AN-1956 LM5001 Boost Evaluation Board

1 Introduction

The LM5001 boost evaluation board is designed to provide the design engineer with a fully functional power converter based on the boost topology to evaluate the LM5001 high voltage switch mode regulator.

The performance of the evaluation board is as follows:

Input Operating Range: 16 to 36V

Output Voltage: 48V

Output Current: 0 to 150 mA

Measured Efficiency: 91% @ 150 mA, 86% @ 75 mA

Frequency of Operation: 240 kHz

Board Size: 1.75 X 1.75 inches

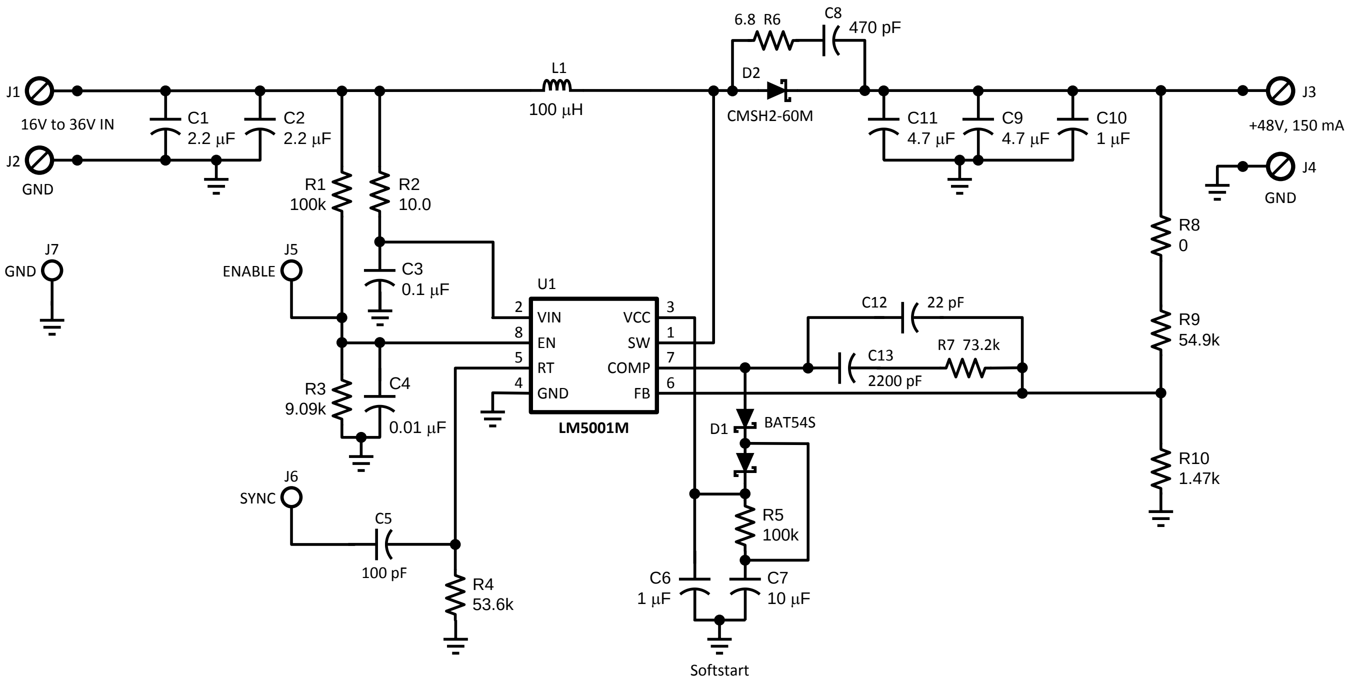
Load Regulation: 1%

Line Regulation: 0.1%

The printed circuit board consists of 2 layers; 1 ounce copper layers FR4 material with a total thickness of 0.062 inches.

