TPS22968EVM-007 Dual 4A Load Switch

The TPS22968EVM-007 evaluation module contains a dual channel, ultra low ON resistance, 4-A load switch with controlled turn and adjustable rise time.

Contents

1   Description

The TPS22968 device contains two N-channel MOSFETs that can operate over an input voltage range of 0.8V 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, a 260-Ω on-chip load resistor is added for quick output discharge (QOD) when the switch is turned off. The rise time of the device is internally controlled in order to avoid in-rush current and can be adjusted using a ceramic capacitor on the CTx pins. The TPS22968 is available in a small, space-saving 2mm x 3mm 14-pin SON package with integrated thermal pad allowing for high power dissipation.

The TPS22968 device is demonstrated using the TPS22968EVM-007 module. The TPS22968 Dual Load Switch device can be configured in either a dual switch configuration or a parallel switch configuration using the TPS22968EVM-007.

1.1   Typical Applications

- Ultrabooks™
- Notebooks/Netbooks
- Tablet PC
- Consumer Electronics
- Set-top Boxes
- Industrial Systems
- Telecom Systems

1.2   Features

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

2 Electrical Performance Specifications
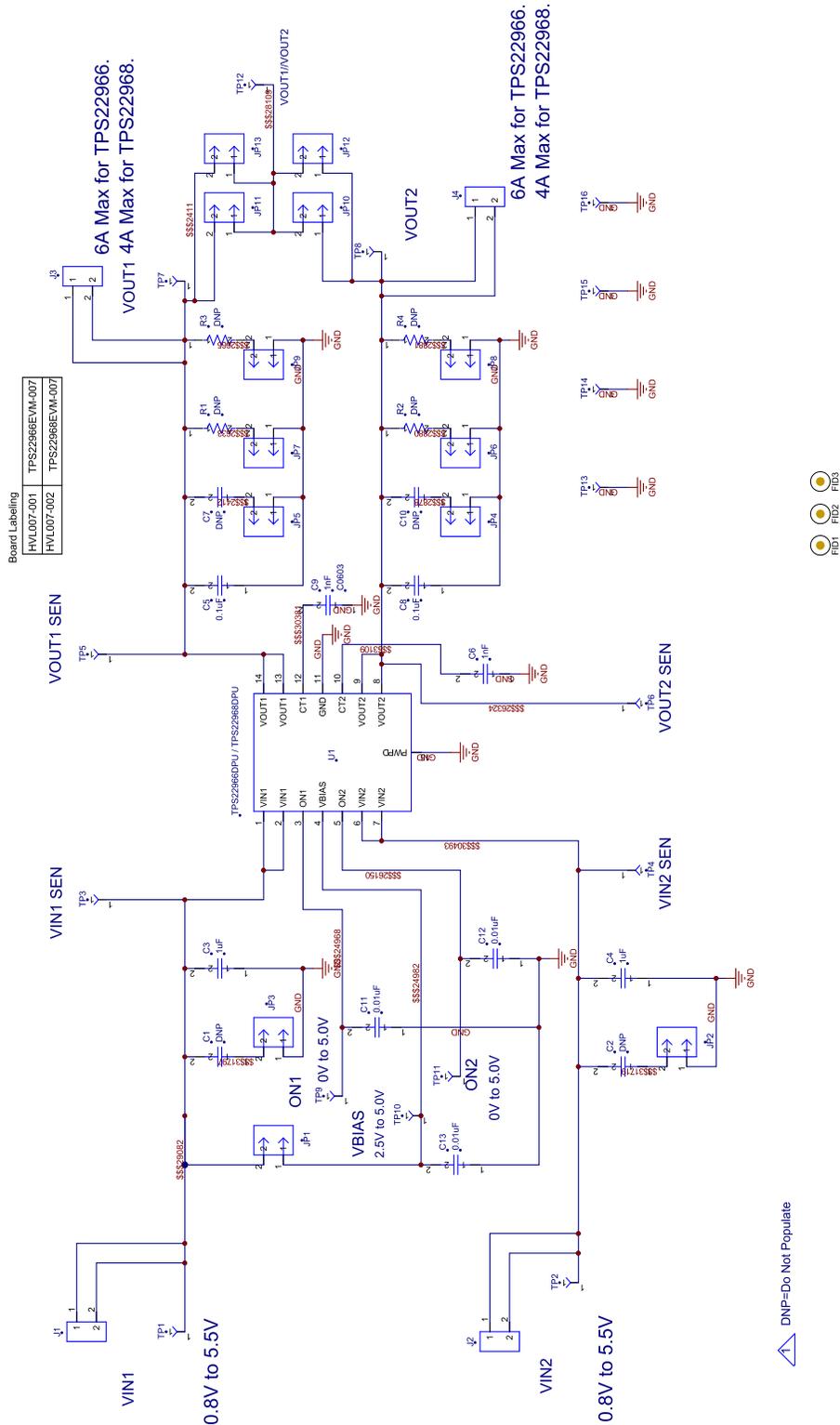
Reference Datasheet SLVSCG3

3 Schematic

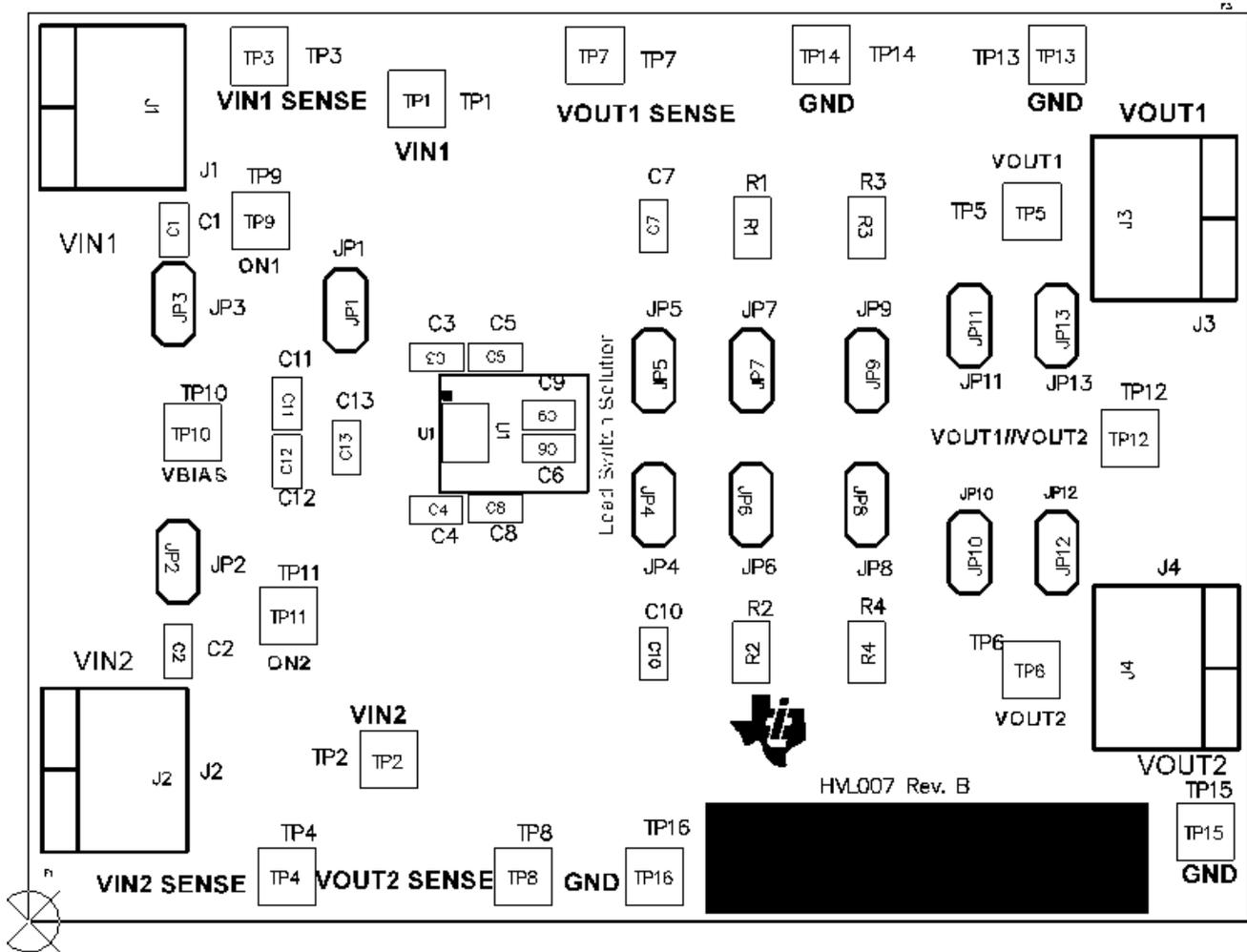**Figure 1. TPS22968EVM-007 Schematic**

4   Layout

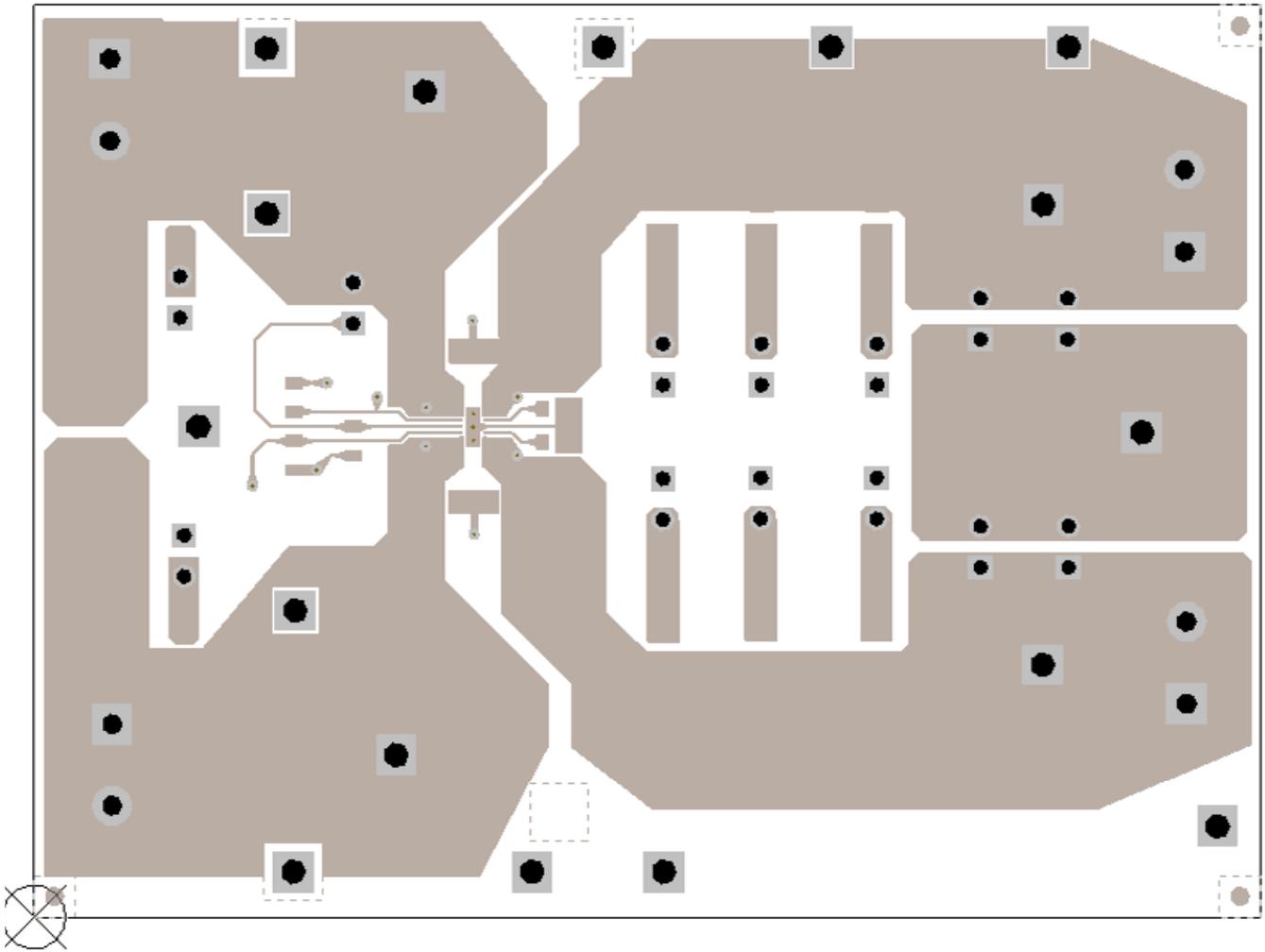**Figure 2. TPS22968EVM-007 Top Assembly**

