

## **TPS1HA08x Evaluation Module**

The TPS1HA08x evaluation module is designed to evaluate the TPS1HA08x integrated circuit. This user's guide provides the connectors and test point description, schematic, bill of materials (BOM), and board layout of the EVM.

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## 1 Introduction

Texas Instruments TPS1HA08x evaluation module contains a TPS1HA08x integrated circuit (IC), supporting single-channel high-side driver applications. The purpose of this EVM is to facilitate evaluation of the TPS1HA08x for resistive, capacitive, and inductive loads.

### 1.1 Descriptions

The Texas Instruments TPS1HA08x EVM helps designers evaluate the operation and performance of the TPS1HA08x.

The TPS1HA08x is a fully-protected high-side switch, with an integrated NMOS power FET, and charge pump. Full diagnostics and high-accuracy current sense features enable intelligent control of the load.

The device diagnostic reporting has two versions to support both digital status output and analog current sense report. The diagnostics can be disabled for multiplexing the sense pin between different devices.

### 1.2 Applications

The EVM is used in the following applications:

- High-side relay drivers
- High-side power switch for submodule power supply
- Bulb driver
- General resistive, inductive, and capacitive loads
- Replace electromechanical relays and fuses

### 1.3 Features

The EVM supports the following features:

- Single-channel high-side power switch, tested according to AECQ100-12
- Operating voltage 3 to 36 V
- Operating junction temperature:  $-40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$
- Microcontroller input control: 3.3-V and 5-V logic compatible
- High-accuracy current sense
  - Analog current sense as a ratio of the load current
- Protection:
  - Reverse battery protection with external resistor
  - Short-circuit protection
  - Overvoltage protection
  - Thermal shutdown and thermal swing with self-recovery
  - ESD protection
- Diagnostic:
  - On and off state output open or short to battery detection
  - Overload and short-to-ground detection and power limiting
  - Thermal shutdown and thermal swing diagnostic
  - Version A, B, or E: Shutdown on current limit
  - Version C or D: Constant current output on current limit
  - Diagnostic enable function for multiplexing of MCU analog or digital port

## 2 TPS1HA08x Schematic

Figure 1 illustrates the TPS1HA08x schematic.

