AN-2065 LM5119 Evaluation Board

1 Introduction

The LM5119EVAL evaluation board provides the design engineer with a fully functional dual output buck converter, employing the LM5119 Dual Emulated Current Mode Synchronous Buck Controller. The evaluation board is designed to provide both 10V and 5V outputs over an input range of 14V to 55V. Also the evaluation board can be easily configured for a single 10V, 8A regulator.

2 Performance of the Evaluation Board

- Input Voltage Range: 14V to 55V
- Output Voltage: 10V (CH1), 5V (CH2)
- Output Current: 4A (CH1), 8A (CH2)
- Nominal Switching Frequency: 230 KHz
- Synchronous Buck Operation: Yes
- Diode Emulation Mode: Yes
- Hiccup Mode Overload Protection: Yes
- External VCC Sourcing: Yes

3 Powering and Loading Consideration

When applying power to the LM5119 evaluation board, certain precautions need to be followed. A misconnection can damage the assembly.

3.1 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.

3.2 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 0.7V. 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 LM5119. For complete design information, see the *LM5119/LM5119Q Wide Input Range Dual Synchronous Buck Controller Data Sheet* (SNVS676).

3.3 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.

3.4 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.

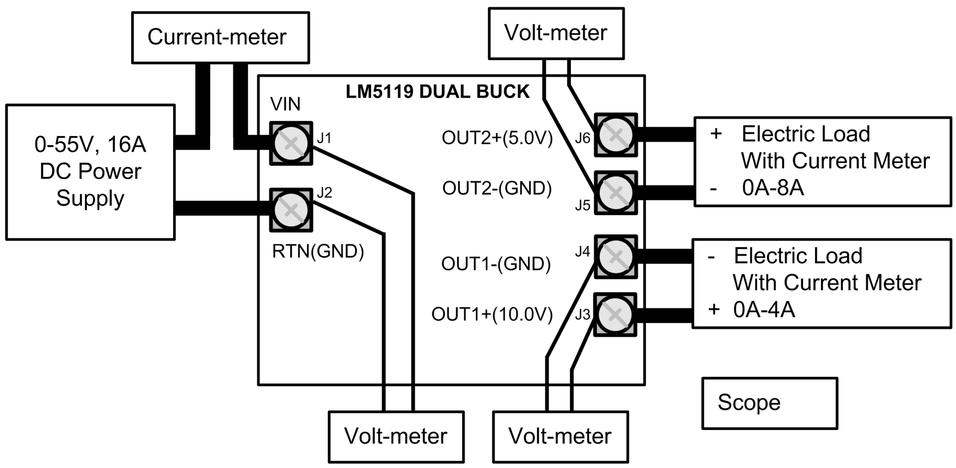


Figure 1. Typical Evaluation Setup

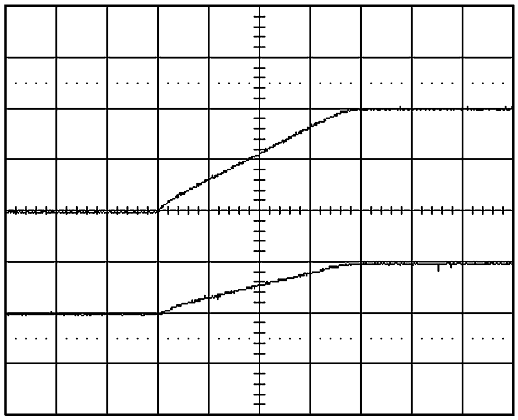
3.5 Quick Start-Up Procedure

1. Set the power supply current limit to at least 16A. Connect the power supply to J1 and J2.
2. Connect one load with a 4A capacity between J3 and J4. Connect another load with an 8A capacity between J6 and J5.
3. Set input voltage to 24V and turn it on.
4. Measure the output voltages. CH1 should regulate at 10V and CH2 should regulate at 5V.
5. Slowly increase the load current while monitoring the output voltages. The outputs should remain in regulation up to full load current.
6. Slowly sweep the input voltage from 14V to 55V while monitoring the output voltages. The outputs should remain in regulation.

