

AN-2134 LMZ13610/8/6 and LMZ12010/8/6 Evaluation Board

1 Introduction

The LMZ13610/8/6 and LMZ12010/8/6 SIMPLE SWITCHER® power modules are easy-to-use DC-DC solution capable of driving up to a 10, 8 or 6 ampere load. They are available in an innovative package that enhances thermal performance and allows for hand or machine soldering. The LMZ13610/8/6 can accept an input voltage rail between 6V and 36V and the LMZ12010/8/6 can accept an input voltage rail between 6V and 20V.

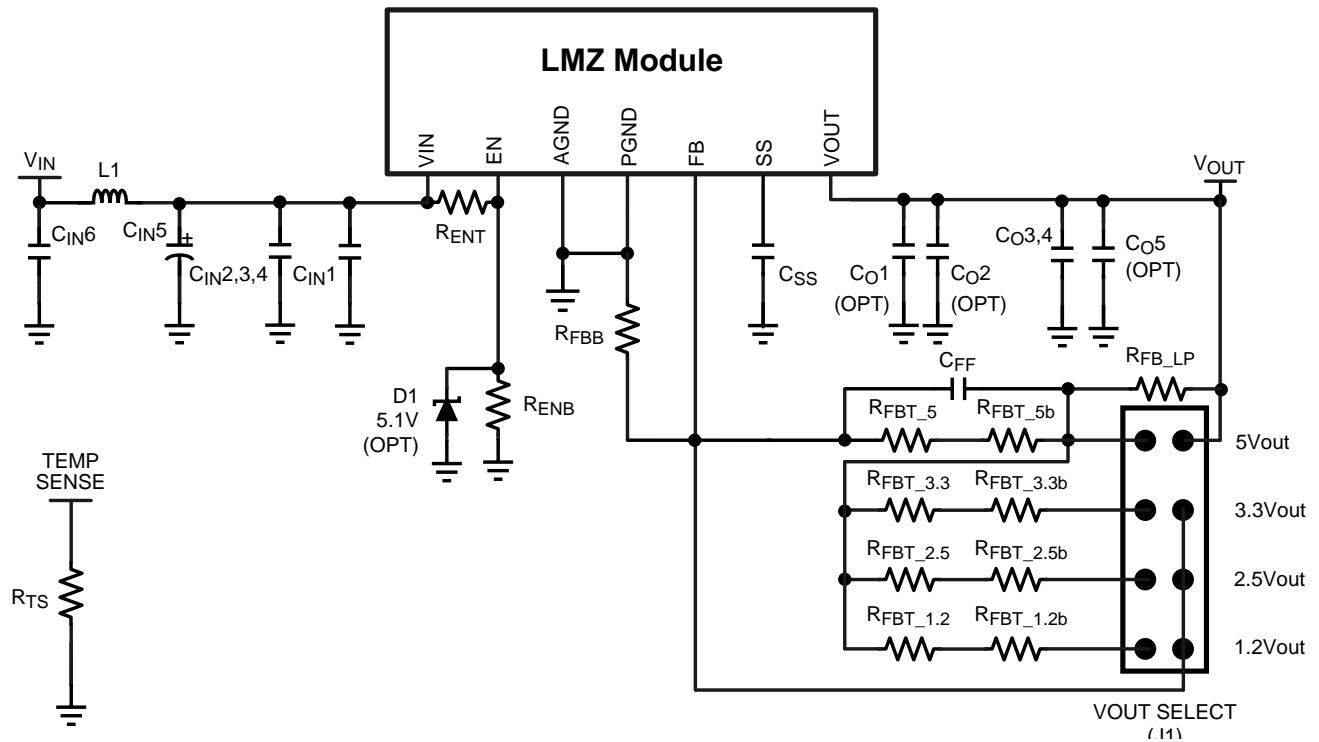
The evaluation board is highly configurable. The output voltage can be adjusted to 5V, 3.3V, 2.5V or 1.2V with a jumper change. The external soft-start capacitor facilitates a controlled and adjustable startup rise time of the output. The board temperature can be measured with the onboard resistor and the UVLO can be adjusted by changing one resistor. In addition the board comes preconfigured with an LC input filter to pass CISPR-22 class B conducted and radiated emissions.

The LMZ13610 and LMZ12010 family is a reliable and robust solution with the following features: loss-less cycle-by-cycle valley current limit to protect for over current or short-circuit fault, thermal shutdown, input under-voltage lockout, and will start up into a pre-biased output.

