

Using the TPS54JA20EVM-023 12-A, Buck Converter Evaluation Module

This user's guide contains information for the TPS54JA20EVM-023 evaluation module (EVM) as well as for the TPS54JA20 DC/DC converter. Also included are the performance specifications, the schematic, and the list of materials for the TPS54JA20EVM.

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1 Introduction

The TPS54JA20 is a D-CAP3™ synchronous buck converter designed for 12 A output current, and the evaluation module is designed to demonstrate the small printed-circuit-board areas that may be achieved when designing with the device. The high-side and low-side switching MOSFETs are integrated in the device package along with their gate drive circuitry. Rated input voltage and output current ranges for the evaluation module are given in [Table 1](#).

1.1 Background

The EVM is setup to allow the user to evaluate the performance of the TPS54JA20 IC, and easily make changes to multiple settings. The low drain-to-source on resistance of the MOSFETs allows the device to achieve high efficiencies and keep the junction temperature low at high output currents. There is no need for external compensation components since this device is designed with D-CAP3™ control topology. On the EVM the switching frequency and the operation mode are externally selectable using a jumper to set the resistor from the MODE pin to AGND. An external resistor divider allows for an adjustable output voltage. Additionally, the device provides adjustable soft start, adjustable OC limit threshold, external reference input, and an open-drain power good indicator. Lastly the TPS54JA20 device has a fixed internal VIN under voltage lockout and externally adjustable UVLO using a resistor divider at the EN pin.

Table 1. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE RANGE	OUTPUT CURRENT RANGE
TPS54JA20	$V_{IN} = 4\text{ V to }16\text{ V}$	0 A to 12 A

CAUTION:



Hot surface. Contact may cause burns. Do not touch.

Figure 1. Safety Warnings

1.2 Performance Specification Summary

A summary of the TPS54JA20EVM performance specifications is provided in [Table 2](#). Specifications are given for an input voltage of $V_{IN} = 12\text{ V}$ and an output voltage of 2.5 V , unless otherwise specified. The TPS54JA20EVM is designed and tested for $V_{IN} = 4\text{ V}$ to 16 V . The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 2. TPS54JA20EVM Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	Unit	
V_{IN} voltage range (without internal Bias)		4	12	16	V	
V_{IN} voltage range (with external Bias)		2.7	12	16	V	
Output voltage setpoint			2.5		V	
Output current range	$V_{IN} = 4\text{ V}$ to 16 V	0	12	12	A	
Internal LDO Voltage			3.0		V	
Line regulation	$V_{IN} = 4\text{ V}$ to 16 V , $I_O = 12\text{ A}$		+/- 0.07%			
Load regulation	$V_{IN} = 12\text{ V}$, $I_O = 0\text{ A}$ to 12 A		+/- 0.12%			
Load transient response	$I_O = 3\text{ A}$ to 9 A , $2\text{ A}/\mu\text{s}$	Voltage change	-50		mV	
		Recovery time	12		μs	
	$I_O = 9\text{ A}$ to 3 A , $2\text{ A}/\mu\text{s}$	Voltage change		50		mV
		Recovery time		12		μs
Loop bandwidth	$V_{IN} = 12\text{ V}$, $I_O = 12\text{ A}$		75		kHz	
Phase margin	$V_{IN} = 12\text{ V}$, $I_O = 12\text{ A}$		58		degree	
Output ripple voltage	$I_O = 12\text{ A}$		12	15	mVPP	
Operating frequency		600	800	1000	kHz	

1.3 Modifications

These evaluation modules are designed to provide access to the features of the TPS54JA20. Some modifications can be made to this module.

1.3.1 Output Voltage Setpoint

To change the output voltage of the EVM, it is necessary to change the value of resistor R6 and R7. R9 is fixed at $10\text{ k}\Omega$. Changing the total value of R6 plus R7 can change the output voltage above the 0.9 V reference voltage V_{INTREF} . A two resistor configuration of R6+R7 is implemented to give the exact desired output voltage setting. The value of R6 and R7 for a specific output voltage can be calculated using [Equation 1](#).

$$R_{FB_HS} = \frac{V_O - V_{INTREF}}{V_{INTREF}} \times R_{FB_LS} \quad (1)$$

$$V_{INTREF} = 0.9\text{ V}$$

$$R_{FB_HS} = R_6 + R_7$$

$$R_{FB_LS} = R_9 = 10\text{ k}\Omega$$

1.3.2 Frequency and Operation Mode Setting

To change the frequency and operation mode of the part, the MODE pin is used. J6 and the surrounding circuitry allows for an easy change to the frequency and operation mode setting. All 6 options offered by J6 are shown in [Table 3](#)

Table 3. TPS54JA20EVM Mode Pin Selection

Switching Frequency (F_{sw})	Operation Mode Under Light Load	Mode Pin Connections	
		Connection	Jumper Setting
600 kHz	Skip Mode	Short to VCC	Short Pins 1 and 2
800 kHz	Skip Mode	243k Ω +/- 10% to AGND	Short Pins 3 and 4
1000 kHz	Skip Mode	121k Ω +/- 10% to AGND	Short Pins 5 and 6
1000 kHz	Forced CCM	60.4k Ω +/- 10% to AGND	Short Pins 7 and 8
800 kHz	Forced CCM	30.1k Ω +/- 10% to AGND	Short Pins 9 and 10
600 kHz	Forced CCM	Short to AGND	Short Pins 11 and 12

1.3.3 Enable Pin Selection

The converter can be enabled and disabled by J5.
Default setting: EN pin connected to VIN.

Table 4. Enable Pin Selection

Set On Connection	Enable Selection
Pins 2-3 Shorted	EN pin connected to VIN pins through resistor divider
J3 Open	EN pin is left floating
Pins 1-2 Shorted	EN pin connected to PGND

1.3.4 Remote Sensing

The EVM is not set-up for remote sensing by default. To set up remote sensing follow these steps:

1. Replace R8 and R11 with 100 Ω resistors
2. Connect your sense points to the Vsns+ and Vsns- test points

1.3.5 Adjustable UVLO

The undervoltage lockout (UVLO) can be adjusted externally using R2 and R9. See the TPS54JA20 Data Sheet to get detailed instructions for setting the external UVLO.

