TS3DDR32611 Evaluation Board

This user guide describes the TS3DDR32611 evaluation module (EVM) usage. This guide contains the EVM schematics, evaluation examples, and bill of materials to evaluate the performance of the TS3DDR32611 device.

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1 Introduction

The TS3DDR32611 is a sink/source low power double data rate type III (PCDDR3) termination regulator with a 1% accuracy buffered reference output. It has 26 built-in termination SPST switches that can be shut off when the memory system undergoes lower speed operation without the need of termination resistors. Turning off these switches enables huge power saving on the memory system. The switches have low on-state resistance (typical of 1.75Ω and maximum of 4Ω), which helps retain signal integrity of the signal lines.

The TS3DDR32611 is powered from a 3.3V supply. The VDDQ pin takes 1.2V to 1.8V input while the output voltage at VTT pin is 1/2VDDQ±1% × VDDQ. The regulator's VTT output is capable of sinking/sourcing up to 1A current. The TS3DDR32611 maintains fast transient response with the use of a 10uF ceramic output capacitor. While the VREF pin's output is 1/2VDDQ±1% × VDDQ with 10mA current sinking/sourcing capability. The TS3DDR32611 has three modes of operation: high speed, low speed and power down mode, depending on the control signals VTT_EN and ODT_EN. These different modes of operation provide flexibility on controlling the memory system's power usage.

Table 1. TS3DDR32611 Function Table

State	VTT_EN	ODT_EN	VTT	VREF	Switch
Power Down mode(2)	L	L	OFF(Discharge)	OFF(Discharge)	Disabled
Low Speed mode	H	L	ON	ON	Disabled
High Speed mode	H	H	ON	ON	Enabled

The TS3DDR2611 EVM is an evaluation module for the Texas Instruments TS3DDR32611 switchable termination regulator and it provides the basic functionality evaluation for the device.

2 EVM Setup

2.1 Boards

One TS3DDR32611 Evaluation board is provided per EVM kit:

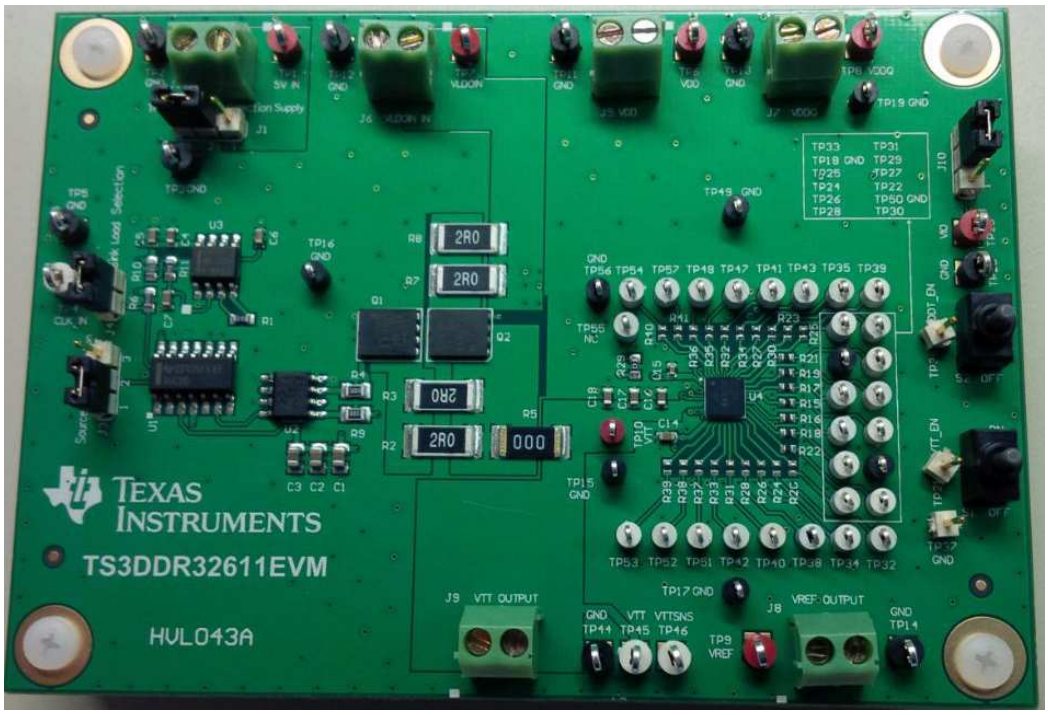

Figure 1. TS3DDR32611 Evaluation board

This evaluation module provides the following signal connection capabilities:

Table 2. TS3DDR32611 Evaluation Module Signal Connections

	Type	Description	Purpose
J1	Jumper	Power enable/disable for sink/source transient load	Provide the power control for sink/source transient load circuit
J2	Power Input Connector	5V IN input	Power supply for sink/source transient load circuit
J3	Jumper	Jumper for source current transient load enable	Source current transient load can be enabled or disabled
J4	Jumper	Jumper for sink current transient load enable	Sink current transient load can be enabled or disabled
J5	Power Input Connector	VDD input	Power supply for VDD
J6	Power Input Connector	VLDOIN input	Power supply for VLDOIN
J7	Power Input Connector	VDDQ input	Power supply for VDDQ
J8	Power Output Connector	VREF output	Power output for VREF
J9	Power Output Connector	VTT output	Power output for VTT

Test points and headers are placed throughout the board to provide testing capability for each pin of the device and are labeled with the corresponding pin name beside the header pins.

2.2 Setup Procedure

2.2.1 Equipment Required

- Power Supply
  - VDD: The VDD DC Source must be a 0-V to 6-V variable dc source capable of supplying 0.5 Adc.
  - VLDOIN: The VLDOIN DC Source must be a 0-V to 6-V variable dc source capable of supplying 5 Adc.

  - VDDQ: The VDD DC Source must be a 0-V to 6-V variable dc source capable of supplying 0.5 Adc.
  - 5V IN: The 5V IN DC Source must be a 0-V to 6-V variable dc source capable of supplying 0.5 Adc.
- Meters
  - V1: DC voltmeter for VTT at TP10 (VTT) and TP15 (GND)
  - V2: DC voltmeter for VREF at TP9 (VREF) and TP14 (GND)
- Load
  - VTT Load: The VTT load must be an electronic constant-current load capable of 0A to 1A at 0.9 Vdc
  - VREF Load: The VTT load must be an electronic constant-current load capable of 0A to 10mA at 0.9 Vdc
- Oscilloscope

  A digital or analog oscilloscope can be used to measure VTT sink/source current transient. The oscilloscope is recommended to set to 1-MΩ impedance, 20-MHz bandwidth, ac coupling, 200-µs/division horizontal resolution, 20-µV/division vertical resolution for VTT transient test. Test point TP10 (VTT) and TP15 (GND) can be used to measure VTT transient. Set horizontal cursor to measure transient load regulation.

2.2.2 Recommended Test Setup

Figure 2 is the recommended test setup to evaluate the TS3DDR32611 EVM. Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM.

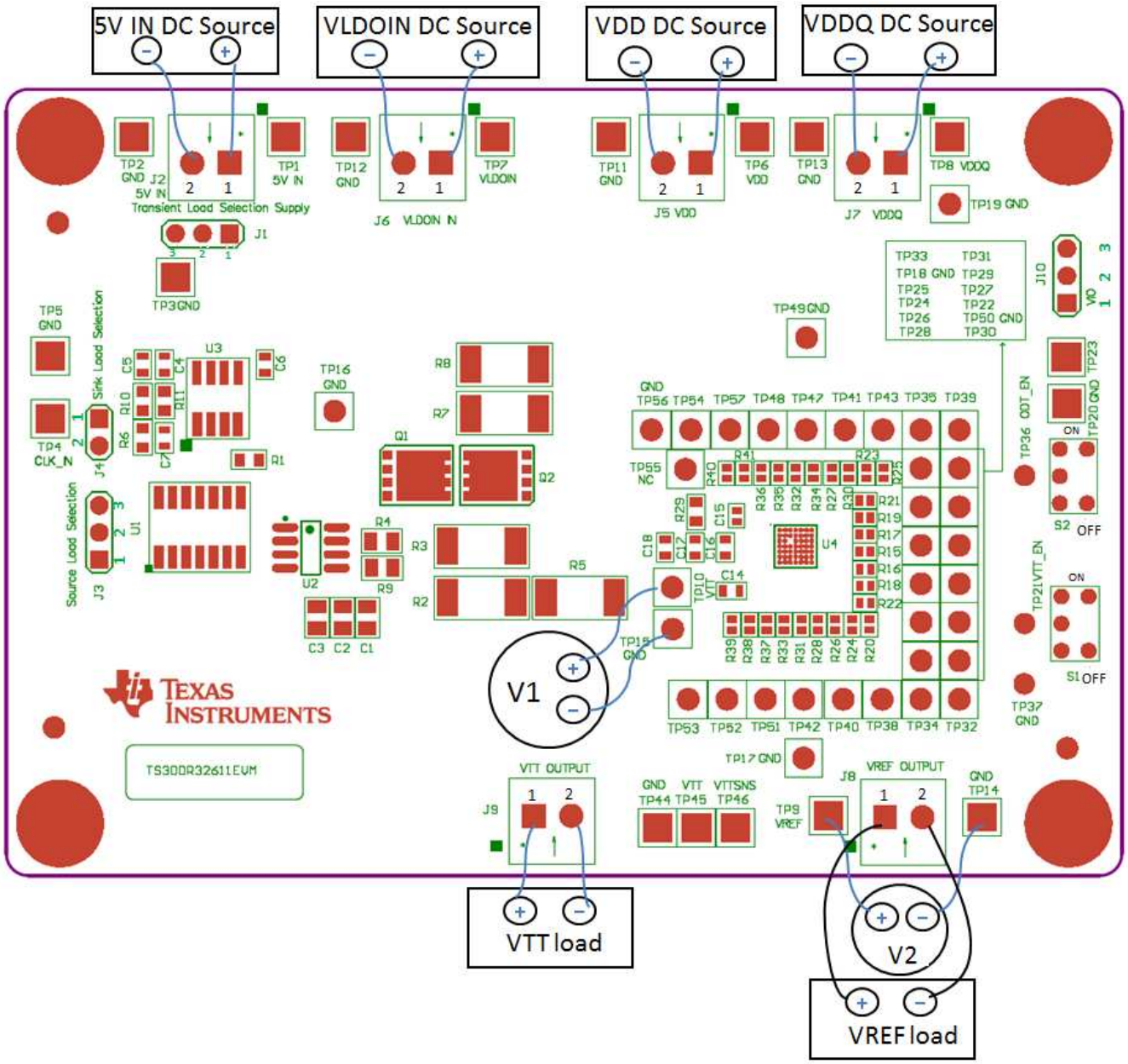

Figure 2. TS3DDR32611 EVM Recommended Test Setup

2.3 Configurations

All jumper selections must be made prior to applying power to the EVM. Users can configure this EVM per the following configurations.

2.3.1 Transient Load Selection

The transient load selection can be set by J1.
Default setting: Jumper shorts on Pin2 and Pin3 of J1 to disable transient load.

