Using the TPS40400EVM-351

User's Guide

TEXAS INSTRUMENTS

Literature Number: SLUU535
September 2011

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8-V to 14-V PMBus Synchronous Buck Converter

1 Introduction

The TPS40400EVM-351 evaluation module (EVM) uses the TPS40400. The TPS40400 is a synchronous buck controller that operates from a nominal 3.0-V to 20-V supply. This controller is an analog PWM controller that allows programming and monitoring via the PMBus interface.

2 Description

The TPS40400EVM-351 is designed to use a regulated 12-V bus to produce a regulated 1.2-V output at up to 20 A of load current. The TPS40400EVM-351 is designed to demonstrate the TPS40400 in a typical low-voltage application while providing a number of test points to evaluate the performance of the TPS40400.

2.1 Typical Applications

- Smart Power Systems
- Power Supply Modules
- Communications Equipment
- Computing Equipment

2.2 Features

The TPS40400EVM-351 features:

- Regulated 1.2-V output, marginable and trimmable via the PMBus interface
- 20-A DC steady state output current
- Programmable soft start via the PMBus interface
- Programmable enable function via the PMBus interface
- Programmable over-current warning and fault limit along with the condition response via the PMBus interface
- Programmable over-voltage warning and fault limit along with the condition response via the PMBus interface
- Programmable high and low output margin voltages with a maximum range of +/-25% of nominal output voltage
- Convenient test points for probing critical waveforms

3 Electrical Performance Specifications

Table 1. TPS40400EVM-351 Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range	VIN	8	12	14	V
Maximum input current	V_{IN} = 8 V, I_O = 20 A		3.5		A
No load input current	V_{IN} = 14 V, I_O = 0 A with auto skip mode		50		mA
Output Characteristics					
Output voltage, VOUT			1.2		V
Output voltage regulation	Line regulation(V_{IN} = 8 V - 14 V)		0.5%		
	Load regulation(V_{IN} = 12 V, Io = 0 A - 20 A)		0.5%		
Output voltage ripple	V_{IN} = 12 V, I_O = 20 A		30		mVpp
Output load current		0		20	A
Output over current			25		A
Systems Characteristics					
Switching frequency			608		kHz
Peak efficiency	V_{IN} = 12 V, 1.2 V / 12 A, F_{SW} = 300 kHz		89.6%		
Full-load efficiency	V_{IN} = 12 V, 1.2 V / 20 A		88.2%		
Operating temperature			25		ºC

4 Schematic

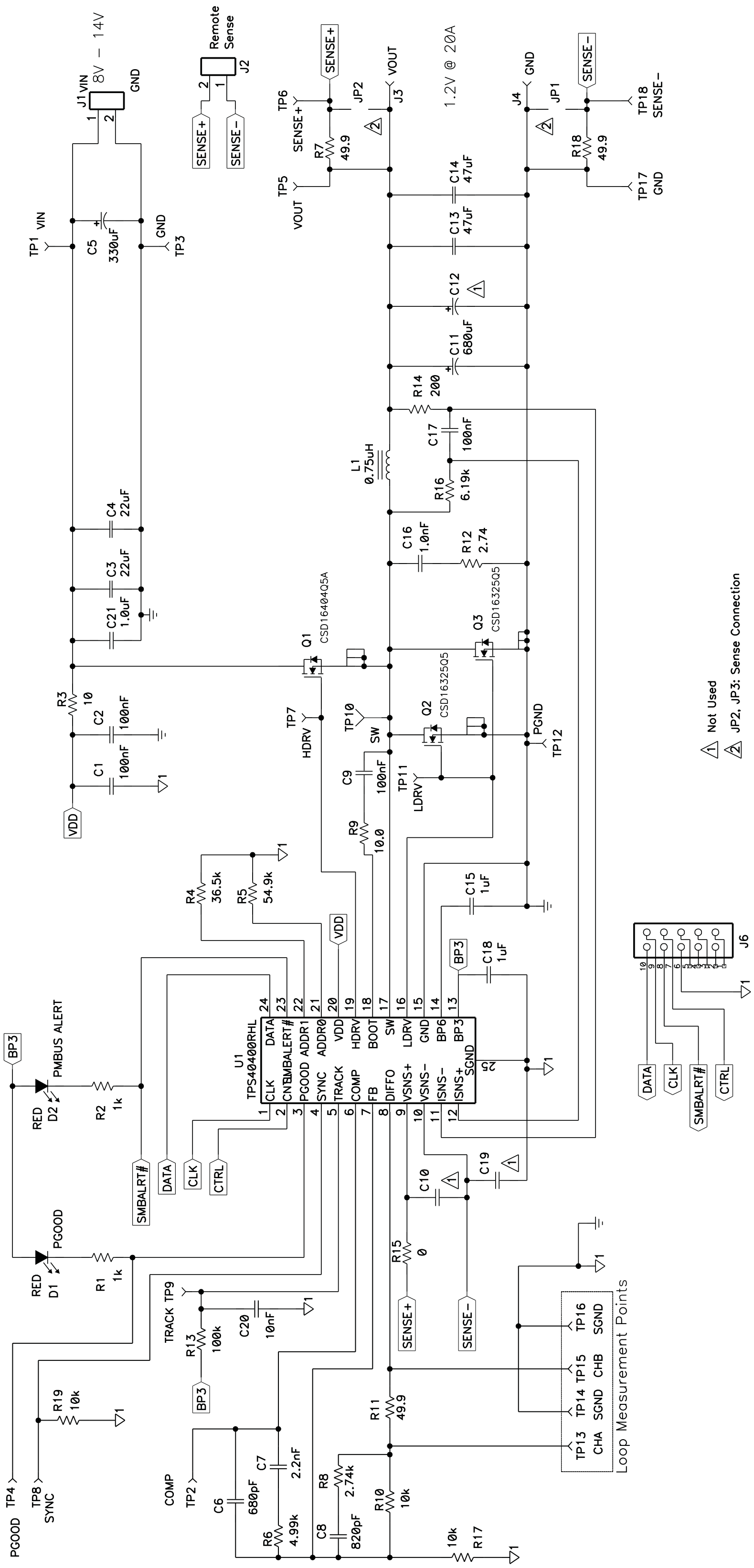

Figure 1. TPS40400EVM-351 Circuit Schematic

5 Test Setup

5.1 Test and Configuration Software

In order to change any of the default configuration parameters on the EVM, it is necessary to obtain the TI Fusion Digital Power Designer software.

5.1.1 Description

Fusion Digital Power Designer is the Graphical User Interface (GUI) used to configure and monitor the Texas Instrument's TPS40400 power controller on this Evaluation Module (EVM). The application uses the PMBus protocol to communicate with the controller over serial bus by way of a TI USB adapter (see Figure 4).

5.1.2 Features

Some of the tasks you can perform with the GUI include:

- Turn on or off the power supply output, either through the hardware control line or the PMBus operation command.
- Monitor real-time data. Items such as input voltage, output voltage, output current, and warnings/faults are continuously monitored and displayed by the GUI.
- Configure common operating characteristics such as V_{OUT}, warning and fault thresholds, and switching frequency.

This software is available for download at this location:
http://focus.ti.com/docs/toolsw/folders/print/fusion_digital_power_designer.html

5.2 Test Equipment

5.2.1 Voltage Source

The input voltage source V_{IN} should be a 0-V to 14-V variable DC source capable of supplying 10 A_{DC}. Connect V_{IN} to J1 as shown in Figure 3.

5.2.2 Multimeters

- DMM 1: V_{IN} at TP1 (V_{IN}) and TP3 (GND).
- DMM 2: Input current measured across Shunt 1.
- DMM 3: V_{OUT} at TP5 (V_{OUT}) and TP17 (GND).
- DMM 4: Output current measured across Shunt 2.

5.2.3 Output Load

The output load should be an electronic constant-resistance mode load capable of 0 A_{DC} to 25 A_{DC} at 1.2 V. An electronic constant-current load is also acceptable.

5.2.4 Oscilloscope

A digital or analog oscilloscope can be used to measure the output ripple. To measure output ripple, the oscilloscope should be set for 1-MΩ impedance, 20-MHz bandwidth, AC coupling, 2-µs/division horizontal resolution, 50-mV/division vertical resolution. As shown below in Figure 2, test points TP5 and TP17 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP5 and holding the ground barrel to TP17. It is not recommended to use a leaded ground connection because this may induce additional noise due to the large ground loop.

To measure other waveforms, adjust the oscilloscope as needed.