When laying out the PCB note the proximity of the ground pin (pin 4) to the output capacitors (see the schematic in Section 2). Placing the ground pin near the output capacitor will minimize the ripple in the output by forcing a constant current to flow across the board for both the switch on and switch off portions of the cycle. If the board is laid out with the ground pin near the input capacitor then a high di/dt condition will occur due to the small conduction loop area during the switch on time and large loop conduction area during the switch off time. The output ripple and noise will be minimized if the conduction loop area and current both remain constant. Placing the ground pin near the output capacitor accomplishes this goal.

2 Schematic



J1
16V to 36V IN
J2
GND
C1
2.2 µF
C2
2.2 µF
L1
100 µH
6.8 R6
C8
470 pF
D2
CMSH2-60M
C11
4.7 µF
C9
4.7 µF
C10
1 µF
J3
+48V, 150 mA
J4
GND
R1
100k
R2
10.0
C3
0.1 µF
J7
GND
J5
ENABLE
U1
VIN
EN
RT
GND
VCC
SW
COMP
FB
LM5001M
R3
9.09k
C4
0.01 µF
C12
22 pF
C13
2200 pF
R7 73.2k
R8
0
R9
54.9k
R10
1.47k
D1
BAT54S
R5
100k
J6
SYNC
C5
100 pF
R4
53.6k
C6
1 µF
C7
10 µF
Softstart

3 Powering and Loading Considerations

When applying power to the LM5001 Boost evaluation board certain precautions need to be followed. A misconnection can damage the board.

3.1 Proper Connections

When operated at low input voltages the evaluation board can draw up to 500mA of current at full load. The maximum rated output current is 150mA. Be sure to choose the correct connector and wire size when attaching the source supply and the load. Monitor the current into and out of the evaluation board. Monitor the voltage directly at the output terminals of the evaluation board. The voltage drop across the load connecting wires will give inaccurate measurements. This is especially true for accurate efficiency measurements. When measuring output ripple with an oscilloscope. Do not use the wire ground lead for the ground connection. The loop formed by the wire lead will pick up noise from the switching circuits and make the ripple voltage look larger then it actually is. Instead use a spring ground clip on the exposed ground ring on the scope probe to minimize the loop area of the ground lead. An alternative is to remove the shroud covering the scope probe. Then touch the exposed scope probe ground connection to the output ground terminal while simultaneously connecting the probe tip to the output terminal.

3.2 Source Power

The power supply and cabling must look like a low impedance voltage source to the evaluation board. High inductance power supply leads like the type typically used for bench power supplies, could cause the LM5001 to become unstable or have poor response to load transients. This is due to the inductance of the power supply wiring interacting with the evaluation board input capacitor and causing a series resonant LC oscillation at a frequency defined by the inductance of the input wiring and the value of the input capacitor. In some cases it may be necessary to add an additional capacitor in parallel with input capacitor to move the resonate frequency away from the unity gain crossover frequency of the LM5001. Twisting the input supply lines together will reduce the inductance and potential for problems. Powering up at max rated voltage or close to this voltage can cause damage due to the inductance of the supply lines. Over shoot and ringing can be several volts under a sudden application of power. When operating near maximum input voltage slowly ramp up the voltage to avoid overshoot.

3.3 Loading

An appropriate electronic load, with specified operation up to 48V maximum or more, is desirable. Monitor both current and voltage at all times. Ensure there is sufficient cooling provided for the load.

3.4 Over Current Protection

The LM5001 monitors the peak current through the inductor on a cycle by cycle basis. If the inductor is sized large enough to not saturate when operating at peak current limit. Then the short circuit can be left on indefinitely with out damaging the device or causing it to go into thermal shutdown.

