TPS65135 SIMO Converter Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPS65135EVM evaluation module (EVM). This EVM contains the Texas Instruments TPS65135 positive and negative output supply integrated circuit. This user's guide includes EVM specifications, recommended test setup, bill of materials, a schematic diagram, and the board layout.

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1 Introduction

The Texas Instruments TPS65135EVM evaluation module uses a TPS65135 single-inductor, multiple output regulator to provide both a positive and negative power rail. The goal of the EVM is to facilitate evaluation of the TPS65135.

1.1 Performance Specification Summary

Table 1 provides a summary of the TPS65135EVM performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. Typical Performance Specification Summary

Specifications		Test Condition	MIN	TYP	MAX	Unit
Input Voltage, V_{IN}			2.5		5.5	V
Input Current, I_{IN}					1000	mA
Output Voltage	OUTP	V_{IN} = 3.7 V, I_{OUTP} = I_{OUTN}	4.95	5.04	5.1	V
	OUTN	V_{IN} = 3.7 V, I_{OUTP} = I_{OUTN}	-4.9	-4.98	5.05	V
Output Current, I_{OUT}		I_{OUTP} = I_{OUTN}	80			mA
Line Regulation		V_{IN} = 2.5 V to 5.5 V, I_{OUTP} = I_{OUTN}		±0.2		%
Load Regulation		I_{OUT} = 1 mA to 100 mA, I_{OUTP} = I_{OUTN}		±0.2		%
Maximum Efficiency		V_{IN} = 3.7 V, I_{OUTP} = I_{OUTN} = 92 mA		71		%

2 Input/Output Connector Descriptions

J1−VIN and GND This is the positive and return connections (three pins each) to the input power supply. Twist the leads to the input supply and keep them as short as possible.

J2−OUTP and GND This is the positive output of the device and some GND pins (two pins each).

J3−EN This is the enable pin for both converters. Placing a jumper across pins 1 and 2 shorts the EN pin to GND (OFF), thereby disabling the device. Placing a jumper across pins 2 and 3 shorts the EN pin to VIN (ON), thereby enabling the converter.

J4−OUTN and GND This is the negative output of the device and some GND pins (two pins each). The load in most applications is connected between OUTP and OUTIN, not to GND.

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3 Test Results

The test results in this user's guide are measured with the load connected between OUTP and OUTN. This means both outputs are loaded with the same current. The results are different with non-symmetrical load. Please review to the datasheet for more details.

3.1 Efficiency

Figure 1shows the efficiency of TPS65135 EVM at an ambient temperature of 25°C.

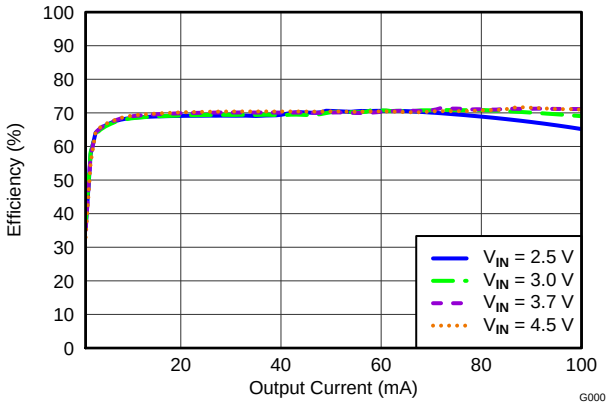


Figure 1. Efficiency

3.2 Load Regulation

The load regulation of the positive output on the TPS65135 EVM is shown in Figure 2 with the outputs normalized to the value measured with 3.7 V input voltage and 50 mA load. The load regulation of the negative output is given in Figure 3.