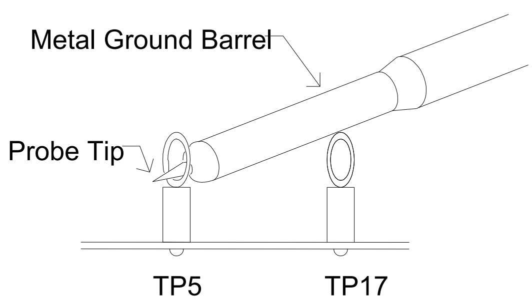

Figure 2. Tip and Barrel Measurement for V_{OUT} Ripple

5.2.5 Fan

Some of the components in this EVM may exceed temperatures of 60ºC during operation. A small fan capable of 200 LFM to 400 LFM is recommended to reduce component temperatures while the EVM is operating at heavy loads. Exercise caution when touching the EVM while the fan is not running, and always exercise caution when touching any circuits that may be live or energized.

5.2.6 Recommended Wire Gauge

Input Wires, VIN to J1 (12-V input): The minimum recommended wire size is 1x AWG #14 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return). Maximum input current should be in the order of 3.5 A.

Output Wires, J3 and J4 to Load: The minimum recommended wire size is 2x AWG #14, with the total length of wire less than 4 feet (2 feet output, 2 feet return). Maximum output current should be in the order of 20 A.

5.3 Recommended Test Setup

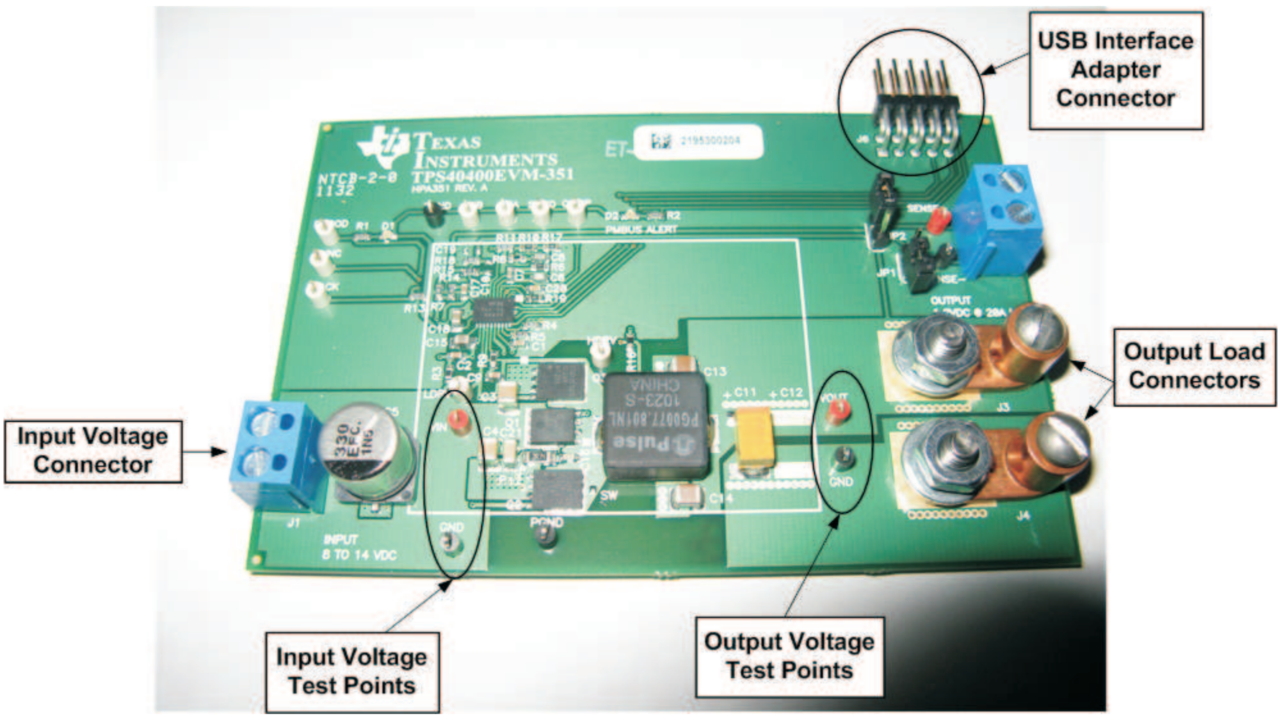

Figure 3. TPS40400EVM-351 Recommended Test Set Up

Figure 3 is the recommended test set up to evaluate the TPS40400EVM-351. It is recommended to work at an ESD-safe workstation while testing the EVM.

5.4 USB Interface Adapter and Cable

Proper connection and polarity for USB interface adapter and cable.

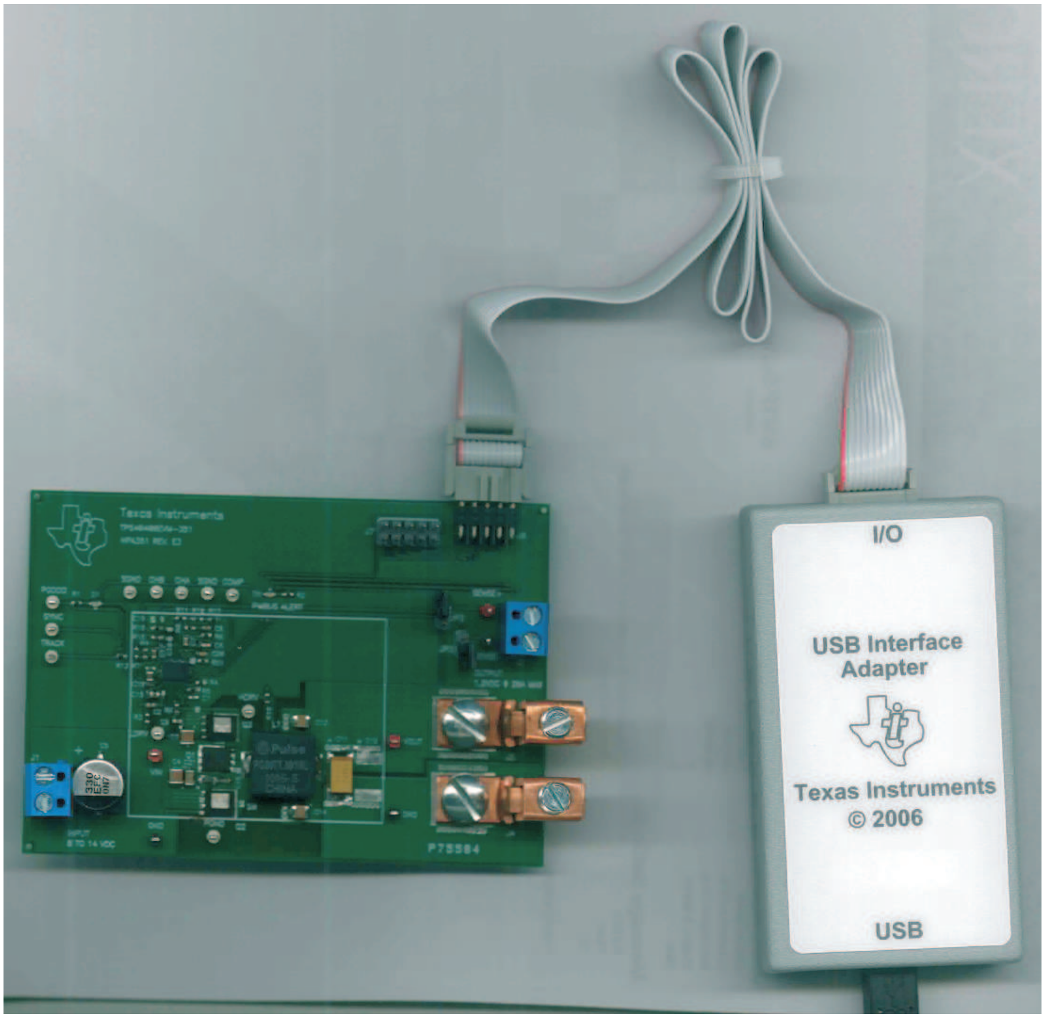

Figure 4. TPS40400EVM-351 USB-To-GPIO Interface Adapter

5.4.1 Input Connections

1. Prior to connecting the DC input source V_{IN}, it is advisable to limit the source current from V_{IN} to 10 A maximum. Make sure V_{IN} is initially set to 0 V and connected as shown in Figure 3.
2. Connect a voltmeter DMM 1 at TP1 (V_{IN}) and TP3 (GND) to measure the input voltage.
3. Connect a voltmeter DMM 2 across shunt to measure the input current.

