User's Guide
SLVUAX8A–November 2016–Revised November 2018

TPS54824EVM-779 8-A, SWIFT™ Regulator Evaluation Module

This user's guide contains information for the TPS54824EVM-779 evaluation module (PWR779) as well as for the TPS54824 dc/dc converter. Also included are the performance specifications, the schematic, and the bill of materials for the TPS54824EVM-779.

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1 Introduction

1.1 Background

The TPS54824 dc/dc converter is a synchronous buck converter designed to provide up to an 8-A output. The input (VIN) is rated for 4.5 V to 17 V. Rated input voltage and output current range for the evaluation module are given in Table 1. This evaluation module is designed to demonstrate the small printed-circuit-board areas that may be achieved when designing with the TPS54824 regulator. The RT/CLK pin is configured for 700-kHz switching frequency. The high-side and low-side MOSFETs are incorporated inside the TPS54824 package along with the gate-drive circuitry. The low drain-to-source on-resistance of the MOSFET allows the TPS54824 to achieve high efficiencies and helps keep the junction temperature low at high output currents. An external divider allows for an adjustable output voltage. Additionally, the TPS54824 provides adjustable soft start and undervoltage lockout inputs and a power good output.

Table 1. Input Voltage and Output Current Summary

EVM	Input Voltage Range	Output Current Range
TPS54824EVM-779	V_{IN} = 4.5 V to 17 V	0 A to 8 A

1.2 Performance Specification Summary

A summary of the TPS54824EVM-779 performance specifications is provided in Table 2. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 1.8 V, unless otherwise specified. The TPS54824EVM-779 is designed and tested for V_{IN} = 4.5 V to 17 V. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 2. TPS54824EVM-779 Performance Specification Summary

Specification	Test Conditions	MIN	TYP	MAX	Unit
V_{IN} voltage range		4.5	12	17	V
V_{IN} start voltage			4.4		V
V_{IN} stop voltage			4		V
Output voltage setpoint			1.8		V

Table 2. TPS54824EVM-779 Performance Specification Summary (continued)

Specification	Test Conditions		MIN	TYP	MAX	Unit
Output current range	V_{IN} = 4.5 V to 17 V		0		8	A
Load regulation	V_{IN} = 4.5 V to 17 V, I_O = 8 A			–0.1%		
Load transient response	I_O = 2 A to 6 A	Voltage change		–50		mV
		Recovery time		75		µs
	I_O = 6 A to 2A	Voltage change		55		mV
		Recovery time		75		µs
Loop bandwidth	V_{IN} = 12 V, I_O = 4 A			116		kHz
Phase margin	V_{IN} = 12 V , I_O = 4 A			58		degree
Input ripple voltage	I_O = 8 A			270		mVPP
Output ripple voltage	I_O = 8 A			11		mVPP
Output rise time				1.1		ms
Operating frequency (f_{SW})				700		kHz
Maximum efficiency	TPS54824EVM-779, V_{IN} = 5 V, I_O = 2 A			94.3%		

1.3 Evaluating the TPS54824EVM-779 at -40 °C

The TPS54824EVM-779 was designed and optimized at room temperature of 25 °C. For evaluation down -40 °C, the compensation must be adjusted to provide sufficient gain and phase margin. Recommended compensation changes for -40 °C evaluation are: R5 = 5.36 kΩ, C18 = 5.6 nF and C17 = 68 pF.

1.4 Modifications

These evaluation modules are designed to provide access to the features of the TPS54824. Some modifications can be made to this module. When modifications are made to the components on the EVM, the compensation components connected to the COMP pin may need to be changed. Changes to the f_{SW}, output voltage, output inductor, and output capacitors may require a change in the external compensation. Table 3 gives some example values for different applications.

1.4.1 Output Voltage Setpoint

The output voltage is set by the resistor divider network of R8 and R6. R6 is fixed at 6.04 kΩ. To change the output voltage of the EVM, it is necessary to change the value of resistor R8. Changing the value of R6 can change the output voltage above the 0.6-V reference voltage V_{REF}. The value of R8 for a specific output voltage can be calculated using Equation 1.

$$R8 = R6 \times \left(\frac{V_{OUT}}{0.6V} - 1 \right) \quad (1)$$

1.4.2 Adjustable UVLO

The undervoltage lockout (UVLO) can be adjusted externally using R2 and R9. See the TPS54824 datasheet (SLVSDC9) for detailed instructions for setting the external UVLO.

1.4.3 Example Component Values For Common Output Voltages

Table 3 shows recommended modifications to the EVM for evaluating different output voltages. Depending on the load step response requirements in the application, the output capacitors may need to be different from the values shown in this table. More or less output capacitance can be used. If the output capacitors are changed, the compensation may need to be adjusted. Additionally if a different f_{SW} is needed, the inductance value (L) may need to be changed. The TPS54824 datasheet equations or WEBENCH can be used to calculate the output capacitor value, compensation, f_{SW} and inductance.

Table 3. Recommended Component Value Changes For Common Output Voltages

V_{OUT} (V)	f_{SW} (kHz)	R_T (R7) (kΩ)	L (µH)	C_{OUT} (µF)	R_{FBT} (R8) (kΩ)	R_C (R5) (kΩ)	C_C (C18) (nF)	C_P (C17) (pF)	C_{FF} (C19) (pF)
1	500	100	1.0	4x 47	4.02	3.32	10	180	470
1.8	500	100	1.5	4x 47	12.1	5.36	5.6	100	150
3.3	500	100	2.2	2x 47	27.4	3.32	10	180	68

2 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS54824EVM-779 evaluation module. The section also includes test results typical for the evaluation module and covers efficiency, output voltage regulation, load transients, loop response, output ripple, input ripple, start-up, and current limit modes.

2.1 Input/Output Connections

The TPS54824EVM-779 is provided with input/output connectors and test points as shown in Table 4. A power supply capable of supplying greater than 5 A must be connected to J1 through a pair of 20-AWG wires or better. The load must be connected to J2 through a pair of 20-AWG wires or better. The maximum load current capability is 12 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the V_{IN} input voltages with TP7 providing a convenient ground reference. TP4 is used to monitor the output voltage with TP9 as the ground reference.

Table 4. TPS54824EVM-779 EVM Connectors and Test Points

Reference Designator	Function
J1	VIN input voltage connector (see Table 1 for V_{IN} range)
J2	VOUT terminal to connect load
J3	2-pin header for enable. Add shunt to connect EN to ground and disable device.
J4	2-pin header for power good resistor pullup connection. Add a shunt to pull up to VOUT.
TP1	VIN test point
TP2	EN test point
TP3	SW node test point
TP4	1.8-V test point
TP5	PGOOD pullup test point
TP6	PGOOD test point
TP7	PGND test point
TP8	SS/TRK test point
TP9	PGND test point
TP10	Test point between voltage divider network and output of TPS54824 converter. Used for loop response measurements.
TP11	PGND test point
TP12	AGND test point
TP13	AGND test point
TP14	PGND test point
TP15	Test point for supplying external CLK for synchronization. C20 and R10 should be populated to use.

2.2 Efficiency

The efficiency of this EVM peaks at a load current of about 4 A and then decreases as the load current increases toward full load. Figure 1 shows the efficiency for the TPS54824EVM-779 at an ambient temperature of 25°C.

