TPS65301EVM User's Guide

1 Introduction

The Texas Instruments TPS65301EVM evaluation module (EVM) evaluates the operation and performance of the TPS65301 power-supply IC for safety applications. The EVM contains the TPS65301 device and some circuitry for basic operation.

Table 1. Device and Package Configurations

CONVERTER	IC	PACKAGE
IC1	TPS65301QPWPRQ1	PWP-24

2 Background

3 Setup

This section describes the jumpers and connectors on the EVM, and how to properly connect, set up, and use the TPS65301EVM.

3.1 Input and Output Connector Descriptions

Table 2. Connectors

Connector	IN/OUT	Name	Description
J1	Output	VREG	Output terminal for the TPS65301 switch-mode converter
J2	Input	VBAT	Power input terminal for the device
J3	Input	IGN	Input terminal to enable the TPS65301
J4	Output	3.3V	Output terminal for the TPS65301 3.3-V linear regulator
J5	Output	1.2V	Output terminal for the TPS65301 1.2-V linear regulator
JP6	Output	5VS	Output terminal for the TPS65301 5-V linear regulator

3.2 Supply

The input voltage range for the converter is VBAT = 5.6 to 40 V. VBAT is supplied to J2.

Table 3. EVM Voltages

Name	IN/OUT	Connector	Pin	GND	Min	Typ	Max	Unit
VBAT	Input	J2	2, 4	12	5.6	13.8	40	V
VREG	Output	J1	22	12	5.3	5.45	5.6	
3.3V	Output	J4	18	12	3.234	3.3	3.366	
1.2V	Output	J5	16	12	1.176	1.2	1.224	
5V	Output	5V	10	12	4.9	5	5.1	
5VS	Output	J6	7	12	4.9	5	5.1	

PowerPAD is a trademark of Texas Instruments.

3.3 Jumper Settings

For proper operation of the TPS65301 device, jumpers must be properly configured. Table 4 shows the recommended jumper settings.

Table 4. EVM Jumper

J	Description	Option	Standard
IGN	When IGN = High (jumper set), the device starts up.	Open shuts down the device	Set
EN	This jumper keeps the outputs of the devices active after ignition is turned off (IGN = low). However, a high level on IGN is required for initial start-up. Before initial start-up, the EN-jumper has no effect. Note that as opposed to IGN, the EN-pin is a logic-level-input, maximum input voltage must not exceed 5.25 V.	Open allows device shutdown with IGN	Set
3.3VPWR	This jumper supplies the 3.3-V regulator out of the buck regulator VREG.		Set
1.2VPWR	This jumper supplies the 1.2-V regulator out of the buck regulator VREG.		Set
J6	This jumper supplies 1.2-V regulator out of 3.3-V Regulator.		Open

3.4 Test Points

Test Points are placed to measure different nodes on the board.

Table 5. Test Points

Test Point	Description
VBAT	Power Input
VIN_D, VIN	Power Input after the reverse battery-protection diode
IGN	Ignition. This test point monitors if IGN-input is high, powering up the device.
IGN_EN	Ignition enable (IGN after series resistor)
BOOT_LDO	Voltage at the internal regulator, which supplies the power to charge the flying-boot capacitor.
VREG	Regulated output of the switch-mode converter, supplying 5.45 V
DELAY	Input for reset delay
SS	Input for soft start time
EN	Enable pin. When EN is high, the device remains active after IGN transitions to low.
GND (×7)	Ground
PH	Switch node, source of internal switching FET
nRST	Reset output for Switcher, which is asserted high after VREG and the 3.3-V and 1.2-V regulator outputs are regulating and after the delay timer expires.
3.3V	3.3-V linear-regulator output
3.3V DRIVE	DRIVE-Base drive for external 3.3-V-regulator bipolar transistor
1.2V	1.2-V linear-regulator output
1.2V DRIVE	DRIVE-Base drive for external 1.2-V-regulator bipolar transistor
VSENSE	Inverting node of the error amplifier for voltage-mode control of VREG
IGN_ST	Ignition input indicator which is asserted high while ignition input is high.
5V	Output of the 5-V linear regulator. Because no screw-terminal is provided for this output, use this test point to attach load.
5VS	Output of the 5-V-sensor linear regulator. Because no screw-terminal is provided for this output, use this test-point to attach load.

3.5 Switch Mode Output 5.45 V

The VREG voltage regulator is supplied by VBAT. Several blocking caps, C4 and C14, are connected from VBAT to GND and help stabilize the supply voltage. For long supply cables, additional bigger caps are helpful. The node PH is the switching node of the buck converter. L1 is the inductor connected to PH and VREG. The diode D1 is the freewheeling diode to allow current flow when the internal High-Side Transistor of the device is turned off. C1 and C2 are the output caps of the VREG regulator. The pin VREG is the feedback line used to close the control loop of the VREG regulator, and is also the supply node for internal use and for the 5-V and 5-VS regulator. The output voltage VREG is available at J1.

