User's Guide

SLVUAB4–October 2014

TPS1H100-Q1 Evaluation Module (EVM)

The TPS1H100-Q1 evaluation module is designed to evaluate the TPS1H100-Q1 integrated circuit. This user's guide provides the connectors and test point description, schematic, bill of materials, and board layout of the EVM.

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1 Introduction

Texas Instruments TPS1H100-Q1 evaluation module contains a TPS1H100-Q1 integrated circuit (IC), supporting 1-channel high-side driver application. The purpose of this EVM is to facilitate evaluation of the TPS1H100-Q1 for resistive, capacitive, and inductive loads.

1.1 Descriptions

The Texas Instruments TPS1H100-Q1 EVM helps designers evaluate the operation and performance of the TPS1H100-Q1.

The TPS1H100-Q1 is a fully-protected high-side switch, with integrated NMOS power FET, and charge pump. Full diagnostics and high-accuracy current sense features enable intelligent control of the load. Programmable current limit function greatly improves the whole system's reliability.

TPS1Hxxx-Q1 family is available in different Rdson values and output current. The device can switch a wide variety of resistive, inductive, and capacitive loads.

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.

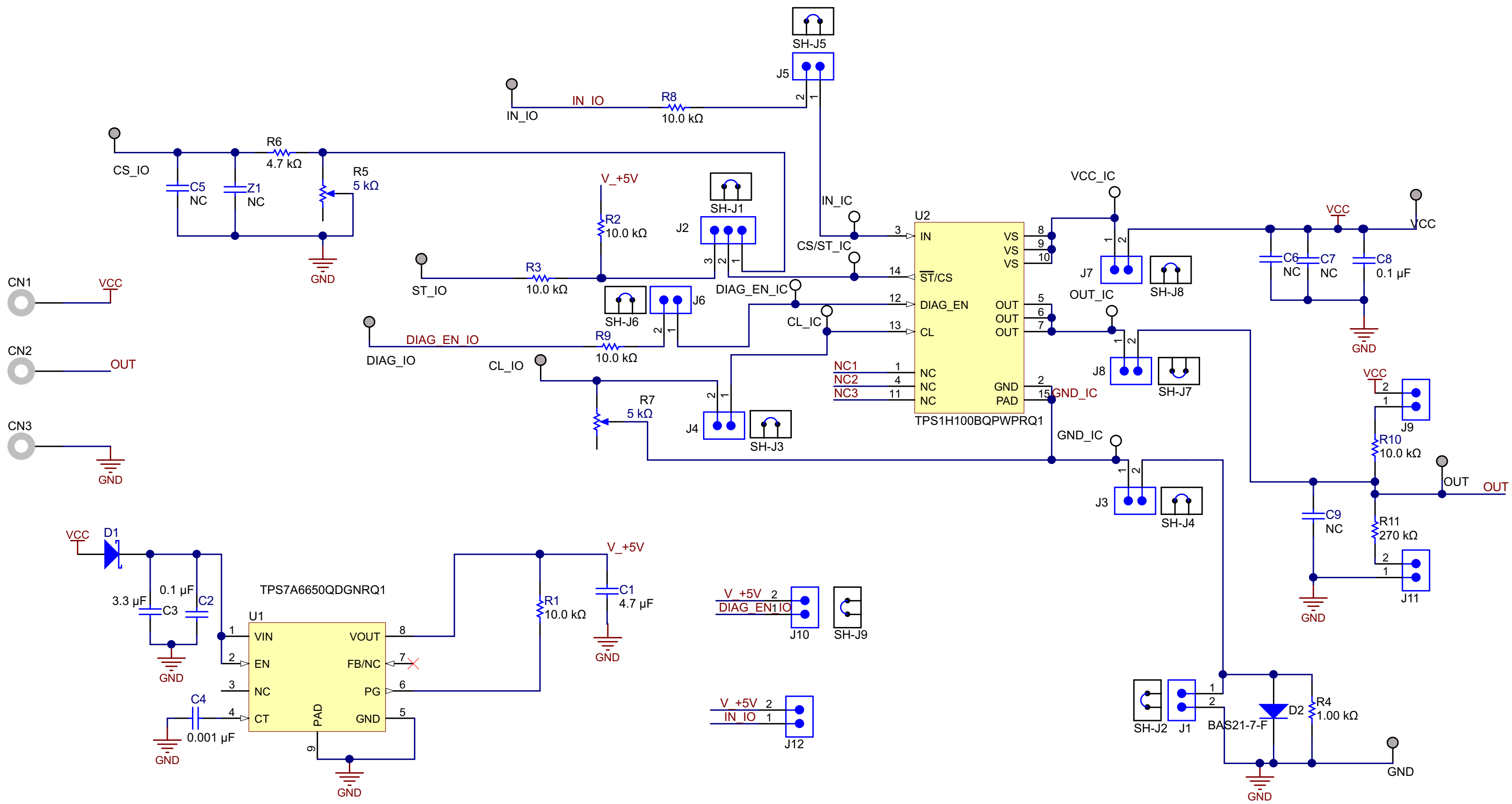
1.2 Applications

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

1.3 Features

- Single-channel high-side power switch, tested according to AECQ100-12
- Operating voltage 5 to 40 V, extended operating down to 3.5 V
- Operating junction temperature: –40ºC to 150ºC
- Very-low standby current: <1 µA
- Microcontroller input control: 3.3-V and 5-V logic compatible
- High-accuracy current sense (version B)
  - Analog current output as a ratio of the output current (3% at nominal load and 20% at light load)
  - Programmable current limit with external resistor
