 to Disable position to disable the controller.
10. Decrease load to 0 A.
11. Decrease VIN to 0 V.

### 7.2 List of Test Points

**Table 2. Test Point Functions**

TEST POINTS	NAME	DESCRIPTION
TP1	VIN	Input voltage
TP2	GND	GND
TP3	VREG5	Output of 5-V linear regulator
TP4	PG	Power good
TP5	EN	Enable pin
TP6	SW	Switching node
TP7	VOUT	Output voltage
TP8	GND	GND
TP9	GND	GND
TP10	GND	GND

### 7.3 Equipment Shutdown

1. Shut down VIN.
2. Shut down Load.
3. Shut down FAN.

## 8 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 14 present typical performance curves for TPS53015EVM-126.

### 8.1 Efficiency

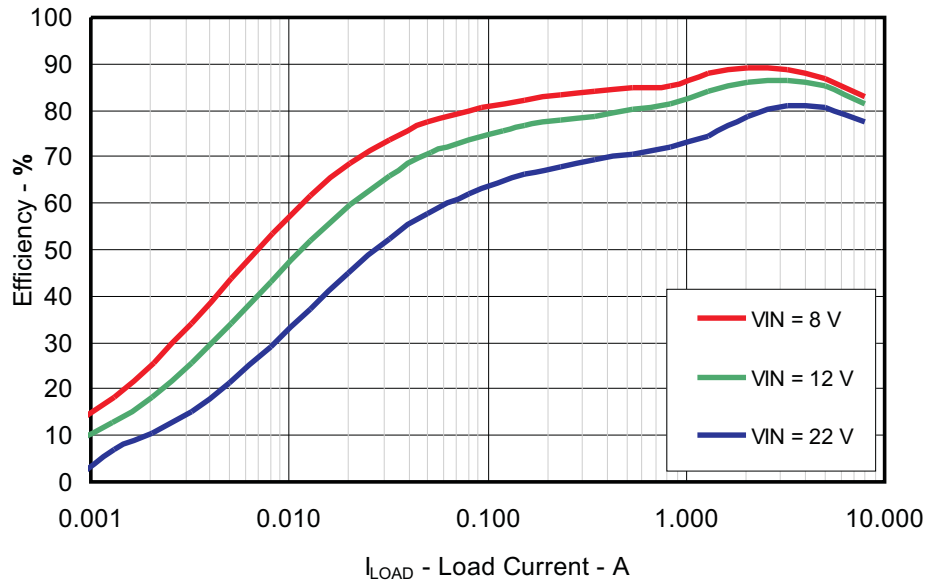


Figure 4. Efficiency

