

# TPS22968/68N-Q1 Dual Channel, 5.5-V, 4-A, 27-mΩ Load Switch Evaluation Module

The TPS22968Q1EVM and TPS22968NQ1EVM evaluation modules contain a dual channel, 5.5-V, 4-A, 27-mΩ on-resistance load switch with controlled turn on and adjustable rise time.

## Contents

1	Description .....	2
	1.1 Typical Applications .....	2
	1.2 Features.....	2
2	Electrical Performance Specifications.....	3
3	Schematic.....	3
4	Layout .....	4
5	Setup .....	5
	5.1 J1 VIN1/J2 VIN2 – Input Connections .....	5
	5.2 J3 VOUT1/J4 VOUT2 – Output Connections .....	5
	5.3 JP1 – VBIAS.....	5
	5.4 JP2/JP3 - Input Capacitors .....	6
	5.5 JP4/JP5/JP6/JP7 – Output Parallel Connections.....	6
	5.6 TP1/TP2 – VIN1-VIN2.....	6
	5.7 TP3/TP4 - VIN Sense, TP7/TP8 - VOUT Sense .....	6
	5.8 TP5/TP6 – VOUT1-VOUT2.....	6
	5.9 TP10 – VBIAS.....	6
	5.10 TP9/TP11 – ON1-ON2 .....	6
	5.11 TP12 – VOUT1 // VOUT2.....	6
	5.12 TP13 – TP17 GND .....	6
	5.13 List of Test Points.....	7
	5.14 Test Procedure .....	7
	5.15 R <sub>ON</sub> Test Procedure .....	8
	5.16 t <sub>R</sub> , t <sub>ON</sub> , t <sub>F</sub> , t <sub>OFF</sub> Test Procedure .....	8
6	Test Setup .....	9
7	Performance Data and Typical Characteristic Curves.....	11
	7.1 t <sub>R</sub> and t <sub>ON</sub> Scope Capture .....	11
	7.2 t <sub>F</sub> and t <sub>OFF</sub> Scope Capture .....	12
	7.3 Parallel Switch Operation .....	12
8	Bill of Materials .....	13

## 1 Description

The TPS22968/68N-Q1 device contains two N-channel MOSFETs that can operate over an input voltage range of 0.8 V to 5.5 V and can support a maximum continuous current of up to 4-A per channel. Each switch is independently controlled by an on/off input (ON1, ON2), which is capable of interfacing directly with low-voltage GPIO control signals. In the TPS22968-Q1, a 260- $\Omega$  on-chip load resistor is added for quick output discharge (QOD) when the switch is turned off. In the TPS22968N-Q1, the output is left floating when the device is disabled. The rise time of the device is internally controlled in order to avoid inrush current and can be adjusted using a ceramic capacitor on the CTx pins. The TPS22968-Q1 is available in a small, space-saving 2 mm x 3 mm 10-pin SON package with integrated thermal pad allowing for high power dissipation. The 0.5mm pin pitch, wettable flanks, and extended temperature range make the TPS22968/68N-Q1 ideal for automotive applications.

The TPS22968-Q1 device can be evaluated using the TPS22968Q1EVM module while the TPS22968N-Q1 can be evaluated using the TPS22968NQ1EVM. The TPS22968/68N-Q1 dual load switch device can be configured in either a dual switch configuration or a parallel switch configuration using the EVM.

### 1.1 Typical Applications

- Automotive Electronics
- Infotainment
- Cluster
- ADAS

### 1.2 Features

- External capacitors for configurable rise time
- High current connection terminals available for 4 A maximum continuous switch current operation
- EVM configurable for single or parallel switch configurations
- VIN input voltage range: 0.8 V to 5.5 V
- Connection points to VIN, VOUT, VBIAS, ON pins as well as SENSE connections for accurate measurement of VIN and VOUT voltages
- VBIAS voltage range: 2.5 V to 5.5 V

## 2 Electrical Performance Specifications

Reference the TPS22968/68N-Q1 datasheet ([SLVSCP7](#)).

