User's Guide

SLVU455A – April 2011 – Revised August 2012

TPS62730, TPS62733 Stepdown Converters With Bypass Mode for Ultralow-Power Wireless Applications

This user's guide describes the TPS62730 and TPS62733 evaluation module (EVM), how to perform a stand-alone evaluation or interface with a host or system. The design of the converter is for delivery of up to 100 mA of continuous current to the output. One can switch the converter into bypass mode by grounding the ON/BYP pin, or the device switches automatically with the input voltage falling to the output regulation voltage. The TPS62730 and TPS62733 have a fixed (regulated) output voltage of 2.1 V and 2.3 V, respectively.

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1 Introduction

The TPS62730 and TPS62733 devices are high-frequency synchronous stepdown dc-dc converters optimized for ultralow-power wireless applications. The devices are optimized to supply TI's low-power wireless sub-1-GHz and 2.4-GHz RF transceivers. The TPS62730 and TPS62733 reduce the current consumption drawn from the battery during TX and RX modes by a highly efficient stepdown voltage conversion. They provide up to 100-mA output current and allow the use of tiny and low-cost chip inductors and capacitors. This devices support most Li-ion primary battery chemistries, with an input range of 1.9 V to 3.9 V dc.

The TPS62730 and TPS62733 feature an ultralow-power bypass mode with a typical 30-nA current consumption to support low-power modes of modern RF transceivers. In this bypass mode, the input is connected to the VOUT pin via an internal 2-Ω bypass FET.

The devices automatically enter bypass mode when the input (battery) voltage falls to the bypass transition threshold.

2 Considerations With Evaluating the TPS62730 and TPS62733

This part has two modes of operation, the switching buck mode and the dc bypass mode. The IC automatically shuts down the switcher once the input voltage drops to the bypass threshold, which is a few millivolts above the regulation voltage. This saves bias power to the switcher.

The user can implement bypass mode at higher input voltages by pulling the ON/BYP pin low. There may be some applications where the input voltage is too high for the system; exercise caution not to perform this mode transfer for these cases. Do not leave the ON/BYP pin floating (open), or the IC may be in an unknown state or mode, and the output voltage may be anywhere between the input voltage and the regulation voltage.

The EVM has a pullup resistor on the ON/BYP pin to Vin so that it stays in the switching mode if the jumper is removed and only goes into the bypass mode if the shunt is moved to ground the ON/BYP pin.

This pullup resistor on the EVM loads the input, when in bypass mode, by Vin / 1 MΩ. In a typical application, a driver controls the ON/BYP pin and does not load the input; thus, do not consider this current in the quiescent current when in bypass mode.

Also consider (ignore) the pullup resistor for the status output on the EVM when calculating the efficiency of the converter. The EVM uses a *stiff* pullup, because loads that may be connected to the STAT pin are not known. When designing the system, a much higher-value resistor may be appropriate.

3 Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input dc voltage, Vin		1.9		3.9	V
Output dc voltage, Vout	TPS62730EVM-726, ON/BYP = HIGH and Vin > $V_{IT\ BYP}$		2.1		V
Output dc voltage, Vout	TPS62733EVM-726, ON/BYP = HIGH and Vin > $V_{IT\ BYP}$		2.3		V
Output current		0		100	mA

4 Test Summary

The TPS62730EVM-726 and TPS62733EVM-726 boards require an adjustable 4-V, ≥150-mA current-limited power source to provide input power and a resistive load between 100 Ω and 21 Ω. The test-setup connections and jumper-setting selections are configured for a stand-alone evaluation, but can be changed to interface with external hardware such as a system load and microcontroller.

4.1 Equipment

- Adjustable dc power supply between 1.8 V and 4 V with adjustable current limit set to approximately 150 mA
- Load: system load or resistive load ≥ 21 Ω
- Three Fluke 75 DMMs (equivalent or better)
- Oscilloscope, model TDS222 (equivalent or better)

4.2 Equipment and EVM Setup

Table 1. Setup I/O Connections and Configuration for Evaluation of TPS62730, TPS62733 EVM

Jack and Component (Silk Screen)	Connect or Adjustment To:
J1 (Vin)	Power supply positive lead, preset to 3.3 VDC, 150-mA current limit
J2-1 (+ SNS); input	Positive lead of DMM #1
J2-2 (- SNS); input	Negative lead of DMM #1
J3 (GND)	Power supply negative lead (3.3 VDC supply)
J4 (Vout)	Positive lead to system load or load resistance
J5-1 (+ SNS); output	Positive lead of DMM #2
J5-2 (- SNS); output	Negative lead of DMM #2
J6 (GND)	Negative lead to system load or load resistance
J7-1 (STAT)	Positive lead of DMM meter #3
J7-2 (GND)	Negative lead of DMM meter #3
JP1 (ON)	Apply shunt to ON (across pins 1 and 2) for converter operation
JP1 (Bypass)	Do not apply shunt to Bypass (across pins 2 and 3) until procedure calls for change.

Connect the meters, scope probes, output load, shunt, and input power supply as listed in Table 1 and set the oscilloscope to 200 ns/div, positive trigger, dc-coupled on CH1, ac-coupled and 10 mV/div on CH2. Use additional channels or move probes as required view Vin, Vstat and Vbypass. Replace the resistive load with a system load or decade load box if desired to vary the load between 1 kΩ and 21 Ω.

