

## **TPS62090EVM-063 Evaluation Module**

This user's guide describes the TPS62090 evaluation module (EVM) and how to perform a stand-alone evaluation or interface with a host or system. The TPS62090 is a step-down converter that operates with an input voltage between 2.5 V and 6 Vdc, an output voltage of 1.8 V using external resistors, and can deliver up to 3000 mA of continuous current. The converter has a programmable soft-start, a power-out good status, and several other safety features. See the data sheet for the complete description.

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## 1 Introduction

The TPS62090 device family is a high-frequency synchronous step down converter optimized for small solution size, high efficiency and is suitable for battery-powered applications. To maximize efficiency, the converter operates in PWM mode with a nominal switching frequency of 2.8 MHz/1.4 MHz and automatically enters Power Save Mode operation at light-load currents. When used in distributed power supplies and point-of-load regulation, the device allows voltage tracking to other voltage rails and tolerates capacitors ranging from 22  $\mu\text{F}$  up to 100  $\mu\text{F}$ . Using the DCS Control™ topology, the device achieves excellent load transient performance and accurate output voltage regulation. The device is available in 3 x 3-mm, 16-pin package with thermal pad.

## 2 Considerations When Evaluating the TPS62090

The TPS62090 can be programmed for a switching frequency of 2.8 MHz/1.4 MHz by JP2. The higher switching frequency reduces the ripple current and voltage. If the LC filter is adjusted, note that the inductor minimum value is 1  $\mu\text{H}$  for the 1.4-MHz setting and 0.47  $\mu\text{H}$  for the 2.8-MHz setting. The EVM was built with a 1- $\mu\text{H}$  inductor and a 22- $\mu\text{F}$  output capacitor. The integrated circuit (IC) has a two-stage input current limit that sets the initial current limit to one third (approximately 1.55 A) of the normal peak current limit of approximately 4.6 A, when the output is less than 0.6 V. Most system loads do not become enabled or active until the output has reached 0.8 V, which is after the initial start-up current limit. If a low-resistance load is used (less than approximately 1  $\Omega$ ), the part can get stuck in short-circuit mode during power up. Thus, very heavy loads may have to be applied after power up or the user can place an N-CH logic level FET in series with the resistor (drain connected to ground side of resistor, source connected to ground and gate tied to the drain). Once the output reaches approximately 1 V, the load turns on.

## 3 Test Summary

The TPS62090EVM-063 board requires an adjustable dc power supply with up to a 6-V output and  $\geq 2.5$  A for powering the input to the EVM and a resistive output load between 1 k $\Omega$  and 0.6  $\Omega$ . Choose the proper power rating for the load resistor,  $P = V^2 / R$ . Use at least 2x the calculated power dissipation. The test setup connections and jumper settings selections are configured for a stand-alone evaluation, but can be changed to interface with external hardware such as a system load and microcontroller.

### 3.1 Equipment

- Adjustable dc power supply between 2.5 V and 6 V with adjustable current limit set to approximately 2.5 A
- Load: System load, resistive load of 2  $\Omega$ , 3 W, and 25  $\Omega$
- Three Fluke 75 digital multimeters (DMM); (equivalent or better)
- Oscilloscope, model TDS222 (equivalent or better)

### 3.2 Equipment and EVM Setup

Table 1 shows the setup input/output connections and configuration of the TPS62090 evaluation module.

The silk screen labels appear in parentheses.