Table 3. Transient Load Selection

Jumper Set to	Transient Load
1-2 pin shorted	Enable
2-3 pin shorted	**Disable**

2.3.2 Source Transient Load Selection

The source transient load selection can be set by J3.
Default setting: Jumper shorts on Pin1 and Pin2 of J3 to enable source transient load.

Table 4. Source Transient Load Selection

Jumper Set to	Transient Load
1-2 pin shorted	**Enable**
2-3 pin shorted	Disable

2.3.3 Sink Transient Load Selection

The sink transient load selection can be set by J4.
Default setting: Jumper shorts on Pin1 and Pin2 of J4 to enable transient load.

Table 5. Sink Transient Load Selection

Jumper Set to	Transient Load
1-2 pin shorted	**Enable**
No Jumper shorted	Disable

2.3.4 VTT_EN, ODT_EN Enable or Disable Selection

The VTT_EN, ODT_EN can be controlled by S1 and S2.
Default setting: Push S1 and S2 to the Bottom (OFF position) to control the ODT_EN and VTT_EN to GND. Short Pin2 and Pin3 of J10 connects the high voltage for VTT_EN and ODT_EN to VDD.

Table 6. Transient Load Selection

S1	S2	VTT_EN	ODT_EN	VTT	VREF	SWITCH
OFF	OFF	L	L	OFF(Discharge)	OFF(Discharge)	Disabled
ON	OFF	H	L	ON	ON	Disabled
ON	ON	H	H	ON	ON	Enabled

NOTE: To use an external power supply for the high voltage of VTT_EN and ODT_EN, short pin1 and pin2 of J10 with a jumper and connect the external power supply to TP23 (VIO).

3 Test Procedure

3.1 0.75VTT/ 0.675VTT/0.625VTT Source Load Regulation

1. Ensure jumper shorts on Pin2 and Pin3 of J1.
2. Ensure jumper shorts on Pin1 and Pin2 of J7, J8.
3. Ensure switches S1 and S2 to OFF position.
4. Set VTT load to 0 A.
5. Increase VDD (VDD DC Source) from 0 V to 3.3V at J5. This is the main power for the DUT.
6. Increase VLDOIN voltage (VLDOIN DC Source) from 0 V to 1.5 V for 0.75VTT or 1.35 V for 0.675VTT

or 1.25V for 0.625VTT at J6. This is the LDO input.

7. Increase VDDQ voltage (VDDQ DC Source) from 0 V to 1.5 V for 0.75VTT or 1.35 V for 0.675VTT or 1.25V for 0.625VTT at J7. This is the VTT and VREF reference input.
8. Set switches S1, S2 to ON position.
9. Use V1, V2 to measure VTT, VREF voltage.
10. Increase VTT load from 0A to 1A and VREF load from 0A to 10mA.
11. Use V1, V2 to measure VTT, VREF voltage.
12. Decrease load to 0 A.
13. Set switches S1, S2 to OFF position.

3.2 0.75VTT/ 0.675VTT/0.625VTT Sink/Source Current Transient

1. Remove VTT load and VREF load from J9 and J8.
2. Remove V1 from TP10 (VTT) and TP15 (GND).
3. Add scope probe Channel 1 on TP4 (CLK_IN) and TP5 (GND).
4. Add scope probe Channel 2 on TP10 (VTT) and TP15 (GND).
5. Remove jumper on Pin2 and Pin3 of J1 and put this jumper on Pin1 and Pin2 of J1.
6. Set switches S1, S2 to ON position.
7. TS3DDR32611 is now operating at sink/source load transient.
8. Use scope probe at TP10 (VTT) and TP15 (GND) to monitor VTT load transient operation, and use cursor to make measurement. The waveform is shown in Section 4.3.
9. Set switch S1, S2 to OFF position.
10. Decrease dc source to 0 V.

3.3 Equipment Shutdown

1. Shut down VDD DC Source, VDDQ DC Source, 5V IN DC Source and VLDOIN SC Source
2. Shut down VTT load and VREF load.
3. Shut down oscilloscope.

