AN-1596 LM5116 Evaluation Board

1 Introduction

The LM5116 evaluation board is designed to provide the design engineer with a fully functional power converter based on emulated current mode control to evaluate the LM5116 controller IC. The evaluation board provides a 5V output with a 7A current capability. The wide input voltage ranges from 7V to 60V. The design operates at 250kHz, a good compromise between conversion efficiency and solution size. The printed circuit board consists of 4 layers, 2 ounce copper top and bottom, 1 ounce copper internal layers on FR4 material with a thickness of 0.06 inches. This application note contains the evaluation board schematic, Bill-of-Materials (BOM) and a quick setup procedure. Refer to the *LM5116 Wide Range Synchronous Buck Controller* (SNVS499) data sheet for complete circuit design information.

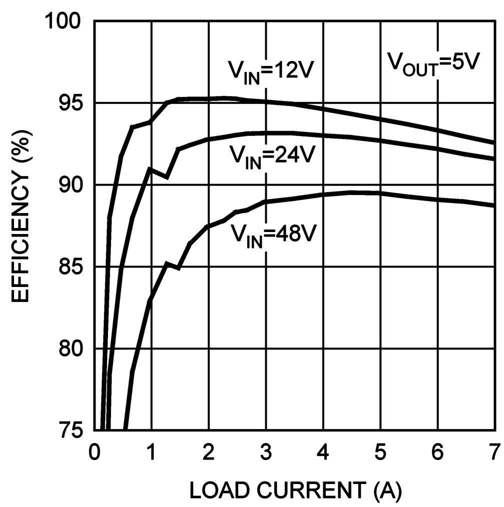

Figure 1. Efficiency with 6 µH Cooper Inductor

The performance of the evaluation board is as follows:

Input Range: 7V to 60V

Output Voltage: 5V

Output Current: 0 to 7A

Frequency of Operation: 250 kHz

Board Size: 2.55 X 2.65 X 0.5 inches

Load Regulation: 1%

Line Regulation: 0.1%

Over Current Limiting

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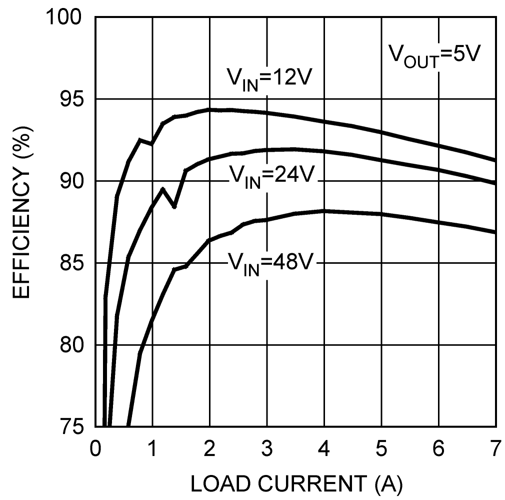


Figure 2. Efficiency with 5.6 µH Pulse Inductor

2 Powering and Loading Considerations

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

2.1 Quick Setup Procedure

Step 1: Set the power supply current limit to 15A. Turn off the power supply. Connect the power supply to the V_{IN} terminals.

Step 2: Connect the load, with a 7A capability, to the V_{OUT} terminals. Positive connection to P3 and negative connection to P4.

Step 3: The EN pin should be left open for normal operation.

Step 4: Set V_{IN} to 48V with no load applied. V_{OUT} should be in regulation with a nominal 5V output.

Step 5: Slowly increase the load while monitoring the output voltage, V_{OUT} should remain in regulation with a nominal 5V output as the load is increased up to 7 Amps.

Step 6: Slowly sweep the input voltage from 7 to 60V, V_{OUT} should remain in regulation with a nominal 5V output.

Step 7: Temporally short the EN pin to GND to check the shutdown function.

Step 8: Increase the load beyond the normal range to check current limiting. The output current should limit at approximately 11A. Cooling is critical during this step.

