LM25117,LM5117,LM5119

Application Note 2066 LM25119 Evaluation Board

Literature Number: SNVA445A

LM25119 Evaluation Board

National Semiconductor
Application Note 2066
Eric Lee
September 28, 2010

Introduction

The LM25119EVAL evaluation board provides the design engineer with a fully functional dual output buck converter, employing the LM25119 Dual Emulated Current Mode Synchronous Buck Controller. The evaluation board is designed to provide both 3.3V and 1.8V outputs over an input range of 6.0V to 36V. Also the evaluation board can be easily configured for a single 3.3V, 16A regulator.

Performance of the Evaluation Board

- Input Voltage Range: 6.0V to 36V
- Output Voltage: 3.3V (CH1), 1.8V (CH2)
- Output Current: 8A (CH1), 8A (CH2)
- Nominal Switching Frequency: 230 KHz
- Synchronous Buck Operation: Yes
- Diode Emulation Mode: Yes
- Hiccup Mode Overload Protection: Yes
- External VCC Sourcing: No

Powering and Loading Consideration

When applying power to the LM25119 evaluation board, certain precautions need to be followed. A misconnection can damage the assembly.

PROPER BOARD CONNECTION

The input connections are made to the J1 (VIN) and J2 (RTN/GND) connectors. The CH1 load is connected to the J3 (OUT1+) and J4 (OUT1-/GND) and the CH2 load is connected to the J6 (OUT2+) and J5 (OUT2-/GND). Be sure to choose the correct connector and wire size when attaching the source power supply and the load.

SOURCE POWER

The power supply and cabling must present low impedance to the evaluation board. Insufficient cabling or a high impedance power supply will droop during power supply application with the evaluation board inrush current. If large enough, this droop will cause a chattering condition during power up. During power down, insufficient cabling or a high impedance power supply will overshoot. This overshoot will cause a non-monotonic decay on the output.

An additional external bulk input capacitor may be required unless the output voltage droop/overshoot of the source power is less than 0.5V. In this board design, UVLO setting is conservative while UVLO hysteresis setting is aggressive. Minimum input voltage can goes down with an aggressive design. Minimum operating input voltage depends on the output voltage droop/overshoot of the source power supply and the forced off-time of the LM25119. Refer to the LM25119 datasheet for complete design information.

LOADING

When using an electronic load, it is strongly recommended to power up the evaluation board at light load and then slowly increase the load. If it is desired to power up the evaluation board at maximum load, resistor banks must be used. In general, electronic loads are best suited for monitoring steady state waveforms.

AIR FLOW

Prolonged operation with high input voltage at full power will cause the MOSFETs to overheat. A fan with a minimum of 200LFM should be always provided.

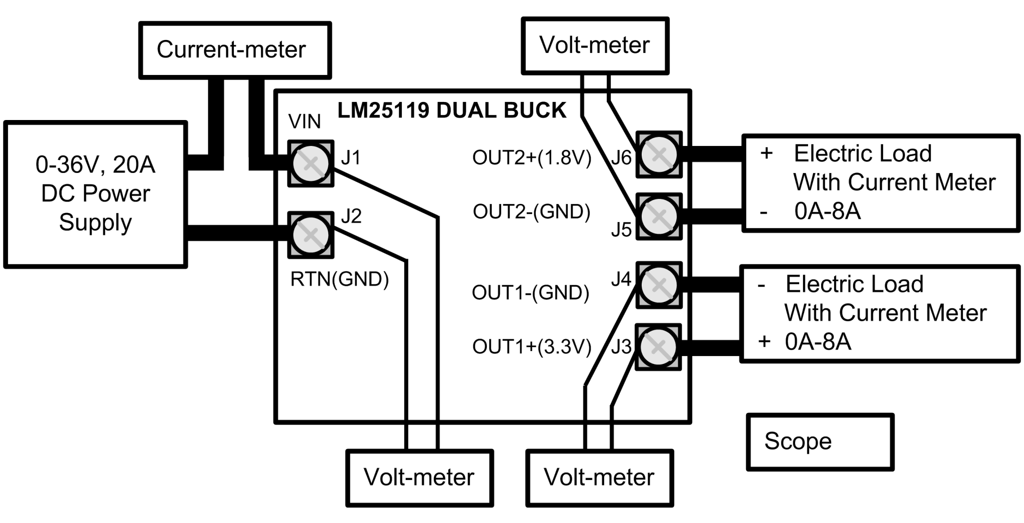


FIGURE 1. Typical Evaluation Setup

QUICK START-UP PROCEDURE

STEP 1: Set the power supply current limit to at least 20A. Connect the power supply to J1 and J2.

