AN-1913 LM5088 Evaluation Board

1 Introduction

The LM5088 evaluation board is designed to provide the design engineer with a fully functional power converter based on Emulated Current Mode Control to evaluate the LM5088 controller IC. The LM5088 evaluation board is available in two versions (like the LM5088 controller): the LM5088-1 evaluation board provides ±5% oscillator frequency dithering to reduce EMI and the LM5088-2 evaluation board provides hiccup mode restart to reduce over load stress. Both the evaluation boards share the same layout except for silkscreen. The printed circuit board consists of 2 layers, 2 ounce of copper top and bottom and the board size is 2.55 × 1.5 × 0.5 inches.

Specification	LM5088-1	LM5088-2
Input Voltage Range	5.5V to 55V	5.5V to 55V
Output Voltage	5.0V	5.0V
Max. Average Load Current	7A	7A
Load Regulation	2%	2%
Current Limit Type	Cycle-by-cycle current limit	Hiccup Mode Restart
Frequency	250 kHz (±5% Oscillator Dithering)	250 kHz

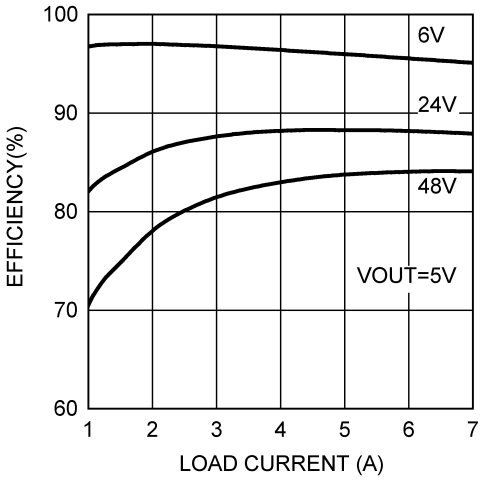


Figure 1. Typical Efficiency Curves of LM5088-1 and LM5088-2 Evaluation Boards

2 Powering and Loading Considerations

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

2.1 Quick Setup Procedure

Step 1: Set the power supply current limit to 10A. Turn off the power supply. Connect the power supply to the VIN terminals.

Step 2: Connect the load, with a 7A capability, to the VOUT terminals.

Step 3: Slowly increase the load while monitoring the output, VOUT should be in regulation with a nominal 5V output.

Step 4: Slowly sweep the input voltage from 5.5V to 55V, VOUT should remain in regulation with a nominal 5V output.

Step 5: Temporarily short the EN pin to check the shutdown function, Also, EN pin can be set between 0.4V and 1.2V, for example, by shorting EN pin to ground with a diode, to check the standby function.

Step 6: Increase the load beyond the rated current to check the current limiting. The output current should limit at approximately 10A. The LM5088-1 board will enter cycle-by-cycle current limiting, while LM5088-2 is configured for a hiccup mode restart. Cooling is critical in this step.

2.2 Air Flow

Prolonged operation with high input voltage (>36V) at full load will cause the LM5088 and MOSFETs to overheat and could potentially result in thermal shutdown. A fan with a minimum of 100LFM should always be used to cool the LM5088 evaluation board.

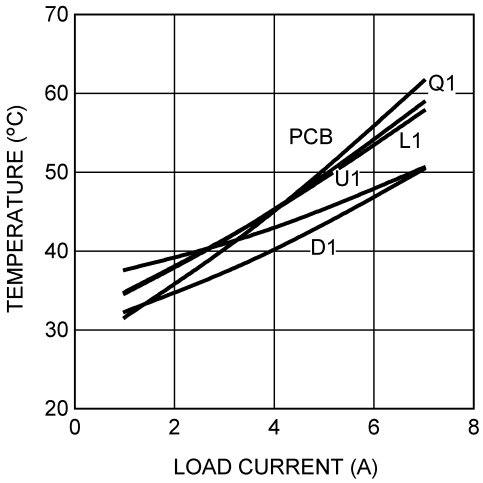


Figure 2. Typical Thermal Profile at 48VIN

2.3 Powering Up

It is suggested that the load be kept low during the first power up. Set the current limit of the source supply to provide about 1.5 times the anticipated wattage of the load. A quick efficiency check is the best way to confirm that everything is operating properly. If something is amiss one can be reasonably sure that it will affect the efficiency adversely. Few parameters can be correct in a switching power supply without creating losses and potentially damaging heat.

