LM5001

Application Note 1588 LM5001 Evaluation Board



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National Semiconductor Application Note 1588 Steven Schulte February 2007



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Introduction

The LM5001 evaluation board is designed to provide the design engineer with a fully functional isolated flyback power converter based on Current Mode Control to evaluate the LM5001 switching regulator IC. The evaluation board provides a 5V output with 1A current capability. The input voltage ranges from 16V to 42V. The design operates at 250kHz, a good compromise between conversion efficiency and solution size. The printed circuit board consists of 2 layers of 2 ounce copper on FR4 material with a thickness of 0.062 inches. This application note contains the evaluation board schematic, Bill-of-Materials (BOM) and a quick setup procedure.

Refer to the LM5001 datasheet for complete circuit design information. The performance of the evaluation board is as follows: Input Range: 16 to 42V Output Voltage: 5V, ±2% Output Current: 0 to 1A Frequency of Operation: 250 kHz Board Size: 2.75 X 1.75 X 0.6 inches Load Regulation: 0.1% Line Regulation: 0.1% Over Current Limiting

Τ1 R12 C11 V_{OUT} = +5V R5 = 160 µH L_{PRI} 470 pF 10 20 D1 I_{OUT} = 1A vcc 8:3:2 41 V_{IN} = 16V - 42V .J3 6 3 õ C1 D4 C2 C12 C14 2.2 µF 2.2 µF J4 100 µF 1μF Ĩ o J2 R6 C7 GND 8.06k 0.01 μF R1 D2 60.4k R2 ≶ R13 .17 10 R17 49.9 0 ENABLE СЗ C4 0.1 µF C15 R14 R15 ≶ 0.01 µF 560 R18 2.2 µF 10k ≶ C16 R16 2.20k 111 0.1 μF 4.99k VIN EN RT GND C5 SW ~^^ 8 100 pF J6 COME 5 6 FB - 1 C9 VCC vcc SYNC LM431 1 μF **≯** ^{R4} 52.3k R19 R3 ≶ 113 ≶ R10 ⋛ 2.20k 6.04k R8 C6 0 249 1 μF R7 C19 100k 2200 pF J8 OPTIONAL D3 SOFT-START C8 2k∖ IGND 10 µF 30009601

Evaluation Board Schematic

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Powering and Loading Considerations

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

QUICK SETUP PROCEDURE

Step 1: Set the input source current limit to 1A. Turn off the input source. Connect the positive output of the input source to J1 and the negative output to J2.

Step 2: Connect the load, with 1A capability, to J3 for the positive connection and J4 for the negative connection.

Step 3: The ENABLE pin, J7, should be left open for normal operation.

Step 4: Set the input source voltage to 28V and the load to 0.1A. The load voltage should be in regulation with a nominal 5V output.

Step 5: Slowly increase the load while monitoring the load voltage at J3 and J4. It should remain in regulation with a nominal 5V output as the load is increased up to 1 Amp.

Step 6: Slowly sweep the input source voltage from 16V to 42V. The load voltage should remain in regulation with a nominal 5V output.

Step 7: Temporally short the ENABLE pin (J7) to GND (J5) to check the shutdown function.

Step 8: Increase the load beyond the normal range to check current limiting while the input source is set to 28V. The output current should limit at approximately 1.9A. The input source current limit should be increased for this step. Fan cooling is critical during this step.

AIR FLOW

Prolonged operation at full power and high ambient temperature will cause the thermal shutdown circuit within the regulator IC to activate. A fan with a minimum of 200 LFM should always be provided.

POWERING UP

Using the ENABLE pin (J7) provided will allow powering up the input source with the current level set low. It is suggested that the load power be kept low during the first power up. Set the current limit of the input source to provide about 1.5 times the anticipated wattage of the load. As you remove the connection from the ENABLE pin to GND (J5), 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.

OVER CURRENT PROTECTION

The evaluation board is configured with cycle-by-cycle overcurrent protection. This function is completely contained in the LM5001. The Primary current is limited to approximately 1A. This equates to about 1.4A load current when the input voltage is 16V, and about 2.1A load current when the input is 42V. The thermal stress on various circuit components is quite severe while in an overloaded condition, therefore limit the duration of the overload and provide sufficient cooling (airflow).

SYNCHRONIZATION

A SYNC pin (J6) has been provided on the evaluation board. This pin can be used to synchronize the regulator to an external clock or multiple evaluation boards can be synchronized together by connecting their SYNC pins together. Refer to the LM5001 datasheet for complete information.

