

LM25119 Evaluation Board

National Semiconductor
Application Note 2066
Eric Lee
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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 connect-

ed 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.

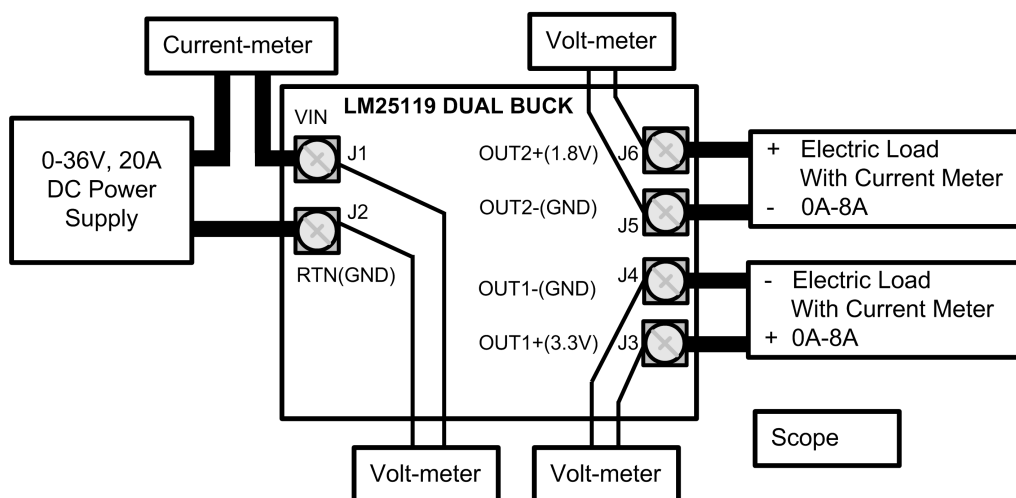
An additional external bulk input capacitor may be required unless the output voltage droop/overshoot of the source power is less than 0.5V. In this board design, UVLO setting is conservative while UVLO hysteresis setting is aggressive. Minimum input voltage can go down with an aggressive design. Minimum 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.



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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.

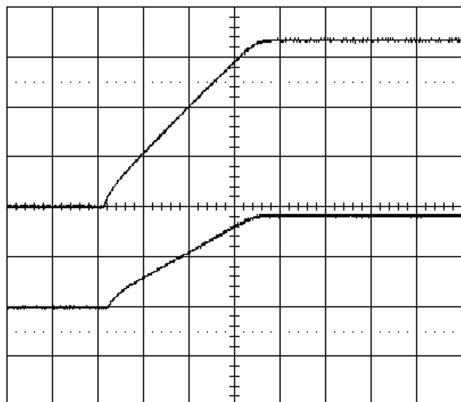
STEP 5: Slowly increase the load current while monitoring the output voltages. The outputs should remain in regulation up to full load current.

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.



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Conditions:

Input Voltage = 12VDC
 0.5Ω Load on 3.3V output
 0.33Ω Load on 1.8V output

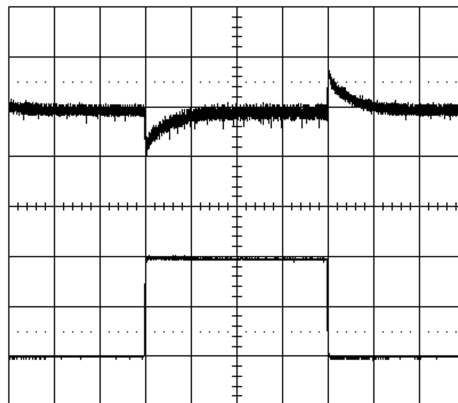
Traces:

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.