2 Board Specifications

- V_{IN} = 6V to 36V (LMZ13610/8/6)
- V_{IN} = 6V to 20V (LMZ12010/8/6)
- V_{OUT} = 1.2V, 2.5V, 3.3V or 5V (minimum input voltage of 7V required for 5V output)
- I_{OUT} = 0 to 10, 8, or 6 Amps
- θ_{JA} = 9.9 °C / W, θ_{JC} = 1.0 °C/W
- Designed on four layers; Inner are 1 oz copper; Outer are 2 oz copper.
- Measures 2.95" x 3.54" (75 mm x 90 mm) and is 62 mils (1.57 mm) thick of FR4 laminate material

For additional circuit considerations, including additional output voltage options, see the *Applications* section of the *LMZ13610 10A SIMPLE SWITCHER® Power Module with 36V Maximum Input Voltage* ([SNVS709](#)) or *LMZ12010 10A SIMPLE SWITCHER® Power Module with 20V Maximum Input Voltage* ([SNVS667](#)) data sheets. For negative output voltage connections, see *AN-2027 Inverting Application for the LMZ14203 SIMPLE SWITCHER Power Module* ([SNVA425](#)).


Figure 1. Simplified Schematic

3 Test Connections

The board should be connected to a power supply and load as shown below in [Figure 2](#). The EN post is connected to the UVLO circuit on the back of the board. There is a resistive divider implemented on the board that can be used to establish a precision UVLO level for the board that is currently set to 5.7V. A common user change to this circuit is to adjust the value of RENT and RENB to adjust the operating UVLO to that of the target application. For calculations, see the device-specific data sheet. Note that if in the end application the EN pin voltage does not exceed 5.5V at maximum V_{in} , then the enable clamp zener D1 can be omitted. (On revision A of the board the overlay for the zener diode has the cathode and anode incorrectly labeled). Pull EN low to shutdown the module.

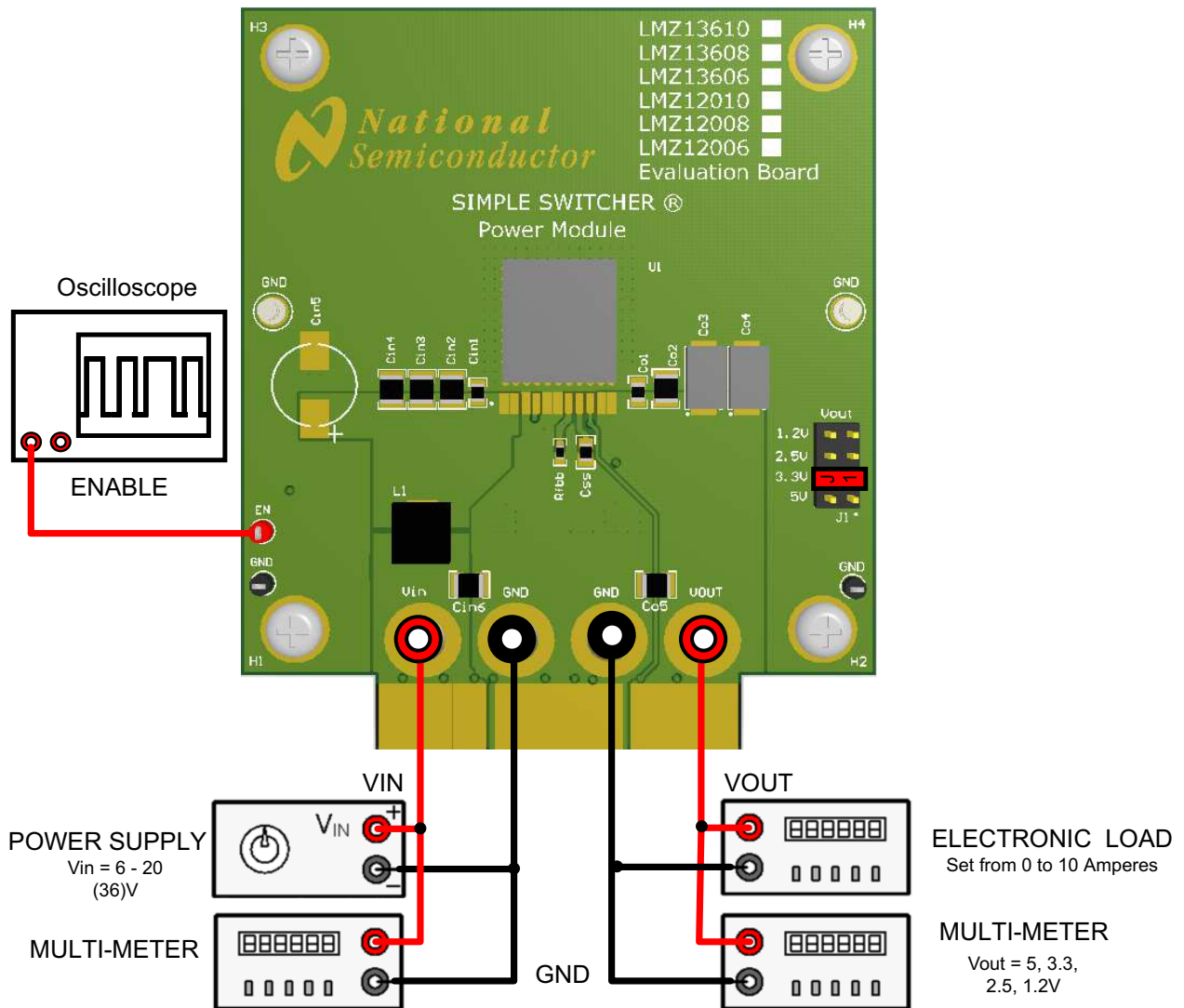
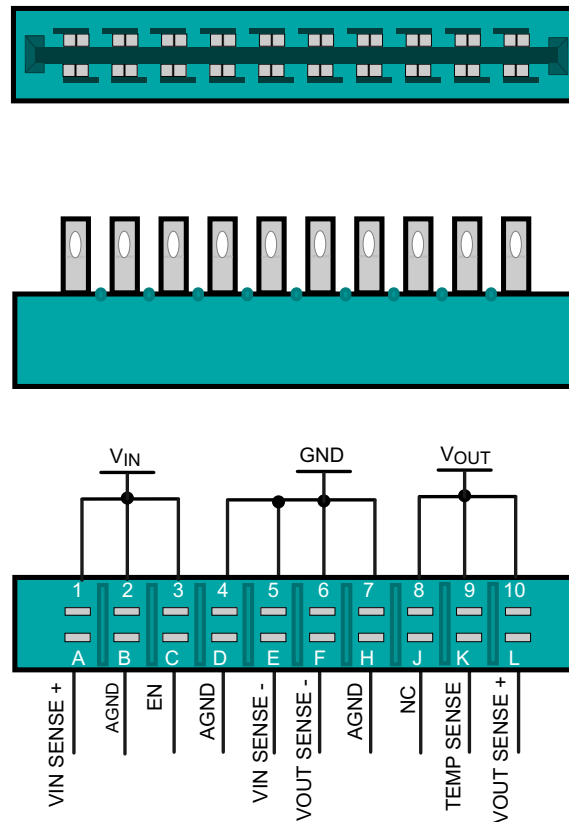