**Table 1. Setup I/O Connections and Configuration for TPS62090EVM Evaluation**

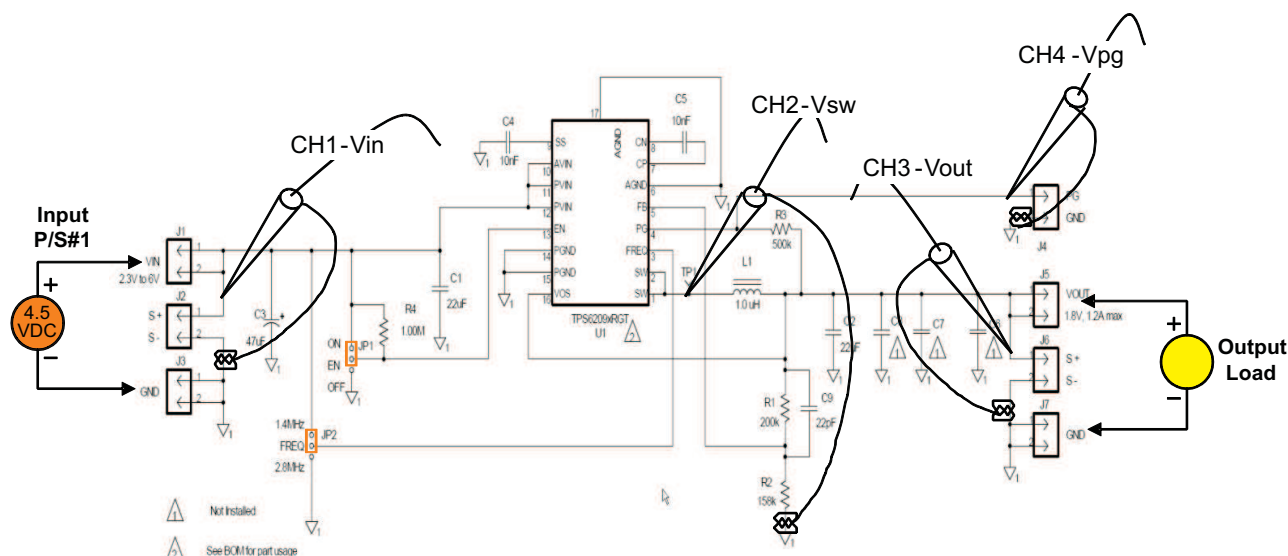
Jack/Component (Silk Screen)	Connect or Adjustment to:
J1-1/2 (Vin)	P/S positive lead, preset to 4.5 Vdc; 2.5-A Current Limit
J2-1 (+ SNS);	Input Positive lead of DMM #1
J2-2 (– SNS);	Input Negative lead of DMM #1
J3-1/2 (GND)	P/S negative lead.
J5-1/2 (Vout)	Positive lead to system load or load resistance
J6-1 (+ SNS);	Output Positive lead of DMM #2
J6-2 (– SNS);	Output Negative lead of DMM #2
J7-1/2 (GND)	Negative lead to system load or load resistance
J4-1 (PG)	Positive lead of DMM #3

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**Table 1. Setup I/O Connections and Configuration for TPS62090EVM Evaluation (continued)**

Jack/Component (Silk Screen)	Connect or Adjustment to:
J4-2 (GND)	Negative lead of DMM #3
JP1-1/2 (ON)	Apply shunt to <b>ON</b> for converter operation
JP1-2/3 (OFF)	
JP2-1/2 (1.4 MHz)	Apply shunt to <b>1.4 MHz</b>
JP1-2/3 (2.8 MHz)	

Connect the meters, scope probes (see [Figure 1](#)), 2- $\Omega$  output load, shunt jumpers, and input power supply ( [Table 1](#)); set the oscilloscope to 200 ns/div, positive trigger or HF trigger on CH2; CH1: ac-coupled, 50 mV/div; CH2: dc-coupled, 2 V/div; CH3: ac-coupled, 10 mV/div; CH4: dc-coupled, 10 V/div. Users can replace resistive load with system load or decade load box to vary load (2- $\Omega$  to 25- $\Omega$  load).



