AN-2094 LM3481 SEPIC Evaluation Board

1 Introduction

The LM3481 SEPIC evaluation board is designed to provide the design engineer with a fully functional power converter solution with two output voltage options. It produces a selectable output voltage of 12 V at 1.25A or 5V at 3A. The switching frequency for the converter is set to 500 kHz. The printed circuit board consists of 2 layers of FR4 material with 2 ounce copper on both layers. This document contains the evaluation board schematics, bill-of-materials (BOM) and a quick setup procedure. For complete circuit design information, see the *LM3481/LM3481Q High Efficiency Low-Side N-Channel Controller for Switching Regulators Data Sheet* (SNVS346).

The performance of the evaluation board is as follows:

5V Output Voltage Option:

Input Voltage Range	: 4.5V to 25V
Output Voltage	: 5V ± 2%
Output Current	: 0A to 3A
Switching Frequency	: 500 kHz
Load Regulation	: 0.1%
Board Size	: 2.4 x 1.8 inches

12V Output Voltage Option:

Input Voltage Range	: 4.5V to 18V
Output Voltage	: 12V ± 2%
Output Current	: 0A to 1.25A
Switching Frequency	: 500 kHz
Load Regulation	: 0.1%
Board Size	: 2.4 x 1.8 inches

2 Powering and Loading Considerations

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

2.1 Qucik Setup Procedure

1. Use an input power supply with at least 5A current capability. Connect the positive output of the power supply to the V_{IN} terminal P1. Connect the negative output of the power supply to the input GND terminal P2.
2. Connect a load with 3A capability to the V_{OUT} terminal P3 and GND terminal P4.
3. To set the output voltage to 5V, the J2 jumper should be out. If the desired output voltage is 12V, the J2 jumper should be in.
4. Set V_{IN} to 12V with no load being applied. Turn on the input power supply. Once the input voltage is applied, the output voltage should be in regulation.
5. Adjust the input voltage and load current and set as desired while making sure that they are in range as described above.

Note: Do not change jumper settings while the board is powered on.

3 Connection Diagram

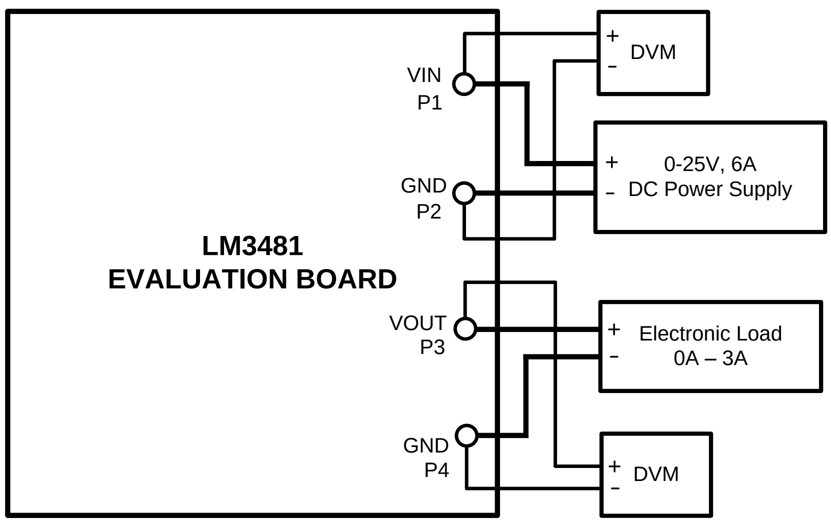


Figure 1. Basic Test Setup for the LM3481 SEPIC Evaluation Board

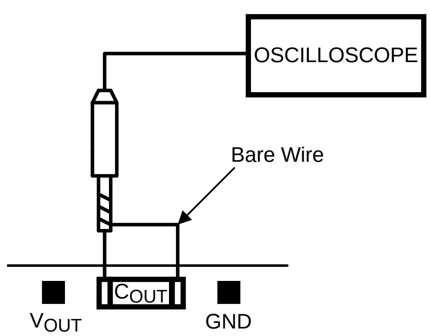


Figure 2. Output Voltage Ripple Measurement Setup

4 Board Configuration

4.1 Output Voltage Option

A jumper has been provided on the evaluation board in order to select the output voltage option of 12V or 5V. Shorting the jumper ses the output voltage to 12V. Leaving the jumper open will set the output voltage to 5V.

4.2 Under-Voltage Lock-Out (UVLO)

The LM3481 evaluation board has a resistor divider connected to the UVLO pin to set the on and off thresholds to 4.25V and 4.05V, respectively. There is also a jumper J1 on the board that provides the 'Enable' feature. If the jumper is open, the board will not produce an output voltage.