Figure 2. Board Connection Diagram


Figure 3. Edge Connector Diagram

The evaluation board is also compatible with the 20-pin edge connector shown in [Figure 3. Table 1](#) explains the functionality of the pins.

Table 1. Functionality of the Pins

Pin	Name	Description
1, 2, 3	VIN	Input supply — Nominal operating range is from 6V to 20V for the LMZ12010/8/6 and from 6V to 36V for the LMZ13610/8/6.
4, 5, 6, 7	GND	Power Ground — Electrical path for the power circuits within the module.
8, 9, 10	VOUT	Output Voltage — Regulated 5, 3.3, 2.5 or 1.2V.
A	VIN SENSE +	Positive Kelvin Sense of Input voltage — Tied to VIN pin of the LMZ module.
E	VIN SENSE -	Negative Kelvin Sense of Input voltage — Tied to PGND (EP) of the LMZ module.
L	VOUT SENSE +	Positive Kelvin Sense of Output voltage — Tied to Vout banana jack.
F	VOUT SENSE -	Negative Kelvin Sense of Output voltage — Tied to AGND of the LMZ module.
B, D, H	AGND	AGND Ground — Tied to AGND pin of module.
J	NC	No Connect — This pin must remain floating, do not ground.
C	EN	Enable — Input to the precision enable comparator of the LMZ Module.
K	TEMP SENSE	Connected to top of the R _{ts} temperature sensing resistor. Temperature measurements can be made by measuring the temperature dependant resistance between TEMP SENSE and VIN SENSE -. Convert the resistance to temperature with the following equation: Temperature (C) \cong 2.6245 x Resistance (Ω) - 262.7

4 Adjusting the Output Voltage

The output voltage of the evaluation board is adjusted to either 5V, 3.3V, 2.5V, or 1.2V by moving jumper J1. For other voltage options see the data sheet for adjusting the feedback resistors.