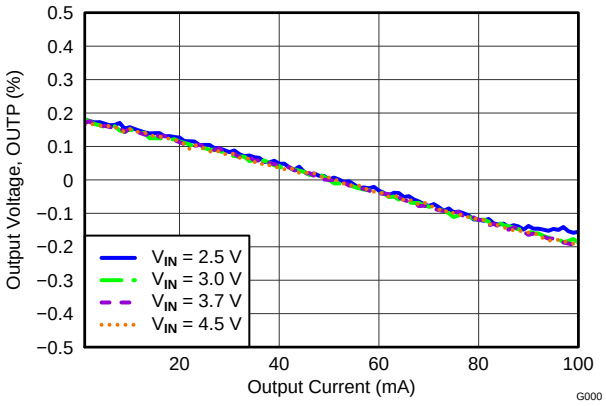


Figure 2. Load Regulation OUTP

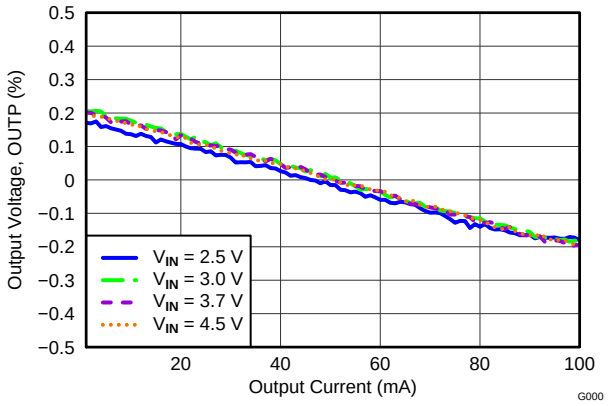


Figure 3. Load Regulation OUTN

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3.3 Line Regulation

The line regulation of the positive output on the TPS65135 EVM is shown in Figure 4 and the line regulation of the negative output is given in Figure 5. The converter is well within 1% accuracy over the whole line and load ranges. The output voltages are normalized to the outputs measured with 3.7 V input voltage and 50 mA load.

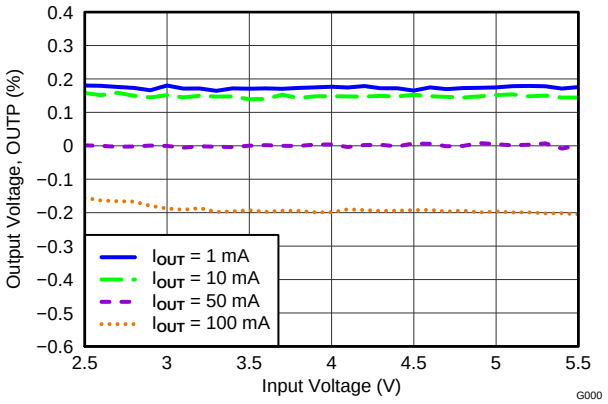


Figure 4. Line Regulation OUTP

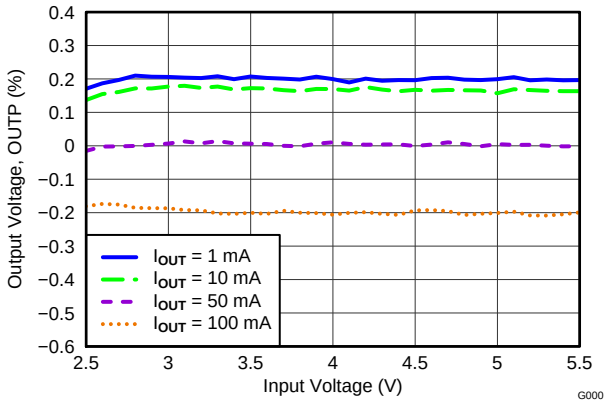


Figure 5. Line Regulation OUTN

3.4 Output Voltage Ripple

Figure 6 to Figure 8 show the output voltage ripple at no load, 30mA (DCM) and 100mA (CCM).