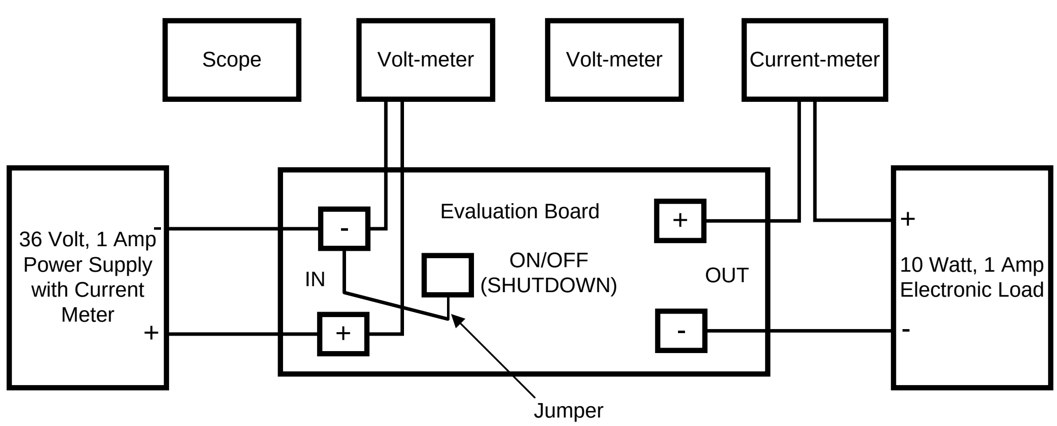


Figure 1. Typical Evaluation Setup

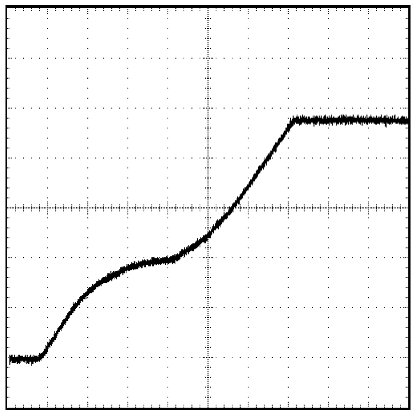
4 Performance Characteristics

Turn-on Waveforms

Figure 2 shows the output voltage during a typical start-up with a 20V input and a load of 150 mA. There is no overshoot during startup.

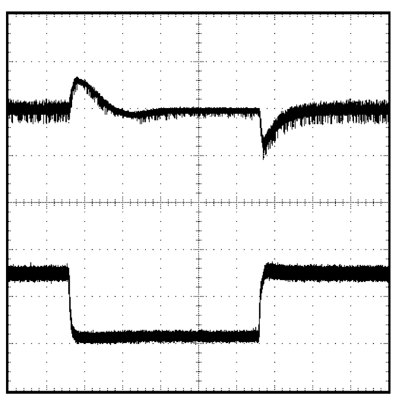
Output Ripple Waveforms

Figure 3 shows the transient response for a load of change from 15 mA to 150 mA. The upper trace shows minimal output voltage droop and overshoot during the sudden change in output current shown by the lower trace.



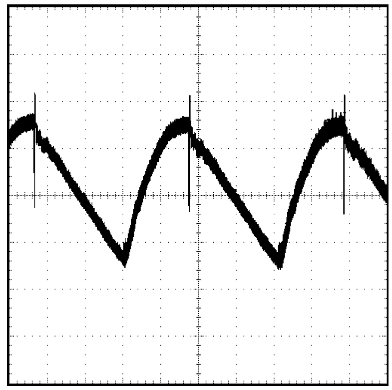
Conditions:
Input Voltage = 20VDC
Output Current = 150 mA
Trace 1:
Output Voltage
Volts/div = 10V
Horizontal Resolution = 4.0 ms/div

Figure 2. Output Voltage During a Typical Start-Up With a 20V Input and a Load of 150 mA



Conditions:
Input Voltage = 20VDC
Output Current = 15 mA to 150 mA
Upper Trace:
Output Voltage
Volts/div = 500 mV
Lower Trace:
Output Current
150 mA to 15 mA to 150 mA
Horizontal Resolution = 0.4 ms/div

Figure 3. Transient Response for a Load of Change From 15 mA to 150 mA



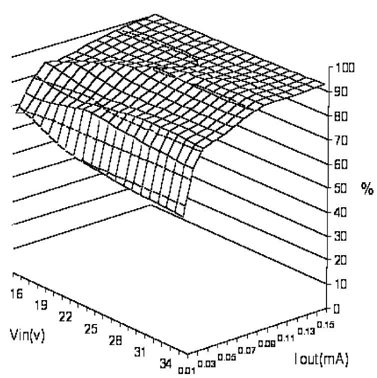
Conditions:
Input Voltage = 20VDC
Output Current = 150 mA
Bandwidth Limit = 20 MHz
Trace 1:
Output Voltage
Volts/div = 20 mV
Horizontal Resolution = 1 µs/div

Figure 4. Typical Output Ripple for an Input Voltage of 20V and a Load of 150 mA

Figure 4 shows typical output ripple, seen directly across the output capacitor, for an input voltage of 20V and a load of 150 mA. This waveform is typical of most loads and input voltages.