4 Waveforms

4.1 Soft Start

When applying power to the LM5119 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 3Ω on the 10V output, and 1Ω on the 5V output, respectively.

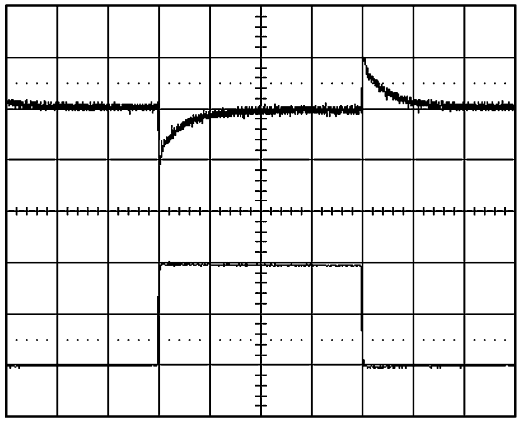


Conditions:
Input Voltage = 24VDC
3Ω Load on 10V output
1Ω Load on 5V output
Traces:
Top Trace: 10V Output Voltage, Volt/div = 5V
Bottom Trace: 5V Output Voltage, Volt/div = 5V
Horizontal Resolution = 1 ms/div

Figure 2. Start-Up With Resistive Load

4.2 Load Transient

Figure 3 shows the transient response for a load of change from 2A to 6A on 5V output. The upper waveform shows output voltage droop and overshoot during the sudden change in output current shown by the lower waveform.

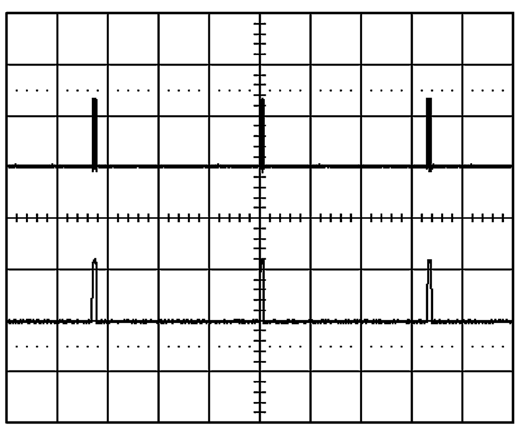


Conditions:
Input Voltage = 24VDC
Output Current 2A to 6A
Traces:
Top Trace: 5V Output Voltage, Volt/div = 100mV, AC coupled
Bottom Trace: Output Current, Amp/div = 2A
Horizontal Resolution = 0.5 ms/div

Figure 3. Load Transient Response

4.3 Overload 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 CH2 output. One channel may operate in the normal mode while the other is in hiccup mode overload protection.

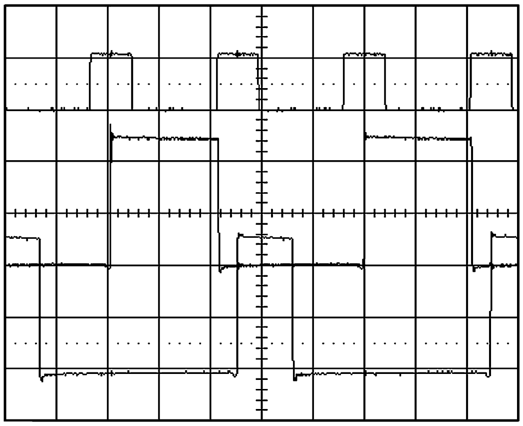


Conditions:
Input Voltage = 24VDC
Output Short on 5V
Traces:
Top Trace: SW Voltage on CH2, Volt/div = 20V
Bottom Trace: Inductor Current, Amp/div = 10A
Horizontal Resolution = 20 ms/div

Figure 4. Short Circuit

4.4 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° out of phase from the other.