4 Performance Data and Typical Characteristic Curves

4.1 VTT Load Regulation

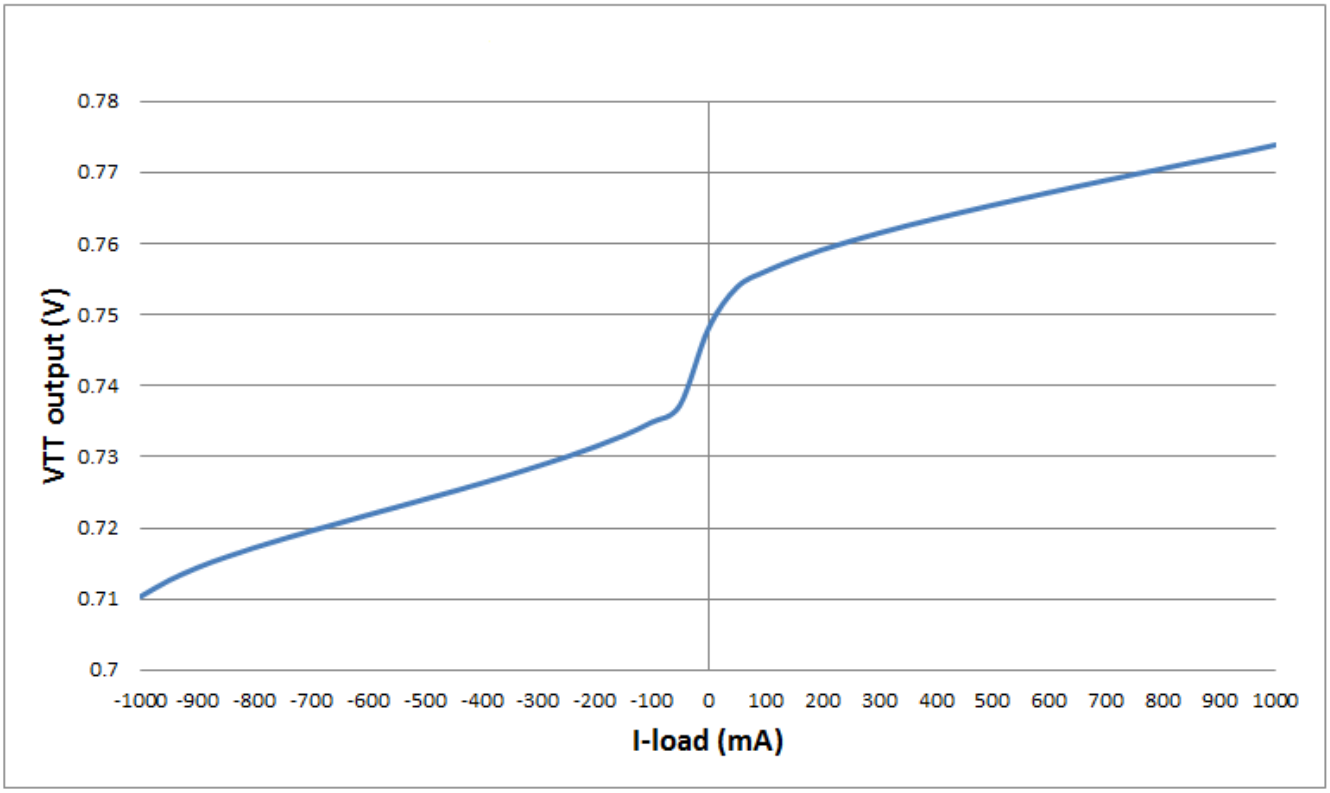

Figure 3. 0.75VTT Load Regulation

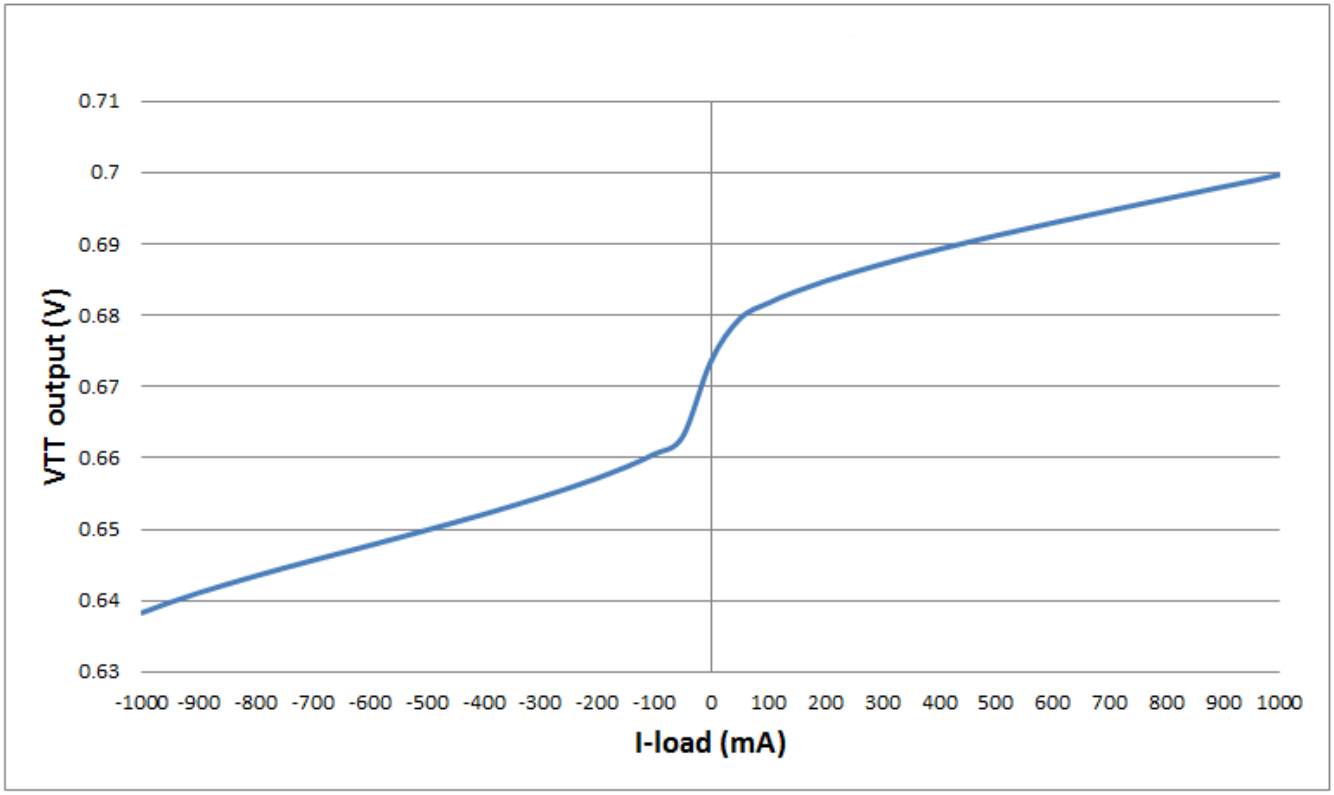

Figure 4. 0.675VTT Load Regulation

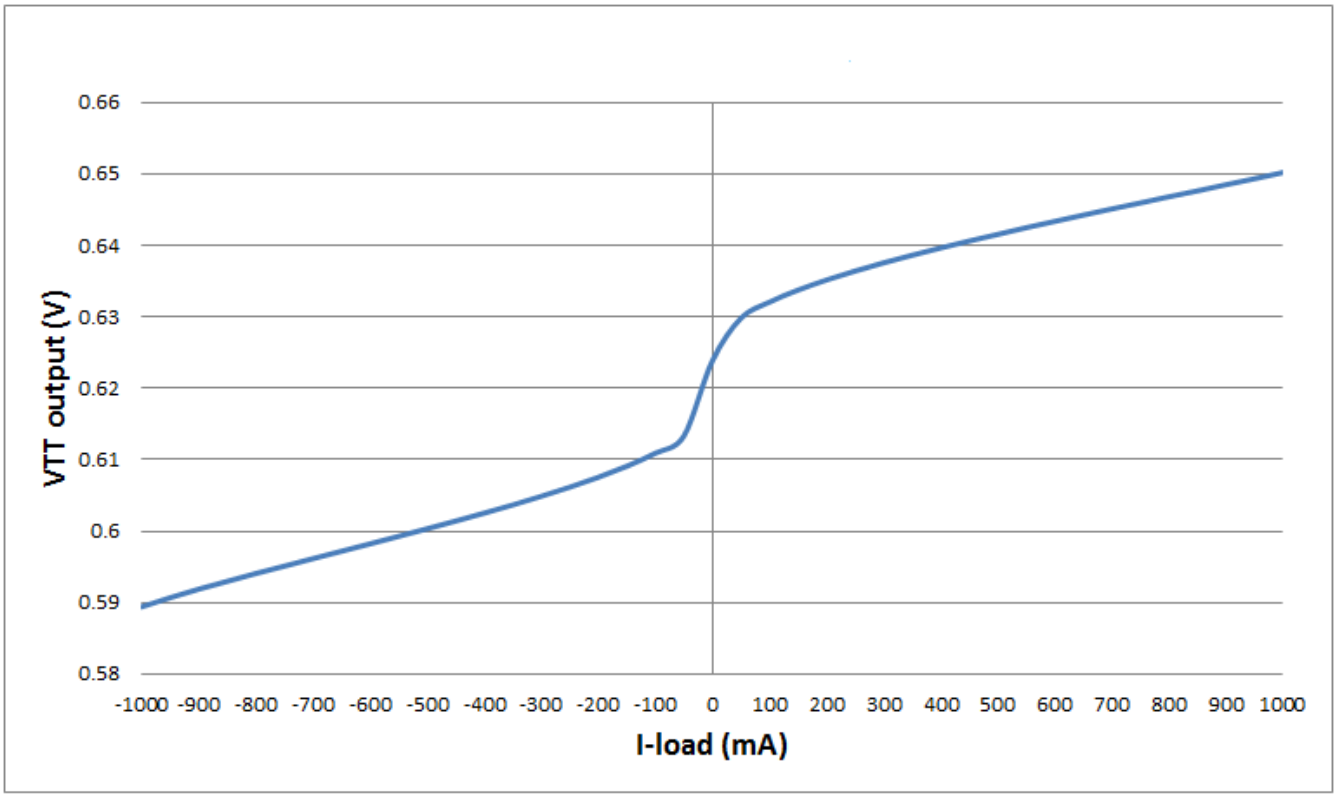

Figure 5. 0.625VTT Load Regulation

4.2 VREF Load Regulation