4.3 Output Voltage Ripple

Output voltage ripple measurement should be taken directly across the output capacitor C12 between terminals P3 and P4. Care must be taken to minimize the loop area between the scope probe tip and the ground lead in order to minimize noise in the measurement. This can be achieved by removing the probe's spring tip and ground lead and then wrap a bare wire around the scope probe shaft. The bare wire should be in contact with the probe shaft since this is the ground lead for the probe. The measurement can be taken by connecting the bare wire onto the ground side of the capacitor and the probe tip onto the positive side of the capacitor. Figure 2 shows a diagram of this measurement technique.

4.4 External Clock Synchronization

A SYNC terminal has been provided on the evaluation board in order to synchronize the converter to an external clock or other fixed frequency signal. For complete information on setting up the external clock, see the *LM3481/LM3481Q High Efficiency Low-Side N-Channel Controller for Switching Regulators Data Sheet* (SNVS346).

4.5 Active Loads

Many constant-current types of active loads can exhibit an initial short circuit, which is sustained well beyond the normal soft-start cycle. To avoid loss of regulation of the output voltage during current limit during startup, wait until the output voltage is up before turning on the load. Using an active load with a constant-resistance mode will avoid this startup timing issue.

4.6 SEPIC Operation and Advantages

The Single Ended Primary Inductance Converter (SEPIC) is a DC-DC converter that allows the output voltage to be either higher than or lower than the input voltage. The SEPIC capacitor is charged to a voltage potential of approximately V_{IN}. This capacitor acts as an AC short placing the two coils of the inductor in parallel. The duty cycle relationship and operation is similar to that of the Buck-Boost. During the on-time of the MOSFET a voltage of V_{IN} is applied across the mutual inductor. During the off-time of MOSFET, the mutual inductor voltage flies to V_{OUT} refreshing the charge on the output capacitor. Since the SEPIC capacitor is charged to V_{IN}, the voltage across the MOSFET is $V_{IN} + V_{OUT}$. Additionally, the current through the MOSFET is $I_{IN} + I_{OUT}$.

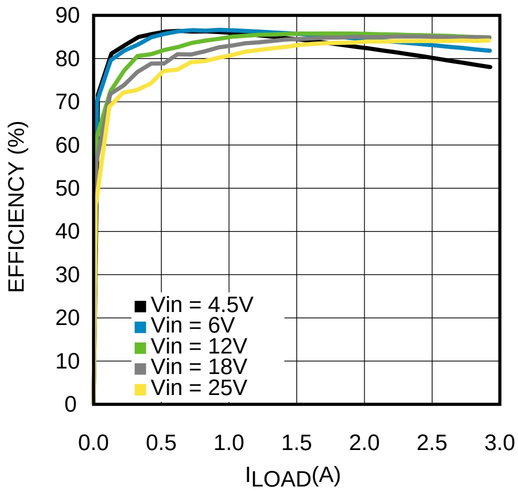
The SEPIC has quite a few advantages over the inverting Buck-Boost and the Flyback topology. The power MOSFET and the diode voltages in the Flyback topology are unclamped and are largely functions of the transformer leakage inductance and the stray capacitance. This causes large voltage spikes at the switching intervals. Compared to this for the SEPIC topology the MOSFET and the diode are clamped by the output and blocking capacitors and thus there is little circuit ringing. The SEPIC also has a common ground, unlike the Buck-Boost topology, which makes the input and output voltage sensing very easy.

4.7 Momentary Overload or Short Circuit Protection

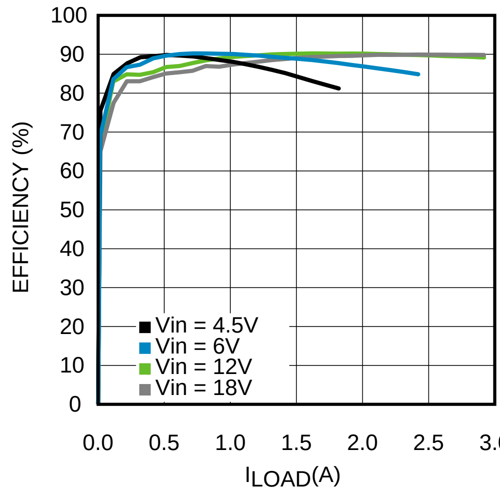
In case of an overload or a short circuit event, the voltage across the sense resistor would increase beyond 220 mV. This would then activate the short circuit current limit and limit the switching frequency by a factor of 8 while the event exists. In case of a prolonged overload/short circuit event, the large currents would cause the junction temperatures of the MOSFET and the diode to increase significantly and potentially cause thermal failure.