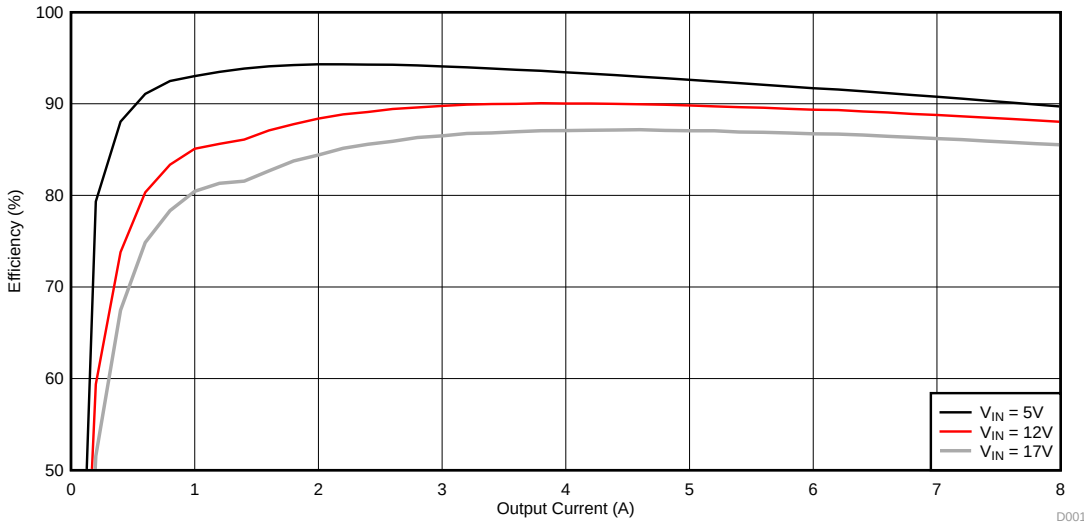

Figure 1. TPS54824EVM-779 Efficiency - Cyntec Inductor

Figure 2 shows the efficiency for the TPS54824EVM-779 using a semi-log scale to more easily show efficiency at lower output currents. The ambient temperature is 25°C.

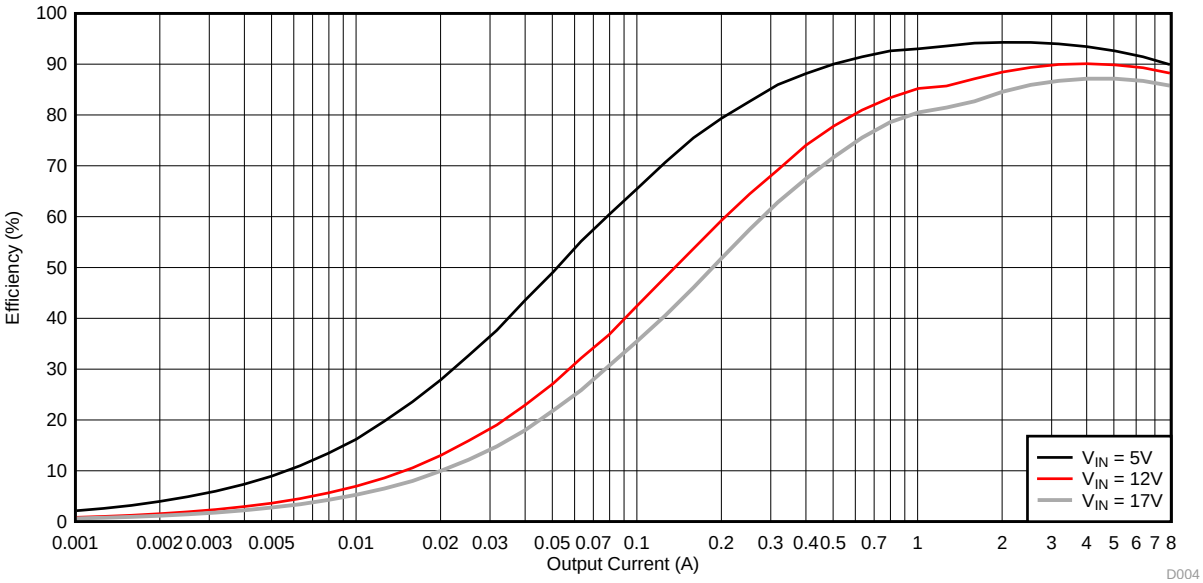

Figure 2. TPS54824EVM-779 Low Current Efficiency - Cyntec Inductor

Figure 3 shows the efficiency for the TPS54824EVM-779 with a WE 744311100 inductor. The ambient temperature is 25°C.

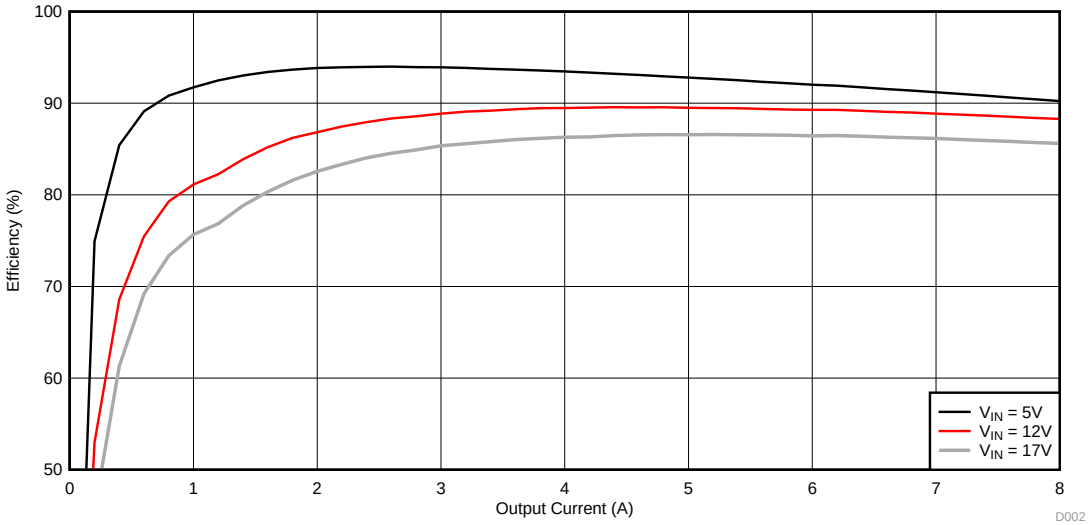

Figure 3. TPS54824EVM-779 Efficiency - Wurth Electronics 744311100 Inductor

The efficiency may be lower at higher ambient temperatures, due to temperature variation in the drain-to-source resistance of the internal MOSFETs.

2.3 Output Voltage Load Regulation

Figure 4 shows the load regulation for the TPS54824EVM-779.

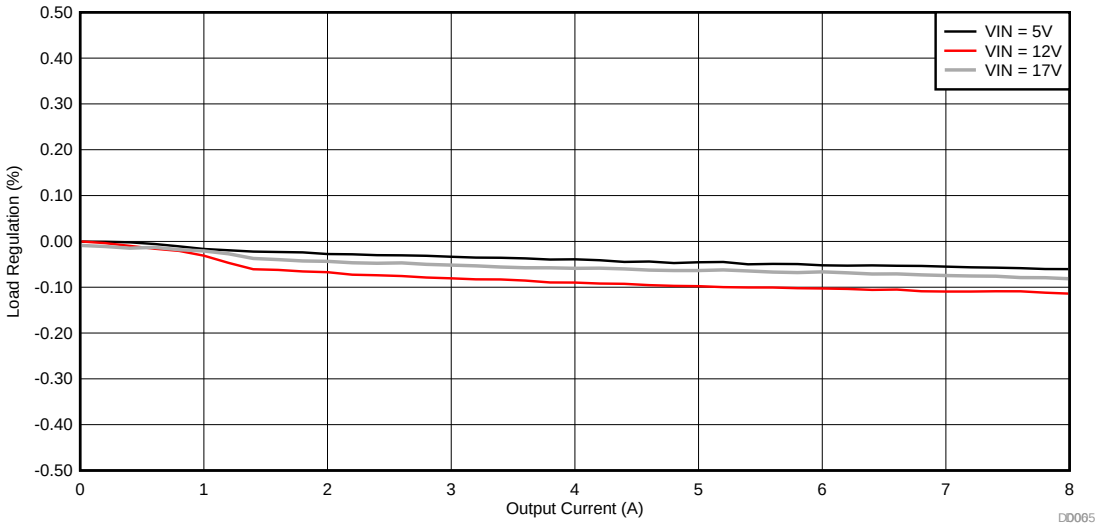

Figure 4. TPS54824EVM-779 Load Regulation

Measurements are given for an ambient temperature of 25°C.