- Protection
  - Reverse battery protection with external resistor
  - Short-circuit protection
  - Overvoltage protection
  - Thermal shutdown/swing with self-recovery
  - Loss of GND, loss of Vs protection
  - ESD protection
- Diagnostic
  - On/off state output open/short to battery detection
  - Overload and short-to-ground detection and power limiting
  - Thermal shutdown/swing diagnostic
  - Version A: Open-drain status output
  - Version B: Current-sense analog diagnostic
  - Diagnostic enable function for multiplexing of MCU analog or digital port

2 TPS1H100-Q1 Schematic



3 Connections Descriptions

3.1 Connectors and Test Points

Table 1. Connector and Test Point Descriptions

Connectors and Test Points	Descriptions
CN1-VCC	Board positive input supply voltage connector, the drain terminal of DMOS
CN2-OUT	Board output pin connector, the source terminal of DMOS
CN3-GND	Board GND connector, the return connection to the input power supply
GND	Board GND connector, the return connection to the input power supply
IN_IO	Board input connector, 3.3- or 5-V control signal connection pin
OUT	Board output pin connector, the source terminal of DMOS
ST_IO	Board status output connector, only effective for version A
CS_IO	Board current sense output connector, only effective for version B
CL_IO	Board current limit output connector
DIAG_IO	Board Diag_En input connector, 3.3- or 5-V control signal connection pin
VCC	Board positive input supply voltage connector, the drain terminal of DMOS
GND_IC	IC GND test point, the return connection to the input power supply
IN_IC	IC Input test point
OUT_IC	IC output pin test point, the source terminal of DMOS
CS/ST_IC	IC status output test point, effective for both version A and B
CL_IC	IC current limit output test point
DIAG_EN_IC	IC Diag_En test point
VCC_IC	IC positive input supply voltage test point, the drain terminal of DMOS