2 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS54JA20EVM. This section also includes test results typical for the evaluation module and covers efficiency, output voltage regulation, load transient, loop response, output ripple, and start-up.

2.1 Input/Output Connections

The TPS54JA20EVM is provided with input/output connectors and test points as shown in [Table 5](#). A power supply capable of supplying greater than 15 A must be connected to J1 and J2 through a pair of 20-AWG wires or better. The load must be connected to J3 and J4 through a pair of 20-AWG wires or better on each connector. The maximum load current capability is 12 A.

Wire lengths must be minimized to reduce losses in the wires. Test point VIN_SENSE+ provides a place to monitor the input voltage with Test point VIN_SENSE- providing a convenient ground reference. Test point VOUT+ is used to monitor the output voltage with VOUT- as the ground reference.

Table 5. TPS54JA20EVM EVM Connectors and Test Points

REFERENCE DESIGNATOR	FUNCTION
J1	VIN input voltage connector (see Table 1 for V_{IN} range)
J2	PGND connection for input
J3	VOUT, 2.5V at 12A maximum
J4	PGND connection for output
J5	3-pin header for enable. ON -> Connects EN to VIN to enable the device. OFF- > Connects EN to GND to disable device. Floating EN will prevent the part from operating.
J6	12 Pin header for Mode selection (see Table 3)
VIN_SENSE+, VIN_SENSE-	VIN voltage sensing test points
VOUT+, VOUT-	VOUT voltage sensing test points
VCC, PGND	VCC voltage forcing/sensing test points
PGOOD	PGOOD output test point (pulled up to VCC pin through a 30k Ω resistor)
EN	EN test point
VSNS+, VSNS-	Remote sensing test points
AGND	AGND test point
BODE+, BODE-	Loop measurement test points (BODE+ is at the same net as VOUT, but is closer to FB divider and IC)
SS/REFIN	Can be used to monitor the reference voltage
SW	Switch Node test point

2.2 Start Up Procedure

1. Make sure the EN jumper (J5) is in the ON position (shorting pin 2 and pin 3) to connect the EN pin to the resistor divider from VIN.
2. (Optional) Apply appropriate external bias voltage on VCC and PGND test points. If no external bias, please go directly to step 3. The external bias range is 3.3V to 5.3V.
3. Apply appropriate VIN voltage to the VIN and PGND terminals at J1 and J2.

2.3 Efficiency

The efficiency of this EVM peaks at a load current of about 6 A and then decreases as the load current increases toward full load. The following images show the efficiency for the TPS54JA20EVM at an ambient temperature of 25°C. Figure 2 shows the efficiency over a range of V_{in} values, Figure 3 shows efficiency over a range of V_{CC} values, and Figure 4 shows how the light load efficiency is improved in DCM. Figure 2 and Figure 4 compare the efficiency of FCCM and Skip modes.