2.2 Air Flow

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

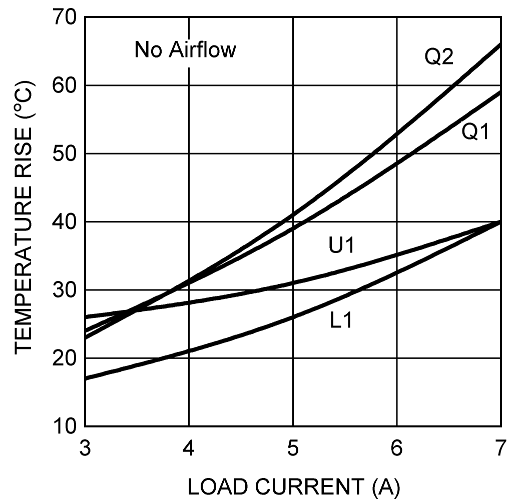


Figure 3. Temperature Rise at $48V_{IN}$ with 6 µH Cooper Inductor

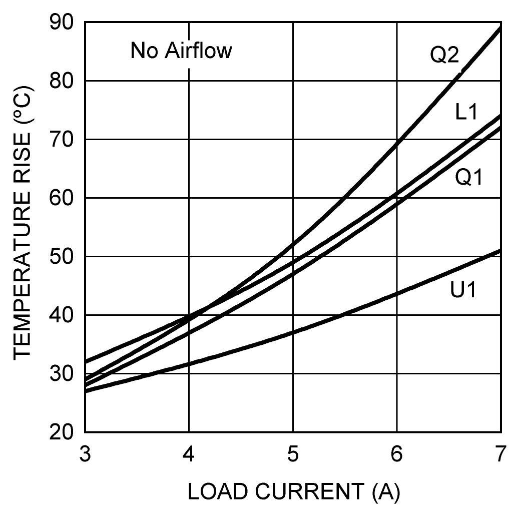


Figure 4. Temperature Rise at $48V_{IN}$ with 5.6 µH Pulse Inductor

2.3 Powering Up

Using the enable pin provided will allow powering up the source supply with the current level set low. 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. As you remove the connection from the enable pin to ground, immediately check for 5 volts at the output.

A quick efficiency check is the best way to confirm that everything is operating properly. If something is amiss you can be reasonably sure that it will affect the efficiency adversely. Few parameters can be incorrect in a switching power supply without creating losses and potentially damaging heat.

For operation at $7V_{IN}$ with full load, a 100 µF aluminum electrolytic capacitor installed across V_{IN} will prevent input filter oscillation for a typical bench test setup. See *LM5116 Wide Range Synchronous Buck Controller* (SNVS499) for complete design information.

2.4 Over Current Protection

The evaluation board is configured with over-current protection. The output current is limited to approximately 11A. The thermal stress is quite severe while in an overloaded condition. Limit the duration of the overload and provide sufficient cooling (airflow).

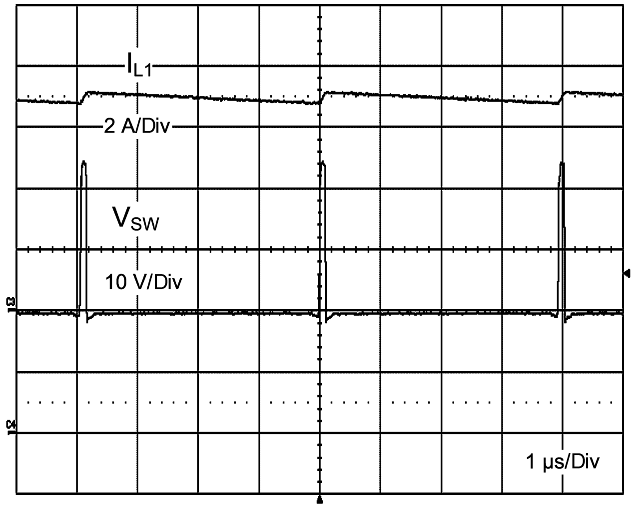


Figure 5. Short Circuit at 24V_{IN} Room Temperature

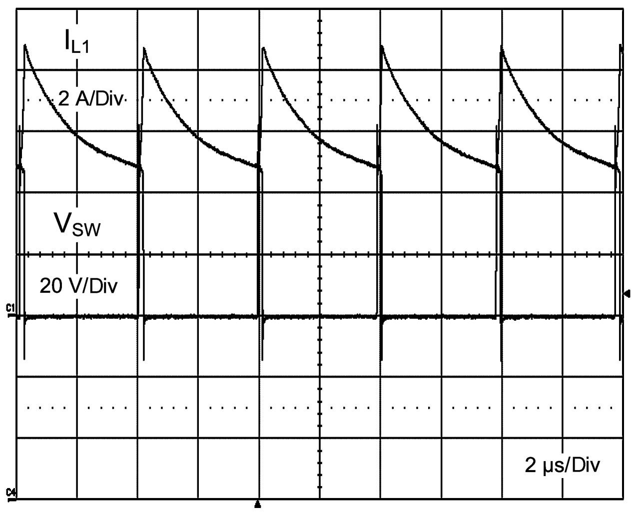


Figure 6. Short Circuit at 48V_{IN} 125°C

For sustained short circuit protection, adding C7 ≥ 1 µF will limit the short circuit power dissipation. D2 should be installed when using C7.

