AN-2279 LMR12020 Evaluation Module

1 Introduction

The LMR12020 evaluation module is designed to provide the power supply design engineer with a fully functional regulator design which can be synchronized to an external clock between 1000 kHz and 2350 kHz. The evaluation module provides two output voltage options viz. 3.3V and 5V with a 2A current capability. Without an external synchronization signal, the design operates at 2000 kHz reducing the solution size and keeping switching noise out of the AM radio band. The PCB consists of 4 layers of copper on FR4 material. The first middle layer is a solid ground layer which helps in minimizing the AC current loop. The LMR12020 is thermally tied to the other layers by thermal vias directly underneath the device. This user's guide contains the evaluation module schematic, a quick setup procedure, and a Bill-of-Materials (BOM). For complete circuit design information, see *LMR12015/LMR12020 SIMPLE SWITCHER 20Vin, 1.5A/2A Step-Down Voltage Regulator in WSON-10* (SNVS817).

2 Features

Parameter	3.3V Output Voltage Option	5V Output Voltage Option
Input Range	5 to 20V	7 to 20V
Output Voltage	3.3V	5V
Output Current	0 to 2A	0 t0 2A
Frequency of Operation	1000 kHz - 2350 kHz	1000 KHz - 2350 KHz
Default Frequency of Operation	2000 kHz	2000 kHz
Board Size	1.944 × 1.35 inches (49.37 × 34.29 mm)	1.944 × 1.35 inches (49.37 × 34.29 mm)

3 Evaluation Module Schematic

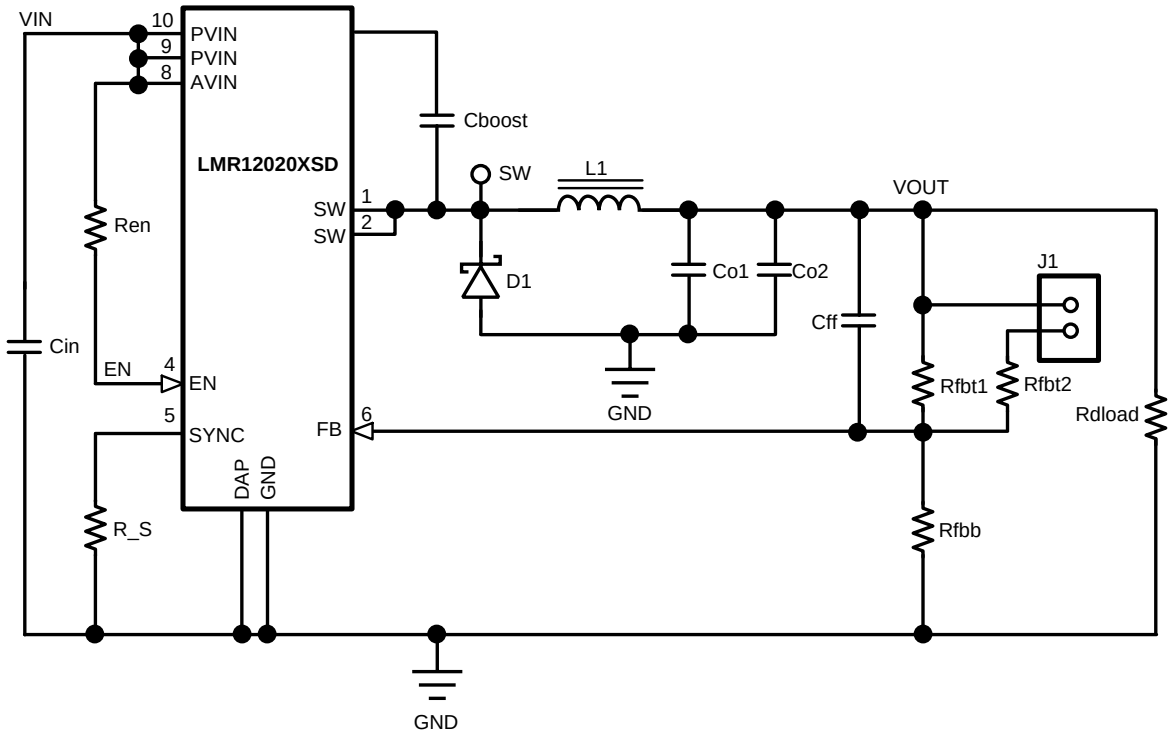


Figure 1. LMR12020 Evaluation Module Schematic

4 Powering and Loading Considerations

Read this entire section prior to attempting to power the evaluation board.

4.1 Quick Start Procedure

Step 1: Set the bench power supply current limit to 2A. Set the power supply voltage to 12V. Turn off the power supply output. Connect the power supply to the LMR12020 demo board. Positive connection to V_{IN} and negative connection to GND.

Step 2: Connect a load, as high as 2A, to the V_{OUT} terminal. Positive connection to V_{OUT} and negative connection to GND.