**Figure 1. EVM Schematic and Evaluation Setup**

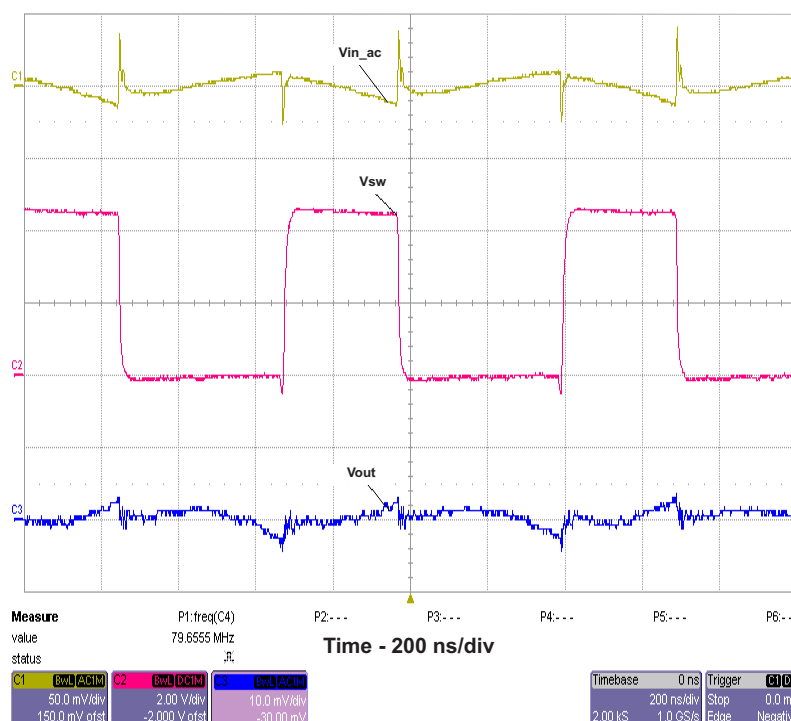
### 3.3 Test Procedure

1. Set up the EVM is according to [Table 1](#) and [Figure 1](#), and preset the power supply to 4.5 Vdc at approximately 2.5-A current limit.
2. Turn on input supply, and verify that the input voltage is approximately 4.5 Vdc (DMM#1) and the output voltage is at approximately 1.8 Vdc (DMM#2).
3. Refer to [Figure 2](#), and verify that the duty cycle is near 40%, input ripple is less than 50 mVpp (ignoring switching spikes) and the output ripple is less than 10 mVpp. These waveforms were taken with high-frequency probes (meaning that the ground lead was short (approximately 1 cm). This reduces the high-frequency spikes that the ground loop on the probe picks up.
4. Vary input voltage between 2.6 V and 5.5 V, and observe the change in duty cycle and ripple waveforms. Set Vin back to 4.5 Vdc.
5. Move JP2 From: 1.4 MHz to 2.8 MHz. Verify that the change is switching frequency as shown in [Figure 3](#). Return the JP2 shunt back to the 1.4-MHz setting.
6. Change the output load to 25  $\Omega$ , set CH3 to 50mV/div, and verify how the duty cycle changes into a *burst* low-power mode as seen in [Figure 4](#). At the end of the burst switching, the inductor's current goes to zero, becomes discontinuous, and rings with the FET and output capacitance (normal operation at light loads). Set the load back to approximately 2  $\Omega$ .
7. Turn off the input supply. Set CH1 to dc coupled, 2 V/div; set CH3 to dc coupled, 1 V/div; CH4 to dc coupled, 5 V/div; set oscilloscope timing to 500  $\mu$ s/div, set scope trigger to positive or HF trigger on CH1, and arm oscilloscope. Turn on laboratory supply. The laboratory supply used to capture [Figure 5](#)

ramped up over 3 ms. [Figure 6](#) is a hot plug power up. The output ramp rate is the same in both figures due to the controlled soft-start. The output can be programmed to track another voltage by use of the soft-start pin. See the data sheet for more details.