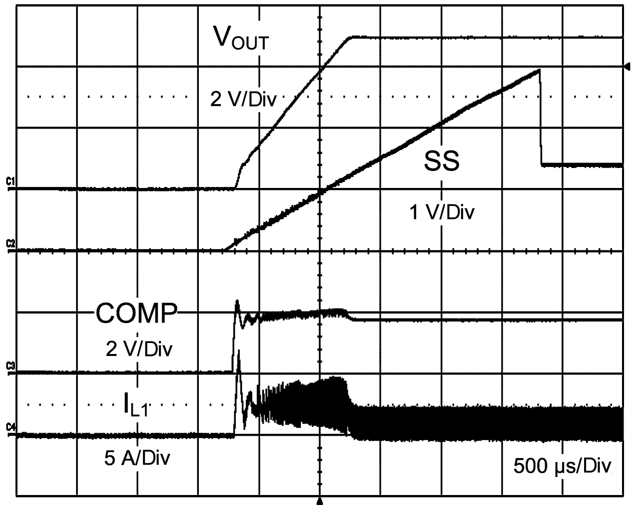


Figure 7. Short Circuit Recovery into Resistive Load with C7 = 1 µF and D2 Installed

2.5 VCCX

This test point supports evaluation of an auxiliary supply voltage derived from V_{OUT}. For output voltages between 7V and 14V, a zero ohm resistor may be installed for R12. The selected MOSFETs need greater than 6V gate drive to fully enhance them for lowest $R_{DS(ON)}$, so R12 is not recommended for the 5V output.

Under no circumstances should an external voltage source be connected to VCCX when V_{IN} < VCC. Damage to the controller will result. A series diode from the input voltage source to pin 1 is required to accommodate V_{IN} < VCC.

2.6 Synchronization

A SYNC pin has been provided on the evaluation board. This pin can be used to synchronize the regulator to an external clock. Refer to the *LM5116 Wide Range Synchronous Buck Controller* (SNVS499) data sheet for complete information.

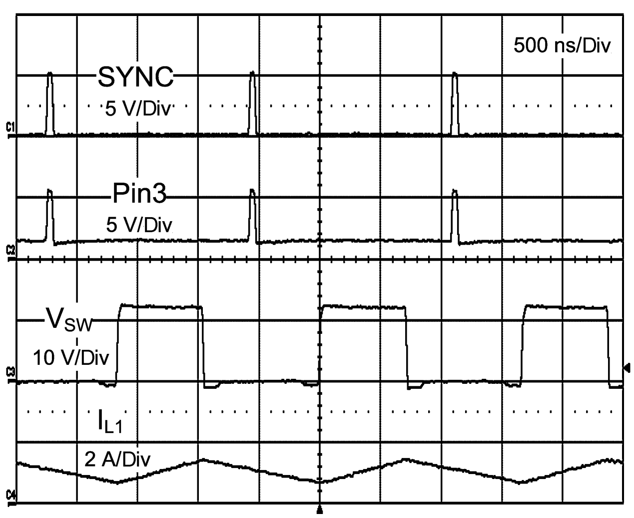


Figure 8. Synchronization at 12V_{IN}

2.7 Active Loads

Figure 12 shows a typical start-up characteristic into a constant current active load. This type of load can exhibit an initial short circuit, which is sustained well beyond the normal soft-start cycle. Overshoot of the output voltage is possible with this condition. Increasing the soft-start time to be longer than the initial short circuit period of the active load will minimize any possible overshoot. When using C7, the hiccup off-time may also need adjustment.