## 3 Schematic

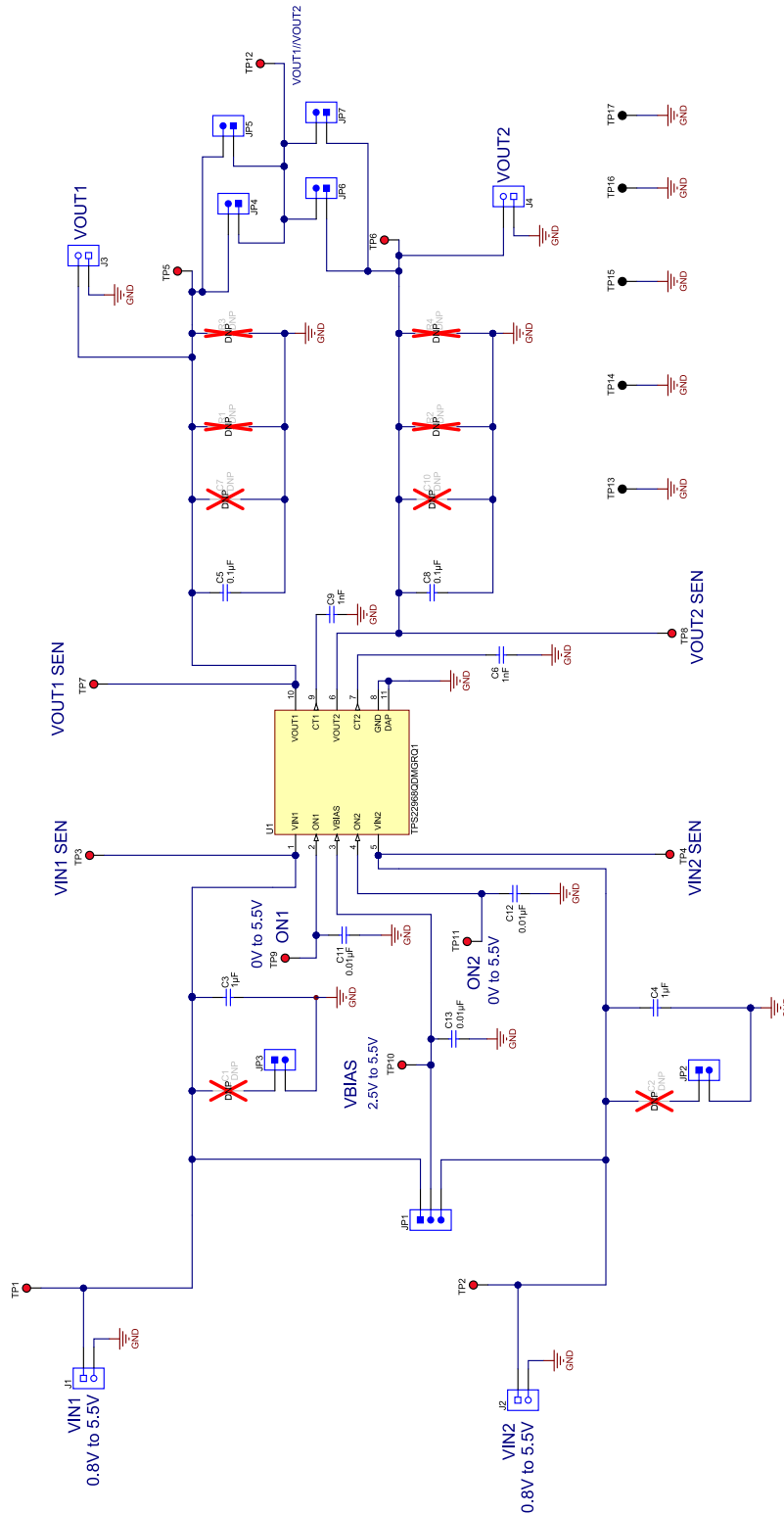


Figure 1. TPS22968Q1EVM / TPS22968NQ1EVM Schematic

4 Layout

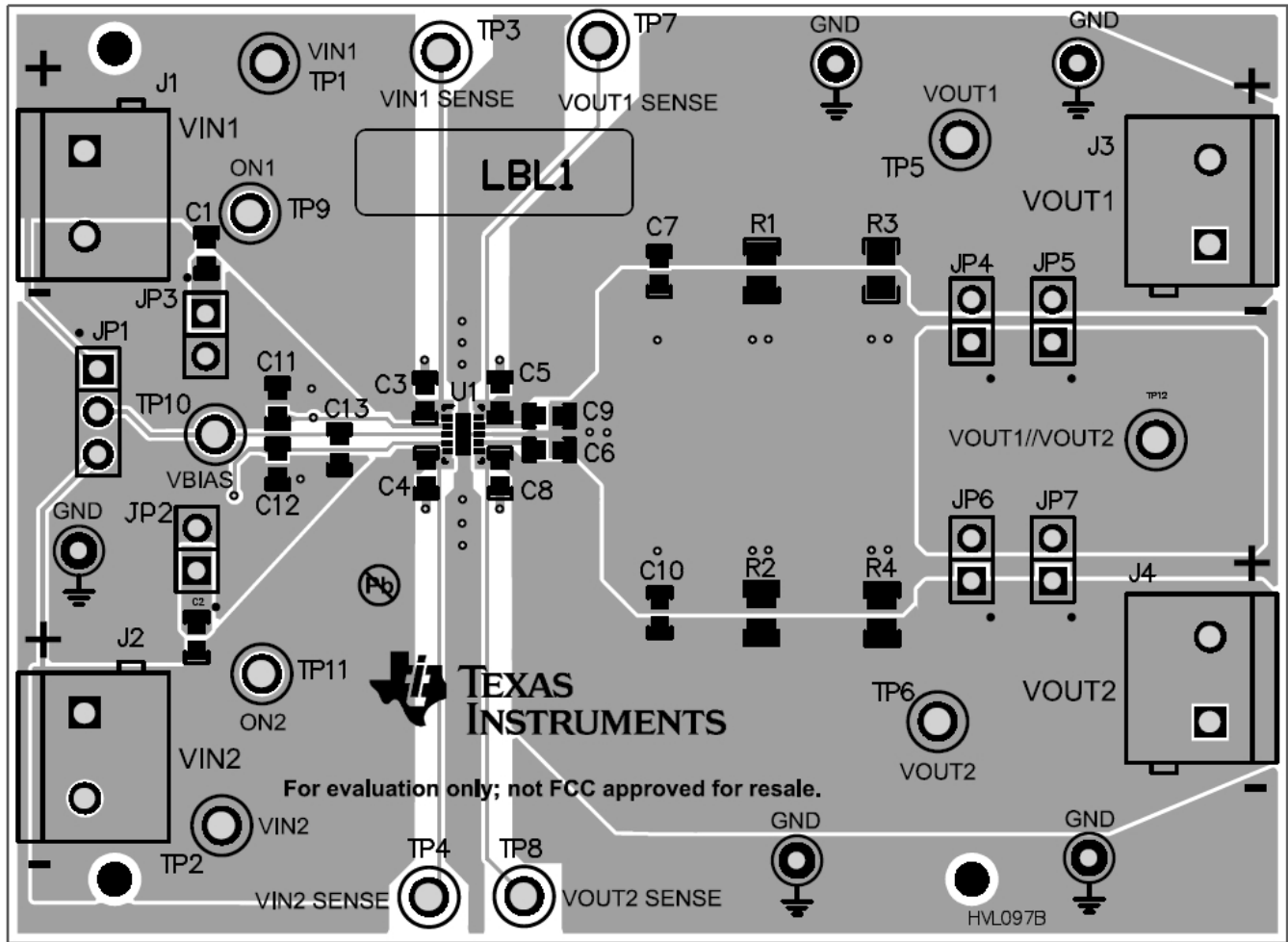
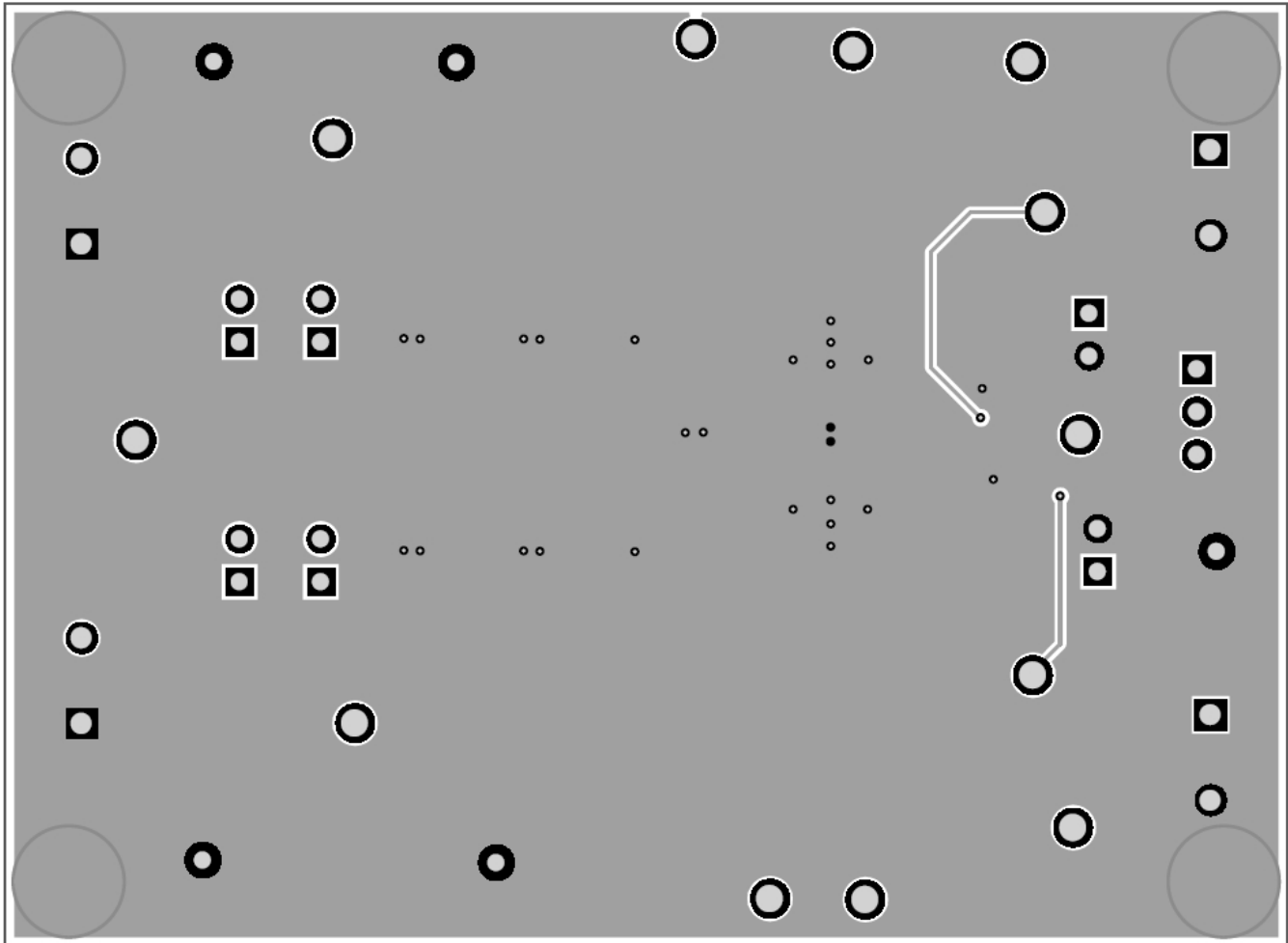


Figure 2. TPS22968Q1EVM / TPS22968NQ1EVM Top



**Figure 3. TPS22968Q1EVM / TPS22968NQ1EVM Bottom**

## 5 Setup

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

### 5.1 J1 VIN1/J2 VIN2 – Input Connections

These are the high current input connections from the input source. Connect the positive lead to J1 and J2 terminal and the negative lead to a GND connection point.