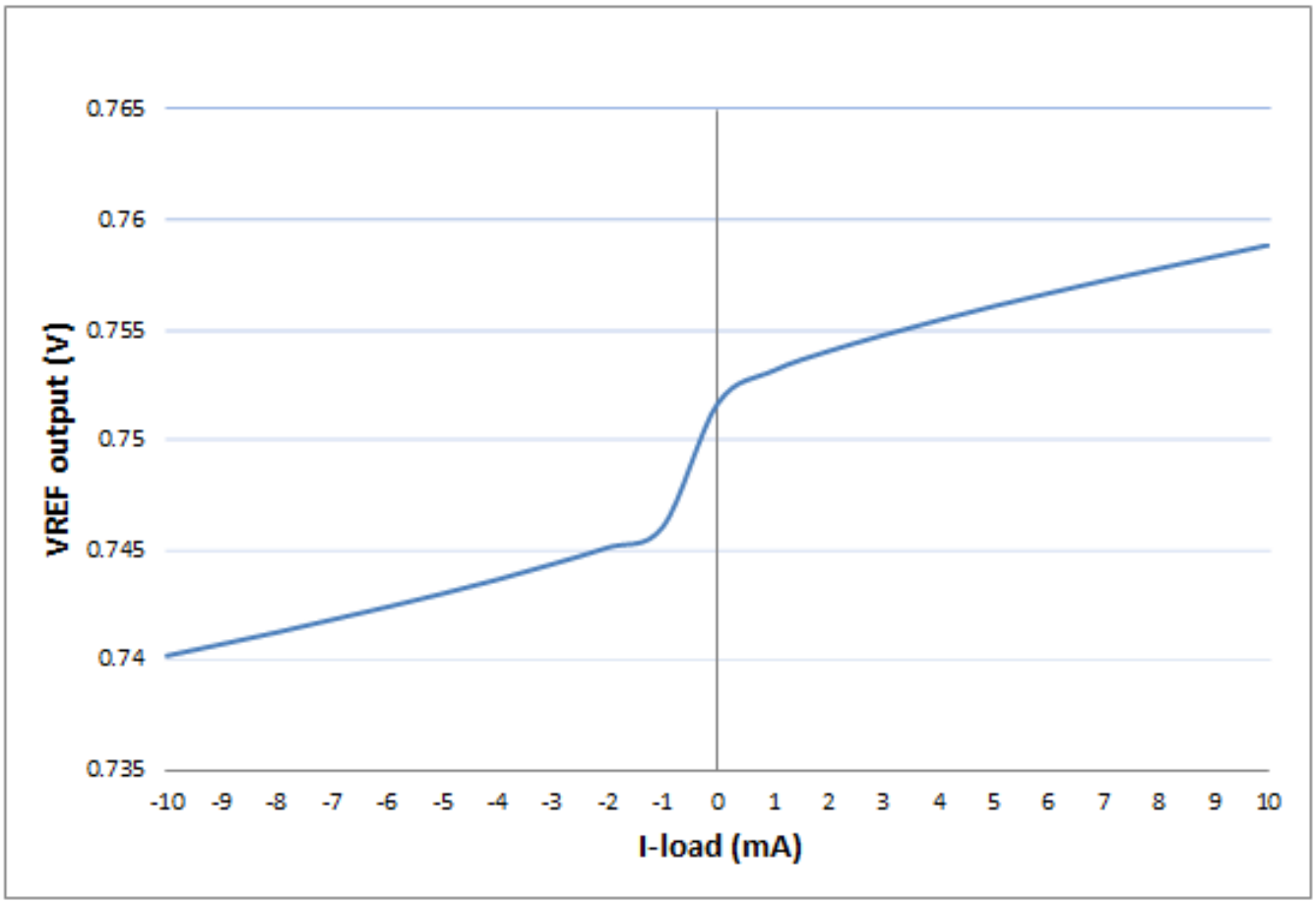

Figure 6. 0.75VREF Load Regulation

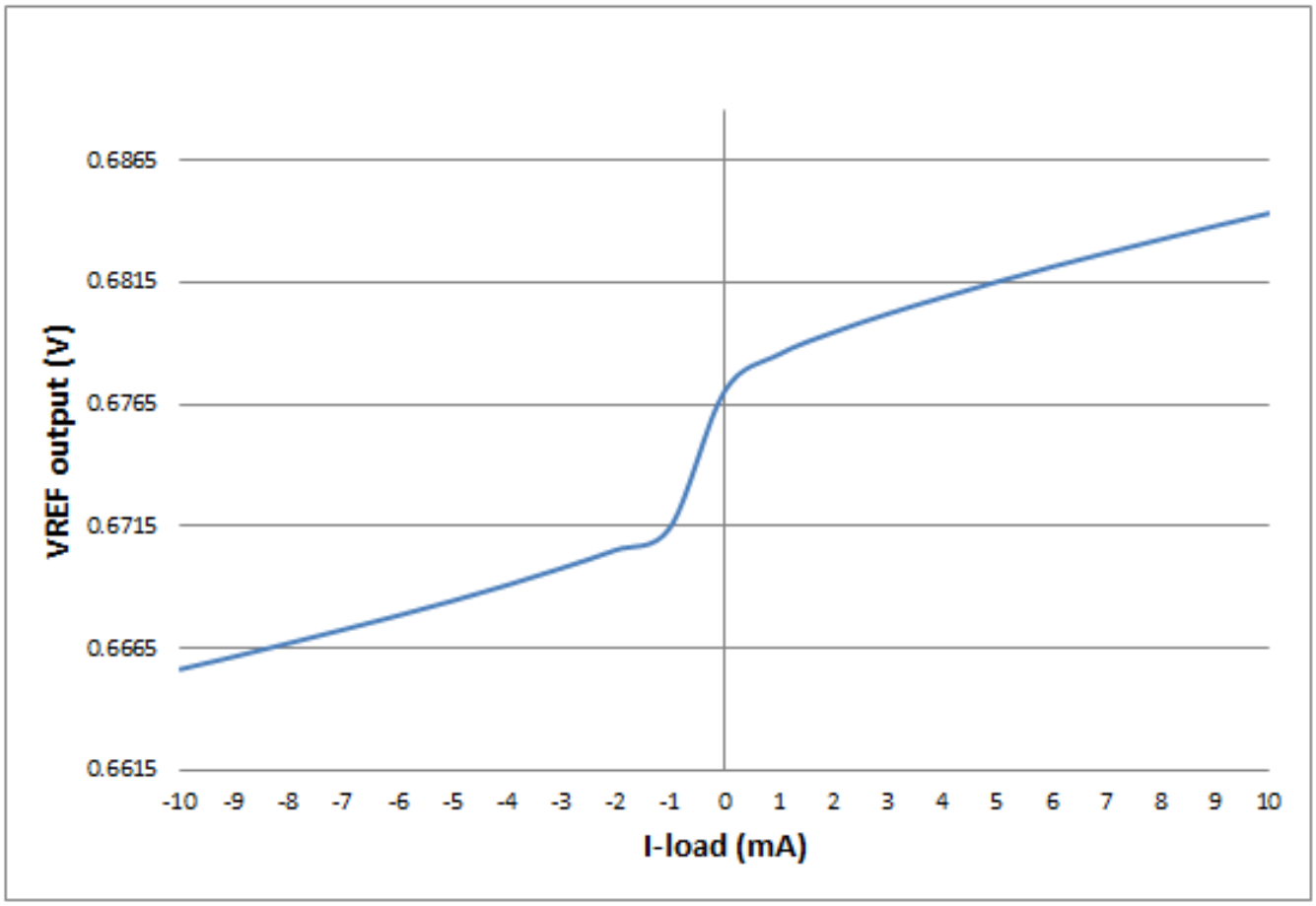

Figure 7. 0.675VREF Load Regulation

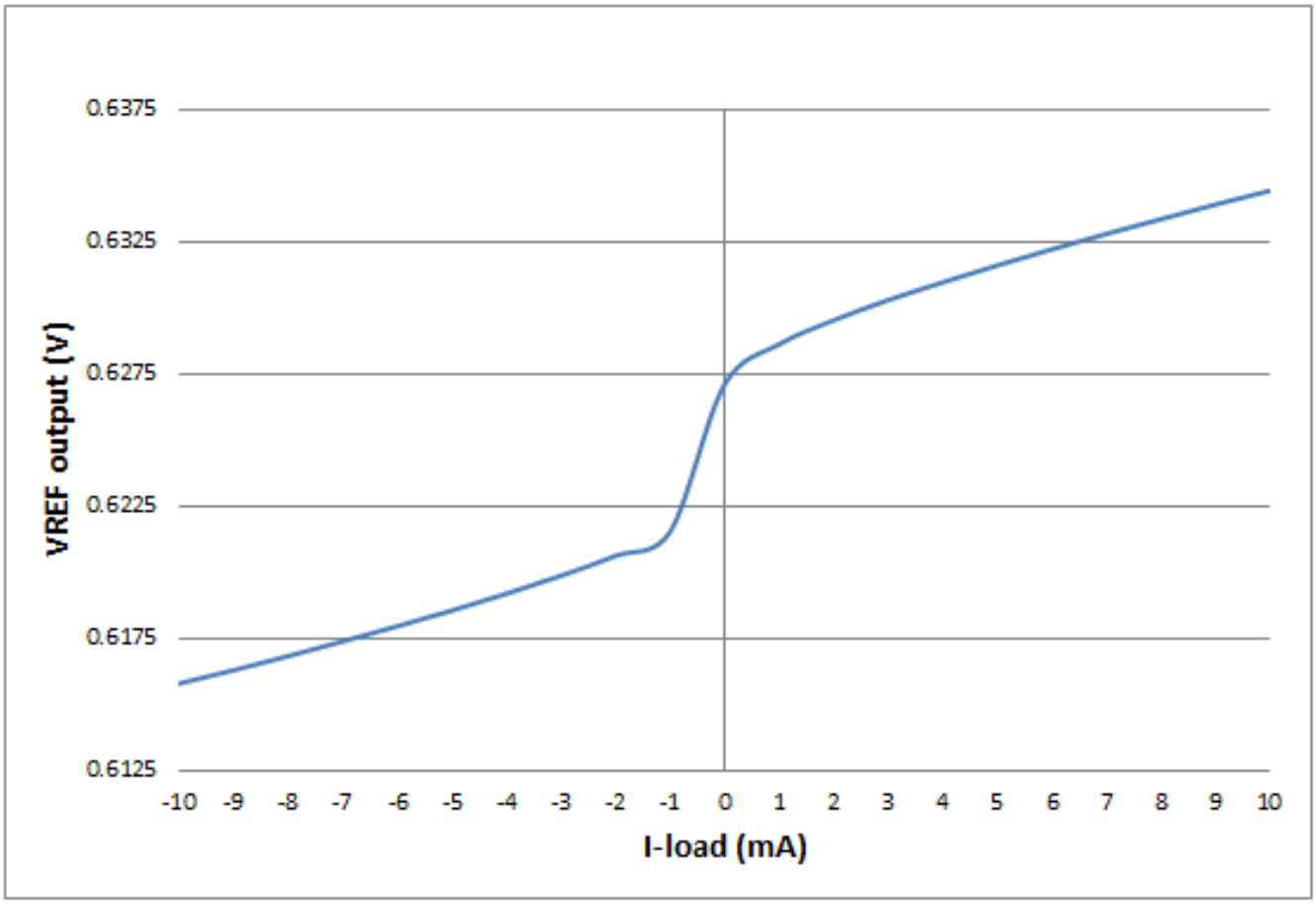

Figure 8. 0.625VREF Load Regulation

4.3 VTT Sink/Source Load Transient

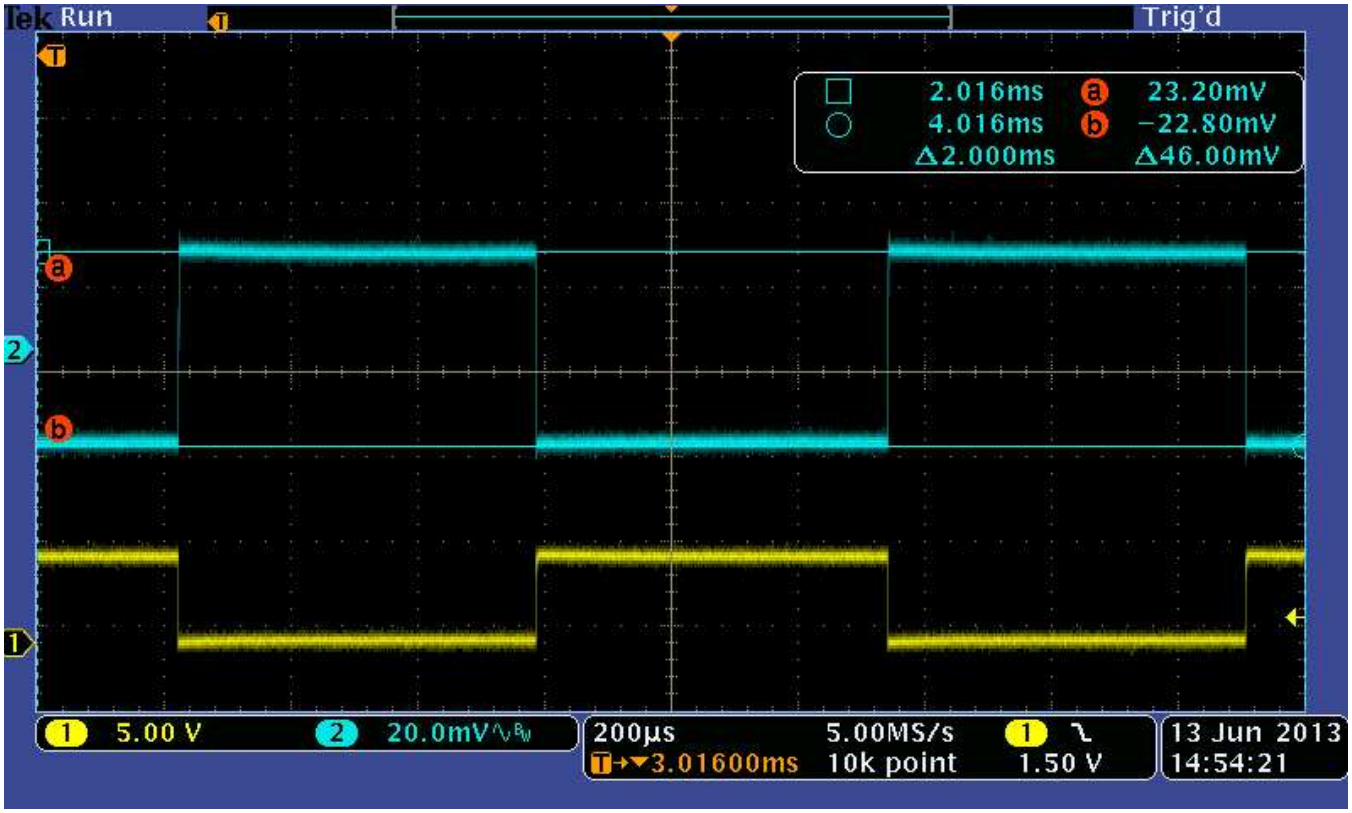