3.6 5V (5-V Linear Regulator)

5V is a fixed-regulated output of 5-V ±2% over temperature and input supply using the precision-voltage sense-resistor network. A low-ESR ceramic capacitor is required for loop stabilization; this capacitor must be placed close to the pin of the IC. This output is protected against shorts to ground by a fold-back current limit for safe operating conditions, and by a current limit for limiting in-rush current due to depleted charge on the output capacitance. On initial IGN_EN or EN power cycle the soft-start circuit on this regulator is initiated. The soft-start takes typically 13 ms. This output may require a larger output capacitor to ensure that during load transients the output does NOT drop below the required regulated specifications.

3.7 3.3V Linear-Regulator Controller (3.3-VSENSE)

The linear regulator controller requires an external NPN bipolar pass transistor of sufficient gain-stage to support the maximum load current required. The base-drive output current is protected by current-limiting both the source- and sink-drive circuitry. The 3.3VSENSE is the remote sense input of the output of REG3 supply and controls the 3.3VDRIVE output accordingly. This regulator is fixed at 3.3 V with ±2% tolerance using a precision-voltage sense-resistor network. A low-ESR ceramic output capacitor is used for loop compensation of the regulator. A voltage on this pin of less-than approximately 50% of the regulated value initiates a current limit on the 3.3VDRIVE output. This output may require larger output capacitors to support load transients, so the output does *not* drop below 90% of 3.3 V.

3.8 1.2V Linear-Regulator Controller (1.2-VSENSE)

The linear regulator controller requires an external NPN bipolar pass transistor of sufficient gain stage to support the maximum load current required. The 1.2VSENSE is the remote-sense input of the output of 1.2-V supply and controls the 1.2VDRIVE output accordingly. This regulator output is 1.2 V with ±2% tolerance using a precision-voltage sense-resistor network. A low-ESR ceramic-output capacitor is used for loop compensation of the regulator. A voltage on this pin of less-than approximately 50% of the regulated value initiates a current limit on the 1.2VDRIVE output. This output may require larger output capacitors to support load transients, so the output does *not* drop below 90% of 1.2 V.

3.9 5VS (Protected Sensor-Supply Linear Regulator)

5VS is a fixed-regulated output of 5-V ±2% over temperature and input supply using a precision-voltage sense-resistor network. A low-ESR ceramic capacitor is required for loop stabilization; this capacitor must be placed close to the pin of the IC. This output is protected against shorts to ground by a fold-back current limit for safe operating conditions, and by a current limit for limiting in-rush current due to depleted charge on the output capacitance. This output is also protected against shorts to battery voltage by limiting the reverse current, and because of this, this supply is used to power a sensor outside the electrical-control unit, ECU.

On initial IGN_EN or EN power cycle the soft-start circuit on this regulator is initiated. The soft-start takes typically 10 ms. This output may require a larger output capacitor to ensure that during load transients the output does *not* drop below the required regulated specifications.