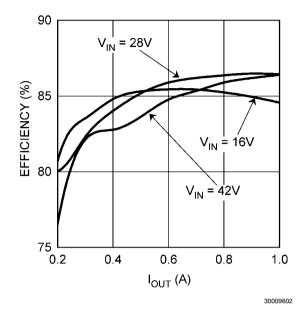
FLYBACK TOPOLOGY

An excellent introduction to the isolated flyback converter is available on the National Semiconductor website. The Application Note AN-1095 discusses both loop compensation with a secondary side error amplifier and the phase-shift caused by opto-couplers.

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Performance Characteristics EFFICIENCY PLOTS

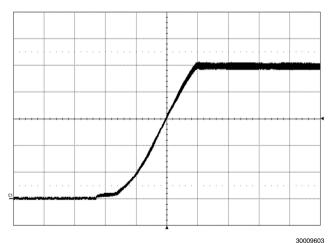
Figure 1 shows the conversion efficiency versus output current for several input voltage conditions.





TURN-ON WAVEFORM

When applying power to the LM5001 evaluation board a softstart sequence occurs. Figure 2 shows the output voltage during a typical start-up sequence.

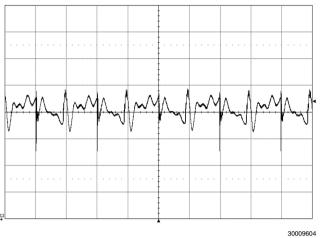


Conditions: Input Voltage = 28VDC, Output Current = 1A Trace 1: Output Voltage Volts/div = 1V Horizontal Resolution = 5ms/div

FIGURE 2.

OUTPUT RIPPLE WAVEFORM

Figure 3 shows the output voltage ripple. This measurement was taken with a very short ground clip and 20MHZ bandwidth limiting.



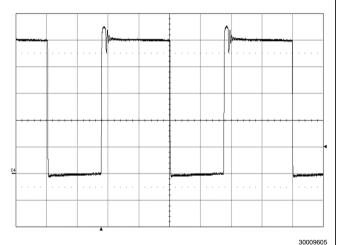
Conditions: Input Voltage = 28VDC, Output Current = 1A, Bandwidth Limit = 20MHZ Trace 1: Output Ripple Voltage Volts/div = 50mV

Horizontal Resolution = 2µs/div

FIGURE 3.

PRIMARY SWITCHNODE WAVEFORM

FIGURE 4 shows the typical primary voltage during continuous conduction mode (CCM).



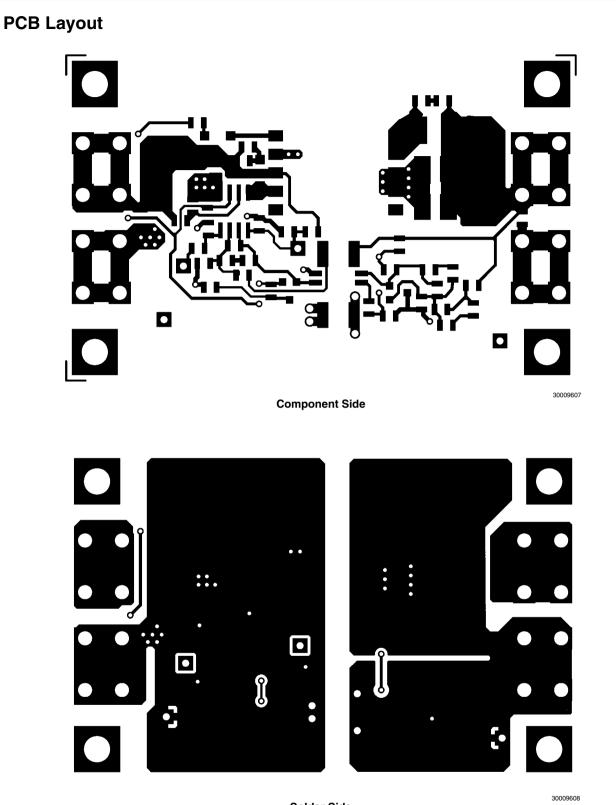
Conditions: Input Voltage = 28VDC, Output Current = 1A, Bandwidth Limit = 20MHZ Trace 1: LM5001 SW Pin Volts/div = 10V Horizontal Resolution = 2µs/div

FIGURE 4.