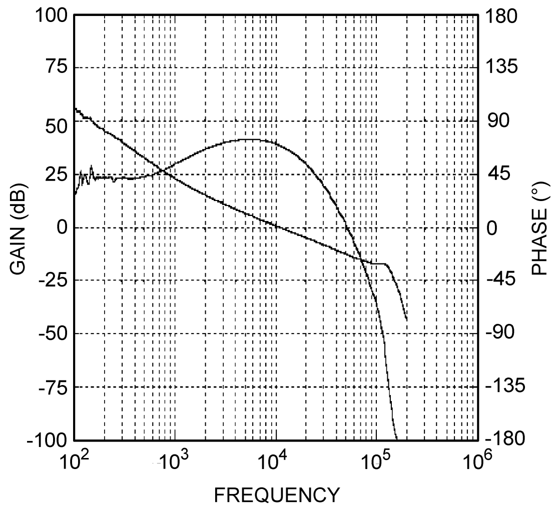
Figure 5 shows power efficiency over full input voltage and output current range. Peak efficiency is at full rated load and is greater then 90% across the input voltage range.

Figure 6 shows the small signal closed loop response with 20V input and 150 mA load current into a resistive load. The gain curve starts at around 60dB the phase curve starts at around 45°. 0dB of crossover frequency is at 11 kHz with a phase margin of 70°.



Conditions:
Input Voltage = 16 - 36VDC
Output Current = 10 mA - 150 mA

Figure 5. Power Efficiency Over Full Input Voltage and Output Current Range



Conditions:
Input Voltage = 20VDC
Output Current = 150 mA

Figure 6. Small Signal Closed Loop Response With 20V Input and 150 mA Load

5 Bill of Materials

Table 1. Bill of Materials

Designator	Qty	Part Number	Description	Value
C1, C2	2	GRM31CR71H225KA88L	CAPACITOR, 1206 X7R CER, Murata	2.2µF, 50V
C3	1	C2012X7R1H104M	CAPACITOR, 0805 X7R CER, TDK	0.1µF, 50V
C4	1	C2012X7R1H103M	CAPACITOR, 0805 X7R CER, TDK	0.01µF, 50V
C5	1	C2012COG1H101J	CAPACITOR, 0805 COG CER, TDK	100pF, 50V
C6	1	C3216X7R1C105K	CAPACITOR, 0805 X7R CER, TDK	1µF, 16V
C7	1	GRM21BR61C106KE15L	CAPACITOR, 0805 X7R CER, Murata	10µF, 16V
C8	1	C2012COG1H471J	CAPACITOR, 0805 COG CER, TDK	470pF, 100V
C9, C11	2	C5750X7R2A475M	CAPACITOR, 2220 X7R CER, TDK	4.7µF, 100V
C10	1	C3225X7R2A105K	CAPACITOR, 1210 X7R CER, TDK	1µF, 100V
C12	1	C2012COG1H220J	CAPACITOR, 0805 COG CER, TDK	22pF, 50V
C13	1	C2012COG1H222J	CAPACITOR, 0805 COG CER, TDK	2200pF, 50V
D1	1	BAT54S	DIODE, SOT-23, DUAL, SCHOTTKY, Fairchild Semiconductor	200mA, 30V
D2		CMSH2-60M	DIODE, SMA, SCHOTTKY, Central Semiconductor Corp.	2A, 60V
L1	1	MSS1260	INDUCTOR, COILCRAFT	100µH, 1.8A
R1, R5	2	CRCW08051003F	RESISTOR, 0805, VISHAY	100K
R2	1	CRCW080510R0F	RESISTOR, 0805, VISHAY	10
R3	1	CRCW08059091F	RESISTOR, 0805, VISHAY	9.09K
R4	1	CRCW08055362F	RESISTOR, 0805, VISHAY	53.6K
R6	1	CRCW080568R1F	RESISTOR, 0805, VISHAY	6.8
R7	1	CRCW08057322F	RESISTOR, 0805, VISHAY	73.2K
R8	1	CRCW08050000F	RESISTOR, 0805, VISHAY	0
R9	1	CRCW08055492F	RESISTOR, 0805, VISHAY	54.9K
R10		CRCW08051471F	RESISTOR, 0805, VISHAY	1.47K
J1, J2, J3, J4	4	7693	Keystone Screw Terminal	
J5, J6, J7	Mar-36	PTC36SAAN	0.025" Sq post, 36 position, Sullins	3 posts used
U1	1	LM5001	High Voltage Switch Mode Regulator, Texas Instruments	