3 Typical Performance Waveforms

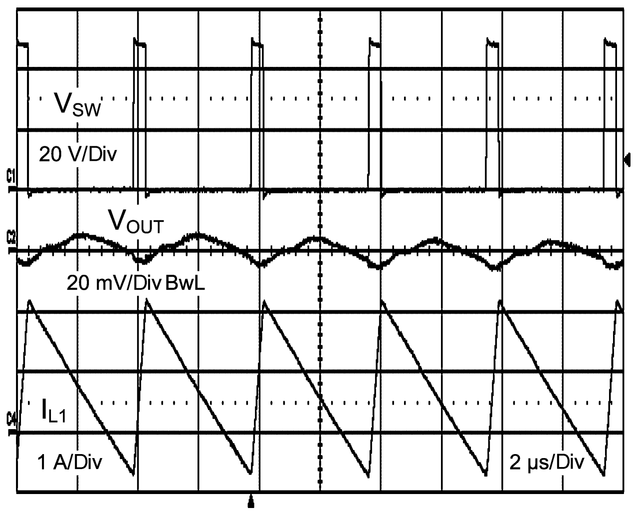


Figure 9. Full Synchronous Operation at $48V_{IN}$ with JMP1 Removed

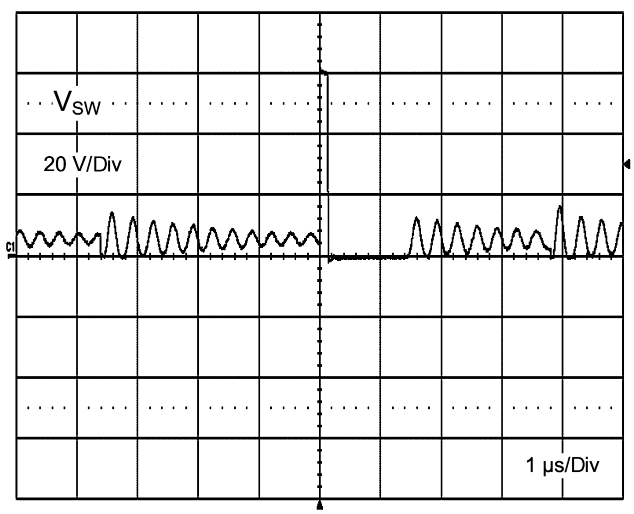


Figure 10. Discontinuous Operation using Diode Emulation Mode at $60V_{IN}$ with JMP1 Installed