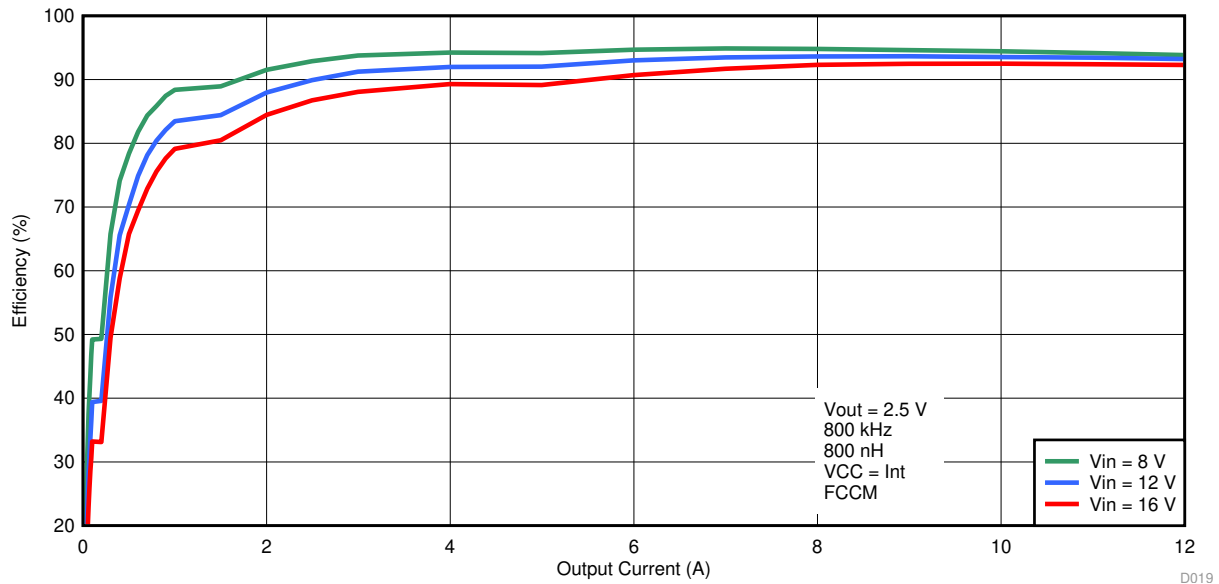


Figure 2. TPS54JA20 Efficiency Plot: V_{in} Range

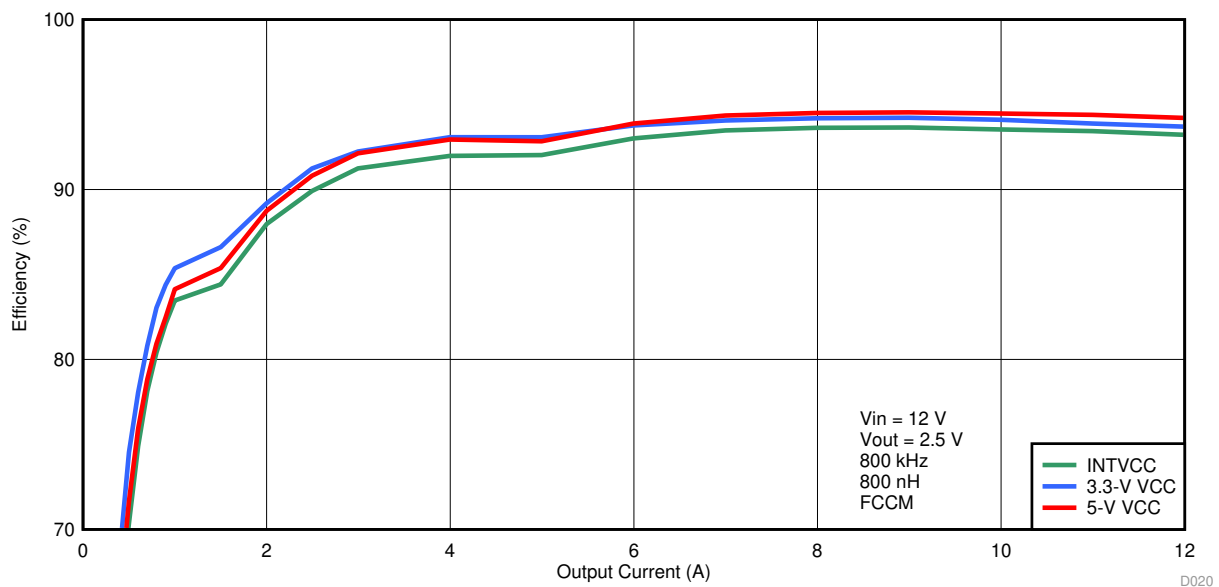


Figure 3. TPS54JA20 Efficiency Plot: V_{CC} Range

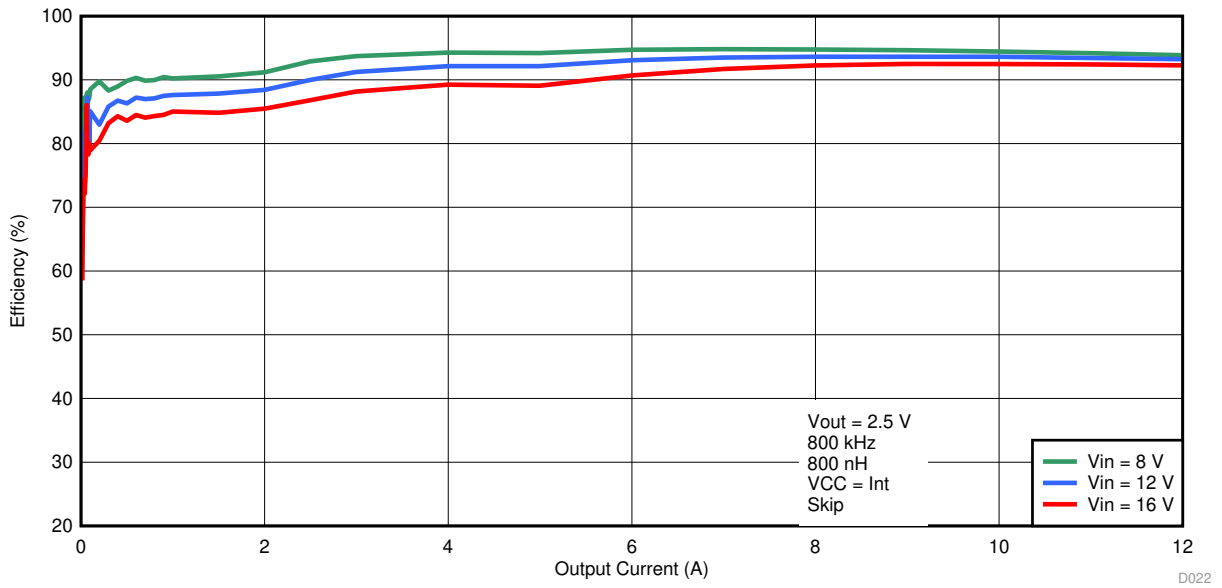


Figure 4. TPS54JA20 Efficiency Plot: Skip Mode

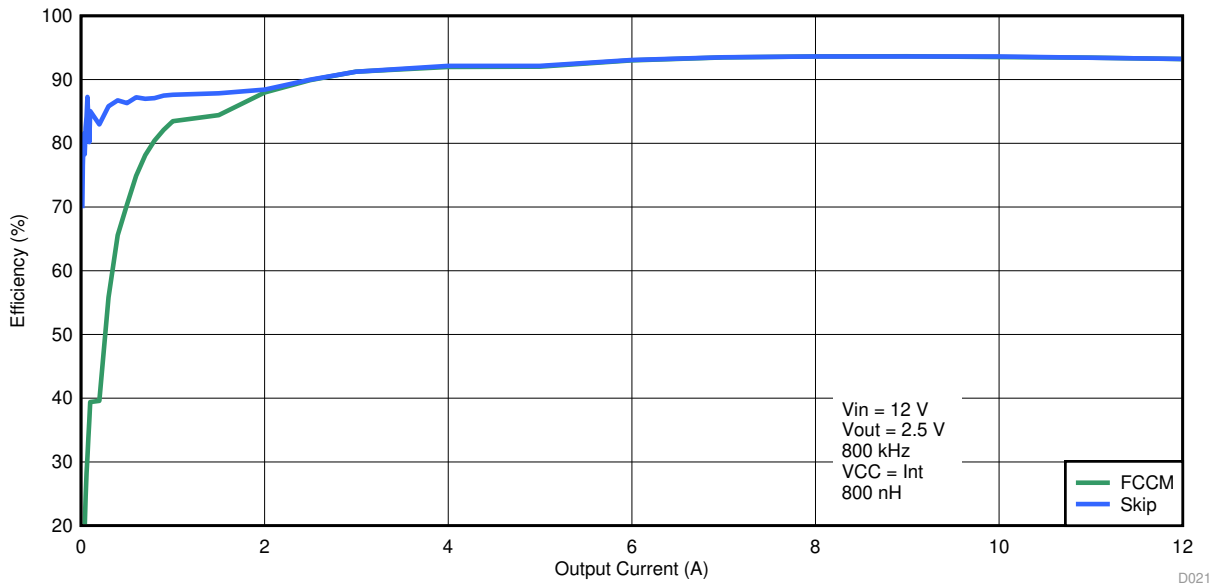


Figure 5. TPS54JA20 Efficiency Plot: FCCM and Skip Mode

2.4 Load Regulation

Figure 6 and Figure 7 show the load regulation for the TPS54JA20EVM.