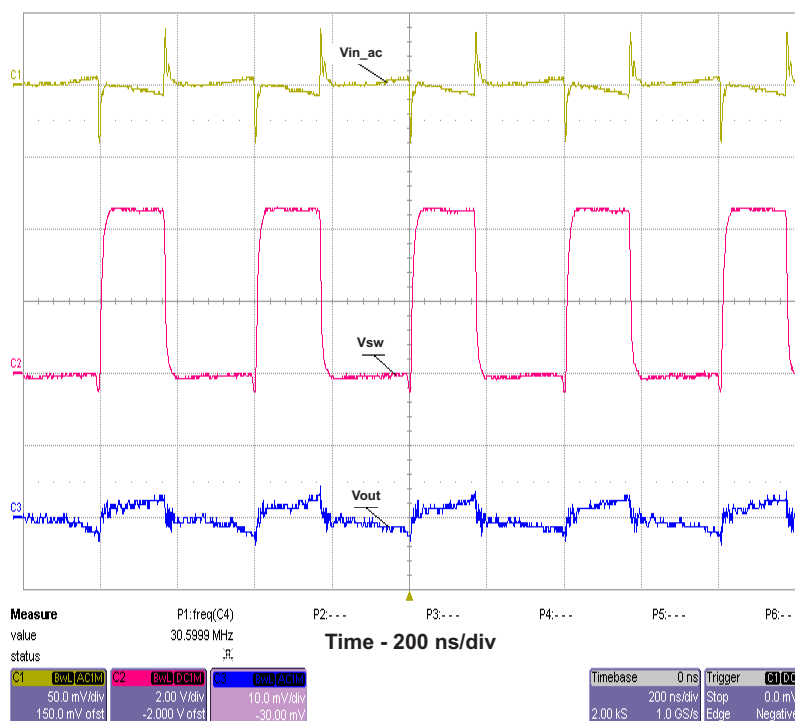
8. Move CH1 to JP1-2 (Enable pin), and set JP1 shunt to off. Arm the scope and remove JP1 shunt. [Figure 7](#) shows the power-up of the converter via the enable pin.
9. Set the scope trigger to negative, arm the oscilloscope, and apply a shunt on JP1-OFF. See [Figure 8](#) for the power-down sequence.
10. With an understanding of the basic functions of the EVM, users may want to integrate the EVM into their system using short, twisted wires, to minimize connection impedances.

## 4 Waveforms



4.5V input, 1.8V output, 1.4MHz Switching; CH1: Input Ripple, CH2: Switching Node, CH3: Output Ripple

**Figure 2. Typical Switching Waveforms**



4.5V input, 1.8V output, 2.8MHz Switching; CH1: Input Ripple, CH2: Switching Node, CH3: Output Ripple

