

## TPS62366AEVM-757

This user's guide describes the characteristics, operation, and use of the Texas Instruments TPS62366A evaluation module (EVM). This EVM is designed to help the user easily evaluate and test the operation and functionality of the TPS62366A. The EVM converts a 2.5-V to 5.5-V input voltage to a regulated output voltage that delivers 4 A. The output voltage is programmable via the I2C interface in 10-mV steps between 0.5V and 1.77V. This user's guide includes setup instructions for the hardware, printed-circuit board layouts for the EVM, a schematic diagram, a bill of materials, and test results for the EVM.

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## 1 Introduction

### 1.1 Requirements

To operate this EVM, connect and properly configure the following components:

A personal computer (PC) with a USB port is required to operate this EVM. The TPS62366A interface software runs on the PC and communicates with the EVM via the PC's USB port. Commands can be sent to the internal registers of the TPS62366A through the USB port. The software has been tested with the PC requirements listed below. It may work with other operating systems and configurations, but this has not been verified.

#### Personal Computer Requirements

- Windows XP™ operating system
- .NET 2.0 or higher
- USB port
- 10 MB of free hard disk space
- 512 MB of RAM

#### USB-TO-GPIO Adapter

The USB-TO-GPIO adapter is the link that allows the PC and the EVM to communicate. One end of the USB-TO-GPIO adapter connects to the PC with the supplied USB cable. The other end of the USB-TO-GPIO adapter connects to the EVM with the supplied ribbon cable.

When a command is written to the EVM, the interface program running on the PC sends the commands to the PC USB port. The USB-TO-GPIO adapter receives the USB command, converts the signal to an I<sup>2</sup>C protocol, and sends the I<sup>2</sup>C signal to the TPS62366A EVM board.

#### Software

Texas Instruments provides software to assist in evaluating this EVM. This software can be downloaded from the TPS62366AEVM-757 Product Page, located at: <http://focus.ti.com/docs/toolsw/folders/print/tps62366Aevm-757.html>.

#### Printed-Circuit Board Assembly

The board contains the TPS62366A IC and the required external components to evaluate it as a processor power supply solution.

### 1.2 Performance Specification Summary

A summary of the performance specifications is provided in [Table 1](#). Specifications are given for an input voltage of 3.6V and an output voltage of 1.2V, unless otherwise specified. The TPS62366A is designed and tested for  $V_{IN} = 2.5V$  to 5.5V. The ambient temperature is 25°C for all measurements, unless otherwise noted.

**Table 1. Performance Specification Summary**

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{IN}$ voltage range		2.5	3.6	5.5	V
Output voltage set point	Programmable in 10 mV steps	0.5		1.77	V
Output current range		0		4	A
Line regulation	$I_{OUT} = 2A, V_{OUT} = 1.2V$		±0.1%		
Load regulation	$V_{IN} = 3.6V, V_{OUT} = 1.2V$		±0.1%		
Load transient response	$I_{OUT} = 1A$ to 2A	Voltage change	40		mV
		Recovery time	8		µs
	$I_{OUT} = 2A$ to 1A	Voltage change	42		mV
		Recovery time	9		µs
Input ripple voltage	$V_{IN} = 3.6V, V_{OUT} = 1.2V, I_{OUT} = 4A$		76		mV <sub>PP</sub>
Output ripple voltage	$V_{IN} = 3.6V, V_{OUT} = 1.2V, I_{OUT} = 4A$		6		mV <sub>PP</sub>
Maximum efficiency	$V_{IN} = 3.6V, V_{OUT} = 1.77V, I_{OUT} = 760mA$		92.1%		

## 2 Setup

This section describes the jumpers and connectors on the EVM as well as how to properly connect, set up, and use the TPS62366AEVM-757.

### 2.1 Connector/Jumper Descriptions

#### 2.1.1 J1 – $V_{IN}$

This header is for the positive input supply voltage to the converter. The leads to the input supply should be twisted and kept as short as possible to minimize EMI transmission and reduce inductive voltage droop during a load transient event. This voltage should be between 2.5V and 5.5V.

#### 2.1.2 J2 – S+/S-

Sense connector for  $V_{IN}$ . Connect input supply's sense leads to this point. Monitor the  $V_{IN}$  voltage at this point.

#### 2.1.3 J3 – GND

This is the return connection for the input power supply of the converter. The leads to the input supply should be twisted and kept as short as possible to minimize EMI transmission and reduce inductive voltage droop during a load transient event.

#### 2.1.4 J4 – $V_{OUT}$

This header connects to  $V_{OUT}$ . Connect the load (processor) at this point if the load current will remain below 1A. If the load current will exceed 1A, use terminal block J7 instead. The leads to the load should be twisted and kept as short as possible to minimize EMI transmission and reduce inductive voltage droop during a load transient event.

#### 2.1.5 J5 – SNS+/SNS-

Remote sense connector for the IC. **For proper regulation, this must be connected at the load.** The leads to the load should be twisted and kept as short as possible to minimize noise pickup. This is a high impedance connection back to the TPS62366A's remote sense inputs and is required for output regulation. Monitor the output voltage at this point.

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**NOTE:** User must connect J5 to load.

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#### 2.1.6 J6 – GND

This is the return connection for the load. If the load current will exceed 1A, do not use headers J4 and J6, but use terminal block J7 instead. The leads to the load should be twisted and kept as short as possible to minimize EMI transmission and reduce inductive voltage droop during a load transient event.

#### 2.1.7 J7 – $V_{OUT}$ /GND Terminal Block

This terminal block should be used to connect to the load (processor) if the load current will exceed 1A. If the load current will remain below 1A, the J4/J6 headers may be used instead. The leads to the load should be twisted and kept as short as possible to minimize EMI transmission and reduce inductive voltage droop during a load transient event.

#### 2.1.8 J8 – I<sup>2</sup>C Connection from USB-TO-GPIO Adaptor

This connects the USB-TO-GPIO adaptor to the TPS62366AEVM-757. It provides the I<sup>2</sup>C signals and a 3.3V supply for powering  $V_{DD}$ . If the USB-TO-GPIO adaptor is not used, do not connect to J8, but connect the I<sup>2</sup>C signals to the J9 header instead. This connector is keyed to prevent incorrect installation.

### 2.1.9 J9 – I<sup>2</sup>C Monitor Point and Alternate Connection

This header is provided to connect to or monitor the I<sup>2</sup>C signals on the TPS62366AEVM-757. If the I<sup>2</sup>C signals are being sent via this header (and not via the USB-TO-GPIO adaptor), do not plug into the J8 header and provide a separate V<sub>DD</sub> supply on JP1 without any jumper installed.

### 2.1.10 J10 – Load Step Signal Input

This SMA connector accepts a signal input from a function generator that drives Q1 in order to evaluate the TPS62366A's transient response. Since this connector is not installed, TP4 can be used for the same function.

### 2.1.11 JP1 – V<sub>DD</sub> Control

This jumper is used to connect V<sub>DD</sub> to either a 3.3V rail provided by the USB-TO-GPIO adaptor (jumper across pins 1 and 2) or to GND to reset the I<sup>2</sup>C registers (jumper across pins 2 and 3). Alternatively, the user can provide their own V<sub>DD</sub> voltage (1.15 - 3.6V) between pins 2 and 3 of JP1. No jumper should be installed in this case. For normal operation without an external supply voltage, the jumper should be installed between pins 1 and 2.

### 2.1.12 JP2 – VSEL

This jumper sets the VSEL pin to either a logic high (jumper across pins 1 and 2) or a logic low (jumper across pins 2 and 3).