5 Optional Components

The evaluation board has many options for input and output filtering. C_{O1} , C_{O2} and C_{O5} have been installed to decrease high frequency noise on the output. Their removal will not effect other performance parameters of the design. Similarly, C_{IN1} has been installed to provide a high frequency bypass for the input current. The second order filter consisting of $L1$ and C_{IN6} has been designed to provide enough attenuation of the conducted noise to comply with EN 55022. This filtering is not required for normal operation of the module.

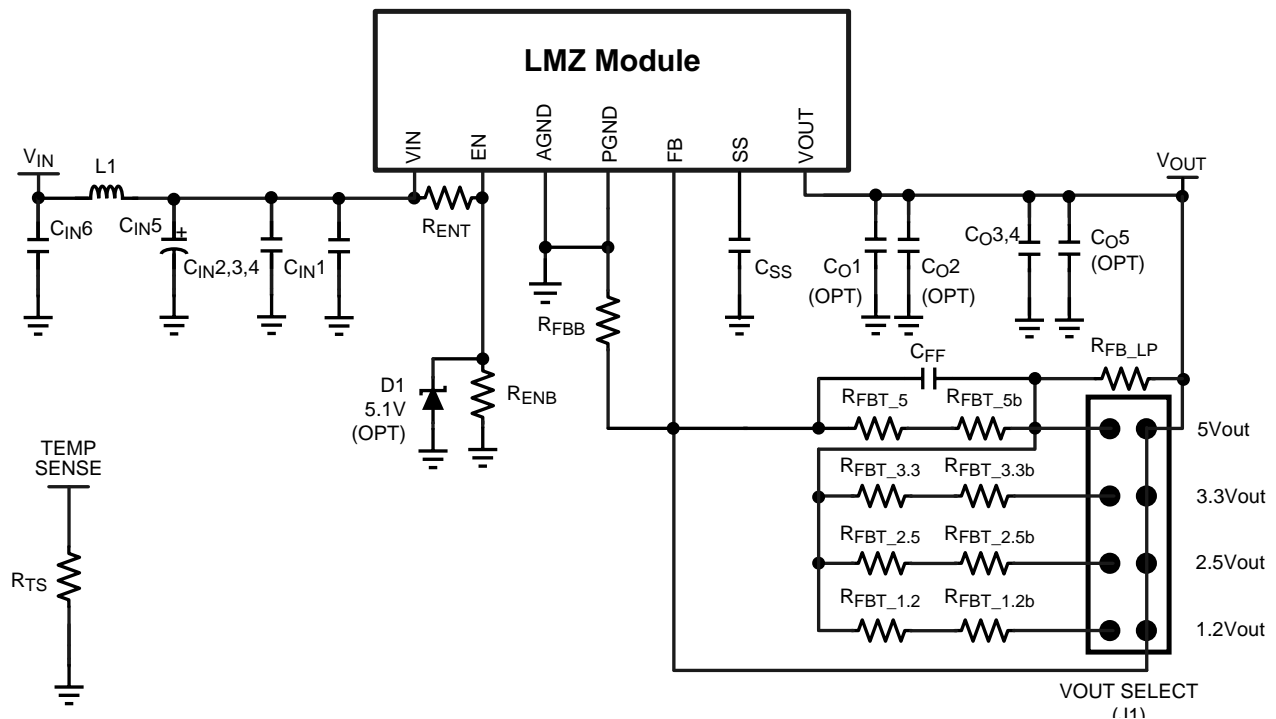


Figure 4. Evaluation Board Schematic

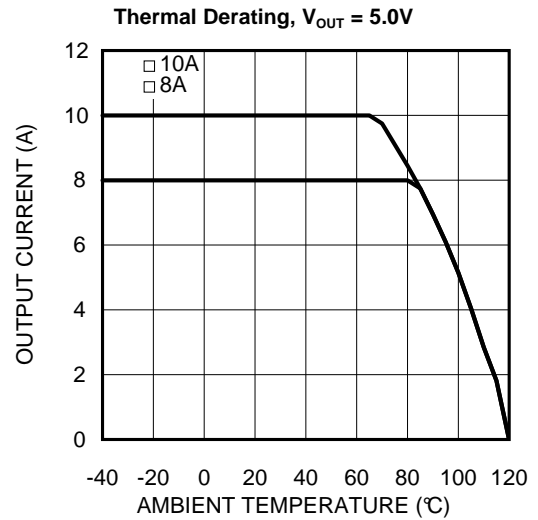
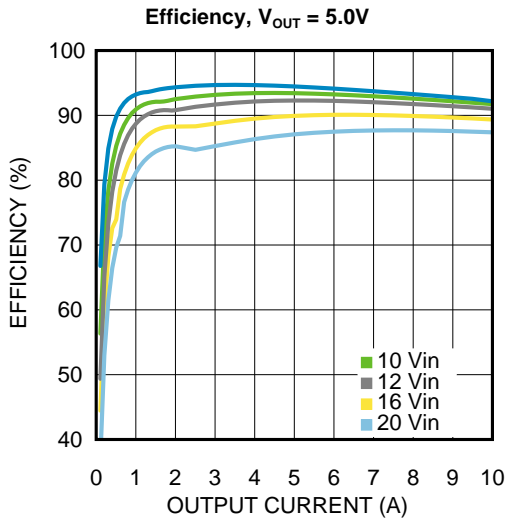
6 Bill of Materials
Table 2. Evaluation Board Bill of Materials, $V_{IN} = 6V$ to $36V$ (20V), $V_{OUT} = 1.2 / 3.3V / 5V$, $I_{OUT (MAX)} = 10/08/06A$

Designator	Description	Case Size	Manufacturer	Manufacturer P/N	Quantity
U1	SIMPLE SWITCHER	PFM-11	Texas Instruments	LMZ13610/LMZ13608/LMZ13606 or LMZ12010/LMZ12008/LMZ12006	1
Cin1 Co1 Co5	0.047uF, X7R, 50V	0805	Kemet	C0805C473K5RACTU	3
Cin2 Cin3 Cin4 Cin6	10 μ F, X7S, 50V	1210	TDK	C3225X7S1H106M	4
Cin5	150 μ F, Aluminum Electrolytic, 50V	G	Panasonic	EEE-FK1H151P	1
Co2	47uF, X5R, 10V	1210	Murata	GRM32ER61A476KE20L	1
Co3 Co4	330 μ F, 6.3V, 0.015 ohm,	2917	Kemet	T520D337M006ATE015	2
Cff	4700 pF, X7R, 50V	0805	Kemet	C0805C472K5RACTU	1
Css	0.15uF, X7R, 10V	0603	Murata	GRM188R71A154KA01D	2
L1	Shielded Drum Core, Powdered Iron, 3.3uH, 12A, 0.011 ohm		Würth	744314330	1