Figure 3. TPS22968EVM-007 Top
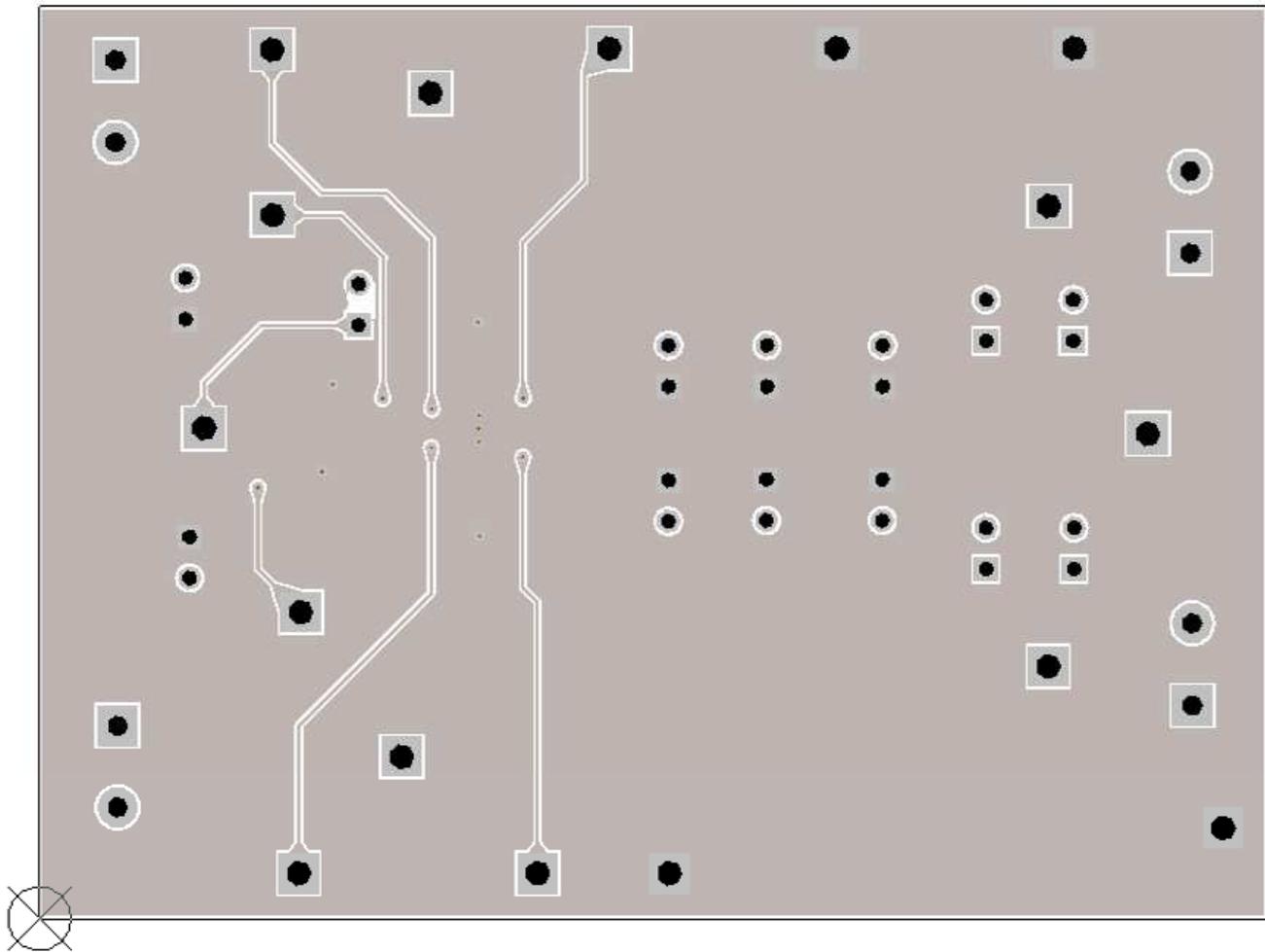
Figure 4. TPS22968EVM-007 Bottom

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

This jumper connects VBIAS to VIN1 voltage source. VBIAS must be maintained between 2.5V – 5.5V for proper operation on the TPS22968 device. If testing conditions involve taking VIN1 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 JP2 and JP3. 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 - Output Capacitors

During normal operation the shorting jumper is removed on JP4 and JP5. These jumpers connect C7 and C10 capacitors (unpopulated) from the output of the device to ground. Refer to the Applications Section of the Datasheet for additional information on selecting the output capacitor.

5.6　JP6/JP7/JP8/JP9 – Output Resistors

During normal operation no shorting jumper is placed on JP6-JP9. A shorting jumper may be used on JP6-JP9 to connect R1-R4 load resistors from the output of the device to ground. R1-R4 is for user selected values and are unpopulated.

5.7　JP10/JP11/JP12/JP13 – Output Parallel Connections

JP10-JP12 connects VOUT1 and VOUT2 together and is used when testing both device switches in parallel configuration.

5.8　TP1/TP2 – VIN1-VIN2

These are input connections to the device.

5.9　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.

5.10　TP5/TP6 – VOUT1-VOUT2

These are output connections to the device.

5.11　TP10 – VBIAS

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

5.12　TP9/TP11 – ON1-ON2

These are the enable inputs for the device. Apply an external enable/disable source to TP9 and TP11. The TPS22968 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.

5.13　TP12 – VOUT1 // VOUT2

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

5.14　TP13 – TP16 GND

These are the GND connection points to the EVM.

5.15 List of Test Points

Table 1. The Functions of Each Test Points

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
JP2	C2	Connects C2 from VIN2 to GND
JP3	C1	Connects C1 from VIN1 to GND
JP4	C10	Connects C10 from VOUT2 to GND
JP5	C7	Connects C7 from VOUT1 to GND
JP6	R2	Connects R2 from VOUT2 to GND
JP7	R1	Connects R1 from VOUT1 to GND
JP8	R4	Connects R4 from VOUT2 to GND
JP9	R3	Connects R3 from VOUT1 to GND
JP10, JP11, JP12, JP13	VOUT1 // VOUT2	Shorts VOUT1 and VOUT2 together used in parallel switch configuration
TP1	VIN1	VIN1 connection
TP2	VIN2	VIN2 connection
TP3	VIN1 SEN	Sense connect to VIN1
TP4	VIN2 SEN	Sense connect to VIN2
TP5	VOUT1	VOUT1 connection
TP6	VOUT2	VOUT2 connection
TP7	VOUT1 SEN	Sense connect to VOUT1
TP8	VOUT2 SEN	Sense connect to VOUT2
TP9	ON1	ON1 connection
TP10	VBIAS	VBIAS connection
TP11	VOUT1 VOUT2	ON2 connection
TP12	VOUT1 // VOUT2	VOUT1 VOUT2 connected in parallel configuration
TP13	AGND	Ground Connection
TP14	AGND	Ground Connection
TP15	AGND	Ground Connection
TP16	AGND	Ground Connection

5.16 Test Procedure

Figure 5 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 2.5V-5.25V. Adding a shunt across JP1 will connect the VBIAS pin to VIN1. When testing with VIN1 below 2.5V JP1 shunt must be removed and VBIAS tied to another voltage source.

