Low Noise Split Rail Non-Isolated Power Supply

National Semiconductor
RD-184
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1.0 Design Specifications

Inputs	Output #1	Output #2
VinMin=4.5V	Vout1=12V	Vout2=-12V
VinMax=5.5V	Iout1=.04A	Iout2=.04A

2.0 Design Description

This circuit boosts 5V to a low noise +/- 12V bias at 40mA for use in analog circuitry. This design uses the LM5001 fully integrated switch mode regulator in concert with a very small EP5 transformer to create a non-isolated positive and negative power rail (for isolation see RD-171). This design uses less than 1 square inch of double sided PCB with components on only one side. The same basic circuit can be used to develop other voltages such as +/- 15V or +/- 5V.

3.0 Features

- 5V Input
- +/- 12V Outputs
- Over 40mA Output Current
- Low Ripple Noise for split rail analog circuits (< 2mV p-p)
- Small Size ~1" x 1"

4.0 Block Diagram

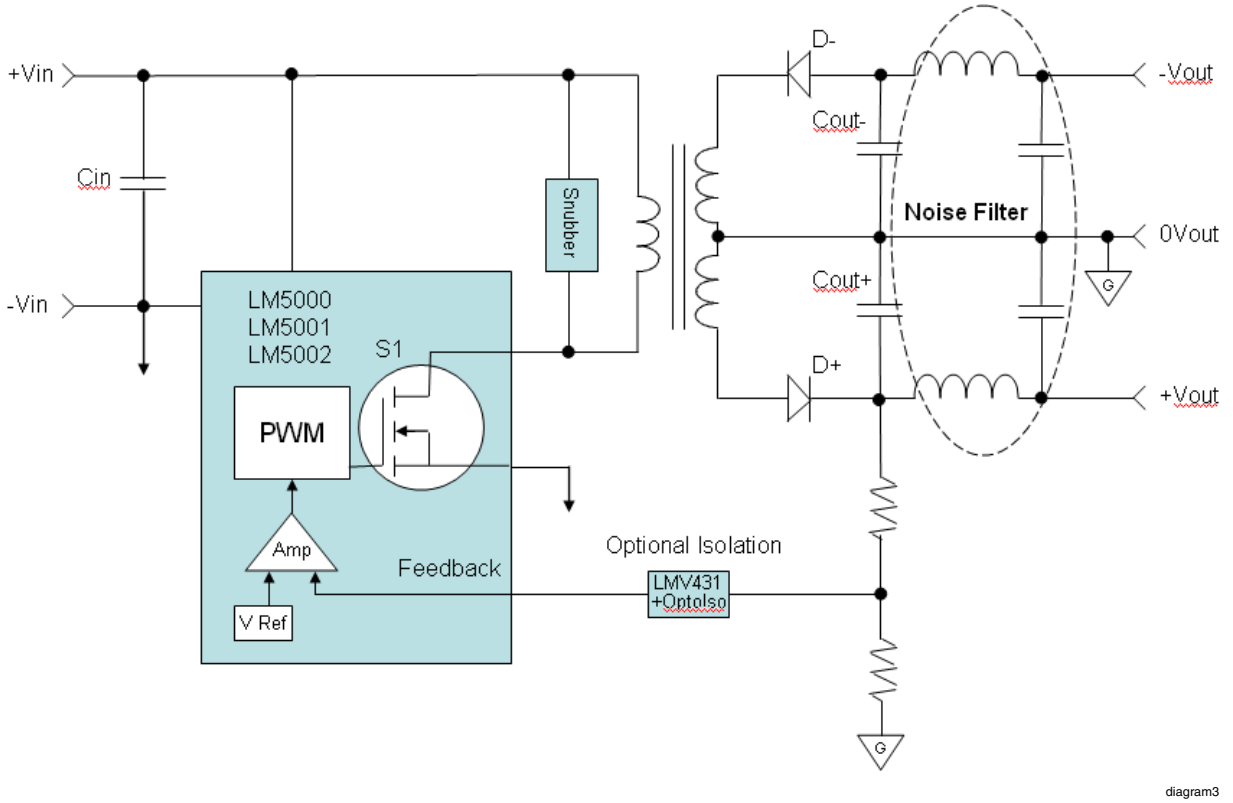


FIGURE 1. Block Diagram

5.0 Schematic

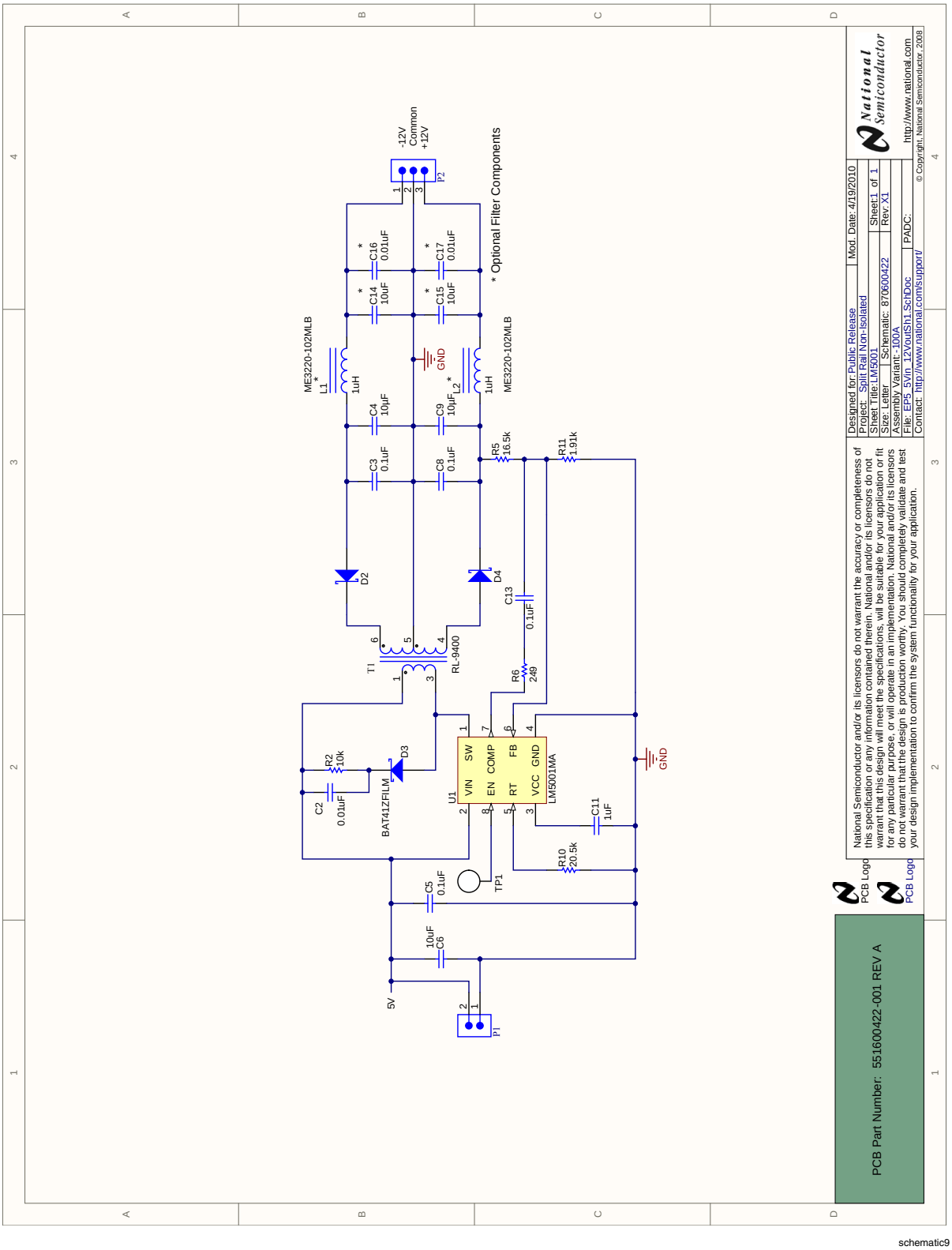


FIGURE 2. Split Rail Schematic

Designator	Description	Manufacturer	Part Number	RoHS
AA	Printed Circuit Board	TBD		O
C2, C16, C17	Ceramic, X7R, 50V, 10%	TDK	C1608X7R1H103K	Y
C3, C8	Ceramic, X7R, 50V, 5%	Kemet	C0805C104J5RACTU	Y
C4, C9	CAP, CERM, 10uF, 16V, +/-20%, X5R, 0805	AVX	0805YD106MAT2A	Y
C5, C13	Ceramic, X7R, 25V, 10%	MuRata	GRM188R71E104KA01D	Y
C6	Ceramic, X5R, 10V, 10%	Kemet	C1210C106K8PACTU	Y
C11	Ceramic, X7R, 16V, 10%	MuRata	GRM188R71C105KA12D	Y
C14, C15	Ceramic, X5R, 16V, 10%	Taiyo Yuden	EMK212BJ106KG-T	Y
D2, D4	Diode, Schottky, 60V, 1A, SOD-123F	NXP Semiconductor	PMEG6010CEH,115	Y