5 Typical Performance Characteristics

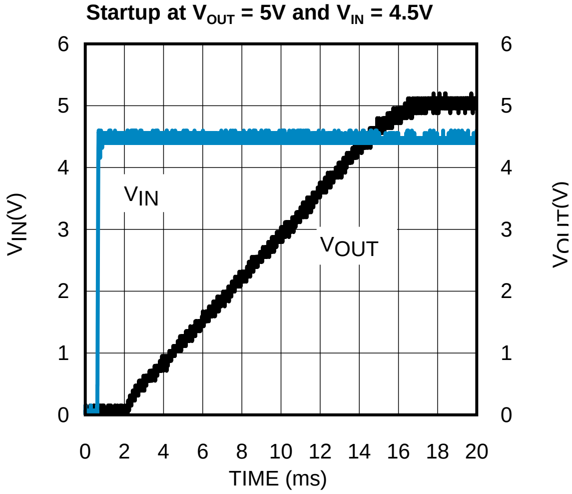
Efficiency at V_{OUT} = 5V



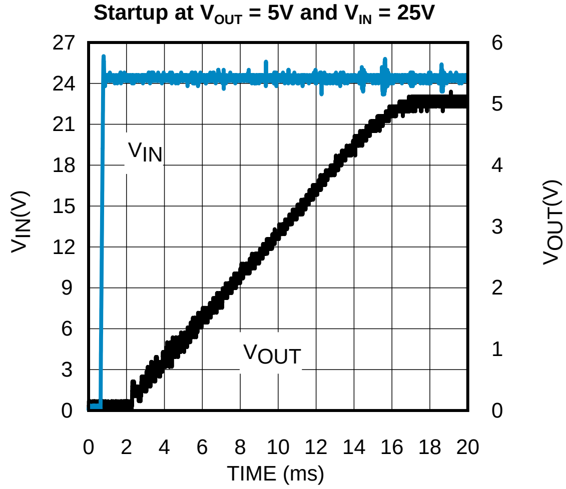
Efficiency at V_{OUT} = 12V



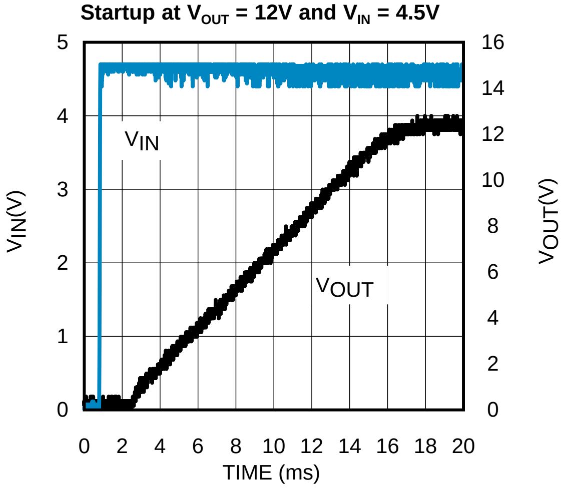
Startup at V_{OUT} = 5V and V_{IN} = 4.5V



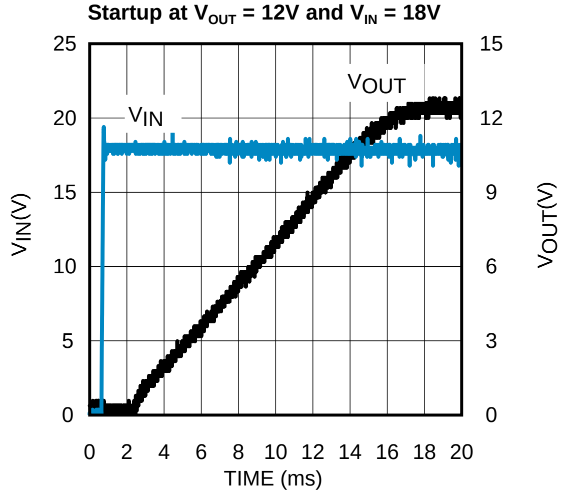
Startup at V_{OUT} = 5V and V_{IN} = 25V