Figure 3. Typical Switching Waveforms

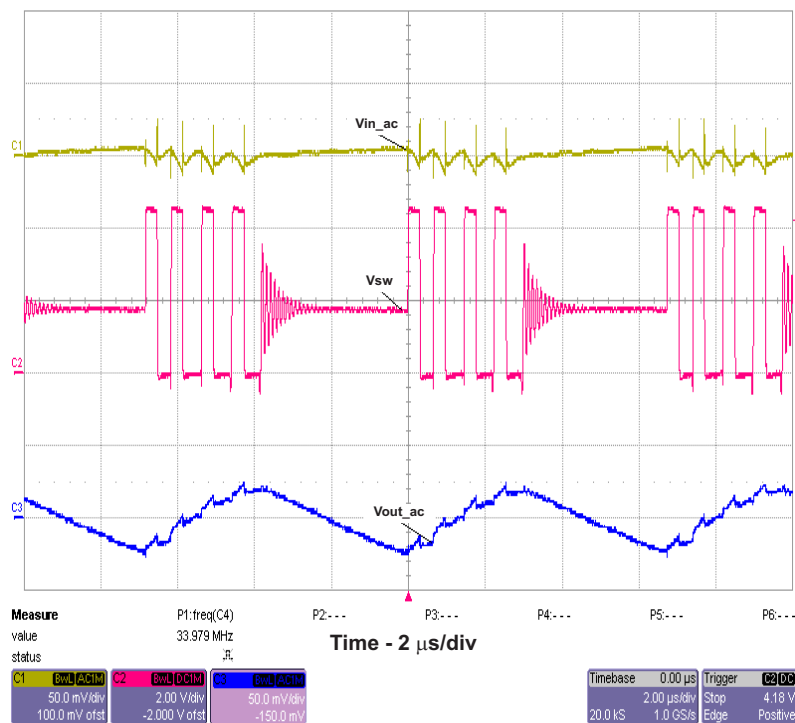


Figure 4. Low-Power Mode, 25-Ω Load – Shows Burst Low-Power Mode

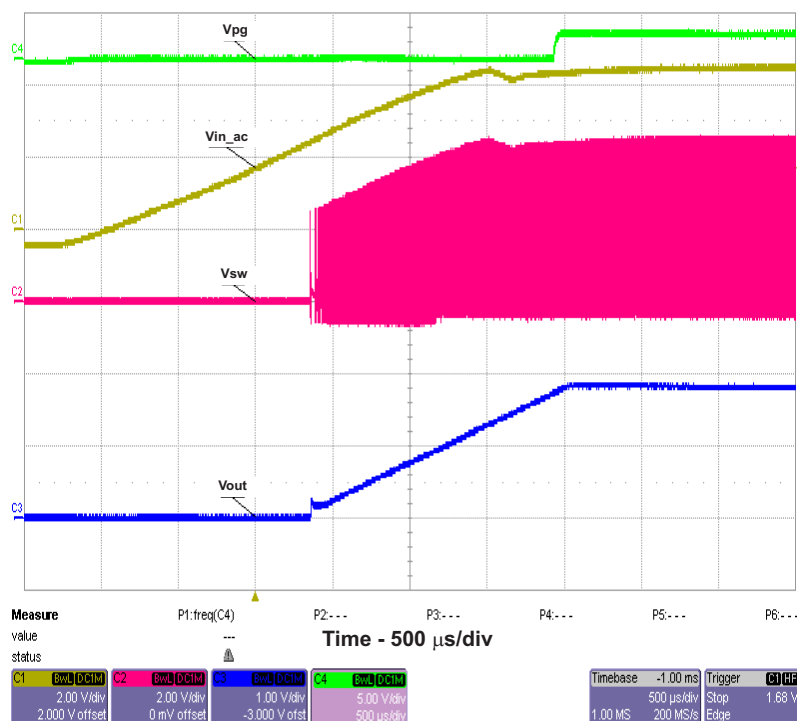