2.4 Output Voltage Line Regulation

Figure 5 shows the line regulation for the TPS54824EVM-779.

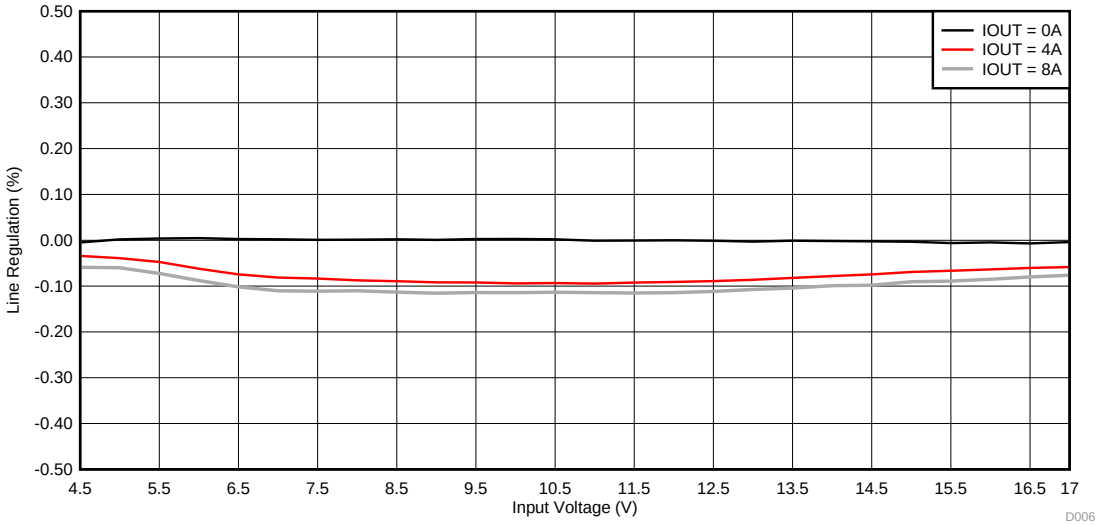

Figure 5. TPS54824EVM-779 Line Regulation

2.5 Load Transients

Figure 6 shows the TPS54824EVM-779 response to load transients. The current step is from 2 A to 6 A. The current step slew rate is 1 A/µs. Total peak-to-peak voltage variation is as shown, including ripple and noise on the output.

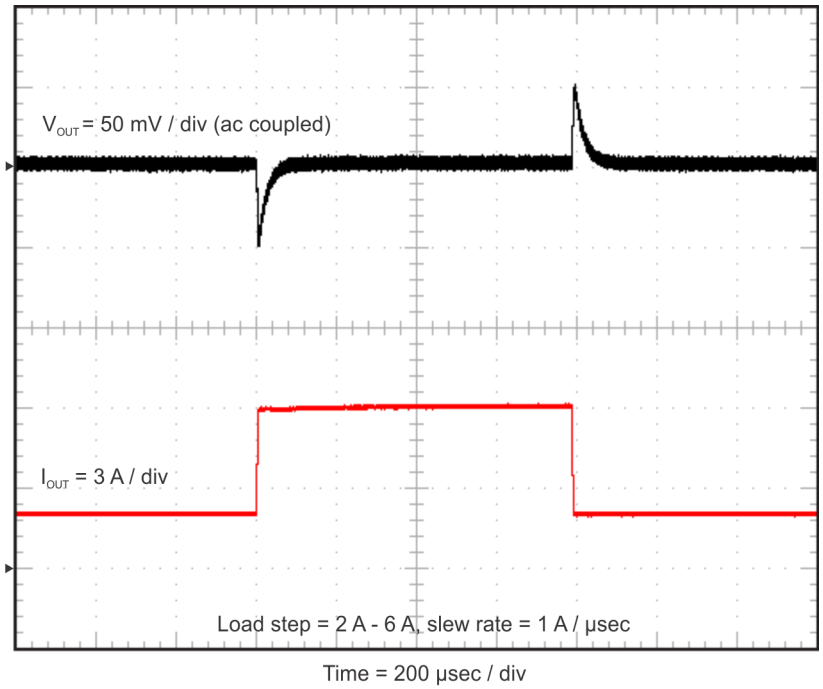

Figure 6. TPS54824EVM-779 Transient Response

2.6 Loop Characteristics

Figure 7 shows the TPS54824EVM-779 loop-response characteristics. Gain and phase plots are shown for V_{IN} voltage of 12 V. Load current for the measurement is 4 A.

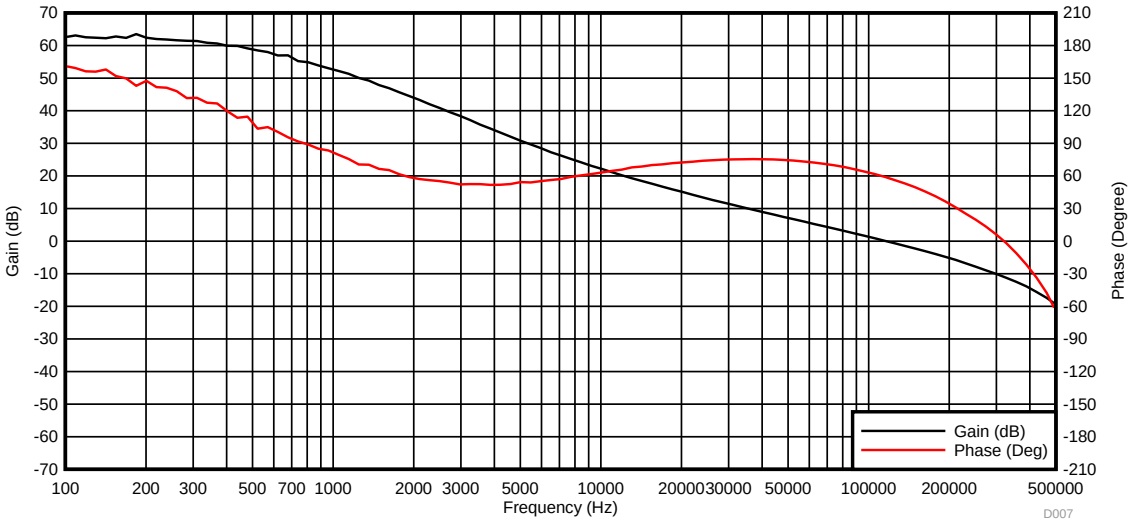

Figure 7. TPS54824EVM-779 Loop Response

2.7 Output Voltage Ripple

Figure 8 and Figure 9 show the TPS54824EVM-779 output voltage ripple. The load currents are no load and 8 A. V_{IN} = 12 V. The ripple voltage is measured directly across TP9 and TP4.