L1_alternate *used in conducted EMI measurement	Shielded Drum Core, 3.3uH, 0.011 ohm		Toko	892NAS-3R3M	
D1	4.7V, 500mW	SOD-123	Vishay	MMSZ4688-V-GS08	1
Rent	4.12k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08054K12FKEA	1
Renb	1.27k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08051K27FKEA	1
Rfbb	1.07k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08051K07FKEA	1
Rfbt_1.2	576 ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW0805576RFKEA	1
Rfbt_1.2b	9.53 ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08059R53FKEA	1
Rfbt_2.5	3.74k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08053K74FKEA	1
Rfbt_2.5b	84.5 ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW080584R5FKEA	1
Rfbt_3.3	8.06k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08058K06FKEA	1
Rfbt_3.3b	169 ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW0805169RFKEA	1
Rfbt_5	5.6k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08055K60FKEA	1
Rfbt_5b	73.2 ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW080573R2FKEA	1
RFB_LP	20 Ω	0805	Vishay-Dale	CRCW080520R0FKEA	1
Rts	100 ohm, Temp Sense Resistor	0805	Vishay	PTS08051B100RP 100	1
EN	Test Point, TH, Miniature, Red		Keystone Electronics	5000	1
GND GND	Test Point, TH, Miniature, Black		Keystone Electronics	5001	2
GND GND VIN VOUT	Banana Jack Connector		Keystone Electronics	575-8	4
SH-1	Shunt, 100mil, Gold plated, Black		Amp	382811-6	1

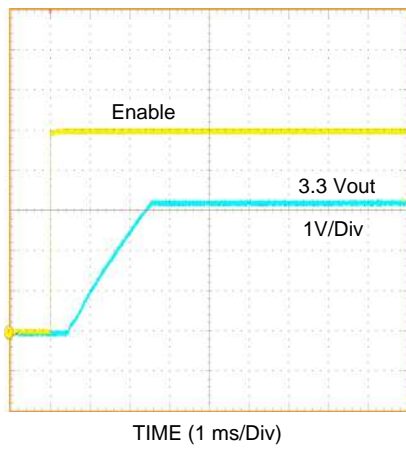
Table 2. Evaluation Board Bill of Materials, $V_{IN} = 6V$ to $36V$ (20V), $V_{OUT} = 1.2 / 3.3V / 5V$, $I_{OUT (MAX)} = 10/08/06A$ (continued)