4 EVM Schematic

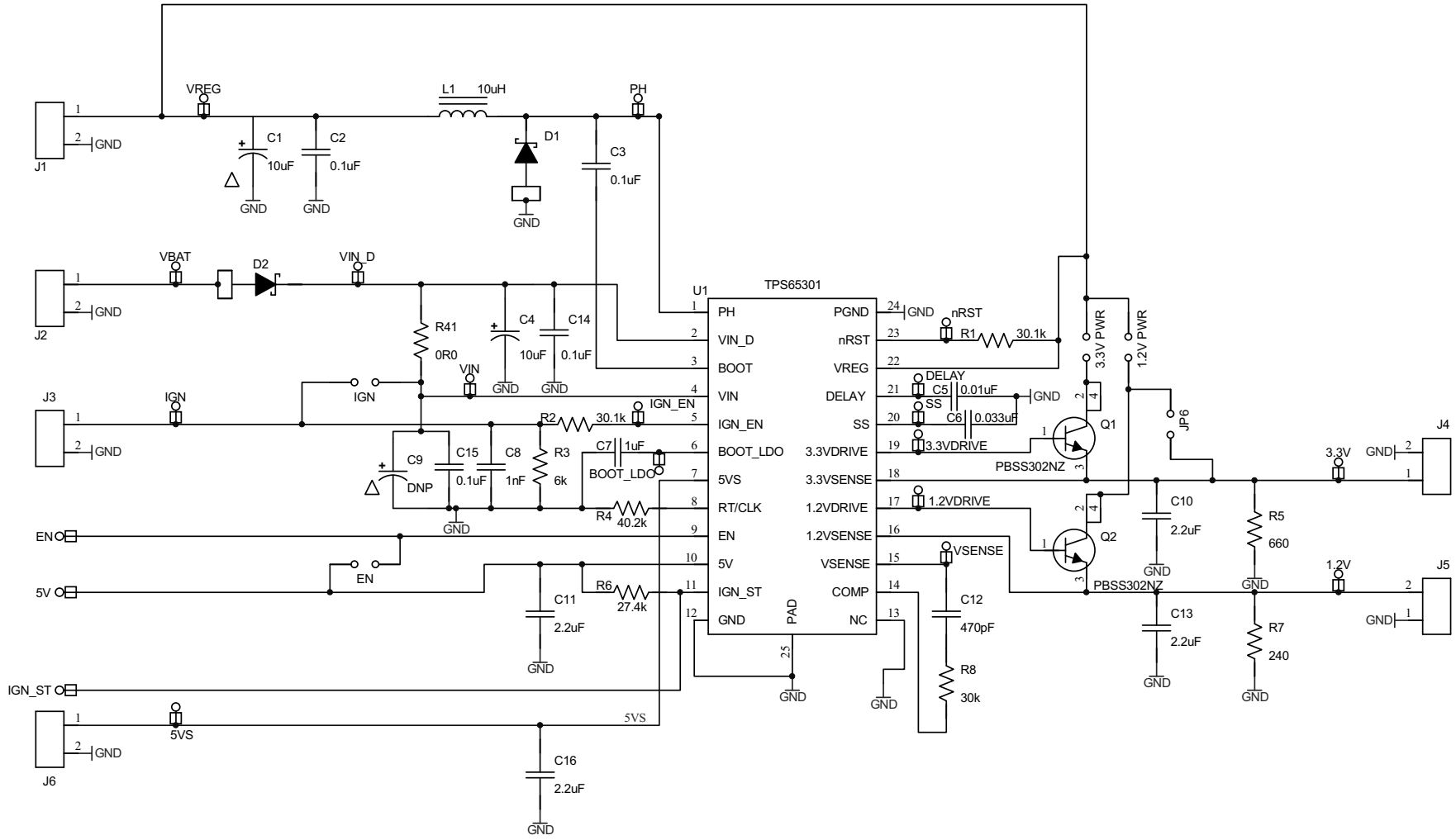

Figure 1. Schematic

5 Board Layout

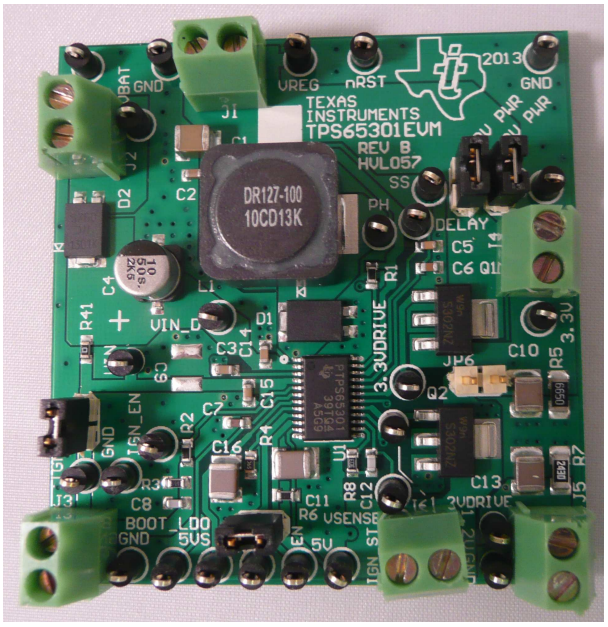

Figure 2. EVM Top Side

6 Board Assembly

Figure 3 shows the board assembly for the TPS65301EVM. The external components of the EVM operate the TPS65301 device.

Although the TPS65301 converter offers high efficiency, it dissipates power. The PowerPAD™ package offers an exposed thermal pad to enhance thermal performance. This pad must be soldered to the copper landing on the PCB for optimal performance. The PCB provides 2-oz copper planes on the top and bottom of the board to dissipate heat.