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

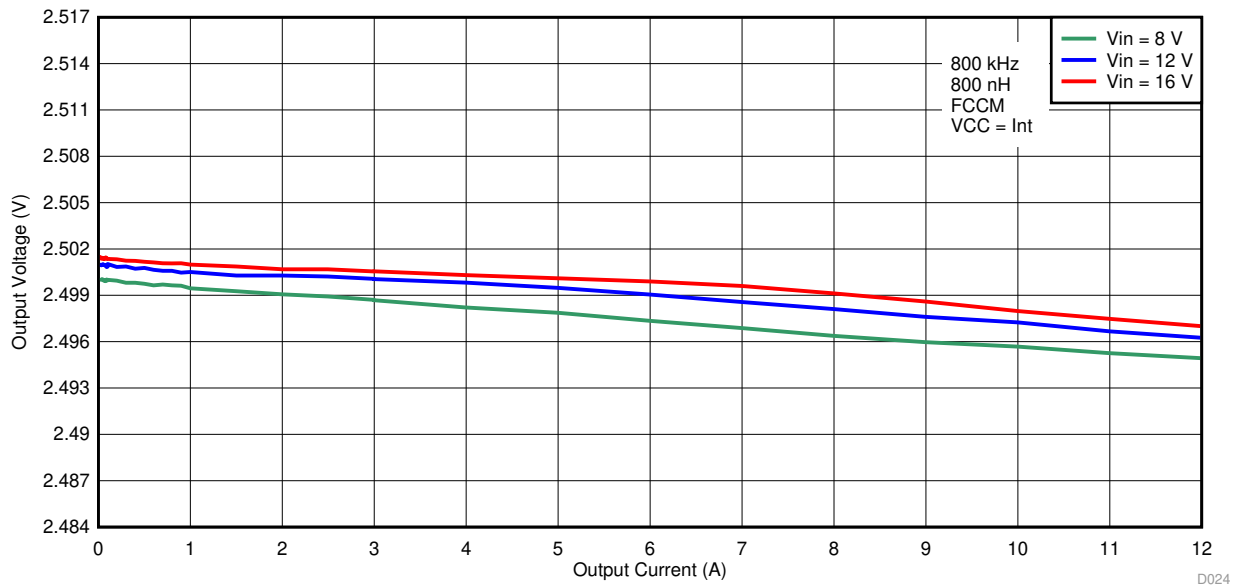


Figure 6. TPS54JA20 Load Regulation

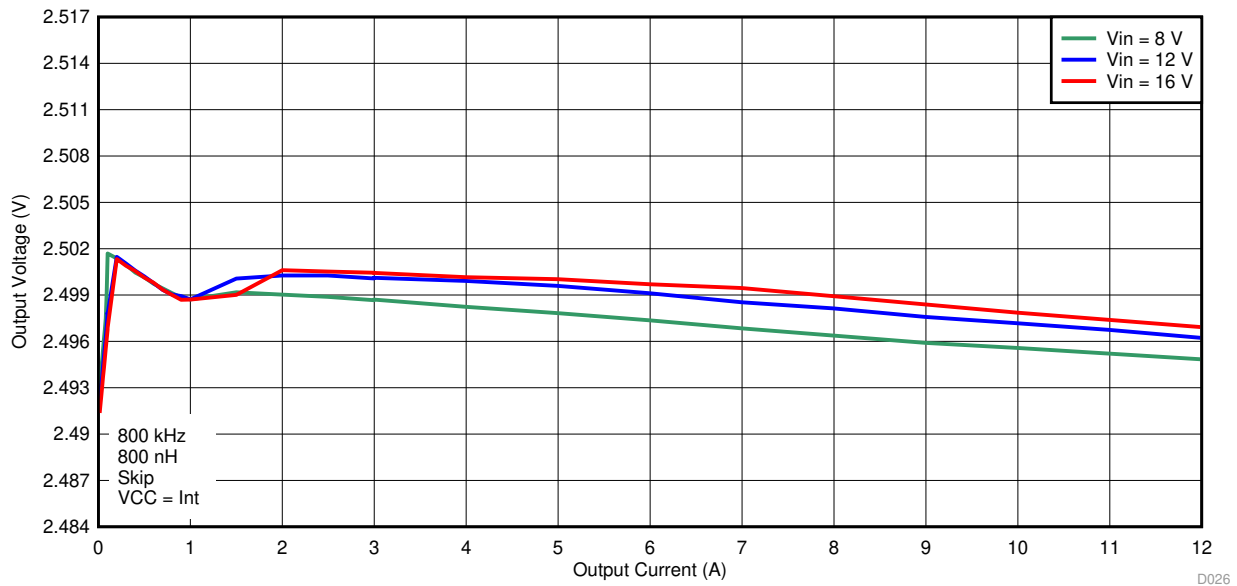


Figure 7. TPS54JA20 Load Regulation

2.5 Load Transients

Figure 8 and Figure 9 show how the TPS54JA20EVM response to load transients. The current step is from 25% to 75% Load. The current step slew rate is $2 \text{ A}/\mu\text{s}$. Total peak-to-peak voltage variation is as shown, including ripple and noise on the output.