Figure 5. Power Up by Powering Laboratory Supply Connected to Vin

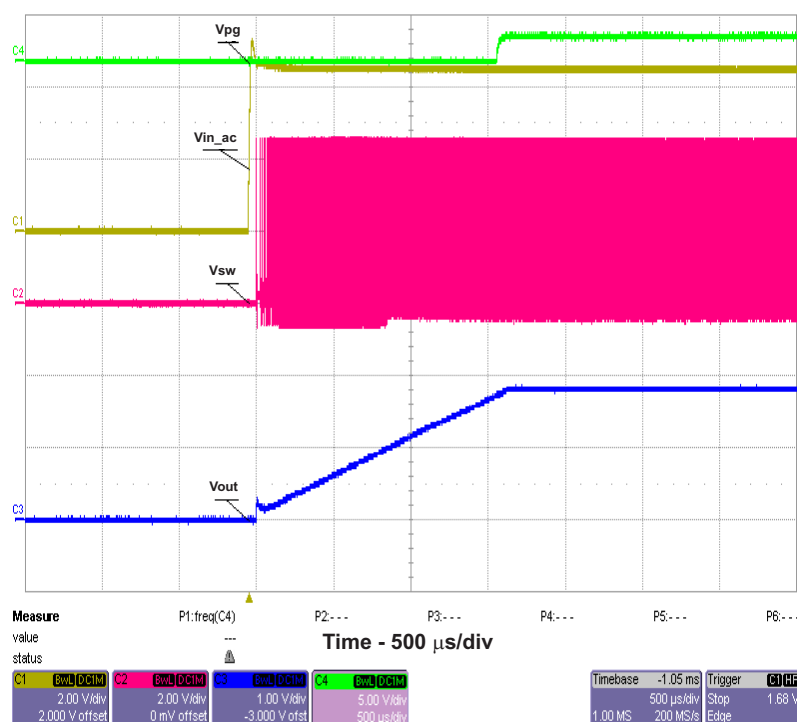


Figure 6. Power Up by Hot Plugging Vin