5.4.2 Output Connections

1. Connect Load between J3 and J4; and set Load to constant-resistance mode to sink 0 A_{DC} before V_{IN} is applied.
2. Connect a voltmeter DMM 3 at TP5 (V_{OUT}) and TP17 (GND) to measure the output voltage.
3. Connect a voltmeter DMM 4 across shunt to measure the output current.

5.4.3 Jumper Connections, JP1 and JP2

For most tests it is recommended to install both jumpers, JP1 and JP2 on their respective headers. This will result in the remote sense points (the nodes at which the converter will regulate the output voltage) be located near the output connectors J3 and J4. This configuration is best for most functional testing.

These jumpers can be arranged differently depending on the desired location of remote sense.

NOTE: The amount of voltage drop between the output connectors J3 and J4 and the remote sense points is limited by the power dissipation in the internal remote sense resistors R7 and R18 (see schematic, Figure 1).

These resistors are rated for 0.0625 W and are 49.9 Ω. This implies a remote sense voltage drop of no more than 1.7 V in each of the +VE and –VE sense lines. Since this EVM is configured as a 1.2-V output, this will likely not be the limiting factor, but caution is still advised because when remote sense is being utilized, the EVM will attempt to regulate out a lossy load wire installation.

NOTE: The EVM may detect an Over-Voltage (OV) condition when remote sensing is being used, depending on the configurable OV setting. Refer to Section 5.2.6 for wire gauge recommendations.

When remote sense is not being utilized and the sense points are defaulted to the output connector of the EVM, the voltage drop in the load wires and the resulting reduced voltage applied to the electronic load may cause erratic behavior with the electronic load. This is because many loads will not function properly at input voltages lower than 1 V, which implies no more than 0.2-V drop combined in the load wires (+ and – load wires). Consult the documentation of the electronic load being used.

5.4.4 Jumper Configurations

All Jumper selections should be made prior to applying power to the EVM. User can configure this EVM as per following configurations.

Table 2. Jumper Configurations

JUMPERS JP1 AND JP2	DISCRETE SENSE WIRES	RESULT	USED FOR
Installed	Do not use	Default. Sense points are at the output connectors of the EVM.	Most testing.
Not installed	Not installed	Sense points are at the output connectors of the EVM, but through R7 and R18. Regulation will be degraded.	Not usually desired in this configuration.
Not installed	Installed and connected to the output voltage at the location where regulation is desired	Regulation will be at the far end location of the added discrete sense wires, usually desired to be the point of load.	Tight regulation of output voltage at a remote location, subject to the limitations mentioned in 5.4.3.

6 EVM Configuration Using the Fusion GUI

In order to configure the TPS40400 controller on the EVM, it is required to use the TI Fusion Digital Power Designer software. It is necessary to have input voltage applied to the EVM prior to launching the software so that the TPS40400 may respond to the GUI and the GUI can recognize the TPS40400. The default configuration for the EVM is to start converting at an input voltage of 7 V, so in order to avoid any converter activity during initial configuration, an input voltage less than 7 V should be applied.

6.1 Configuration Procedure

1. Adjust the input supply to provide 5 V_{DC}, current limited to 1 A.
2. Apply the input voltage to the EVM. Refer to Figure 3: and Figure 4: for connections and test setup.
3. Launch the Fusion GUI software. Refer to the following screenshots in section 6.2 for more information.
4. Configure the EVM operating parameters as needed.

> **CAUTION**
>
> Some parameters can be configured to values that can result in erratic or unexpected behavior on this EVM. Consult the TPS40400 datasheet for guidance in configuration of parameters.

6.2 Fusion GUI Screenshots

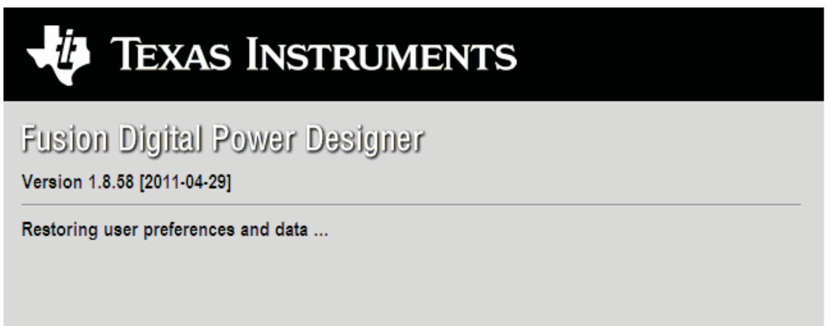

Figure 5. Screenshot 1: First Screen Upon Launching Fusion Software (Version may not match)

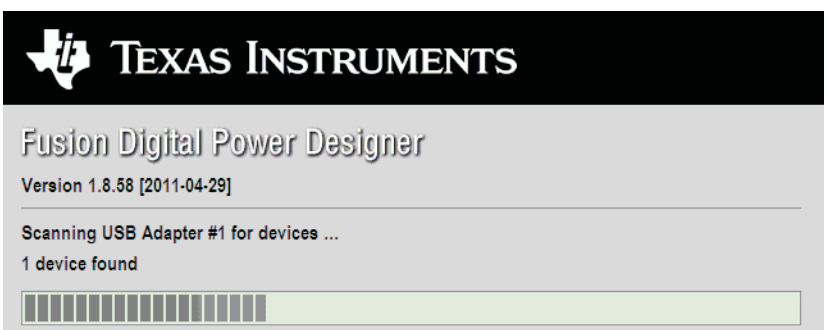

Figure 6. Screenshot 2: Fusion Successfully Recognizes the Device on EVM

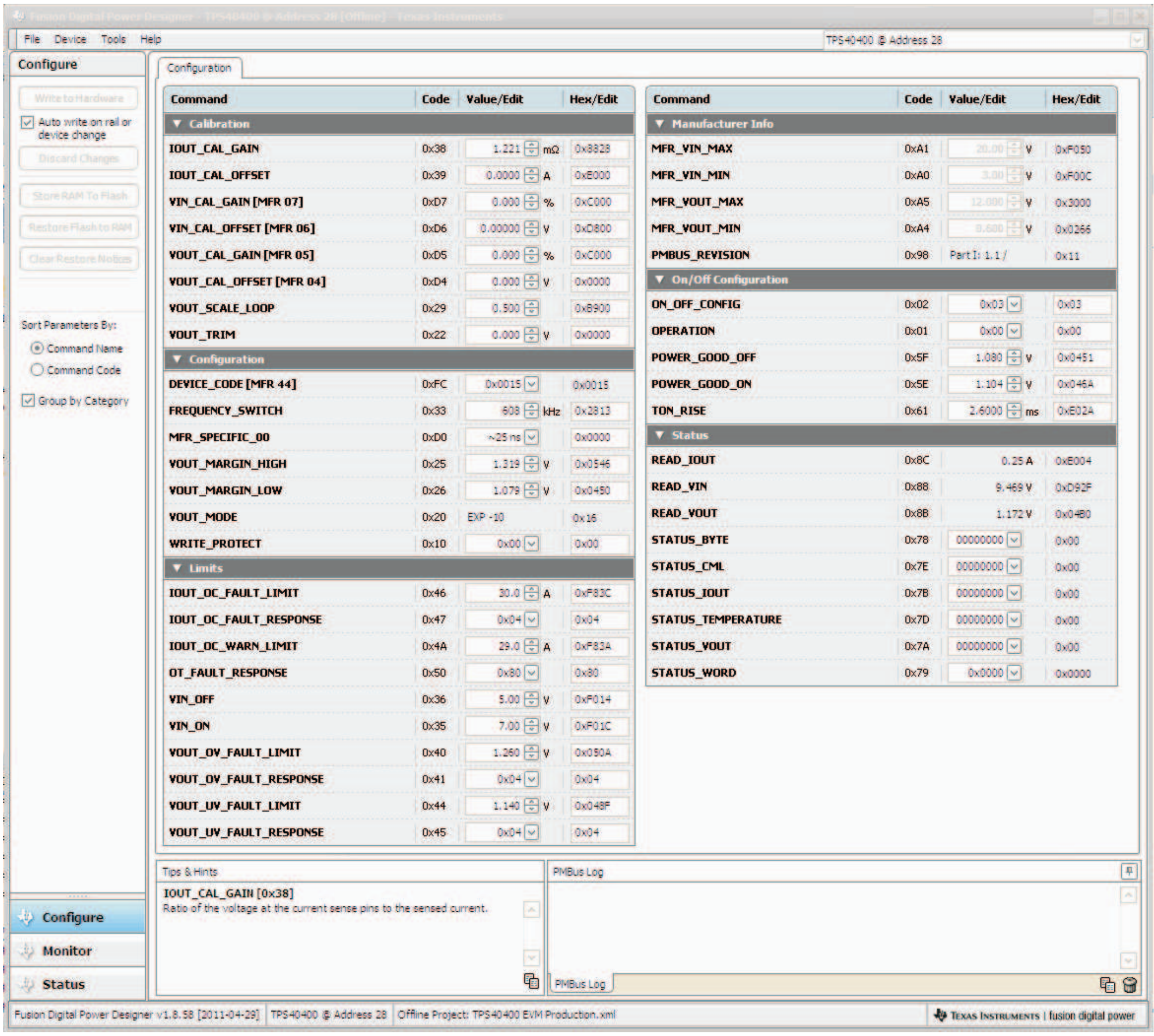

Figure 7. Screenshot 3: First Functional Screen, Configure Screen

NOTE: Most of these parameters are configurable. Consult the datasheet for the TPS40400 for details on how to configure the device to achieve the desired performance.