Designator	Description	Case Size	Manufacturer	Manufacturer P/N	Quantity
H1 H2 H3 H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead		B and F Fastener Supply	NY PMS 440 0025 PH	4
H5 H6 H7 H8	Standoff, Hex, 0.5"L #4-40 Nylon		Keystone	1902C	4
J1	Header, 4x2, Gold plated, 230 mil above insulator	TH, 100mil	Samtec Inc.	TSW-104-07-G-D	1
J2	20-Pin Dual Edge Connector, 0.156" pitch		EDAC	305-020-500-202	0

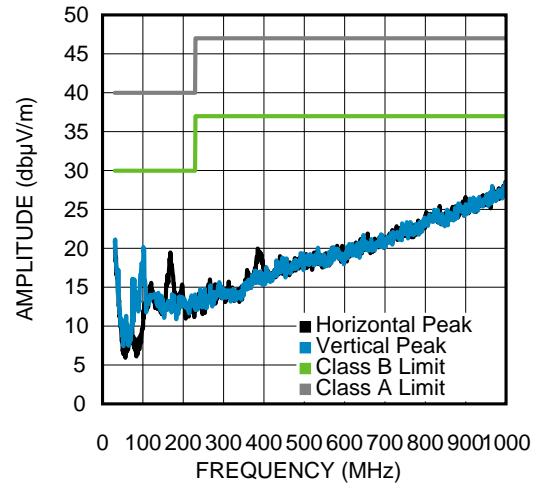
7 Performance Characteristics



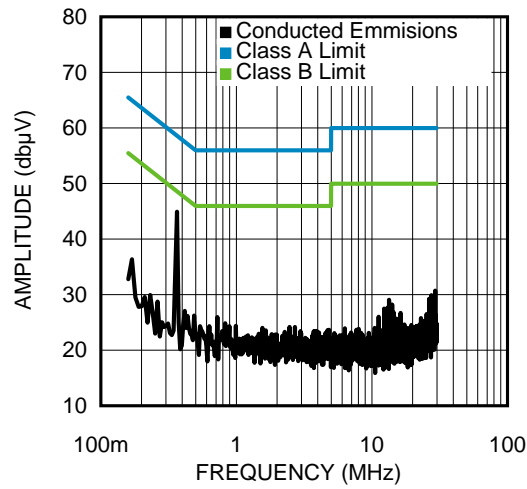
Startup, $V_{IN} = 12V$, $V_{OUT} = 3.3V$



Radiated EMI (EN 55022)
 $V_{IN} = 12V$, $V_{OUT} = 5.0V$, $I_{OUT} = 10A$



Conducted EMI (EN 55022) *L1_alternate
 $V_{IN} = 12V$, $V_{OUT} = 5.0V$, $I_{OUT} = 10A$



8 PCB Layout Diagrams

Gerber and CAD files can be downloaded from the associated product folder.

