

AN-2093 LMZ23610/8/6 and LMZ22010/8/6 Current Sharing Evaluation Board

1 Introduction

The LMZ23610/8/6 and LMZ22010/8/6 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 LMZ23610/8/6 can accept an input voltage rail between 6V and 36V and the LMZ22010/8/6 can accept an input voltage rail between 6V and 20V.

The current sharing evaluation board is designed so that four modules can be easily connected to supply up to a 40 amp load. More can be connected as long as care is taken to not exceed the current capabilities of the banana plug connectors and the 5-amp per pin rating of the edge board connector.

The current sharing evaluation board is highly configurable. The output voltage can be changed 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. The UVLO can be adjusted by adding one resistor. To simplify the synchronization of the modules an onboard 555 timer provides an adjustable frequency clock from 350 to 600 kHz.

The LMZ23610 and LMZ22010 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 (LMZ23610/8/6)
- $V_{IN} = 6V$ to 20V (LMZ22010/8/6)
- $V_{OUT} = 1.2V, 2.5V, 3.3V$ or 5V (minimum input voltage of 7V required for 5V output)
- $I_{OUT} = 0$ to 10, 8, or 6 Amps
- $\theta_{JA} = 8.8\text{ }^{\circ}\text{C} / \text{W}$, $\theta_{JC} = 1.0\text{ }^{\circ}\text{C/W}$
- Designed on four layers; Inner are 2 oz copper; Outer are 2 oz copper.
- Measures 3.54" x 3.54" (90 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, refer to the *Applications* section of the *LMZ23610 10A SIMPLE SWITCHER® Power Module with 36V Maximum Input Voltage and Current Sharing* ([SNVS707](#)) or *LMZ22010 10A SIMPLE SWITCHER® Power Module with 20V Maximum Input Voltage and Current Sharing* ([SNVS687](#)) data sheets. For negative output voltage connections see *AN-2027 Inverting Application for the LMZ14203 SIMPLE SWITCHER® Power Module* ([SNVA425](#)).

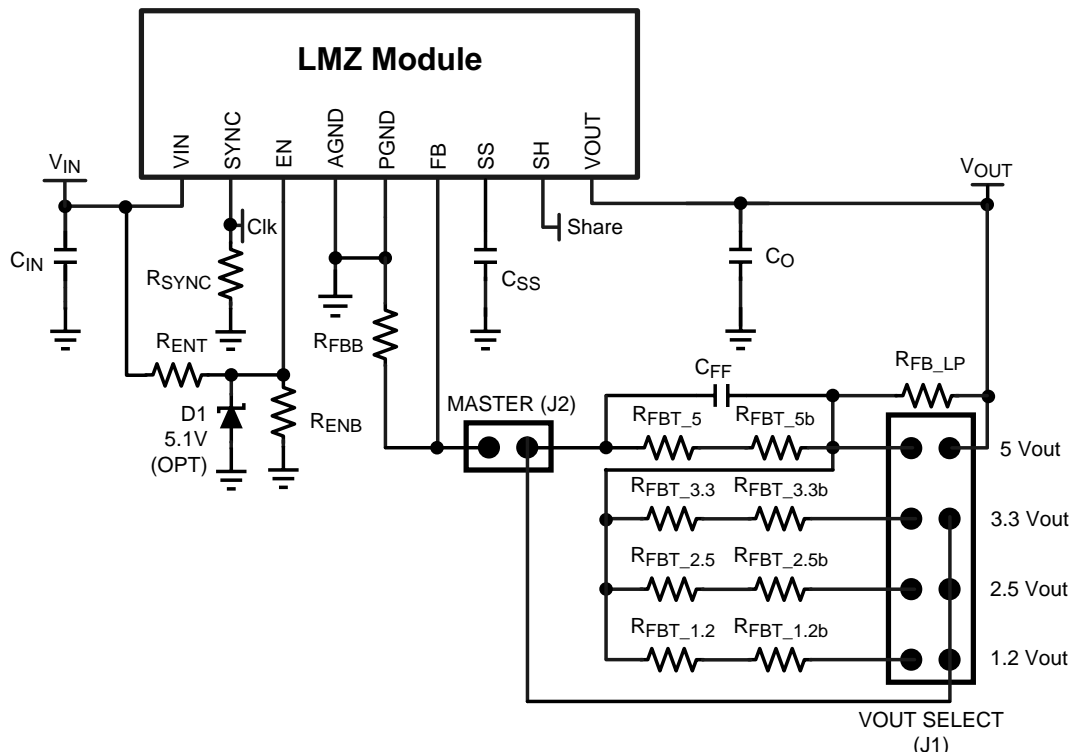


Figure 1. Simplified Schematic

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, with the bottom resistor unpopulated, that can be used to establish a precision UVLO level of the board. 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. Refer to the respective data sheet for calculation. Note that if in the end application the EN pin voltage does not exceed 5.5V at maximum Vin, then the enable clamp zener D1 can be omitted. Pull EN low to shutdown the module and clock circuitry.