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Conditions:

Input Voltage = 12VDC
 Output Current 2A to 6A

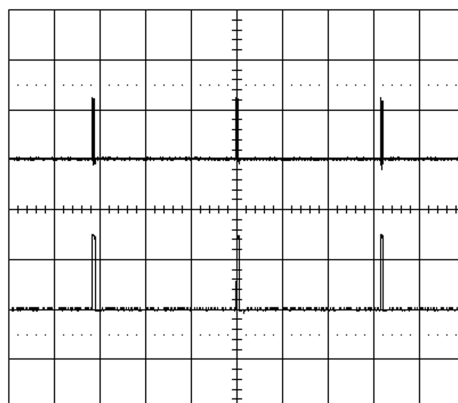
Traces:

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 over-load 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.



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Conditions:

Input Voltage = 12VDC
 Output Short on 3.3V

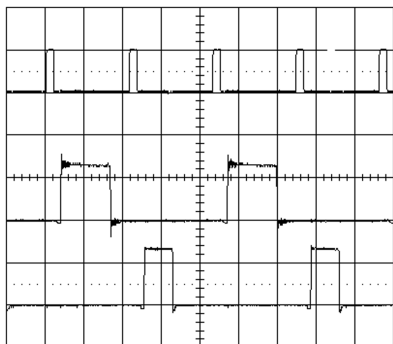
Traces:

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.



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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

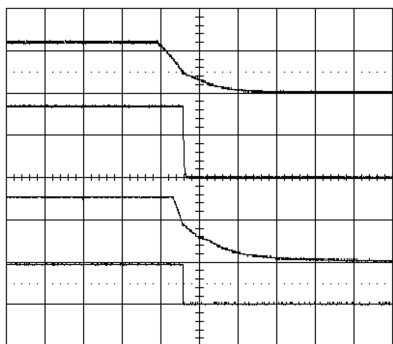
Bottom Trace: SW voltage on CH2, Volt/div = 10V

Horizontal Resolution = 1 μ s/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.



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Conditions:

Input Voltage = 12VDC

0.5 Ω 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

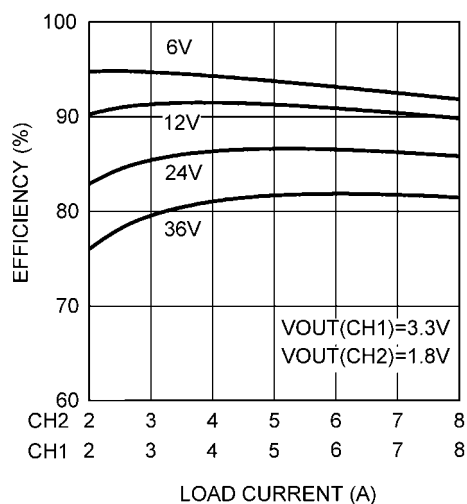
Bottom Trace: SS voltage, Volt/div = 5V

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.



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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.

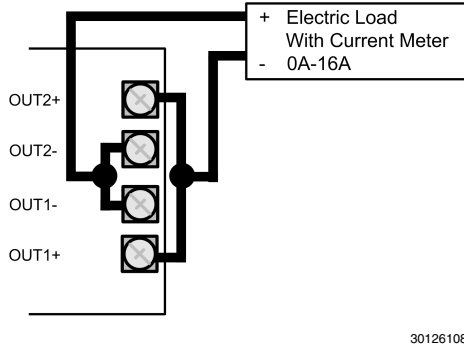


FIGURE 8. Load Connection for Single Output

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.