STEP 2: Connect one load with an 8A capacity between J3 and J4. Connect another load with an 8A capacity between J6 and J5.

STEP 3: Set input voltage to 12V and turn it on.

STEP 4: Measure the output voltages. CH1 should regulate at 3.3V and CH2 should regulate at 1.8V.

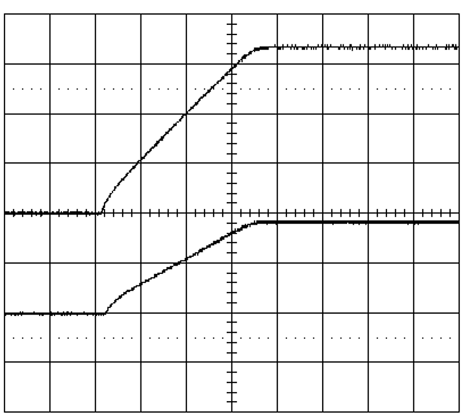
STEP 5: Slowly increase the load current while monitoring the output voltages. The outputs should remain in regulation up to full load current.

STEP 6: Slowly sweep the input voltage from 6.0V to 36V while monitoring the output voltages. The outputs should remain in regulation.

Waveforms

SOFT START

When applying power to the LM25119 evaluation board a certain sequence of events occurs. Soft-start capacitors and other components allow for a linear increase in output voltages. The soft-start time of each output can be controlled independently. *Figure 2* shows the output voltage during a typical start-up with a load of 0.5Ω on the 3.3V output, and 0.33Ω on the 1.8V output, respectively.



30126102

Conditions:

Input Voltage = 12VDC

0.5Ω Load on 3.3V output

0.33Ω Load on 1.8V output

Traces:

Top Trace: 3.3V Output Voltage, Volt/div = 1V

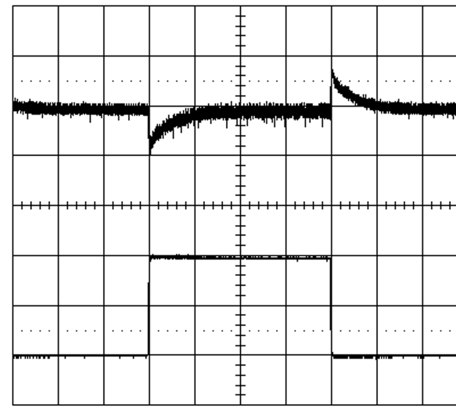
Bottom Trace: 1.8V Output Voltage, Volt/div = 1V

Horizontal Resolution = 1 ms/div

FIGURE 2. Start-up with Resistive Load

LOAD TRANSIENT

Figure 3 shows the transient response for a load of change from 2A to 6A on 3.3V output. The upper waveform shows output voltage droop and overshoot during the sudden change in output current shown by the lower waveform.



30126103

Conditions:

Input Voltage = 12VDC

Output Current 2A to 6A

Traces:

Top Trace: 3.3V Output Voltage, Volt/div = 100mV, AC coupled

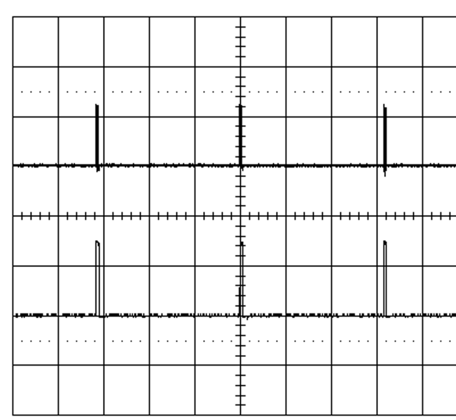
Bottom Trace: Output Current Amp/Div = 2A

Horizontal Resolution = 0.5 ms/div

FIGURE 3. Load Transient Response

OVER LOAD PROTECTION

The evaluation board is configured with hiccup mode overload protection. The restart time can be programmed by C11. *Figure 4* shows hiccup mode operation in the event of an output short on CH1 output. One channel may operate in the normal mode while the other is in hiccup mode overload protection.