Setup

5.17 R_{ON} Test Procedure

1. Setup the EVM per Figure 5.

2. Set SOURCE1 level to 5.0V.

3. Place a shunt across JP1.

4. Connect ON1 to a DC source between 1.05v and 5.5v, 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. Connect ON2 to GND. This keeps switch 2 in the off state.

6. Place a load on VOUT1 and VOUT2.

7. Turn on SOURCE1.

8. Record the voltage reading from METER1, record the input current reading from SOURCE1. Calculate Ron by dividing METER1 voltage level by the current reading from SOURCE1. The result will be the R_{ON} value for switch 1.

9. Turn SOURCE1 off.

10. Remove ON1 from SOURCE1 and connect to GND.

11. Remove ON2 from GND and connect to SOURCE1.

12. Turn SOURCE1 on.

13. Record the voltage reading from METER2, record the input current reading from SOURCE1. Calculate R_{ON} by dividing the voltage reading of METER2 by the current reading from SOURCE1. The results will be the R_{ON} value for switch 2.

14. Turn SOURCE1 off.

5.18 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 1nF.

2. Set up the EVM per Figure 6

3. Set SOURCE1 level to 5.0V.

4. Place a shunt across JP1.

5. Place a load on VOUT1 and VOUT2 (a 10Ω, 3.25W resistor is recommended for this test).

6. Set Signal Generator output to 0-2Vpp, 10-100Hz, 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 Datasheet under the Switching Characteristics Section.

10. Fall time (t_F) and turn-of 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.
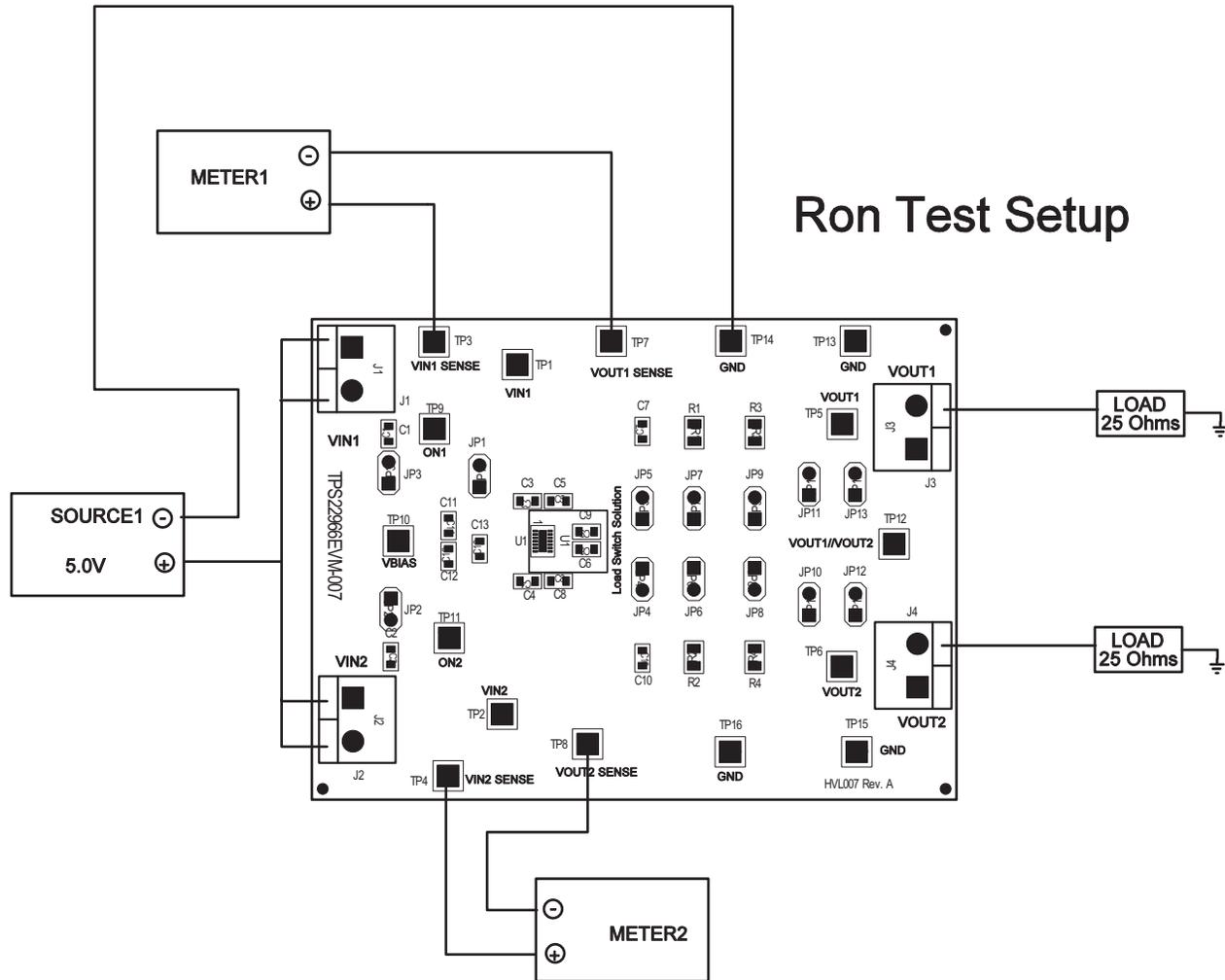
6   Test Setup