CAUTION

Some parameters can be configured to values that can result in erratic or unexpected behavior on this EVM. Consult the TPS40400 datasheet for guidance in configuration of parameters.

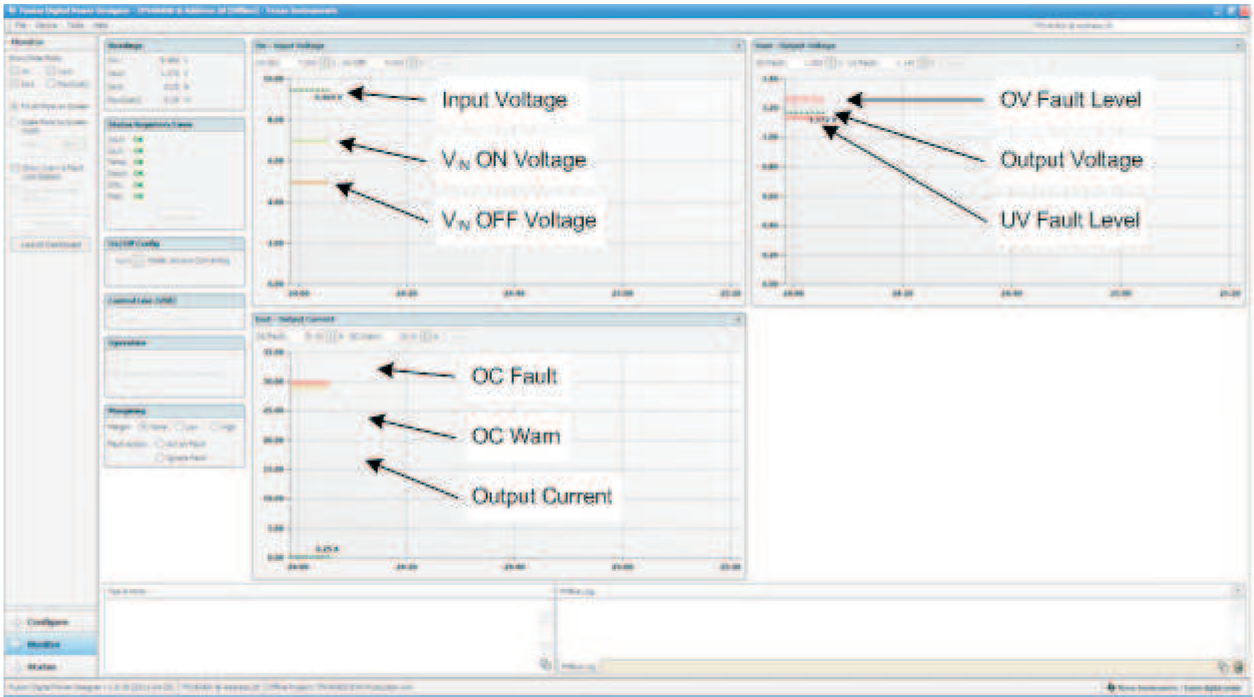

Figure 8. Screenshot 4: “Monitor” Screen

7 Test Procedure

7.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in Section 5.3 and Figure 3.
2. Ensure load is set to draw 0 A_{DC}.
3. Ensure all jumper configuration settings per Section 5.4.4.
4. Increase V_{IN} from 0 V to 12 V. Using DMM 1 to measure input voltage.
5. Use DMM 3 to measure output voltage V_{OUT}.
6. Vary Load from 0 A_{DC} to 20 A_{DC}, V_{OUT} should be remain in load regulation.
7. Vary V_{IN} from 8 V to 14 V, V_{OUT} should remain in line regulation.
8. Decrease Load to 0 A
9. Decrease V_{IN} to 0 V.

7.2 Control Loop Gain and Phase Measurement Procedure

TPS40400EVM-351 contains a 49.9-Ω series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in Section 5.3 and Figure 3.
2. Connect isolation transformer to test points marked TP13 and TP15.
3. Connect input signal amplitude measurement probe (channel A) to TP13. Connect output signal amplitude measurement probe (channel B) to TP15.
4. Connect ground lead of channel A and channel B to TP14 and TP16.
5. Inject 40-mV or less signal through the isolation transformer.
6. Sweep the frequency from 100 Hz to 1 MHz with 10-Hz or lower post filter. The control loop gain and phase margin can be measured.
7. Disconnect isolation transformer from bode plot test points before making other measurements (Signal injection into feedback may interfere with accuracy of other measurements).

7.3 List of Test Points

Table 3. TPS40400EVM-351 Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1	V_{IN}	Input voltage
TP2	COMP	Output of error amplifier
TP3	GND	Ground
TP4	PGOOD	Power good
TP5	VOUT	Output voltage
TP6	SENSE +	Positive remote sense
TP7	HDRV	High-side driver output
TP8	SYNC	Input, to synchronize oscillator to external frequency
TP9	TRACK	Input to non-inverting side of error amplifier
TP10	SW	Switch node
TP11	LDRV	Low side driver output
TP12	PGND	Power ground
TP13	CHA	Input A for loop injection
TP14	SGND	Signal ground
TP15	CHB	Input B for loop injection
TP16	SGND	Signal ground
TP17	GND	Ground
TP18	SENSE -	Negative remote sense

7.4 Equipment Shutdown

1. Reduce load current to zero amperes.
2. Reduce input voltage to zero volts.
3. Shut down FAN.

8 Performance Data and Typical Characteristic Curves

Figure 9 through Figure 20 represent typical performance curves for TPS40400EVM-351.

8.1 Efficiency

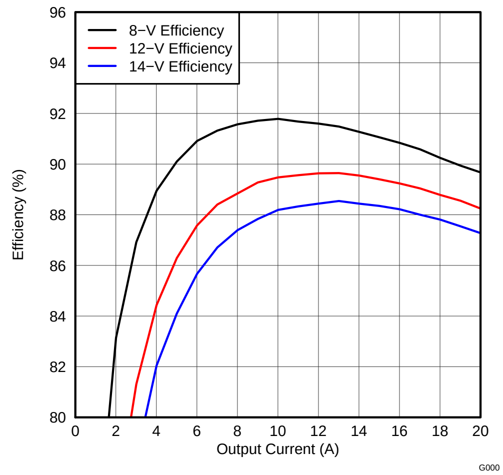

Figure 9.

8.2 Load Regulation

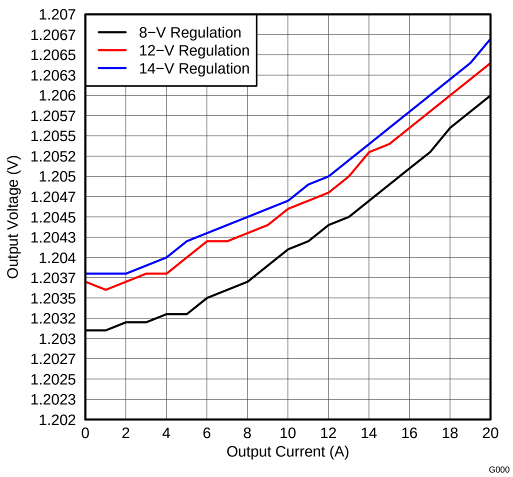

Figure 10.

8.3 Load Transients 1

Table 4. Load Transients 1

V_{IN}	TRANSIENT	TIMEBASE	CH2	CH4
8 V	5 A - 11 A - 5 A	100 µs	V_{OUT}	I_{OUT} 5 A/div.