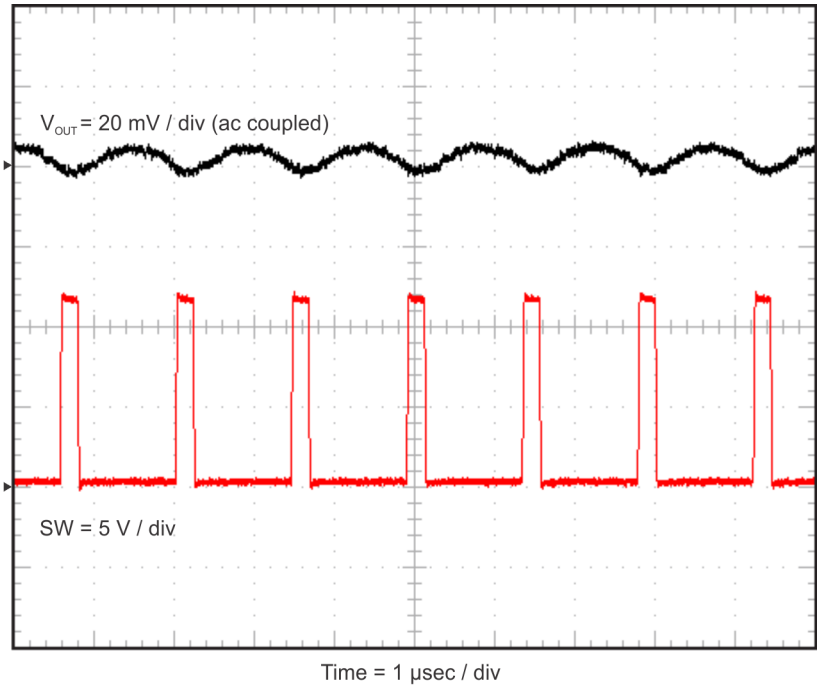

Figure 8. TPS54824EVM-779 Output Ripple, No Load

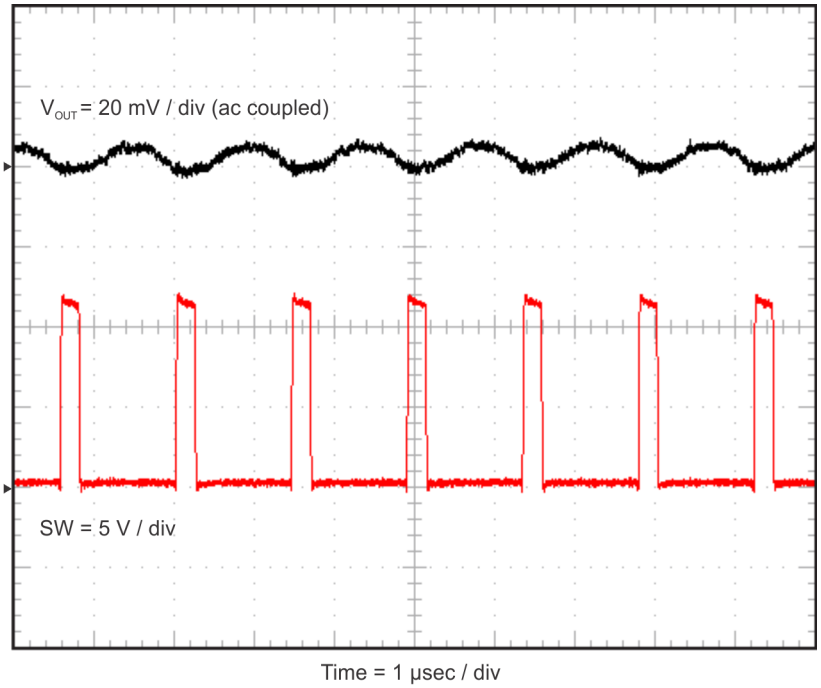

Figure 9. TPS54824EVM-779 Output Ripple, 8-A Load

2.8 Input Voltage Ripple

Figure 10 and Figure 11 show the TPS54824EVM-779 input voltage ripple. The load currents are no load and 8 A. V_{IN} = 12 V. The ripple voltage is measured directly across TP1 and TP7.

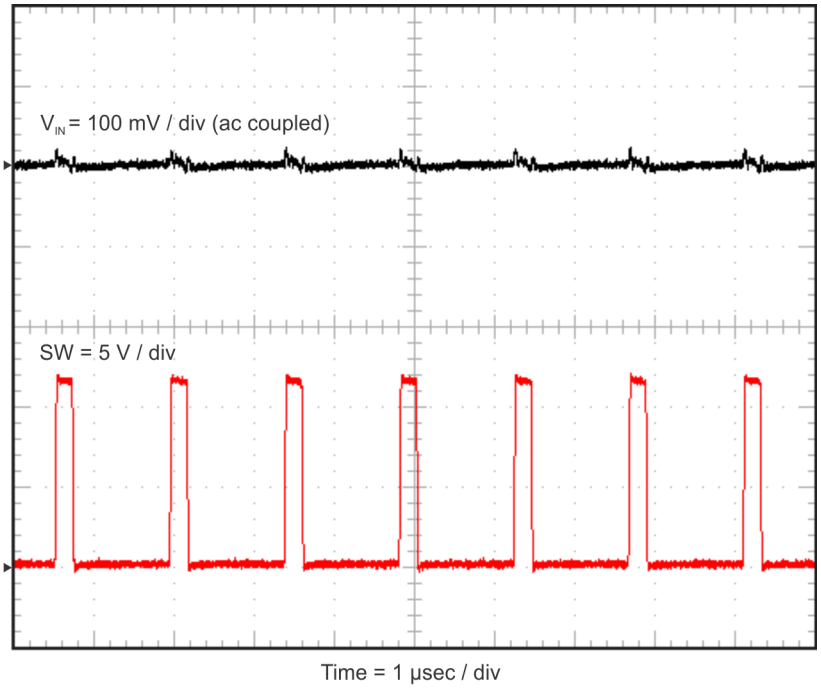

Figure 10. TPS54824EVM-779 Input Ripple, No Load

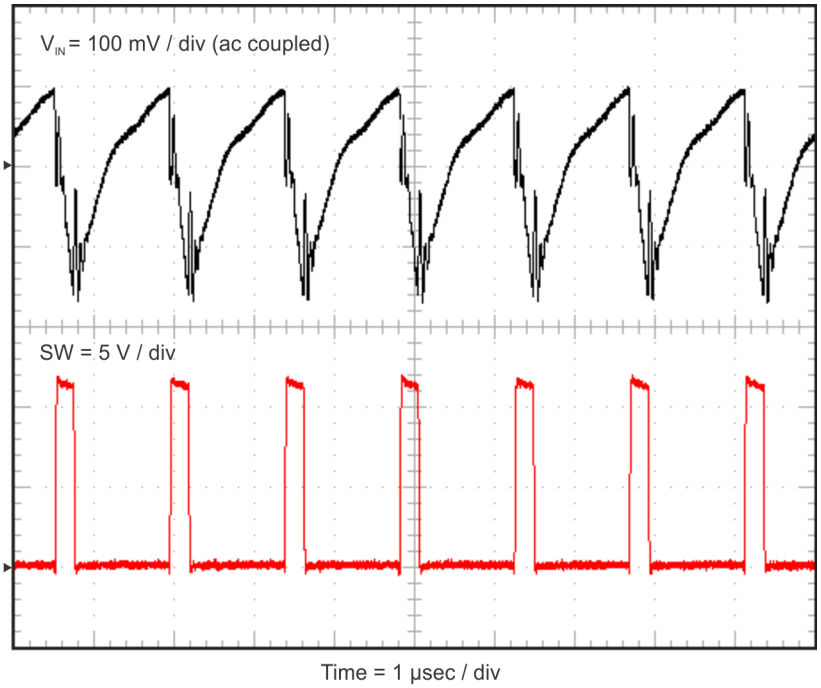

Figure 11. TPS54824EVM-779 Input Ripple, 8-A Load

2.9 Powering Up

Figure 12 and Figure 13 show the start-up waveforms for the TPS54824EVM-779. In Figure 12, the output voltage ramps up as soon as the input voltage reaches the UVLO threshold. In Figure 13, the input voltage is initially applied and the output is inhibited by pulling EN to GND using an external function generator. When the EN voltage is increased above the enable-threshold voltage, the start-up sequence begins and the output voltage ramps up to the externally set value of 1.8 V. The input voltage for these plots is 12 V and the load is 1 Ω. Alternatively, a jumper at J3 to tie EN to GND can also be used. When the jumper is removed, EN is released and the start-up sequence will begin.