Step 3: Turn on the bench power supply with no load applied to the LMR12020 and the shunt for the jumper J1 in place. The V_{OUT} would be in regulation at a nominal 3.3V output. With the shunt out, a minimum load of 10mA would be required to have the V_{OUT} in regulation at 5V.

Step 4: Gradually increase the load and V_{OUT} should remain in regulation as the load is increased up to 2 Amps. The V_{OUT} should also be regulated when the input is swept from the minimum input to 20V.

4.2 Starting Up

The EN pin is tied to V_{IN} to simplify start-up. The pull-up resistor allows the power supply design engineer to toggle EN independently, if desired, and observe the start-up behavior of the LMR12020. Use the EN post to disable the device by pulling this node to GND. A logic signal may be applied to the post to test startup and shutdown of the device.

4.3 Synchronization

A SYNC pin has been provided on the evaluation board. This pin can be used to synchronize the regulator to an external clock or multiple evaluation boards can be synchronized together by connecting their SYNC pins together. For complete information, see *LMR12015/LMR12020 SIMPLE SWITCHER 20Vin, 1.5A/2A Step-Down Voltage Regulator in WSON-10* (SNVS817).

4.4 No Load Startup at High Output Voltage

The LMR12020 cannot startup at no load when the output voltage goes above 3.3V. Refer to the LMR12020 datasheet for more information regarding minimum load requirements. A position for a dummy load is provided on the board. Populating that with a 500 ohm resistor facilitates the startup at no load for the 5V output voltage options.

4.5 Adjusting the Output Voltage

The output voltage is set using the following equation where R_{fbb} is connected between the FB pin and GND, and R_{fbt} is connected between V_{OUT} and FB.

$$V_{OUT} = V_{FB}(1 + (R_{fbt}/R_{fbb})) \quad (1)$$

Adjusting the output voltage will affect the performance of the LMR12020. In addition, output capacitors might not be rated for the new output voltage. For more information, see *LMR12015/LMR12020 SIMPLE SWITCHER 20Vin, 1.5A/2A Step-Down Voltage Regulator in WSON-10* (SNVS817).