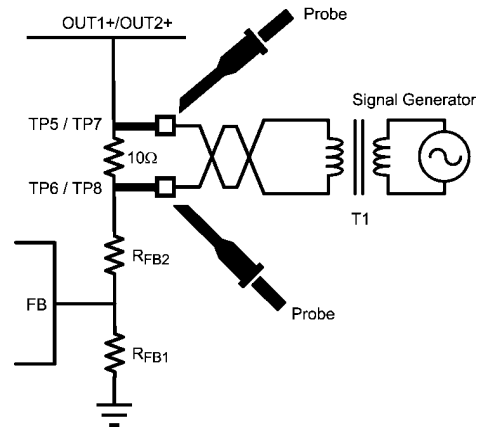
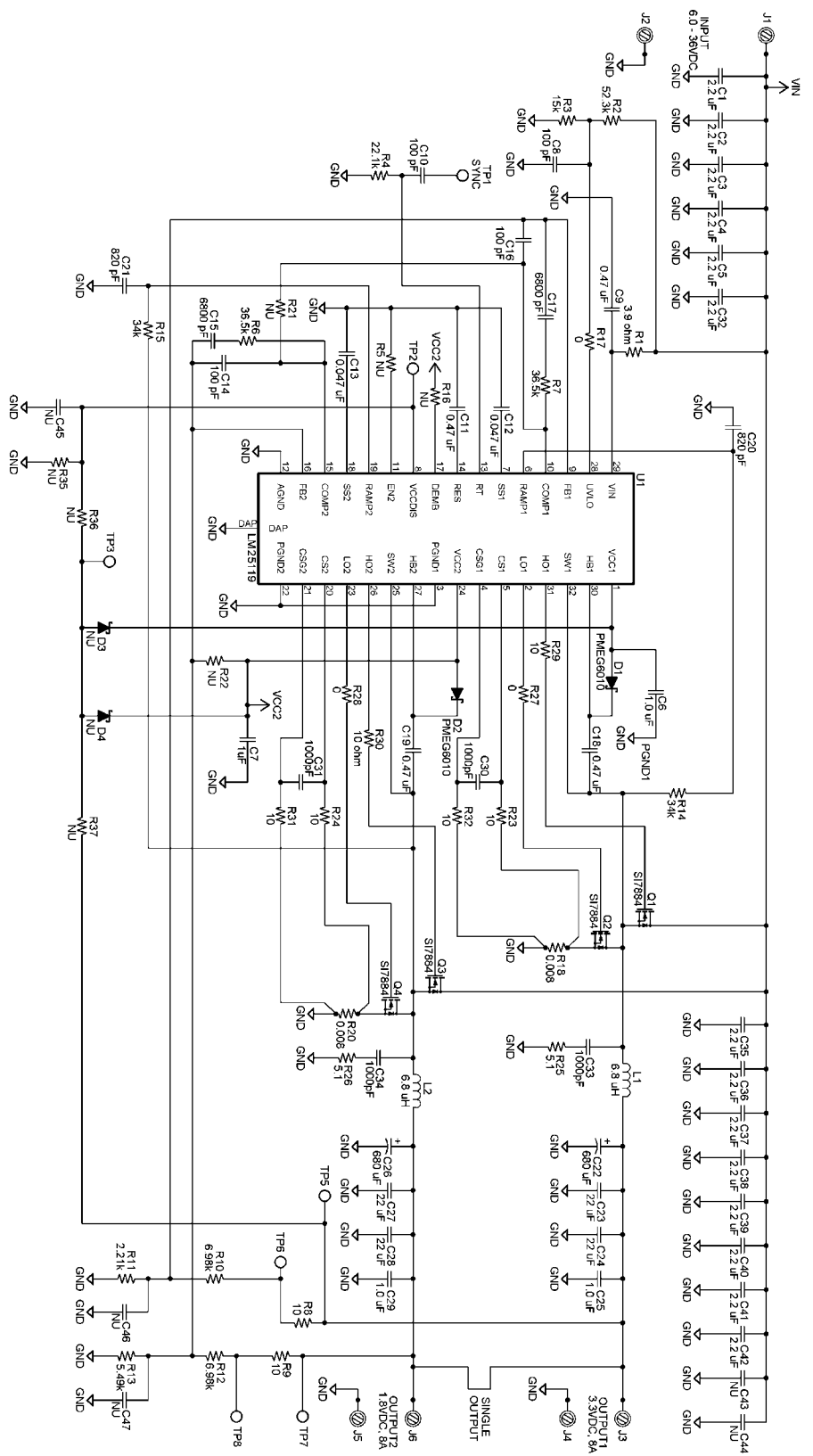