2.4 Over Current Protection

The LM5088-1 and LM5088-2 evaluation boards are both configured with over-current protection schemes. The LM5088-1 employs a cycle-by-cycle current limiting, while the LM5088-2 is configured for a hiccup mode restart. For more information on RES pin, see *LM5088/LM5088Q Wide Input Range Non-Synchronous Buck Controller* (SNVS600).

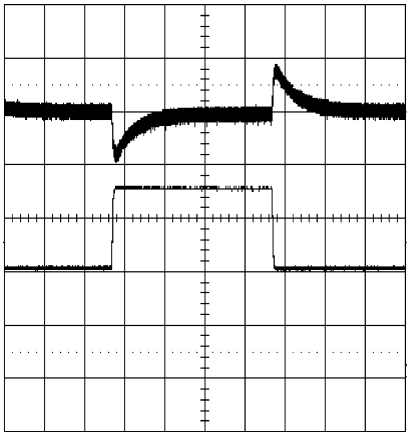
2.5 Synchronization

A Sync pin has been provided on the evaluation board. This pin can be used to synchronize the LM5088 to an external clock. For more information on Sync pin, see *LM5088/LM5088Q Wide Input Range Non-Synchronous Buck Controller* (SNVS600).

2.6 Active Loads

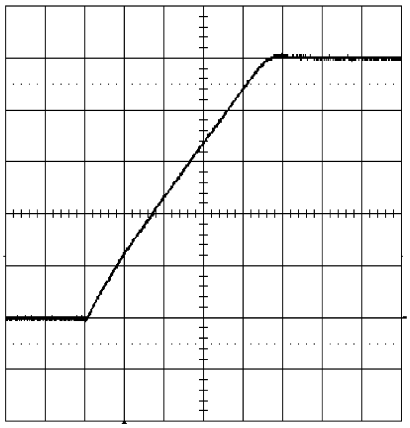
When using electronic load, it is strongly recommended to power up the evaluation board at light load and then slowly increase the load. This is necessary as most of the electronic loads do not draw any current till the output reaches an internally set point; this can result in soft-start function to not work as desired and can trip the current sense comparator. Electronic loads, in general, are best suited for monitoring steady state waveforms. If it is desired to power up the evaluation board at maximum load, resistor banks can be used. This will ensure a soft-start and evaluation board will perform as desired. Ensure that there is sufficient cooling for both the resistor banks and the LM5088 evaluation board, while running at full load.

3 Typical Performance Waveforms of LM5088-1 and LM5088-2 Evaluation Boards



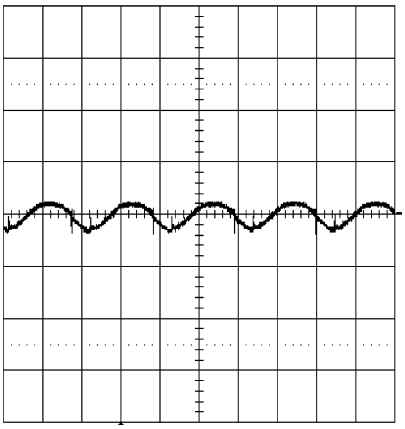
Conditions:
Input Voltage = 48VDC
Output Current = 4A to 7A
Bandwidth Limit = 20 MHz
Traces:
Bottom Trace: Output Current
Amps/div = 2A
Top Trace: Output Voltage response
Volts/div = 100 mV
Horizontal Resolution = 500 µs/div

Figure 3. Transient Response



Conditions:
Input Voltage = 48VDC
Output Current = 7A
Trace:
Output Voltage
Volts/div = 1V