4.6 Typical Test Setup

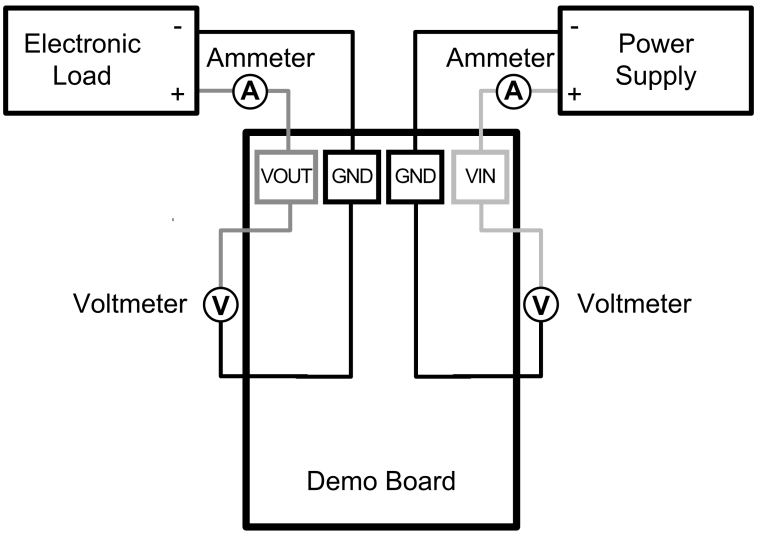


Figure 2. Efficiency Measurements

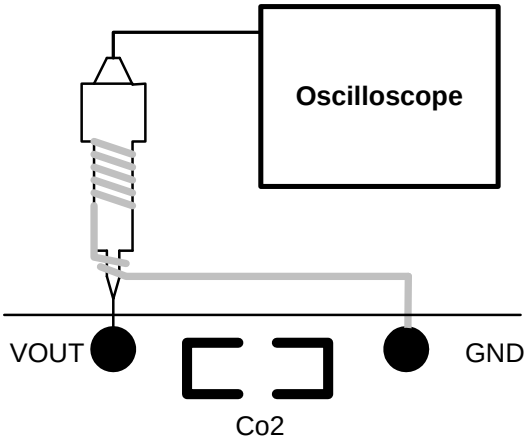


Figure 3. Voltage Ripple Measurements

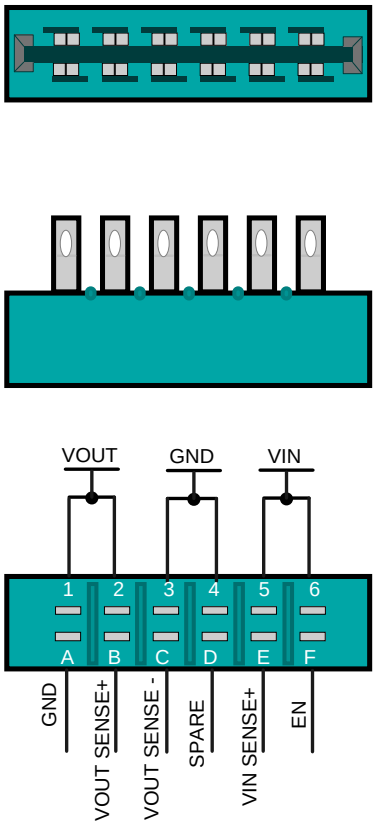


Figure 4. Edge Connector Schematic

5 Board Images

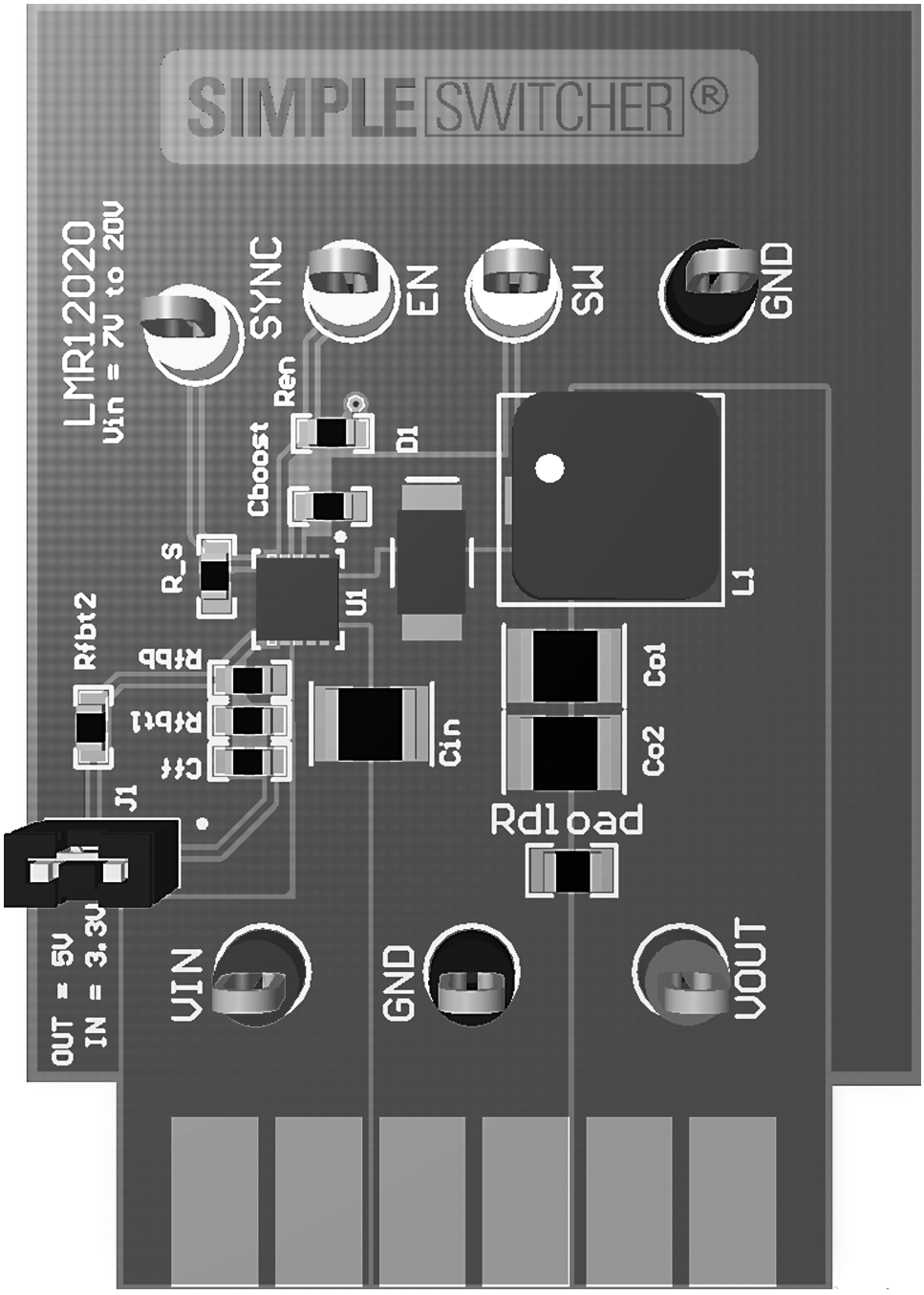