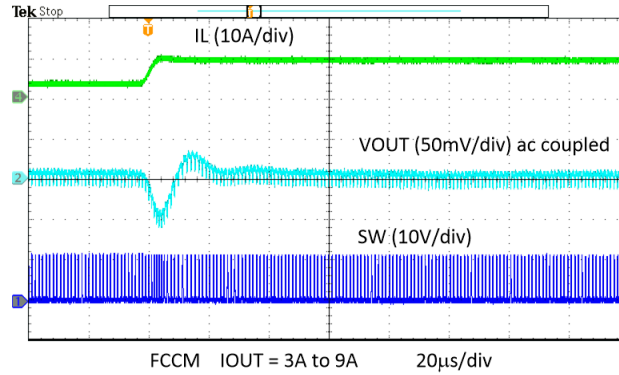


Figure 8. TPS54JA20 Load Transient Response

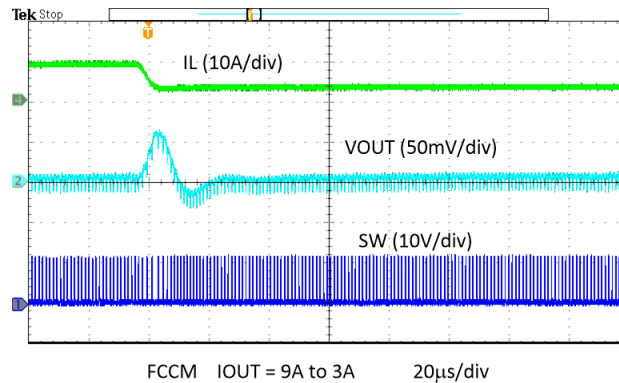


Figure 9. TPS54JA20 Load Transient Response

2.6 Loop Characteristics

Figure 10 shows the TPS54JA20EVM loop-response characteristics. Gain and phase plots are shown for V_{IN} voltage of 12 V. Load current for the measurement is 100%.

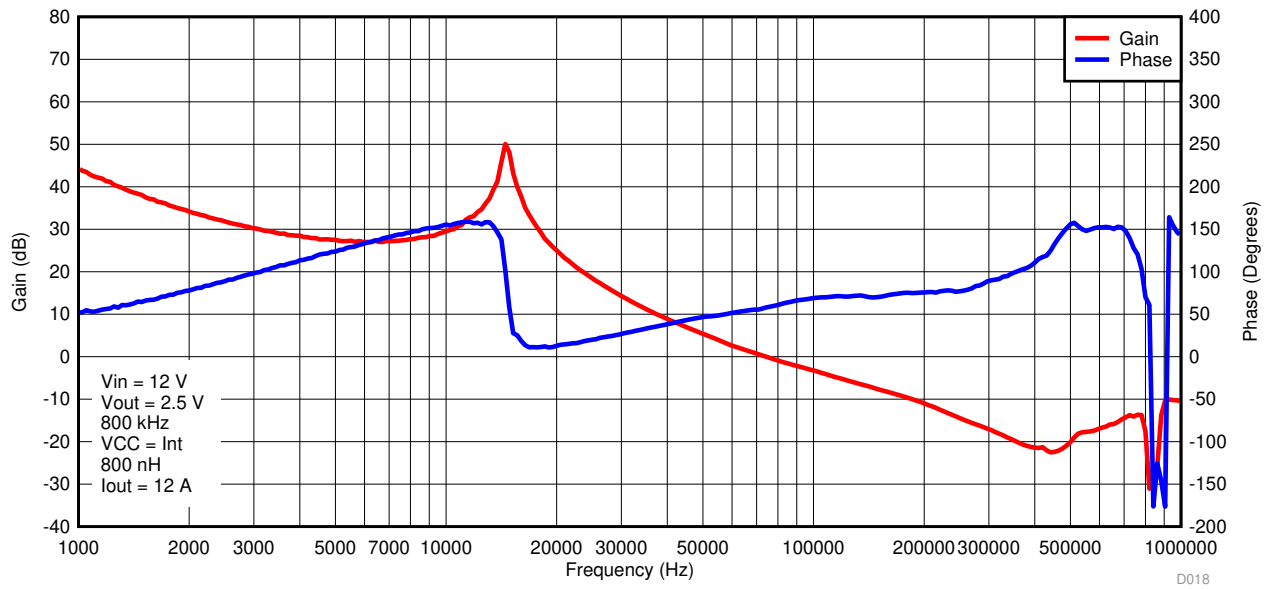


Figure 10. TPS54JA20 Bode Plot

2.7 Output Voltage Ripple

Figure 11, Figure 12, and Figure 13 show the TPS54JA20EVM output voltage ripple. $V_{IN} = 12\text{ V}$. The ripple voltage is measured directly across the last ceramic output capacitor.