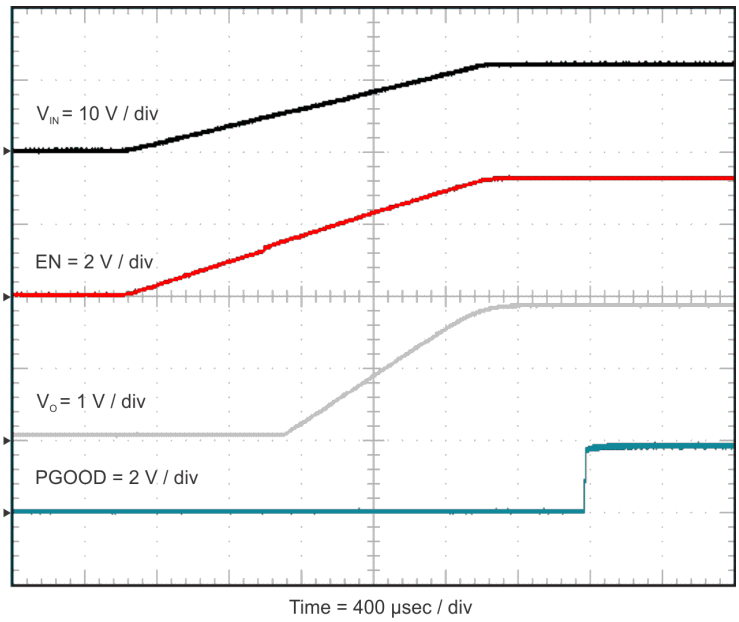

Figure 12. TPS54824EVM-779 Start-Up Relative to V_{IN}

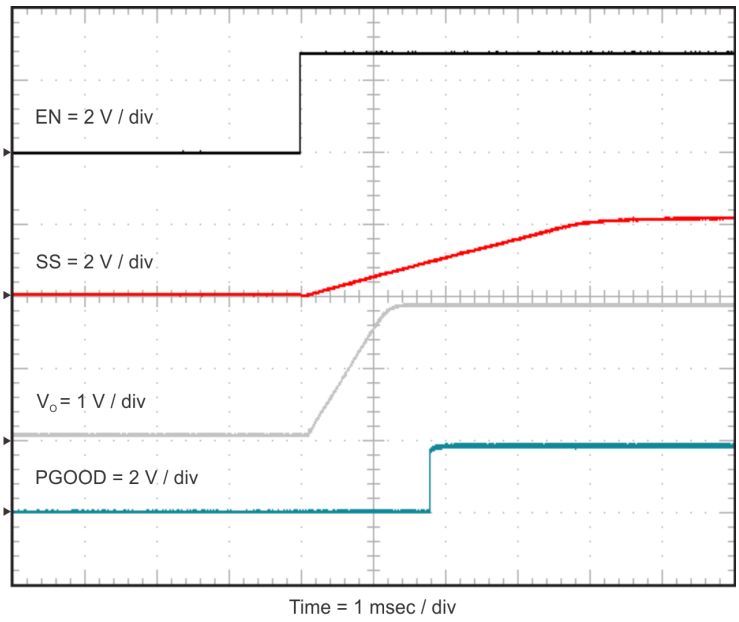

Figure 13. TPS54824EVM-779 Start-Up Relative to Enable

2.10 Powering Down

Figure 14 and Figure 15 show the TPS54824EVM-779 shutdown. The input voltage for these plots is 12 V and the load is 1 Ω.

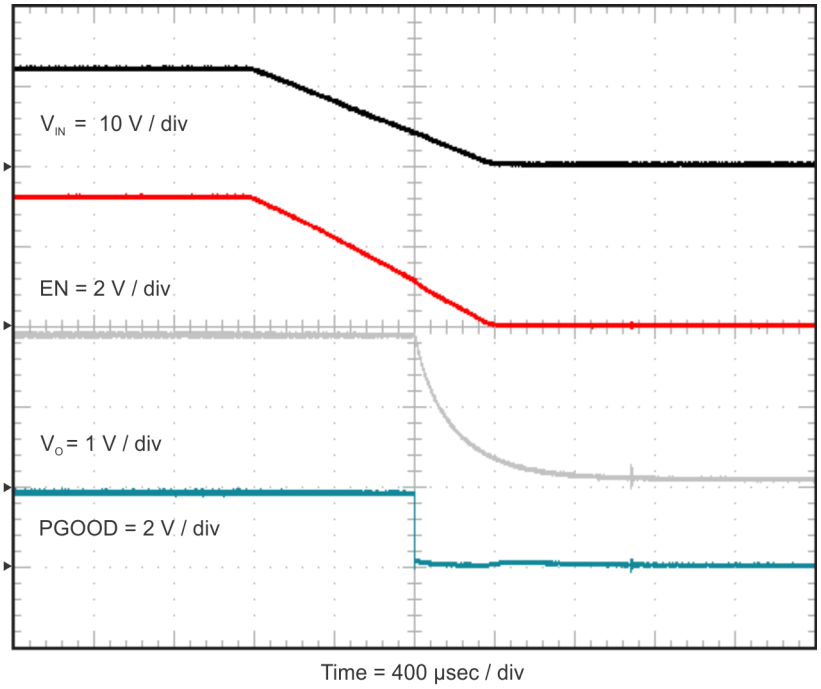

Figure 14. TPS54824EVM-779 Shutdown Relative to V_{IN}

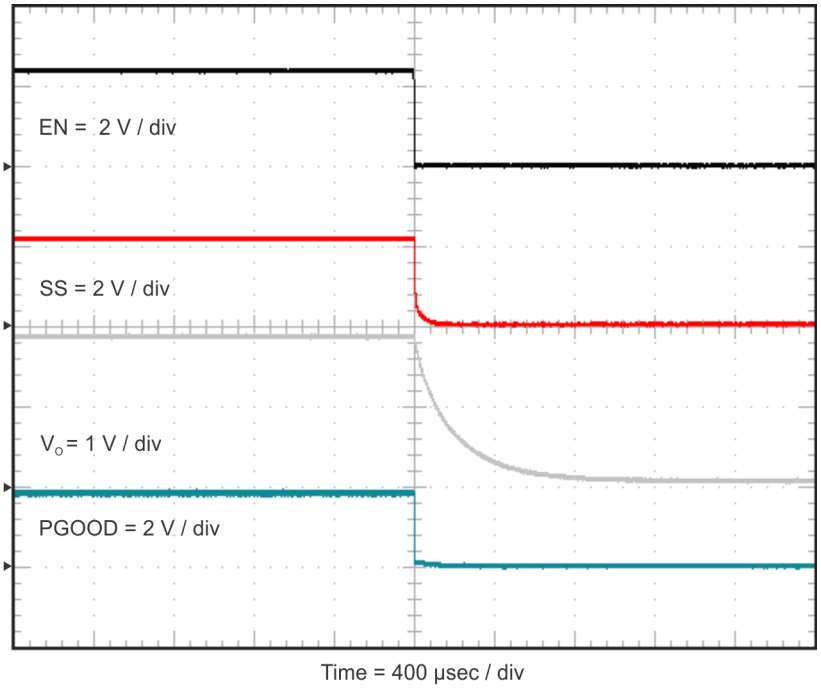

Figure 15. TPS54824EVM-779 Shutdown Relative to Enable

2.11 Start-Up Into Pre-Bias

Figure 16 shows the TPS54824EVM-779 start up into a pre-biased output. The output voltage is pre-biased to 1 V.