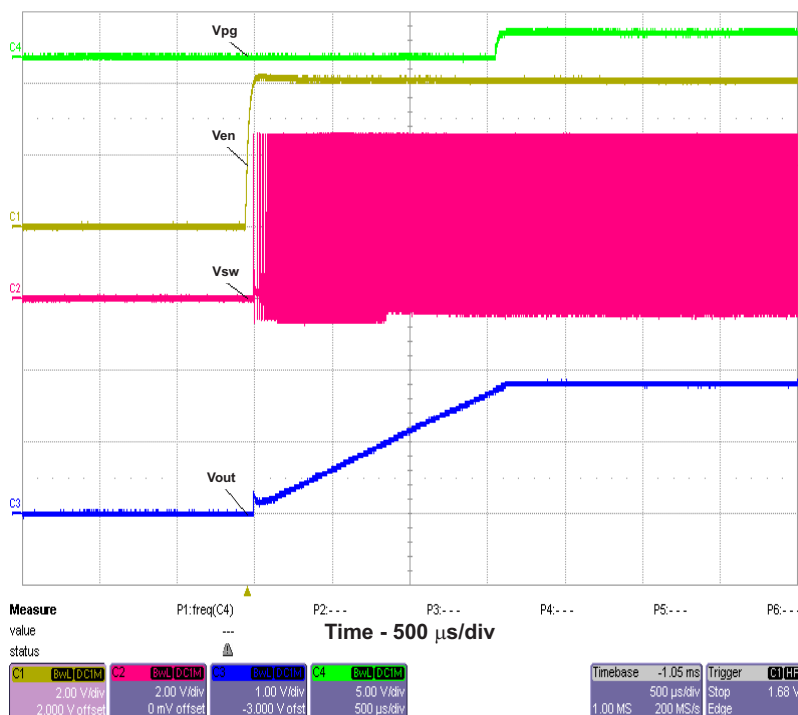


Figure 7. Power Up by Enable Pin Pulled High

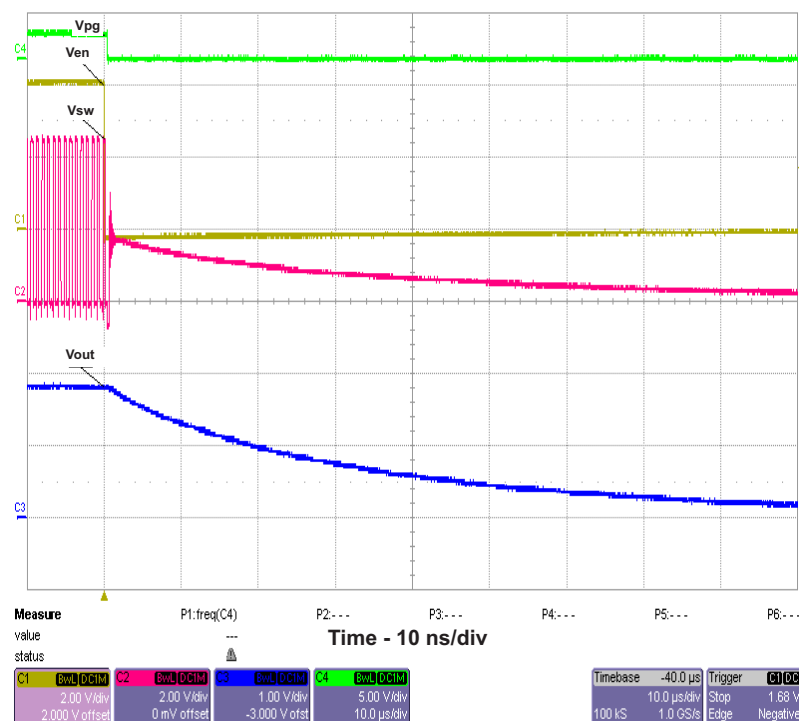
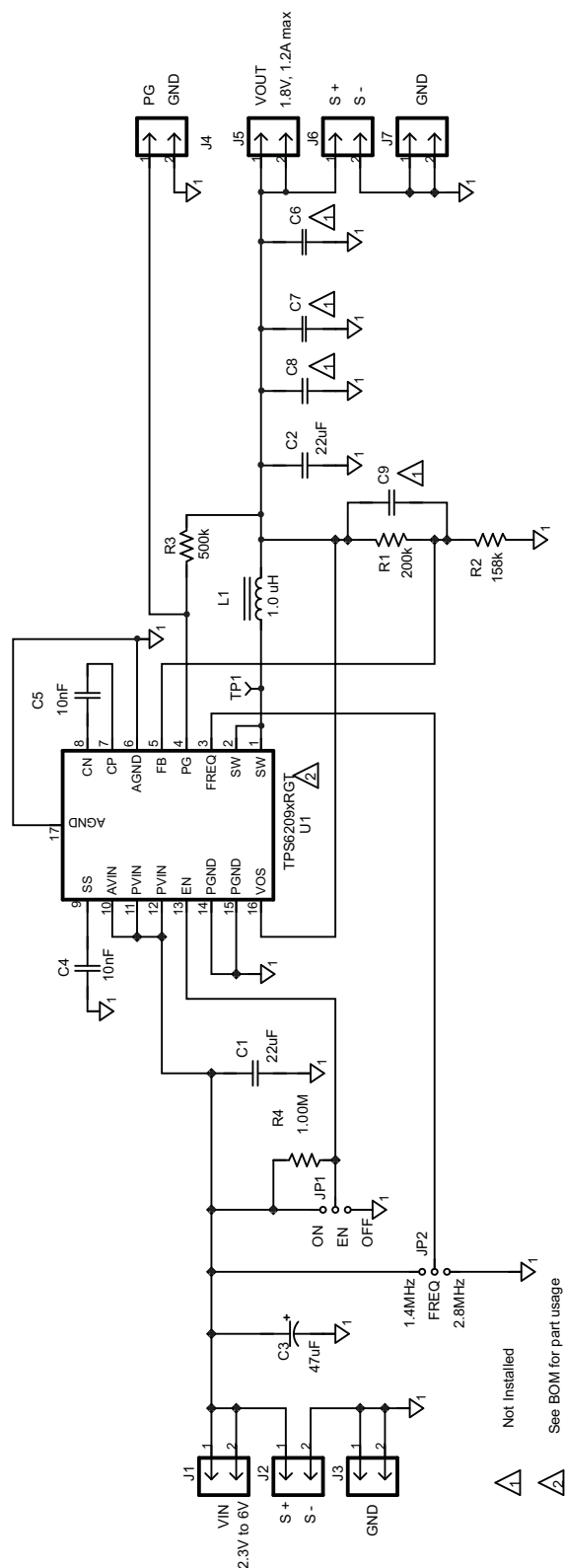