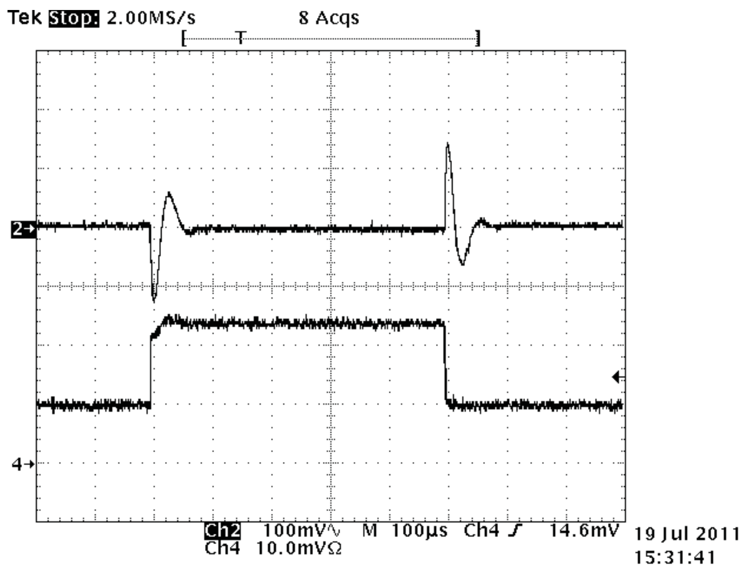

Figure 11.

8.4 Load Transient 2

Table 5. Load Transients 2

V_{IN}	TRANSIENT	TIMEBASE	CH2	CH4
8 V	5 A - 11 A	10 µs	V_{OUT}	I_{OUT} 5 A/div.

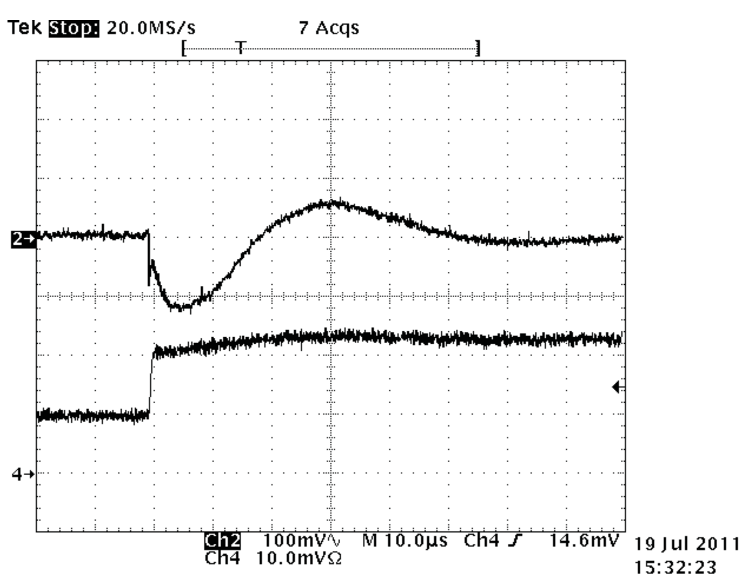

Figure 12.

8.5 Load Transient 3

Table 6. Load Transients 3

V_{IN}	TRANSIENT	TIMEBASE	CH2	CH4
8 V	11 A -5 A	10 µs	V_{OUT}	I_{OUT} 5 A/div.

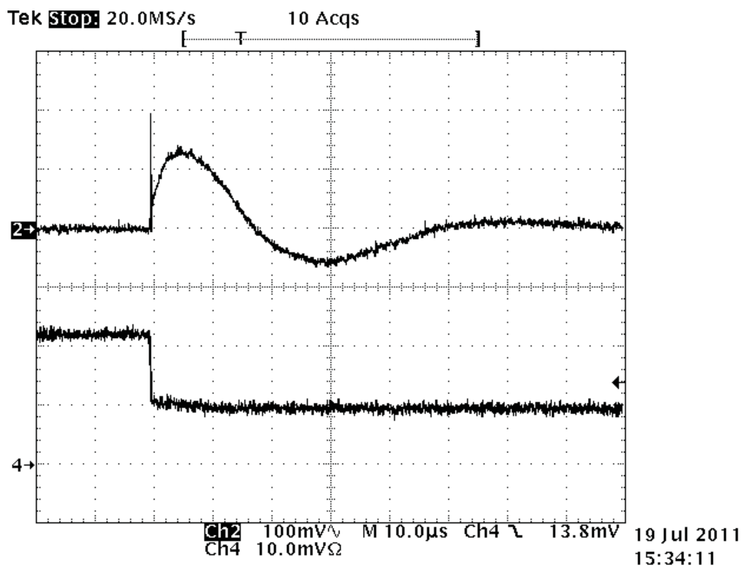

Figure 13.

8.6 Input and Output Ripple

Table 7. Input and Output Ripple

V_{IN}	TRANSIENT	TIMEBASE	CH1	CH2
14 V	20 A	400 ns	V_{IN}	V_{OUT}

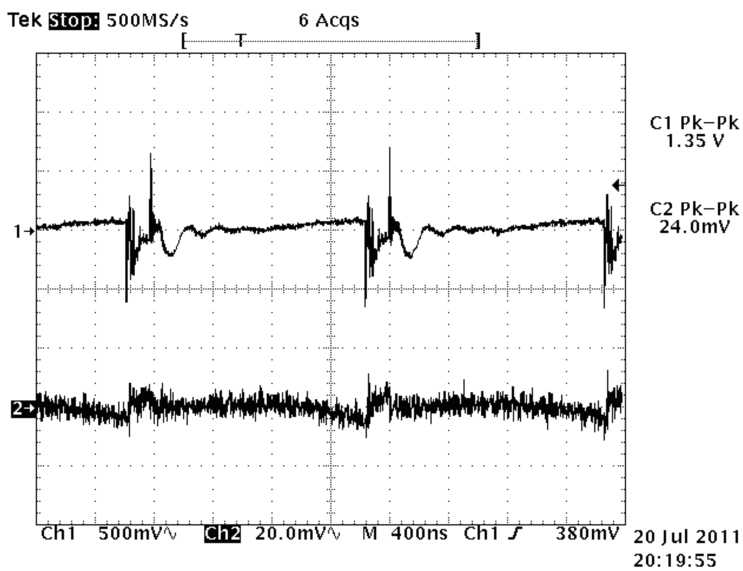

Figure 14.

8.7 Switch Node and HDRV

Table 8. Switch Node and HDRV

V_{IN}	TRANSIENT	TIMEBASE	CH1	CH2
8 V	20 A	40 ns	HDRV	SW

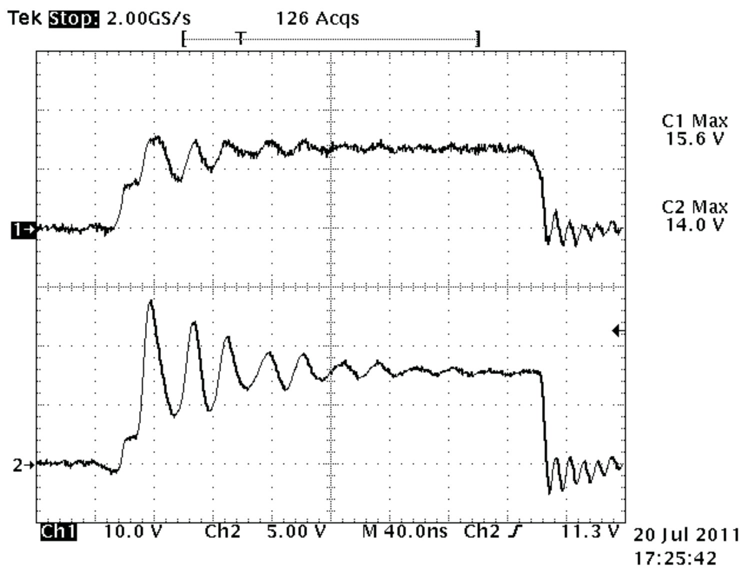

Figure 15.