### 8.2 Load Regulation

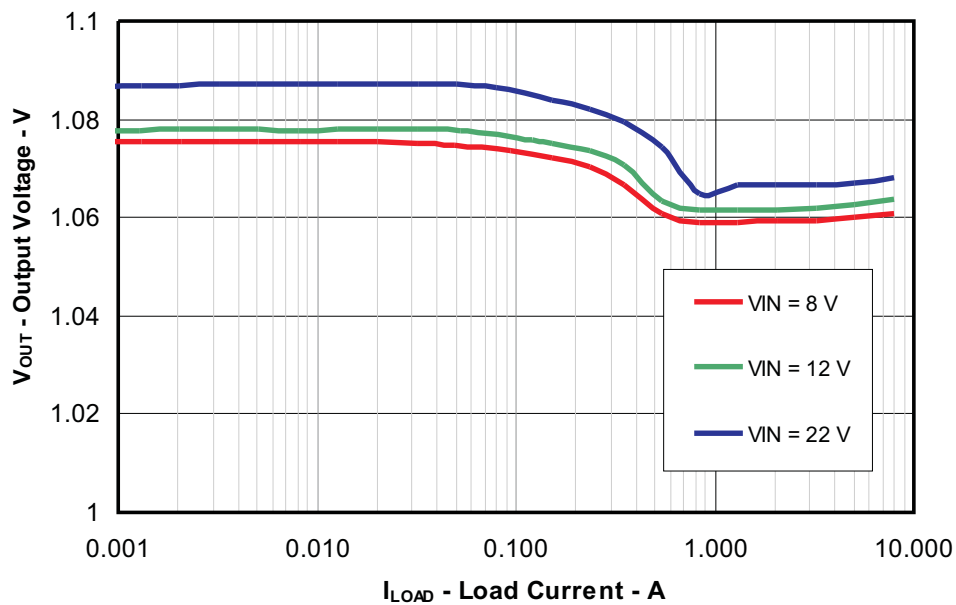


Figure 5. Load Regulation



### 8.3 Line Regulation

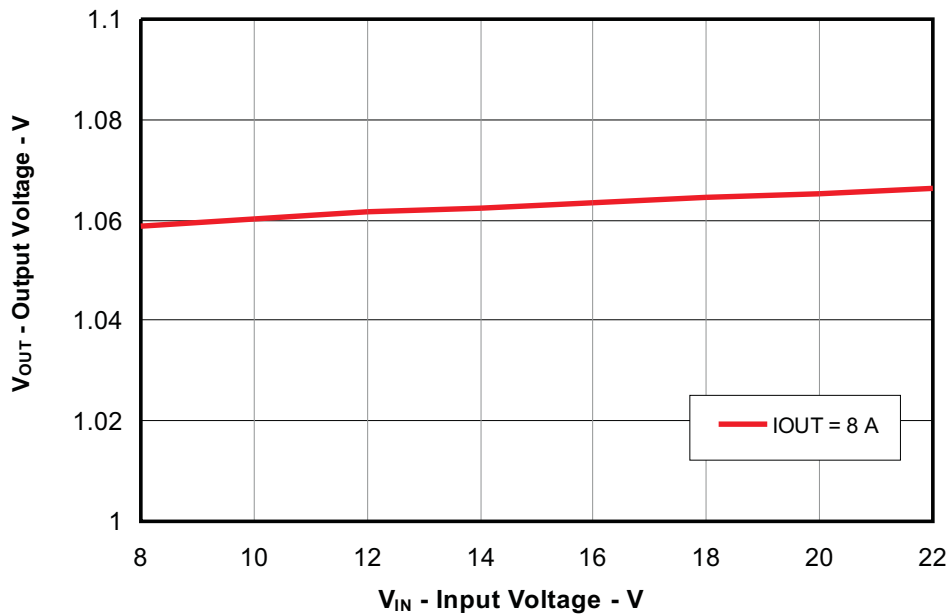


Figure 6. Line Regulation

### 8.4 Load Transient

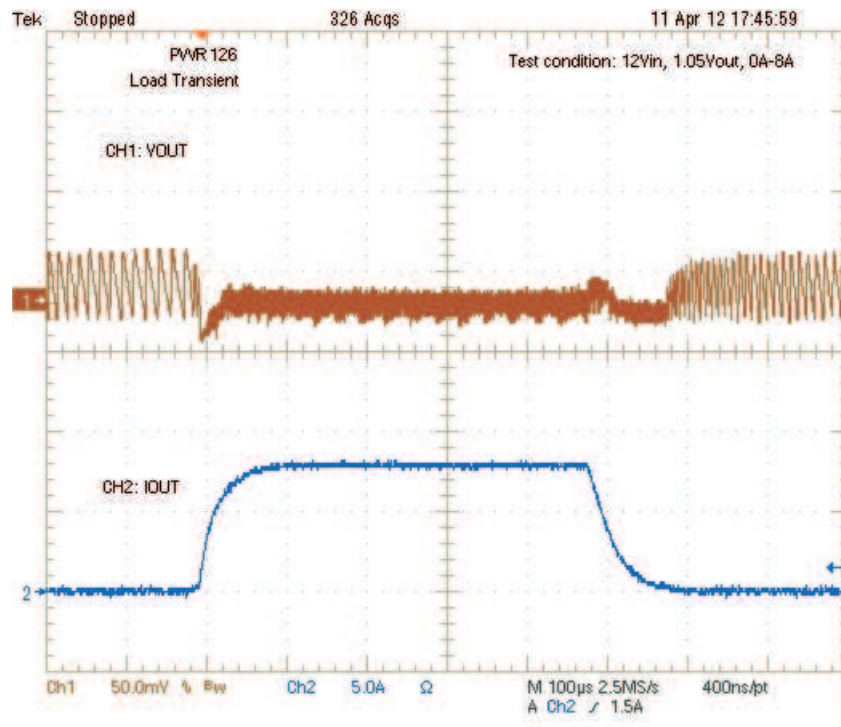
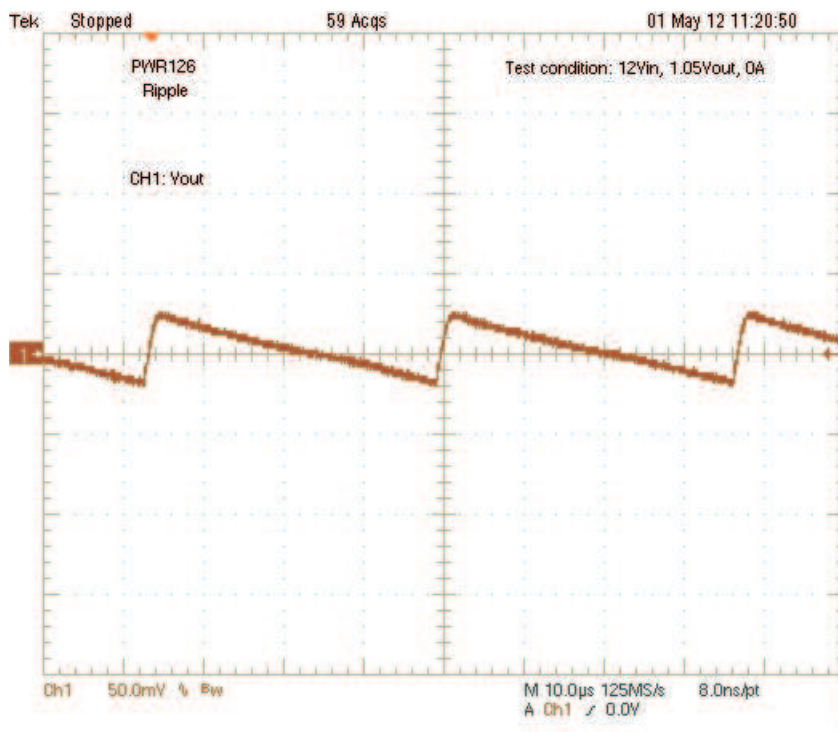
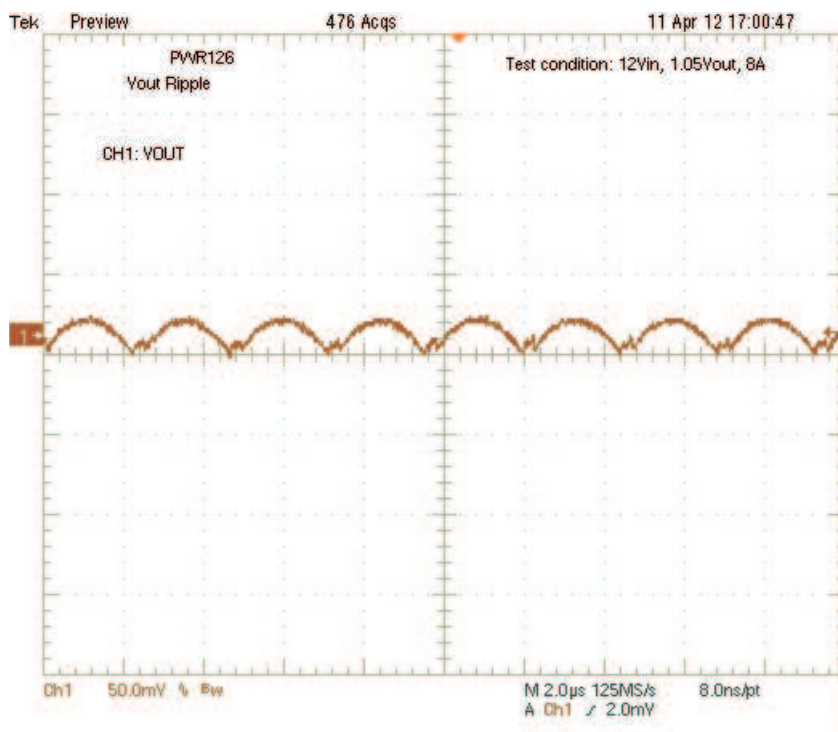