30126104

Conditions:

Input Voltage = 12VDC

Output Short on 3.3V

Traces:

Top Trace: SW voltage on CH1, Volt/div = 10V

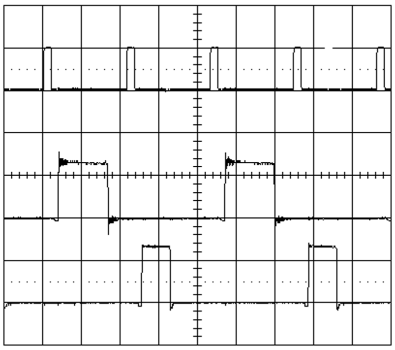
Bottom Trace: Inductor Current Amp/div = 10A

Horizontal Resolution = 20 ms/div

FIGURE 4. Short Circuit

EXTERNAL CLOCK SYNCHRONIZATION

A TP1 (SYNC) test point has been provided on the evaluation board in order to synchronize the internal oscillator to an external clock. *Figure 5* shows the synchronized switching operation. Each channel operates 180 degrees out of phase from the other.



Conditions:

Input Voltage = 12VDC

8A on 3.3V output

8A on 1.8V output

Traces:

Top Trace: SYNC pulse, Volt/div = 5V

Middle Trace: SW voltage on CH1, Volt/div = 10V

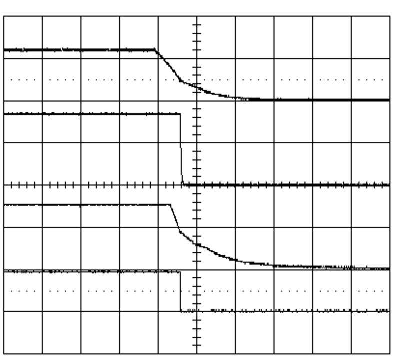
Bottom Trace: SW voltage on CH2, Volt/div = 10V

Horizontal Resolution = 1 µs/div

FIGURE 5. Clock Synchronization

SHUTDOWN

Figure 6 shows the shutdown procedure by powering off the source power. When UVLO pin voltage is less than 1.26V, the switching stops and soft-start capacitors are discharged by internal switches.



Conditions:

Input Voltage = 12VDC

0.5Ω Load on 3.3v output

Traces:

Top Trace: Input Voltage, Volt/div = 10V

Middle Trace1: 3.3V Output, Volt/div = 2V

Middle Trace2: VCC, Volt/div = 5V

Bottom Trace: SS voltage, Volt/div = 5V

Horizontal Resolution = 20 ms/div

FIGURE 6. Shutdown

Performance Characteristics

Figure 7 shows the efficiency curves. The efficiency of the power converter is 90% at 12V with full load current. Monitor the current into and out of the evaluation board. Monitor the voltage directly at the input and output terminals of the evaluation board.

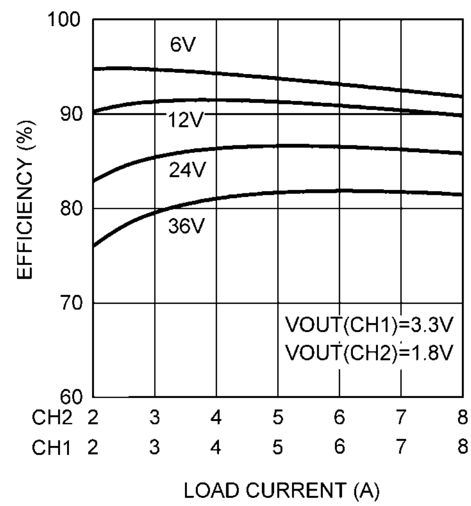


FIGURE 7. Typical Efficiency vs Load Current

Board Configuration

INTERLEAVED BUCK OPERATION FOR SINGLE 3.3V 16A OUTPUT

The evaluation board is designed to be easily converted to a 3.3V, 16A single output regulator with the interleaved operation. Proper electronic load connection is shown in *Figure 8*. Connecting the electronic load at the center of shorting bar is recommended to prevent a voltage difference between CH1 and CH2 output. In order to produce a single 3.3V output with 16A maximum output current, populate R21 and R22 with 0Ω resistor and open R6, C15 and C14. The electronic load should have over 16A capability to test the interleaved operation.