8.8 V_{IN} Turn On

Table 9. V_{IN} Turn On

V_{IN}	TRANSIENT	TIMEBASE	EVENT	CH1	CH2
8 V	10 A	1 ms	V_{IN} ON	V_{IN}	V_{OUT}

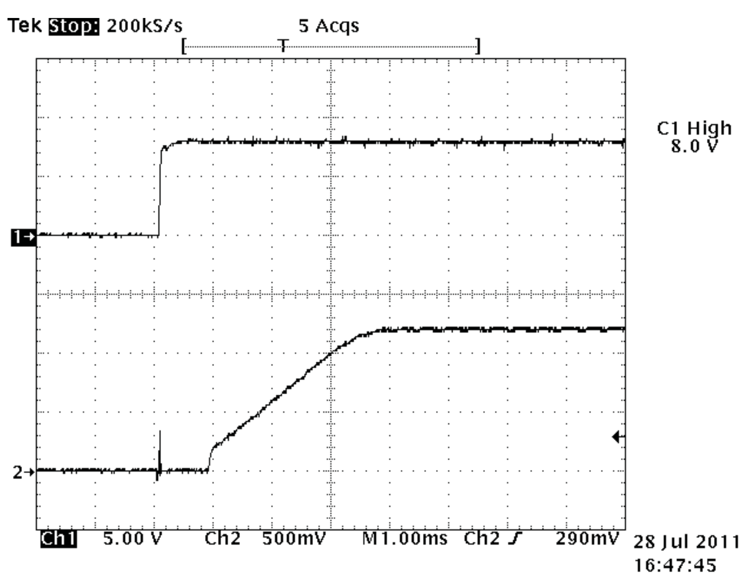

Figure 16.

8.9 Enable ON / OFF

Table 10. Enable ON/OFF 1

V_{IN}	I_{OUT}	TIMEBASE	EVENT	CH1	CH2	CH3
8 V	10 A	400 µs	CNTRL ON	V_{OUT}	CNTRL	V_{IN}

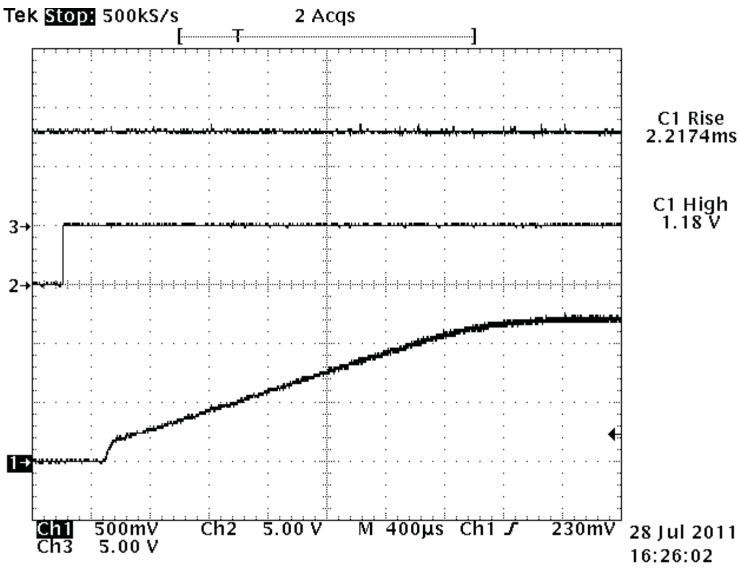

Figure 17.

Table 11. Enable ON/OFF 2

V_{IN}	I_{OUT}	TIMEBASE	EVENT	CH1	CH2	CH3
8 V	10 A	20 µs	CNTRL OFF	CNTRL	V_{IN}	V_{OUT}

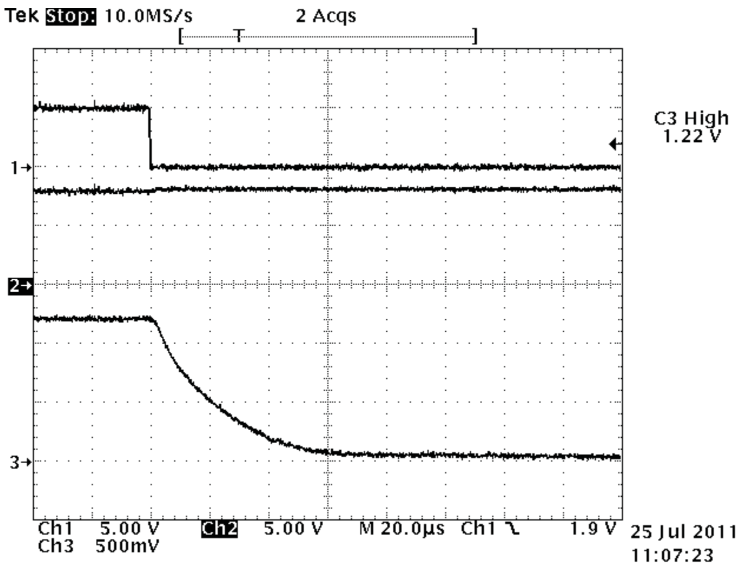

Figure 18.

8.10 Turn ON with 92% (1.1V) Pre-bias

Table 12. Turn ON with 92% (1.1 V) Pre-Bias

V_{IN}	I_{OUT}	TIMEBASE	EVENT	CH1	CH2	CH3	PREBIAS VOLTAGE
14 V	0 A	1 ms	PreBias Turn ON	CNTRL	V_{IN}	V_{OUT}	1.1 V

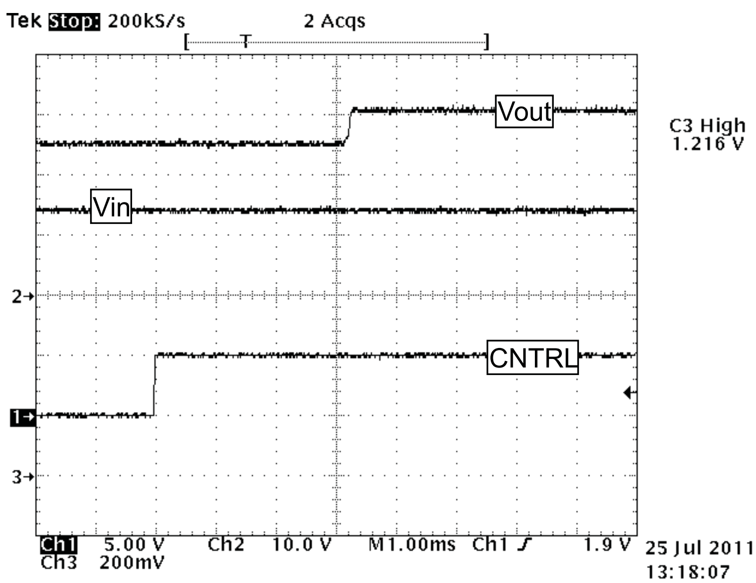

Figure 19.

8.11 TPS40400EVM-351 Bode Plot (20-A output)

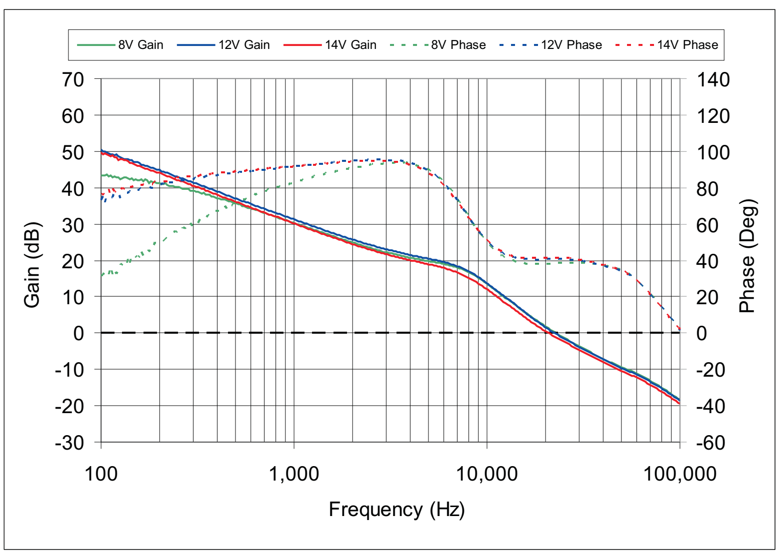

Figure 20.

9 EVM Assembly Drawing and PCB Layout

The following figures (Figure 21 through Figure 24) show the design of the TPS40400EVM-351 printed circuit board. The EVM has been designed using 2 Layers, 2-oz copper circuit board.