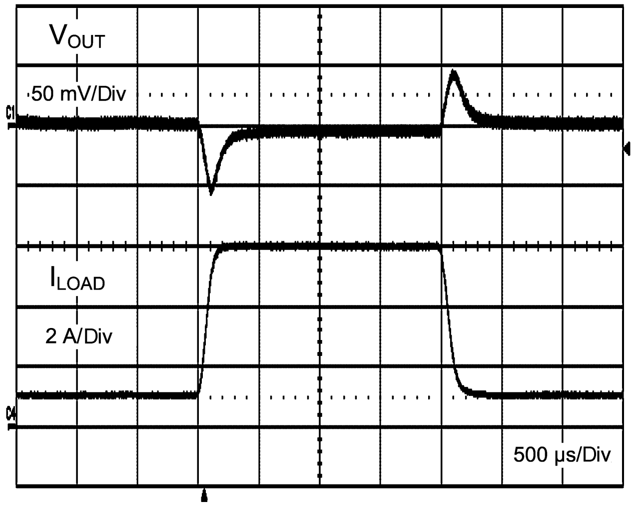


Figure 11. Transient Response at $24V_{IN}$

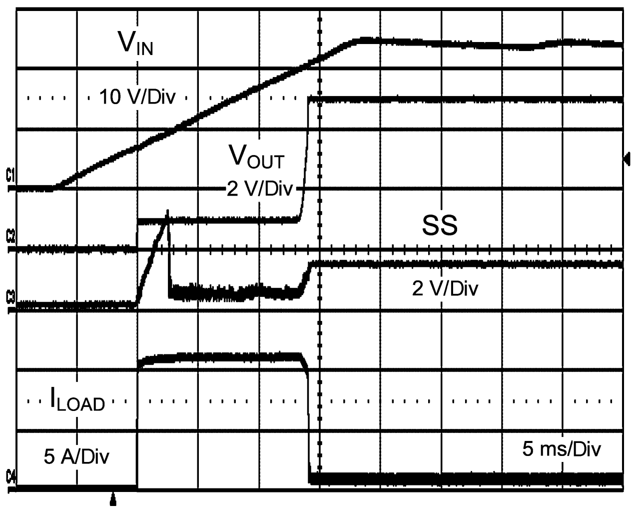
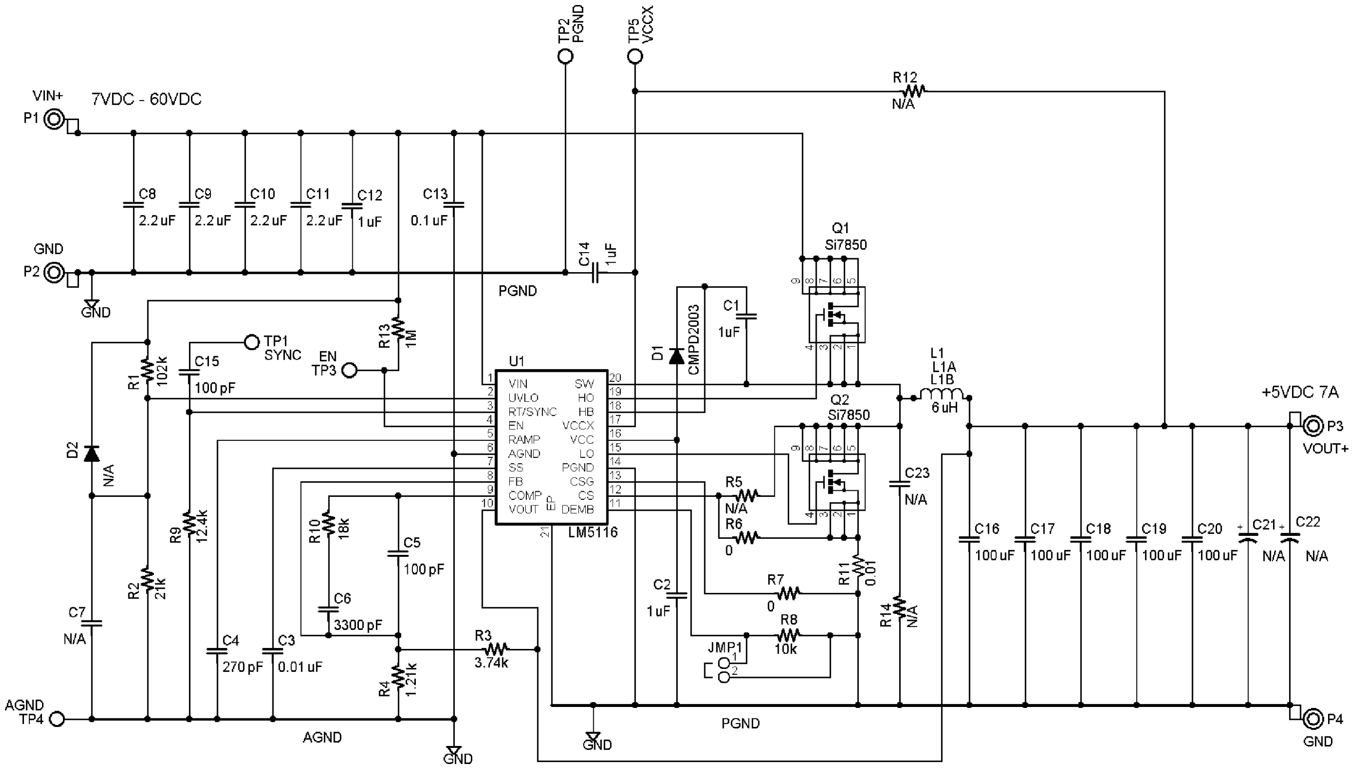


Figure 12. Start-up into Active Load at $24V_{IN}$

4 Evaluation Board Schematic



5 Bill of Materials

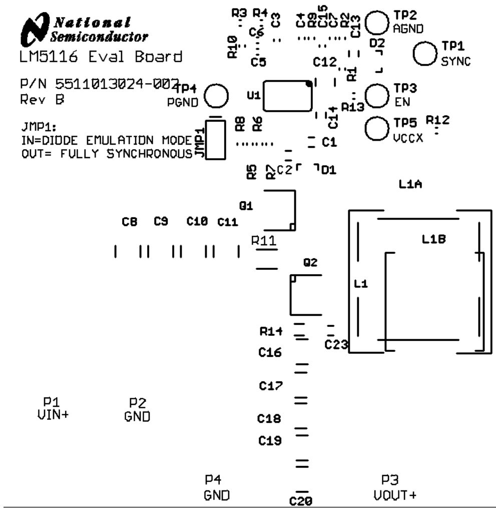
Table 1. Bill of Materials for 7V-60V Input, 5V 7A Output, 250kHz

ID	Part Number	Type	Size	Parameters	Qty	Vendor
C1, C2, C14	C2012X7R1E105K	Capacitor, Ceramic	0805	1µF, 25V, X7R	3	TDK
C3	VJ0603Y103KXAAT	Capacitor, Ceramic	0603	0.01µF, 50V, X7R	1	Vishay
C4	VJ0603A271JXAAT	Capacitor, Ceramic	0603	270pF, 50V, COG, 5%	1	Vishay
C5, C15	VJ0603Y101KXATW 1BC	Capacitor, Ceramic	0603	100pF, 50V, X7R	1	Vishay
C6	VJ0603Y332KXXAT	Capacitor, Ceramic	0603	3300pF, 25V, X7R	1	Vishay
C7		Capacitor, Ceramic	0603	Not Used	0	
C8, C9, C10, C11	C4532X7R2A225M	Capacitor, Ceramic	1812	2.2µF, 100V X7R	4	TDK
C12	C3225X7R2A105M	Capacitor, Ceramic	1210	1µF, 100V X7R	1	TDK
C13	C2012X7R2A104M	Capacitor, Ceramic	0805	0.1µF, 100V X7R	1	TDK
C16, C17, C18, C19, C20	C4532X6S0J107M	Capacitor, Ceramic	1812	100µF, 6.3V, X6S, 105°C	5	TDK
C21, C22		Capacitor, Tantalum	D Case	Not Used	0	
C23		Capacitor, Ceramic	0805	Not Used	0	
D1	CMPD2003	Diode, Switching	SOT-23	200mA, 200V	1	Central Semi
D2	CMPD2003	Diode, Switching	SOT-23	Not Used	0	Central Semi
JMP1		Connector, Jumper		2 pin sq. post	1	
L1	PD0120.532	Inductor		5.6µH, 10.4A	1	Pulse
L1A	HC2LP-6R0	Inductor		6µH, 16.5A	0	Cooper
L1A	P7611-5R6M	Inductor		5.6µH, 17A	0	Profec