Figure 5. Top Side

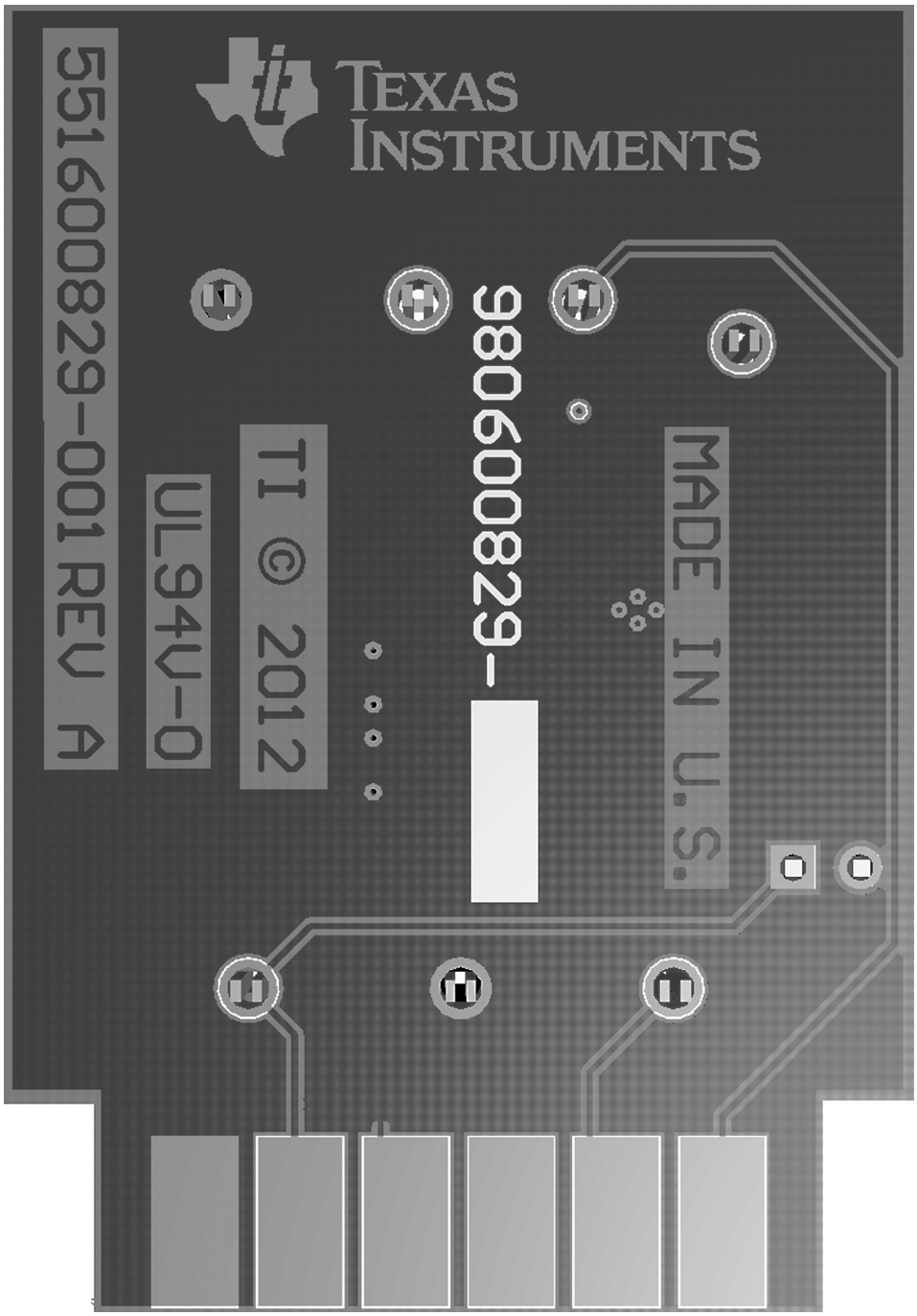
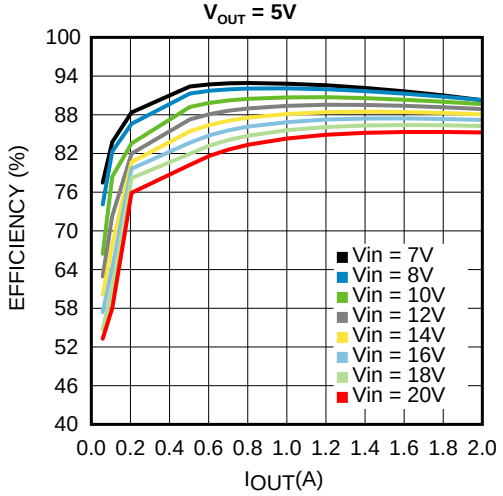


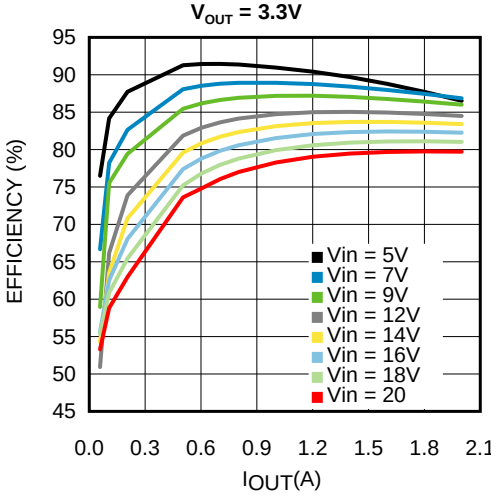
Figure 6. Bottom Side

6 Performance Characteristics

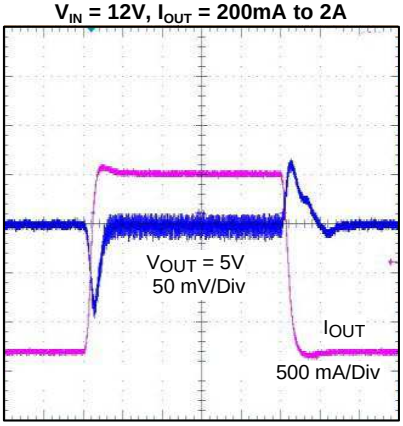
Efficiency vs. Load Current LMR12020
V_{OUT} = 5V