Figure 9. 0.75VTT 685mA Sink/Source

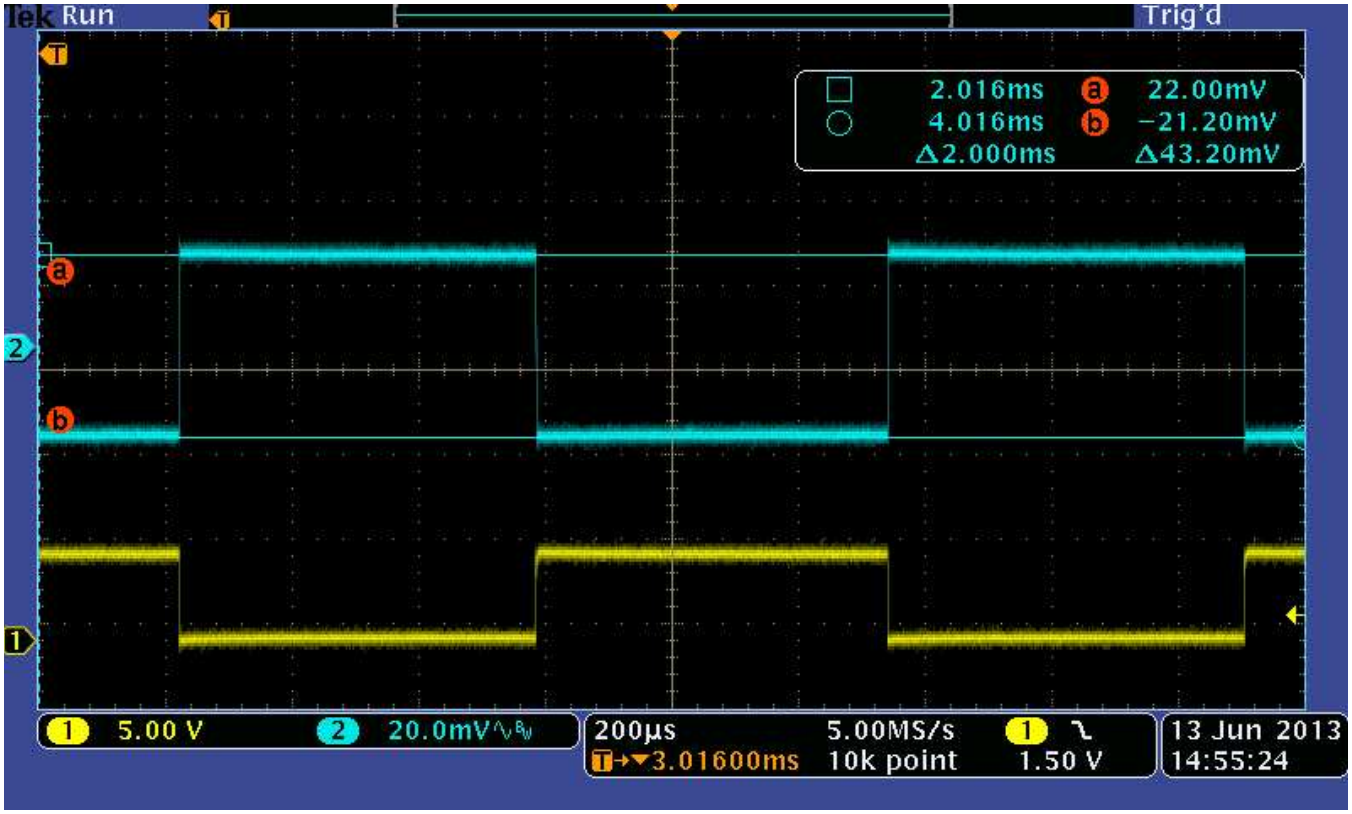

Figure 10. 0.675VTT 615mA Sink/Source

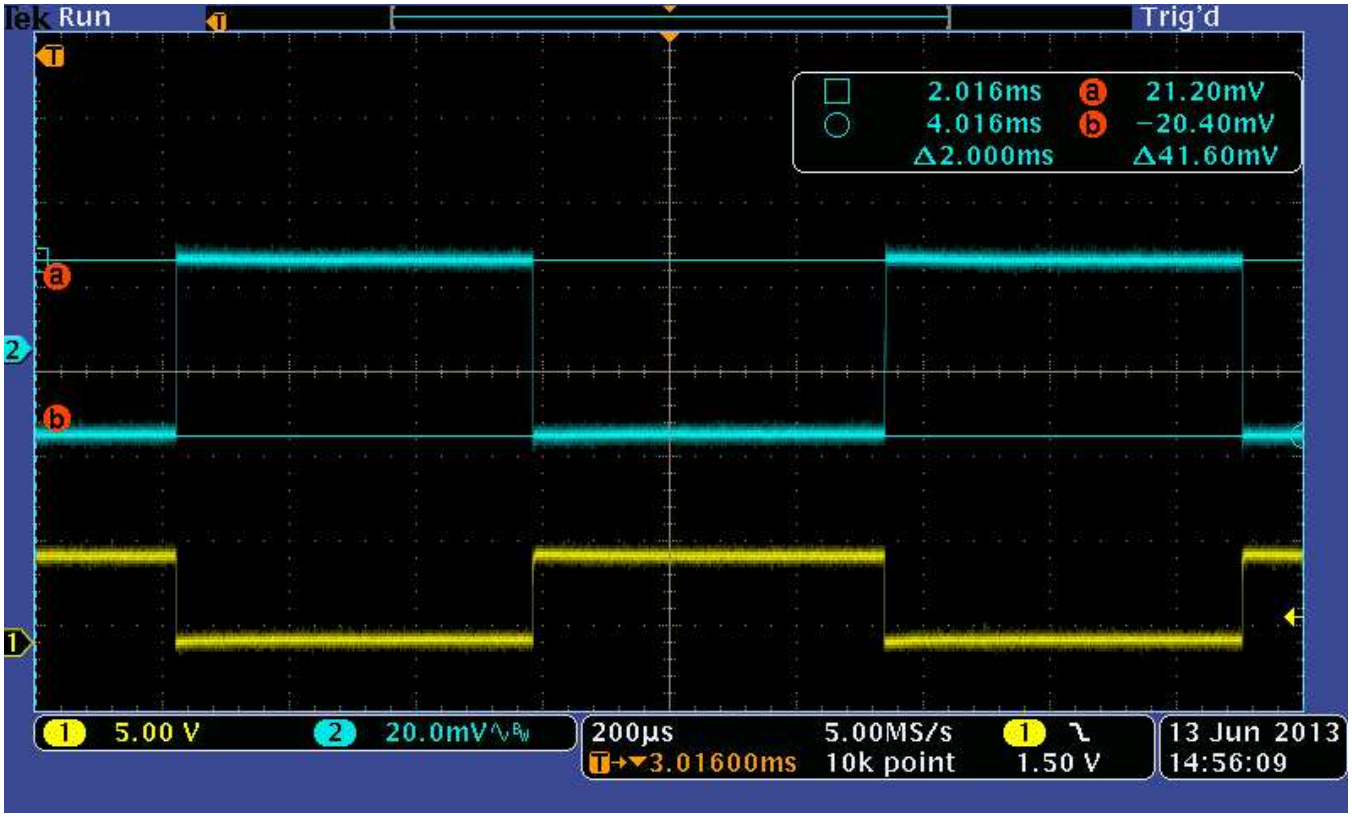

Figure 11. 0.625VTT 570mA Sink/Source

4.4 0.75VTT Turn on/Turn off

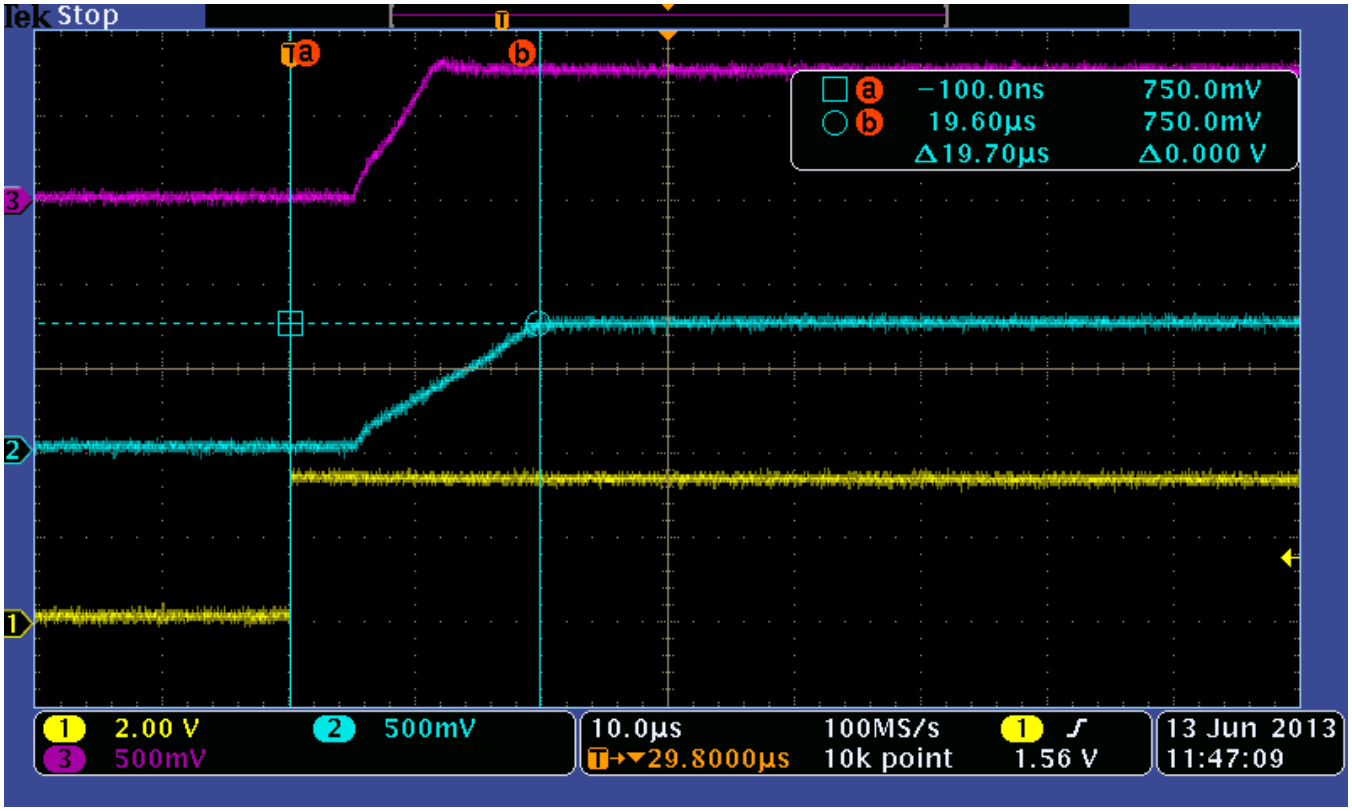

Figure 12. ODT_EN Enable Turn on

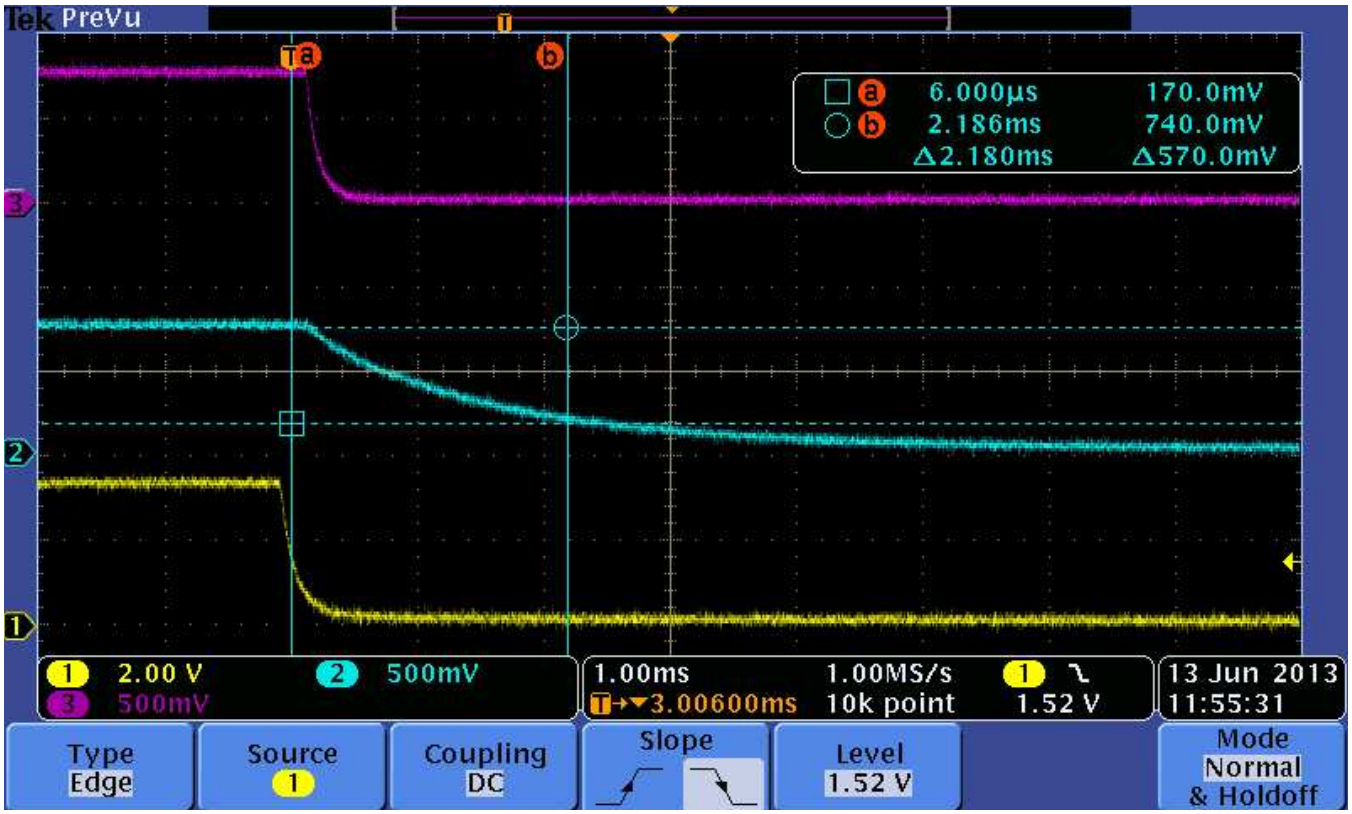