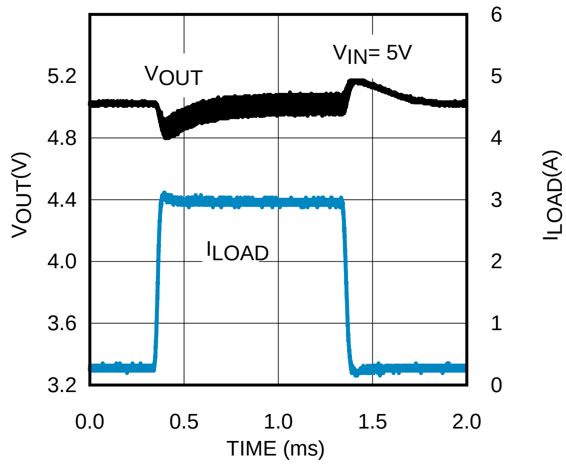
Startup at V_{OUT} = 12V and V_{IN} = 4.5V



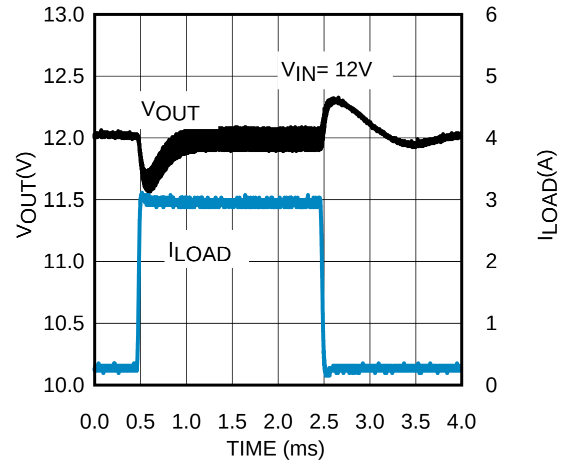
Startup at V_{OUT} = 12V and V_{IN} = 18V



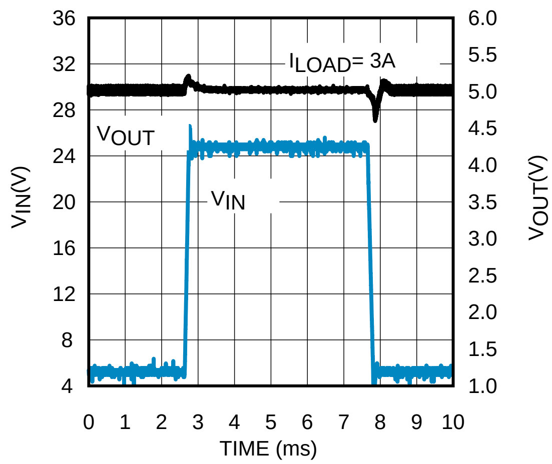
Load Transient at V_{IN} = 5V



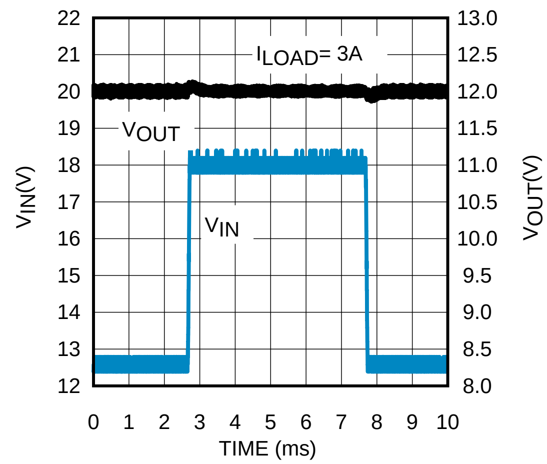
Load Transient at V_{IN} = 12V



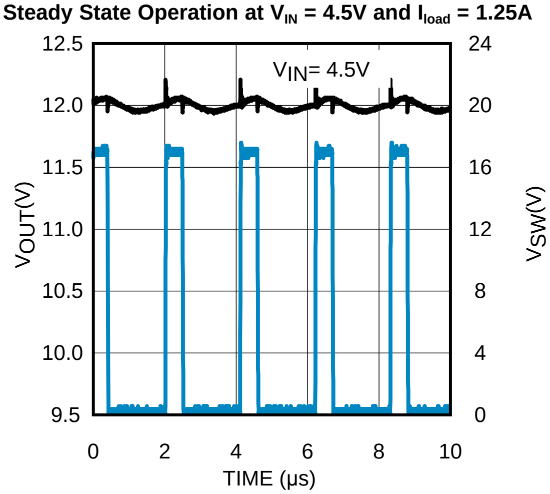
Input Transient at I_{load} = 3A and V_{OUT} = 5V