3.2 Jumpers

Table 2. Jumper Descriptions

Jumpers	Description
J1	This jumper is used to short IC GND and board GND. When floating, there is a diode in parallel with a resistor between IC GND and board GND, which is designed for the reverse polarity protection.
J2	This jumper is used to select ST/CS functions; version A short pin 2 and pin 3, version B short pin 2 and pin 1.
J3	This jumper is used to isolate GND_IC from board GND.
J4	This jumper is used to isolate CL_IC from CL_IO.
J5	This jumper is used to isolate IN_IC from IN_IO.
J6	This jumper is used to isolate DIAG_EN_IC from DIAG_EN_IO.
J7	This jumper is used to isolate VCC_IC from board VCC.
J8	This jumper is used to isolate OUT_IC from board OUT.
J9	This jumper is used to set a pull up for OUT, if off-state open load/short to battery are required.
J10	When floating, DIAG_EN _IO is controlled by MCU. When connected, DIAG_EN_IO is pulled up to 5 V, for easy test usage.
J11	This jumper is used to set a pull down for OUT, if distinguish of open load and short to battery are required.
J12	When floating, IN_IO is controlled by MCU. When connected, IN_IO is pulled up to 5 V, for easy test usage.

4 TPS1H100-Q1 EVM Assembly Drawings and Layout

Figure 1 through Figure 3 show the design of the TPS1H100-Q1 PCB. The EVM was designed using FR4 material, four-layer (2s2p), 2 × 70-µm Cu in top and bottom layers, and 2 × 35-µm Cu in internal plane layers. The board size is 80 mm × 65 mm. 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.