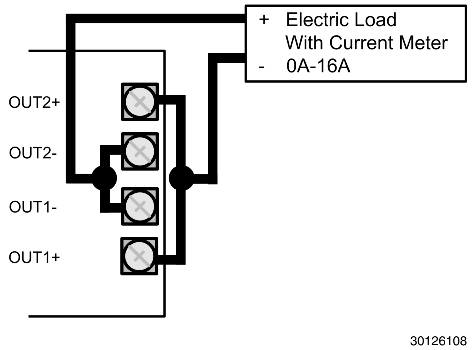


FIGURE 8. Load Connection for Single Output

EXTERNAL VCC SUPPLY & VCC DISABLE

External VCC supply helps to reduce the temperature and the power loss of the LM25119 at high input voltage. By populating D3 and D4, VCC can be supplied from an external power supply. Use TP3 as an input of the external VCC supply with 0.1A current limit. R36, R35 and C45 should be populated with proper value when the voltage of the external VCC is smaller than 7V. The voltage at the VCCDIS pin can be monitored at TP2. To prevent a reverse current flow from VCC to VIN through the internal diode, the external VCC voltage should always be lower than VIN.

LOOP RESPONSE

TP5 and TP6 (TP7 and TP8) have been provided in order to measure the loop transfer function of CH1 (CH2). Refer to AN-1889 for detail information about the loop transfer function measurement.

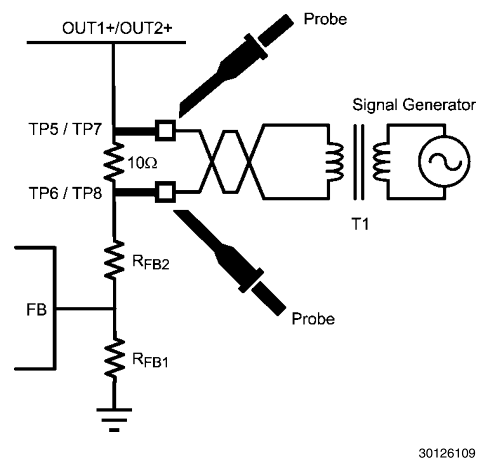
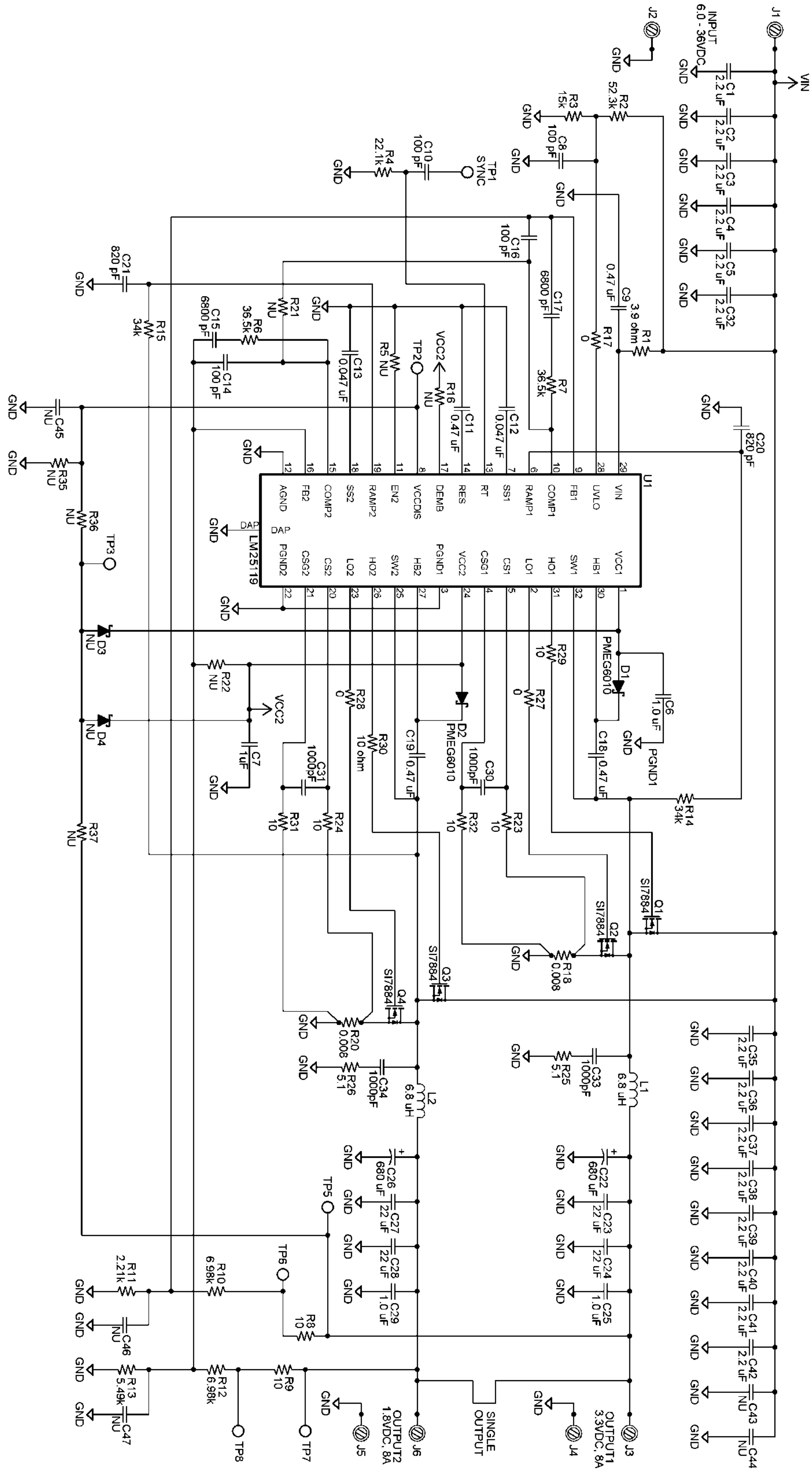