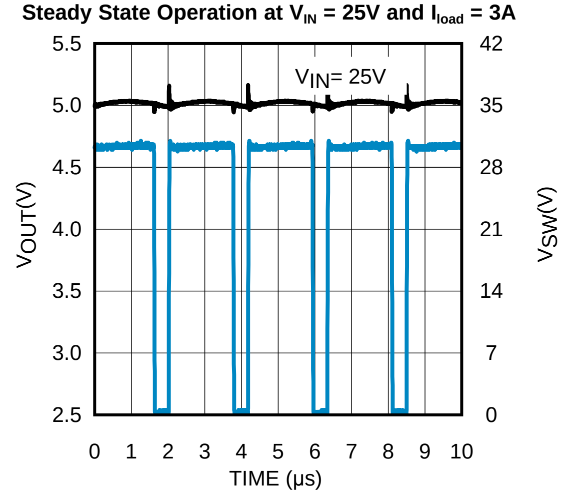
Input Transient at I_{load} = 3A and V_{OUT} = 12V



Steady State Operation at V_{IN} = 4.5V and I_{load} = 1.25A



Steady State Operation at V_{IN} = 25V and I_{load} = 3A



6 Evaluation Board Schematic

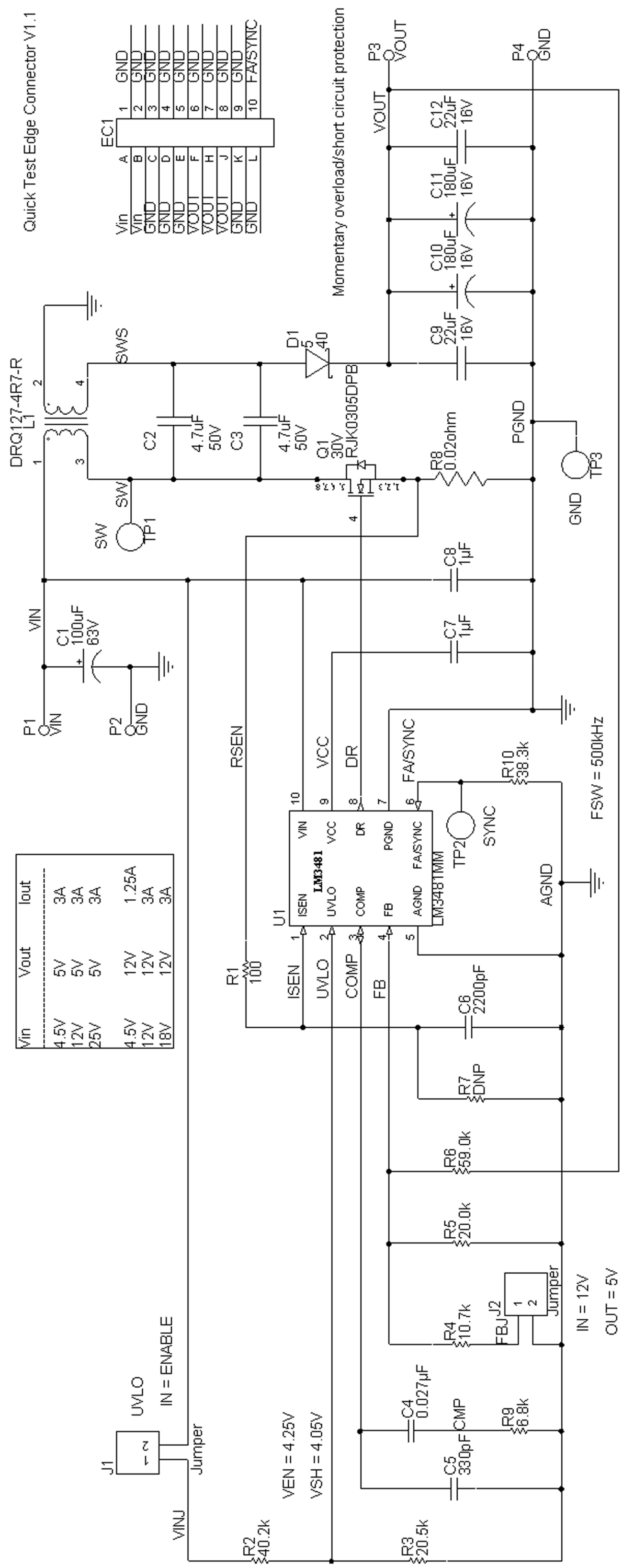


Figure 3. LM3481 Evaluation Board Schematic

Table 1. LM3481 Bill of Materials (BOM)