### 2.1.13 JP3 – EN

This jumper sets the EN pin to either a logic high (jumper across pins 1 and 2) or a logic low (jumper across pins 2 and 3). When EN is low, the TPS62366A output will be off and not switching. Set EN to high to turn on the output voltage.

## 2.2 Software Setup

The software is available at the TI website,

<http://focus.ti.com/docs/toolsw/folders/print/tps62366Aevm-757.html>.

Download and unzip the file. Run setup.exe and follow the on screen instructions to complete the installation.

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**NOTE:** The installation page is best viewed with Microsoft Internet Explorer browser (it may not work correctly with other browsers).

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The Microsoft .Net Framework 2.0 is required for the software to run.

After installation, the software should automatically run. To run the software later, go to

Start→All Programs→Texas Instruments→TPS62366x EVM→TPS62366x EVM.

During future use of the software, it may prompt you to install a new version if one becomes available on the Web.

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**NOTE:** VeriSign™ Code Signing is used to prevent any malicious code from changing this application. If at any time in the future the binaries are modified, the code will no longer attempt to run.

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## 2.3 Hardware Setup

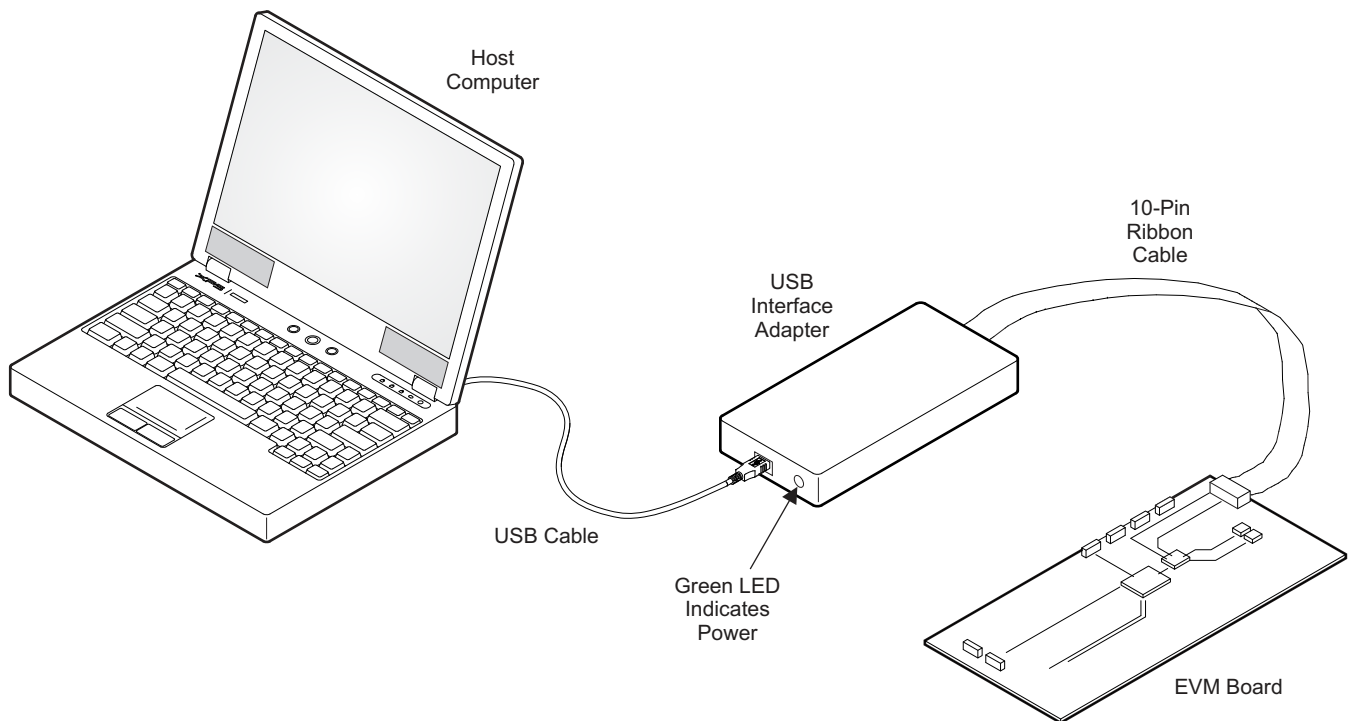
Table 2 shows the default jumper settings.

**Table 2. Default Jumper Settings**

JUMPER	DEFAULT
JP1	Installed across pins 1 and 2
JP2	Installed across pins 2 and 3
JP3	Installed across pins 1 and 2

Connect the USB-TO-GPIO adapter to your PC using the supplied USB cable. Connect the TPS62366AEVM connector J8 to the USB-TO-GPIO adapter using the supplied 10-pin ribbon cable. The connectors on the ribbon cable are keyed to prevent incorrect installation.

### USB Interface Adaptor Quick Connection Diagram



Connect the load (processor) to either the output headers J4 and J6 (for currents below 1A) or to the output terminal block J7 (for currents greater than 1A). The leads should be short and twisted.

Connect the SNS+ and SNS- signals from header J5 to the load. **For proper regulation, these must be connected to the output.**

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**NOTE:** User must connect J5 to load.

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Install jumpers, JP1 through JP3 to the desired positions. Jumper JP3 must be across pins 1 and 2 for the TPS62366A to operate.

Connect at least a 2 A rated input power supply, set to provide between 2.5V and 5.5V, between J1 and J3. The leads should be short and twisted. Turn on the power supply.

### 3 Software Setup and Operation

This section provides descriptions of the EVM software and functionality.

The supplied software is used to communicate with the TPS62366AEVM. Click on the icon on the host PC to start the software. The host PC software first checks the firmware version of the USB-TO-GPIO adapter. If an incorrect firmware version is installed, the software automatically searches on the Internet (if connected) for updates. If a new update is available, the software notifies the user of the update, downloads and installs the software. Note that after the firmware is updated, the user must disconnect and then reconnect the USB cable between the adapter and PC, as instructed during the install process. The host PC software also automatically searches on the Internet (if connected) for updates to the EVM software. If a new update is available, the software notifies the user of the update, downloads and installs the update.

$V_{IN}$  and  $V_{DD}$  must be supplied for the software to detect the TPS62366A and run.

The software reads the registers on the TPS62366A and automatically determines which version of the IC is installed. Even if the IC is disabled via the EN pin (JP3), the user can still communicate with the TPS62366A if  $V_{IN}$  and  $V_{DD}$  are supplied. If no IC is detected, the software aborts loading.

The software displays the main panel for the user interface, shown in [Figure 1](#).