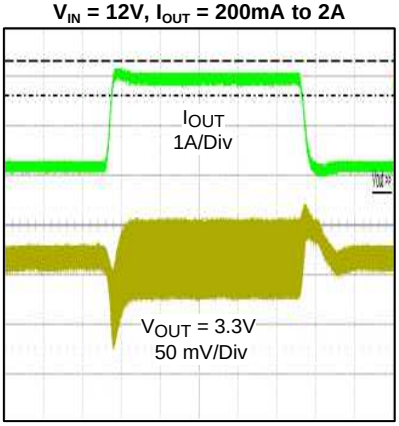
Efficiency vs. Load Current LMR12020
V_{OUT} = 3.3V



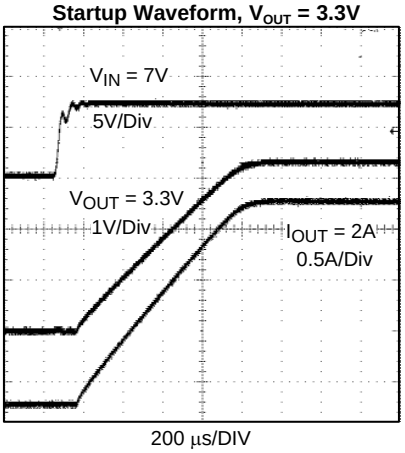
Load Transient Waveforms LMR12020, V_{OUT} = 5V
V_{IN} = 12V, I_{OUT} = 200mA to 2A



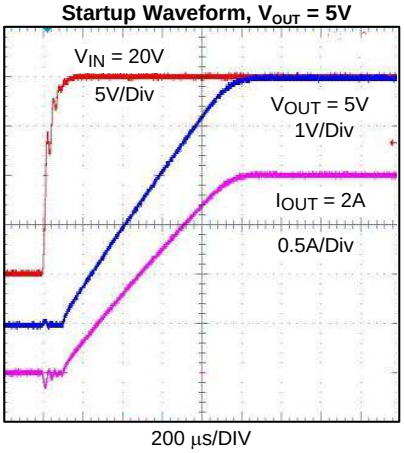
Load Transient Waveforms LMR12020, V_{OUT} = 3.3V
V_{IN} = 12V, I_{OUT} = 200mA to 2A



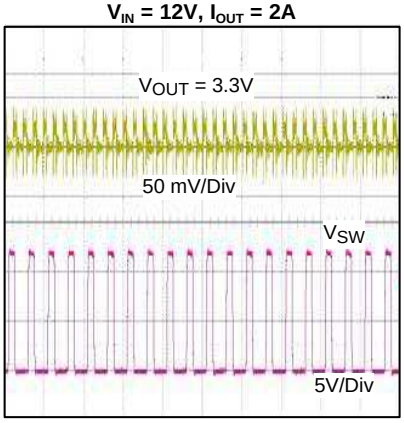
Startup Waveform, V_{OUT} = 3.3V



Startup Waveform, V_{OUT} = 5V



Switching Node and Output Voltage Waveforms
V_{IN} = 12V, I_{OUT} = 2A



7 Bill of Materials

Part Name	Part ID	Part Value	Part Number	Manufacturer
Buck Regulator	U1	2A Buck Regulator	LMR12020	Texas Instruments
Input Capacitor	Cin	10 µF	C1210C106K8PACTU	Kemet
Bootstrap Capacitor	Cboost	0.1 µF	C0603C104K8RACTU	Kemet
Output Capacitor	Co1	22 µF	GRM32ER71C226KE18L	Murata
Output Capacitor	Co2	22 µF	GRM32ER71C226KE18L	Murata
Catch Diode	D1	Schottky Diode Vf = 0.32V	CMS01	Toshiba
Inductor	L1	3.3 µH	7447789003	Wurth Elektronik eiSos
Feedback Resistor	Rfbt1	4.02k Ω	CRCW06034K02FKEA	Vishay-Dale
Feedback Resistor	Rfbt2	5.49k Ω	CRCW06035K49FKEA	Vishay-Dale
Feedback Resistor	Rfbb	1.02k Ω	CRCW06031K02FKEA	Vishay-Dale
Pull-up Resistor	Ren	4.75 kΩ	CRCW06034K75FKEA	Vishay-Dale
Pull-down Resistor	R_S	4.75 kΩ	CRCW06034K75FKEA	Vishay-Dale
Test Point	VIN	Test Point Loop	5010	Keystone
Test Point	SW	Test Point Loop	5012	Keystone
Test Point	GND	Test Point Loop	5011	Keystone
Test Point	GND	Test Point Loop	5011	Keystone
Test Point	VOUT	Test Point Loop	5013	Keystone
Test Point	EN	Test Point Loop	5014	Keystone
Test Point	SYNC	Test Point Loop	5014	Keystone
Header	J1	2X1 Header, TH, 100mil	TSW-102-07-G-S	Samtec, Inc.
Shunt	SH-J1	Black 100mil Gold Plated Shunt	969102-0000-DA	3M