### 5.2 J3 VOUT1/J4 VOUT2 – Output Connections

These are the high current connections for the outputs of the EVM. Connect the positive lead to J3 and J4 terminal and the negative lead to GND connection point.

### 5.3 JP1 – VBIAS

These jumpers connect VBIAS to either VIN1 or VIN2 voltage source. VBIAS must be maintained between 2.5 V – 5.5 V for proper operation on the TPS22968/68N-Q1 device. If testing conditions involve taking the VIN voltage levels Below 2.5V, remove the shunt across JP1 and connect VBIAS voltage at TP10.

#### **5.4 JP2/JP3 - Input Capacitors**

During normal operation the shorting jumper is removed on JP3 and JP4. These jumpers connect C1 and C2 capacitors (unpopulated) from the input of the device to ground. Refer to the Applications Section of the Datasheet for additional information on selecting the input capacitor.

#### **5.5 JP4/JP5/JP6/JP7 – Output Parallel Connections**

JP4-JP7 connects VOUT1 and VOUT2 together and is used when testing both device switches in parallel configuration.

#### **5.6 TP1/TP2 – VIN1-VIN2**

These are input connections to the device.

#### **5.7 TP3/TP4 - VIN Sense, TP7/TP8 - VOUT Sense**

These two connections are used when very accurate measurements of the input or output are required. RON measurements should be made using these sense connections when measuring the voltage drop from VIN to VOUT and then calculating the resistance.

#### **5.8 TP5/TP6 – VOUT1-VOUT2**

These are output connections to the device.

#### **5.9 TP10 – VBIAS**

This is the VBIAS connection point. VBIAS must be applied to the TPS22968/68N-Q1 device at a voltage level of 2.5 V to 5.5 V level for proper operation. VBIAS may be applied direct at this connection point or applied using JP1.

#### **5.10 TP9/TP11 – ON1-ON2**

These are the enable inputs for the device. Apply an external enable/disable source to TP9 and TP11. The TPS22968/68N-Q1 is active high. ON1 and ON2 must not be left floating. Refer to the datasheet for proper ON and OFF voltage level settings. A switching signal may also be used and connected at these points.

#### **5.11 TP12 – VOUT1 // VOUT2**

This is the common connection point for VOUT when the switch output are connected in parallel configuration.

#### **5.12 TP13 – TP17 GND**

These are the GND connection points to the EVM.

### 5.13 List of Test Points

**Table 1. Test Points Functions**

Test Points	Name	Description
J1	VIN1	DC Input to VIN1
J2	VIN2	DC Input to VIN2
J3	VOUT1	DC Output from VOUT1
J4	VOUT2	DC Output from VOUT2
JP1	VBIAS	Connects VBIAS to VIN1 or VIN2
JP2	C2	Connects C2 from VIN2 to GND
JP3	C1	Connects C1 from VIN1 to GND
JP4, JP5, JP6, JP7	VOUT1 // VOUT2	Shorts VOUT1 and VOUT2 together used in parallel switch configuration
TP1	VIN1	VIN1 Connection
TP2	VIN2	VIN2 Connection
TP3	VIN1 SEN	Sense connection to VIN1
TP4	VIN2 SEN	Sense connection to VIN2
TP5	VOUT1	VOUT1 Connection
TP6	VOUT2	VOUT2 Connection
TP7	VOUT1 SEN	Sense connection to VOUT1
TP8	VOUT2 SEN	Sense connection to VOUT2
TP9	ON1	ON1 Connection
TP10	VBIAS	VBIAS Connection
TP11	ON2	ON2 Connection
TP12	VOUT1 // VOUT2	VOUT1 VOUT2 connected in parallel configuration
TP13	GND	Ground Connection
TP14	GND	Ground Connection
TP15	GND	Ground Connection
TP16	GND	Ground Connection
TP17	GND	Ground Connection

### 5.14 Test Procedure

Figure 4 shows a typical setup for the  $R_{ON}$  test of the EVM. VBIAS voltage must be present for the device to function, keep this voltage level constant between 2.5 V – 5.25 V. Adding a shunt across JP1 will connect the VBIAS pin to VIN1 (pin1 to pin2) or VIN2 (pin2 to pin3). When testing with input voltages below 2.5 V JP2 shunt must be removed and VBIAS tied to another voltage source.