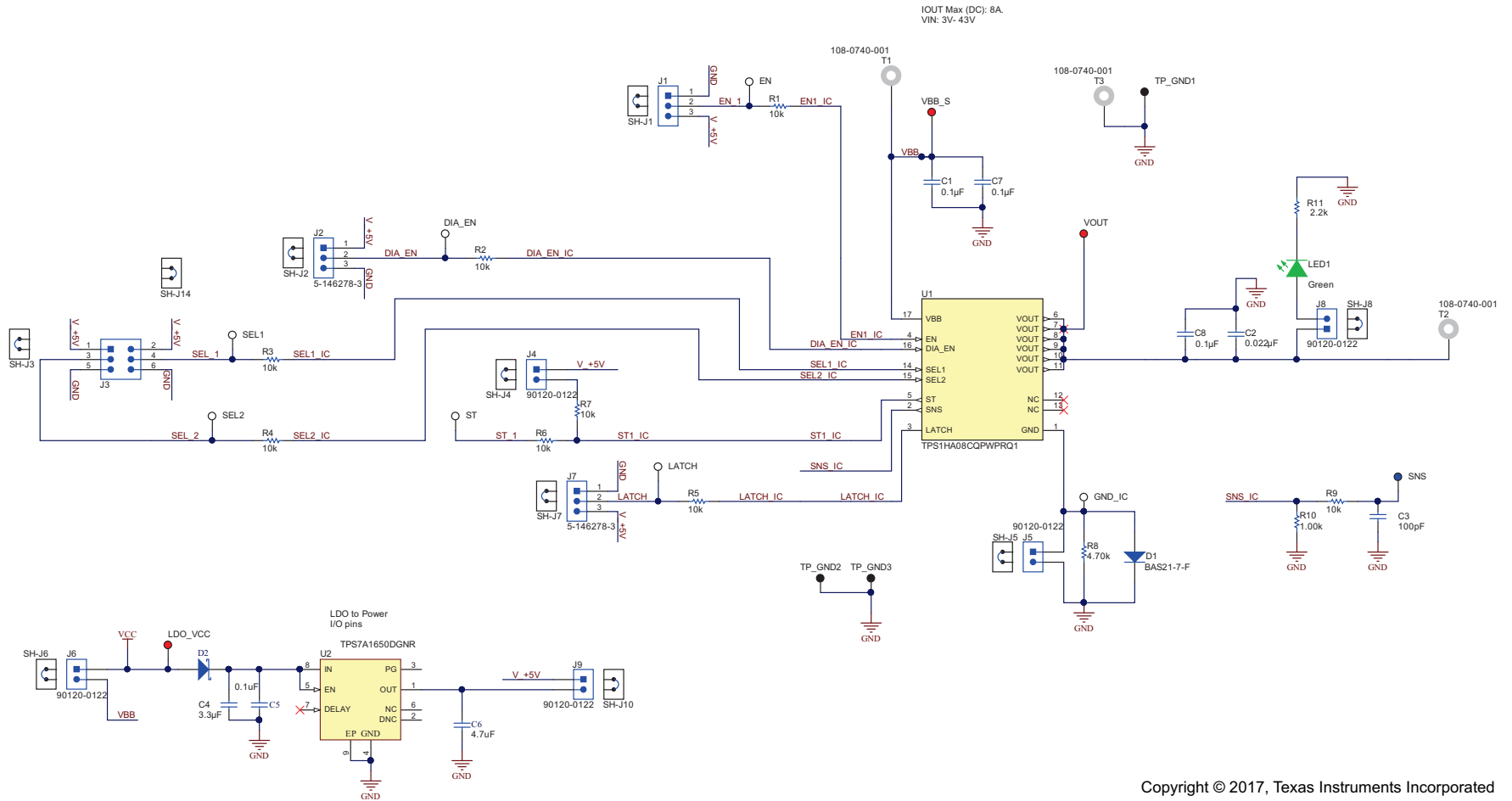


Figure 1. TPS1HA08x Schematic

### 3 Connections Descriptions

#### 3.1 Connectors and Test Points

Table 1 lists the EVM connector and test point descriptions.

**Table 1. Connector and Test Point Descriptions**

Connectors and Test Points	Descriptions
T1	High current input terminal for VBB
T2	High current output terminal for VOUT
T3	High current input terminal for GND
VBB_S	Test point used to measure VBB
VOUT	Test point used to measure VOUT
EN	Test point used to apply power to EN, only use when J1 is not connected to 5 V or GND
DIA_EN	Test point used to apply power to DIA_EN, only use when J2 is not connected to 5 V or GND
SEL1	Test point used to apply power to SEL1, only use when J3 is not connected to 5 V or GND
SEL2	Test point used to apply power to SEL2, only use when J3 is not connected to 5 V or GND
ST	Test point used to measure ST
LATCH	Test point used to apply power to LATCH, only use when J7 is not connected to 5 V or GND
SNS	Test point used to measure SNS
LDO_VCC	Test point used to apply power to the 5-V TPS7A1650DGNR LDO, only use when J6 is disconnected
GND_IC	This is a direct connection to the GND pin of the IC
TP_GND1	This is a connection to the GND plane of the EVM
TP_GND2	This is a connection to the GND plane of the EVM
TP_GND3	This is a connection to the GND plane of the EVM

#### 3.2 Jumpers

Table 2 lists the EVM jumper descriptions.

**Table 2. Jumper Descriptions**

Jumpers	Description
J1	This jumper is used to connect the EN pin to 5 V (2-3) or GND (1-2)
J2	This jumper is used to connect the DIA_EN pin to 5 V (1-2) or GND (2-3)
J3	This jumper is used to connect the SEL1 and SEL2 pins to 5 V or GND
J4	This jumper connects the ST pin to a 10-k $\Omega$ pullup resistance
J5	This jumper is used to bypass the ground network used for reverse polarity protection
J6	This jumper is used to power the 5-V TPS7A1650DGNR LDO with the VBB input for the EVM
J7	This jumper is used to connect the LATCH pin to 5 V (2-3) or GND (1-2)
J8	This jumper connects VOUT to an indication LED, showing the user when VOUT is powered
J9	This jumper connects the output of the TPS7A1650DGNR LDO to the 5-V supply net on the EVM

#### 4 TPS1HA08x EVM Assembly Drawings and Layout

Figure 2 through Figure 4 show the design of the TPS1HA08x PCB. The EVM was designed using FR4 material on a four-layer (2s2p) board. All components are located in an active area on the top side and active traces are provided in the top and bottom layers to allow the user to easily view, probe, and evaluate. Moving components to both sides of the PCB can offer additional size reduction for space-constrained systems.