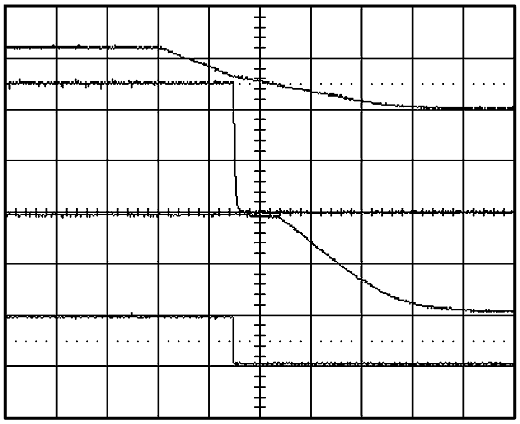


Conditions:
Input Voltage = 24VDC
4A on 10V Output
8A on 5V Output
Traces:
Top Trace: SYNC pulse, Volt/div = 5V
Middle Trace: SW voltage on CH1, Volt/div = 10V
Bottom Trace: SW voltage on CH2, Volt/div = 10V
Horizontal Resolution = 1 µs/div

Figure 5. Clock Synchronization

4.5 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 = 24VDC
1Ω Load on 5V Output
Traces:
Top Trace: Input Voltage, Volt/div = 20V
Middle Trace1: 5V 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

5 Performance Characteristics

Figure 7 shows the efficiency curves. The efficiency of the power converter is 96% at 24V 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.

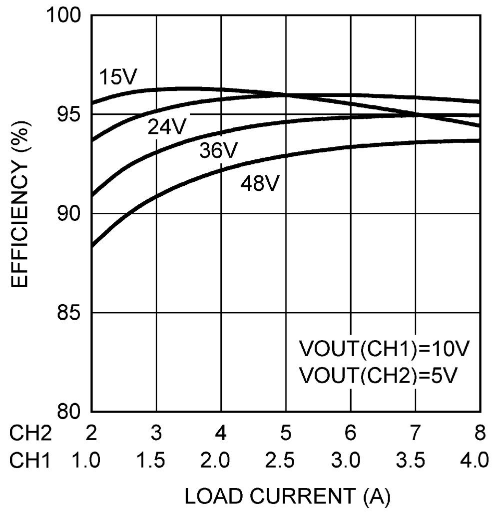


Figure 7. Typical Efficiency vs Load Current

6 Board Configuration

6.1 Interleaved Buck Operation for Single 10V 8A Output

The evaluation board is designed to be easily converted to a 10V, 8A 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 10V output with 8A maximum output current, populate R21 and R22 with 0Ω resistor and open R6, C15 and C14. The electronic load should have over 8A capability to test the interleaved operation.

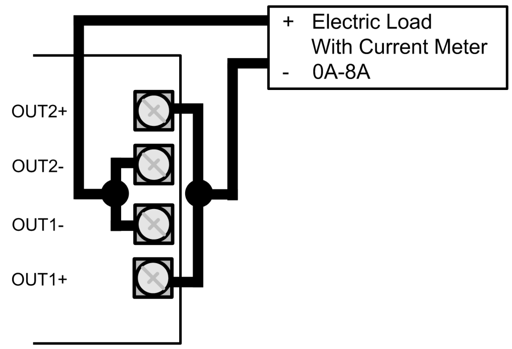


Figure 8. Load Connection for Single Output

6.2 External VCC Supply and VCC Disable

External VCC supply helps to reduce the temperature and the power loss of the LM5119 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. In this LM5119 evaluation board, VCC1 and VCC2 are supplied from the 10V output to achieve high efficiency.