Figure 7. Output Load 0-8A Transient (12-V V<sub>IN</sub>, 1.05-V V<sub>OUT</sub>)

### 8.5 Output Ripple

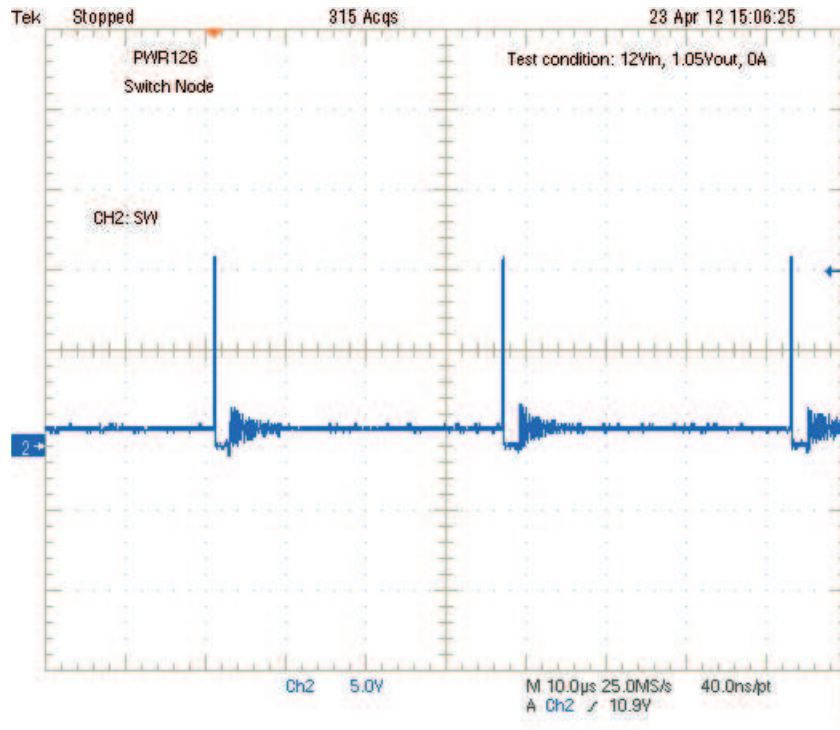


**Figure 8. Output Ripple at No Load (12-V VIN, 1.05-V VOUT, 0-A)**

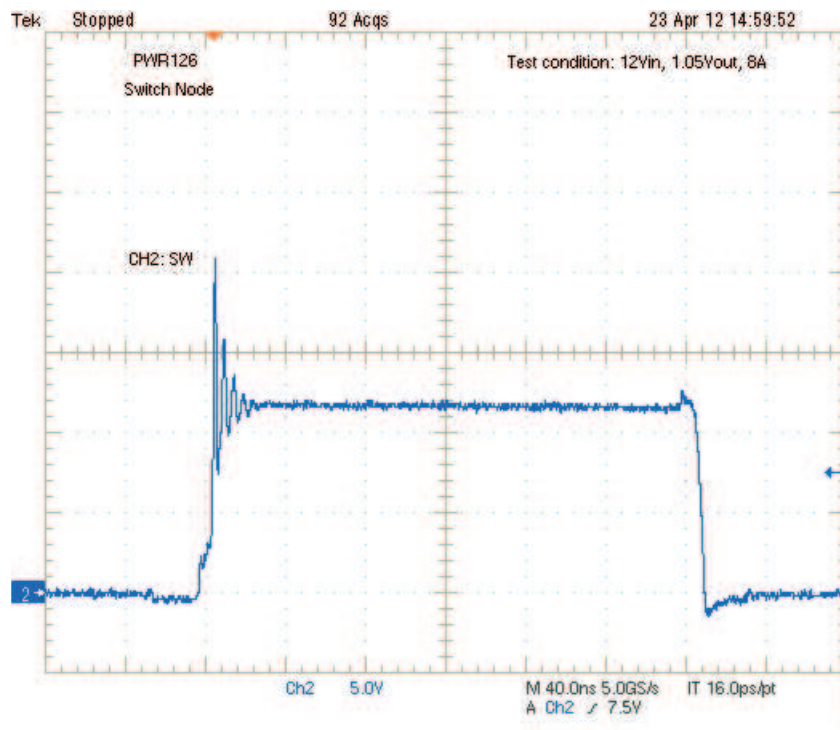


**Figure 9. Output Ripple at Full Load (12-V VIN, 1.05-V VOUT, 8-A)**

### 8.6 Switching Node

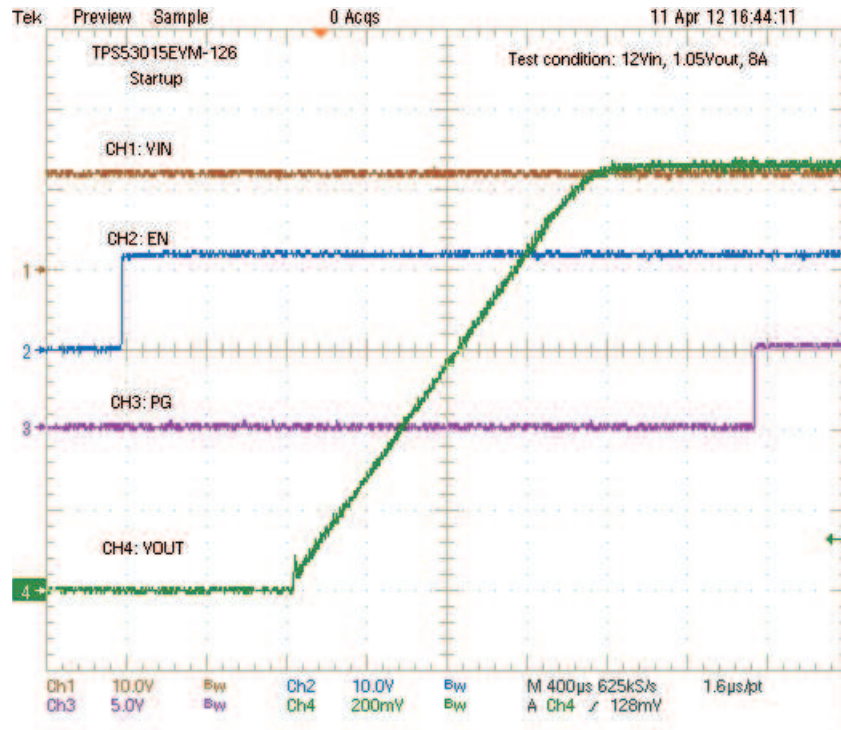


**Figure 10. Switching Node at No Load  
(12-V VIN, 1.05-V VOUT, 0-A)**



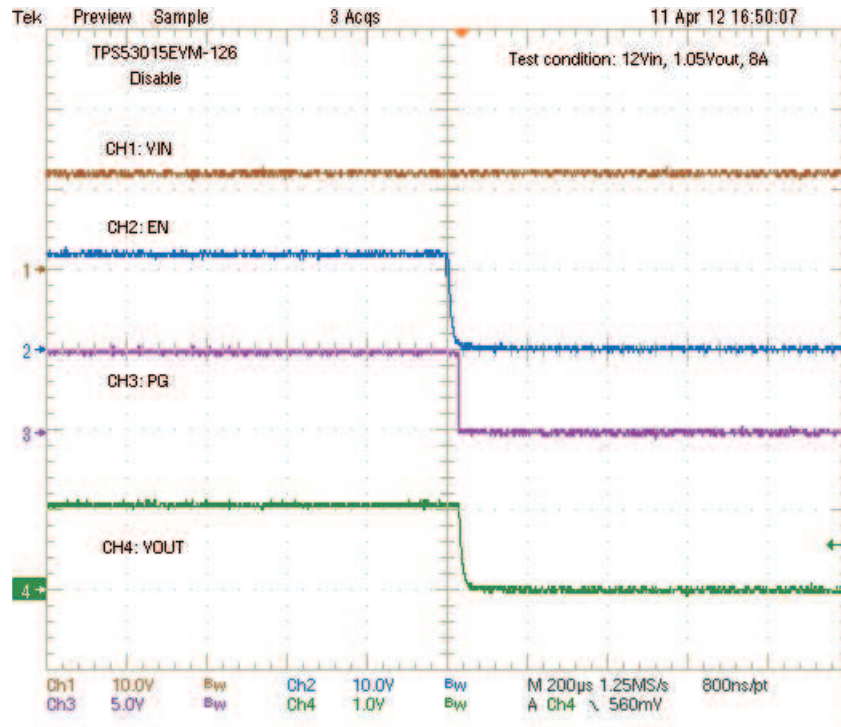
**Figure 11. Switching Node at Full Load  
(12-V VIN, 1.05-V VOUT, 8-A)**

### 8.7 Enable Start-up



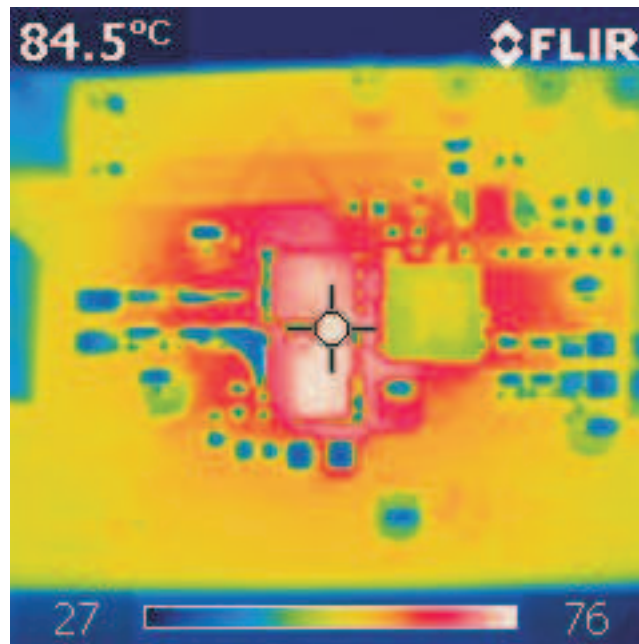
**Figure 12. Start-up Waveform**  
(12-V VIN, 1.05-V VOUT, 8-A IOUT)

### 8.8 Disable



**Figure 13. Shut-down Waveform**  
(12-V VIN, 1.05-V VOUT, 8-A IOUT)

## 8.9 Thermal Image



**Figure 14. Thermal Image**  
(22-V VIN, 1.05-V VOUT, 8-A IOU, no air flow)

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**NOTE:** The hottest spot is the surface of snubber resistor and power MOSFET, not the surface of TPS53015 controller device.

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## 9 EVM Assembly Drawing and PCB Layout

The following figures (Figure 15 through Figure 19) show the design of the TPS53015EVM-126 printed circuit board. The EVM has been designed using a 4-layer, 2-ounce copper circuit board.