FIGURE 9. Loop Response Measurement Setup

Evaluation Board Schematic

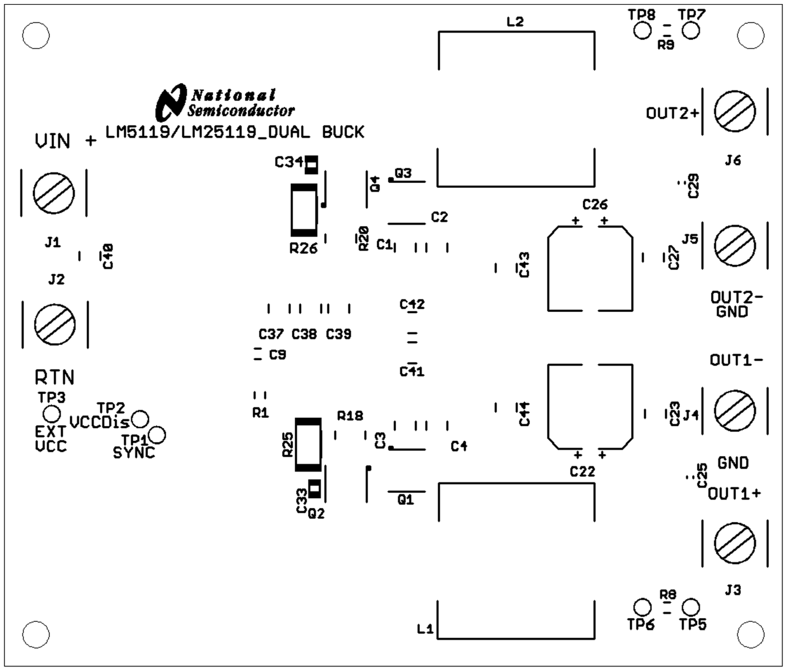


30126110

TABLE 1. Bill of Materials

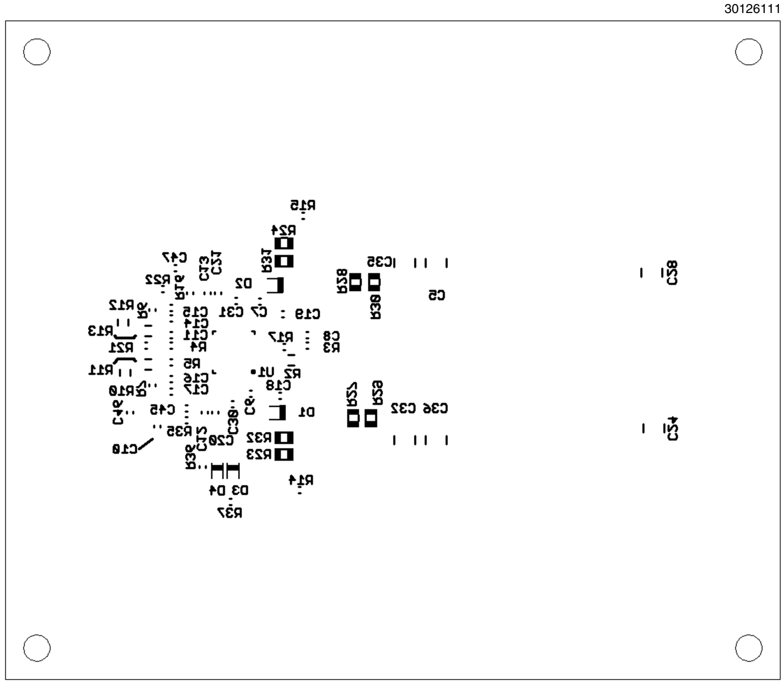
Part	Value	Package	Part Number	Manufacturer
C1,C2,C3,C4,C5,C32, C35,C36,C37,C38,C39 ,C40,C41,C42	2.2 µF, 50V, X7R	1210	C3225X7R1H225K	TDK
C6,C7,C25,C29	1µF, 16V, X7R	0603	C1608X7R1C105K	TDK
C8,C10,C14,C16	100pF, 50V, C0G	0603	C1608C0G1H101J	TDK
C9	0.47µF, 50V, X7R	0805	UMK212B7474KG	Taiyo Yuden
C11,C18,C19	0.47µF, 25V, X7R	0603	GRM188R71E474KA12	Murata
C12,C13	0.047µF, 16V, X7R	0603	C1608X7R1C473K	TDK
C15,C17	6800pF, 25V, C0G	0603	C1608C0G1E682J	TDK
C20,C21	820pF, 50V, C0G	0603	C1608C0G1H821J	TDK
C22,C26	680µF, 6.3V	Φ10	APXA6R3ARA681MJC0G	NIPPON CHEMI-CON
C23,C24,C27,C28	22µF,10V, X7R	1210	C1210C226K8RAC	Kemet
C30,C31	1000pF, 50V, X7R	0603	C1608X7R1H102K	TDK
C33,C34	1000pF,100V, C0G	0805	C2012C0G2A102J	TDK
C43,C44,C45,C46,C47	NU			