The SYNC post is connected to the output of a 555 timer on the back of the board and is fed to the SYNC pin of the device. This clock is provided to simplify the testing of the current sharing features of the device and is not required for stand alone operation. The frequency of the clock can be adjusted from 350kHz to 600kHz using the potentiometer labeled R_freq_adj. Jumper J3 (SLAVE) can be used to disable the 555 timer and allow the use of external clocks from 314 to 600 kHz.

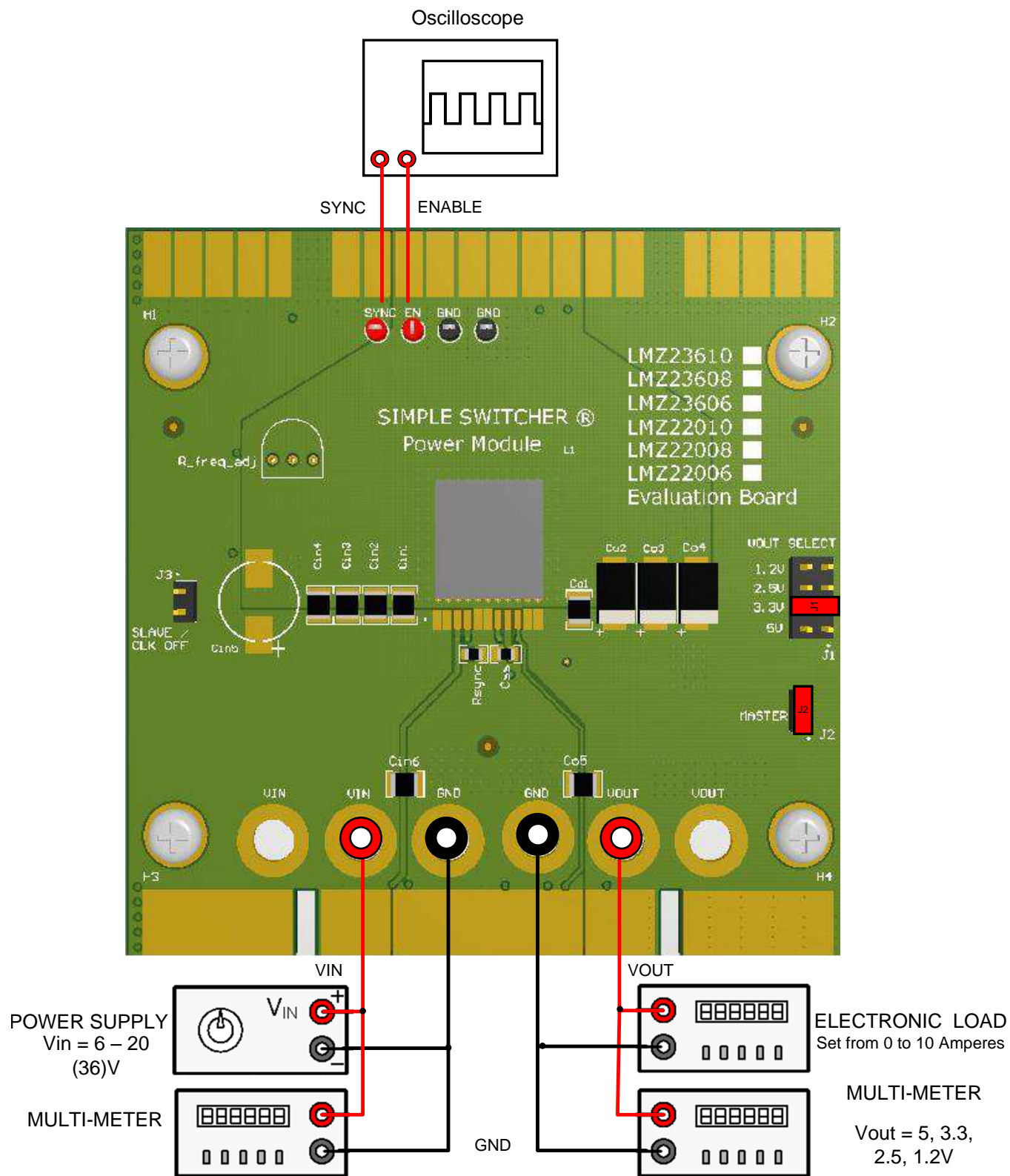


Figure 2. Board Connection Diagram

Edge Connector

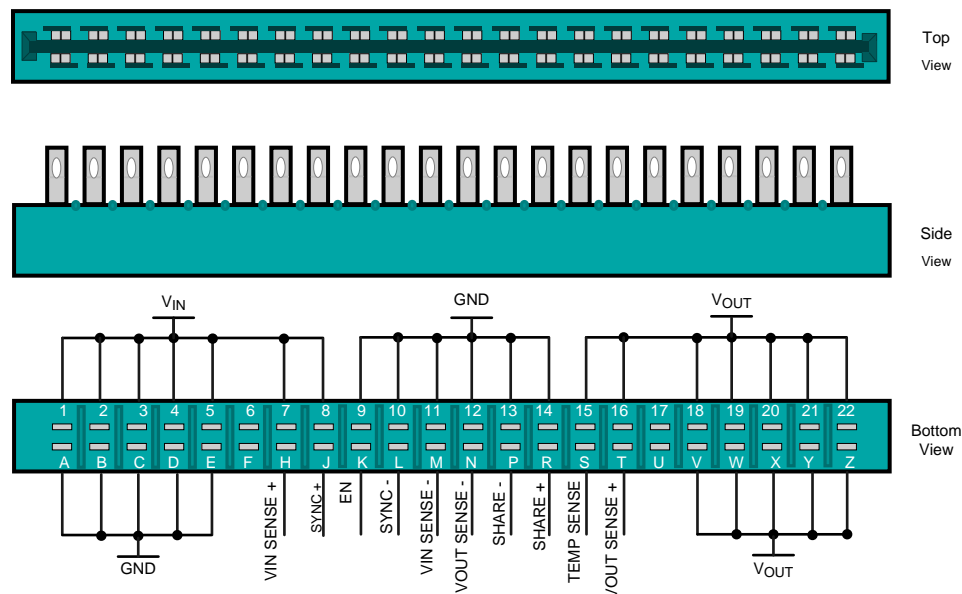


Figure 3. Edge Connector Diagram

The evaluation board is also compatible with the 44-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, 4, 5, 7, 8	VIN	Input supply — Nominal operating range is from 6V to 20V for the LMZLMZ22010/8/6 and from 6V to 36V for the LMZLMZ23610/8/6.
9, 10, 11, 12, 13, 14, A, B, C, D, E	GND	Power Ground — Electrical path for the power circuits within the module.
15, 16, 18, 19, 20, 21, 22, V, W, X, Y, Z	VOUT	Output Voltage — Regulated 5, 3.3, 2.5 or 1.2V.
H	VIN SENSE +	Positive Kelvin Sense of Input voltage — Tied to VIN pin of the LMZ module.
M	VIN SENSE -	Negative Kelvin Sense of Input voltage — Tied to PGND (EP) of the LMZ module.
T	VOUT SENSE +	Positive Kelvin Sense of Output voltage — Tied to Vout banana jack.
N	VOUT SENSE -	Negative Kelvin Sense of Output voltage — Tied to AGND of the LMZ module.