Qty	Designator	Value	Package	Description	Manufacturer	Part Number
1	C1	100 µF		Polarized Capacitor, 63V, 10%	Sanyo	63CV100KX
2	C2, C3	4.7 µF	1812	Ceramic, X7R, 50V, 10%	MuRata	C4532X7R1H475M
1	C4	0.027 µF	0603	Ceramic, X7R, 100V, 10%	Kemet	C0603C273K1RACTU
1	C5	100 pF	0603	Ceramic, X7R, 100V, 10%	AVX	06031C331KAT2A
1	C6	4700 pF	0603	Ceramic, X7R, 100V, 10%	AVX	06031C222KAT2A
1	C7	2200 pF	0603	Ceramic, X7R, 16V, 10%	TDK	C1608X7R1C105K
1	C8	1000 pF	1206	Ceramic, X7R, 50V, 10%	TDK	C3216X7R1H105K
2	C9, C12	22 µF	1812	Ceramic, X7R, 20V, 20%	TDK	C4532X7R1C226M
2	C10, C11	180 µF		Electrolytic capacitor	Sanyo	16SVP180M
1	D1		SMC	Schottky Diode, 40V	Central Semi	CMSH5-40
2	J1, J2			Through Hole Jumpers	Sullins Electronics	PBC02SAAN
1	L1	4.7 µH		Coupled Inductor, 8.25A	Cooper	DRQ127-4R7-R
4	P1, P2, P3, P4			Terminal, Turret, TH	Keystone Electronics	1598-2
1	Q1		PowerPAK	N Channel MOSFET, 30V	Vishay	Si7386DP
1	R1	100 ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW0603100RFKEA
1	R2	40.2k ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW060340K2FKEA
1	R3	20.5k ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW060320K5FKEA
1	R4	10.7k ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW060310K7FKEA
1	R5	20.0k ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW060320K0FKEA
1	R6	59.0k ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW060359K0FKEA
1	R7	DNP		Resistor		DNP Resistor
1	R8	20m ohm		RES, 1%, 1W	Vishay-Dale	WSL2512R0200FEA
1	R9	6.8k ohm	0603	RES, 5%, 0.1W	Vishay-Dale	CRCW06036K80JNEA
1	R10	38.3k ohm	0603	RES, 1%, 0.1W	Vishay-Dale	CRCW060338K3FKEA
3	TP1, TP2, TP3			Through Hole Test Point, Miniature, White	Keystone Electronics	5002
1	U1		VSSOP	Low-Side N-Channel Controller	Texas Instruments	LM3481