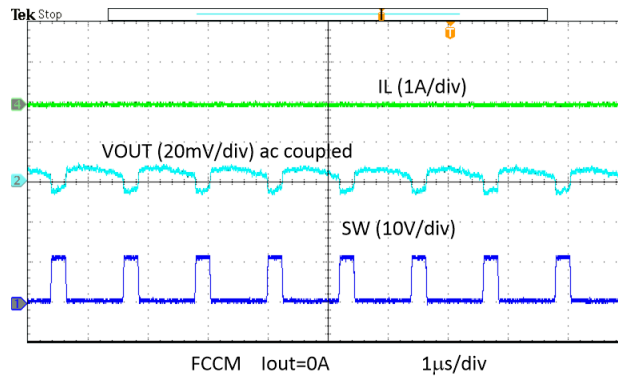


Figure 11. TPS54JA20 Output Ripple, No Load

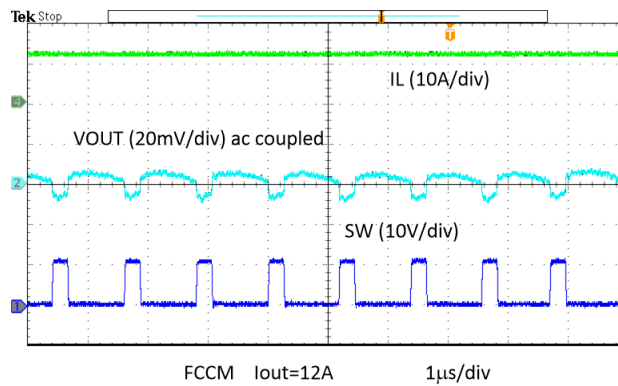


Figure 12. TPS54JA20 Output Ripple, 12-A Load

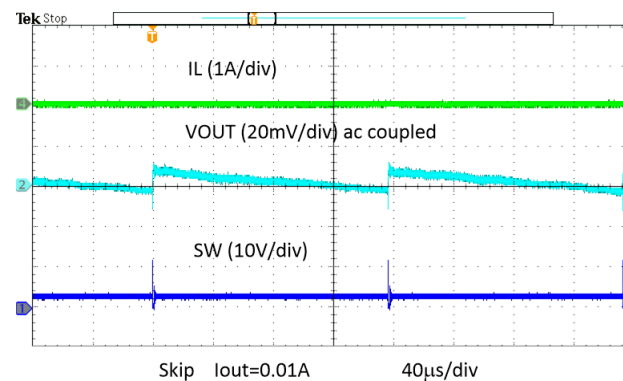


Figure 13. TPS54JA20 Output Ripple, Skip Mode, 10mA Load

2.8 Powering Up

Figure 14 shows the start-up waveforms for the TPS54JA20EVM. In Figure 14, the start-up sequence begins as soon as the EN voltage is increased above the enable-threshold voltage, and the output voltage ramps up to the externally set value of 2.5 V. The input voltage for these plots is 12 V.

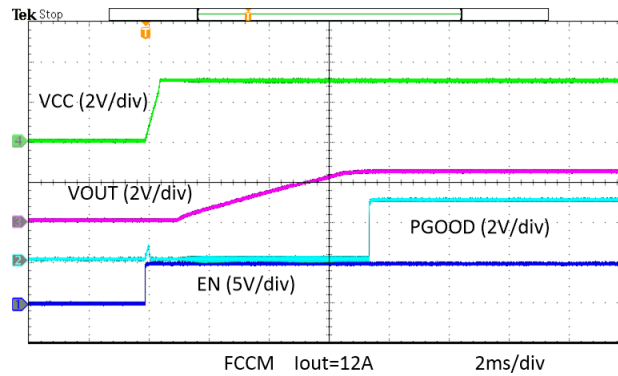


Figure 14. TPS54JA20 Enable Start-Up, 12A Load

2.8.1 Powering Down

Figure 15 shows the TPS54JA20EVM shutdown. The input voltage for these plots is 12 V.

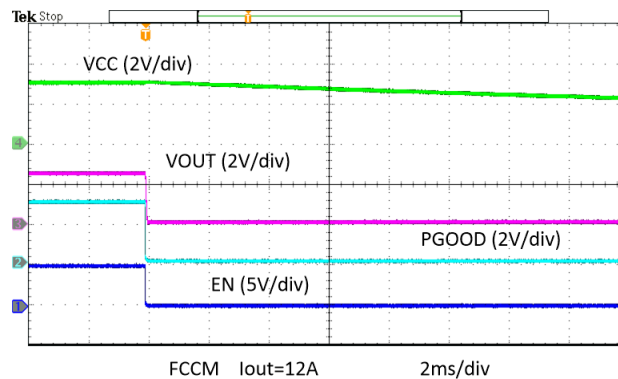


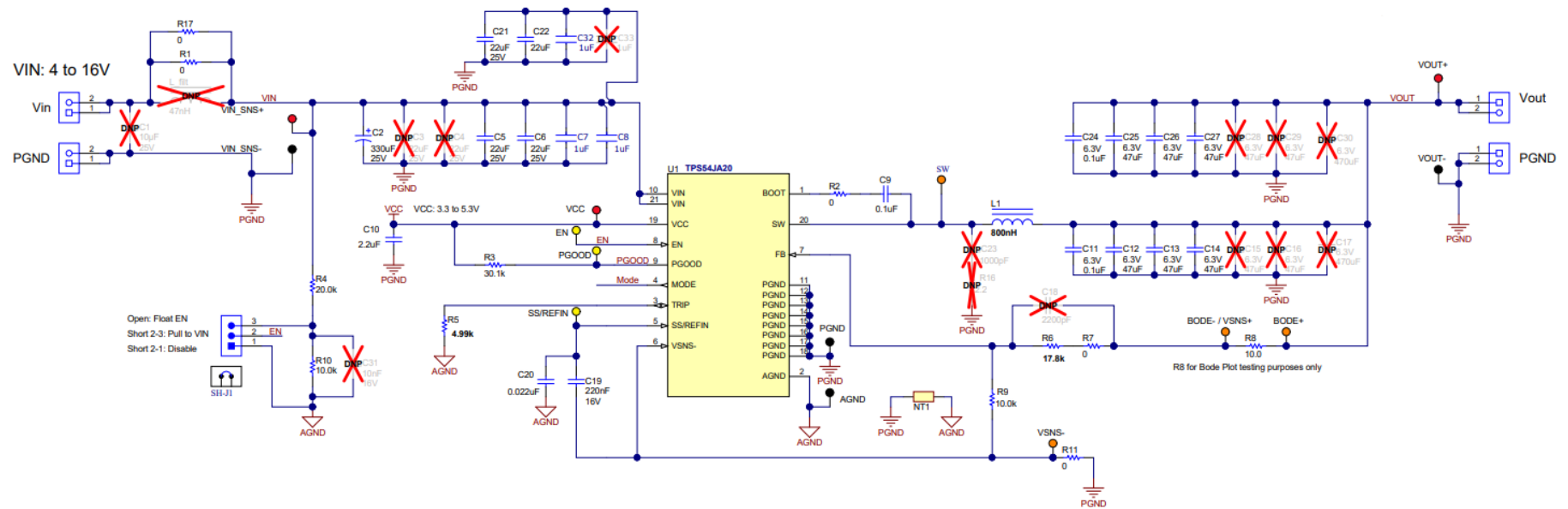
Figure 15. TPS54JA20 EN Shutdown, 12A Load