Figure 13. ODT_EN Enable Turn off

5 EVM Schematics

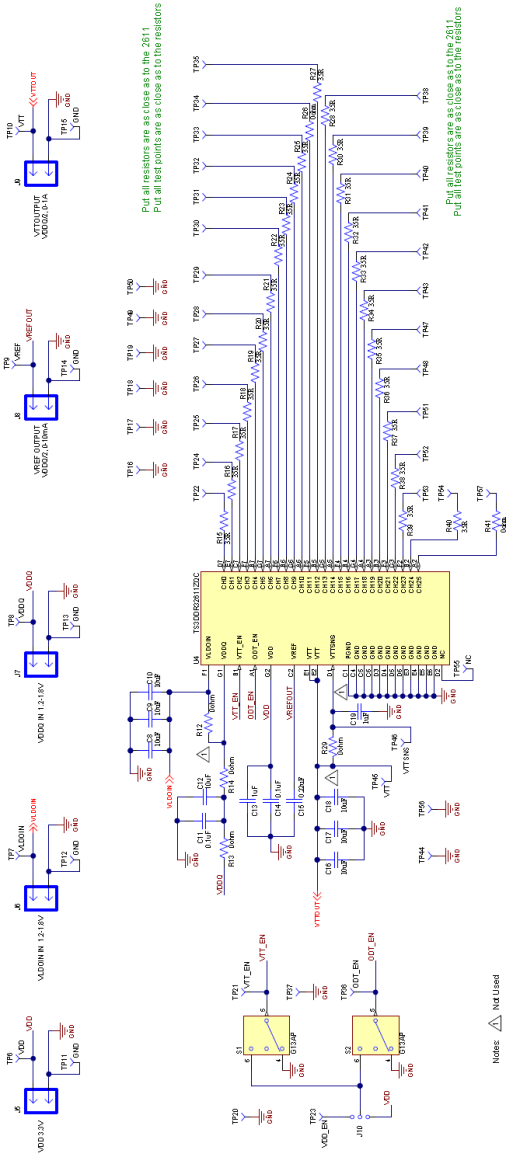

Figure 14. TS3DDR32611 EVM Schematic 1

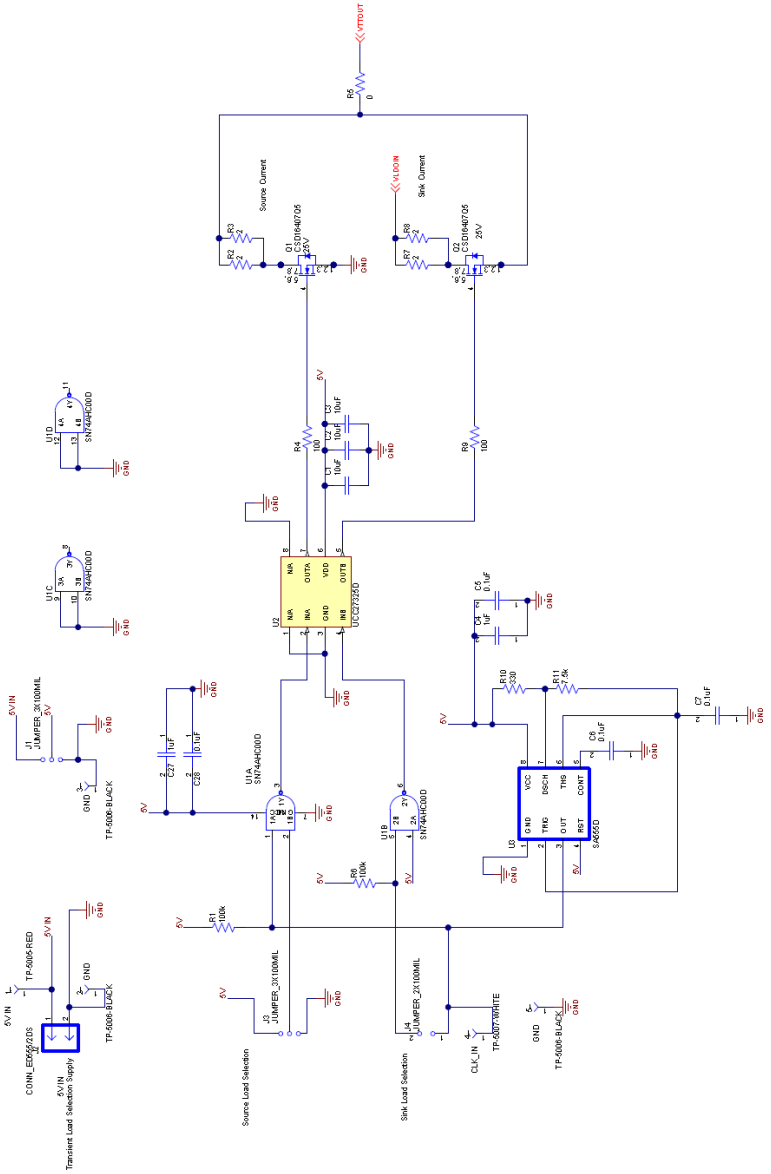

Figure 15. TS3DDR32611 EVM Schematic 2

6 EVM Assembly Drawing and PCB Layout

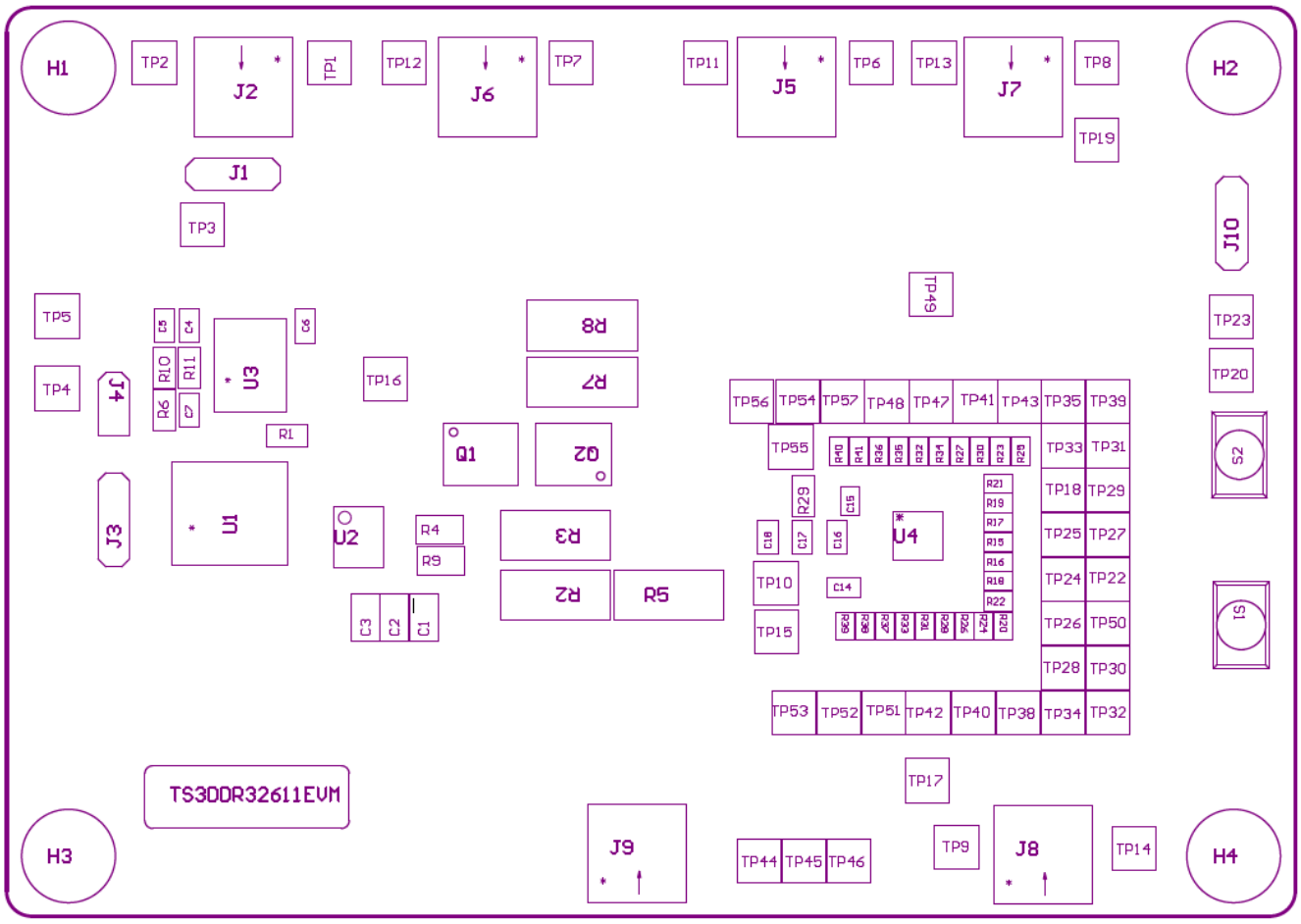