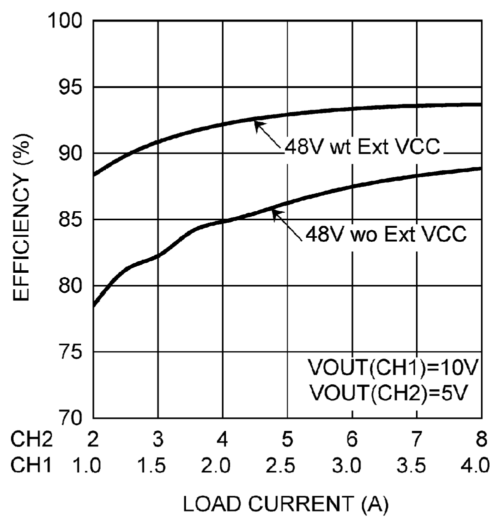


Figure 9. Efficiency Comparison at 48V With External VCC vs Without External VCC

6.3 Loop Response

TP5 and TP6 (TP7 and TP8) have been provided in order to measure the loop transfer function of CH1 (CH2). For detail information about the loop transfer function measurement, see *AN-1889 How to Measure the Loop Transfer Function of Power Supplies* (SNVA364).

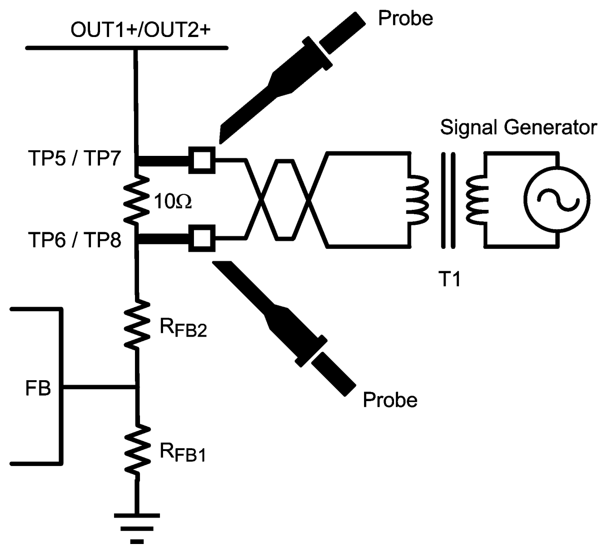
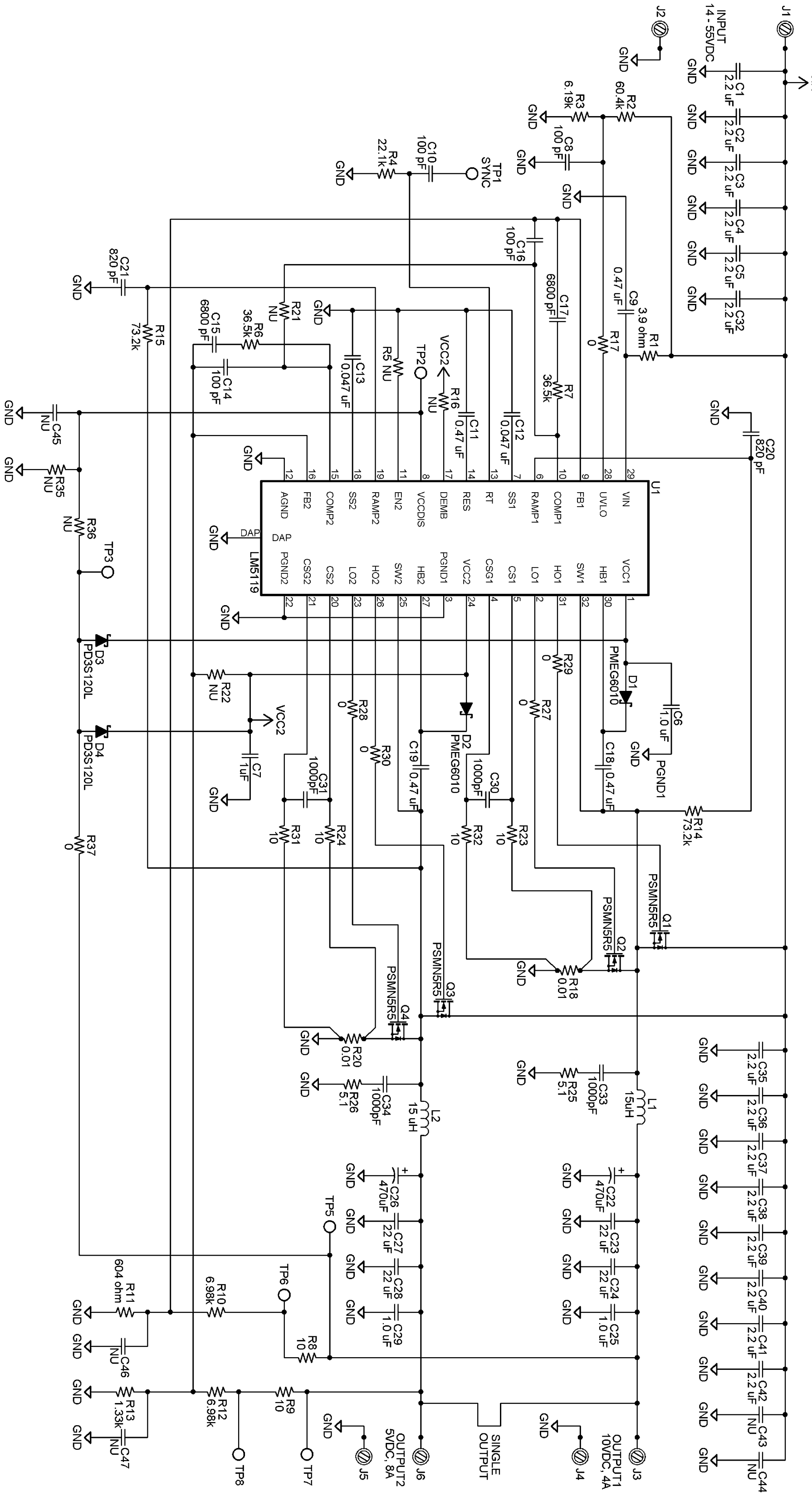