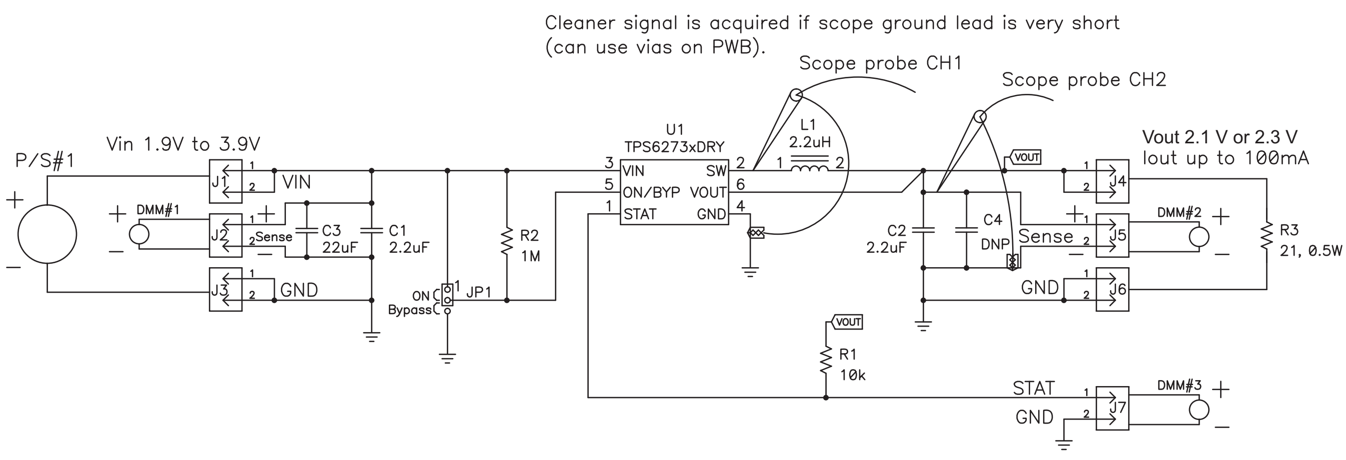

Figure 1. EVM Schematic and Evaluation Setup

4.3 Test Procedure

1. Make sure that the EVM setup is according to Table 1 and Figure 1, and preset the power supply to 3.3 VDC at a current limit of approximately 150 mA.
2. Turn on the input supply and verify the input voltage is approximately 3.3 VDC (DMM 1) and the output voltage is at approximately 2.1 or 2.3 VDC for TPS62730 or TPS62733, respectively (DMM 2).
3. Look at CH1 and CH2 and verify that the duty cycle is near 70% and the ripple is less than 10-mV ripple; see Figure 6 for typical waveforms.
4. Vary the load between 0 and 100 mA [1 kΩ to 21 Ω (TPS62730) or 1 kΩ to 23 Ω (TPS62733)]. Observe the change in the switching waveform from PFM with discontinuous ringing to PWM mode. It may be necessary to change the time scale on the scope to 1 µs/div for light loads. See Figure 7 and Figure 8 for various loads. Set the load back to approximately 21 Ω.
5. Vary the input voltage from 3.3 VDC to 3.9 VDC and back to 2.4 VDC to see the change in duty cycle.
6. Reduce the input voltage from 2.4 VDC to 1.9 VDC and verify that the switcher automatically goes into bypass mode, disabling the switcher and turning on the internal bypass FET. The output should be the input voltage minus the IR drop across the pass FET (approximately 2 Ω). The STAT pin should go to the high-impedance state with R1 pulling it to the output voltage. Conditions for the capture of Figure 9 were: CH2 moved to the J7 (STAT) header relative to ground, 1 V/div, dc-coupled, the time scale set to 50 µs/div (a slower time scale may be required, depending on power-supply decay), single-sequence trigger on CH2, and input power removed. The figure shows the switch node going into PFM, then disabling switching, and then indicating bypass mode by R1 pulling the STAT pin up to the output voltage (approximately 2.2 VDC).

CAUTION

The following step disables the buck converter and switches the input voltage to the output. Make sure not to exceed the maximum system input voltage in this step or the later steps that place the JP1 shunt in the bypass position.

7. Move the shunt on jumper JP1 from the ON position to the Bypass position. Notice that this action disables the switcher and switches the input voltage to the output via the bypass switch. The output should be the input voltage minus the IR drop across the pass FET (approximately 2 Ω). The STAT pin should go to the high-impedance state with R1 pulling it to the output voltage. Move the shunt on jumper JP1 to the ON position.
8. For steps 9 through 13, one can view the figure and determine the oscilloscope setup.
9. See Figure 10 for the transition from converter switch mode to bypass mode by pulling the ON/BYP pin low.
10. Remove the bypass jumper to see the transition from bypass mode to converter switch mode; see Figure 11.
11. See Figure 12 for typical hot-plug power up.
12. See Figure 13 for the transient output-load step from 50 mA to 100 mA.
13. See Figure 14 for the transient output-load step from 100 mA to 50 mA.