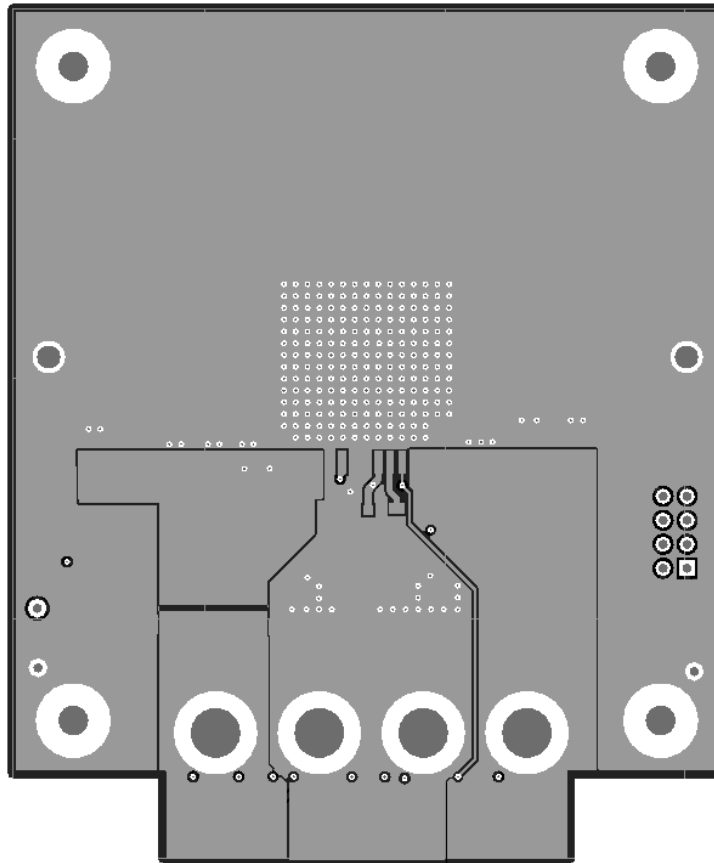
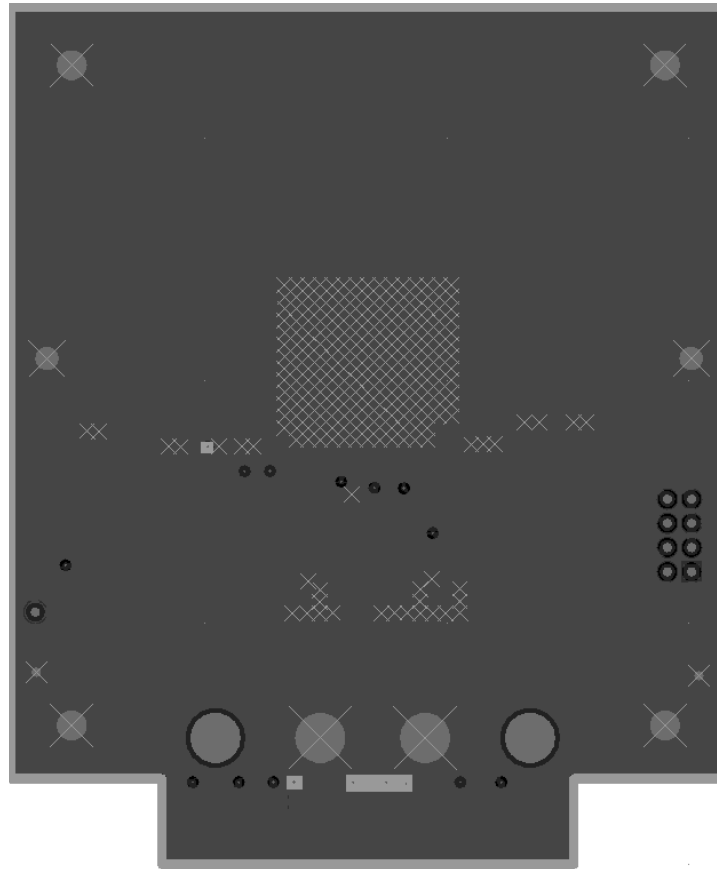
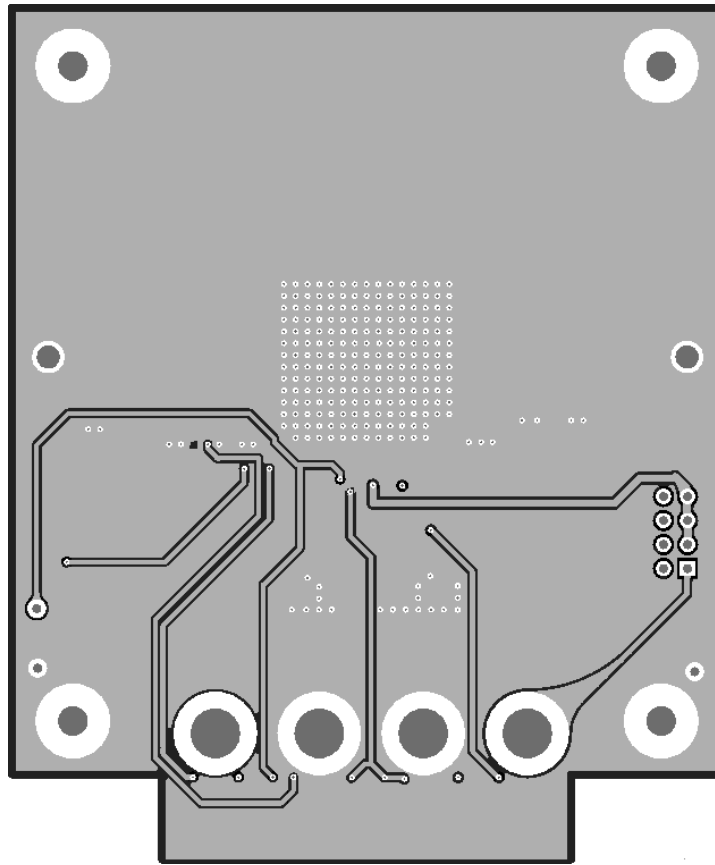