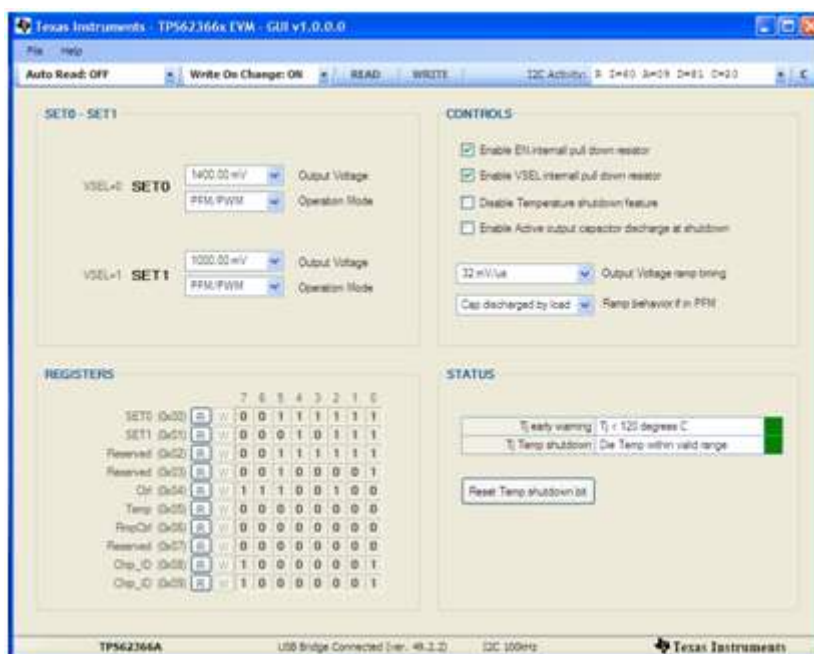


Figure 1. TPS62366A Software Main Panel

It is recommended that the user press the 'READ' button at the top of the screen immediately after loading the software to confirm that the software and cable connections are working properly. The message box at the top right of the main panel (I<sup>2</sup>C Activity) displays all I<sup>2</sup>C activity. The message box at the bottom (USB Bridge Connected) displays whether or not the USB-TO-GPIO connection is functional.

The software itself performs no calculations or computations and simply reads and writes to and from the IC's registers through the I<sup>2</sup>C interface. Each register's bits can either be changed manually by changing the boxes corresponding to each bit in the panel's bottom left half (REGISTERS section), or they can be changed through the drop-down boxes and buttons in the rest of the panel. Some bits are reserved and not writeable. These will not allow you to click on them to change their setting. For example, since register 0x07h is reserved and not writeable, the software main panel does not allow writes to those bits. The I<sup>2</sup>C bus speed is fixed at 100 kbps and this is noted at the bottom of the screen.

*Following any change to an individual bit, drop-down box, or button, the user must write the new values to the registers by either clicking the 'W' button to the left of each affected register or by clicking the 'WRITE' button at the top of the screen.*

In order to reduce the amount of manual reading and writing required, the two drop-downs at the top left of the screen have been provided to do this automatically. The 'Auto Read' drop down allows the option of automatically reading all the registers at specific time intervals. The 'Write On Changes' drop-down allows the option of automatically writing a change to the registers as soon as it is made in the software.

The TPS62366A datasheet is available via the 'Help' menu (Internet access is required). The datasheet discusses the functionality of the various register bits, which is also briefly repeated here.

The drop-downs in the top left section of the software (SET0-SET1 section) correspond to registers 0x00h and 0x01h in the TPS62366A. These registers set the target output voltage and operating mode (PFM/PWM or forced PWM). The output voltage on the TPS62366A is settable in 10 mV steps between 0.5V and 1.77V. The operating mode is either PFM/PWM, in which the IC is allowed to skip switching pulses at light loads to keep the converting efficiency high, or forced PWM mode, in which the IC allows negative inductor current at light loads to maintain a specific switching frequency and output noise. The TPS62366A only runs at the settings of one of these two registers at a time. This operating register is selected by the VSEL jumper and can be changed during operation.

The top right section of the software (CONTROLS section) contains the functionality of registers 0x04h and 0x06h and some of the functionality of register 0x05h. The first two check boxes enable an internal resistor on either the EN or VSEL pins. This resistor, which is internal to the TPS62366A, keeps that pin in a defined state if it were left floating. The 'Disable Temperature shutdown feature' bit disables the temperature shutdown internal to the IC, if selected. The 'Enable Active output capacitor discharge at shutdown' forces the IC to actively discharge the output capacitor during shutdown. The first drop-down sets the output voltage ramp timing and the final drop-down describes the ramp behavior when the TPS62366A is changing its output voltage in PFM mode.

The bottom right section of the software (STATUS section) contains the remaining bits from register 0x05h. The top indicator is green if the IC die temperature is low enough and turns red when the bit is set corresponding to a die temperature exceeding 120°C typical. The indicator on the bottom turns red if thermal shutdown has occurred. When this occurs, the TPS62366A latches off and the temperature must decrease below a hysteresis amount and the T<sub>J</sub> Temp shutdown bit needs to be reset by the user. The button at the bottom of this section is provided for this purpose.

## 4 Circuit Use and Modifications

Besides the required circuitry to operate the TPS62366A (outlined in a white silk screen border on the PCB), there are additional circuits present on the TPS62366AEVM-757 that assist in evaluating the TPS62366A as a processor power supply solution. Additionally, there are modifications that can be made to adapt the circuit's performance to the needs of a particular application.

### 4.1 Load Step Circuit

The TPS62366AEVM-757 contains a simple circuit that produces fast load current steps at the output of the TPS62366A. This evaluates the response of the TPS62366A to various load transients. To operate this circuit, connect a function generator to TP4. The output of the function generator should be a square wave with a small duty cycle. The output high level controls the gate to source voltage of the power transistor, Q1, and should be adjusted to generate the desired step current high level. The output low level sets the step current low level. Good settings to start with are a square wave signal running at 100 Hz and 5% duty cycle going from 0V to 3V. These settings can be adjusted in order to generate the desired load step.

Resistor R6 is present to observe the load step current by measuring the voltage across TP2 and TP3. Oscilloscope settings of 100mV / div translate to a current in R6 of 1A / div.

### 4.2 Output Voltage Buffer

The output voltage buffer circuit simply buffers the SNS+/- output with a unity gain op amp. This transforms SNS+ and SNS- to a lower impedance signal that can be measured by high impedance measurement equipment, such as an oscilloscope. The op amp, U2, is powered from the USB-TO-GPIO adaptor. The USB-TO-GPIO adaptor must be installed for the output voltage buffer circuit to operate.

C14 is provided to reduce the bandwidth and noise of the input signal to the operational amplifier.

### 4.3 Circuit Modifications

Modifications may be made to the circuit. Any modifications affect the performance of the EVM and must remain within the limits of the TPS62366A IC, as detailed in the datasheet.

#### 4.3.1 Output Capacitors

There are four locations for extra output capacitors to be installed in order to reduce output ripple or lessen the voltage drop due to a load transient. C7 allows an extra capacitor to be installed near the TPS62366A IC, while C10, C11, and C12 allow extra capacitors to be installed closer to the point of load, which is simulated by the load step circuit. The total output capacitance must remain below the maximum capacitance allowed in the datasheet. C10, C11, and C12 come pre-installed with typical capacitances used at the processor's input.

#### 4.3.2 Input Capacitors

C9 is provided to locate additional input capacitance near the TPS62366A input. Additional capacitance at C9 decreases the input voltage ripple.

C8 is provided to form a complete 'PI'-type filter for the AVIN input. With the change of R1 to some small value (around 10  $\Omega$ ), the C-R-C filter is complete. This filter is not necessary for operation of the TPS62366A.

#### 4.3.3 I<sup>2</sup>C Pull-up Resistors

R2 and R3 are locations for optional pull-up resistors for the I<sup>2</sup>C signals. They are required when not using the USB-TO-GPIO adaptor but are not recommended when using the adaptor. If used, their typical value is around 2.2k $\Omega$ .



#### **4.3.4 Local Sensing Resistors**

If it is not desired to connect the SNS+ and SNS- signals at the load, they may be connected on the EVM by installing 0-Ω resistors in both R4 and R5.

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**NOTE:** User must connect J5 to load or populate R4 and R5.

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## 5 Test Results

This section provides typical performance waveforms for the TPS62366AEVM-757.