5 Schematic, Physical Layouts and Bill of Materials

5.1 Schematic

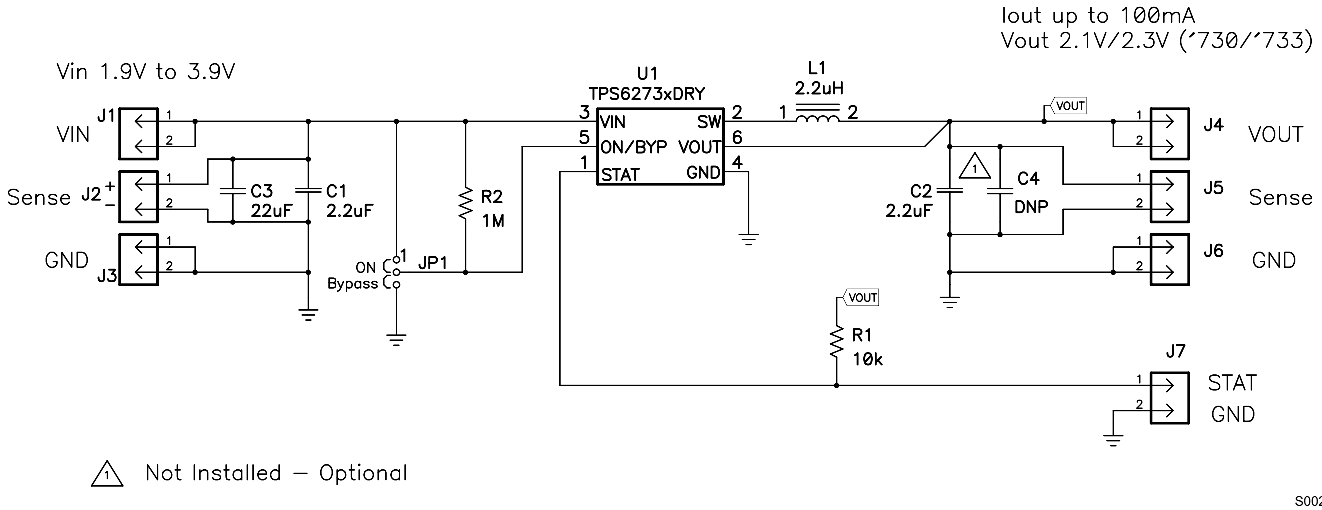

Figure 2. TPS62730 and TPS62733 EVM Board Schematic

5.2 Physical Layouts

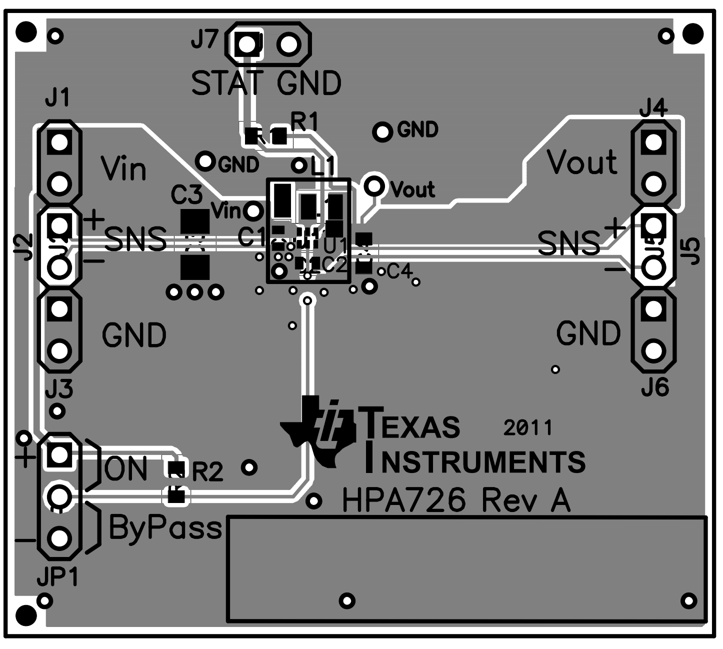

Figure 3. Assembly Layer

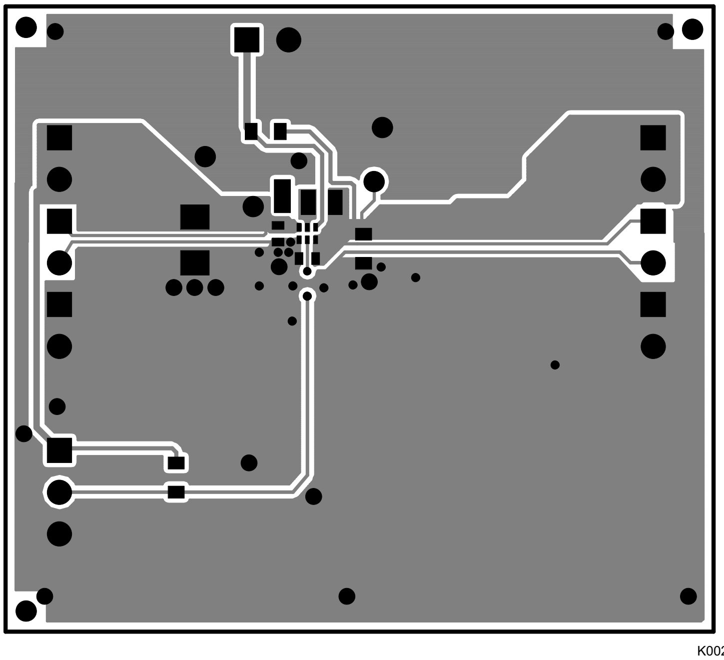

Figure 4. Top Layer

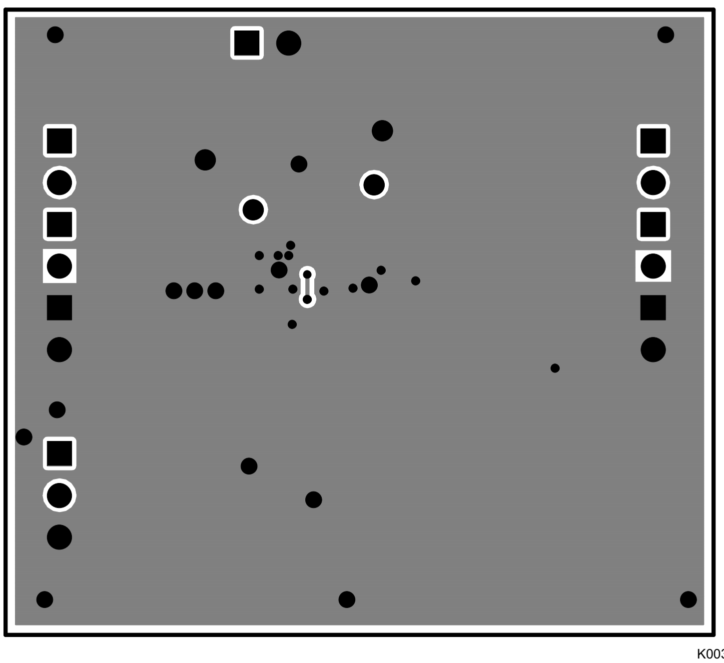

Figure 5. Bottom Layer

5.3 Bill of Materials

Table 2. HPA726 Bill of Materials

COUNT		RefDes	Value	Description	Size	Part Number	MFR
-001	-002						
2	2	C1, C2	2.2 µF	Capacitor, Ceramic, 6.3V, X5R, 20%	0402	GRM155R60J225ME15D	muRata
0	0	C4	Open	Capacitor, Ceramic, 6.3V, X5R, 20%	0603	Std	Std
1	1	C3	22 µF	Capacitor, Ceramic, 16V, X5R, 20%	1206	GRM31CR61C226ME15L	muRata
1	1	L1	2.2 µH	Inductor, SMT, 0.8A, 0.23 ohm	0805	LQM21PN2R2NGC	MuRata
1	1	R1	10 kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	R2	1 MΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	0	U1	TPS62730DRY	IC, Step Down Converter with Bypass Mode for Low Power Wireless, 2.1V Output	1,5 mm × 1 mm	TPS62730DRY	TI
0	1	U1	TPS62733DRY	IC, Step Down Converter with Bypass Mode for Low Power Wireless, 2.3V Output	1,5 mm × 1 mm	TPS62733DRY	TI