7 PCB Layout

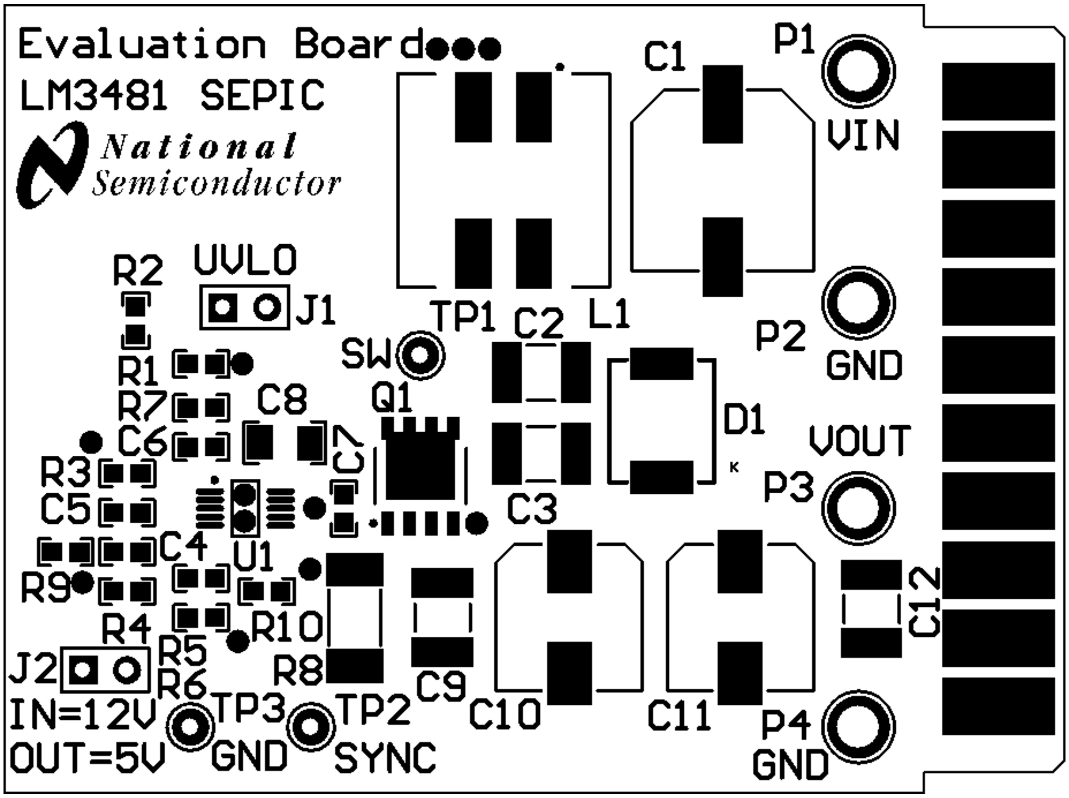


Figure 4. Top Layer Components and Overlay

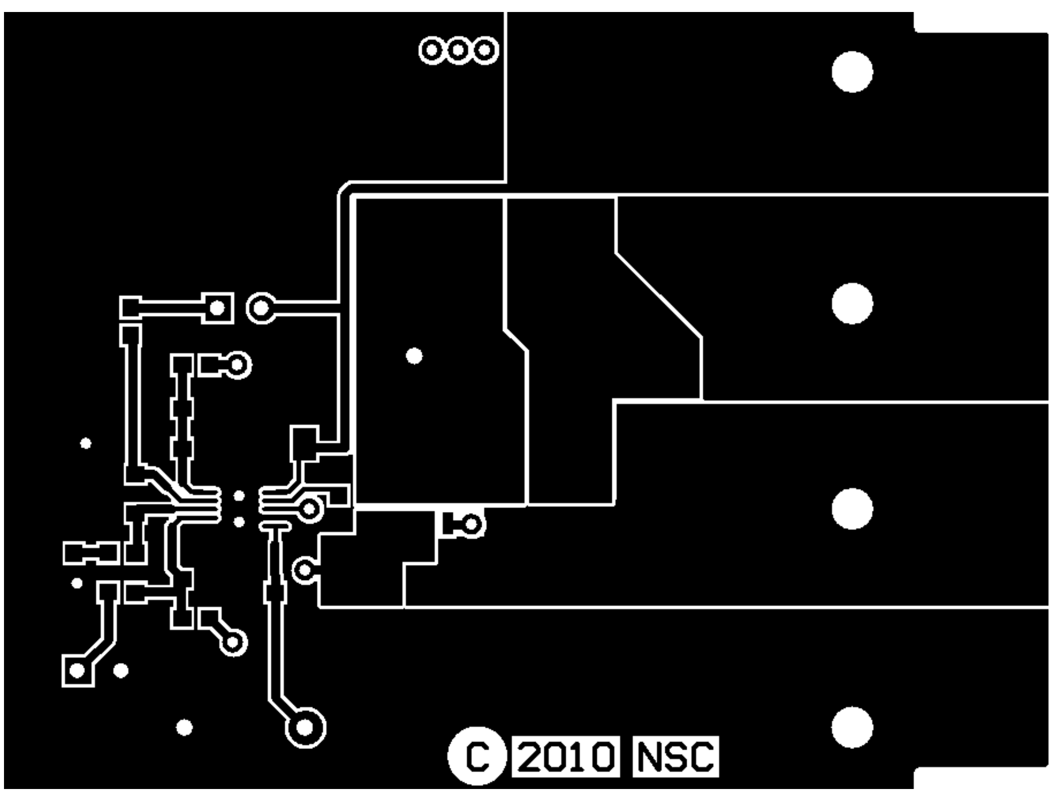


Figure 5. Top Layer Copper