Layout and Bill of Materials

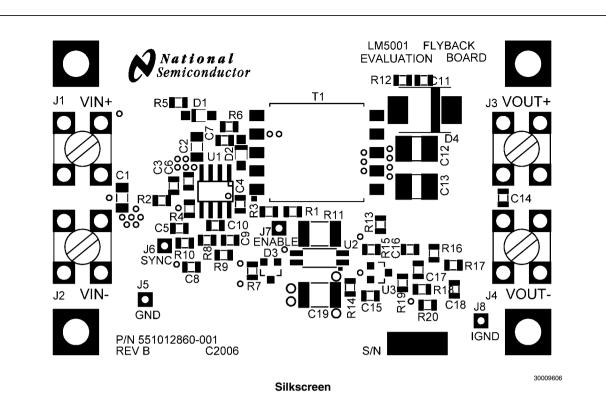
The Bill of Materials is shown below, including the manufacturer and part number.

DESIGNATOR	TOR QTY PART NUMBER DESCRIPTION		DESCRIPTION	VALUE	
C1,2	2	C3225X7R1H225K	CAPACITOR, 1210 X7R CER, TDK	2.2µ, 50V	
C3,16	2	C2012X7R2A104K	CAPACITOR, 0805 X7R CER, TDK	0.1µ, 100V	
C4, 7	2	C2012X7R2A103K	012X7R2A103K CAPACITOR, 0805 X7R CER, TDK		
C5	1	C0805C101M5RAC	CAPACITOR, 0805 COG CER, KEMET	100p, 50V	
C6, 9, 14	3	C2012X7R1A105K	CAPACITOR, 0805 X7R CER, TDK	1µ, 10V	
C8	1	C2012Y5V1A106Z	CAPACITOR, 0805 Y5V CER, TDK	10µ, 10V	
C11	1	C0805C471M5RAC	CAPACITOR, 0805 COG CER, KEMET	470p, 50V	
C12	1	C1210C107M9PAC3810	PPAC3810 CAPACITOR, 1210 X5R CER, KEMET		
C15	1	C2012X7R1C225K	C2012X7R1C225K CAPACITOR, 0805 X7R CER, TDK		
C19	1	C4532X7R3D222K	CAPACITOR, 1812, X7R CER, TDK	2200p, 2000V	
D1	1	CMHSH-3	CMHSH-3 DIODE, SOD-123 SCHOTTKY, CENTRAL SEMI		
D2	1	1CMMR1U-2DIODE, SOD-123F, CENTRAL SEMI1BAT54SDIODE, SOT-23 SCHOTTKY, VISHAY1CMSH5-40DIODE, SMC SCHOTTKY, CENTRAL SEMI		1A, 200V	
D3	1			200mA, 30V	
D4	1			5A, 40V	
R1	1 CRCW08056042F RESISTOR, 0805, VISHAY 2 CRCW080510R0F RESISTOR, 0805, VISHAY		60.4k		
R2,12			10		
R3	1	CRCW08056041F RESISTOR, 0805, VISHAY		6.04k	
R4	1	CRCW08055232F	RESISTOR, 0805, VISHAY	52.3k	
R5	1	CRCW080520R0F	RESISTOR, 0805, VISHAY	20	
R6	1	CRCW08058061F	RESISTOR, 0805, VISHAY	8.06k	
R7	1	CRCW08051003F	RESISTOR, 0805, VISHAY	100k	
R8	1	CRCW08052490F	RESISTOR, 0805, VISHAY	249	
R10,17	2	CRCW08050000Z0EA	RESISTOR, 0805, VISHAY	0	
R13	1	CRCW080549R9F	RESISTOR, 0805, VISHAY	49.9	
R14	1	CRCW08055600F	RESISTOR, 0805, VISHAY	560	
R15	1 CRCW08051002F RESISTOR, 0805, VISHAY		10.0k		
R16			4.99k		
R18,19			2.2k		
T1	1	FA2636-AL	FA2636-AL POWER XFR, COILCRAFT		
U1	1	LM5001MA	LM5001MA REGULATOR, NATIONAL SEMI		
U2	1 PS2811-1M OPTO-COUPLER, NEC		100% - 200% CTR		
U3	1	LM431CIM3	REFERENCE, SOT23, NATONAL SEMI	2.500V	
J1,2,3,4	4	7693	TERMINAL, 6-32 SCREW, 4 PIN, KEYSTONE	SNAP IN, PC MOUNT	
J5,6,7,8	4	5002	5002 TERMINAL, SINGLE PIN, KEYSTONE TESTPO		



Solder Side

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