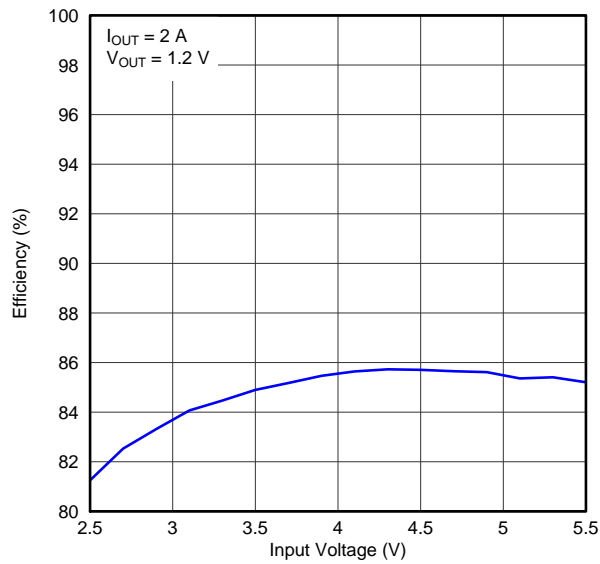


Figure 2. Efficiency vs Input Voltage

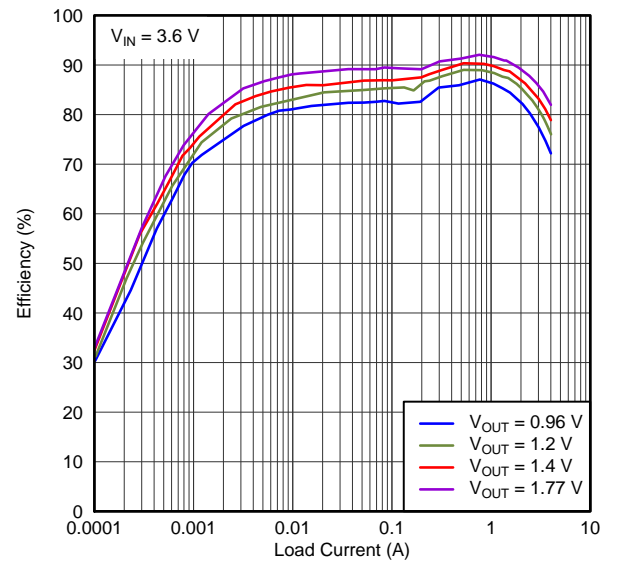


Figure 3. Efficiency vs Output Current

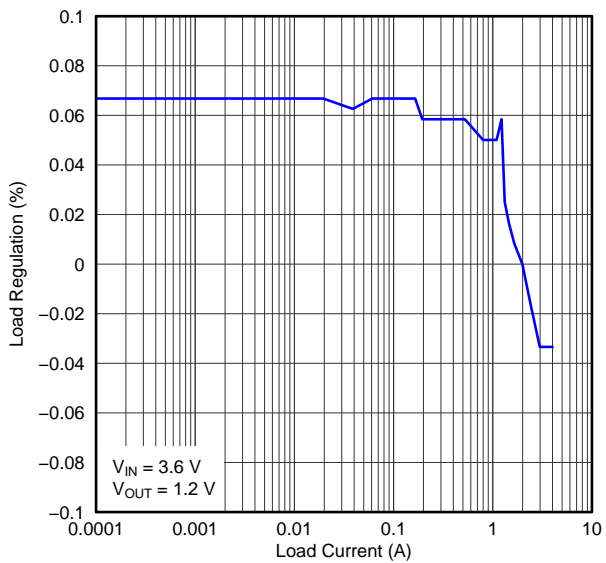


Figure 4. Load Regulation (Forced PWM Mode)

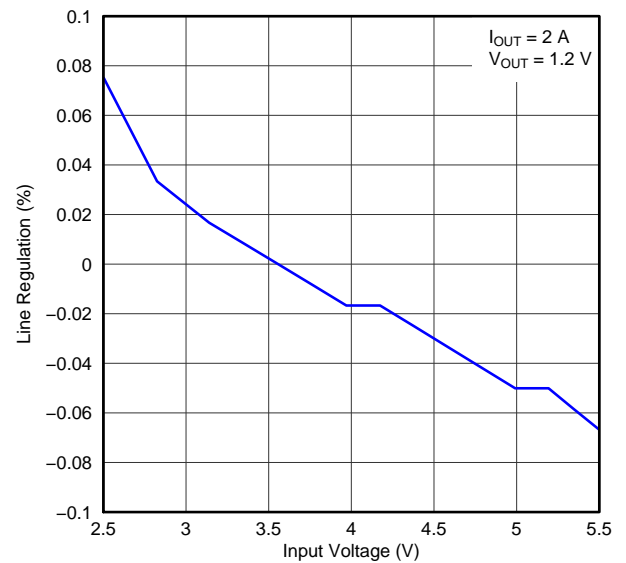


Figure 5. Line Regulation

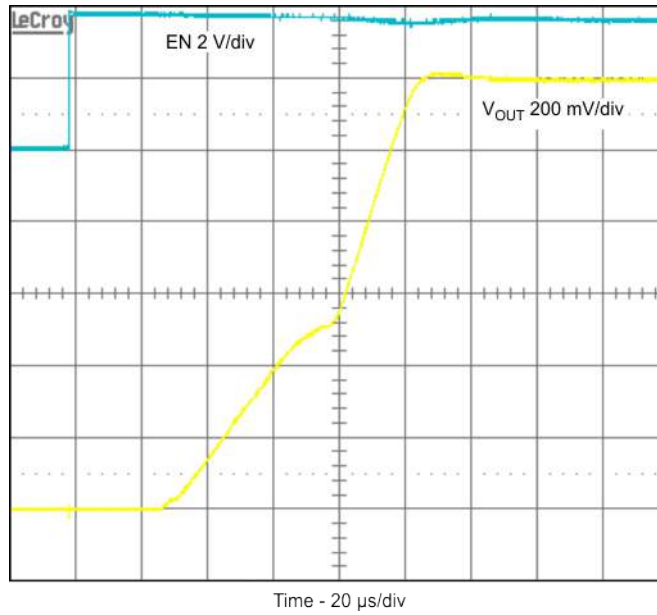


Figure 6. Start-up ( $V_{IN} = 3.6V$ ,  $V_{OUT} = 1.2V$ ,  $I_{OUT} = 2A$ )

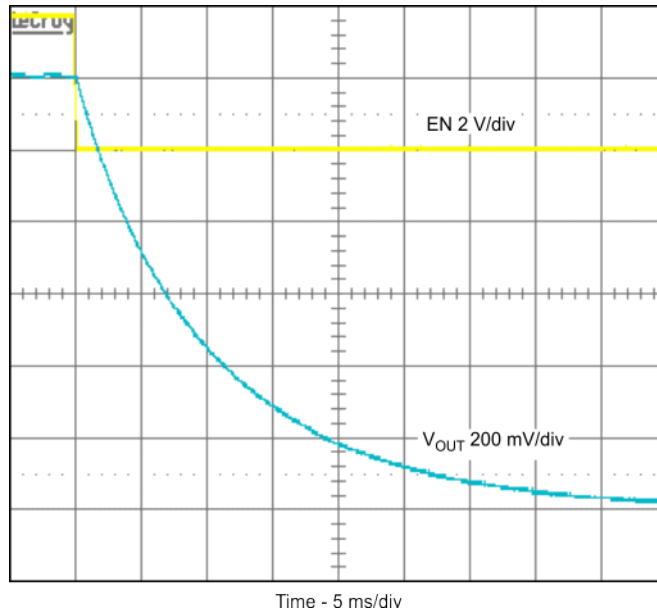


Figure 7. Shutdown ( $V_{IN} = 3.6V$ ,  $V_{OUT} = 1.2V$ ,  $I_{OUT} = 0$ , active output capacitor discharge enabled)