### 5.15 $R_{ON}$ Test Procedure

1. Setup the EVM per [Figure 4](#).
2. Set SOURCE1 level to 5.0 V.
3. Place a shunt across JP1 from pin1 to pin2.
4. Connect ON1 and ON2 to a DC source between 1.2 V and 5.5 V, SOURCE1 supply can be used for this. (When testing  $R_{ON}$  it is desired to have the switch operating in the always ON condition.)
5. Place a load on VOUT1 and VOUT2.
6. Turn on SOURCE1.
7. Record the voltage reading from METER1 and METER2 as well as the input current reading from SOURCE1.
8. Turn SOURCE1 off.
9. Calculate the  $R_{ON}$  value for switch 1 by dividing the METER1 voltage level by half of the current reading from SOURCE1.
10. Calculate the  $R_{ON}$  value for switch 2 by dividing the METER2 voltage level by half of the current reading from SOURCE1.

### 5.16 $t_R$ , $t_{ON}$ , $t_F$ , $t_{OFF}$ Test Procedure

1. The rise time ( $t_R$ ) is selected by the CT capacitor value on each switch channel. The EVM is shipped with a default CT value of 1 nF.
2. Set up the EVM per [Figure 5](#)
3. Set SOURCE1 level to 5.0 V.
4. Place a shunt across JP1 from pin1 to pin2.
5. Place a load on VOUT1 and VOUT2 (a 10  $\Omega$ , 3.25 W resistor is recommended for this test).
6. Set Signal Generator output to 0–2 Vpp, 10–100 Hz, and 25% duty cycle.
7. Turn SOURCE1 on.
8. Enable the Signal Generator output.
9. Rise time ( $t_R$ ) and turn-on time ( $t_{ON}$ ) can be observed with a Oscilloscope sync the scope trigger on the rising edge of the on signal.. A detailed description of  $t_R$ ,  $t_{ON}$ ,  $t_F$  and  $t_{OFF}$  are listed in the TPS22968/68N-Q1 Datasheet under the Switching Characteristics Section.
10. Fall time ( $t_F$ ) and turn-off time ( $t_{OFF}$ ) can be observed from the oscilloscope by charging the scope triggering to sync with the falling edge of the ON signal.
11. Turn SOURCE1 off and disable the signal Generator output.