J	SYNC +	Synchronization Positive Input — This is the positive probe point for viewing the clock generated by the 555 timer and is connected to the SYNC pin of the LMZ module. If the 555 timer is shutdown using J3 then an external clock can be used. The external clock must provide a CMOS logic level square wave whose frequency is between 314 kHz and 600 kHz.
L	SYNC -	Synchronization Negative Input — Tied to AGND of the LMZ module.
R	SHARE +	Share Positive Input — Connect this pin to the share pin of other LMZ modules to share the load between the devices.
P	SHARE -	Share Negative Input — Tied to AGND of the LMZ module.
K	EN	Enable — Input to the precision enable comparator of the LMZ Module. Also tied to a pull-up resistor to enable the 5v bias supply and the 555 timer.
S	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) $\approx 2.6245 \times \text{Resistance } (\Omega) - 262.7$

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 Current Sharing

Current sharing is easy to evaluate. The next steps should be implemented only while the power to the device is off.

Select which board will be the master. This is usually the board closer to the load. Connect the master board as described above in Test Connections. Insert the slave board into the socket on the master. If there is no socket, connect a 44-pin board-edge extender to the top of the master board and solder the pins. The board-edge connector will connect Vin, Gnd, Vout, Enable, Sync and the Share pin between the boards to split the current demand between multiple boards.