R1	3.9 ohm, 5%	0805	CRCW08053R90JNEA	Vishay
R2	52.3k, 1%	0805	MCR10EZHF5232	Rohm
R3	15k, 1%	0603	MCR03EZPFX1502	Rohm
R4	22.1k, 1%	0603	CRCW060322K1FKEA	Vishay
R5,R16,R21,R22,R35, R36,R37	NU			
R6,R7	36.5k, 1%	0603	CRCW060336K5FKEA	Vishay
R8,R9, R23,R24,R29,R30, R31, R32	10 ohm, 5%	0805	CRCW080510R0JNEA	Vishay
R10,R12	6.98k, 1%	0805	CRCW08056K98FKEA	Vishay
R11	2.21k, 1%	0805	MCR10EZHF2211	Rohm
R13	5.49k, 1%	0805	MCR10EZHF5491	Rohm
R14,R15	34k, 1%	0603	CRCW060334K0FKEA	Vishay
R17	0 ohm	0603	MCR03EZPJ000	Rohm
R18,R20	0.008 ohm, 1W, 1%	0815	RL3720WT-R008-F	Susumu
R25,R26	5.1 ohm, 1W, 1%	2512	ERJ-1TRQF5R1U	Panasonic-ECG
R27,R28	0 ohm, 5%	0805	MCR10EZPJ000	Rohm
D1,D2	60V, 1A	SOD123F	PMEG6010CEH	NXP
D3,D4	NU			
L1,L2	6.8µH, 18.5A	18.2x18.3	7443556680	WE
Q1,Q2,Q3,Q4	40V, 58A	PowerPAK SO-8	SI7884BDP	Vishay
U1		LLP32	LM25119	NSC
J1,J2,J3,J4,J5,J6	15A		7693	Keystone
TP1,TP2,TP3		Φ10	5002	Keystone
TP5,TP6,TP7,TP8			1040	Keystone