6 Test Setup

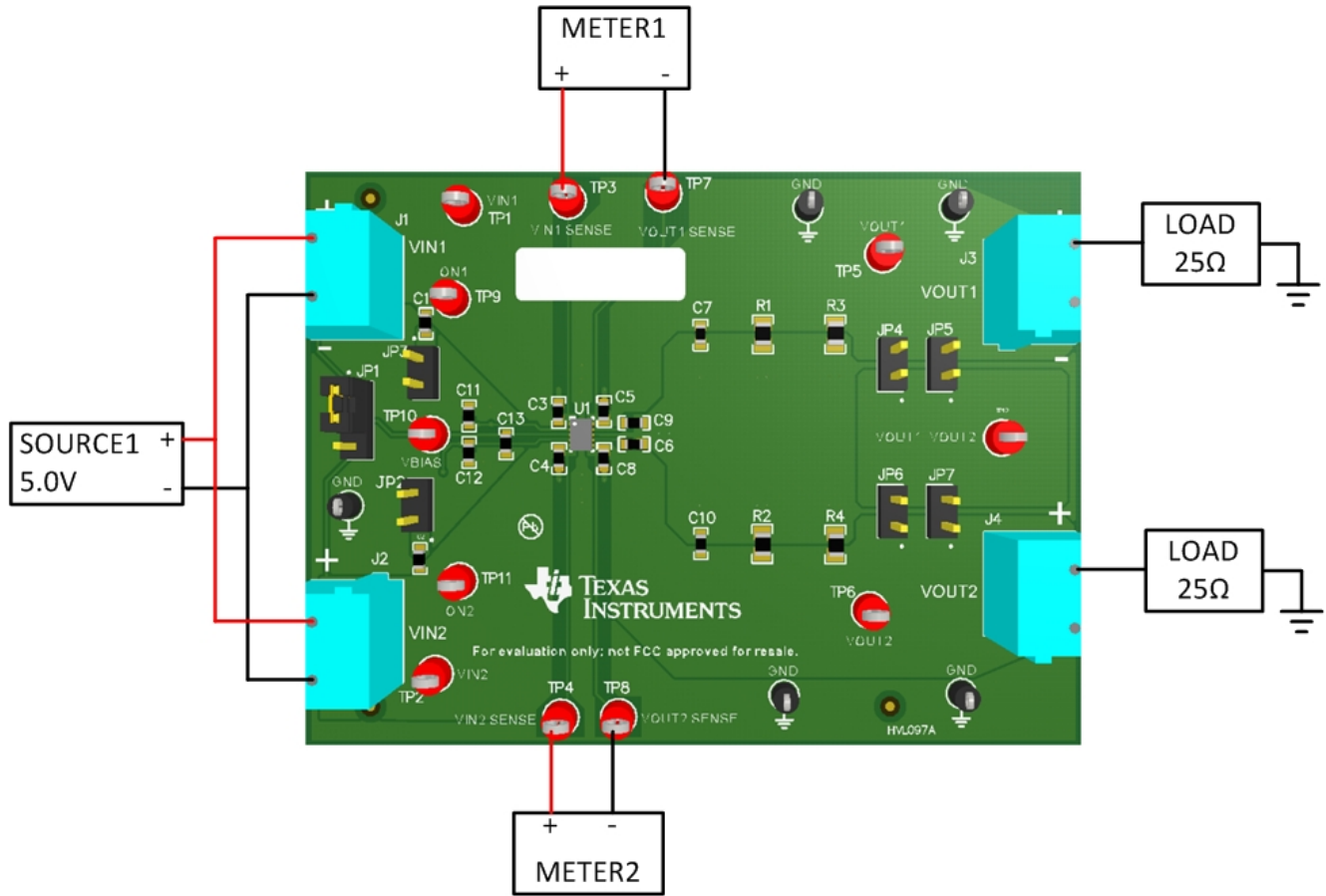


Figure 4. TPS22968Q1EVM / TPS22968NQ1EVM Recommended  $R_{ON}$  Test Set Up

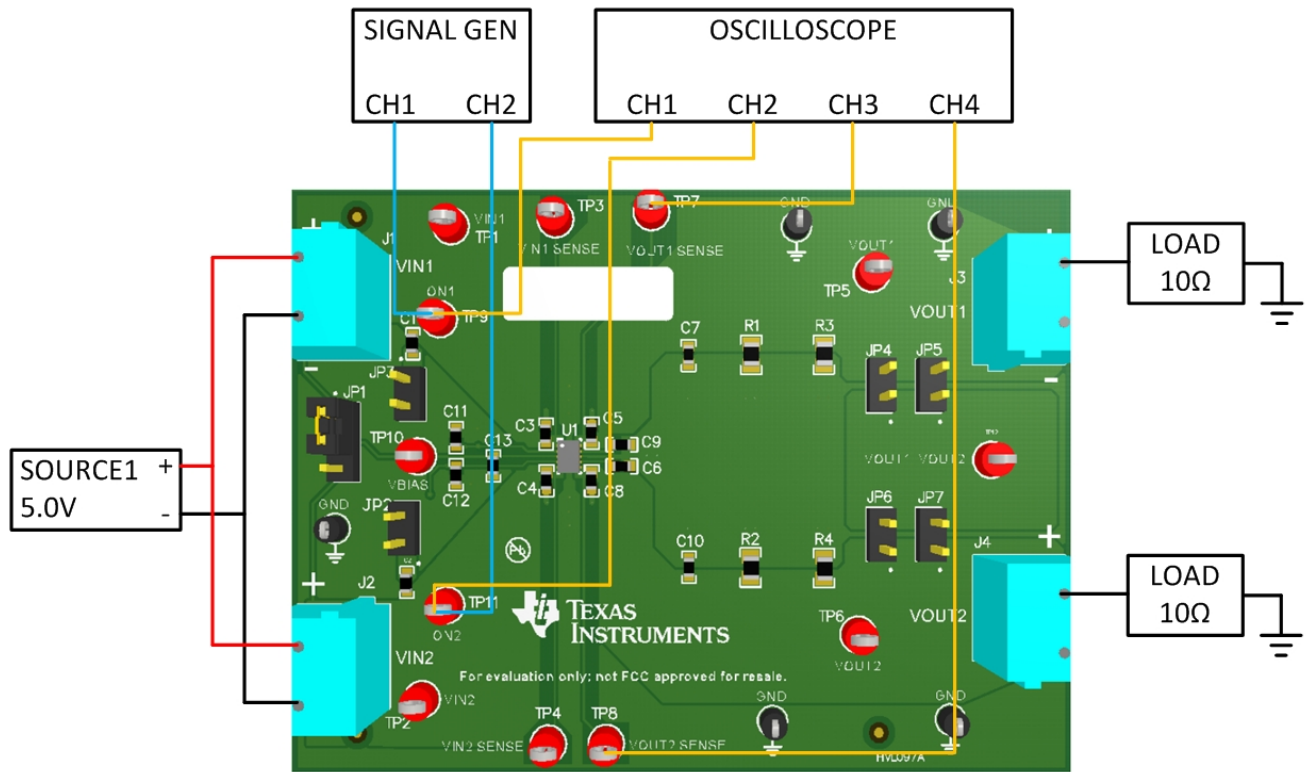


Figure 5. TPS22968Q1EVM / TPS22968NQ1EVM Recommended  $T_R$  Test Set Up

## 7 Performance Data and Typical Characteristic Curves

Figure 6 and Figure 7 present typical performance curves for TPS22968Q1EVM and TPS22968NQ1EVM.