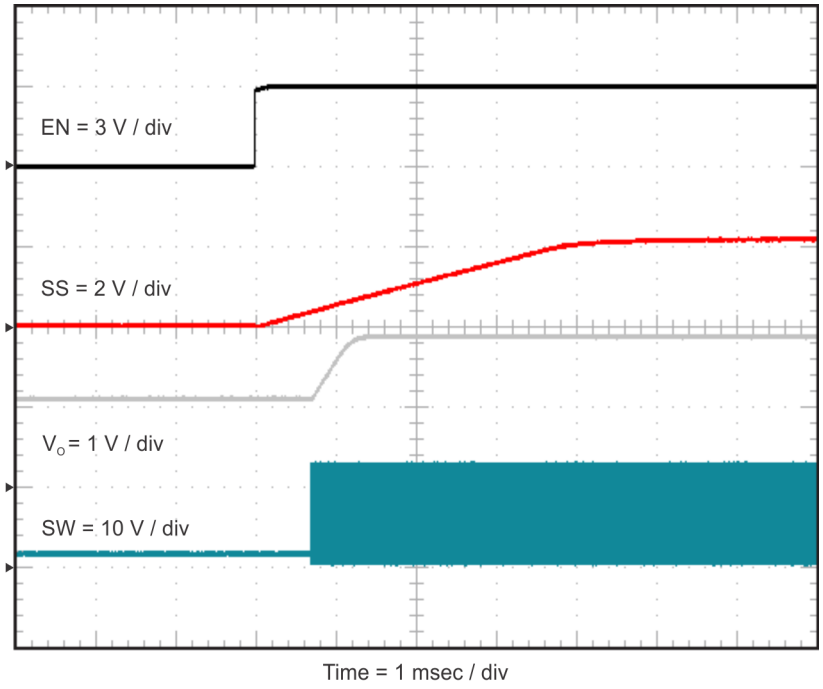

Figure 16. TPS54824EVM-779 Start-Up Into Pre-Bias

2.12 Hiccup Mode Current Limit

Figure 17, Figure 18, and Figure 19 show the TPS54824EVM-779 hiccup mode current limit feature. When an overcurrent event occurs, the TPS54824EVM-779 shuts down and restarts. Figure 17 shows the restart sequence in an overcurrent condition. Figure 18 shows TPS54824EVM-779 entering hiccup mode and Figure 19 shows TPS54824EVM-779 exiting hiccup mode.

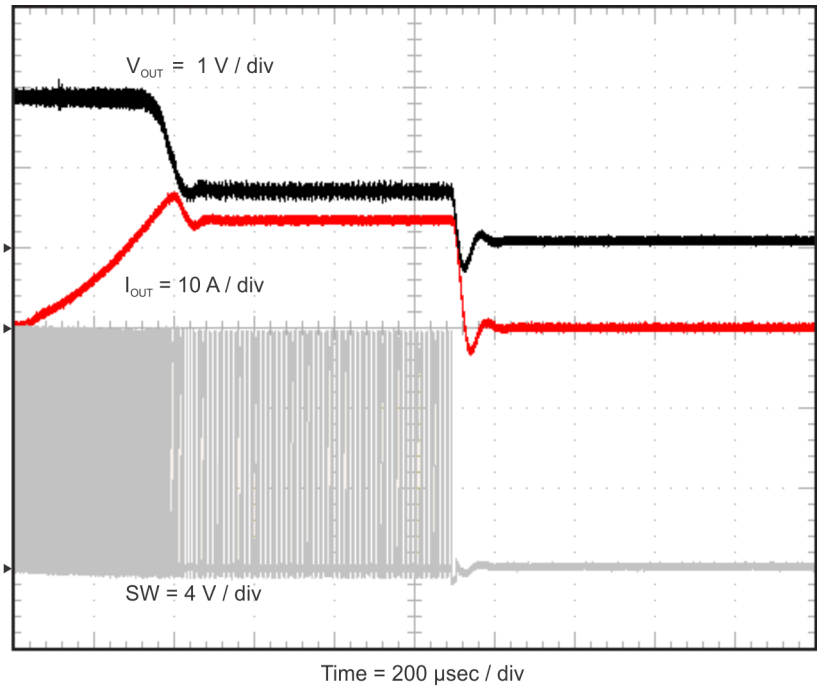

Figure 17. TPS54824EVM-779 Hiccup Mode Current Limit

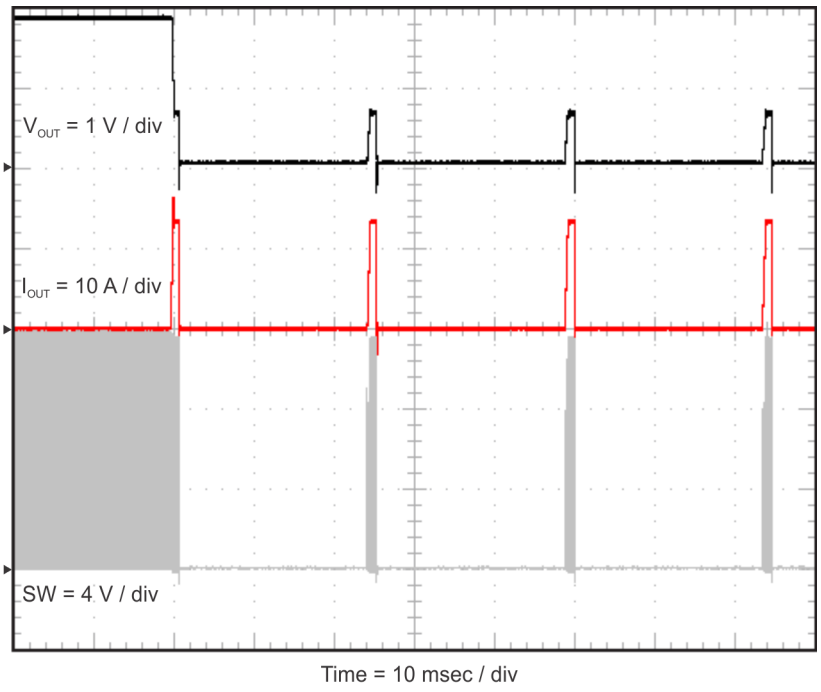

Figure 18. TPS54824EVM-779 Hiccup Mode Start

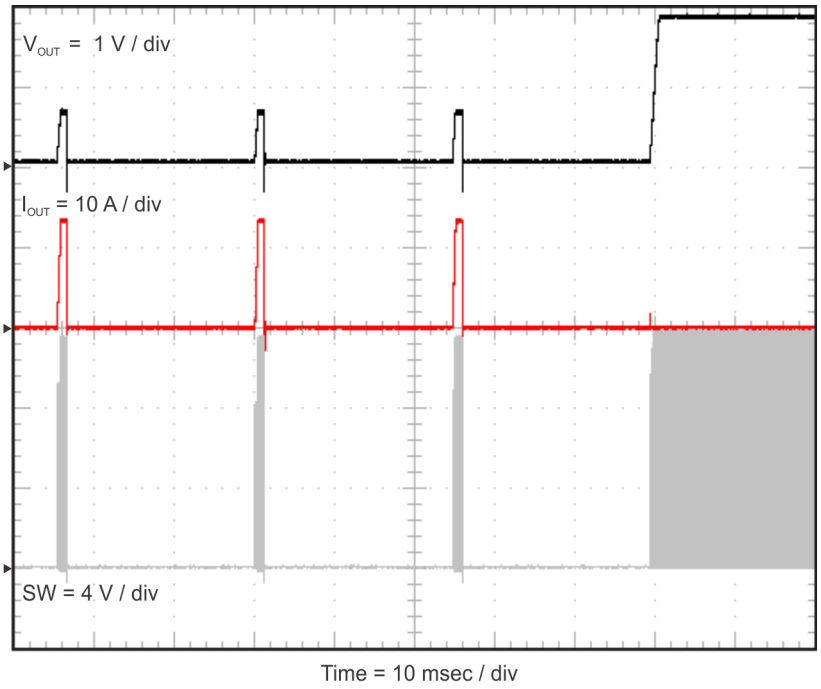

Figure 19. TPS54824EVM-779 Hiccup Mode Stop

3 Board Layout

This section provides a description of the TPS54824EVM-779 board layout and layer illustrations.