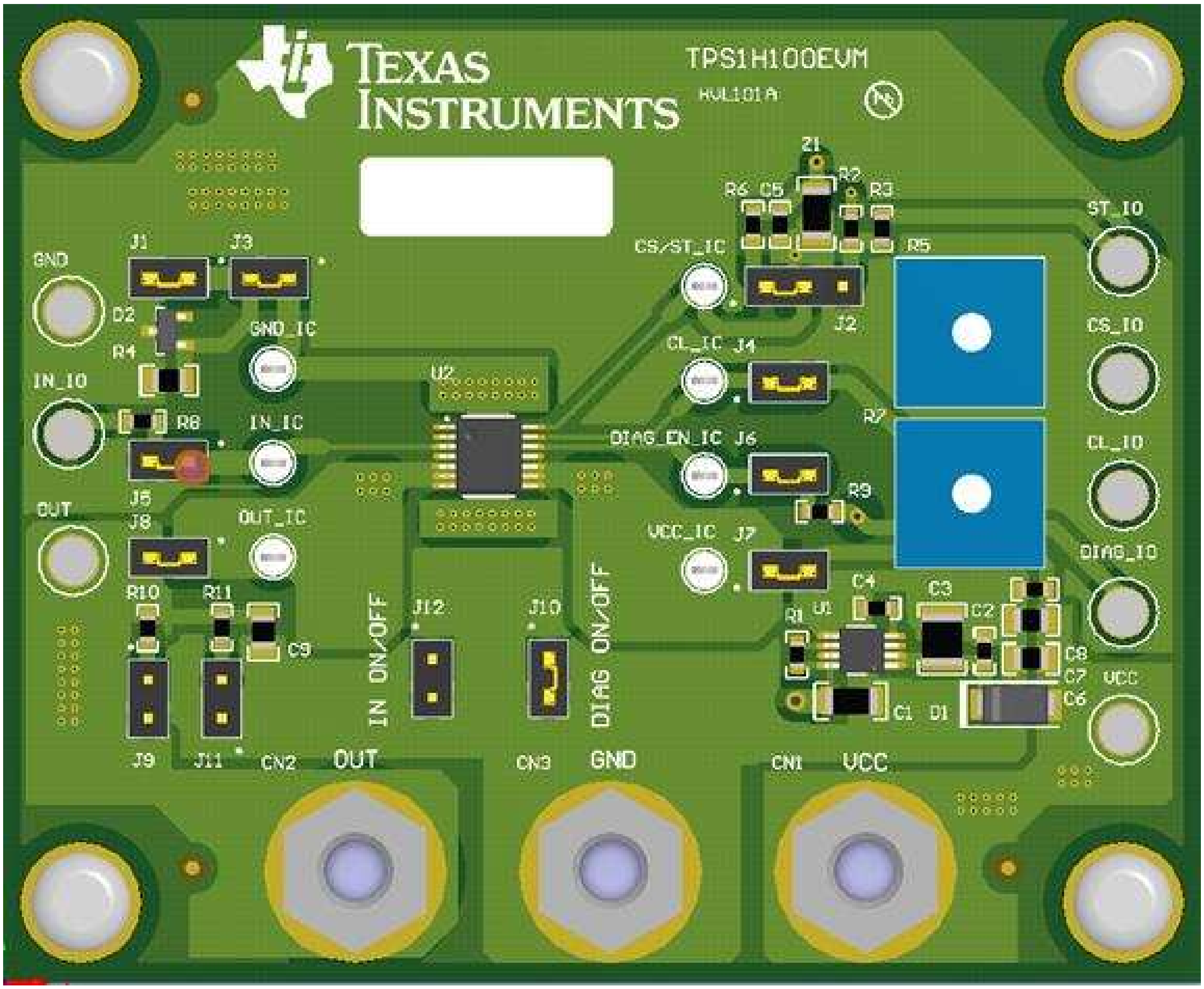


Figure 1. TPS1H100-Q1 EVM Component Placement (Top View)

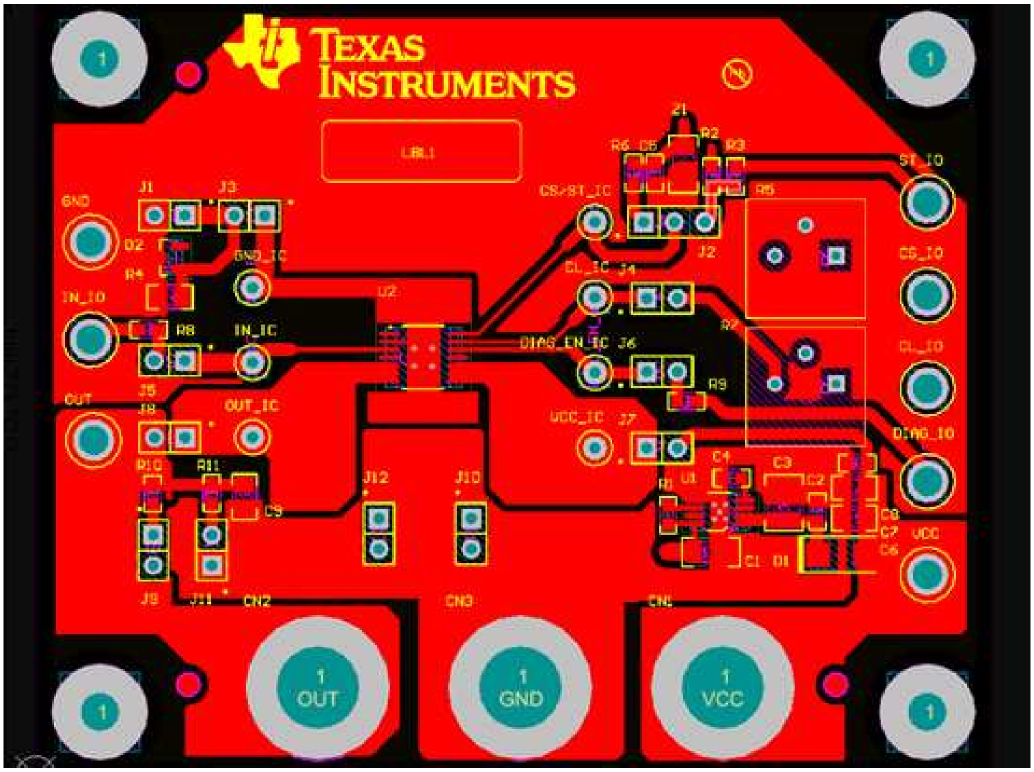


Figure 2. TPS1H100-Q1EVM Top Layer (Top View)