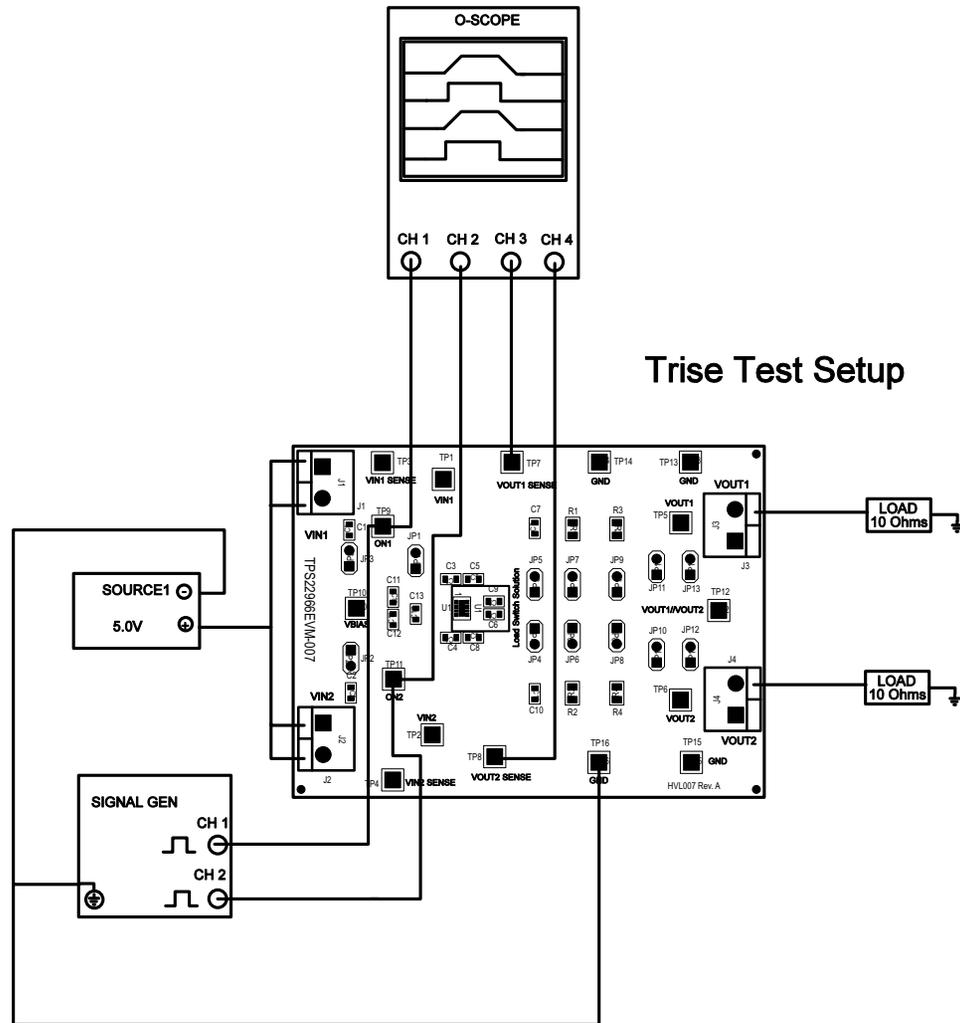**Figure 5. TPS22968EVM-007 Recommended Ron Test Set Up**