Figure 4. Soft-Start



Conditions:
Input Voltage = 48VDC
Output Current = 7A
Bandwidth Limit = 20 MHz
Trace:
Output Ripple
Volts/div = 50 mV
Horizontal Resolution = 5.0 µs/div

Figure 5. Output Voltage Ripple

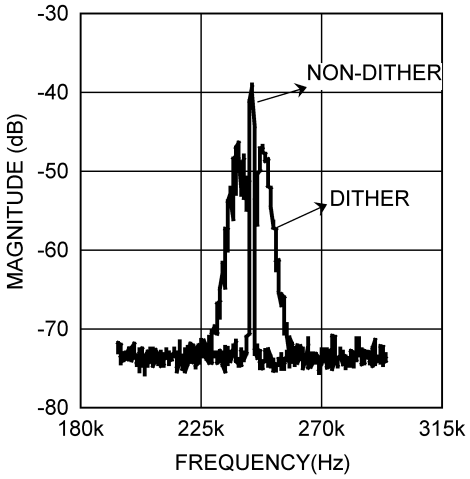


Figure 6. Conducted Emissions Measured at the Input of a LM5088-1 Evaluation Board

4 Bill of Materials for LM5088-1 and LM5088-2 Evaluation Boards

Part	Value	Package	Manufacturer	Manufacturer Part Number	Description
C1,C2,C3, C4,C5	2.2 µF	C1210	Murata	GRM32ER72A225KA35L	CAP CER 2.2 µF 100V X7R 1210
C6,C19	0.1 µF	C0805	TDK Corporation	C2012X7R2A104K	CAP CER .10 µF 100V X7R 10% 0805
C7	1 µF	C0603	Murata	GRM188R71C105KA12D	CAP CER 1 µF 16V X7R 0603
C8,C11	100 pF	C0603	AVX Corporation	06031A101FAT2A	CAP CERM 100 pF 1% 100V NP0 0603
C9	270 pF	C0603	Murata	GRM1885C2A271JA01D	CAP CER 270 pF 100V 5% C0G 0603
C13	0.1 µF	C0603	Murata	GRM188R72A104KA35D	CAP CER .1 µF 100V X7R 0603
C10	0.022 µF	C0603	Murata	GRM188R71C223KA01D	CAP CER 22000 pF 16V 10% X7R 0603
C12	0.015 µF	C0603	Murata	GRM188R71H153KA01D	CAP CER 15000 pF 50V 10% X7R 0603
C15	470 µF	0.327 × 0.327 × 0.303	Nippon-Chemicon	APXF6R3ARA471MH80G	CAP 470 µF 6.3V ELECT POLY SMD
C17,C18	47 µF	C1210	Murata	GRM32ER61A476KE20L	CAP CER 47 µF 10V X5R 1210
C20	1000 pF	C0805	Murata	GRM2195C2A102JA01D	CAP CER 1000 pF 100V 5% C0G 0805
C16	NU	0.327 × 0.327 × 0.303	NU	NU	NU
C21	NU	C0603	NU	NU	NU
C14 (LM5088-1)	0.1 µF	C0603	Murata	GRM188R72A104KA35D	CAP CER .1 µF 100V X7R 0603
C14 (LM5088-2)	0.022 µF	C0603	Murata	GRM188R71C223KA01D	CAP CER 22000 pF 16V 10% X7R 0603
D1	Schottky Diode	D2PAK	On Semi	MBRB2060CT	Schottky Rectifiers 20 Amp 60 Volt
D2	NU	SOD123	NU	NU	NU
L1	6.8 µH	HC9 series	Coiltronics	HC9-6R8-R	INDUCTOR HIGH CURRENT 6.8 µH
Q1	MOSFET	SO-8	Vishay IR	SI7148DP-T1-E3	MOSFET N-CH 75V 28A PWR PAK SO8
R1	54.9 kΩ	R0805	Rohm	MCR10EZHF5492	RES 54.9 kΩ 1/8W 1% 0805 SMD
R2	16.2 kΩ	R0603	Rohm	MCR03EZPFX1622	RES 16.2 kΩ 1/10W 1% 0603 SMD
R3	24.9 kΩ	R0603	Rohm	MCR03EZPFX2492	RES 24.9 kΩ 1/10W 1% 0603 SMD
R4	18.2 kΩ	R0603	Rohm	MCR03EZPFX1822	RES 18.2 kΩ 1/10W 1% 0603 SMD
R5	10 mΩ	R0815	Susumu Co Ltd	RL3720WT-R010-F	RES .01Ω 1W 1% 0815 SMD
R6	5.1Ω	R2512	Panasonic - ECG	ERJ-1TRQF5R1U	RES 5.1Ω 1W 1% 2512 SMD
R7	10Ω	R0805	Rohm	MCR10EZHF10R0	RES 10.0Ω 1/8W 1% 0805 SMD
R8	5.11 kΩ	R0603	Rohm	MCR03EZPFX5111	RES 5.11 kΩ 1/10W 1% 0603 SMD
R9	1.62 kΩ	R0603	Rohm	MCR03EZPFX1621	RES 1.62 kΩ 1/10W 1% 0603 SMD
R10	NU	R0603	NU	NU	NU
J1,J2,J3, J4	Terminal_ Turret		Keystone	1509	Terminal, Turret
TP1,TP2	Slotted test point		Keystone	1040	Terminal test point slotted
U1	PWM IC	HTSSOP-16	Texas Instruments	LM5088-1/LM5088-2	ECM Buck Controller