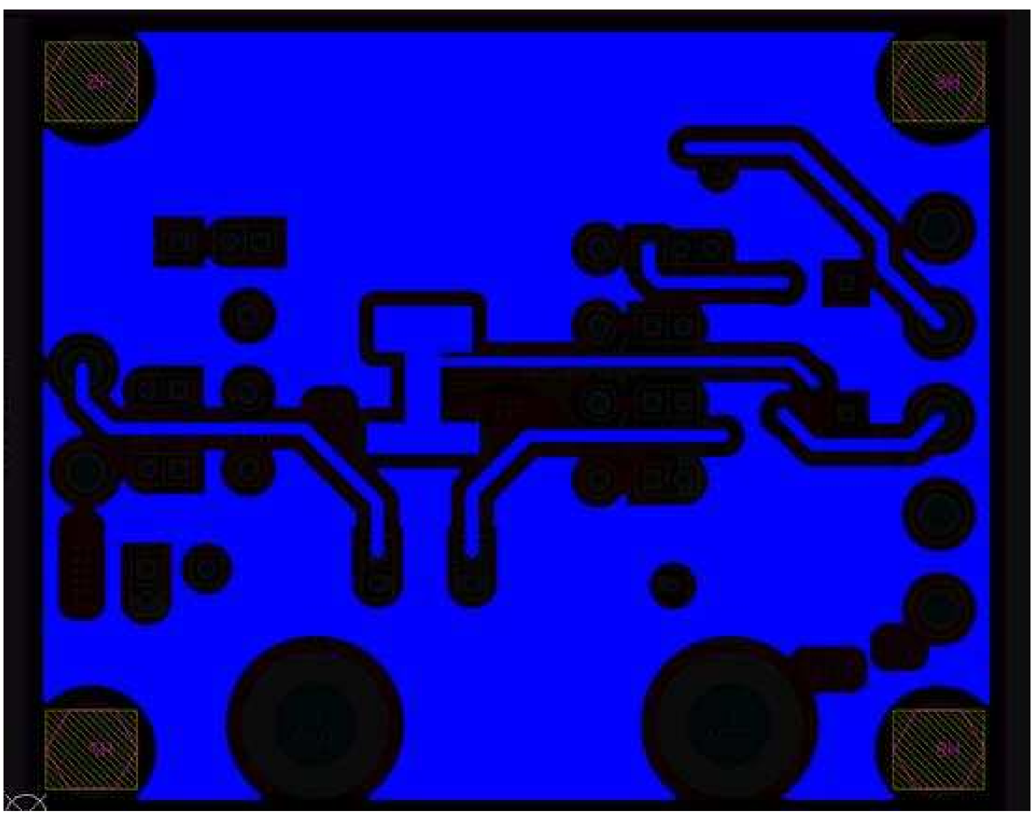


Figure 3. TPS1H100-Q1EVM Bottom Layer (Bottom View)

5 Variable Resistor for CS and CL

5.1 Current Sense Resistor

For version B, high-accuracy current sensing allows better real-time monitoring of effects and more accurate diagnostics without further calibration.

It provides the real-time output current monitoring. A current mirror is used to source 1/K of the load current, and reflected as $V_{CS} = I_{CS} \times R_{CS}$. When choosing the resistor, ensure the CS voltage is in the linear region (0 to 4 V) when in normal operation.

Also, when a fault condition happens, it works as a diagnostics report pin. When an open load/short to battery event happens in on-state, V_{CS} almost equals to 0. When a current limit, thermal shutdown/swing, open load/short to battery event in off-state happens, the voltage is clamped at $V_{CS,H}$.

R5 is a variable resistor, from 0 Ω to 5 kΩ. The CS resistor can be changed through R5.