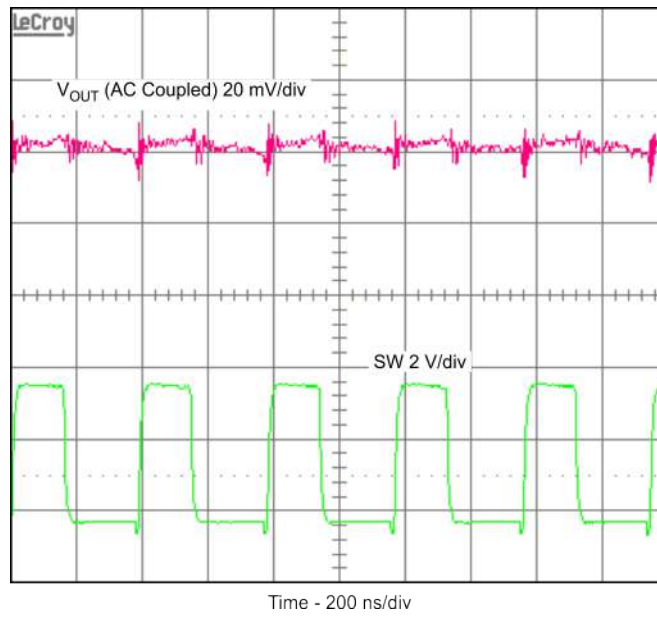


Figure 8. Output Voltage Ripple ( $V_{IN} = 3.6V$ ,  $V_{OUT} = 1.2V$ ,  $I_{OUT} = 4A$ )

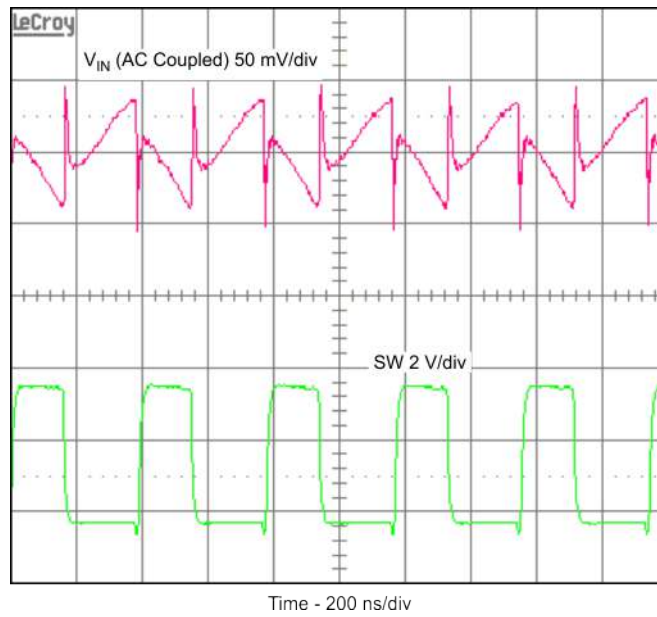
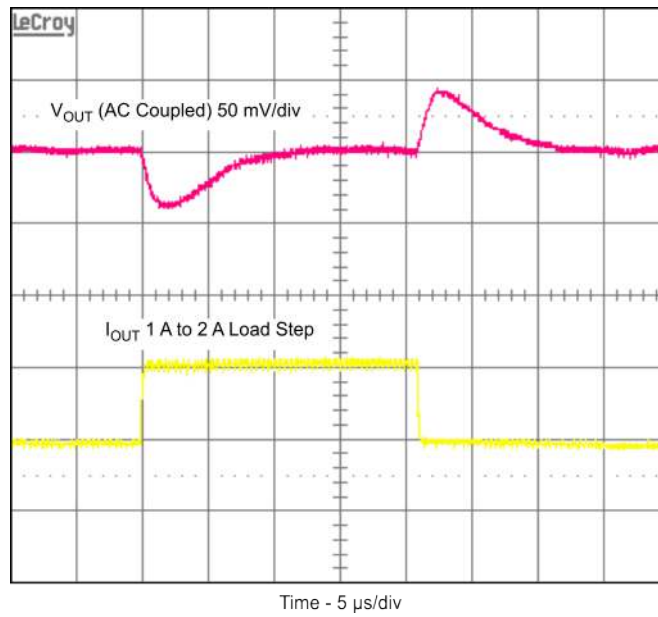


Figure 9. Input Voltage Ripple ( $V_{IN} = 3.6V$ ,  $V_{OUT} = 1.2V$ ,  $I_{OUT} = 4A$ )