5 PCB Layout

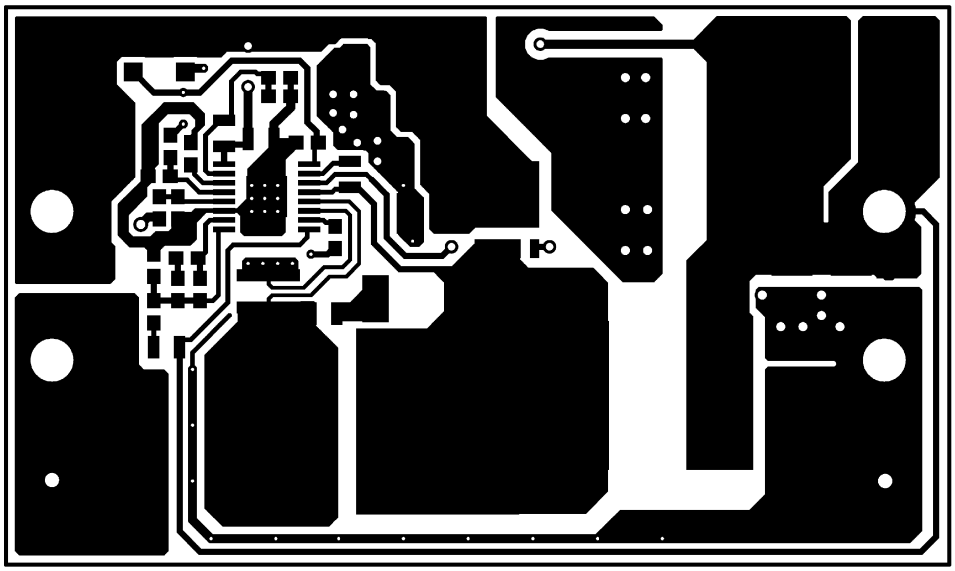


Figure 7. LM5088-1 and LM5088-2 Top Layer

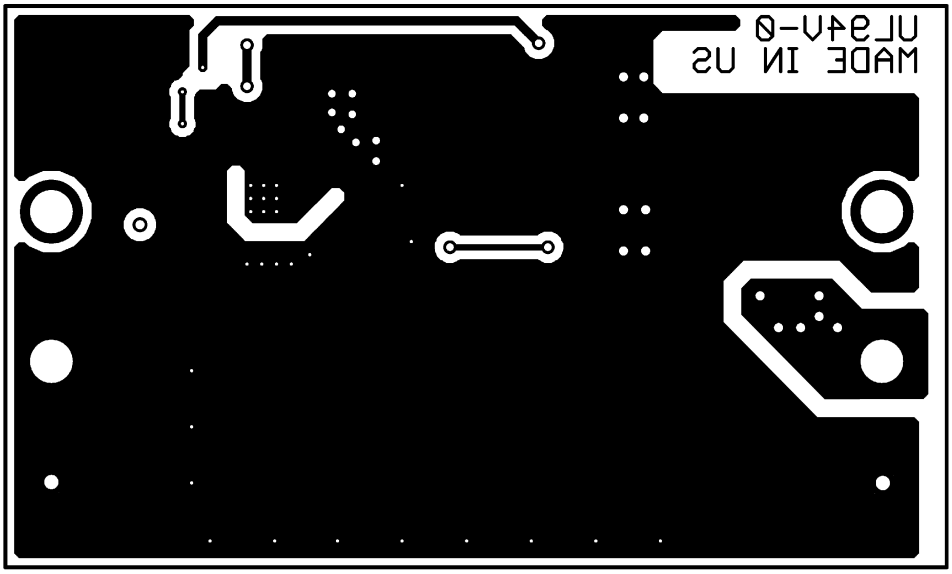