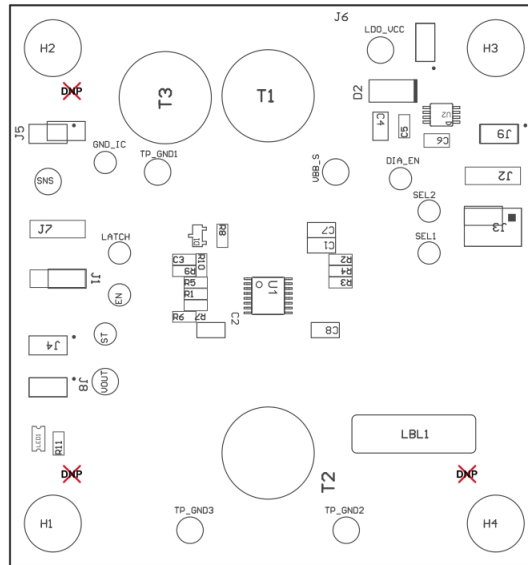


Figure 2. TPS1HA08x EVM Component Placement (Top View)

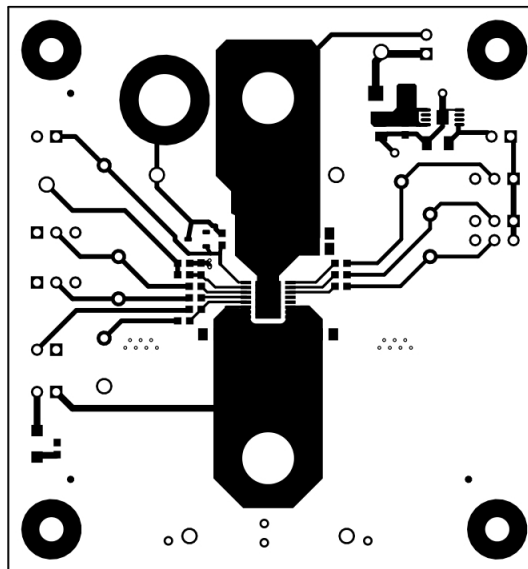
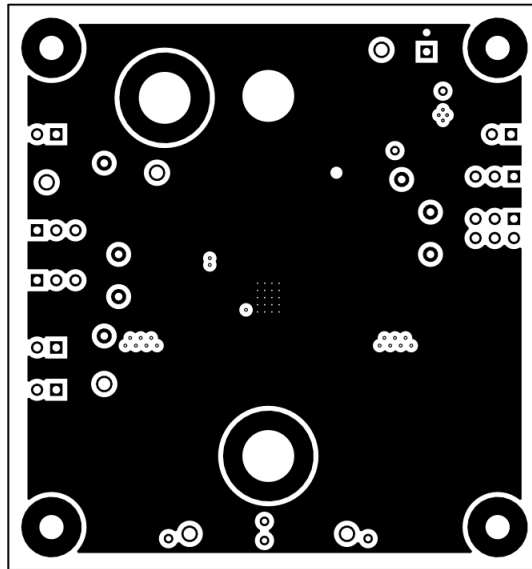


Figure 3. TPS1HA08xEVM Top Layer (Top View)



**Figure 4. TPS1HA08xEVM Bottom Layer (Bottom View)**

## 5 Current Limit

When  $I_{OUT}$  reaches the current limit threshold,  $I_{CL}$ , the device can switch off immediately (versions A, B, and E), or the device can remain enabled and limit  $I_{OUT}$  (versions C and D). The TPS1HA08-Q1 will be available in multiple variants which collectively allow both of these behavior options. In the case that the device remains enabled (and limits  $I_{OUT}$ ), the thermal shutdown or energy limit protection feature may be triggered due to the high amount of power dissipation in the device.

## 6 Current Sense

High-accuracy current sensing allows real-time monitoring and more diagnostics without further calibration. A current mirror is used to source a 1/4600 of the load current on SNS pin. The 1-k $\Omega$  R10 resistor is connected to the SNS pin to convert the current source into a voltage:

$$V_{SNS} = 1000 \times I_{OUT} / 4600$$

## 7 Bill of Materials

Table 3 displays the TPS1HA08x BOM.