Figure 16. TS3DDR32611 EVM Top Layer Assembly Drawing

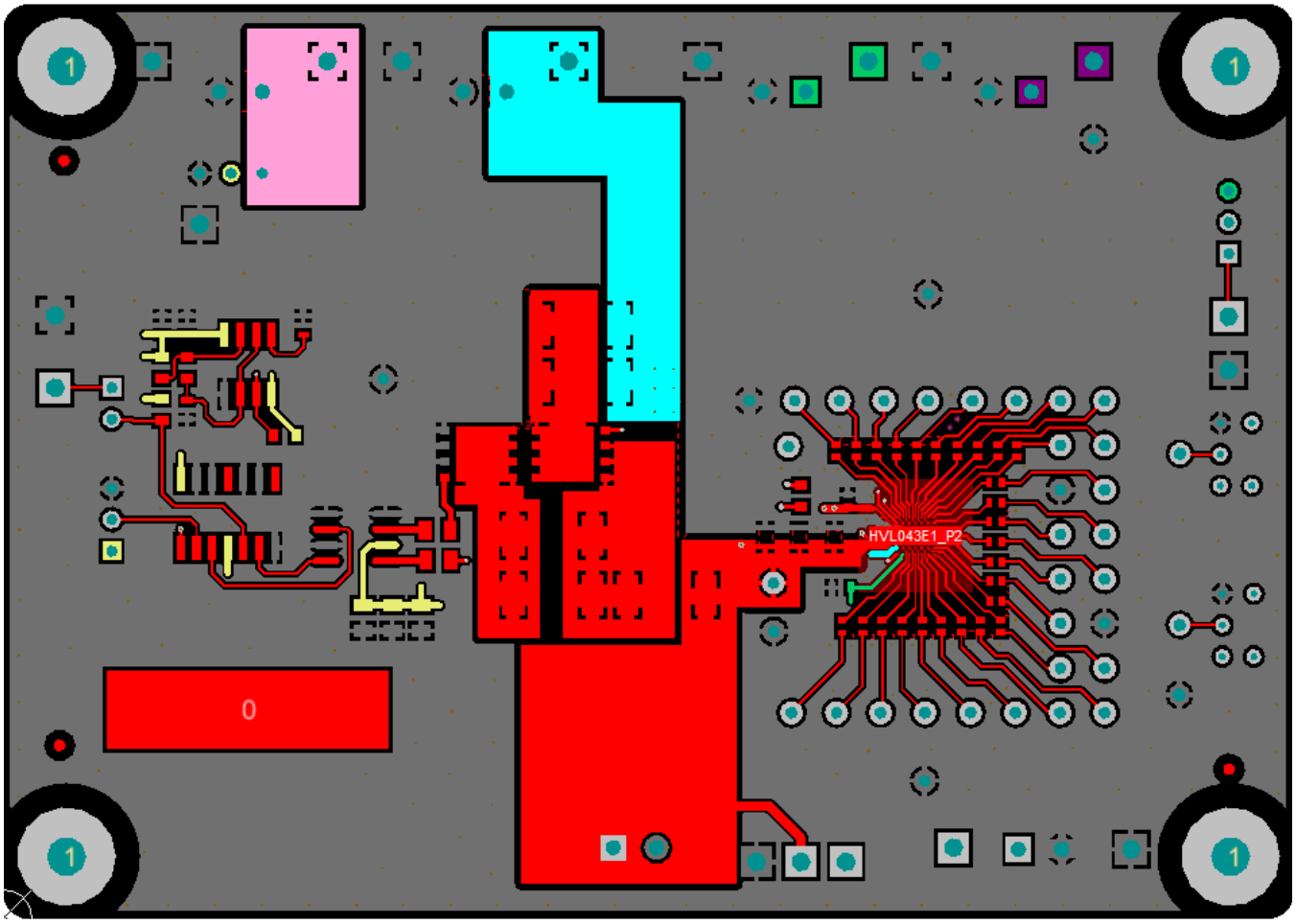

Figure 17. TS3DDR32611 EVM Top Layer

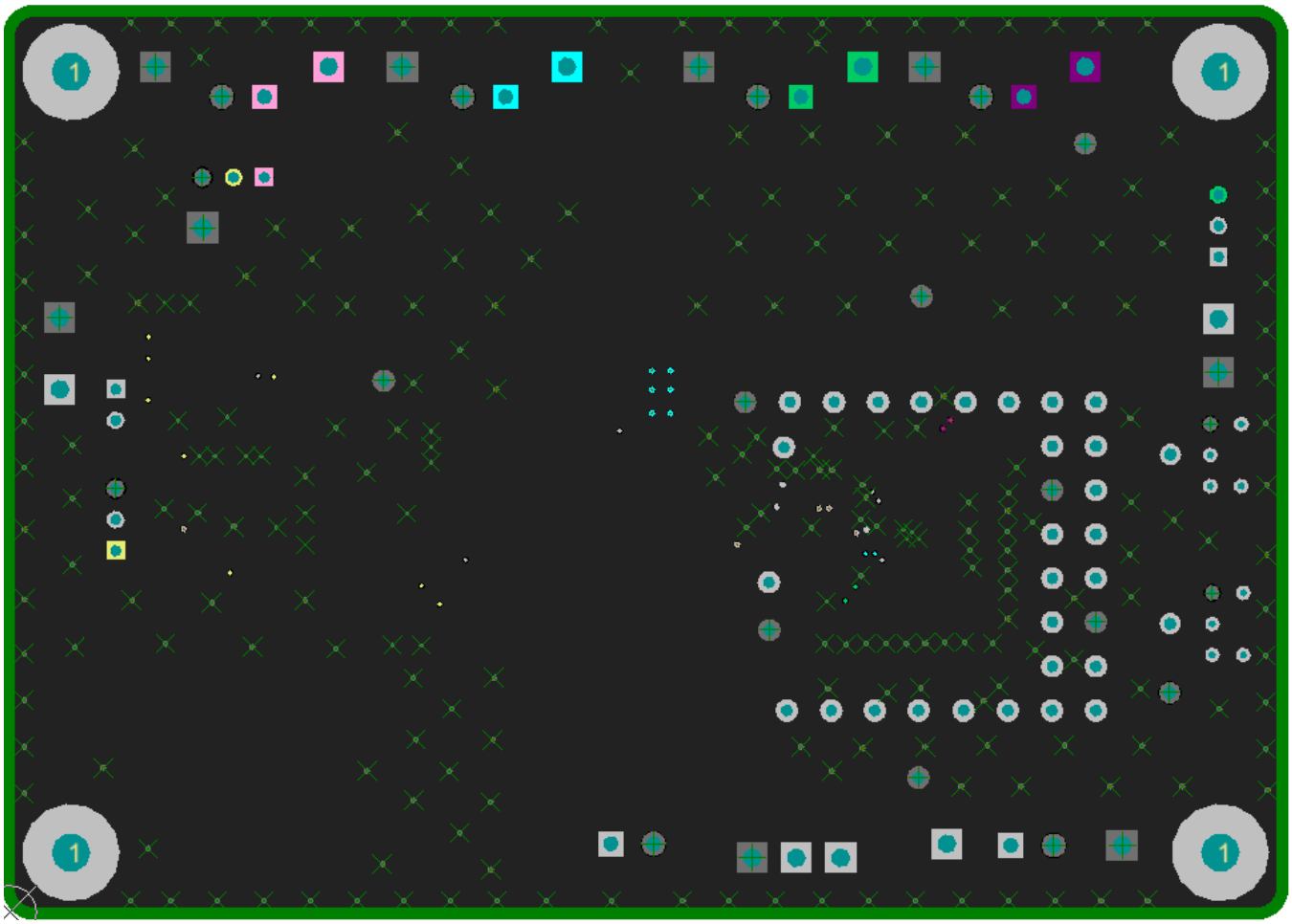

Figure 18. TS3DDR32611 EVM Internal Layer 1 (GND Layer)

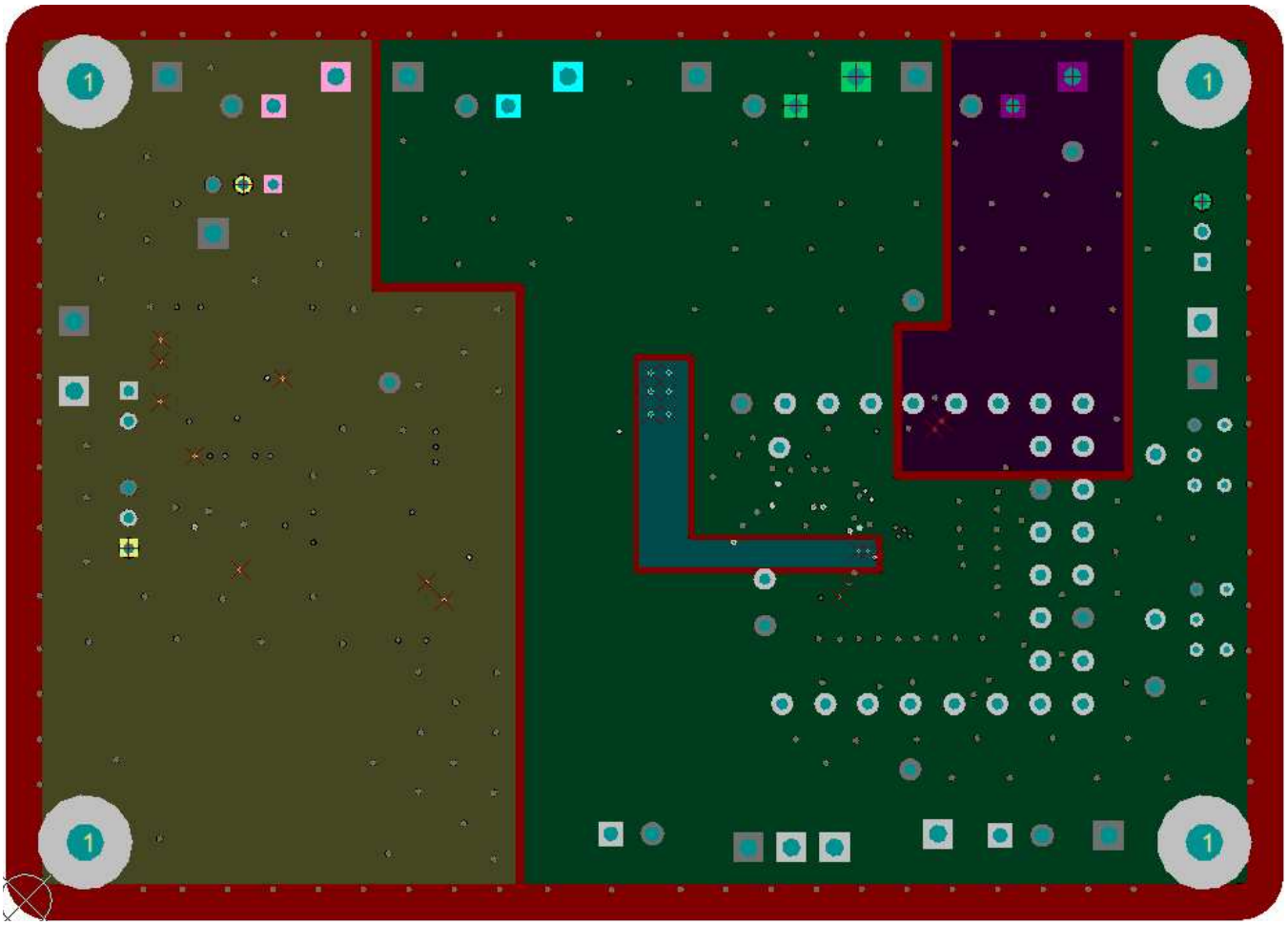

Figure 19. TS3DDR32611 EVM Internal Layer 2 (Power Layer)