Figure 10. Loop Response Measurement Setup

7 Evaluation Board Schematic

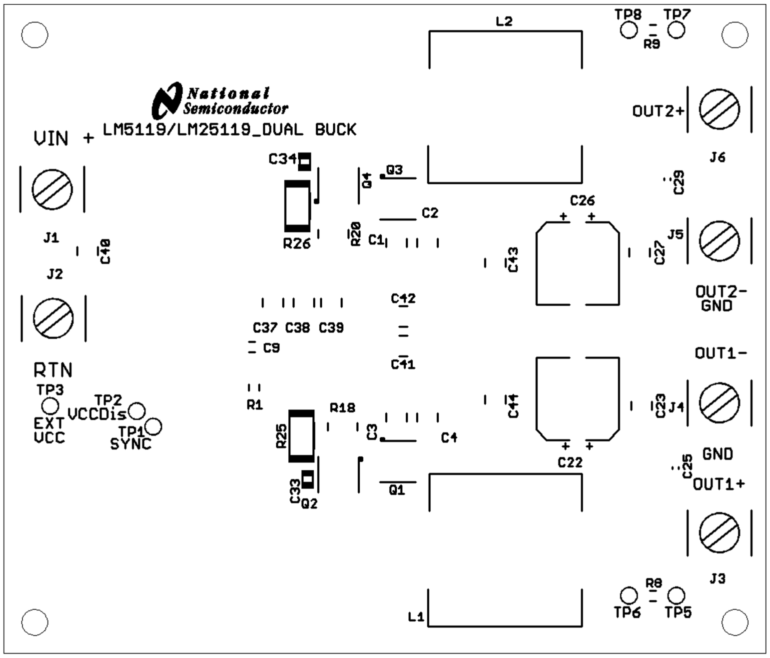


8 Bill of Materials (BOM)

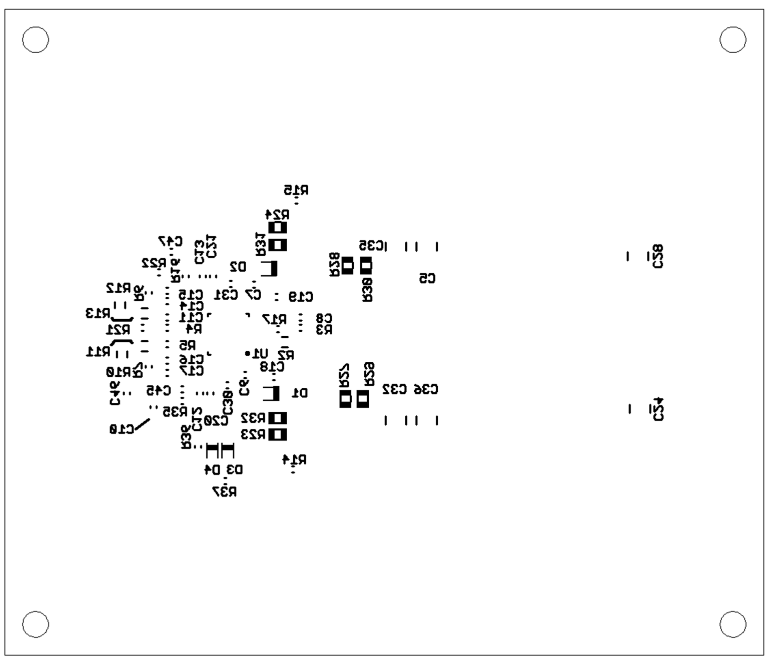
Table 1. Bill of Materials (BOM)

Part	Value	Package	Part Number	Manufacturer
C1, C2, C3, C4,C5, C32, C35,C36, C37, C38, C39, C40, C41, C42	2.2µF, 100V, X7R	1210	C3225X7R2A225K	TDK
C6, C7, C25,C29	1µF, 16V, X7R	0603	C1608X7R1C105K	TDK
C8, C10, C14, C16	100pF, 50V, C0G	0603	C1608C0G1H101J	TDK
C9	0.47µF, 100V, X7R	0805	GRM21BR72A474KA73	Murata
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	470µF, 16V	Φ10	PCG1C471MCL1GS	Nichicon
C23,C24,C27,C28	22µF,16V, X7R	1210	C3225X7R1C226K	TDK
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	60.4k, 1%	0805	CRCW080560K4FKEA	Vishay
R3	6.19k, 1%	0603	CRCW06036K19FKEA	Vishay
R4	22.1k, 1%	0603	CRCW060322K1FKEA	Vishay
R5,R16,R21,R22,R35,R36	NU			
R6,R7	36.5k, 1%	0603	CRCW060336K5FKEA	Vishay
R8,R9,R23,R24,R31, R32	10 ohm, 5%	0805	CRCW080510R0JNEA	Vishay
R10,R12	6.98k, 1%	0805	CRCW08056K98FKEA	Vishay
R11	604 ohm, 1%	0805	MCR10EZHF6040	Rohm
R13	1.33k, 1%	0805	MCR10EZHF1331	Rohm
R14,R15	73.2k, 1%	0603	CRCW060373K2FKEA	Vishay
R17,R37	0 ohm	0603	MCR03EZPJ000	Rohm
R18,R20	0.01 ohm, 1W, 1%	0815	RL3720WT-R010-F	Susumu
R25,R26	5.1 ohm, 1W, 1%	2512	ERJ-1TRQF5R1U	Panasonic — ECG
R27,R28,R29,R30	0 ohm	0805	MCR10EZPJ000	Rohm
D1,D2	60V, 1A	SOD123F	PMEG6010CEH	NXP
D3,D4	20V, 1A	PowerDI323	PD3S120L	Diodes
L1,L2	15µH, 14A	18.2x18.3	74435571500	WE
Q1,Q3, Q2,Q4	60V, 100A	LFPAK SO-8	PSMN5R5-60YS	NXP
U1		WQFN32	LM5119	TI
J1,J2,J3,J4,J5,J6	15A		7693	Keystone
TP1,TP2,TP3		Φ0.1	5002	Keystone
TP5,TP6,TP7,TP8			1040	Keystone