D3	Vr = 100V, Io = 0.2A, Vf = 1V	ST Microelectronics	BAT41ZFILM	Y
L1, L2	Drum Core, 2.6A, 0.058 Ohm	Coilcraft Inc.	ME3220-102MLB	Y
P1	Header, TH, 100mil, 1x2, Tin plated, 230 mil above insulator	Samtec Inc.	TSW-102-07-T-S	Y
P2	Header, TH, 100mil, 1x3, Tin plated, 230 mil above insulator	Samtec Inc.	TSW-103-07-T-S	Y
R2	5%, 0.1W	Vishay-Dale	CRCW060310k0JNEA	Y
R5	1%, 0.1W	Vishay-Dale	CRCW060316k5FKEA	Y
R6	1%, 0.1W	Vishay-Dale	CRCW0603249RFKEA	Y
R10	1%, 0.1W	Vishay-Dale	CRCW060320k5FKEA	Y
R11	RES, 1.91k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW06031K91FKEA	Y
T1	Flyback Transfomer	Renco Electronics, Inc.	RL-9400	Y
U1	High Voltage Switch Mode Regulator	National Semiconductor	LM5001MA	Y

schematic6

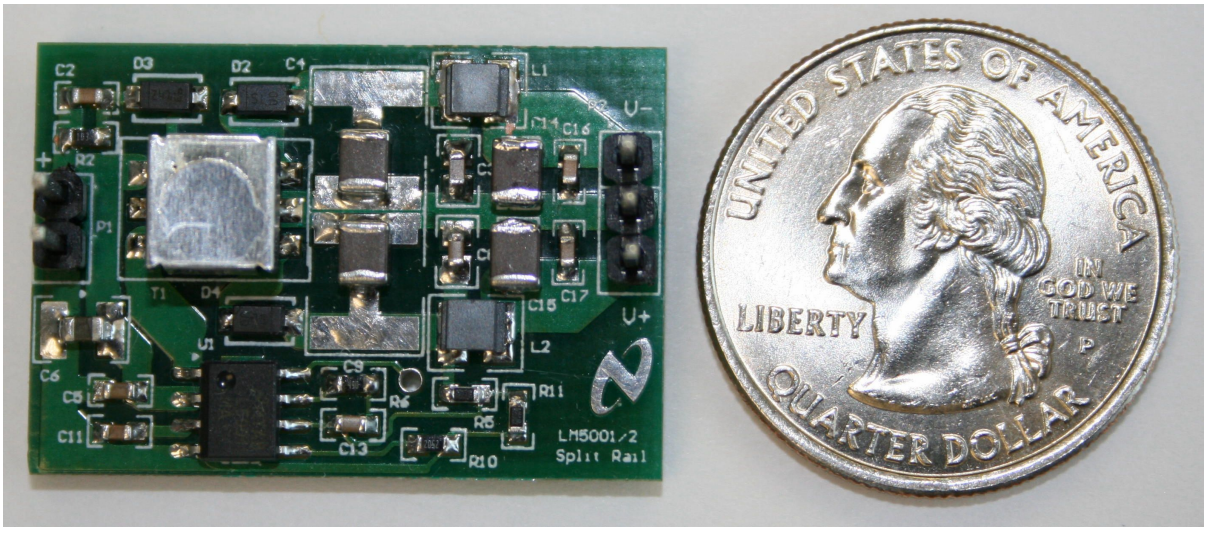
FIGURE 3. Reference Design Bill of Materials-5Vin12VOut_1(-100A)