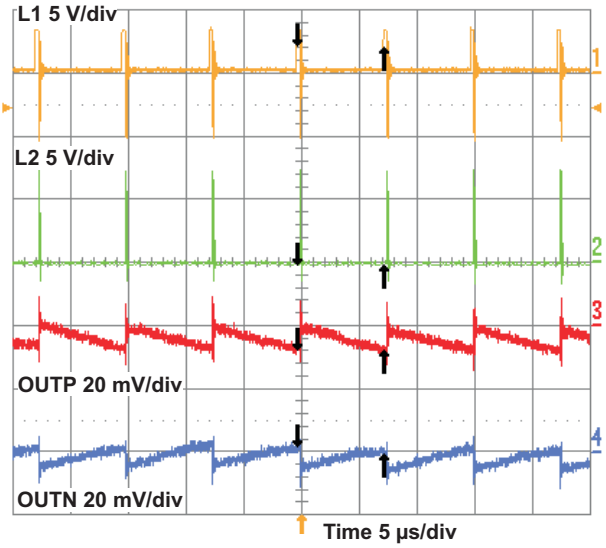


Figure 6. Output Voltage Ripple at No Load

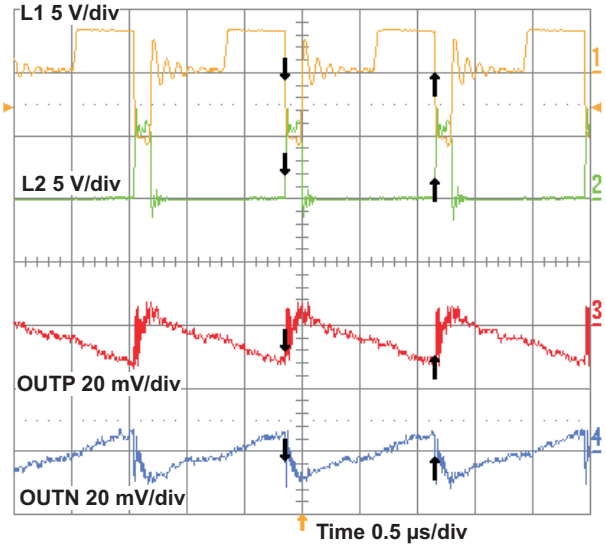


Figure 7. Output Voltage Ripple in DCM

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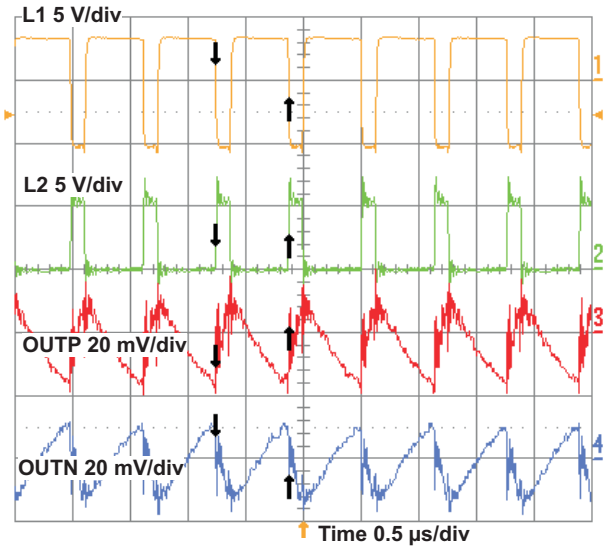


Figure 8. Output Voltage Ripple in CCM

3.5 Startup and Shutdown

The TPS65135 EVM start-up waveform relative to V_{IN} is shown in Figure 9 and the shut-down waveform is shown in Figure 10.

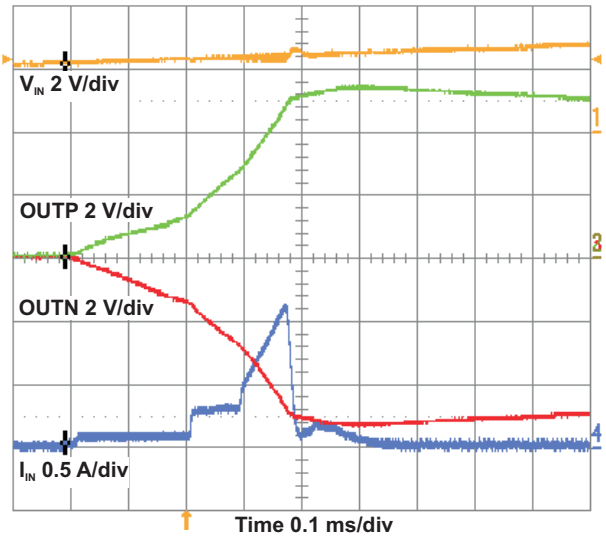


Figure 9. UVLO Startup

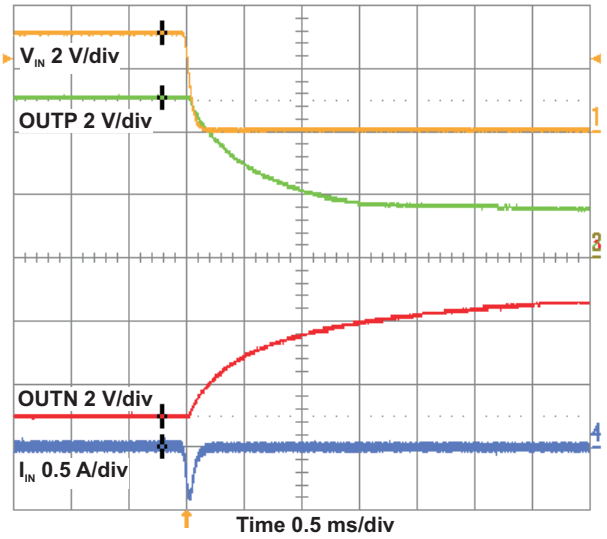


Figure 10. UVLO Shutdown

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The TPS65135 EVM start-up waveforms relative to EN is shown in Figure 11 and the shut-down waveform is shown in Figure 12.