PCB Layout



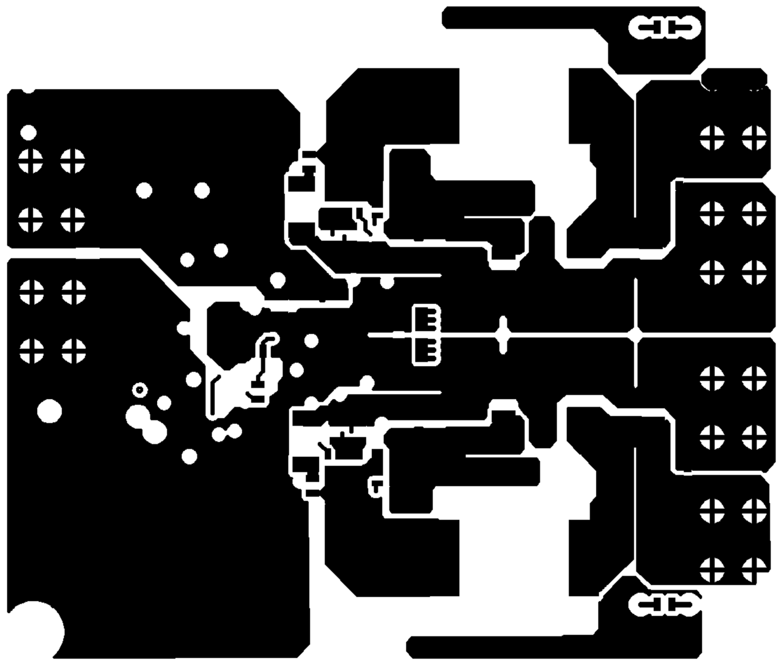
TOP SILKSCREEN (.PLC) AS VIEWED FROM TOP

30126111



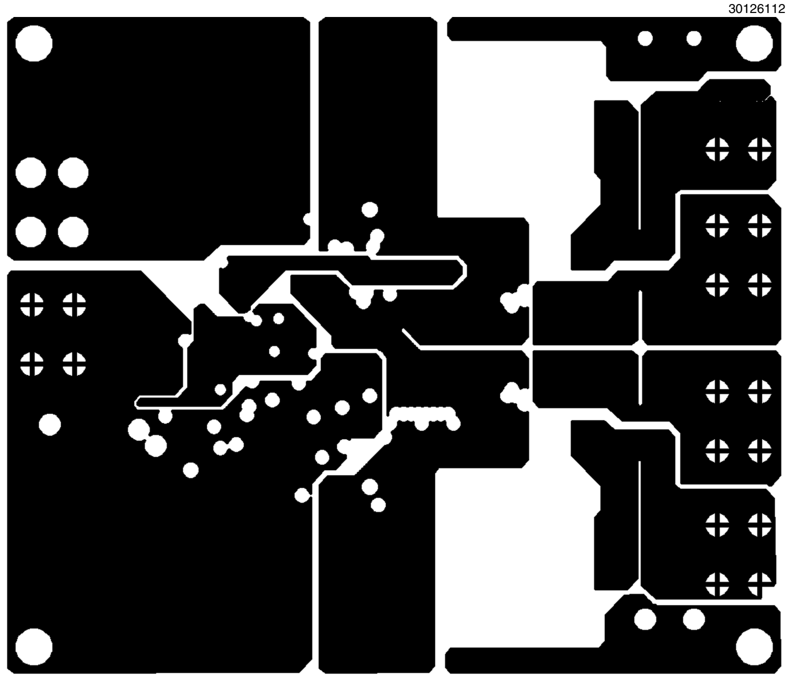
BOTTOM SILKSCREEN (.PLS) AS VIEWED FROM TOP