### 7.1 $t_R$ and $t_{ON}$ Scope Capture

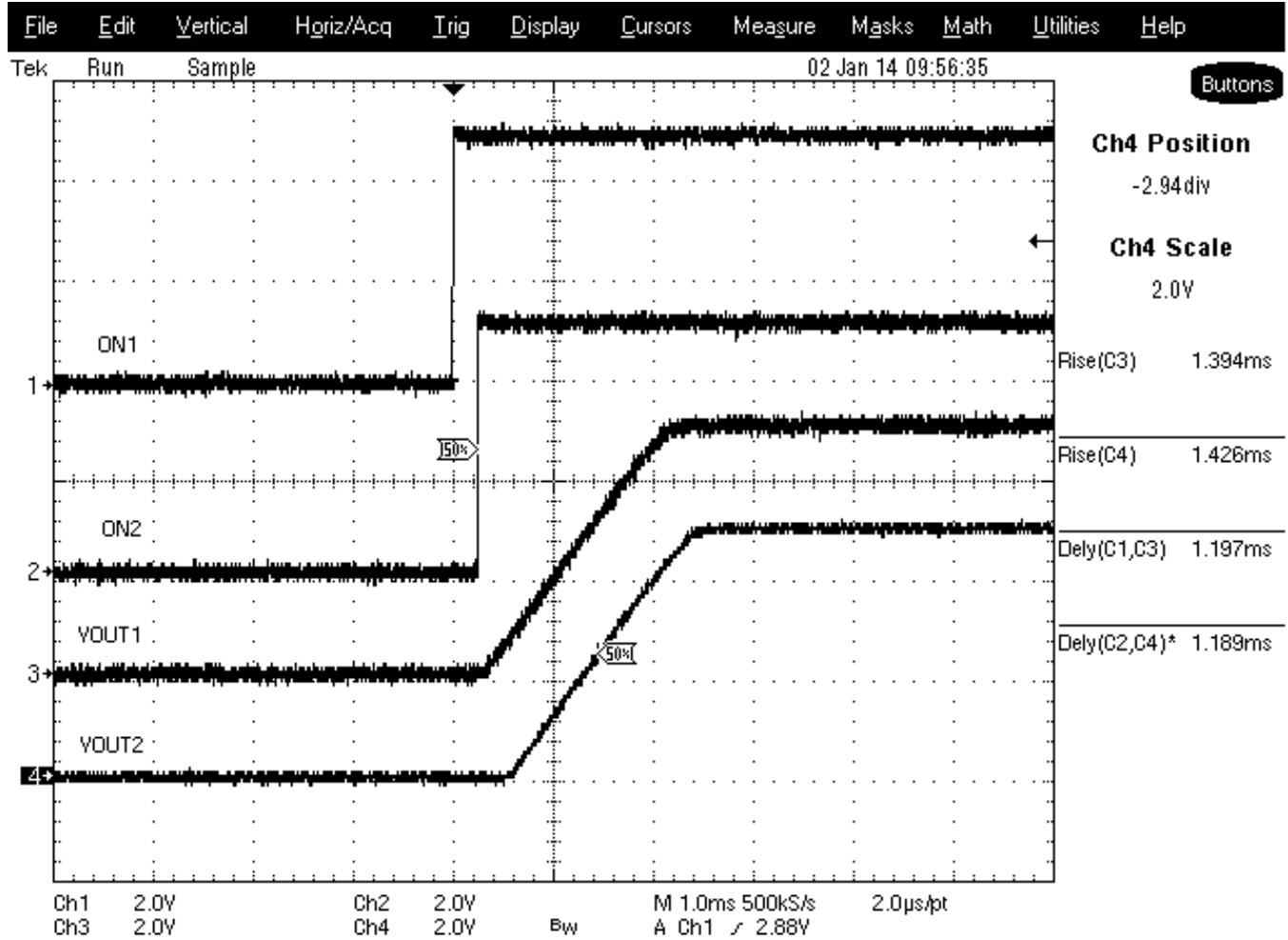


Figure 6. TPS22968Q1EVM / TPS22968NQ1EVM  $t_R$  With  $V_{IN} = 5\text{ V}$ ,  $C_T = 1\text{ nF}$  and Load =  $10\ \Omega$