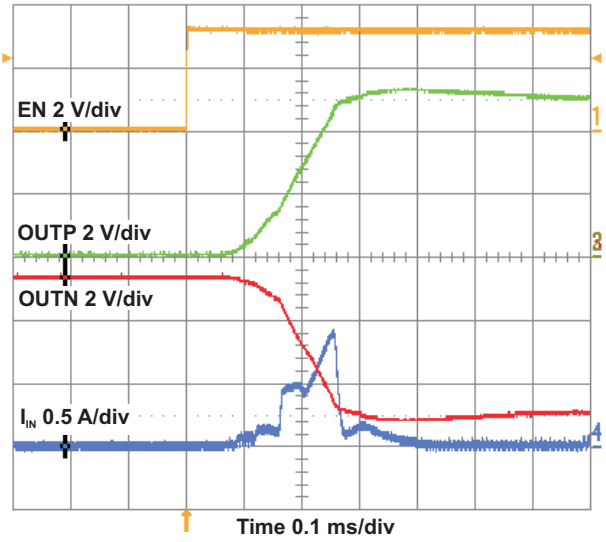


Figure 11. EN Startup

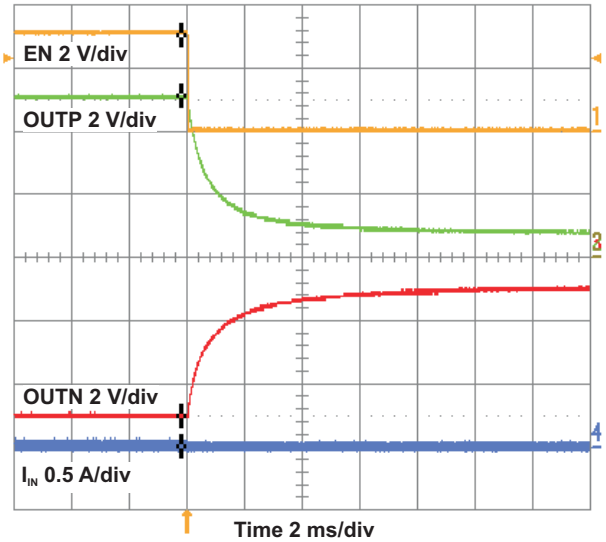


Figure 12. EN Shutdown

4 Board Layout

Board layout is critical for all switch mode power supplies. Figure 13, Figure 14, and Figure 15 show the board layout for the HPA265 PCB. The switching nodes with high-frequency noise are isolated from the noise-sensitive feedback circuitry, and careful attention has been given to the routing of high-frequency current loops. See the data sheet for more specific layout guidelines.