FIGURE 9. Loop Response Measurement Setup

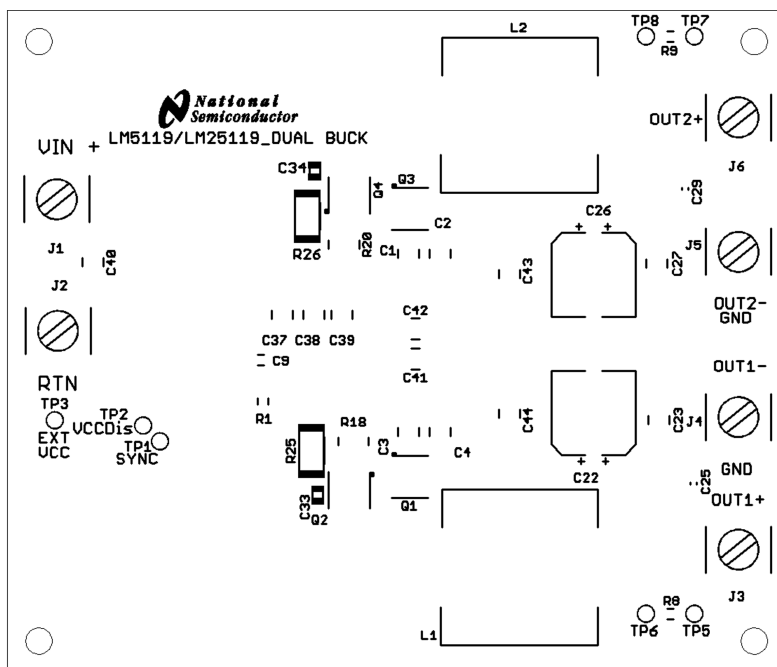
Evaluation Board Schematic



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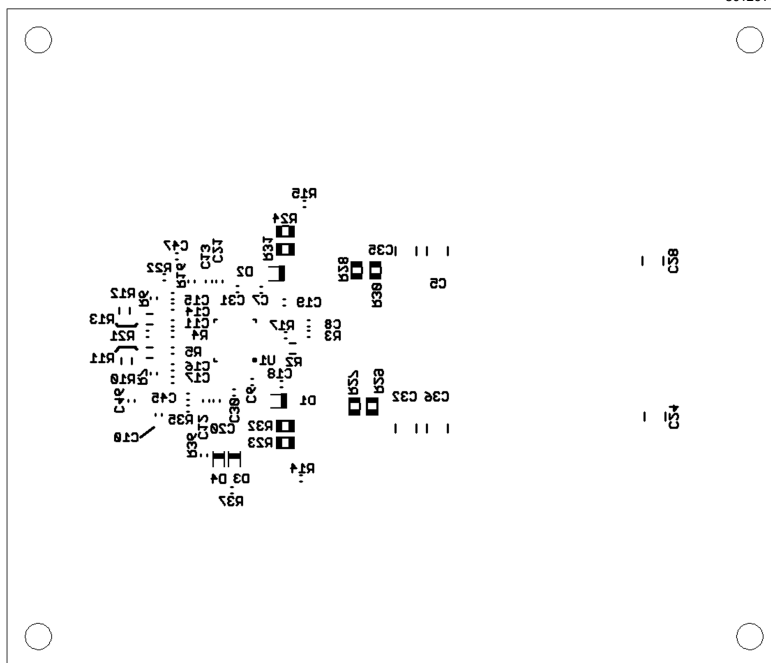
TABLE 1. Bill of Materials