3 Schematic, List of Materials, and Layout

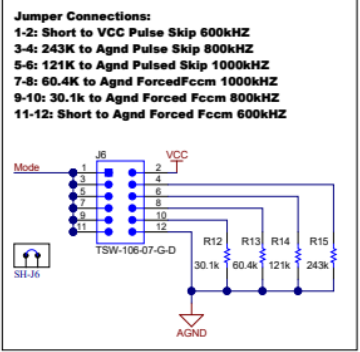
This section provides a schematic, a description of the TPS54JA20EVM board layout, and layer illustrations.

3.1 Schematic

The following image illustrates the schematic for the TPS54JA20EVM.



MODE SELECTIONS (SWITCHING FREQUENCY)



3.2 List of Materials

Table 6 presents the List of materials for the TPS54JA20EVM.

Table 6. TPS54JA20EVM List of Materials

DES	QTY	DESCRIPTION	PART NUMBER	MANUFACTURER
C2	1	CAP, AL, 330 uF, 25 V, +/- 20%, 0.15 ohm, SMD, 330uF	EEE-FC1E331P	Panasonic
C5, C6, C21, C22	4	CAP, CERM, 22 uF, 25 V, +/- 20%, X6S, 1206_190	GRM31CC81E226ME 11L	MuRata
C7, C8, C32	3	CAP CER 1UF 25V X6S 0402	GRM155C81E105KE 11D	Murata
C9	1	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R1H104K 080AA	TDK
C10	1	CAP, CERM, 2.2 uF, 10 V, +/- 10%, X7R, 0603	GRM188R71A225KE 15D	MuRata
C11, C24	2	CAP, CERM, 0.1 uF, 6.3 V, +/- 10%, X7R, 0402	GRM155R70J104KA0 1D	MuRata
C12, C13, C14, C25, C26, C27	6	CAP, CERM, 47 uF, 6.3 V, +/- 10%, X6S, 1206	GRM31CC80J476KE 18L	MuRata
C19	1	CAP, CERM, 0.22 uF, 16 V, +/- 10%, X7R, 0603	C1608X7R1C224K08 0AC	TDK
C20	1	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0603	C0603C223K4RACTU	Kemet
L1	1	Inductor, Shielded, Composite, 800 nH, 25.8 A, 0.00208 ohm, SMD	XAL7070-801MEB	Coilcraft
R1, R17	2	RES, 0, 1%, 0.5 W, 1206	5108	Keystone
R2, R7, R11	3	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R3, R12	2	RES, 30.1 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060330K1FKE A	Vishay-Dale
R4	1	RES, 20.0 k, 0.1%, 0.1 W, 0603	RT0603BRD0720KL	Yageo America
R5	1	RES, 4.99 k, 1%, 0.1 W, 0603	RC0603FR-074K99L	Yageo
R6	1	RES, 17.8 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060317K8FKE A	Vishay-Dale
R8	1	RES, 10.0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310R0FKE A	Vishay-Dale
R9, R10	2	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKE A	Vishay-Dale
R13	1	RES, 60.4 k, 1%, 0.1 W, 0603	RC0603FR-0760K4L	Yageo
R14	1	RES, 121 k, 1%, 0.1 W, 0603	RC0603FR-07121KL	Yageo
R15	1	RES, 243 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603243KFKE A	Vishay-Dale
U1	1	4-V to 16-V Input, 12-A Single Synchronous Step-Down Converter, RWW0021A (VQFN-HR-21)	TPS54JA20RWWT	Texas Instruments

3.3 Layout

The board layout for the TPS54JA20EVM is shown in [Figure 16](#) through [Figure 19](#). 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 V_{IN} , V_{OUT} , and SW. Also on the top layer are connections for the remaining pins of the TPS54JA20 and the majority of the signal traces. The top layer has a 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. The internal layer-2 contains an additional large ground copper area as well as an additional V_{OUT} copper fill. The bottom layer is another ground plane with two additional traces for the output voltage feedback and various signals routed to test points and headers. There are also additional V_{IN} and V_{OUT} planes on the bottom layer. The top-side ground traces are connected to the bottom and internal ground planes with multiple via groupings 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 that are noise sensitive are terminated to the quiet analog ground island on the top layer.