Figure 6. TPS22968EVM-007 Recommended Trise Test Set Up

7 Performance Data and Typical Characteristic Curves

Figure 7 through Figure 8 present typical performance curves for TPS22968EVM-007.
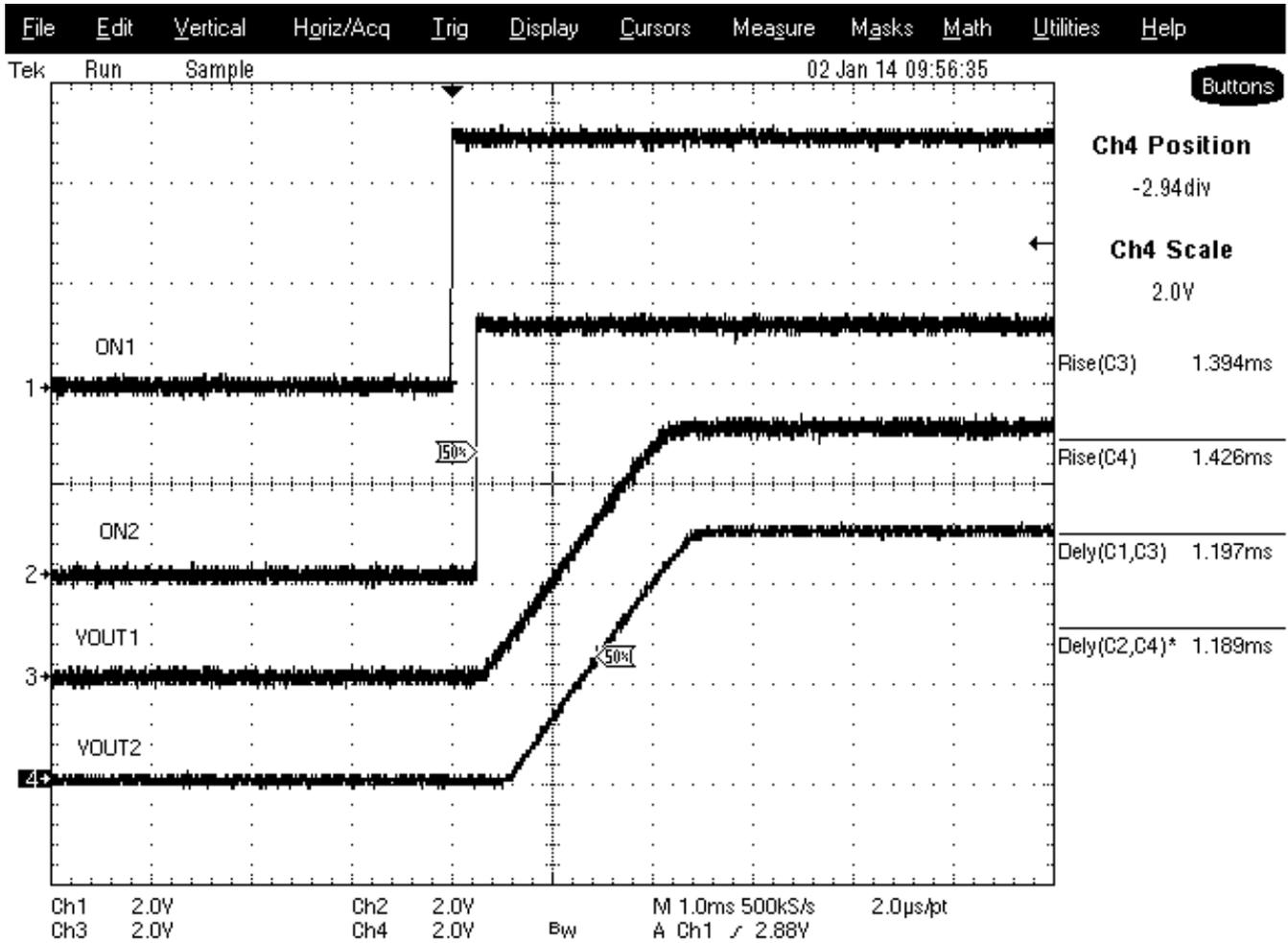
7.1 t_R and t_{ON} Scope Capture