Figure 8. LM5088-1 and LM5088-2 Bottom Layer

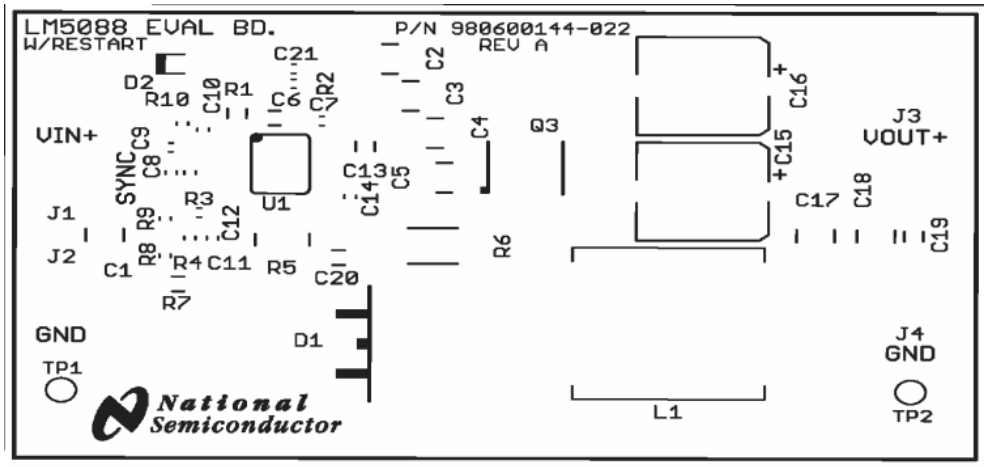


Figure 9. LM5088-2 Silk Screen

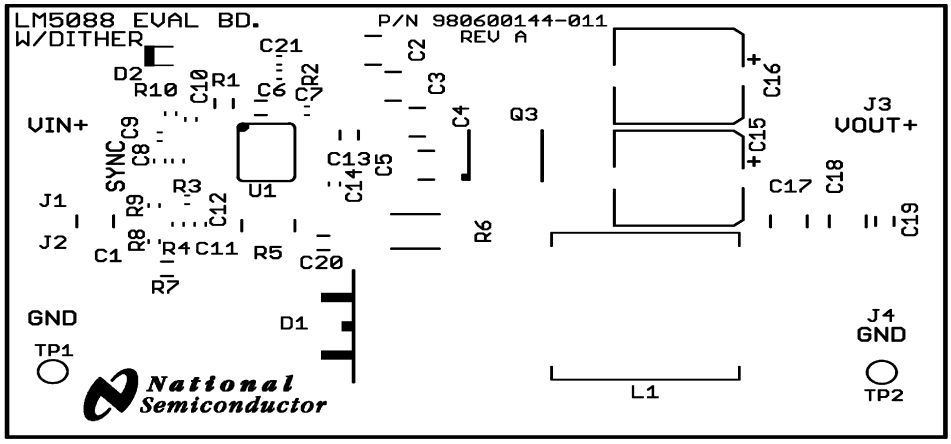