5.2 Current Limit Resistor

An external resistor is used to convert a proportional load current into a voltage, which is compared with an internal reference voltage. When the voltage on the CL pin exceeds the reference voltage, the current is clamped.

The inherent current limit ($I_{lim,nom}$) is still present when using an external current limit. The smaller value of the internal or external set value decides the actual nominal current limit. If the user decides not to use the external programmable current, tie the CL pin to ground.

Equation 1 and Equation 2 show an example of setting the current limit at 5 A.

$$I_{CL} = \frac{V_{CL,th}}{R_{CL}} = \frac{I_{out}}{K_{CL}} \rightarrow R_{CL} = \frac{V_{CL,th} \times K_{CL}}{I_{out}} \quad (1)$$

$$R_{CL} = \frac{V_{CL,th} \times K_{CL}}{I_{out}} = \frac{1.233 \times 2000}{5} = 493.2\ \Omega \quad (2)$$

R7 is a variable resistor, from 0 Ω to 5 kΩ. The CL resistor can be changed through R7. When 0 Ω, there is no external current limit function and the internal current limit is active. When 5 kΩ, the current limit value is around 0.5 A.

6 Bill of Materials

Designator	Quantity	Comment	Description	Footprint
C1	1	12063D475KAT2A	CAP, CERM, 4.7uF, 25V, +/-10%, X5R, 1206	1206
C2, C8	2	GRM188R71H104KA93D	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	0603
C3	1	C3225X7R1H335M	CAP, CERM, 3.3uF, 50V, +/-20%, X7R, 1210	1210
C4	1	06035A102KAT2A	CAP, CERM, 1000pF, 50V, +/-10%, C0G/NP0, 0603	0603
CL_IC, CS/ST_IC, DIAG_EN_IC, GND_IC, IN_IC, OUT_IC, VCC_IC	7	5002	Test Point, TH, Miniature, White	Keystone5002
CL_IO, CS_IO, DIAG_IO, GND, IN_IO, OUT, ST_IO, VCC	8	Suggest using a net name here	Terminal, Turret, TH, Double	Keystone1502-2
CN1, CN2, CN3	3	108-0740-001	Standard Banana Jack, Uninsulated, 15A	Johnson_108-0740-001
D1	1	B150-13-F	Diode, Schottky, 50V, 1A, SMA	SMA
D2	1	BAS21-7-F	Diode, Switching, 200V, 0.2A, SOT-23	SOT-23
H1, H2, H3, H4	4	NY PMS 440 0025 PH	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH
H5, H6, H7, H8	4	1902C	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone_1902C
J1, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12	11	TSW-102-07-G-S	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	TSW-102-07-G-S
J2	1	TSW-103-07-G-S	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	TSW-103-07-G-S
LBL1	1	Size: 0.65" x 0.20 "	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Label_650x200
R1, R2, R3, R8, R9, R10	6	CRCW060310K0FKEA	RES, 10.0k ohm, 1%, 0.1W, 0603	0603
R4	1	CRCW08051K00FKEA	RES, 1.00k ohm, 1%, 0.125W, 0805	0805_HV
R5, R7	2	3386P-1-502LF	TRIMMER, 5k ohm, 0.5W, TH	BOURNS_3386P
R6	1	CRCW06034K70JNEA	RES, 4.7k ohm, 5%, 0.1W, 0603	0603
R11	1	RC0603FR-07270KL	RES, 270k ohm, 1%, 0.1W, 0603	0603
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9	969102-0000-DA	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G
U1	1	TPS7A6650QDGNRQ1	High-Voltage Ultralow-Iq Low-Dropout Regulator, DGN0008D	DGN0008D_N
U2	1	TPS1H100BQPWPRQ1	TPS1H100-Q1 Single Channel Smart High Side Driver, PWP0014C	PWP0014C_N

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      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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      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.

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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*

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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.

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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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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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8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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