Figure 7. TPS22968EVM-007 t_R with VIN=5V, CT=1nF and Load =10Ω.
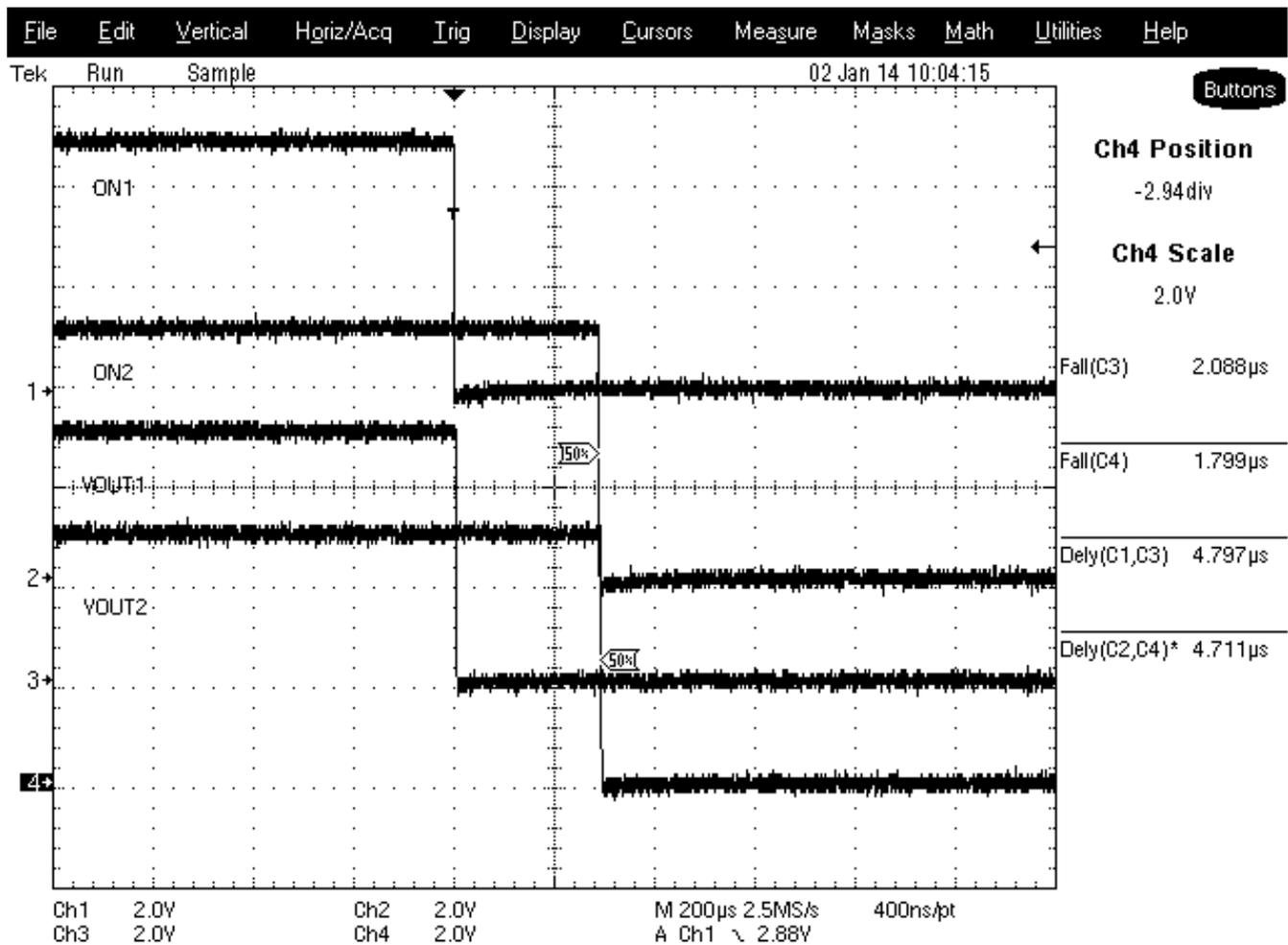
7.2 t_F and t_{OFF} Scope Capture

Figure 8. TPS22968EVM-007

7.3   Parallel Switch Operation

The TPS22968 device switches can be connected in parallel configuration by adding shorting shunts across JP10, JP11, JP12, and JP13. Parallel switch configuration lowers RON 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

Count	RefDes	Value	Description	Size	Part Number	MFR
0	C1, C2, C7, C10	DNP	Capacitor, Ceramic, 25V, X7R, 20%	603	Std	Std
3	C11, C12, C13	0.01µF	Capacitor, Ceramic, 16V, X7R, 20%	603	Std	Std
2	C3, C4	1µF	Capacitor, Ceramic,16V, X7R, 20%	603	Std	Std
2	C5, C8	0.1µF	Capacitor, Ceramic, 25V, X7R, 20%	603	Std	Std
2	C6, C9	1nF	Capacitor, Ceramic, 25V, X7R, 20%	603	Std	Std
1	JP1	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
12	JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP12, JP13	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
0	R1, R2, R3, R4	DNP	Resistor, Chip, 1/16W, x%	805	Std	Std
12	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	5010	Test Point, Red, Thru Hole Compact Style	0.125 x 0.125 inch	5010	Keystone
4	TP13, TP14, TP15, TP16	5011	Test Point, Black, Thru Hole Compact Style	0.125 x 0.125 inch	5011	Keystone
4	J1, J2, J3, J4	ED120/2DS	Terminal Block, 2-pin, 15-A, 5.1mm	0.512 inch	ED120/2DS	OST
1	U1	TPS22968DPU	IC, 6-A Dual Load Switch With Controlled Turn-On	PWSON	TPS22968DPU	TI
1	--		PCB, 2.98 In x 2.22 In x 0.062 In		HVL007	Any
1			Shunt, Black	100-mil	929950-00	3M

Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.

2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.

3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.

4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.

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For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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.

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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.

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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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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(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

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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. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. 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.

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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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