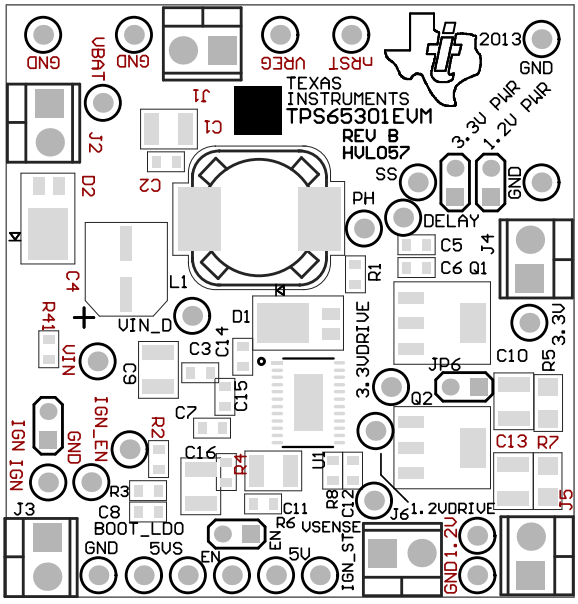

Figure 3. Top-Side Assembly Layer

7 Bill of Materials

Designator	Quantity	Description	Manufacturer	Part Number
PCB	1	Size 52.96 × 50.80 × 1,5 mm	Any	HVL057
C9	0	Uninstalled CAP1210	Uninstalled	CAP_0603 (UN)
C1	1	Capacitor, SMT, 1210, ceramic,100 µF,16V,20%,X5R	TAIYO YUDEN	EMK325ABJ107MM
C10, C11, C13, C16	4	Capacitor, SMT,1210, ceramic,2.2 µF,100V,10%,X7R	KEMET	C1210C225K1RAC
C2, C3, C14, C15	4	Capacitor, SMT,0603, ceramic,50V,10%,0.1 µF,X7R	PANASONIC	ECJ-1VB1H104K
C5	1	Capacitor, SMT,0603, ceramic,0.01 µF,100V,5%,X7R	KEMET	C0603C103J1RAC
C7	1	Capacitor, SMT,0603, ceramic,1.0 µF,16V,10%,X5R	KEMET	C0603C105K4PAC
C8	1	Capacitor, SMT,0603, ceramic,0.001 µF,50V,5%,X7R	KEMET	C0603C102J5RAC
C6	1	Capacitor, SMT,0603, ceramic,10%_25V_0.033 µF	MURATA	GRM39X7R333K025A
C12	1	Capacitor, SMT,0603, ceramic,470pF,5%,50V,C0G(NP0)	KEMET	C0603C472J5RAC
C4	1	Capacitor aluminum elec, 10 µF, 50 V, 20%, SMD	PANASONIC	EEE-1HA100WAR
D1, D2	2	Diode, Schottky, 7 A, 60 V	DIODES INC	PDS760-13
J1, J2, J3, J4, J5, J6	6	TBLK_6A_2x3.5mm_Terminal, 2 pin, 6 A, 3,5 mm	OnShore technology Inc.	ED555/2DS
JP2, JP3, JP4, JP5, JP6	5	Header, THU, 1 × 2, 2,54 mm	Sullins	PEC02SAAN
L1	1	Festinduktoren 10 µH 11.2 A 0.0172 Ω	Coiltronics	DR127-100-R
Q1, Q2	2	20 V, 5.8 A NPN low VCEsat (BISS) transistor	NXP	PBSS302NZ
R1, R2	2	Resistor, SMT, 0603, 1%, 1/10 W, 30.1K	VISHAY	CRCW06033012F
R4	1	Resistor, SMT, 0603, 1%, 1/10W, 40.2K	VISHAY	CRCW06034022F
R6	1	Resistor, SMT, 0603, 1%, 1/10 W, 27.4K	VISHAY	CRCW06032742F
R41	1	Resistor, SMT, 0603,1/10 W, 0 Ω	VISHAY	CRCW0603000Z
R8	1	Resistor, SMT, 0603, 5%, 1/10 W, 30K	PANASONIC	ERJ-3GSYJ303
R3	1	Resistor, SMT, 0603, 1%, 1/10 W, 6.04K	VISHAY	CRCW06036041F
R5	1	Resistor, SMT, 1206, 1%, ¼ W, 665 Ω	VISHAY	CRCW12066650F
R7	1	Resistor, SMT, 1206, 1%, ¼ W, 243 Ω	VISHAY	CRCW12062430F
TP1-TP27	27	Testpoint mini , 040'D black, Glass Beaded Test Point	Keystone	5001
U1	1	DUT,SMT,PWP,R-PDSO-G24, 0,65 mm LS, 7,9 × 6,6 × 1,2 mm, Thermal Pad	TI	TPS65301QPWPRQ1

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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.

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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.

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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.

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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.

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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.

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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
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