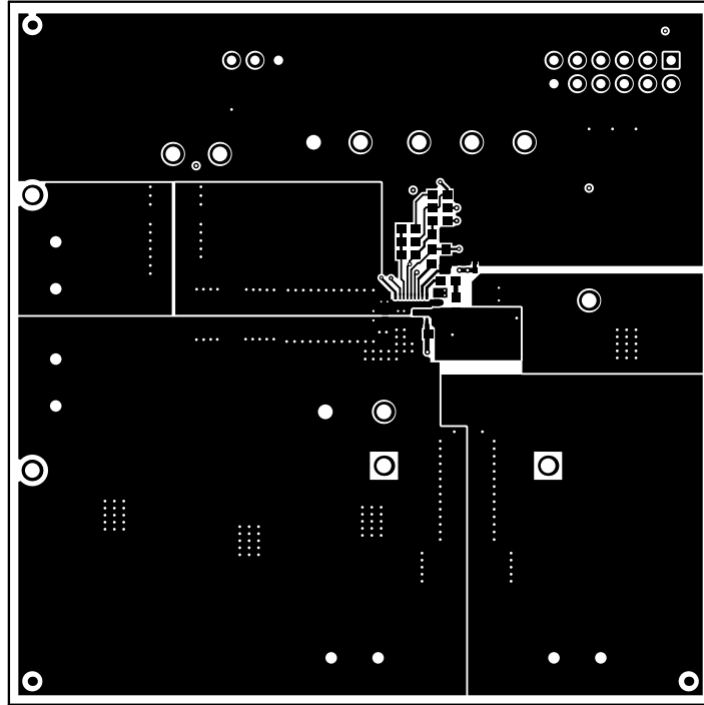


Figure 16. TPS54JA20EVM Top-Side Layout

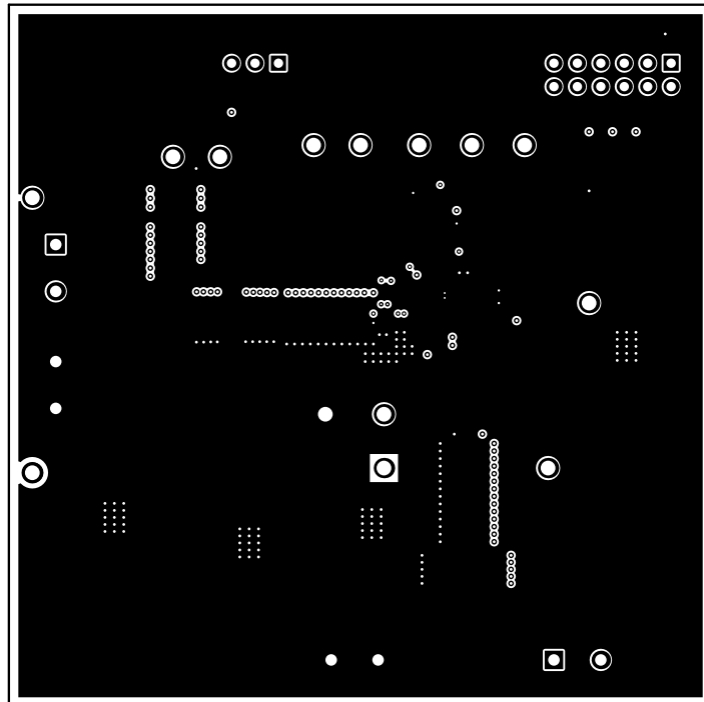


Figure 17. TPS54JA20EVM Internal Layer-1 Layout

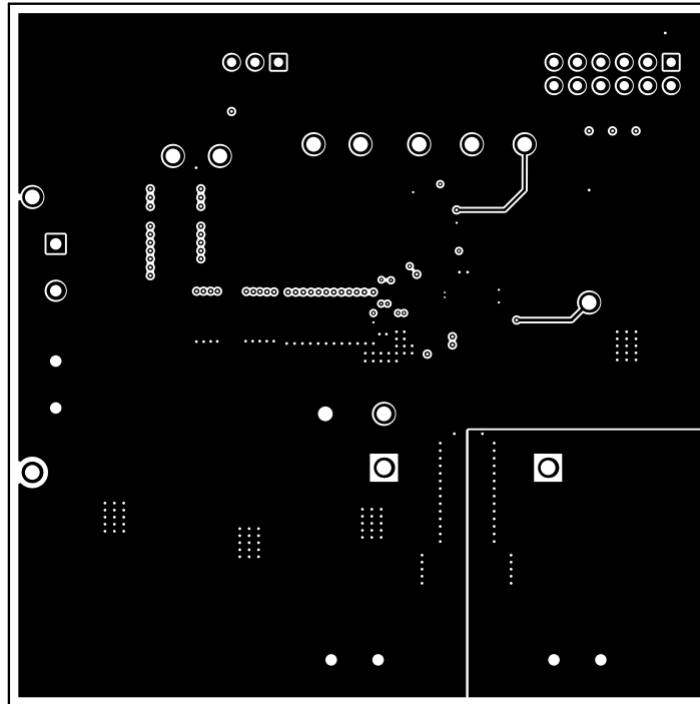


Figure 18. TPS54JA20EVM Internal Layer-2 Layout

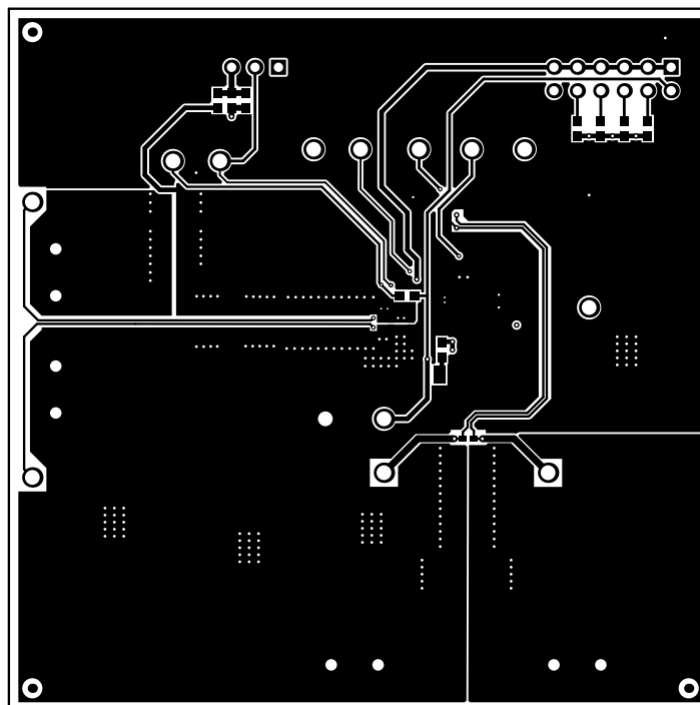


Figure 19. TPS54JA20EVM Bottom-Side Layout

Revision History

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

Changes from Original (March 2020) to A Revision	Page
• Changed marketing status from <i>select disclosure</i> to <i>catalog</i>	1

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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.
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Evaluation Kits 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 shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

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EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

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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/lstds/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/lstds/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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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.

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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 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, INDEMNITY 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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