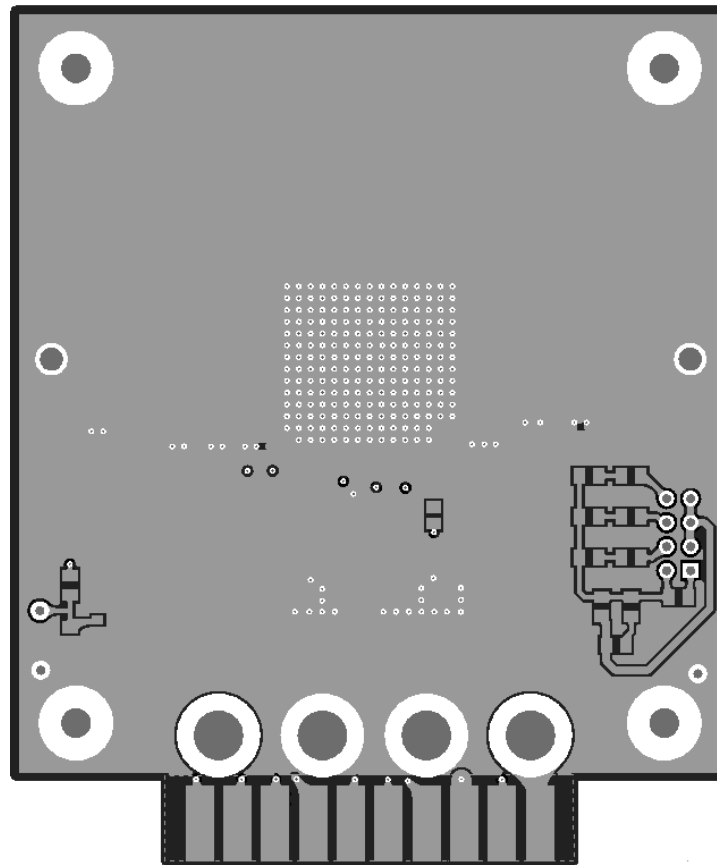
Figure 5. Top Layer



**Figure 6. Internal Layer I (Ground)
Heat Sinking Layer**



**Figure 7. Internal Layer II (Routing)
Heat Sinking Layer**



**Figure 8. Bottom Layer (Ground and Routing)
Heat Sinking Layer**

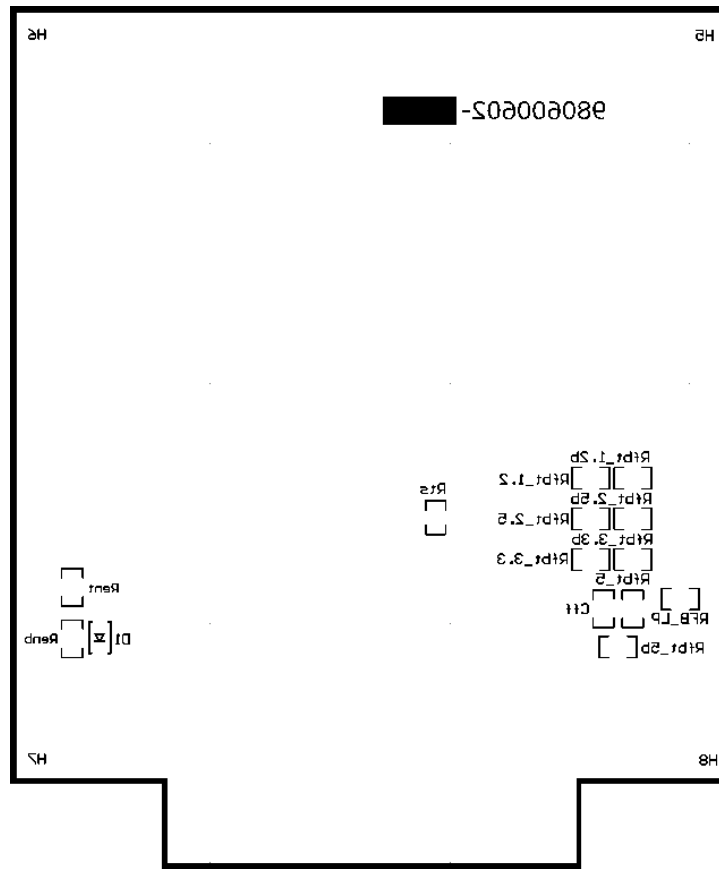


Figure 10. Bottom Silkscreen

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com