7.0 Other Operating Values

Operating Values

Description	Parameter	Value	Unit
Modulation Frequency	Frequency	600	KHz
Total output power	Pout	1.2	W
Steady State Efficiency	Efficiency	>80	%
Peak-to-peak ripple noise	Vout p-p	<2	mV

8.0 Board Photos



boardphoto1

FIGURE 4. +/- Split Rail

9.0 Hardware Description

The circuit employs a LM5001 regulator in a flyback configuration to produce +12 and -12V (see fig. 2). During the first phase the switch within the regulator is turned on connecting U1 pin 1 to ground causing current to flow through the primary of the transformer (T1). During the second phase, the switch is open and the energy stored in the core is delivered to the secondary's. Also during this phase diode D3 is turned on and C2/R2 act as a snubber to limit transient noise while the primary field collapses. The output voltages are rectified by catch diodes D2 and D4 and filtered by C3, C4, C8, and C9. When D2 and D4 turn off one must be careful to ensure that the peak inverse voltage on the secondary does not exceed the maximum reverse voltage specification of the diodes (Vr). Although the average voltage across the diodes is about 28V, the peak voltage can be significantly higher. With this design transients were measured up to 47V when delivering 40mA. For this reason diodes with 60V Vr rating or higher are required unless a snubber circuit is employed. An RC across D2 and D4 would limit this transient voltage at the expense of additional power loss. Additional noise filtering is performed by L2/C15 for the positive and L1/C14 for the negative output. This additional filtering is not necessary but does significantly reduce the switching ripple and transient noise. C4 and C9 can be increased to 47uF ceramic capacitors to further decrease output noise.

10.0 Test Results

The test results were obtained at room temperature using the following equipment:

Agilent E3632A Power Supply

Kikusui PLZA 164W Electronic Load

LeCroy 454 Oscilloscope

LeCroy AP033 Differential Probe

HP 3478A Multimeter

Fluke 189 Multimeter

11.0 Appendix

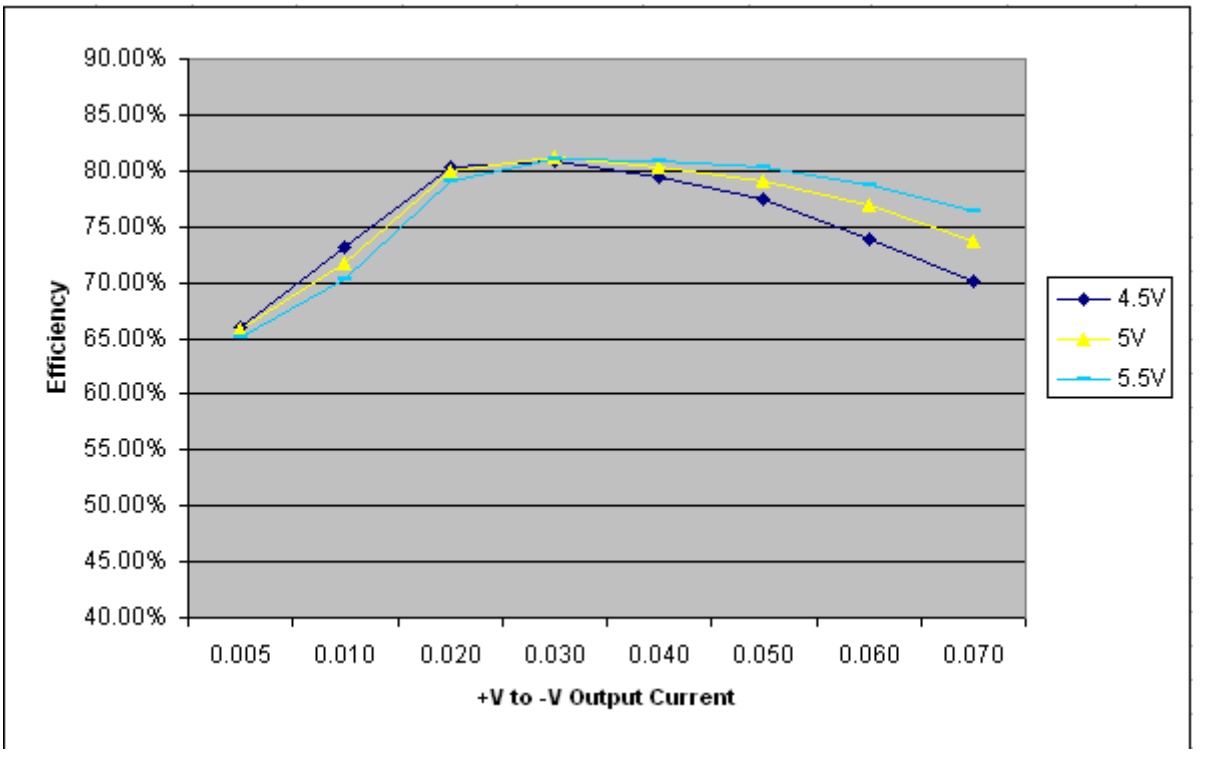


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FIGURE 5. Efficiency Graph

Vin	Iout(A)	Iin (A)	V+	V-	Vout Diff	Pin (W)	Pout (W)	Efficiency
4.500	0.005	0.041	12.184	-12.190	24.374	0.185	0.122	66.05%
4.500	0.010	0.074	12.185	-12.187	24.372	0.333	0.244	73.19%
4.500	0.020	0.135	12.185	-12.188	24.373	0.608	0.487	80.24%
4.500	0.030	0.201	12.186	-12.188	24.374	0.905	0.731	80.84%
4.500	0.040	0.273	12.188	-12.192	24.380	1.229	0.975	79.38%
4.500	0.050	0.350	12.187	-12.192	24.379	1.575	1.219	77.39%
4.500	0.060	0.439	12.166	-12.164	24.330	1.976	1.460	73.90%
4.500	0.070	0.459	10.309	-10.378	20.687	2.066	1.448	70.11%
5.000	0.005	0.037	12.180	-12.186	24.366	0.185	0.122	65.85%
5.000	0.010	0.068	12.180	-12.184	24.364	0.340	0.244	71.66%
5.000	0.020	0.122	12.180	-12.184	24.364	0.610	0.487	79.88%
5.000	0.030	0.180	12.182	-12.184	24.366	0.900	0.731	81.22%
5.000	0.040	0.243	12.183	-12.189	24.372	1.215	0.975	80.24%
5.000	0.050	0.308	12.183	-12.187	24.370	1.540	1.219	79.12%
5.000	0.060	0.380	12.184	-12.188	24.372	1.900	1.462	76.96%
5.000	0.070	0.463	12.184	-12.186	24.370	2.315	1.706	73.69%
5.500	0.005	0.034	12.176	-12.183	24.359	0.187	0.122	65.13%
5.500	0.010	0.063	12.184	-12.173	24.357	0.347	0.244	70.29%
5.500	0.020	0.112	12.184	-12.173	24.357	0.616	0.487	79.08%
5.500	0.030	0.164	12.180	-12.181	24.361	0.902	0.731	81.02%
5.500	0.040	0.219	12.180	-12.183	24.363	1.205	0.975	80.91%
5.500	0.050	0.276	12.180	-12.184	24.364	1.518	1.218	80.25%
5.500	0.060	0.338	12.181	-12.184	24.365	1.859	1.462	78.64%
5.500	0.070	0.406	12.181	-12.184	24.365	2.233	1.706	76.38%

image1

FIGURE 6. Measured Data

Vout+	Iout+	Vout-	Iout-
12.170	0.005	-7.160	0.036
12.181	0.010	12.020	0.036
12.181	0.025	12.182	0.036
12.181	0.050	12.251	0.036
12.182	0.070	12.363	0.036
12.181	0.036	-12.406	0.005
12.181	0.036	-12.358	0.010
12.182	0.036	-12.259	0.025
12.183	0.036	-12.120	0.050
12.183	0.036	-12.011	0.070

other

FIGURE 7. Cross Regulation

FIGURE 8. 40mA Differential Noise

Notes

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