6 Oscilloscope Traces (taken on the TPS62730EVM-726)

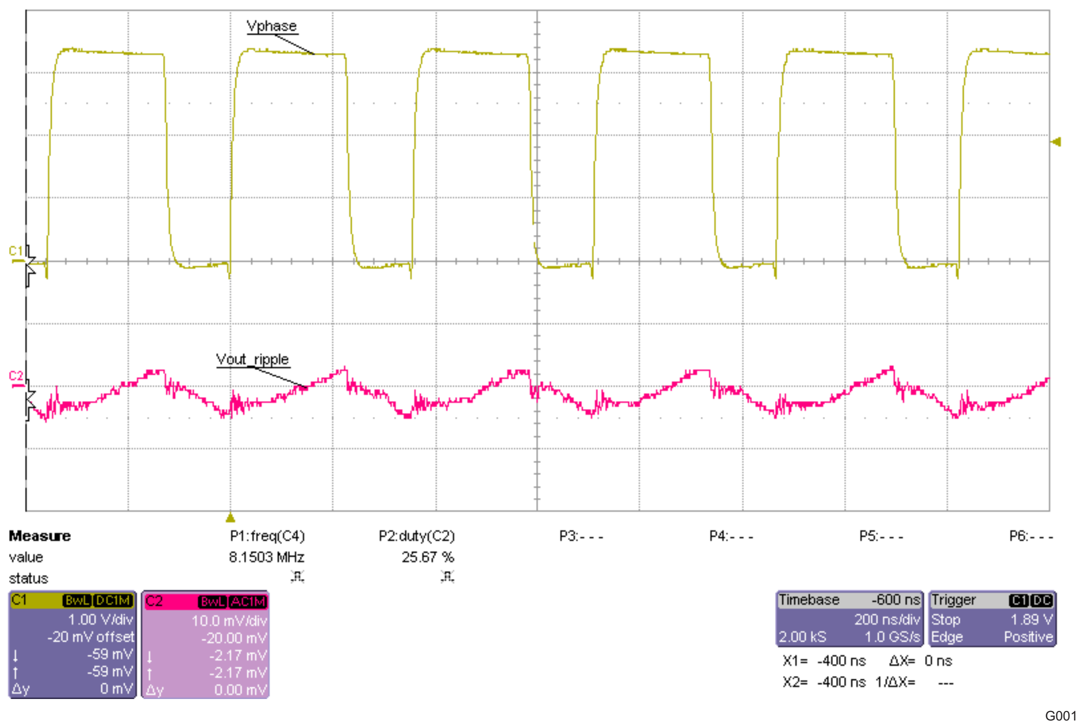

Figure 6. CH1: Phase; CH2: Output Ripple, Vin = 3.3 V, and 21-Ω Load

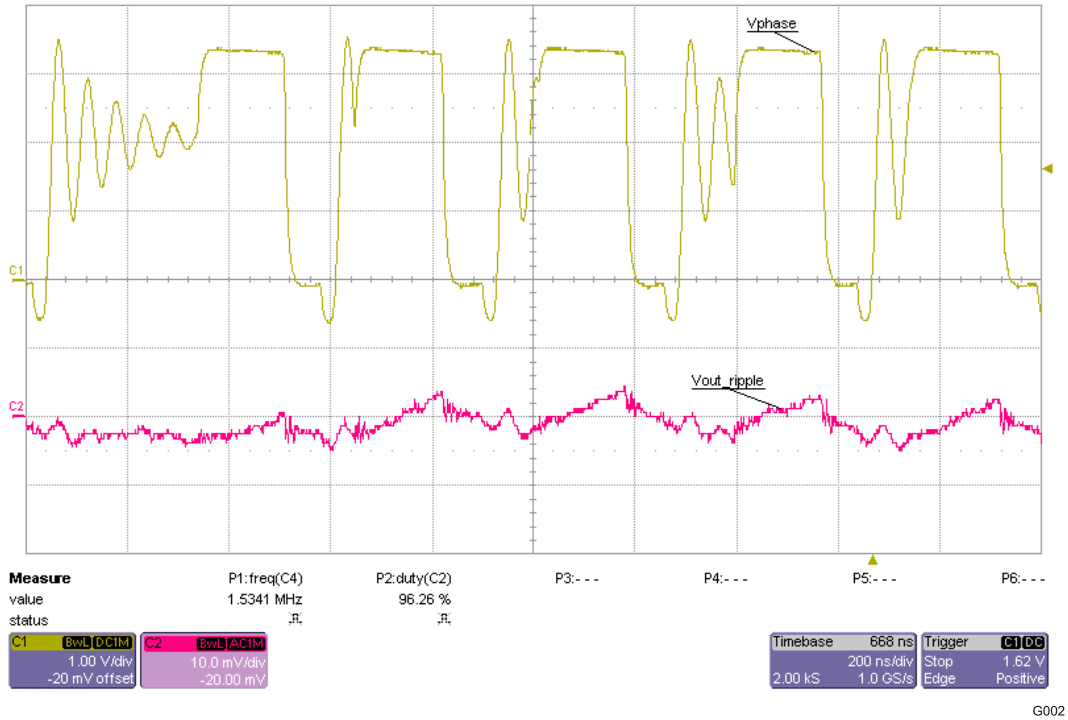

Figure 7. PFM Mode at Low Load, 40 mA – CH1: Phase; CH2: Output Ripple; 0.2 µs/div