On the slave board(s) remove the jumper J1 (MASTER) and move it to jumper J2 (SLAVE). This disconnects the FB pin of the slave converter(s) (J1) and disables the clock that is provided on the slave board (J2). The slave module's switching frequency will now be controlled by the clock on the master board. Turning the R_freq_adj pot counter clockwise lowers the clock frequency and turning the pot clockwise increases the frequency. By placing an additional jumper on J3 (SLAVE) of the master board, the 555 timer is disabled on both boards. With the clock disabled you can observe the parts performance when the devices are not synchronized, or you can supply an external clock through the SYNC post. J3 must be in place (555 disabled) on all boards to use an external clock on sync. The Sync pin of the slave can also be disconnected from the master board by removing the RSHORT resistor. This allows the user to provide a multiphase clock of their choosing to the boards.

The advantage to running the clocks out of phase is to reduce the current stress on the input and output capacitors. For two modules the clocks should be run 180 degrees out of phase, for three modules the clocks should be run 120 degrees out of phase and so on. Although local input bypass capacitors are still required, the bulk capacitance required for a given ripple voltage can be greatly reduced.

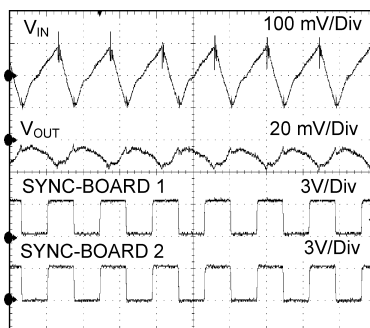


Figure 4. Output Voltage Ripple with Two Boards Synchronized to 350Khz

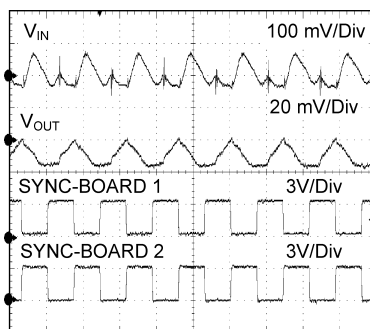


Figure 5. Output Voltage Ripple with Two Boards Synchronized with 180° Phase Shift