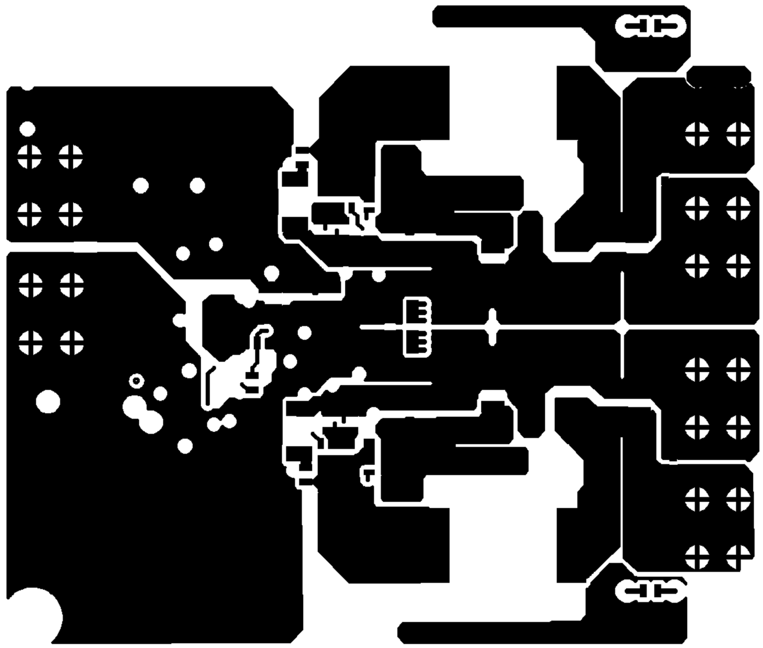
9 PCB Layout



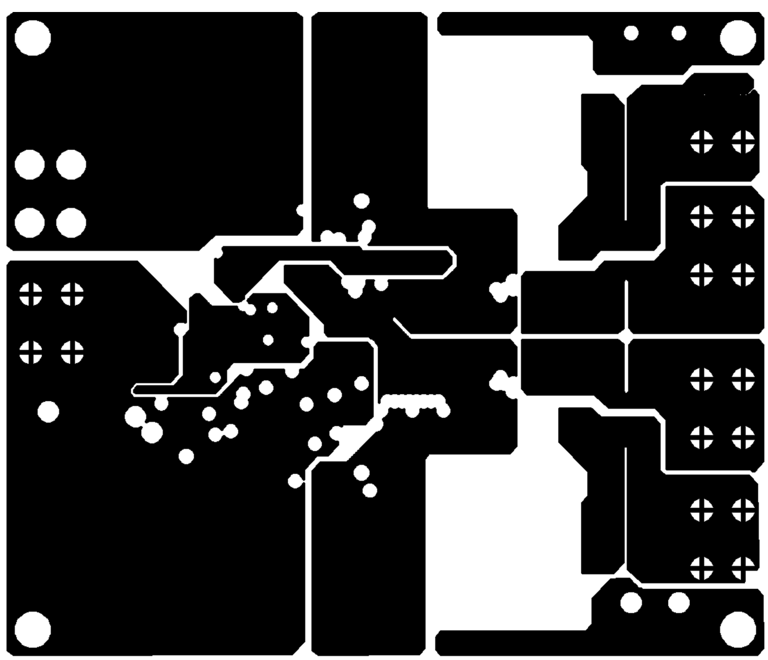
TOP SILKSCREEN (.PLC) AS VIEWED FROM TOP