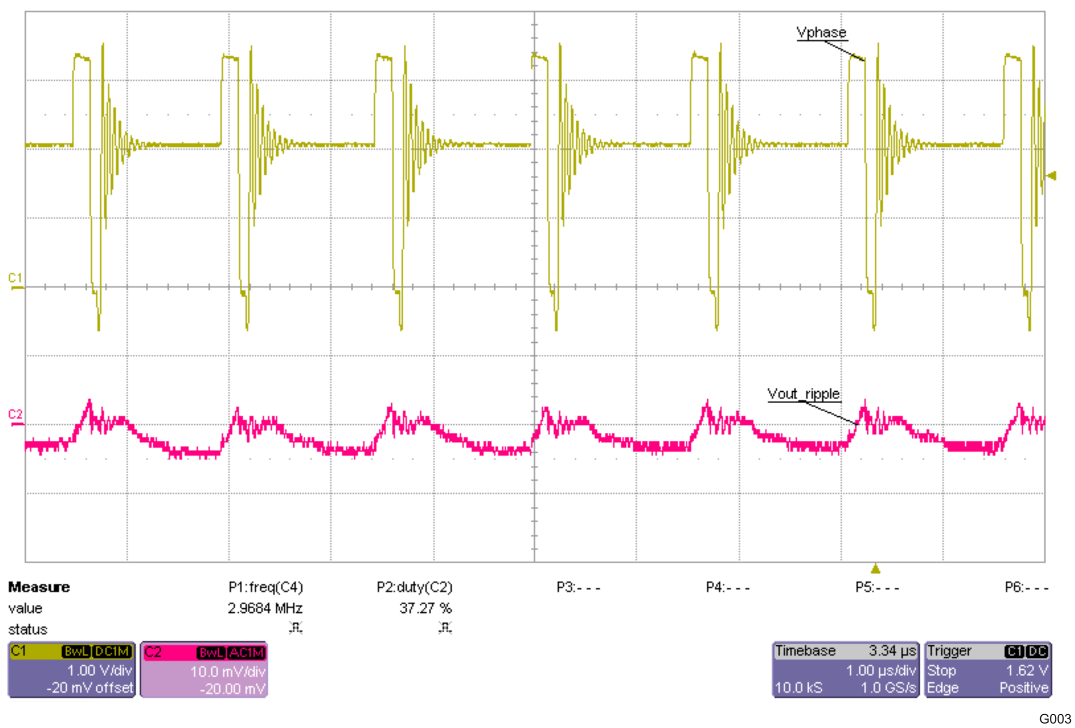

Figure 8. PFM Mode at Low Load, 11 mA – CH1: Phase; CH2: Output Ripple; 1 µs/div

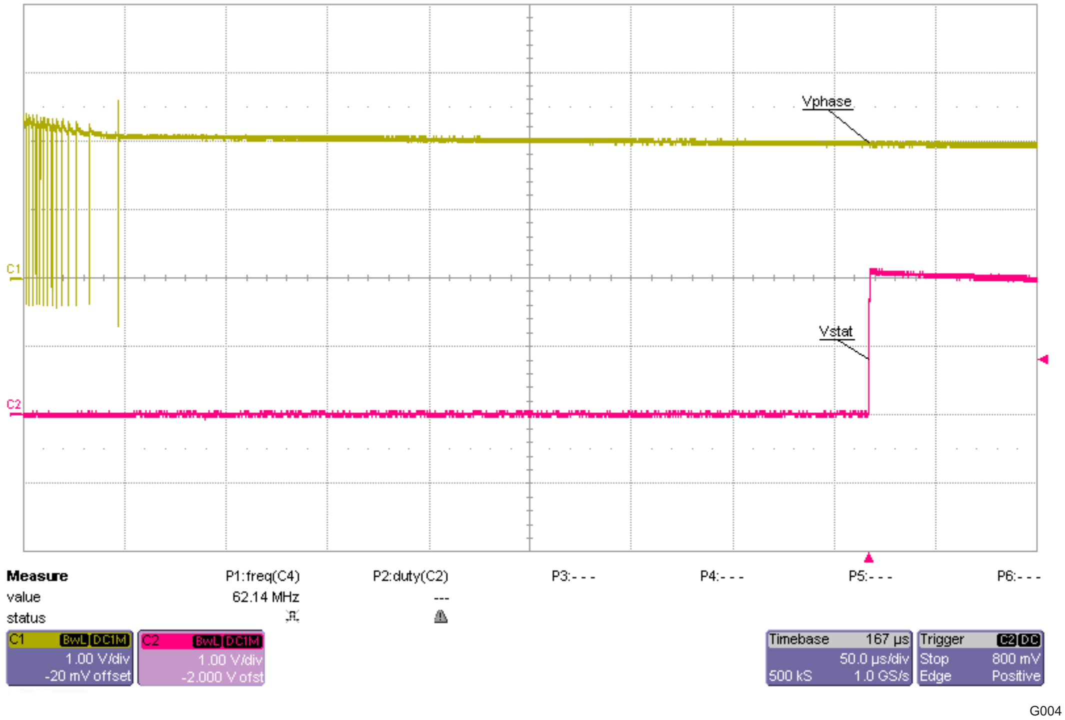

Figure 9. Transition From Switching Converter to Bypass Mode by Removing Input Power – CH1: Phase Node; CH2: STAT Pin

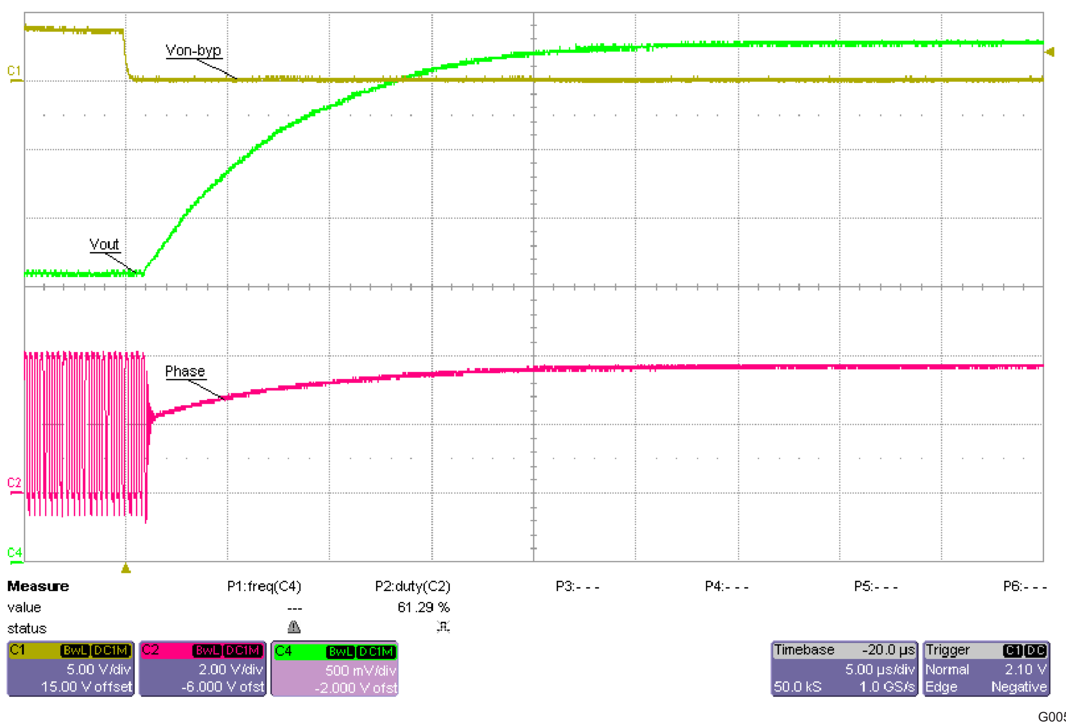

Figure 10. Transition From Converter Switch Mode to Bypass Mode by Pulling ON/BYP Pin Low