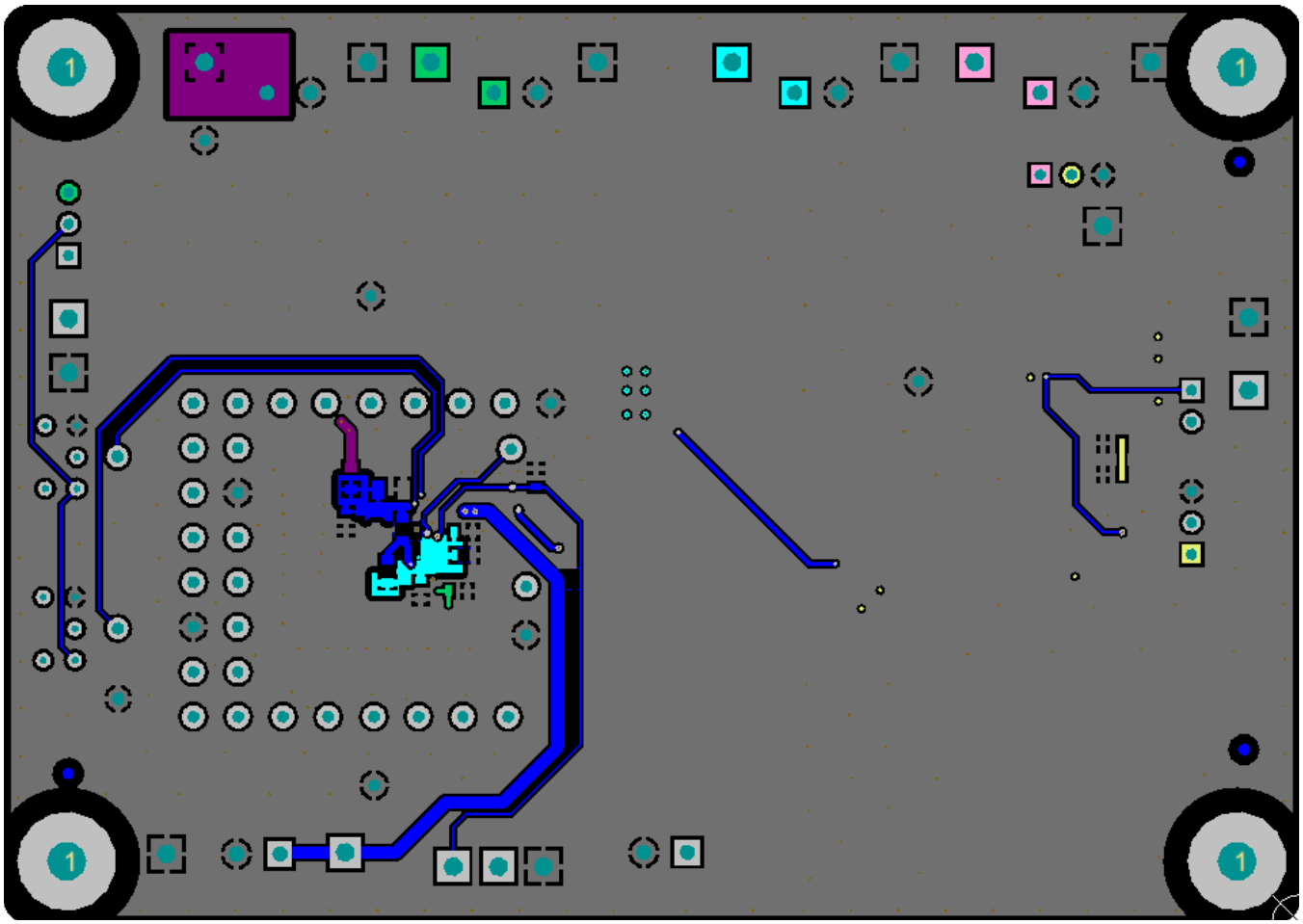

Figure 20. TS3DDR32611 EVM Bottom Layer

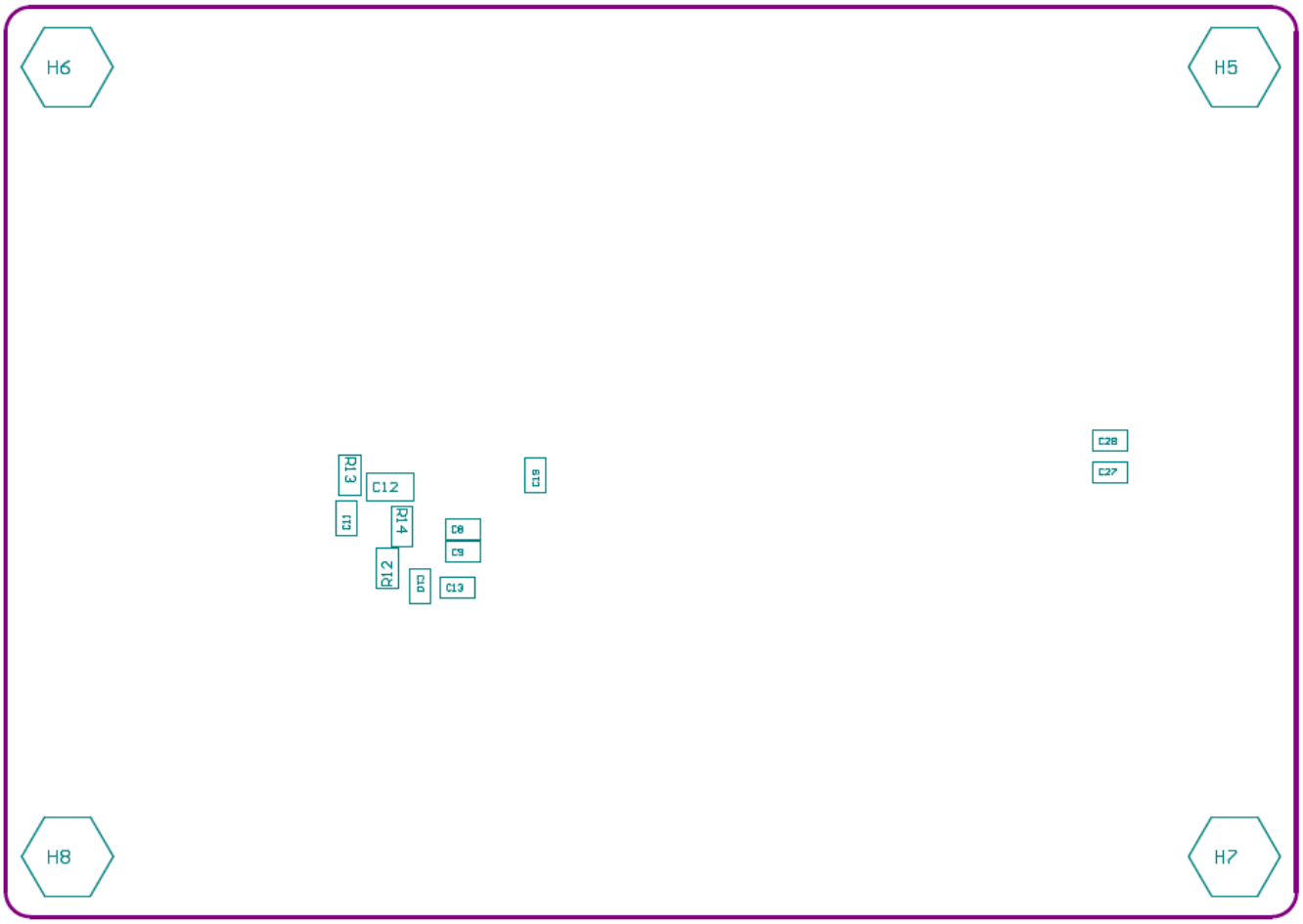

Figure 21. TS3DDR32611 EVM Bottom Layer Assembly Drawing

7 Bill of Materials

Table 7. Bill of Materials

Quantity	Designator	Value	Description	Footprint	Part Number
1	!PCB	HVL043	Printed Circuit Board	10.4cmX7.4cm	HVL043
6	1,6,7, 8, 9, 23	5005	Test Point, Red, Thru Hole Compact Style	TH-63	5005
9	2, 3, 5, 11, 12, 13, 14, 20, 44	5006	Test Point, Black, Thru Hole Compact Style	TH-63	5006
3	4, 45, 46	5007	Test Point, White, Thru Hole Compact Style	TH-63	5007
1	10	5000	Test Point, Red, Thru Hole Color Keyed	TH-40	5000
8	15, 16, 17, 18, 19, 49, 50, 56	5001	Test Point, Black, Thru Hole Color Keyed	TH-40	5001
3	21, 36, 37	PEC01SAAN	CONN HEADER .100 SINGL STR 1POS	0.100 inch x 1	PEC01SAAN
27	22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 38, 39, 40, 41, 42, 43, 47, 48, 51, 52, 53, 54, 55, 57	5002	Test Point, White, Thru Hole Color Keyed	TH-40	5002
3	C1, C2, C3	10uF	Capacitor, Ceramic Chip, 10V,X5R, 20%	C0805	STD
2	C4, C27	1uF	Capacitor, Ceramic Chip, 10V,X5R, 20%	C0603	STD
4	C5, C6, C7, C28	0.1uF	Capacitor, Ceramic Chip, 10V, X5R, 20%	C0603	STD
6	C8, C9, C10, C12, C16, C17	10uF	Capacitor, Ceramic Chip, 6.3V, X5R,20%	C0603	JMK107BJ106 MA
2	C11, C14	0.1uF	Capacitor, Ceramic Chip, 6.3V, X5R, 20%	C0603	EMK107BJ104 KA
1	C15	0.22uF	Capacitor, Ceramic Chip, 6.3V,X5R,10%	C0402	JMK105BJ224 KA
2	C13,C19	1uF	Capacitor, Ceramic Chip, 6.3V,X5R,10%	C0603	EMK107BJ105 KA
3	J1, J3, J10	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	HDR100_1X3	PEC03SAAN
6	J2, J5, J6, J7, J8, J9	ED555/2DS	Connector, Male 2 Pole 3.5 mm, 6A, 150V	CONN_ED555/2	ED555/2DS
1	J4	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	HDR100_1X2	PEC02SAAN
2	Q1, Q2	25V	MOSFET, N-CH, 25V, 100A, SON 5x6mm	TRANS_NexFET_Q5	CSD16407Q5
2	R1, R6	100k	Resistor, Chip, 1/16W, 1%	R0603	STD
4	R2, R3, R7, R8	2	Resistor, Chip 1W, 5%	R2512	STD
2	R4, R9	100	Resistor, Chip, 1/10W, 5%	R0805	STD
1	R5	0	Resistor, Chip 1W, 5%	R2512	STD
1	R10	330	Resistor, Chip, 1/16W, 1%	R0603	STD
1	R11	7.5k	Resistor, Chip, 1/16W, 1%	R0603	STD
3	R13,R14,R29	0	Resistor, Chip, 1/16W, 5%	R0603	STD

Table 7. Bill of Materials (continued)

Quantity	Designator	Value	Description	Footprint	Part Number
2	R26,R41	0	Resistor, Chip, 1/16W, 1%	R0402	STD
24	R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R27, R28, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40,	35	Resistor, Chip, 1/16W, 1%	R0402	STD
2	S1, S2	G13AP	Switch, Toggle, SPDT 1Pos, TH	SW_G13AP	G13AP
1	U1	SN74AHC00D	IC, QUAD, 2-Input Positive NAND Gates	SO14	SN74AHC00D
1	U2	UCC27325D	DUAL 4-A PEAK HIGH SPEED LOW- SIDE POWER MOSFET DRIVERS, D0008A	D0008A_N	UCC27325D
1	U3	SA555D	IC, Precision Timer	SO8	SA555D
1	U4	TS3DDR32611 ZQC	1A Peak Sink/Source PCDDR3 Termination Regulator with Integrated Isolation Switch and Low Power Mode Operation, ZQC0048A	ZQC0048A	TS3DDR32611 ZQC

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

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*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

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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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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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:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure 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. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

   6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL 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 HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

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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.

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