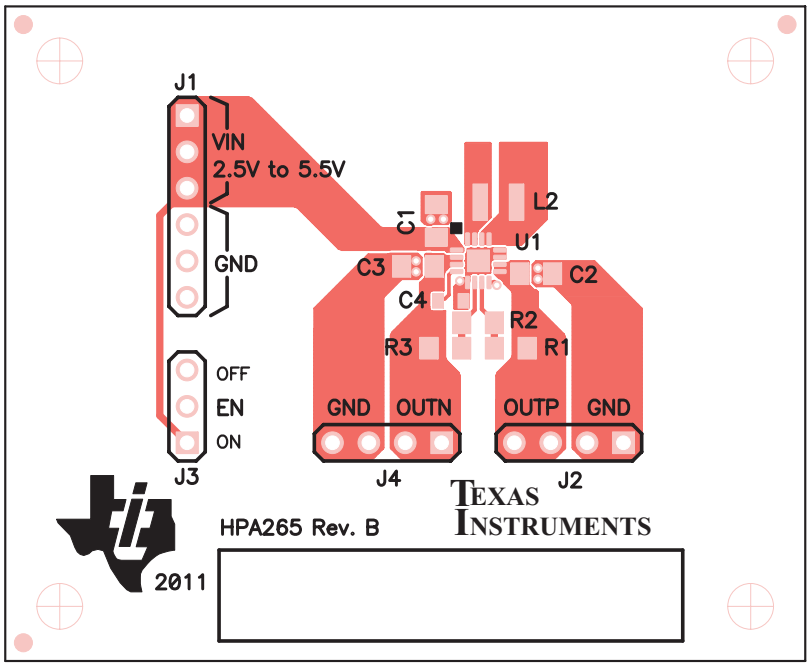


Figure 13. Top Assembly Layer

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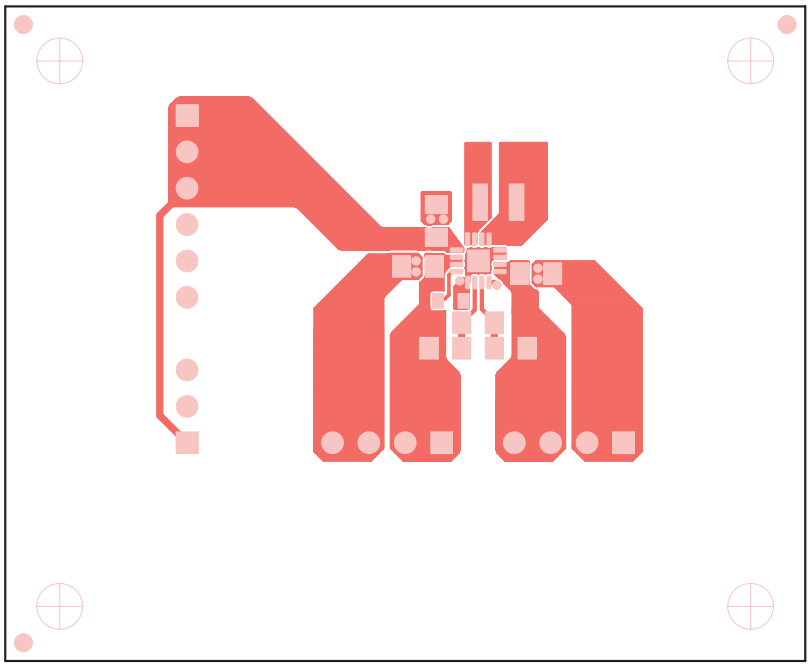