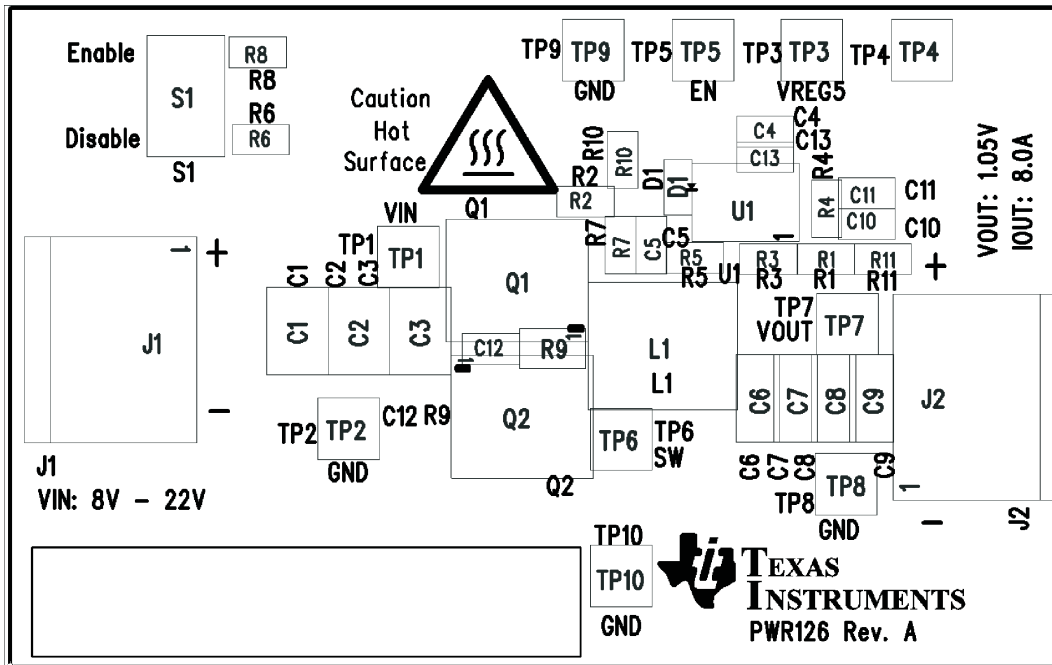


Figure 15. TPS53015EVM-126 Top Layer Assembly Drawing (top view)

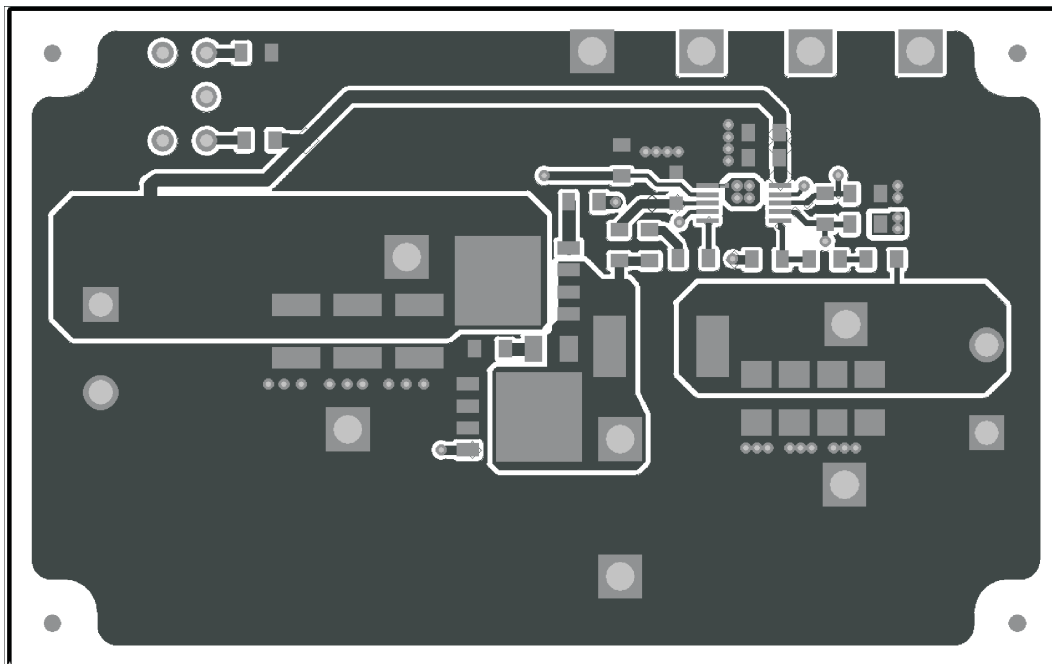


Figure 16. TPS53015EVM-126 Top Copper (top view)