Part	Value	Package	Part Number	Manufacturer
C1,C2,C3,C4,C5,C32, C35,C36,C37,C38,C39 ,C40,C41,C42	2.2 μ F, 50V, X7R	1210	C3225X7R1H225K	TDK
C6,C7,C25,C29	1 μ F, 16V, X7R	0603	C1608X7R1C105K	TDK
C8,C10,C14,C16	100pF, 50V, C0G	0603	C1608C0G1H101J	TDK
C9	0.47 μ F, 50V, X7R	0805	UMK212B7474KG	Taiyo Yuden
C11,C18,C19	0.47 μ F, 25V, X7R	0603	GRM188R71E474KA12	Murata
C12,C13	0.047 μ F, 16V, X7R	0603	C1608X7R1C473K	TDK
C15,C17	6800pF, 25V, C0G	0603	C1608C0G1E682J	TDK
C20,C21	820pF, 50V, C0G	0603	C1608C0G1H821J	TDK
C22,C26	680 μ F, 6.3V	Φ 10	APXA6R3ARA681MJC0G	NIPPON CHEMI- CON
C23,C24,C27,C28	22 μ F, 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	6.8 μ H, 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		Φ 10	5002	Keystone
TP5,TP6,TP7,TP8			1040	Keystone



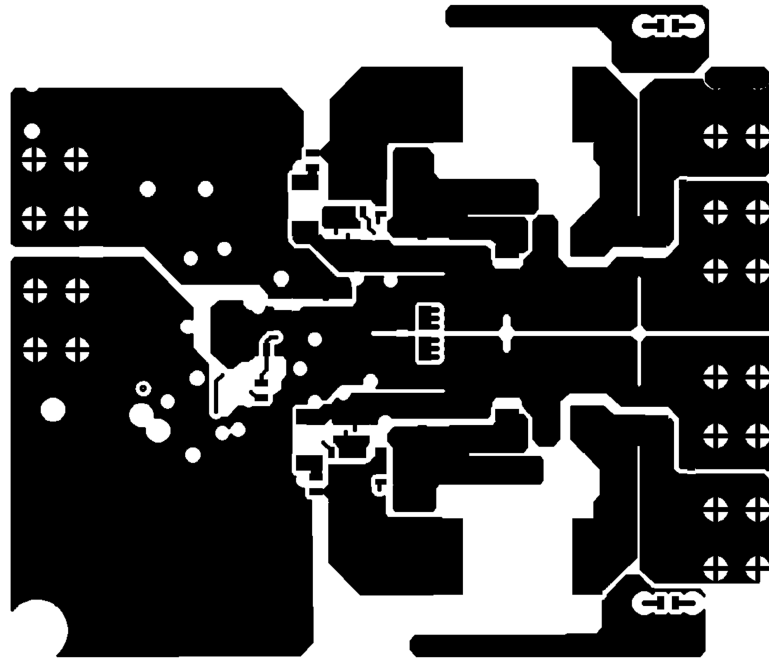
TOP SILKSCREEN (.PLC) AS VIEWED FROM TOP

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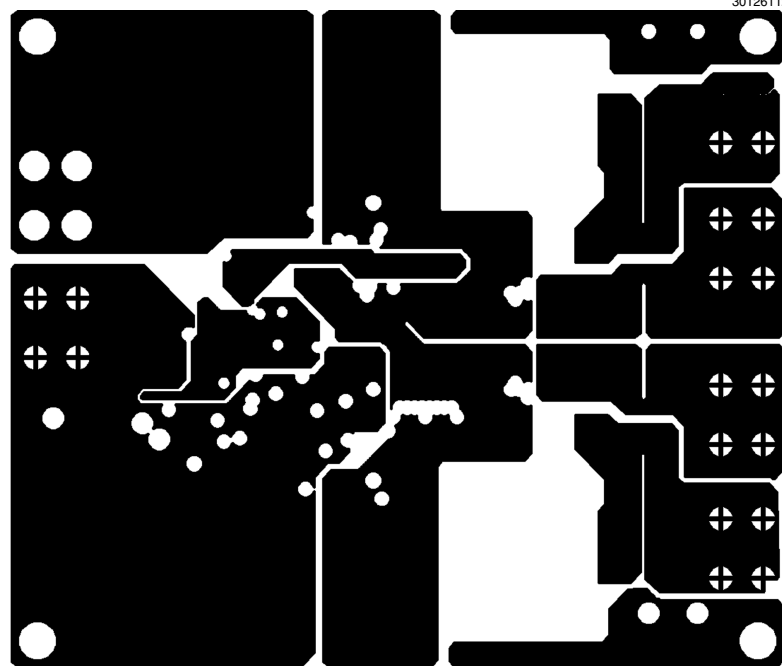