8 PCB Layout

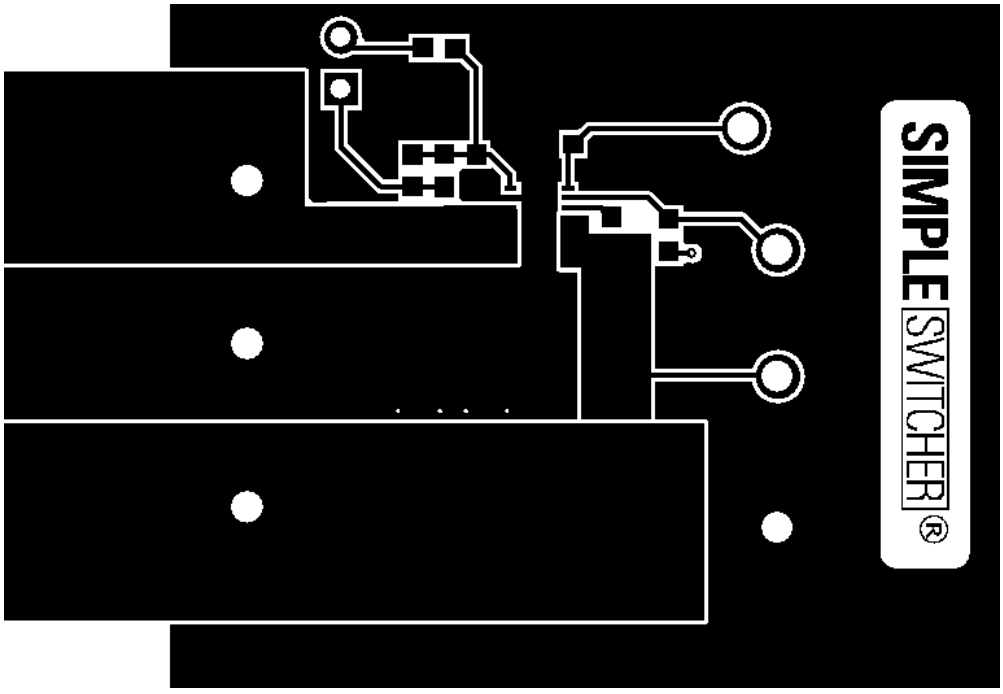


Figure 7. Top Copper

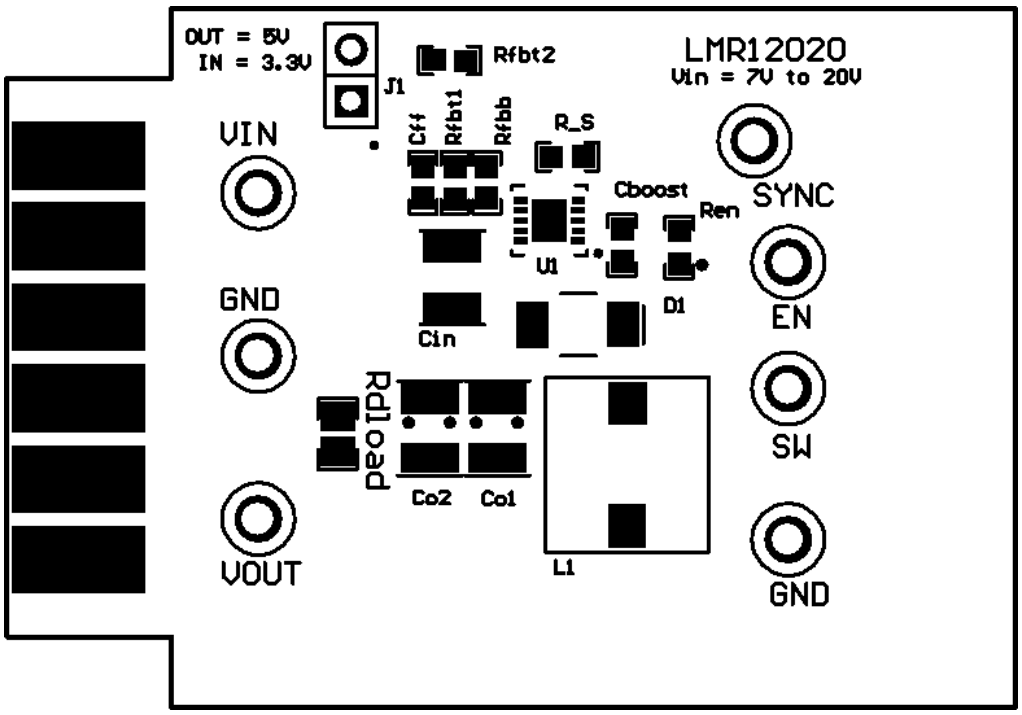


Figure 8. Top Overlay

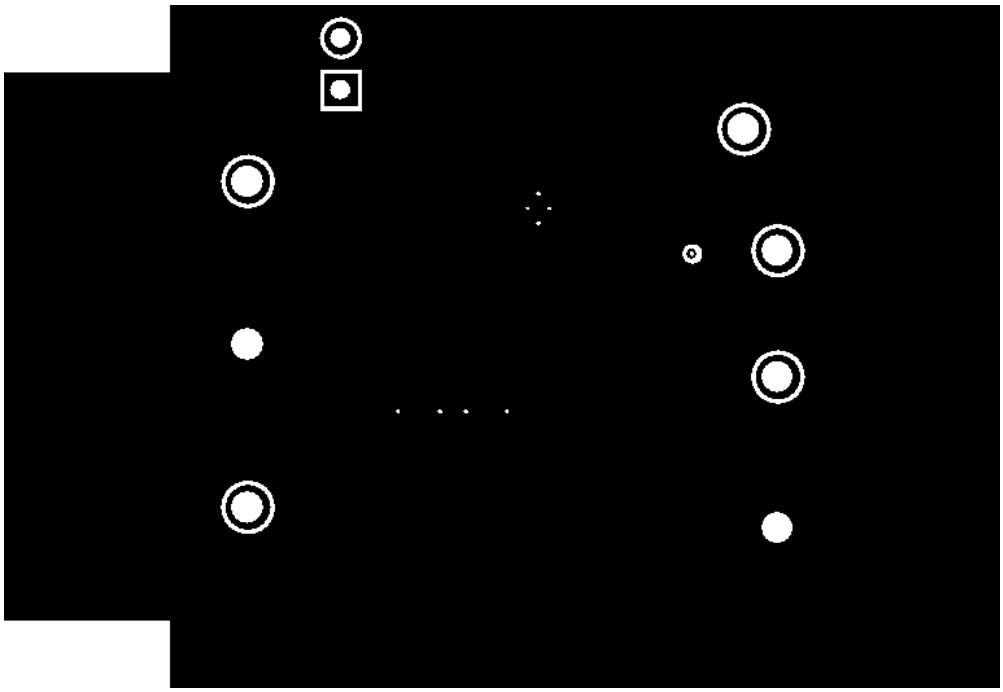