Table 1. Bill of Materials for 7V-60V Input, 5V 7A Output, 250kHz (continued)

ID	Part Number	Type	Size	Parameters	Qty	Vendor
P1-P4	1514-2	Turret Terminal	.090” dia.		4	Keystone
TP1-TP5	5012	Test Point	.040” dia.		5	Keystone
Q1, Q2	Si7850DP	N-CH MOSFET	SO-8 Power PAK	10.3A, 60V	2	Vishay Siliconix
R1	CRCW06031023F	Resistor	0603	102kΩ, 1%	1	Vishay
R2	CRCW06032102F	Resistor	0603	21.0kΩ, 1%	1	Vishay
R3	CRCW06033741F	Resistor	0603	3.74kΩ, 1%	1	Vishay
R4	CRCW06031211F	Resistor	0603	1.21kΩ, 1%	1	Vishay
R5		Resistor	0603	Not Used	0	
R6, R7	CRCW06030R0J	Resistor	0603	0Ω	2	Vishay
R8	CRCW0603103J	Resistor	0603	10kΩ, 5%	1	Vishay
R9	CRCW06031242F	Resistor	0603	12.4kΩ, 1%	1	Vishay
R10	CRCW0603183J	Resistor	0603	18kΩ, 5%	1	Vishay
R11	LRC-LRF2010-01-R010-F	Resistor	2010	0.010Ω, 1%	0	IRC
R11	WSL2010R0100FEA	Resistor	2010	0.010Ω, 1%	1	Vishay
R12		Resistor	0603	Not Used	0	
R13	CRCW0603105J	Resistor	0603	1MΩ, 5%	1	Vishay
R14		Resistor	1206	Not Used	0	
U1	LM5116	Synchronous Buck Controller	HTSSOP-20EP		1	Texas Instruments

6 PCB Layout



TOP SILKSCREEN (.PLC) AS VIEWED FROM TOP
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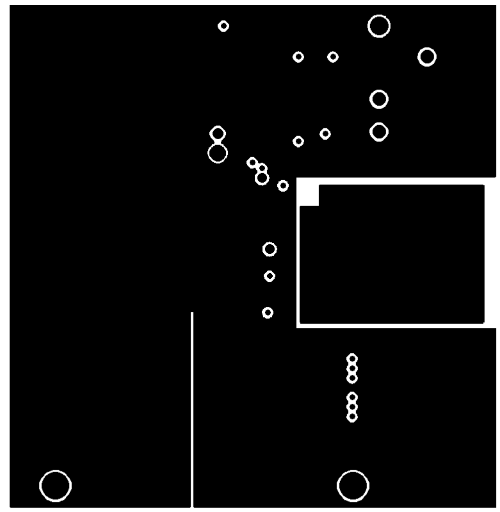

LAYER 2 (.LY2) AS VIEWED FROM TOP
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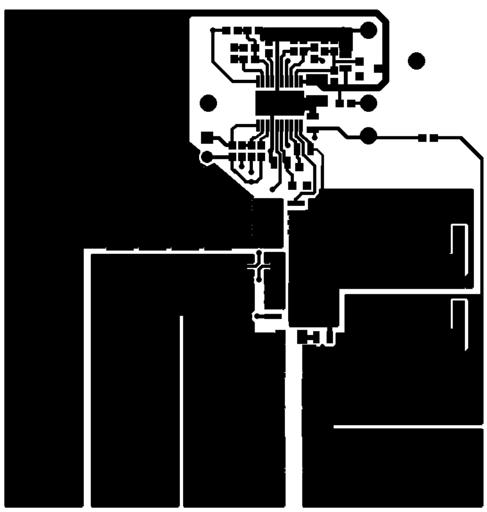