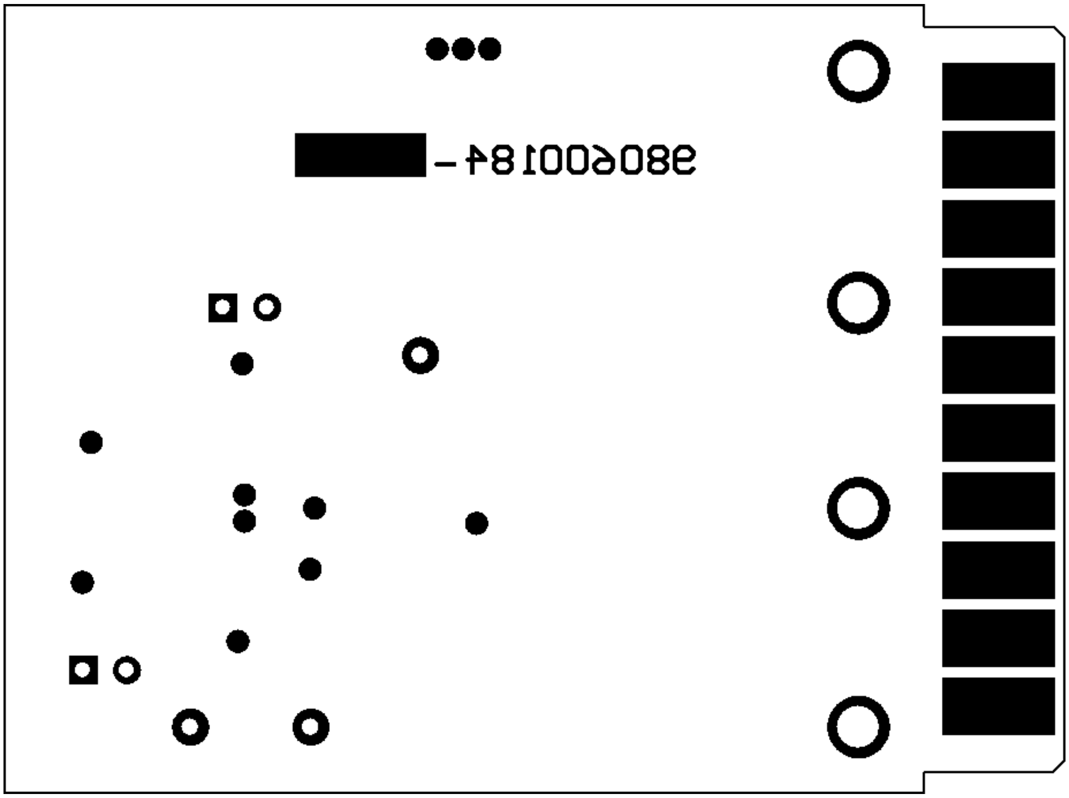


Figure 6. Bottom Overlay

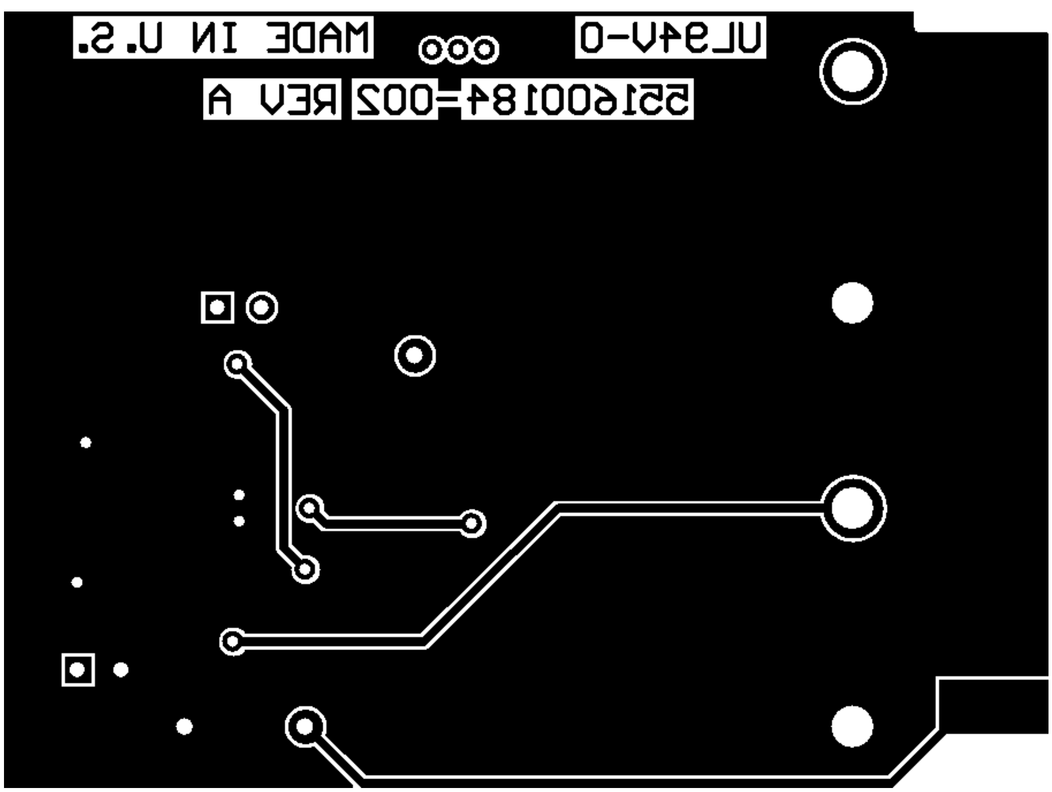


Figure 7. Bottom Layer Copper

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