Figure 9. Internal Layer 1

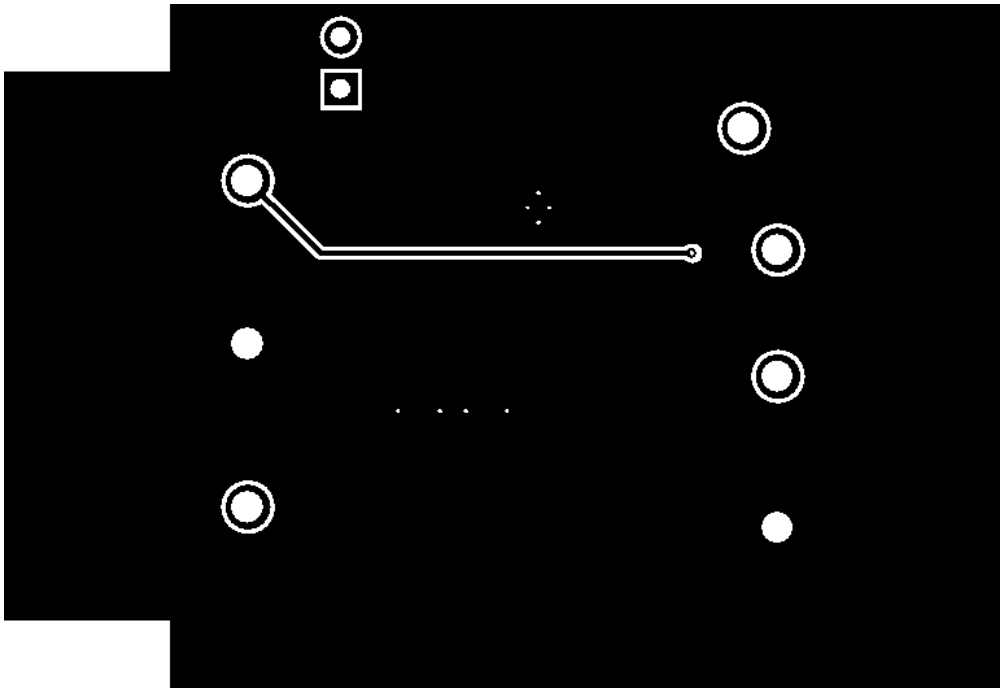


Figure 10. Internal Layer 2

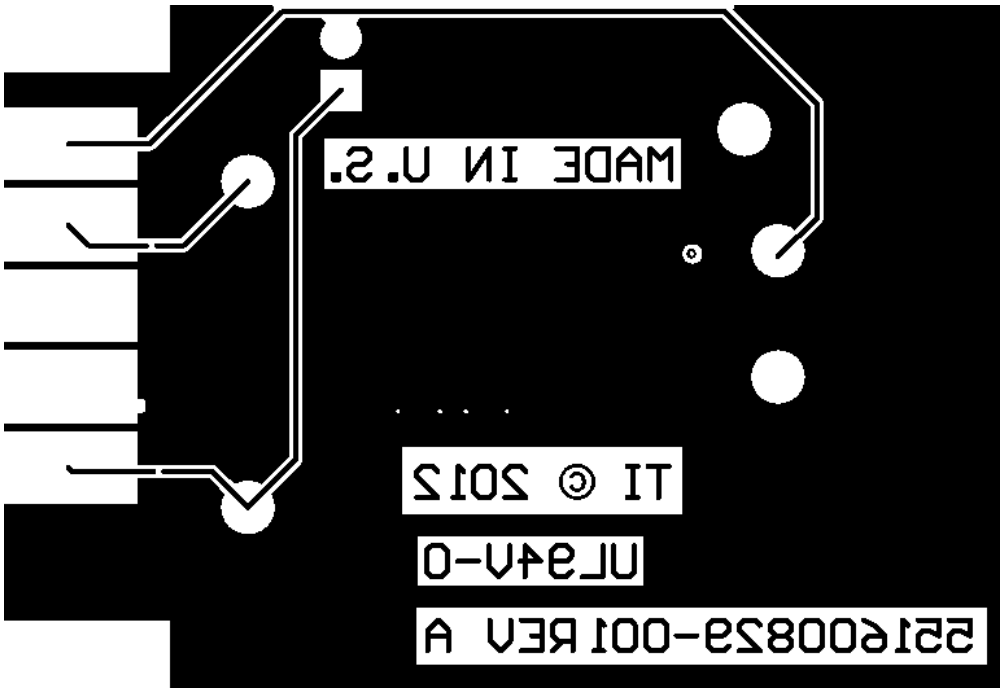


Figure 11. Bottom Copper

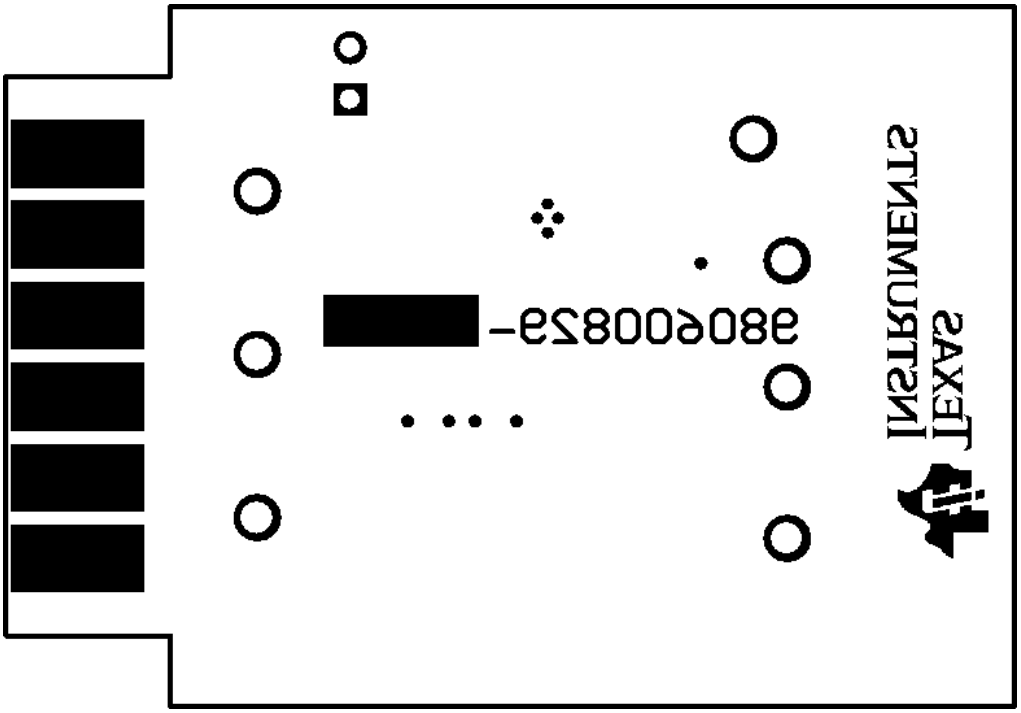


Figure 12. Bottom Overlay

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		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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