Figure 14. Top Layer

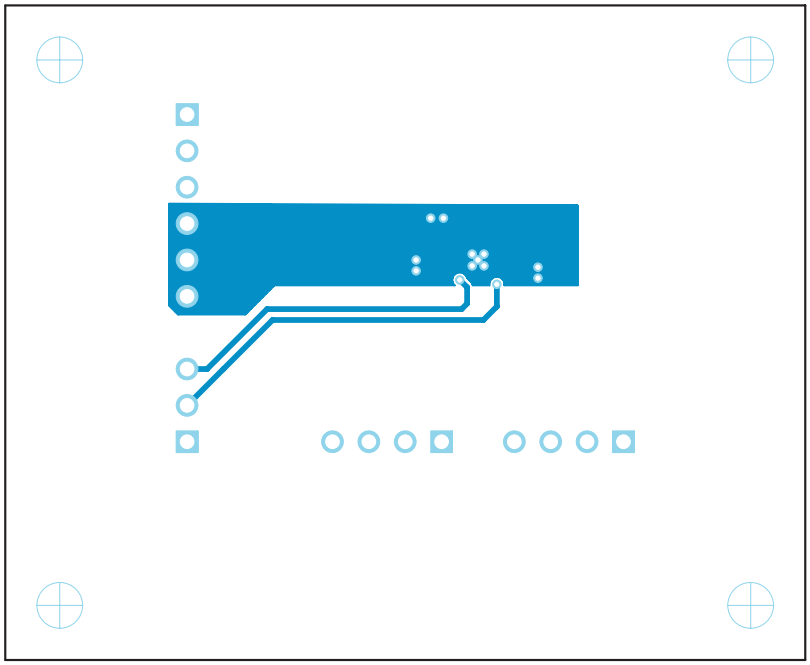


Figure 15. Bottom Layer

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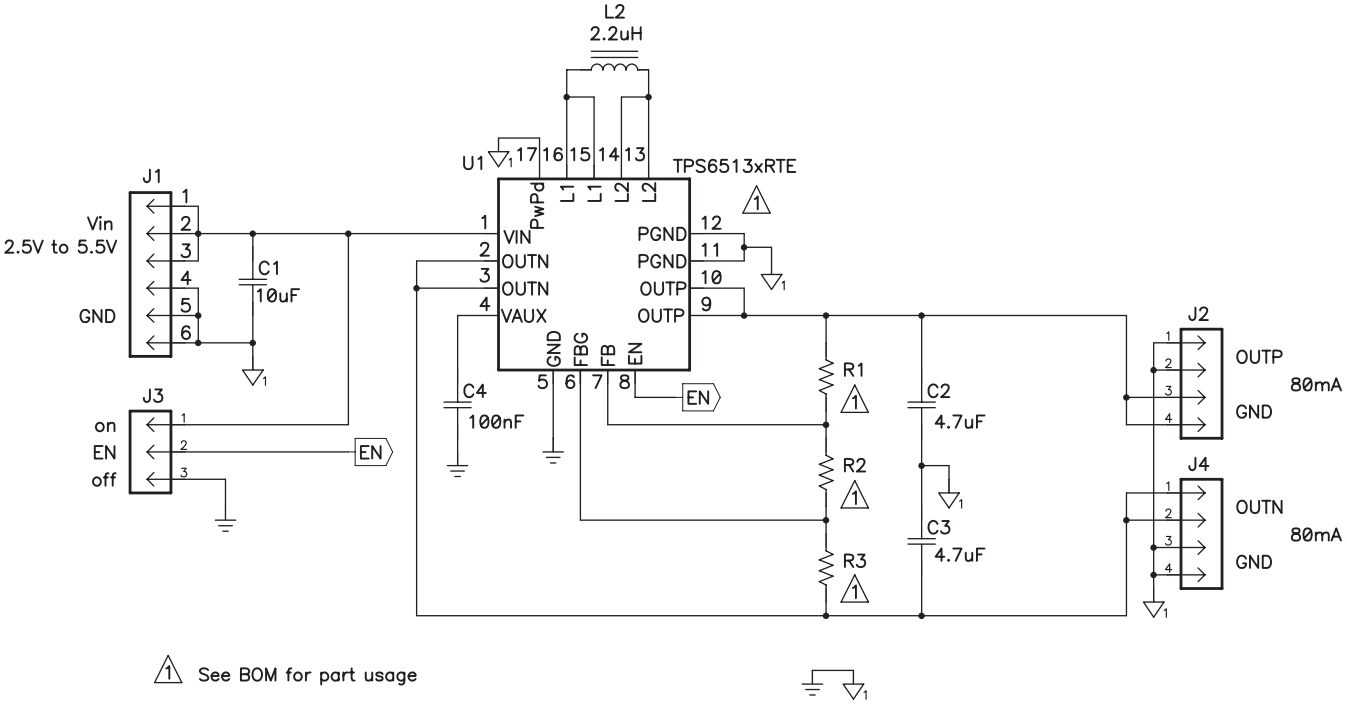
5 Bill of Materials and Schematic

5.1 Bill of Materials

Table 2. HPA265 Bill of Materials

Count	Ref Des	Value	Description	Size	Part Number	MFR
1	C1	10 µF	Capacitor, Ceramic, 10V, X7R, 10%	0805	STD	Murata
2	C2, C3	4.7 µF	Capacitor, Ceramic, 10V, X7R, 10%	0805	STD	Murata
1	C4	100 nF	Capacitor, Ceramic, 10V, X7R	0603	STD	Murata
1	L2	2.2 µH	Inductor DFE252012, SMT, 2.7A, 90mΩ	2.5 mm * 2 mm	1239AS-H-2R2N	Toko
1	R1	309k	Resistor, Chip, 1/10W, 1%	0805	STD	STD
1	R2	100k	Resistor, Chip, 1/10W, 1%	0805	STD	STD
1	R3	412k	Resistor, Chip, 1/10W, 1%	0805	STD	STD
1	U1	TPS65135	IC, Single inductor multiple output regulator	QFN-16	TPS65135RTE	TI

5.2 Schematic



IC Usage	OUTP	OUTN
TPS65135	5 V	−5 V
TPS65136	4.6 V	−5 V

Figure 16. TPS65135EVM Schematic

Related Documentation from Texas Instruments

To obtain a copy of any of the following TI document, call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center (PIC) at (972) 644-5580. When ordering, identify this booklet by its title and literature number. Updated documents can also be obtained through our website at www.ti.com

Data Sheets:	**Literature Number:**
TPS65135	SLVS704

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 2.5 V to 5.5 V and the output voltage range of –5 V to 5 V .

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

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°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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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.

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