BOTTOM SILKSCREEN (.PLS) AS VIEWED FROM TOP

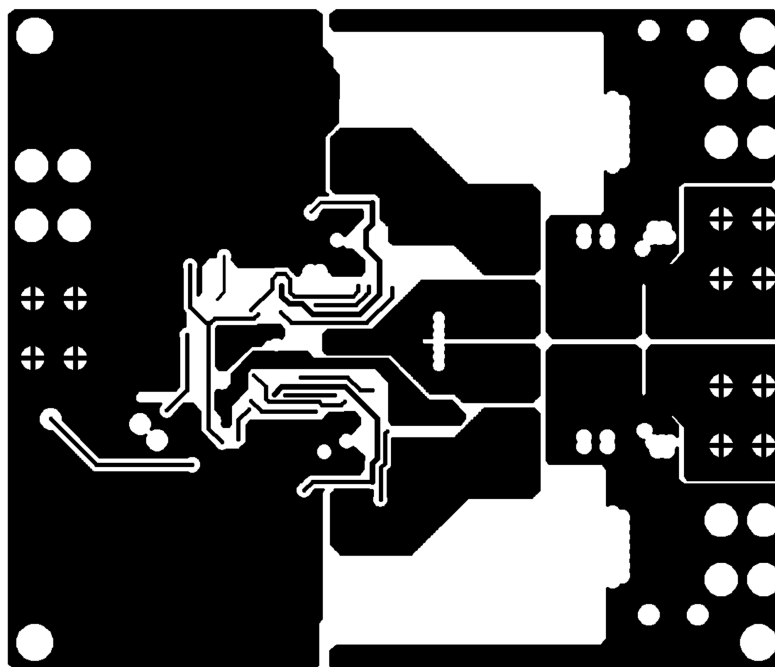
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TOP COMPONENT LAYER (.CMP) AS VIEWED FROM TOP

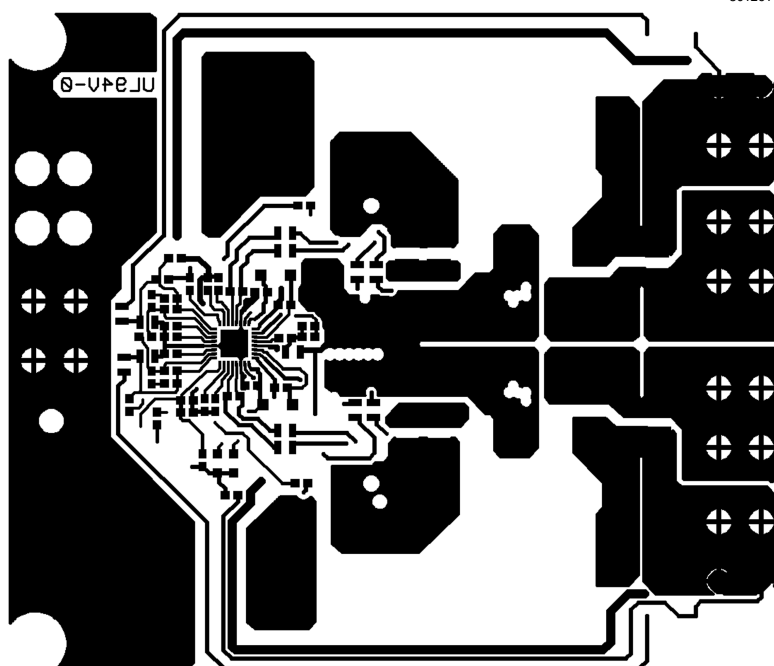


LAYER 2 (.LY2) AS VIEWED FROM TOP



LAYER 3 (.LY3) AS VIEWED FROM TOP

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BOTTOM SOLDER LAYER (.SOL) AS VIEWED FROM TOP

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Notes

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