30126115



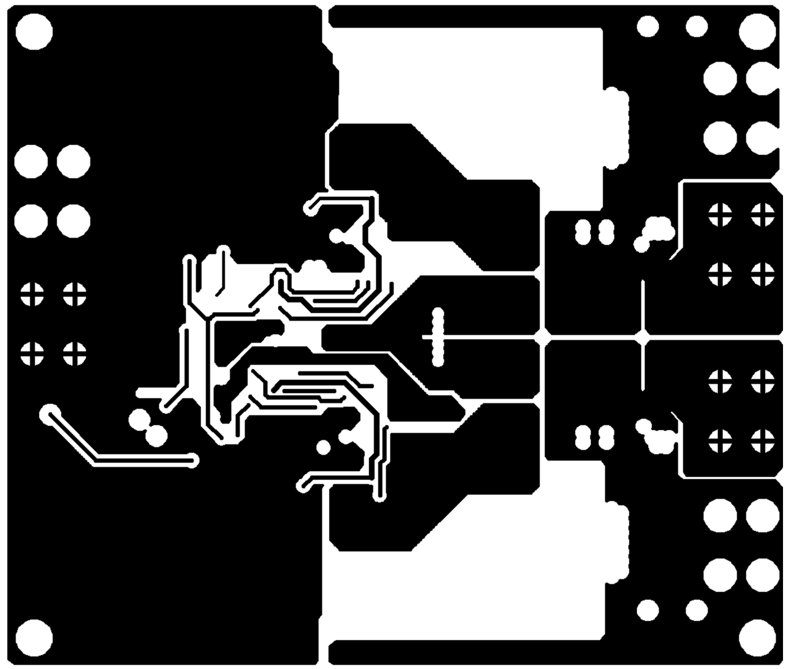
TOP COMPONENT LAYER (.CMP) AS VIEWED FROM TOP

30126112



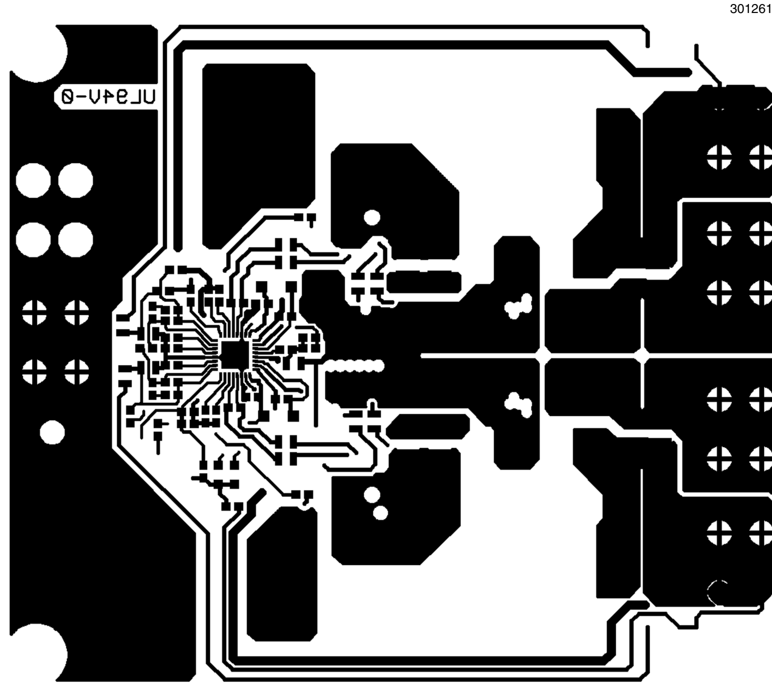
LAYER 2 (.LY2) AS VIEWED FROM TOP

30126113



LAYER 3 (.LY3) AS VIEWED FROM TOP

30126114



BOTTOM SOLDER LAYER (.SOL) AS VIEWED FROM TOP

30126116

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:
www.national.com

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH® Tools	www.national.com/webench
Audio	www.national.com/audio	App Notes	www.national.com/appnotes
Clock and Timing	www.national.com/timing	Reference Designs	www.national.com/refdesigns
Data Converters	www.national.com/adc	Samples	www.national.com/samples
Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempsensors	SolarMagic™	www.national.com/solarmagic
PLL/VCO	www.national.com/wireless	PowerWise® Design University	www.national.com/training

For the most current product information visit us at www.national.com

National Semiconductor Americas Technical Support Center
Email: support@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Technical Support Center
Email: europe.support@nsc.com

National Semiconductor Asia Pacific Technical Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Technical Support Center
Email: jpn.feedback@nsc.com

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

TI products are not authorized for 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, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

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

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