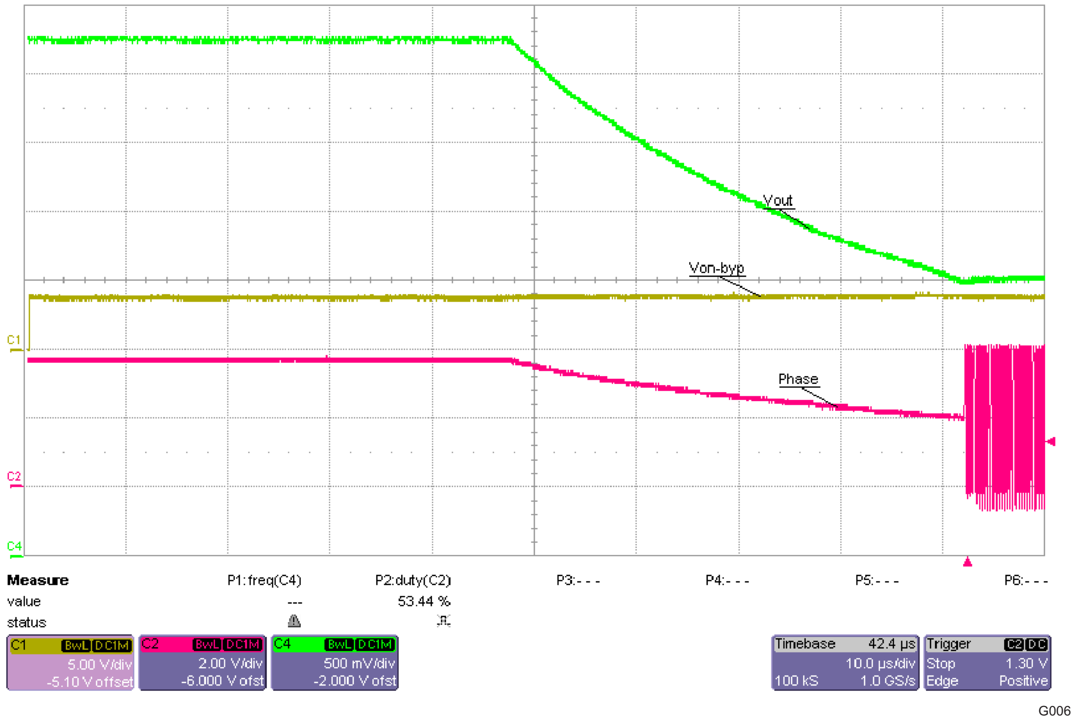

Figure 11. Transition From Bypass Mode to Converter Switch Mode by Pulling ON/BYP Pin High