Figure 10. LM5088-1 Silk Screen

6 Schematics

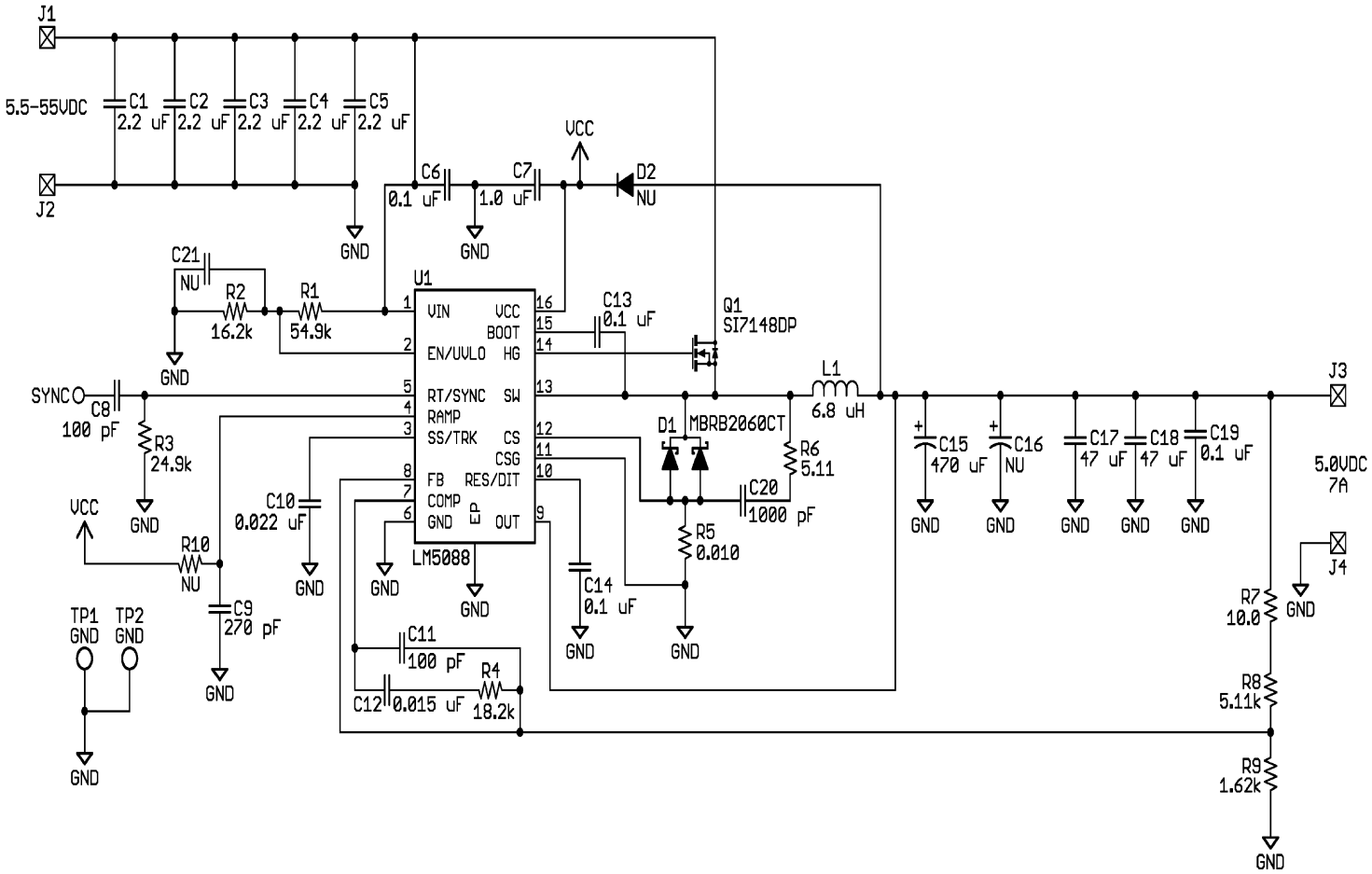


Figure 11. LM5088-1 W/Dithering Schematic