**Figure 10. Load Transient Response ( $V_{IN} = 3.6V$ ,  $V_{OUT} = 1.2V$ ,  $I_{OUT} = 1A$  to  $2A$  step)**

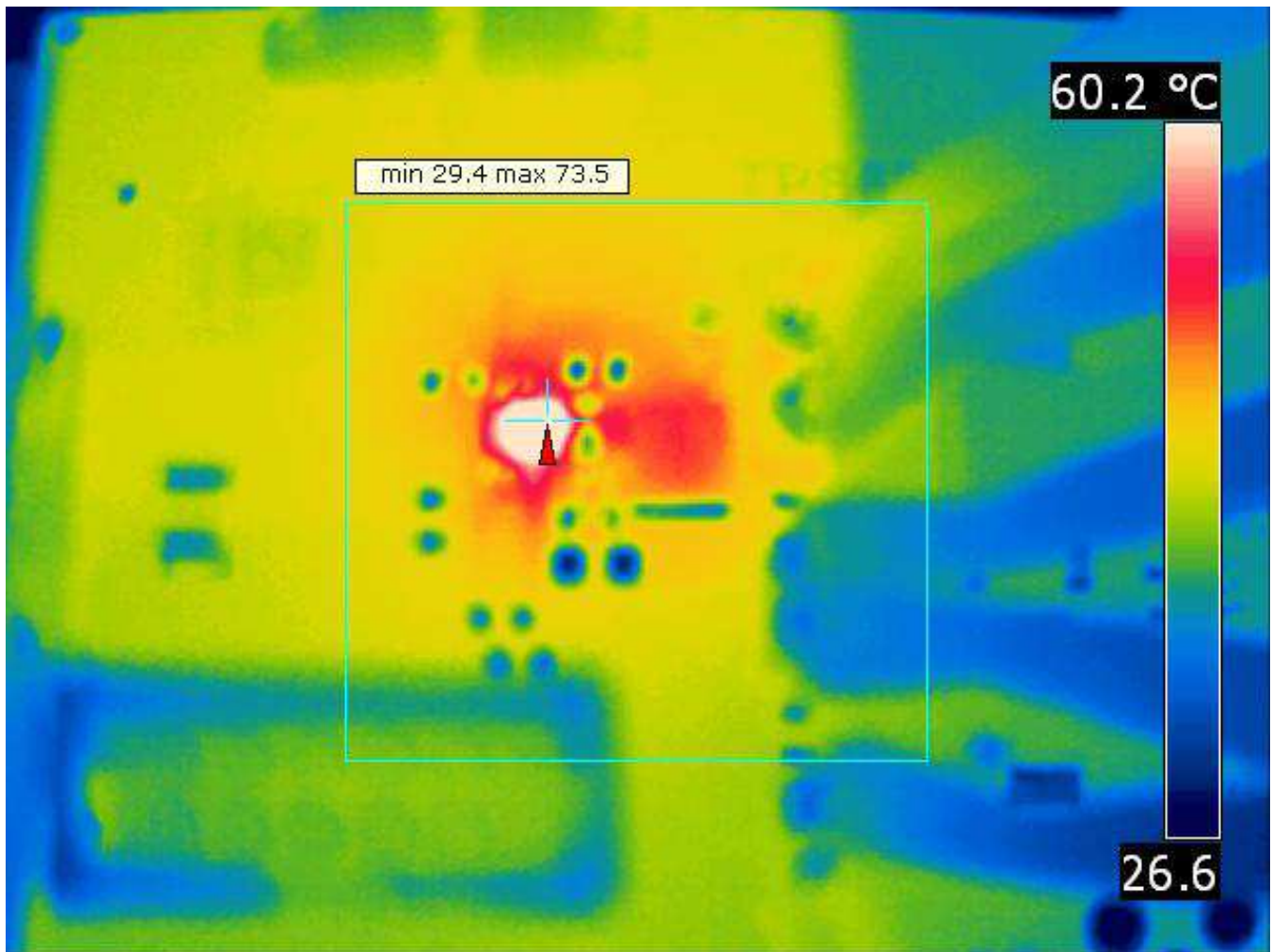


Figure 11. Thermal Performance ( $V_{IN} = 3.6V$ ,  $V_{OUT} = 1.2V$ ,  $I_{OUT} = 4A$ )

## 6 Board Layout

This section provides the TPS62366AEVM-757 board layout and illustrations.

Board layout is critical for all high-frequency, switch-mode power supplies. Figure 12 through Figure 15 show the board layout for the TPS62366AEVM-757 PCB. The nodes with high-switching frequencies and currents are kept as short as possible to minimize trace inductance. Careful attention has been given to the routing of high-frequency current loops and a single-point grounding scheme is used. Also, the majority of the heatsinking for this device occurs through the top layer traces and vias pulled from the IC's solder bumps that carry high currents. See the data sheet for specific layout guidelines.