3.1 Layout

The board layout for the TPS54824EVM-779 is shown in Figure 20 through Figure 23. The top-side layer of the EVM is laid out in a manner typical of a user application. The top, bottom, and internal layers are 2-oz. copper.

The top layer contains the main power traces for VIN, VOUT, and SW. Also on the top layer are connections for the remaining pins of the TPS54824 and the majority of the signal traces. The top layer has dedicated ground plane for quiet analog ground that is connected to the main power ground plane at a single point. The internal layer-1 is a large ground plane and also routes signals to test points. The internal layer-2 contains an additional large ground copper area as well as an additional VIN and VOUT copper fill. The bottom layer is another ground plane with two additional traces for the output voltage feedback. The top-side ground traces are connected to the bottom and internal ground planes with multiple vias placed around the board.

The input decoupling capacitors and bootstrap capacitor are all located as close to the IC as possible. Additionally, the voltage set point resistor divider components are kept close to the IC. The voltage divider network ties to the output voltage at the point of regulation, the copper V_{OUT} trace at the TP4 test point. An additional input bulk capacitor is used to limit the noise entering the converter from the input supply. Critical analog circuits such as the voltage set point divider, EN resistor, SS/TRK capacitor, RT/CLK resistor, and COMP pin are terminated to the quiet analog ground island on the top layer.