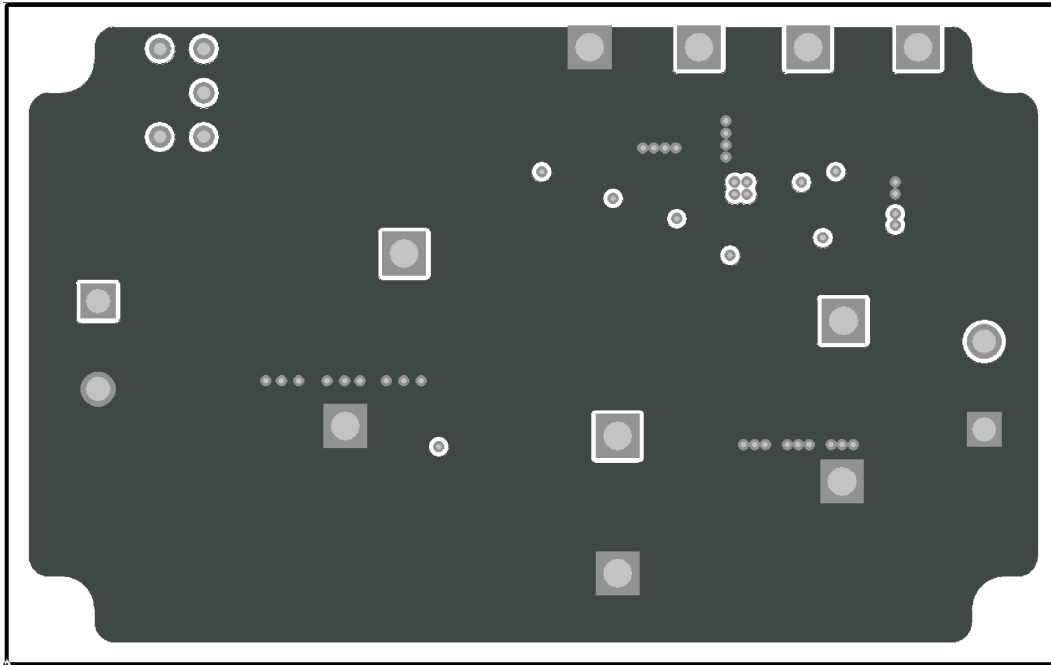


Figure 17. TPS53015EVM-126 Layer 2 (top view)

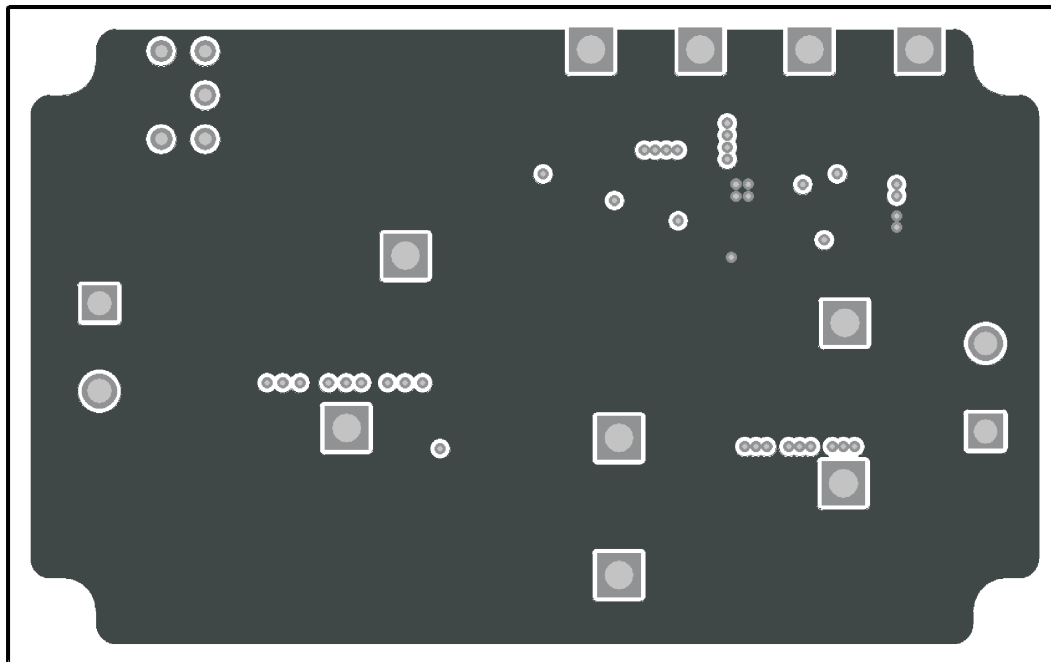


Figure 18. TPS53015EVM-126 Layer 3 (top view)

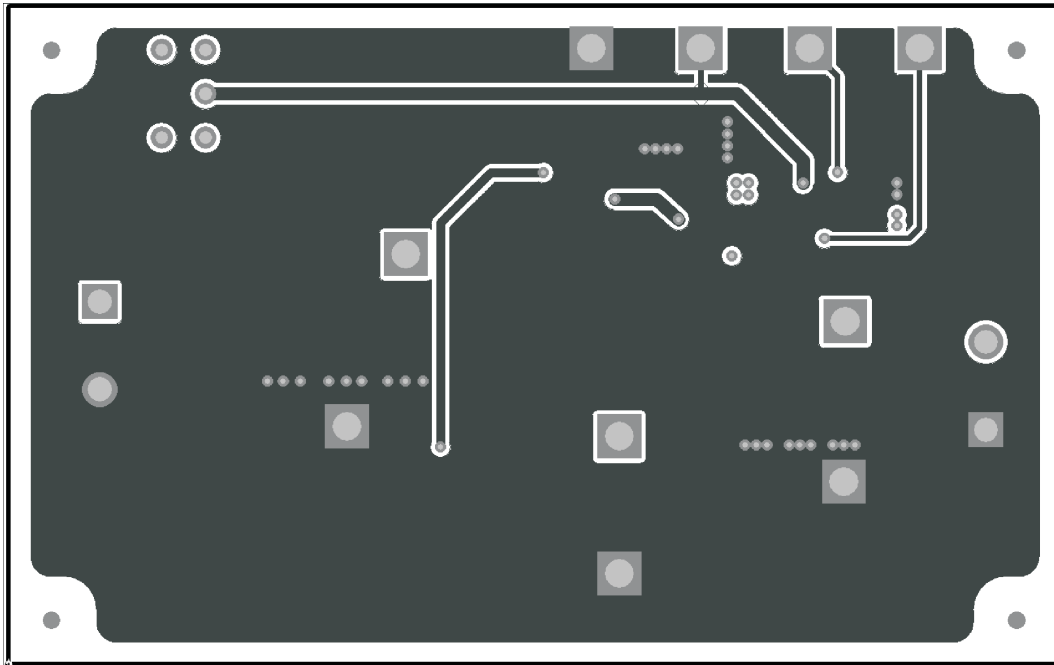


Figure 19. TPS53015EVM-126 Bottom Layer (top view)