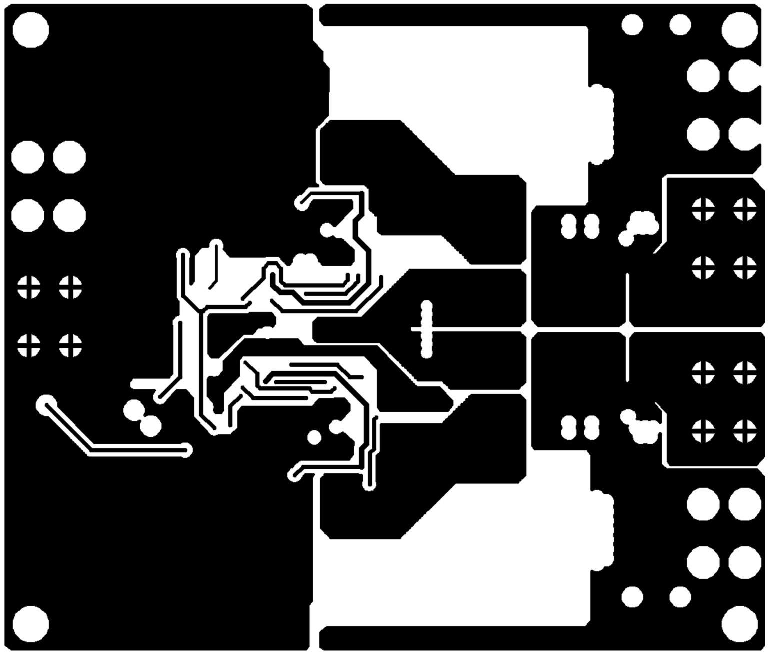
BOTTOM SILKSCREEN (.PLS) AS VIEWED FROM TOP



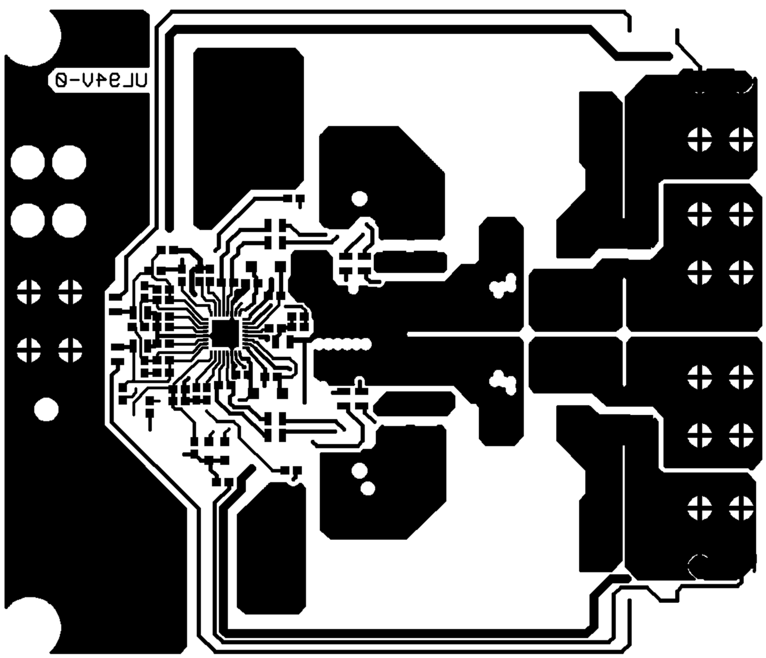
TOP COMPONENT LAYER (.CMP) AS VIEWED FROM TOP



LAYER 2 (.LY2) AS VIEWED FROM TOP



LAYER 3 (.LY3) AS VIEWED FROM TOP



BOTTOM SOLDER LAYER (.SOL) AS VIEWED FROM TOP

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