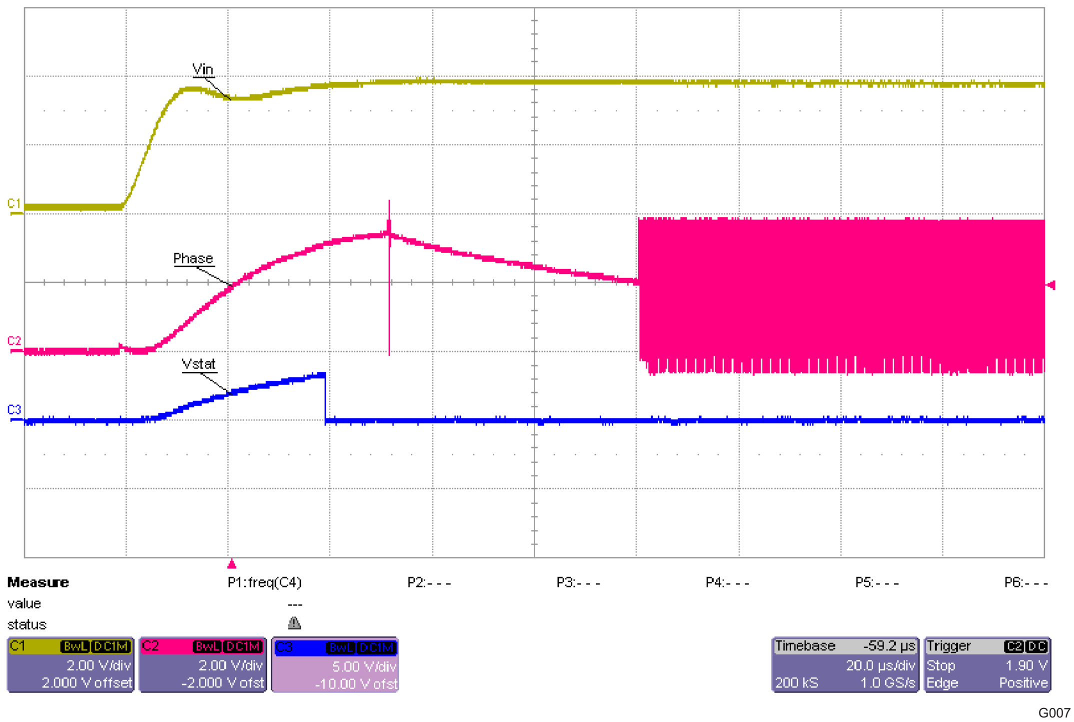

Figure 12. Start-Up by Hot-Plugging the Input Power Source

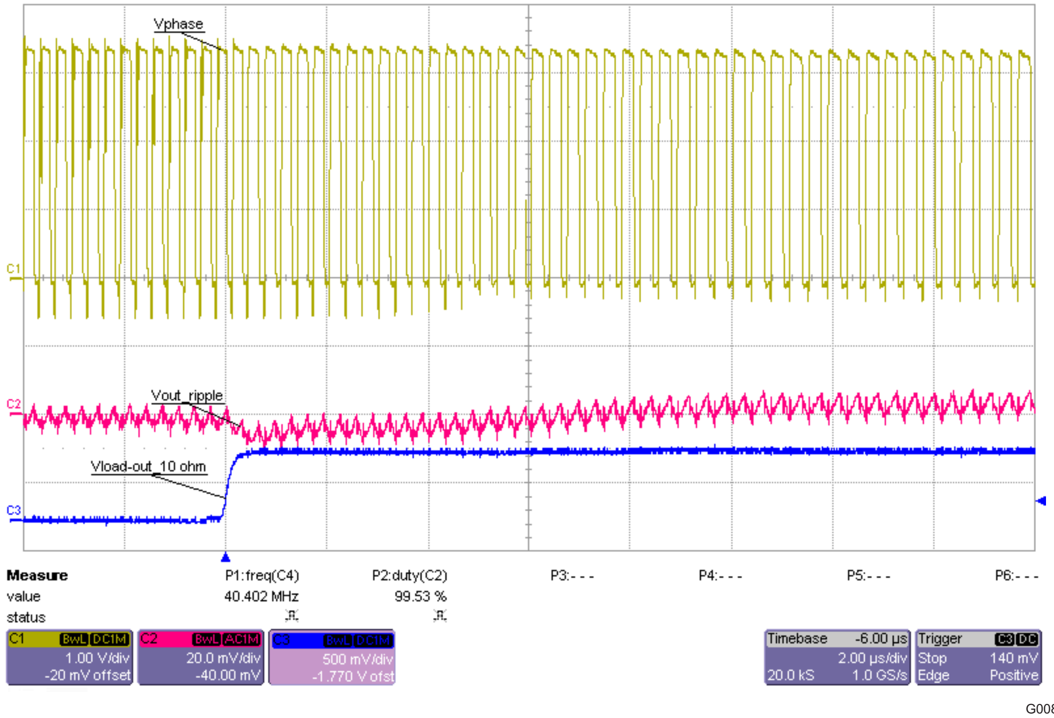

Figure 13. Transient Output Load Step From 50 mA to 100 mA

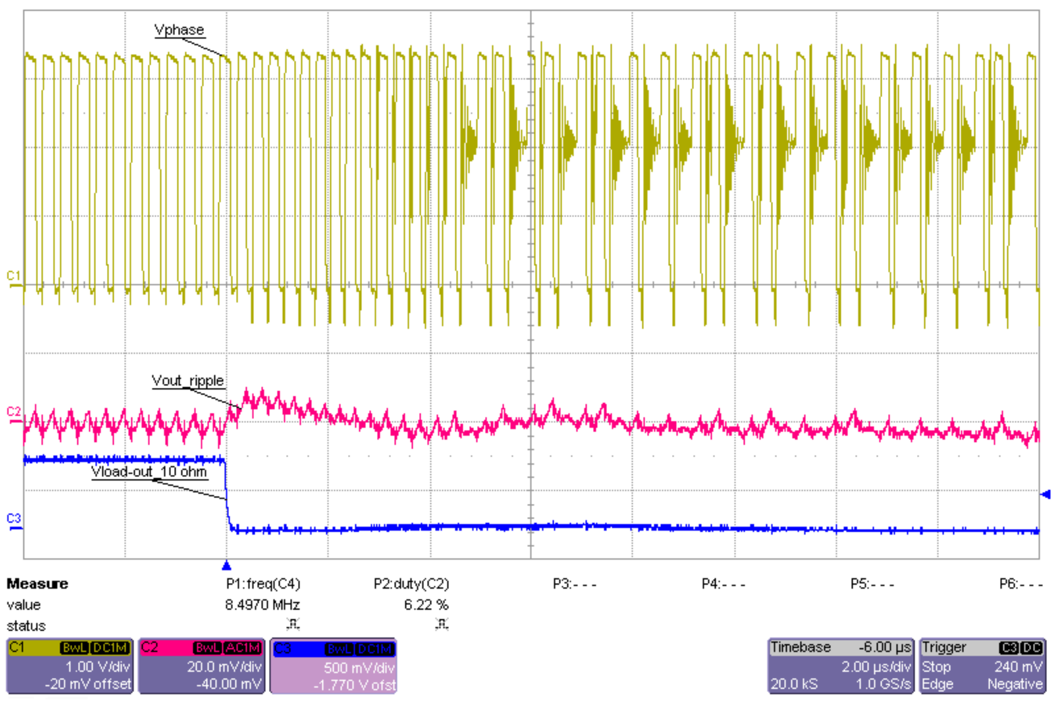

Figure 14. Transient Output Load Step From 100 mA to 50 mA

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Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

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.

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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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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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For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
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. 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.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

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.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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