**Table 3. TPS1HA08x Bill of Materials**

Designator	QTY	Value	Part Number	Description
IPCB	1		N/A	Printed Circuit Board
C1, C7, C8	3	0.1uF	C0805C104M5RACTU	CAP, CERM, 0.1 $\mu$ F, 50 V, $\pm$ 20%, X7R, 0805
C2	1	0.022uF	GRM21BR72A223KA01L	CAP, CERM, 0.022 $\mu$ F, 100 V, $\pm$ 10%, X7R, 0805
C3	1	100pF	06035A101FAT2A	CAP, CERM, 100 pF, 50 V, $\pm$ 1%, C0G/NP0, 0603
C4	1	3.3uF	C2012X5R1H335K125AB	CAP, CERM, 3.3 $\mu$ F, 50 V, $\pm$ 10%, X5R, 0805
C5	1	0.1uF	GRM188R71H104KA93D	CAP, CERM, 0.1uF, 50V, $\pm$ 10%, X7R, 0603
C6	1	4.7uF	12063D475KAT2A	CAP, CERM, 4.7uF, 25V, $\pm$ 10%, X5R, 1206
D1	1	200V	BAS21-7-F	Diode, Switching, 200V, 0.2A, SOT-23
D2	1	0.7V	B150-13-F	Diode, Schottky, 50V, 1A, SMA
DIA_EN, EN, GND_IC, LATCH, SEL1, SEL2, ST	7	White	5002	Test Point, Miniature, White, TH
H1, H2, H3, H4	4		NY PMS 440 0025 PH	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead
H5, H6, H7, H8	4		1902C	Standoff, Hex, 0.5"L #4-40 Nylon
J1, J2, J7	3		5-146278-3	Header, 100mil, 3x1, Tin, TH
J3	1		PEC03DAAN	Header, 100mil, 3x2, Tin, TH
J4, J5, J6, J8, J9	5		90120-0122	Header, 100mil, 2x1, Tin, TH
LBL1	1		THT-14-423-10	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll
LDO_VCC, VBB_S, VOUT	3	Red	5010	Test Point, Multipurpose, Red, TH
LED1	1	Green	LTST-C150KGKT	LED, Green, SMD
R1, R2, R3, R4, R5, R6, R7, R9	8	10k	CRCW060310K0JNEA	RES, 10 k, 5%, 0.1 W, 0603
R8	1	4.70k	RC0603FR-074K7L	RES, 4.70 k, 1%, 0.1 W, 0603
R10	1	1.00k	RNCF0603TKY1K00	RES, 1.00 k, 0.01%, 0.063 W, 0603
R11	1	2.2k	RC0603JR-072K2L	RES, 2.2 k, 5%, 0.1 W, 0603
SH-J1, SH- J2, SH-J3, SH-J4, SH- J5, SH-J6, SH-J7, SH- J8, SH-J10, SH-J14	10	1x2	969102-0000-DA	Shunt, 100mil, Gold plated, Black
SNS	1	Blue	5127	Test Point, Multipurpose, Blue, TH
T1, T2, T3	3		108-0740-001	Standard Banana Jack, Uninsulated, 15A
TP_GND1, TP_GND2, TP_GND3	3	Black	5011	Test Point, Multipurpose, Black, TH
U1	1		TPS1HA08xQPWPRQ1	40-V, 8-m $\Omega$ Single-Channel Smart High-Side Switch, TPS1HA08-Q1 (TSSOP-16)

**Table 3. TPS1HA08x Bill of Materials (continued)**

Designator	QTY	Value	Part Number	Description
U2	1		TPS7A1650DGNR	Single Output LDO, 100 mA, Fixed 5 V Output, 3 to 60 V Input, with Enable and Power Good, 8-pin MSOP (DGN), -40 to 125 degC, Green (RoHS & no Sb/Br)
FID1, FID2, FID3	0		N/A	Fiducial mark. There is nothing to buy or mount.



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**FCC NOTICE:** This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.
    - 3.1.2 *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

*NOTE: 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**

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- 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.

### 3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

#### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSSs. 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.

#### **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.

#### **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.

#### **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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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs 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 EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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##### 3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

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