TOP (.CMP) LAYER AS VIEWED FROM TOP
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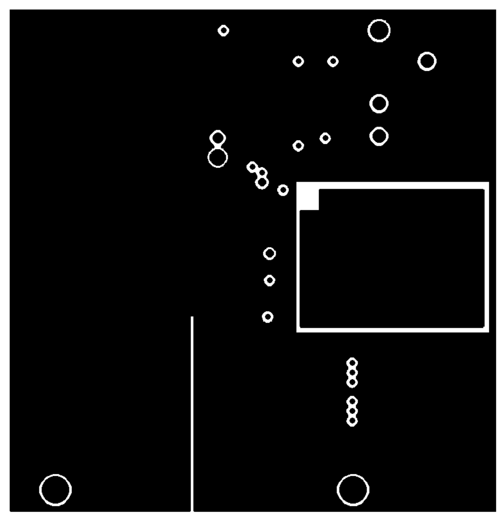

LAYER 3 (.LY3) AS VIEWED FROM TOP
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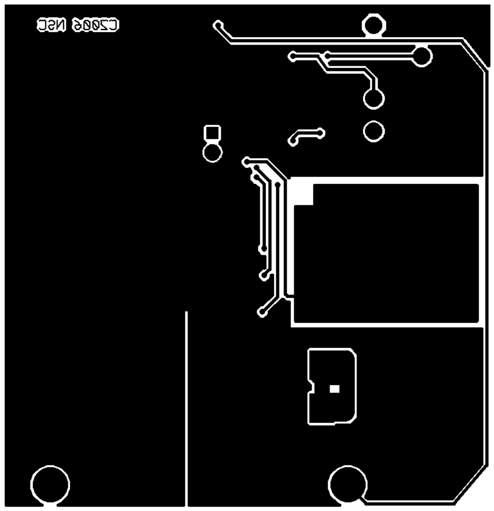

BOTTOM (.SOL) LAYER AS VIEWED FROM TOP
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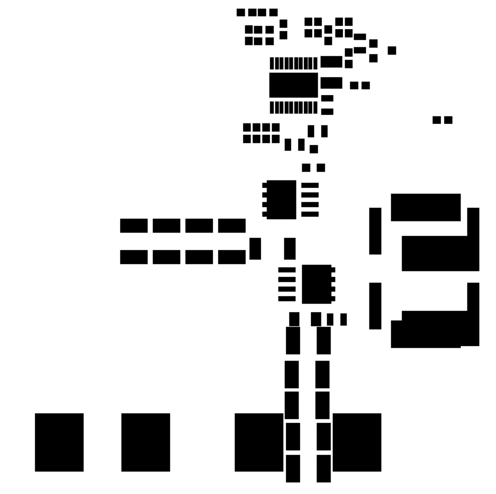

TOP SOLDER PASTE MASK (.CRC) AS VIEWED FROM TOP
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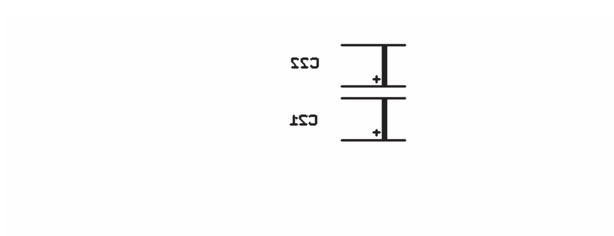

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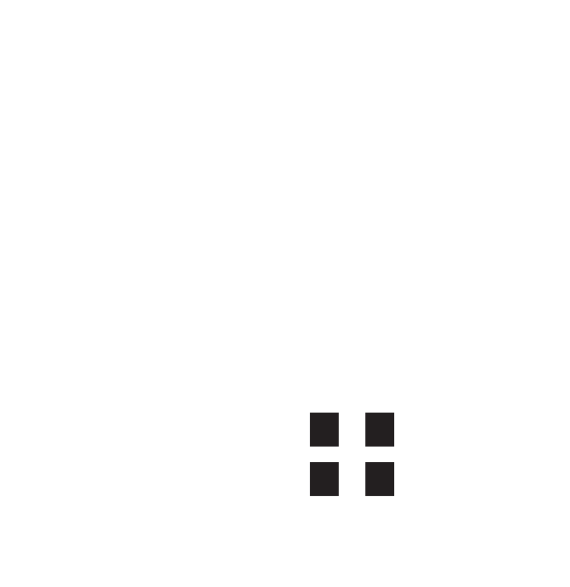