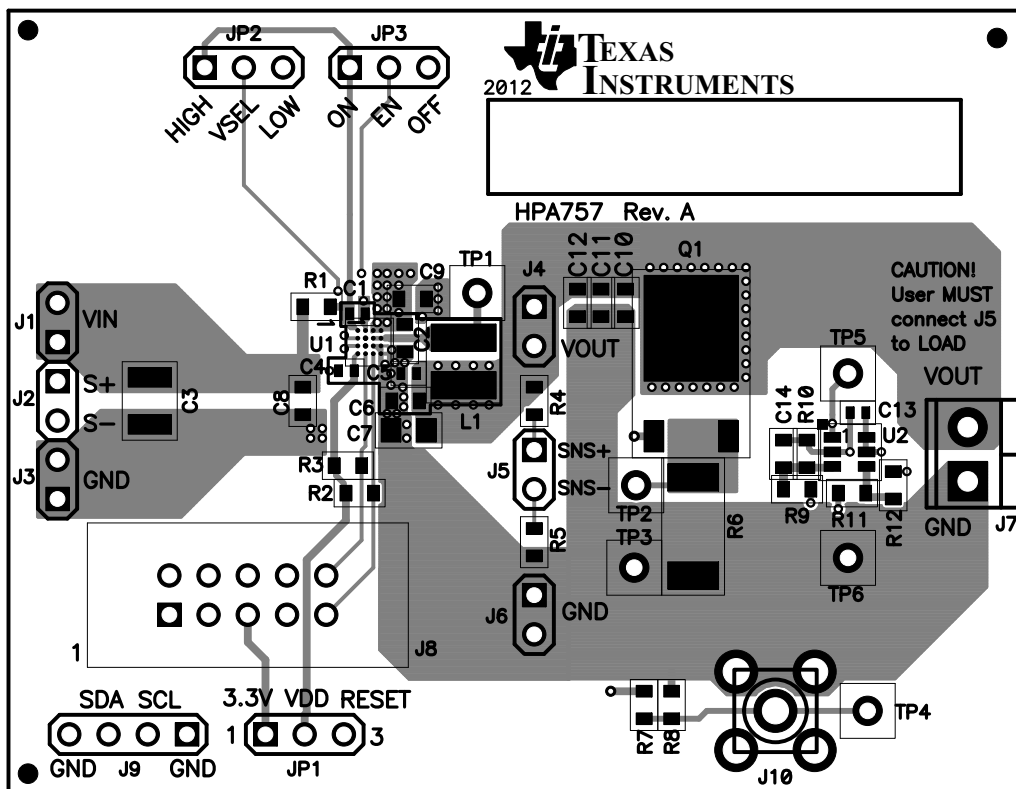


Figure 12. Assembly Layer

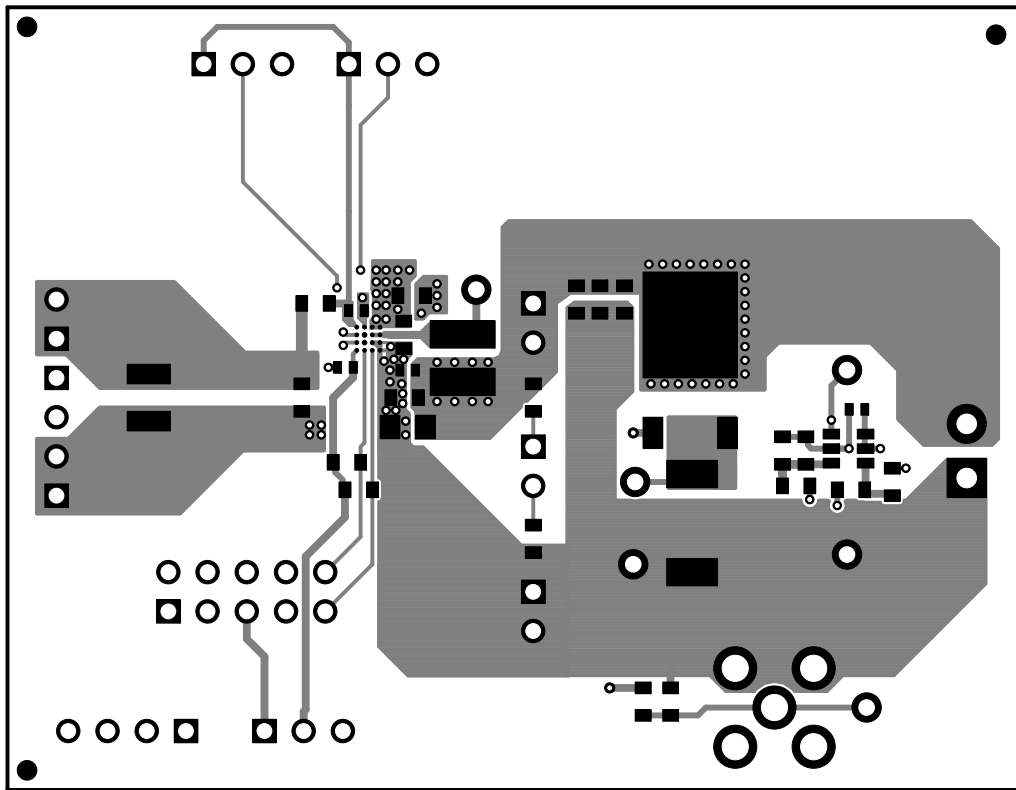


Figure 13. Top Layer

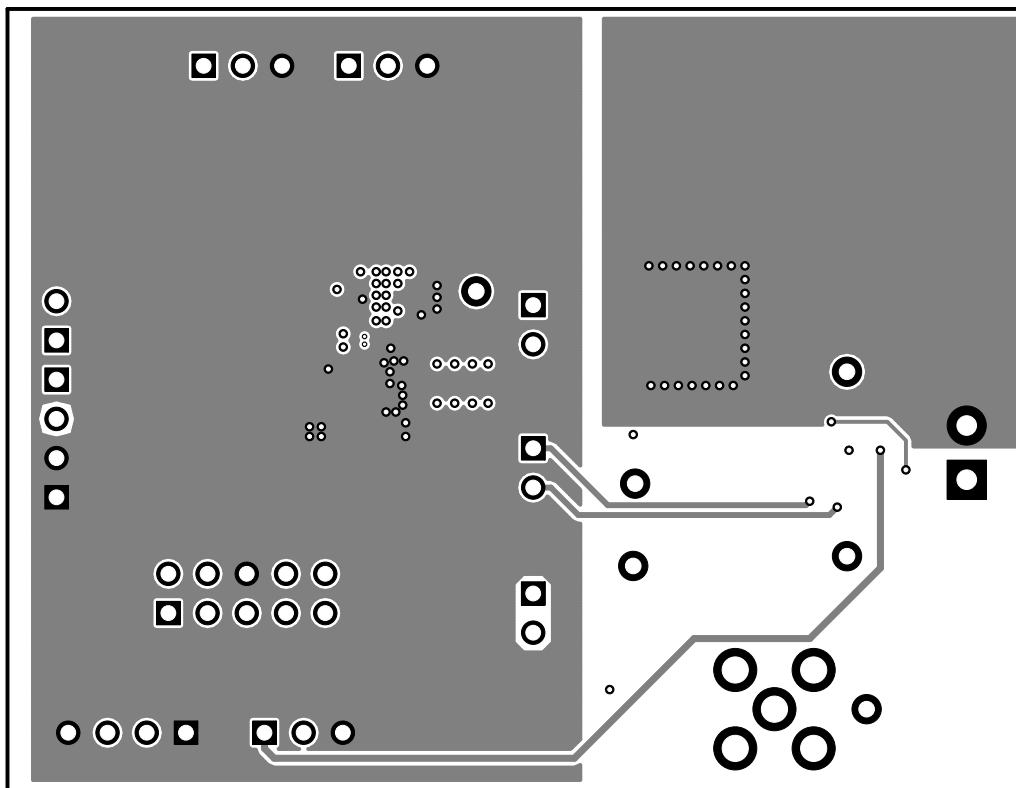


Figure 14. Layer 2



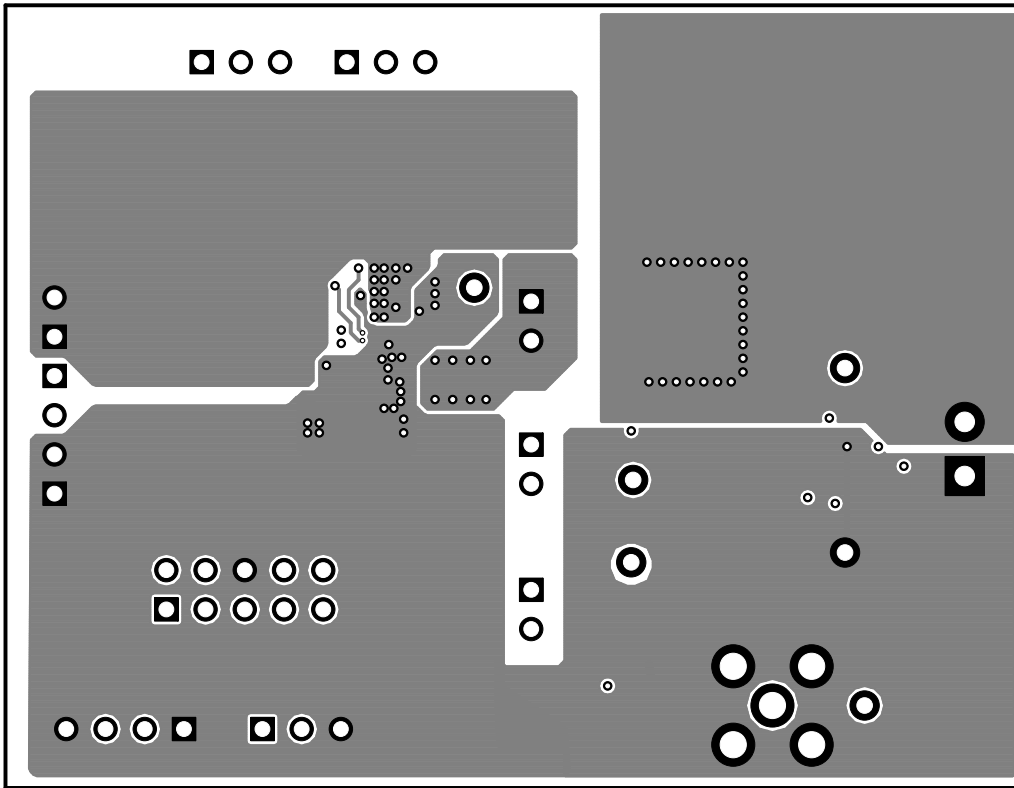


Figure 15. Layer 3

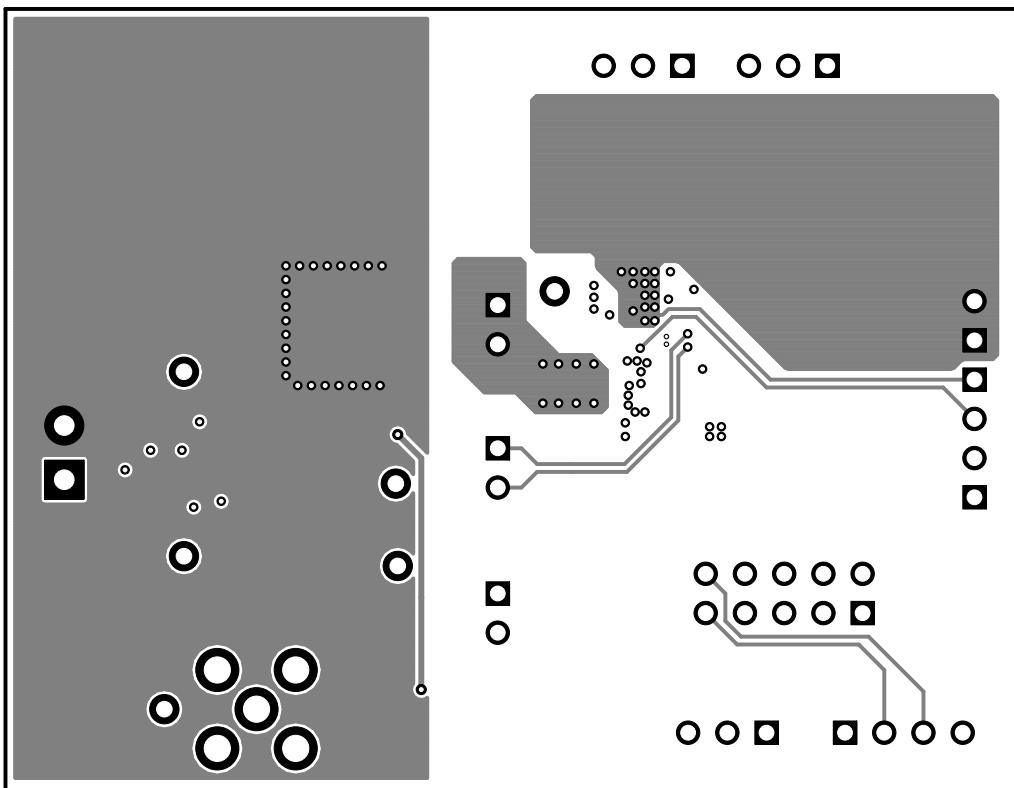
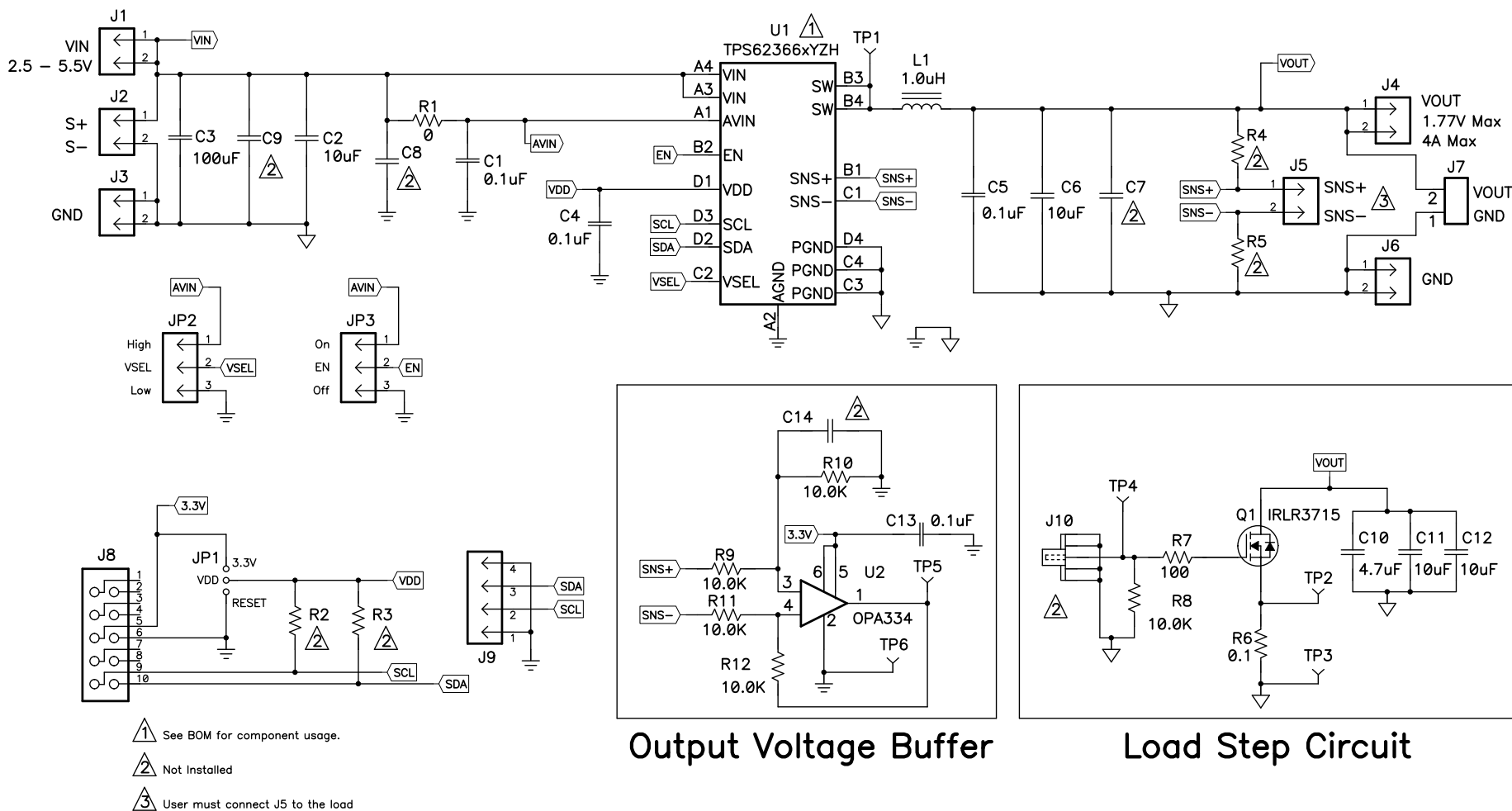


Figure 16. Bottom Layer

## 7 Schematic and Bill of Materials

This section provides the TPS62366AEVM-757 schematic and bill of materials. The bill of materials is provided in two tables. [Table 3](#) are the components required to build the TPS62366A solution. [Table 4](#) are the components used only to evaluate the TPS62366AEVM-757 solution.

### 7.1 Schematic



Output Voltage Buffer

Load Step Circuit

Figure 17. TPS62366AEVM-757 Schematic

## 7.2 Bill of Materials

**Table 3. TPS62366A Solution Required Components**

Count -001	RefDes	Value	Description	Size	Part Number	MFR
3	C1, C4, C5	0.1 $\mu$ F	Capacitor, Ceramic, 10V, X5R, 20%	0402	Std	Std
2	C2, C6	10 $\mu$ F	Capacitor, Ceramic, 6.3V, X5R, 20%	0603	Std	Std
1	L1	1.0 $\mu$ H	Inductor, Power, 5.4 A, 10.8 m $\Omega$ , $\pm$ 20%	4 mm x 4 mm	XFL4020-102ME	Coilcraft
1	U1	TPS62366AYZH	IC, 4A Processor Supply Converter	2 mm x 2 mm	TPS62366AYZH	TI

**Table 4. TPS62366AEVM-757 Evaluation Components**

Count -001	RefDes	Value	Description	Size	Part Number	MFR
1	C3	100 $\mu$ F	Capacitor, Ceramic, 6.3V, X5R, 20%	1210	Std	Std
0	C7	Open	Capacitor, Ceramic, 6.3V, X5R, 20%	0805	Std	Std
0	C8, C9	Open	Capacitor, Ceramic, 6.3V, X5R, 20%	0603	Std	Std
1	C10	4.7 $\mu$ F	Capacitor, Ceramic, 6.3V, X5R, 20%	0603	Std	Std
2	C11,C12	10 $\mu$ F	Capacitor, Ceramic, 6.3V, X5R, 20%	0603	Std	Std
1	C13	0.1 $\mu$ F	Capacitor, Ceramic, 10V, X5R, 20%	0402	Std	
0	C14	Open	Capacitor, Ceramic, 25V, X7R, 10%	0603	Std	Std
1	Q1	IRLR3715	MOSFET, N-ch, 20V, 49A, 11 m $\Omega$	DPAK	IRLR3715ZCPBF	IR
1	R1	0	Resistor, Chip, 1/10W	0603	Std	Std
0	R2, R3, R4, R5	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	0.1	Resistor, Chip, 1W, 1%	2512	Std	Std
1	R7	100	Resistor, Chip, 1/16W, 1%	0603	Std	Std
5	R8, R9, R10, R11, R12	10.0K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U2	OPA334	IC, 0.05 $\mu$ V/ $^{\circ}$ C Max, Single Supply Op Amp, Zero-Drift	SOT23-6	OPA334AIDBV	TI

## 7.3 Related Documentation From Texas Instruments

4A Processor Supply with  $\mu$ C Compatible Interface and Remote Sense data sheet ([SLUSAX3](#))

## EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

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

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.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit [www.ti.com/esh](http://www.ti.com/esh) or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

## 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.

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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.

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

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Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit [www.ti.com/esh](http://www.ti.com/esh) or contact TI.

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### General Statement for EVMs including a radio

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### 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.

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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**

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3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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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.

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

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