6 Printed Circuit Layout

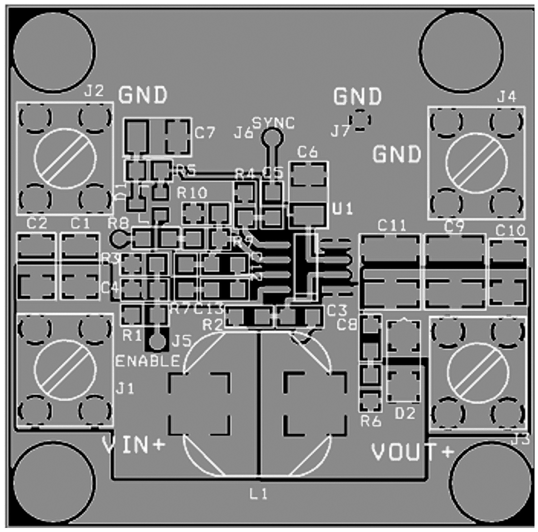


Figure 7. Silkscreen Layer

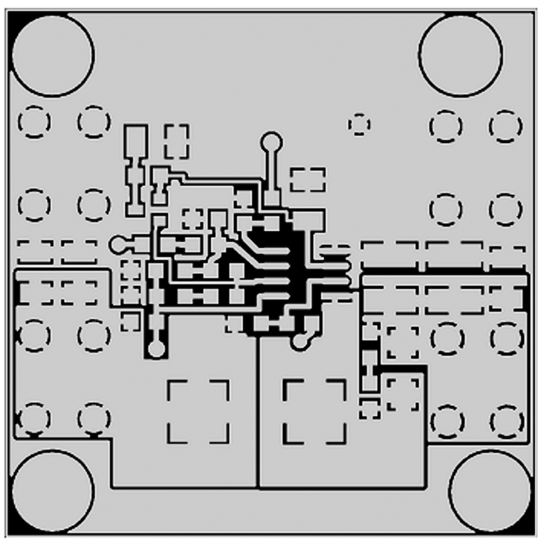


Figure 8. Top Layer

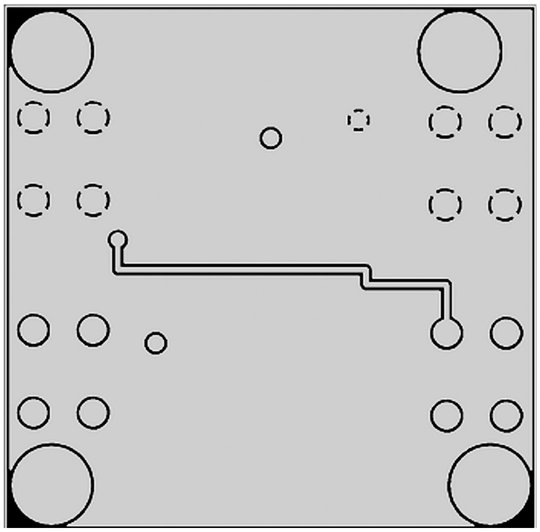


Figure 9. Bottom Layer

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