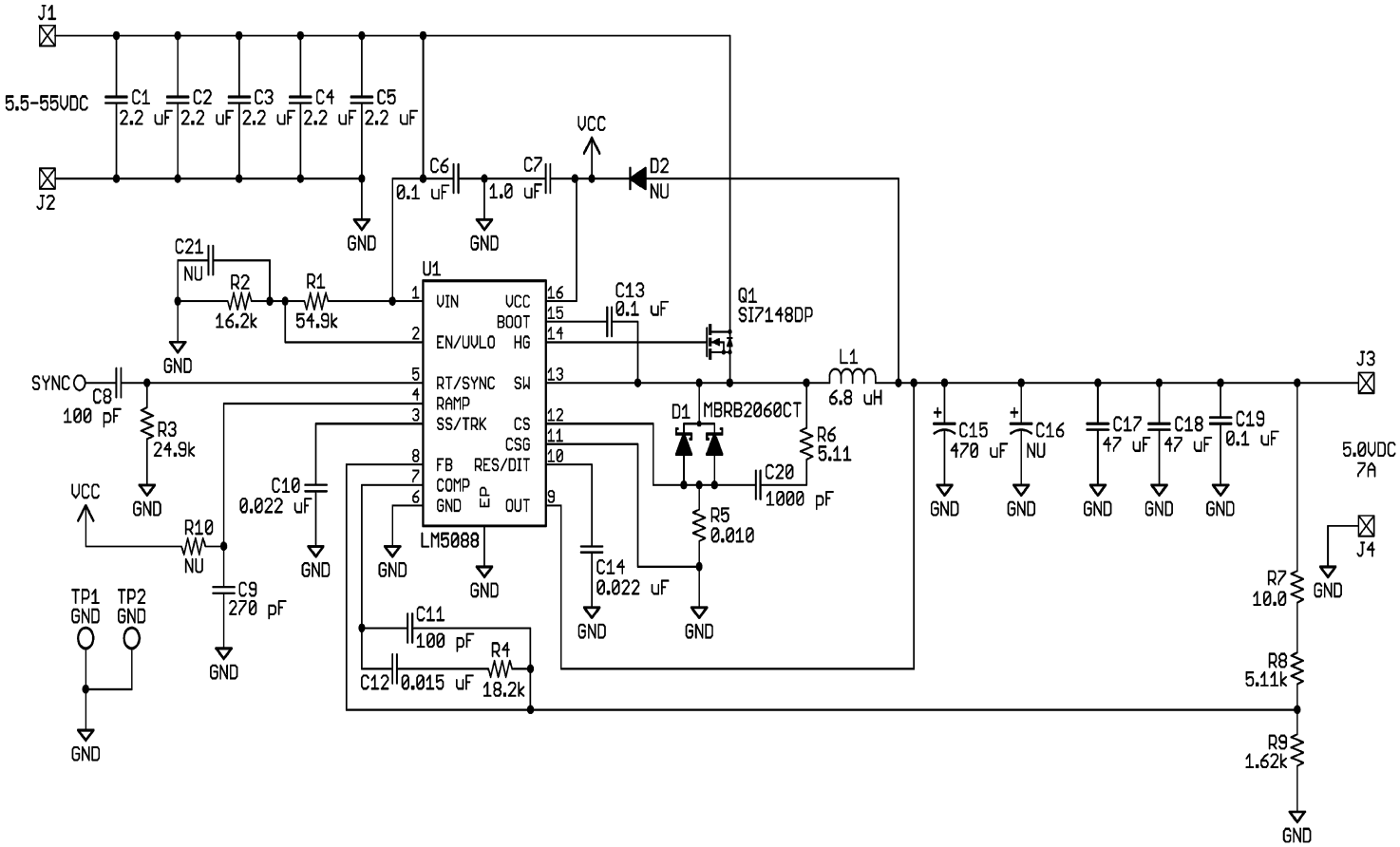


Figure 12. LM5088-2 W/Restart Schematic

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