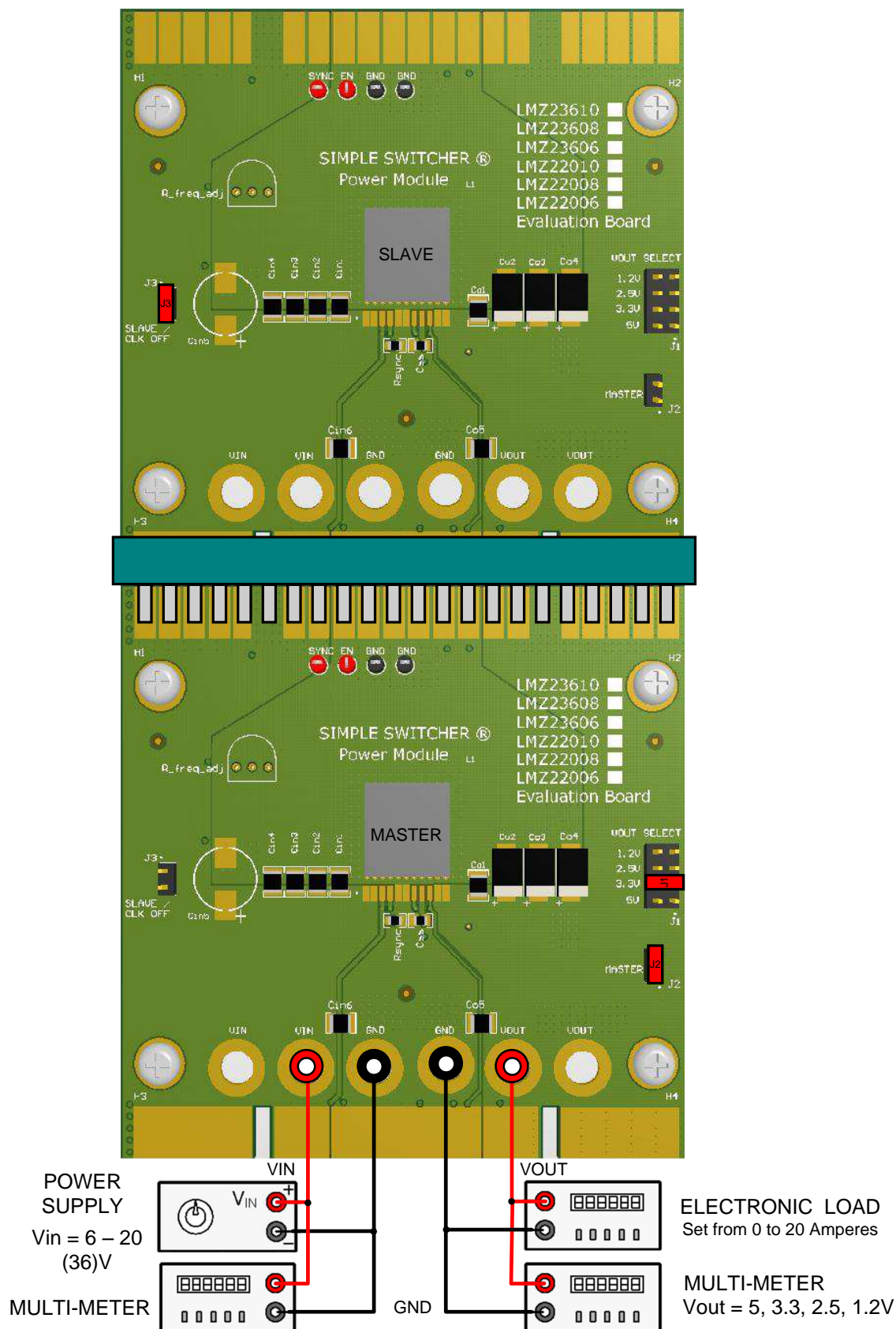


Figure 6. Master Slave Connection

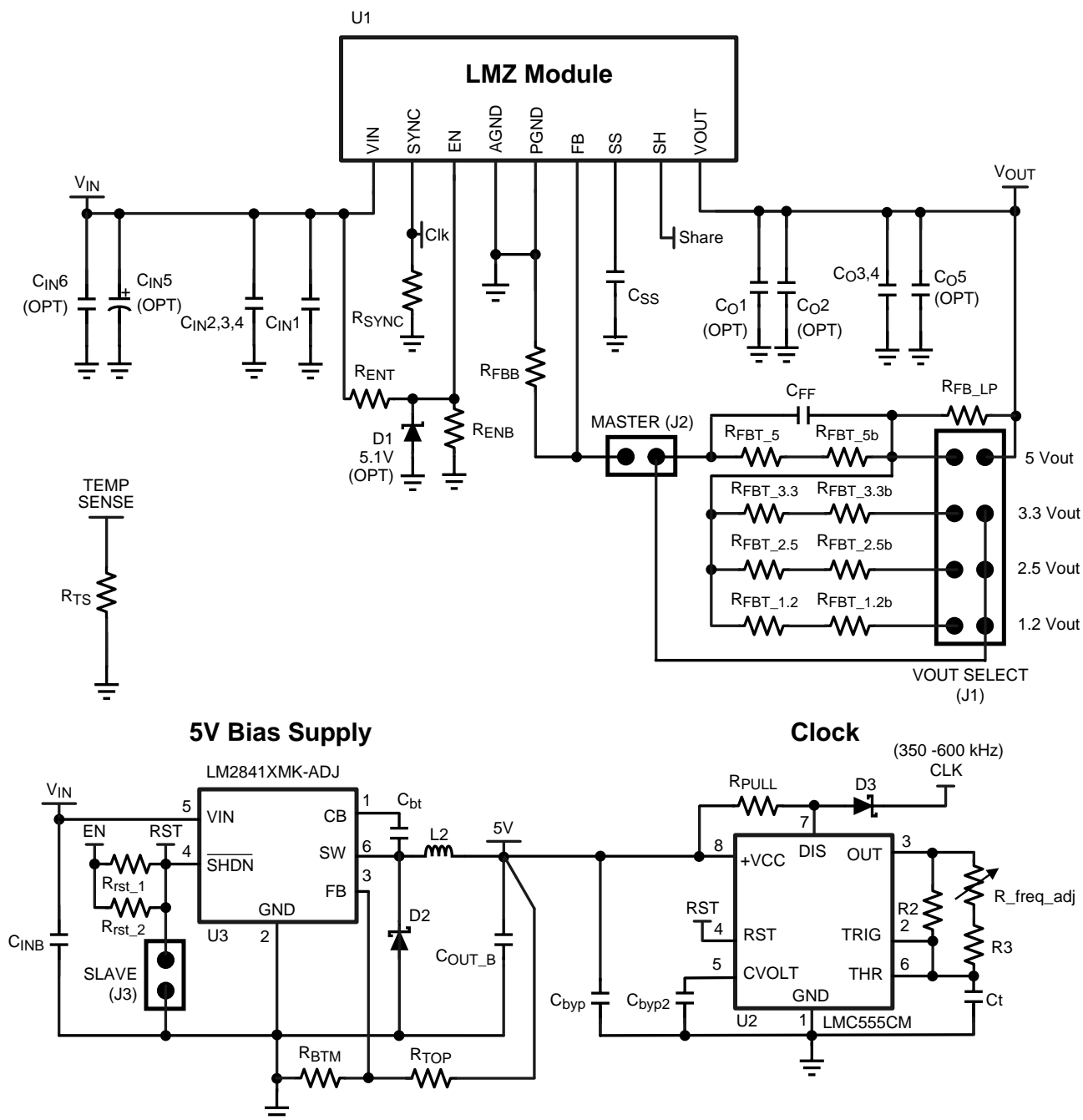


Figure 7. Evaluation Board Schematic

6 Bill of Materials

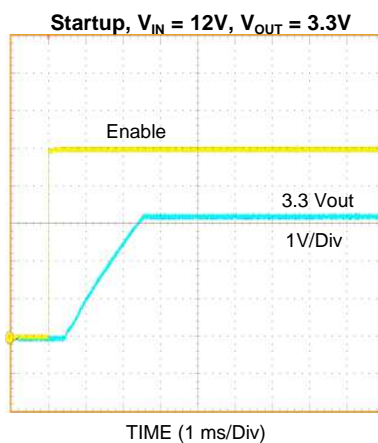
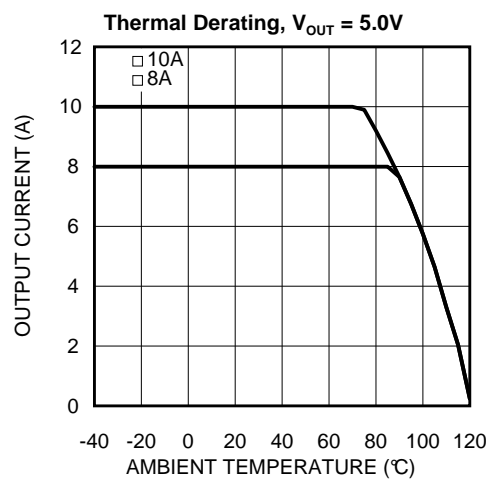
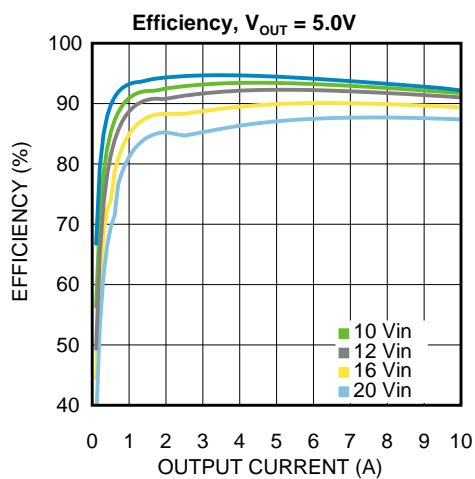
Table 2. Current Sharing Evaluation Board Bill of Materials, $V_{IN} = 6V$ to $36V$ (20V), $V_{OUT} = 1.2 / 3.3V / 5V$, $I_{OUT (MAX)} = 10/08/06A$

Designator	Description	Case Size	Manufacturer	Manufacturer P/N	Quantity
U1	SIMPLE SWITCHER®	TO-PMOD-11	Texas Instruments	LMZ23610/08/06 or LMZ22010/08/06	1
U2	Timer, 8-pin Narrow SOIC, Pb-Free	TSSOP-8	Texas Instruments	LMC555CM/NOPB	1
U3	300 mA/600 mA up to 42V Input Step-Down DC/DC Regulator	SOT23	Texas Instruments	LM2841XMK-ADJL/NOPB	1
Cin1 Cin6 Co1 Co5	0.047µF, X7R, 50V	0805	Kemet	C0805C473K5RACTU	4
Cin_b Cin2 Cin3 Cin4	10 µF, X7S, 50V	1210	TDK	C3225X7S1H106M	4