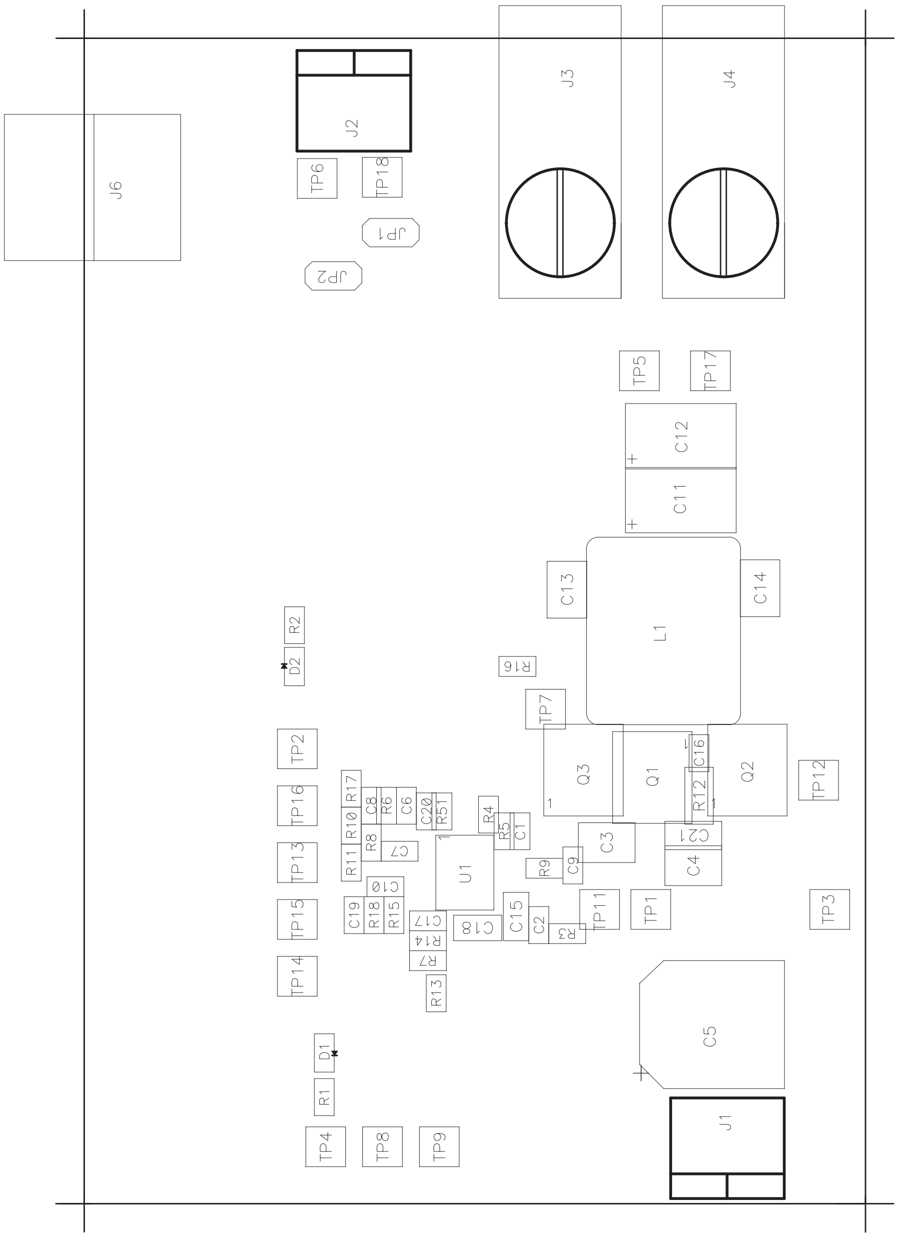

Figure 21. Top Assembly

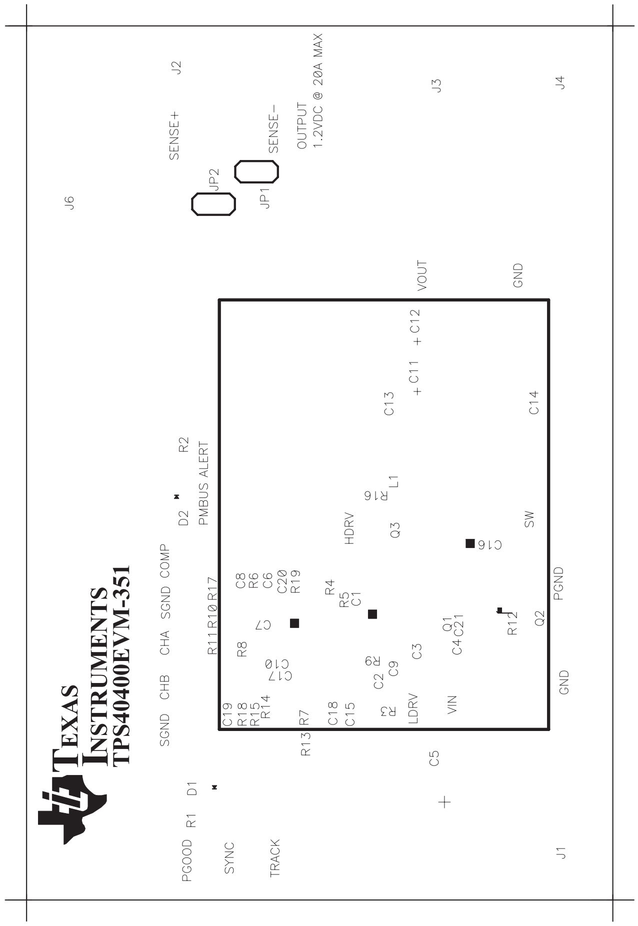

Figure 22. Top Copper

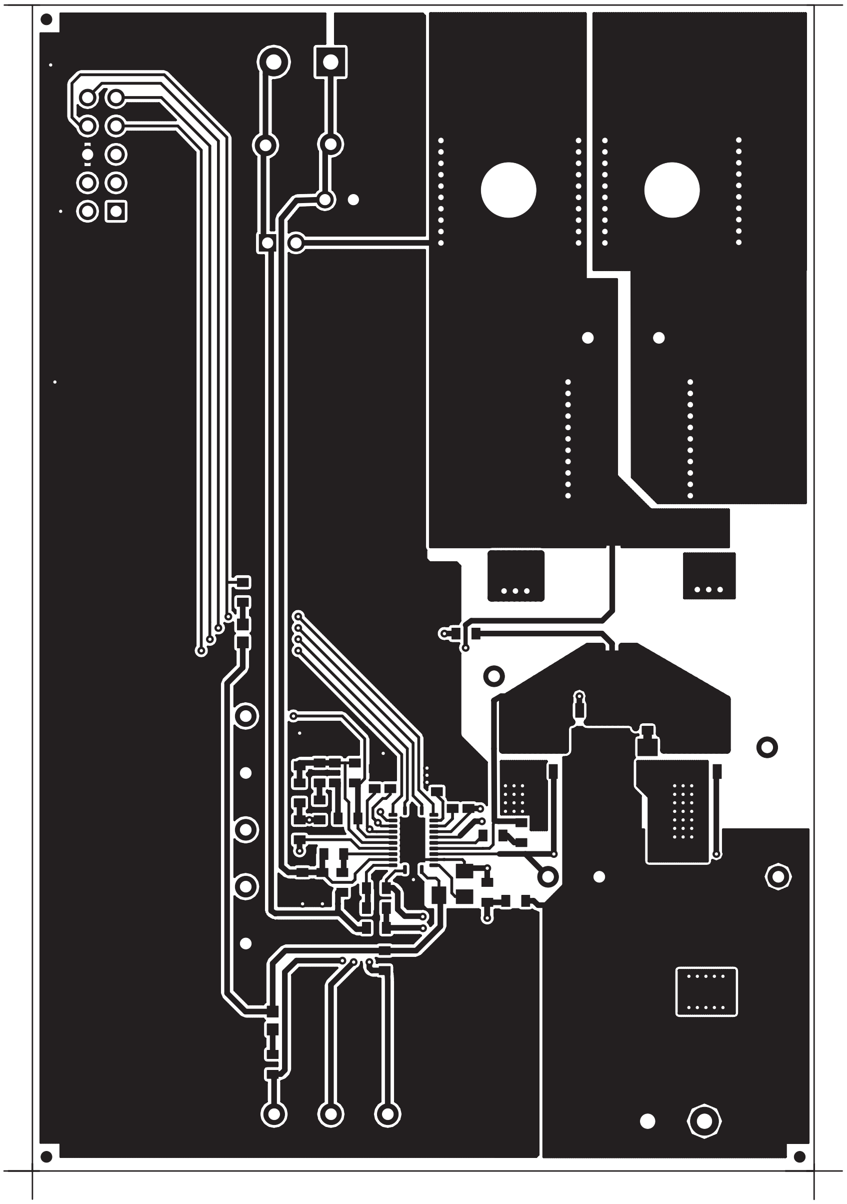

Figure 23. Bottom Copper

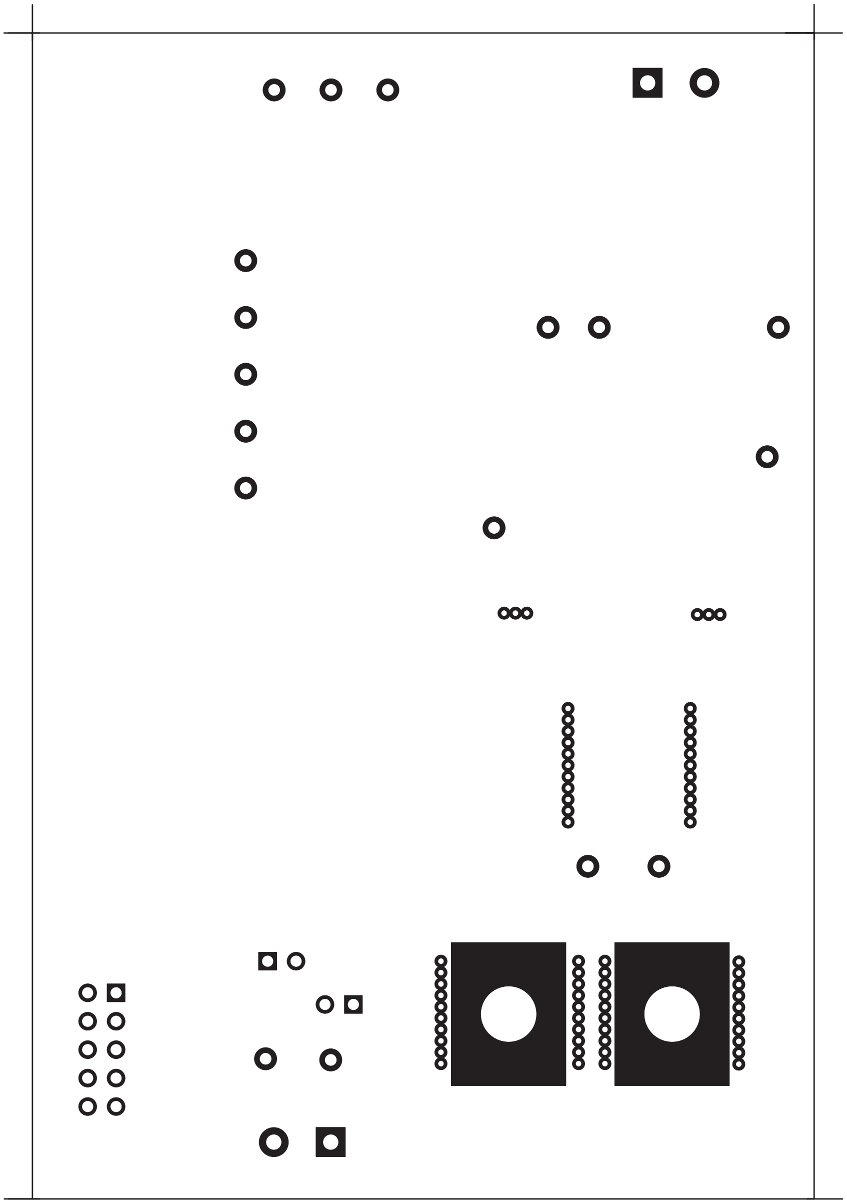

Figure 24. Top Silk

10 List of Materials

The EVM components list according to the schematic shown in Figure 1.

Table 13. TPS40400EVM-351 List of Materials

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
4	C1, C2, C9, C17	Capacitor, ceramic, 25 V, X7R, 10%, 100 nF, 0603	std	std
0	C10	Capacitor, ceramic, open, 0603		
1	C11	Capacitor, tantalum, 6.3 V, 10%, 680 μF, 7343 (D)	TPSE687K006R0045	AVX
0	C12	Capacitor, tantalum, open, 7343 (D)		
2	C13, C14	Capacitor, ceramic, 6.3 V, X7R, 10%, 47 μF, 1210	std	std
2	C15, C18	Capacitor, ceramic, 16 V, X7R, 10%, 1 μF, 0805	std	std
1	C16	Capacitor, ceramic, 25 V, X7R, 10%, 1.0 nF, 0603	std	std
0	C19	Capacitor, ceramic, open, 0603		
1	C20	Capacitor, ceramic, 50 V, X7R, 10%, 10 nF, 0603	std	std
1	C21	Capacitor, ceramic, 25 V, X7R, 10%, 1.0 μF, 1206	std	std
2	C3, C4	Capacitor, ceramic, 25 V, X7R, 10%, 22 μF, 1210	std	std
1	C5	Capacitor, aluminum, SM, 330 μF, 25 V, 150 mΩ, FC series, 10 mm x 12 mm	EEVFC1E331P	Panasonic
1	C6	Capacitor, ceramic, 50 V, X7R, 10%, 680 pF, 0603	std	std
1	C7	Capacitor, ceramic, 50 V, X7R, 10%, 2.2 nF, 0603	std	std
1	C8	Capacitor, ceramic, 50 V, X7R, 10%, 820 pF, 0603	std	std
2	D1, D2	Diode, LED, red, 2.1 V, 20 mA, 6 mcd, 0603	LTST-C190CKT	Lite On
2	J1, J2	Terminal block, 2 pin, 15 A, 5.1 mm, D120/2DS, 0.40 inch x 0.35 inch	ED120/2DS	On Shore Technology
2	J3, J4	Type L - copper single conductor, one-hole mount, L35, 0.813 inch x 0.375 inch	L35	Thomas and Betts
1	J6	Connector, male right angle 2 x 5 pin, 100-mil spacing, 4 wall, 0.607 inch x 0.484 inch	86479-3	AMP
2	JP1, JP2	Header, 2 pin, 100-mil spacing, 0.100 inch x 2 inch	PTC36SAAN	Sullins
1	L1	Inductor, SMT, 0.75 μH, 1.2 mΩ, 31 A, 0.512 inch x 0.571 inch	PG0077.801	Pulse
1	Q1	MOSFET, N-Channel, 25 V, 20 A, 4.1 mΩ, QFN 5 x 6 mm	CSD16404Q5A	TI
2	Q2, Q3	MOSFET, N-Channel, 25 V, 33 A, 1.7 mΩ, QFN-8 POWER	CSD16325Q5	TI