BOTTOM SOLDER PASTE MASK (.CRS) LAYER AS VIEWED FROM TOP
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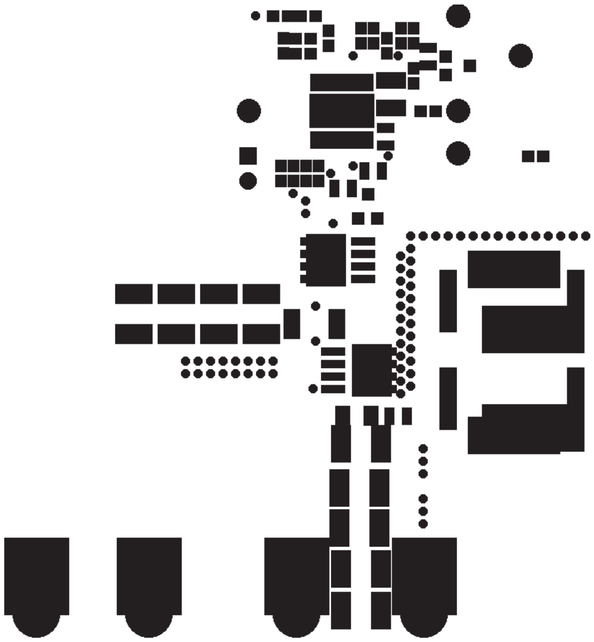

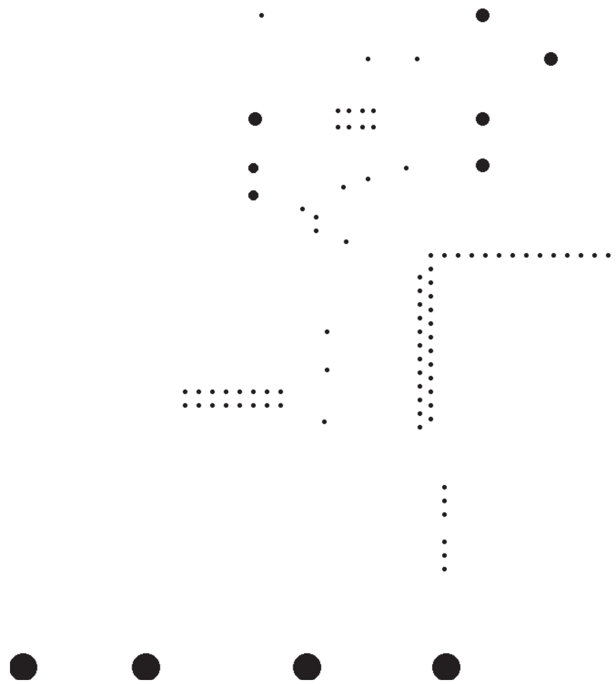

TOP SOLDERMASK (.STC) LAYER AS VIEWED FROM TOP
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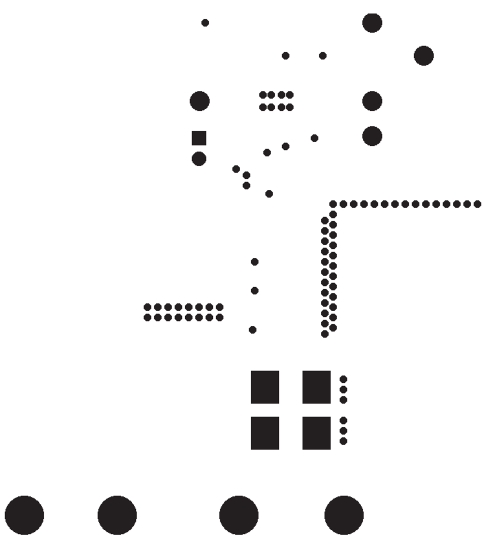

BOTTOM SOLDER MASK (.STS) LAYER AS VIEWED FROM TOP
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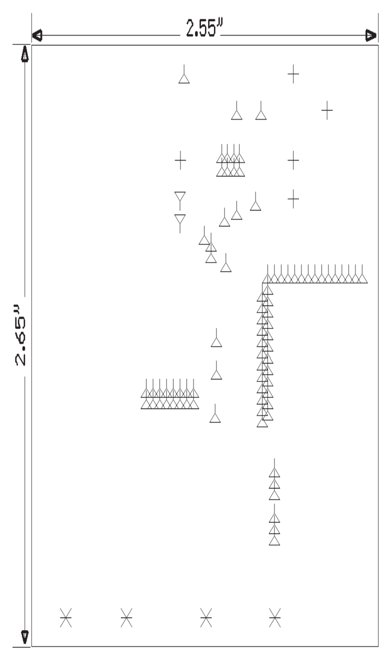

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