Cin5	150 µF, Aluminum Electrolytic, 50V	G	Panasonic	EEE-FK1H151P	1
Co2 Cout_b	47µF, X5R, 10V	1210	Murata	GRM32ER61A476KE20L	2
Co3 Co4	330µF, 6.3V, 0.015 ohm,	2917	Kemet	T520D337M006ATE015	2
Cff	4700 pF, X7R, 50V	0805	Kemet	C0805C472K5RACTU	1
Css Cbt	0.15µF, X7R, 10V	0603	Murata	GRM188R71A154KA01D	2
Cbyp, Cbyp2	0.1µF, X7R, 50V	0805	TDK	C2012X7R1H104K	2
Ct	470pF, C0G/NP0, 50V	0805	AVX	08055A471FAT2A	1
D1	4.7V, 500mW	SOD-123	Vishay	MMSZ4688-V-GS08	1
D2	Diode, Schottky, 40V, 1A	SMA	Diodes Inc.	B140-13-F	1
D3	Diode, Schottky, 20V, 1A	SOD_123FL	ON Semiconductor	MBR120LSFT1G	1
Rent Rrst2 Rsync	1.0k ohm, 5%, 0.125W	0805	Vishay-Dale	CRCW08051K00JNEA	1
Renb	Not Populated	0805			0
Rtop	5.62k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08055K62FKEA	1
Rbtm	1.02k ohm, 1%, 0.125W,	0805	Vishay-Dale	CRCW08051K02FKEA	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