## 7.2 $t_F$ and $t_{OFF}$ Scope Capture

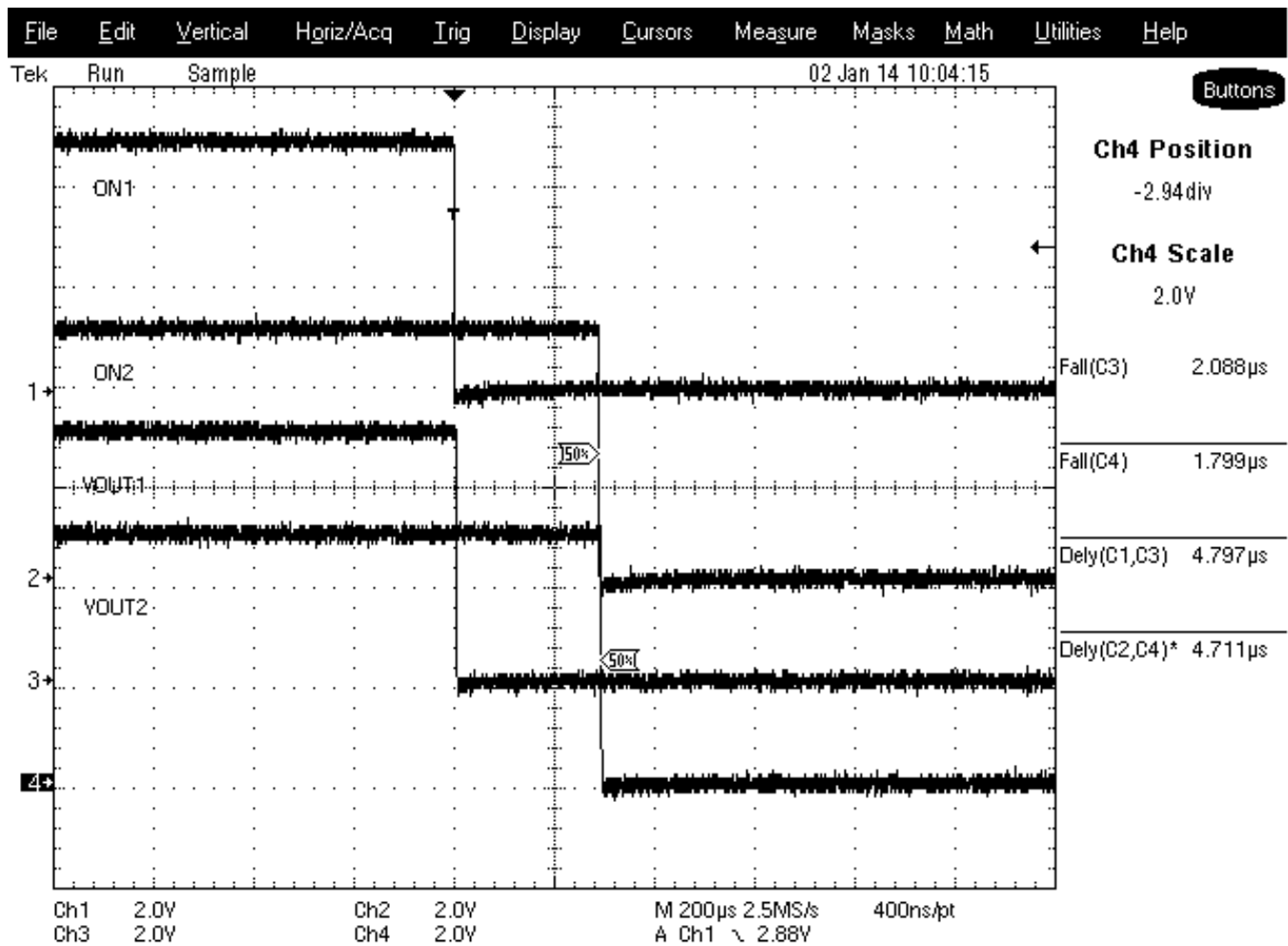


Figure 7. TPS22968Q1EVM with  $V_{IN} = 5\text{ V}$ ,  $C_T = 1\text{ nF}$  and Load =  $10\ \Omega$

## 7.3 Parallel Switch Operation

The TPS22968/68N-Q1 device switches can be connected in parallel configuration by adding shorting shunts across JP4, JP5, JP6, and JP7. Parallel switch configuration lowers  $R_{ON}$  and raises maximum continuous current capability. Refer to Applications Note [SLVA585](#) for further details.

## 8 Bill of Materials

Table 2 is the EVM components list according to the schematic shown in [Figure 1](#).

**Table 2. EVM Components List**

Quantity	Designator	Description	Manufacturer	Part Number
1	IPCB1	Printed Circuit Board	Any	HVL097
2	C3, C4	CAP, CERM, 1 $\mu$ F, 16 V, +/- 10%, X5R, 0603	MuRata	GRM188R61C105KA93D
2	C5, C8	CAP, CERM, 0.1 $\mu$ F, 25 V, +/- 10%, X7R, 0603	MuRata	GRM188R71E104KA01D
2	C6, C9	CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0603	Kemet	C0603C102K5RACTU
3	C11, C12, C13	CAP, CERM, 0.01 $\mu$ F, 16 V, +/- 10%, X7R, 0603	MuRata	GRM188R71C103KA01D
4	J1, J2, J3, J4	Terminal Block, 5.08 MM VERT 2POS, TH	On-Shore Technology	ED120/2DS
14	JP1, JP2, JP3, JP4, JP5, JP6, JP7,	Header, 100 mil, 2x1, Gold, TH	Samtec	TSW-102-07-G-S
1	SH-JP1	Shunt, 100mil, Gold plated, Black	3M	969102-0000-DA
12	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	Test Point, Compact, Red, TH	Keystone	5005
5	TP13, TP14, TP15, TP16, TP17	Test Point, Miniature, Black, TH	Keystone	5001
1	U1	Dual Channel 4A Load Switch	Texas Instruments	TPS22968QDMGRQ1
1	U1	Dual Channel 4A Load Switch	Texas Instruments	TPS22968NQDMGRQ1

## Revision History

Changes from Original (January 2014) to A Revision	Page
• Added the TPS22968NQ1EVM to the user's guide. ....	1
• Changed instances of "TPS22968-Q1" to "TPS22968/68N-Q1". ....	2
• Added a description for the turn off behavior of the TPS22968N-Q1 .....	2
• Modified test setup images to reflect the new board layout .....	9
• Added the TPS22968N-Q1 to the BOM.....	13

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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3. *Regulatory Notices:*
  - 3.1 *United States*
    - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

*NOTE: 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.

### 3.2 Canada

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

#### Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

#### 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.

### 3.3 Japan

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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#### 4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

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.

#### 4.3 *Safety-Related Warnings and Restrictions:*

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