Figure 8. Power Down by Enable Pulled Low

## 5 Schematic, Printed-Circuit Board, and Bill of Materials

### 5.1 Schematic



## 5.2 Printed-Circuit Board Layouts

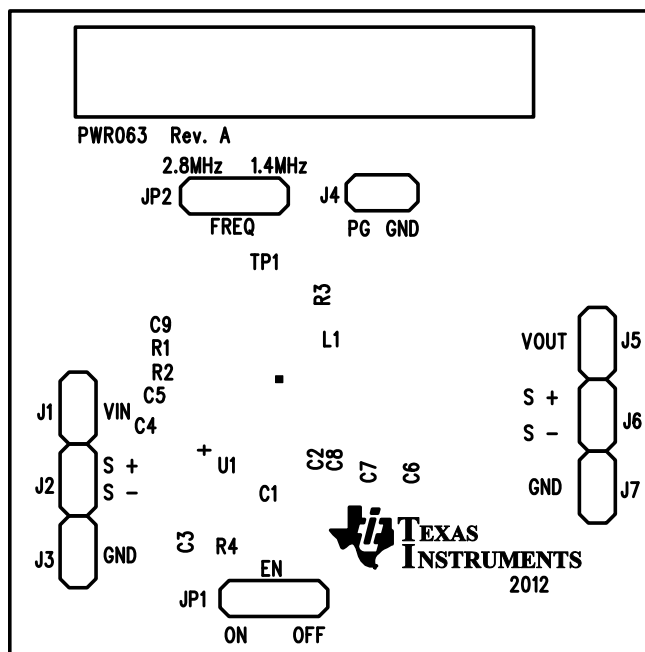


Figure 9. Assembly Layer

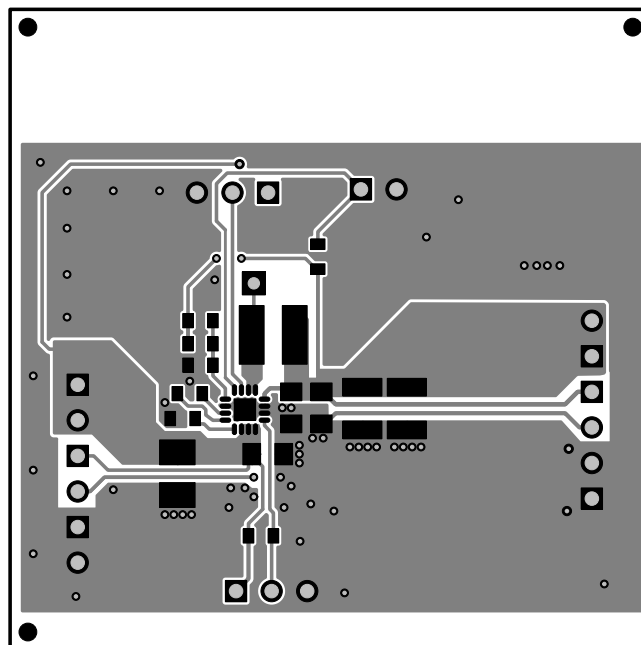
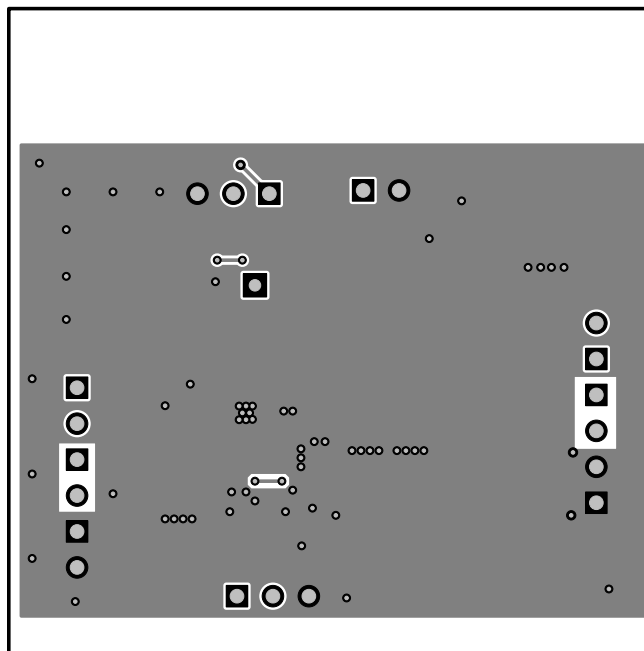


Figure 10. Top Layer



**Figure 11. Bottom Layer**

### 5.3 Bill of Materials

**Table 2. PWR063A Bill of Materials**

Count	RefDes	Value	Description	Size	Part Number	MFR
-001						
2	C1-2	22 $\mu$ F	Capacitor, Ceramic Chip, 10V, X5R, 10%	0805	STD	STD
1	C3	47 $\mu$ F	Capacitor, Tantalum, 8V, 35milliohm, 20%	3528(B)	T520B476M008ATE035	Kemet
2	C4-5	10nF	Capacitor, Ceramic, 25V, X5R, 10%	0603	Std	Std
0	C6-7	open	Capacitor, Ceramic	1210	Std	Std
0	C8	open	Capacitor, Ceramic	0805	Std	Std
0	C9		Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
7	J1-7	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
2	JP1-2	PEC03SAAN	Header, 3 pin, 100mil spacing	0.100 x 3	PEC03SAAN	Sullins
1	L1	1 $\mu$ H	Inductor, Power, 4.5A, $\pm$ 20%	0.157 x 0.157 inch	XFL4020-102ML	Coilcraft
1	R1	200k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	158k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	500k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R4	1.00M	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	TP1	STD	Test Point, 0.032 Hole	0.032	Std	Std
1	U1	TPS62090RGT	IC, 3A High Efficient Synchronous Step Down Converter	QFN-16	TPS62090RGT	TI
2	--	--	Shunt, 100-mil, Black	0.100	929950-00	3M
1	--	--	PCB	1.8 x 1.8 x 0.031 inch	PWR063	Any
1	--	--	Label	1.25 x 0.25 inch	THT-13-457-10	Brady

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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.

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**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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**(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan**

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日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

<http://www.tij.co.jp>

## 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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