Table 2. Current Sharing 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
Rpull	200 ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW0805200RFKEA	1
Rshrt	0 ohm, 5%, 0.125W	0805	Vishay-Dale	CRCW08050000Z0EA	1
Rts	100 ohm, Temp Sense Resistor	0805	Vishay	PTS08051B100RP 100	1
R_freq_adj	ADJ, 100K ohm, 0.5W	Round - 0.350" Dia x 0.150" H	Bourn	3352T-1-104LF	1
R2 R3	3.48k ohm, 1%, 0.125W	0805	Vishay-Dale	CRCW08053K48FKEA	2
L2	Inductor, Shielded Drum Core, Ferrite, 22uH, 0.7A, 0.155 ohm	SMD	Würth Elektronik	744043220	1
SYNC EN	Test Point, TH, Miniature, Red		Keystone Electronics	5000	2
GND GND	Test Point, TH, Miniature, Black		Keystone Electronics	5001	2
GND GND VIN VOUT	Banana Jack Connector		Keystone Electronics	575-8	6
J1	Header, 4x2, Gold plated, 230 mil above insulator	TH, 100mil	Samtec Inc.	TSW-104-07-G-D	1
J2 J3	Header, 2x1, Gold plated, 230 mil above insulator	TH, 100mil	Samtec Inc.	TSW-102-07-G-S	2
SH-1 SH-2 SH-3	Shunt, 100mil, Gold plated, Black		Amp	382811-6	3
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
J4	44-Pin Edge Connector		EDAC	305-044-555-201	1
Rrst1	Not Populated				0

7 Performance Characteristics



8 PCB Layout Diagrams

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

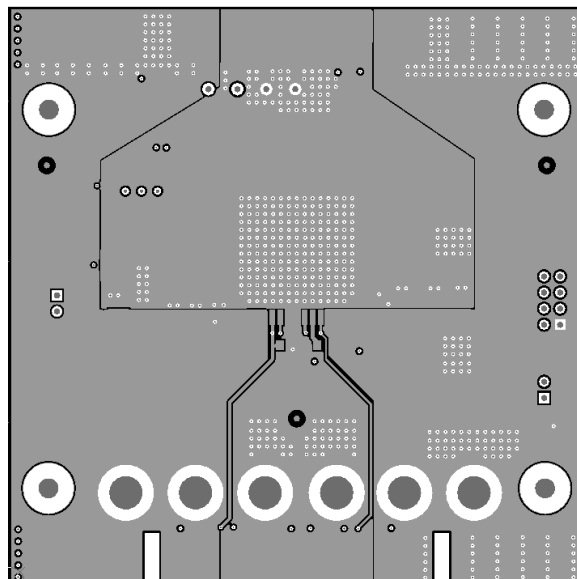
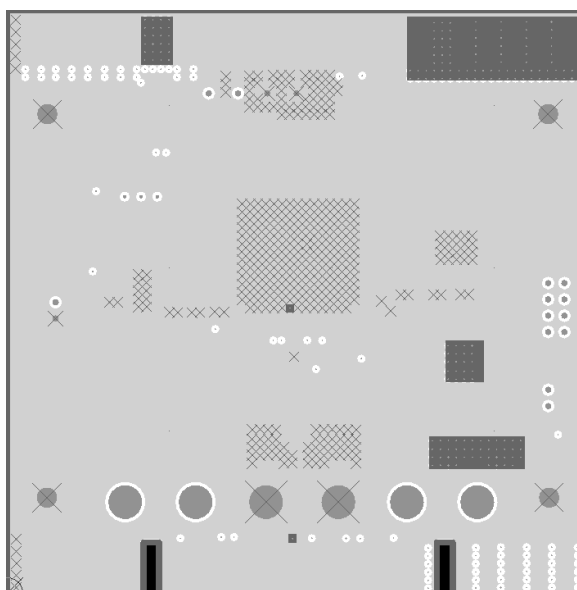
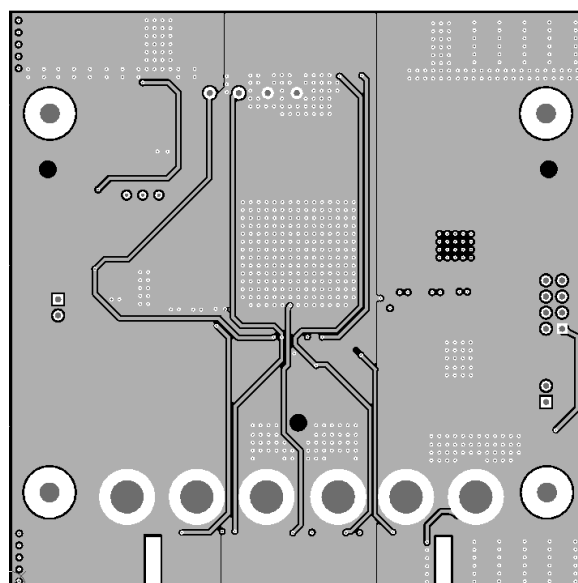