## 10 List of Materials

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

**Table 3. TPS53015EVM-126 List of Materials**

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
3	C1, C2, C3	Capacitor, ceramic, 35 V, X5R, 20%, 10 $\mu$ F, 1210	Std	Std
0	C4	Capacitor, ceramic, 35 V, X7R, 10%, 1 $\mu$ F, 0603	Std	Std
1	C5	Capacitor, ceramic, 10 V, X7R, 10%, 0.1 $\mu$ F, 0603	Std	Std
2	C6, C7	Capacitor, ceramic, 10 V, X5R, 20%, 22 $\mu$ F, 1206	Std	Std
0	C8, C9	Capacitor, ceramic, 10 V, X5R, 20%, 22 $\mu$ F, 1206	Std	Std
0	C10	Capacitor, ceramic, 10 V, X7R, 10%, 0.01 $\mu$ F, 0603	Std	Std
1	C11	Capacitor, ceramic, 10 V, X7R, 10%, 4.7 $\mu$ F, 0603	Std	Std
1	C12	Capacitor, ceramic, 50 V, X7R, 10%, 1000 pF, 0603	Std	Std
1	C13	Capacitor, ceramic, 50 V, X7R, 10%, 0.1 $\mu$ F, 0603	Std	Std
1	D1	Diode, Schottky, 10 mA, 30 V, SOD523	BAT54XV2T1G	On Semi
2	J1, J2	Connector, 15 A, 300 V, male 2 pole, 5.08 mm, 9 mm x 12 mm	ED120/2DS	On Shore Tech
1	L1	Inductor, 11 A, 6 m $\Omega$ , $\pm$ 20%, 1.5 $\mu$ H, 6.6 mm x 7 mm	PCMB065T-1R5MS	Cyntec
2	Q1, Q2 <sup>(1)</sup>	MOSFET, N-channel, 30 V, 13 A, 11.8 m $\Omega$ , SON, 5 mm x 6 mm	CSD17507Q5A	TI
		MOSFET, N-channel, 30 V, 14 A, 9.0 m $\Omega$ , SON, 5 mm x 6 mm	CSD17551Q5A	
1	R1	Resistor, chip, 1/10 W, 1%, 8.66 k $\Omega$ , 0603	Std	Std
1	R2	Resistor, chip, 1/10 W, 1%, 10.0 $\Omega$ , 0603	Std	Std
1	R3	Resistor, Chip, 1/10 W, 1%, 23.7 k $\Omega$ , 0603	Std	Std
1	R4	Resistor, chip, 1/10 W, 1%, 100 k $\Omega$ , 0603	Std	Std
1	R5	Resistor, chip, 1/10 W, 1%, 5.11 $\Omega$ , 0603	Std	Std
2	R6, R8	Resistor, chip, 1/10 W, 1%, 1.00 k $\Omega$ , 0603	Std	Std
1	R7	Resistor, chip, 1/10 W, 1%, 2.05 $\Omega$ , 0603	Std	Std
1	R9	Resistor, chip, 1/4 W, 1%, 3.01 $\Omega$ , 0805	Std	Std
1	R10	Resistor, chip, 1/10 W, 1%, 15.4 k $\Omega$ , 0603	Std	Std
1	R11	Resistor, chip, 1/10 W, 1%, 140 $\Omega$ , 0603	Std	Std
1	S1	Switch, on-none-on, 0.28 inch x 0.18 inch	G12AP-RO	NKK
4	TP1, TP3, TP6, TP7	Test point, red, thru hole, 0.125 inch x 0.125 inch	5010	Keystone
4	TP2, TP8, TP9, TP10	Test point, black, thru hole, 0.125 inch x 0.125 inch	5011	Keystone
2	TP4, TP5	Test point, white, thru hole, 0.125 inch x 0.125 inch	5012	Keystone
1	U1	IC, Single Synchronous Step-Down Controller, VSSOP	TPS53015DGS	TI
1	--	PCB, 2.4 inch x 1.5 inch x 0.062 inch	PWR126	TI

<sup>(1)</sup> The CSD17551Q5A can be used as alternate part to the CSD17507Q5A.

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 8.0 VDC to 22.0 VDC and the output voltage range of 0 ADC to 8 ADC.

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 80°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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### 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

**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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