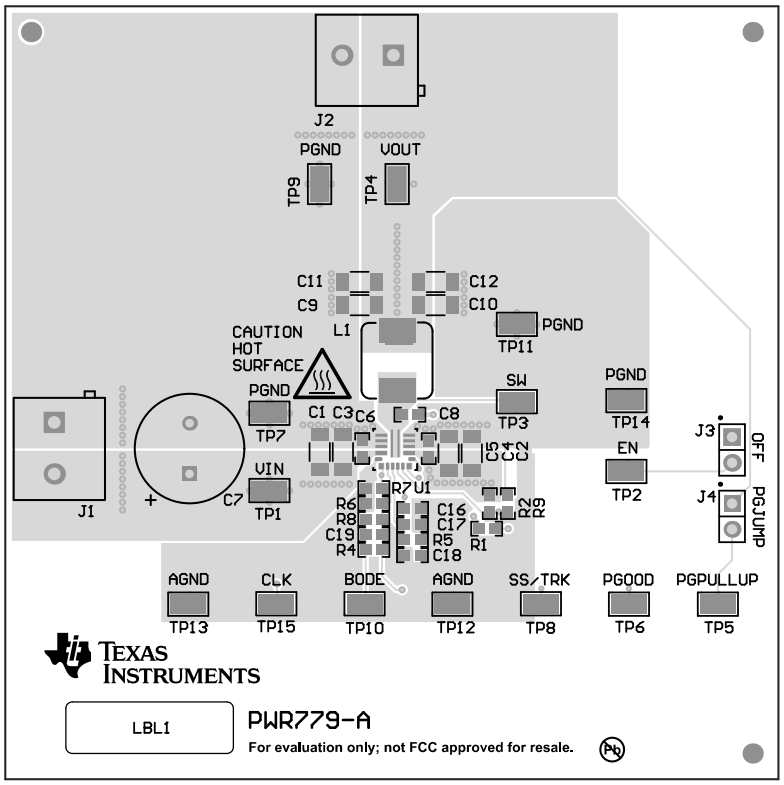

Figure 20. TPS54824EVM-779 Top-Side Layout

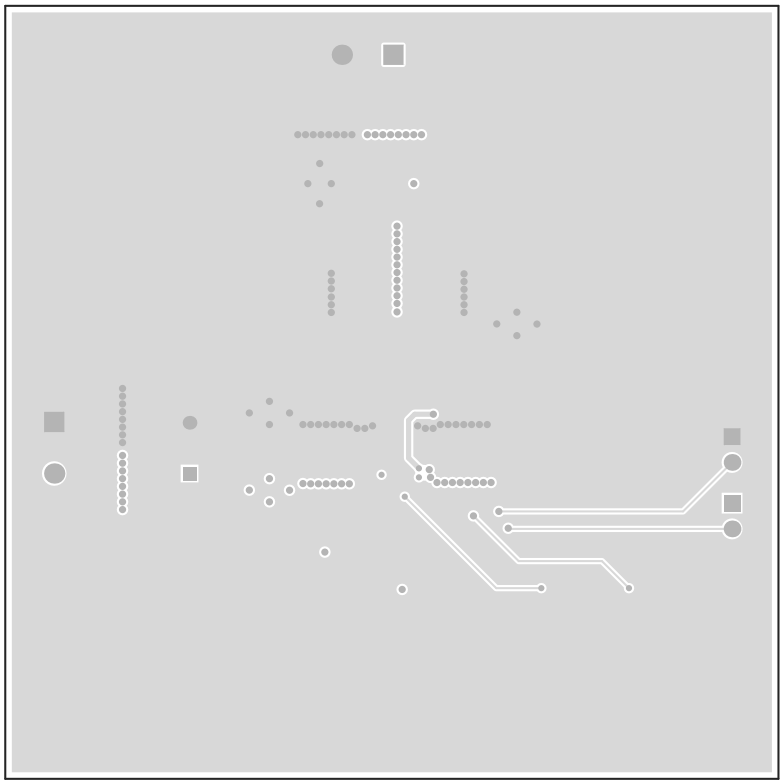

Figure 21. TPS54824EVM-779 Internal Layer-1 Layout

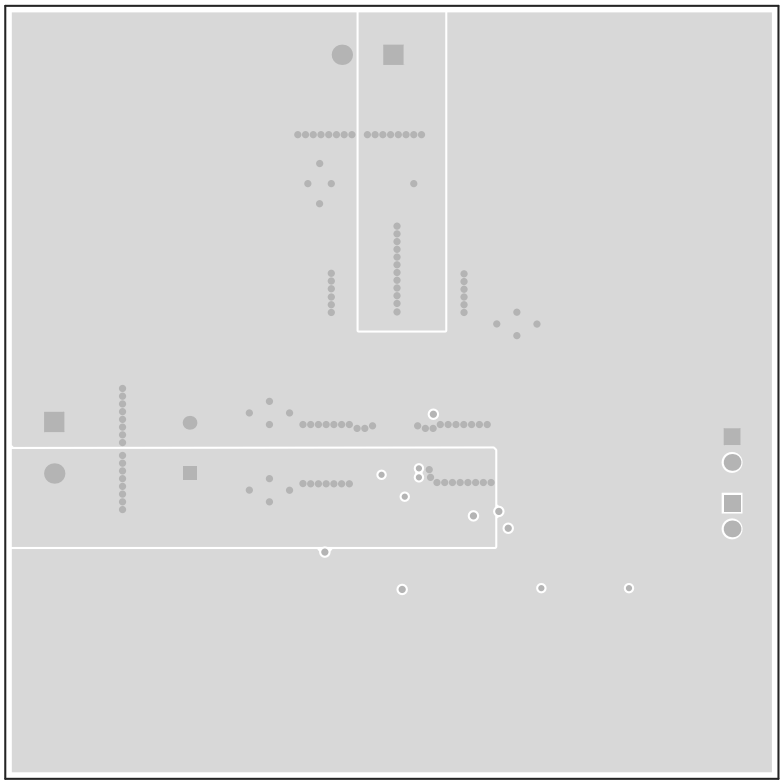

Figure 22. TPS54824EVM-779 Internal Layer-2 Layout

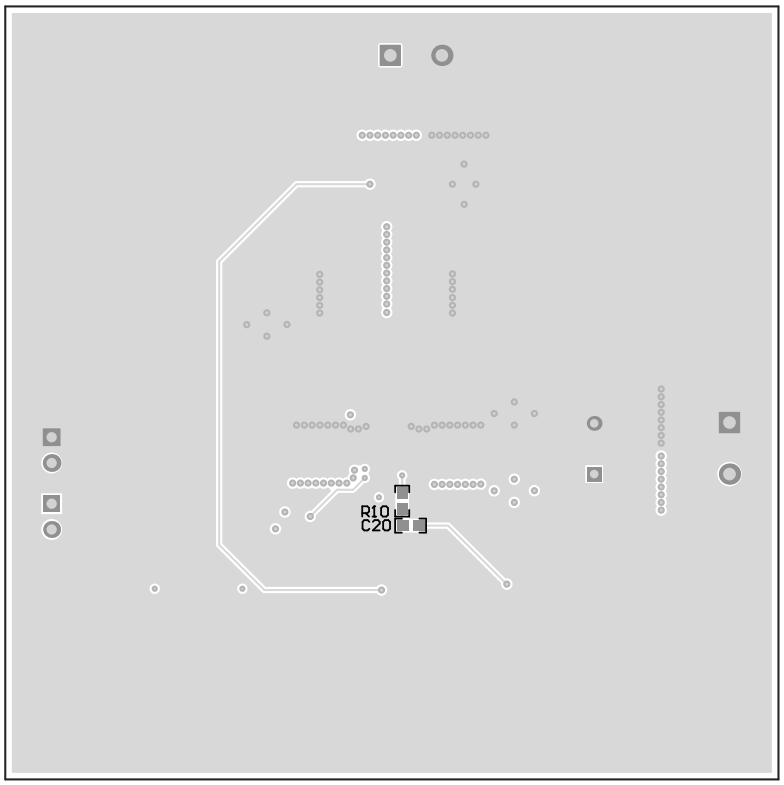

Figure 23. TPS54824EVM-779 Bottom-Side Layout

4 Schematic and Bill of Materials

This section presents the TPS54824EVM-779 schematic and bill of materials.

4.1 Schematic

Figure 24 is the schematic for the TPS54824EVM-779.

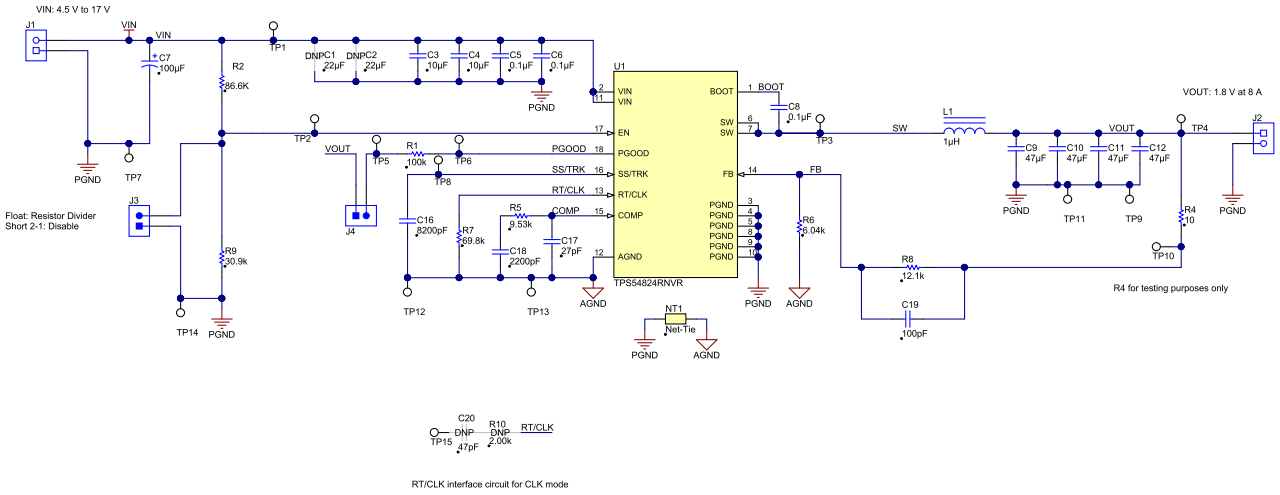

Figure 24. TPS54824EVM-779 Schematic

4.2 Bill of Materials

Table 5 presents the bill of materials for the TPS54824EVM-779.

Table 5. TPS54824EVM-779 Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C3, C4	2	10uF	CAP, CERM, 10 µF, 35 V, +/- 20%, X5R, 1206	1206	C3216X5R1V106M160AB	TDK
C5, C6, C8	3	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603	0603	06033C104KAT2A	AVX
C7	1	100uF	CAP, AL, 100 µF, 50 V, +/- 20%, 0.18 ohm, TH	Cap, 10x12.5mm	UBT1H101MPD1TD	Nichicon
C9, C10, C11, C12	4	47uF	CAP, CERM, 47 µF, 6.3 V, +/- 20%, X5R, 1206	1206	GRM31CR60J476ME19L	Murata
C16	1	8200pF	CAP, CERM, 8200 pF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E822KA01D	Murata
C17	1	27pF	CAP, CERM, 27 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H270JA01D	Murata
C18	1	2200pF	CAP, CERM, 2200 pF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E222KA01D	Murata
C19	1	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	885012006057	Wurth Elektronik
J1, J2	2		Terminal Block, 5.08 mm, 2x1, Brass, TH	2x1 5.08 mm Terminal Block	ED120/2DS	On-Shore Technology
J3, J4	2		Header, 100mil, 2x1, Gold, TH	Header, 100mil, 2x1, TH	HTSW-102-07-G-S	Samtec
L1	1	1uH	Inductor, 1 µH, 14.4 A, 0.0064 ohm, SMD	6.95x2.8x6.6mm	CMLE063T-1R0MS	Cyntec
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
R1	1	100k	RES, 100 k, 5%, 0.1 W, 0603	0603	CRCW0603100KJNEA	Vishay-Dale
R2	1	86.6k	RES, 86.6 k, 1%, 0.1 W, 0603	0603	CRCW060386K6FKEA	Vishay-Dale
R4	1	10	RES, 10, 5%, 0.1 W, 0603	0603	CRCW060310R0JNEA	Vishay-Dale
R5	1	9.53k	RES, 9.53 k, 1%, 0.1 W, 0603	0603	CRCW06039K53FKEA	Vishay-Dale
R6	1	6.04k	RES, 6.04 k, 1%, 0.1 W, 0603	0603	CRCW06036K04FKEA	Vishay-Dale
R7	1	69.8k	RES, 69.8 k, 1%, 0.1 W, 0603	0603	CRCW060369K8FKEA	Vishay-Dale
R8	1	12.1k	RES, 12.1 k, 1%, 0.1 W, 0603	0603	CRCW060312K1FKEA	Vishay-Dale
R9	1	30.9k	RES, 30.9 k, 1%, 0.1 W, 0603	0603	CRCW060330K9FKEA	Vishay-Dale
SH-J1, SH-J2	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15	15		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1		4.5-V to 17-V Input, 8-A Synchronous Step-Down Voltage Regulator, RNV0018B (VQFN-HR-18)	RNV0018B	TPS54824RNVR	Texas Instruments
C1, C2	0	22uF	CAP, CERM, 22 µF, 35 V, +/- 20%, X5R, 1206	1206	C3216X5R1V226M160AC	TDK
C20	0	47pF	CAP, CERM, 47 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	06035A470JAT2A	AVX
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
R10	0	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	0603	CRCW06032K00FKEA	Vishay-Dale

Revision History

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

Changes from Original (November 2016) to A Revision	Page
• Added Section: Evaluating the TPS54824EVM-779 at -40 °C	3
• Added Text: When modifications are made...	3
• Added Section: Example Component Values For Common Output Voltages	4

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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 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 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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:*

      FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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 MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS 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 EPIDEMIC FAILURE WARRANTY OR 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.

   6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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. 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:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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

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

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