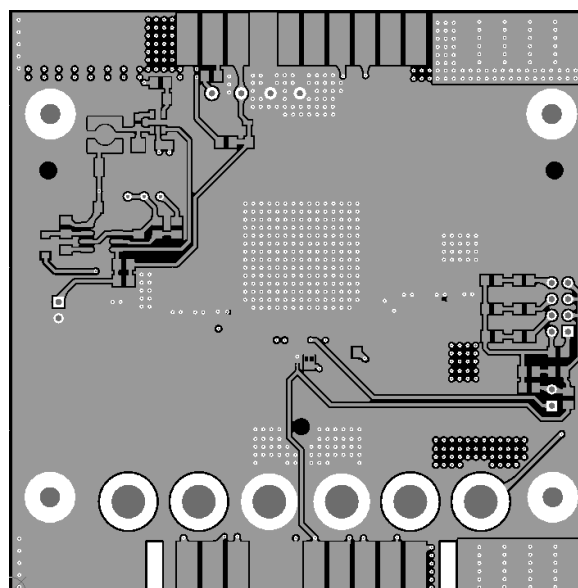
Figure 8. Top Layer



**Figure 9. Internal Layer I (Ground)
Heat Sinking Layer**



**Figure 10. Internal Layer II (Routing)
Heat Sinking Layer**



**Figure 11. Bottom Layer (Ground and Routing)
Heat Sinking Layer**

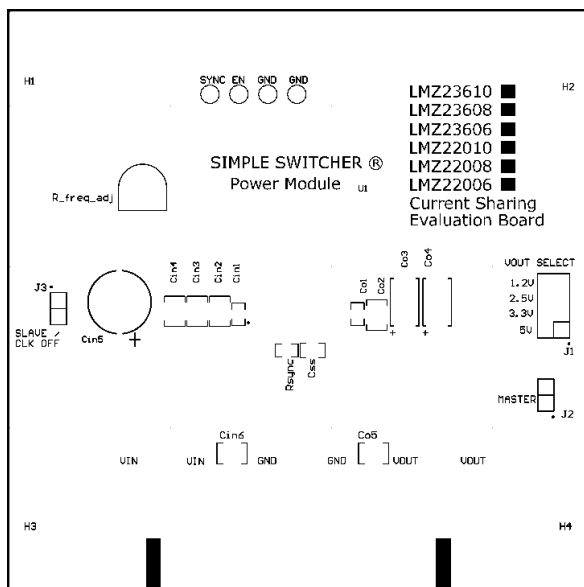


Figure 12. Top Silkscreen

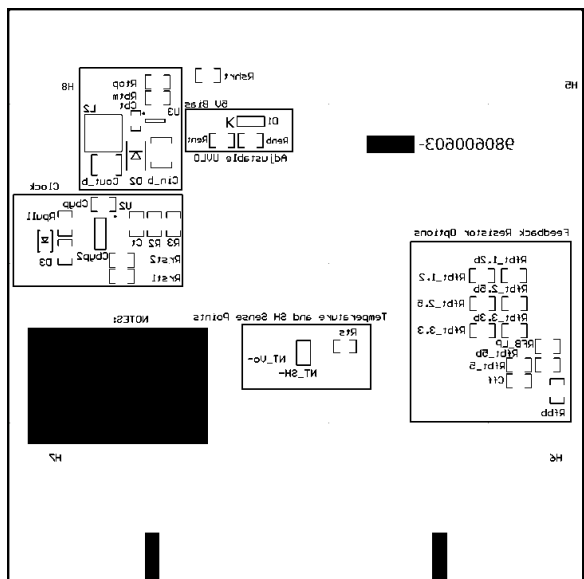


Figure 13. Bottom Silkscreen

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

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

NOTE:

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

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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

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

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

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

3.4 European Union

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

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

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

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

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

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

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025