Table 13. TPS40400EVM-351 List of Materials (continued)

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
2	R1, R2	Resistor, chip, 1/16 W, 5%, 1 kΩ, 0603	std	std
3	R10, R17, R19	Resistor, chip, 1/16 W, 1%, 10 kΩ, 0603	std	std
1	R12	Resistor, chip, 1/8 W, 1%, 2.74 Ω, 1206	std	std
1	R13	Resistor, chip, 1/16 W, 1%, 100 kΩ, 0603	std	std
1	R14	Resistor, chip, 1/16 W, 1%, 200 Ω, 0603	std	std
1	R15	Resistor, chip, 1/16 W, 1%, 0 Ω, 0603	std	std
1	R16	Resistor, chip, 1/16 W, 1%, 6.19 kΩ, 0603	std	std
2	R3, R9	Resistor, chip, 1/16 W, 1%, 10 Ω, 0603	std	std
1	R4	Resistor, chip, 1/16 W, 1%, 36.5 kΩ, 0603	std	std
1	R5	Resistor, chip, 1/16 W, 1%, 54.9 kΩ, 0603	std	std
1	R6	Resistor, chip, 1/16 W, 1%, 4.99 kΩ, 0603	std	std
3	R7, R11, R18	Resistor, chip, 1/16 W, 1%, 49.9 Ω, 0603	std	std
1	R8	Resistor, chip, 1/16 W, 1%, 2.74 kΩ, 0603	std	std
1	U1	3.0-V to 20-V PMBus Synchronous Buck Controller, QFN-24	TPS40400RHL	TI
1	--	PCB, 4.1 inch x 2.75 inch x 0.062 inch	HPA351	Any

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Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of xxx V to xxx V and the output voltage range of xxx V to xxx V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 xxx° C. The EVM is designed to operate properly with certain components above xxx° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

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The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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REGULATORY COMPLIANCE INFORMATION

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.

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.

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.

【Important Notice for Users of this Product in Japan】

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.

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

http://www.tij.co.jp

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

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.

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TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

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