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Sep 08, 2005

APPLICATION NOTE 3581

MAX5074 5V, 3A Reference Design

Abstract: The MAX5074 circuit serves as a reference design for a 5V, 3A, DC-DC step-down power converter with isolated output operating from a 36V to 72V source. Included in this application note are a detailed schematic, complete component list with manufacturer's part numbers, and a planar transformer design example. Conversion efficiency exceeds 84.5% over a 1.5A to 2.5A load range at 48V input. Response to a 1A load transient is below 20mV and settles in 100µs. Ripple is 8mV$_{P-P}$ at a 2.5A load and 60V input. Soft-start provides a 5ms turn on time.

General Description

This Reference Design is based on the MAX5074 evaluation kit, originally designed for supplying 12V, 1.2A from a 36V to 72V input-voltage range. While keeping the simple nonsynchronous architecture, the efficiency at 5V is above 84% at 48V within most of the output-current range. Please refer to the MAX5074 Evaluation Kit data sheet for the warnings appropriate to dangerous voltages and for the general description of the board.

This document includes the Component List for the 5V output application. Performance data are shown. A basic 5-layer planar transformer was built, the layout of which is given for reference.

Features

- Isolated 15W Forward DC-DC Converter
- 36V to 72V Input Range
- 5V Output Provides Up to 3A
- 84.5% Efficiency at 48V and 2.5A
- 1/8th Brick Module Footprint
- Cycle-by-Cycle, Current-Limit Protection
- Programmable Integrating Fault Protection
- Programmed for 250kHz Swictching Frequency
- Internal Thermal Shutdown
- Basic Primary to Secondary Isolation
- Soft-Start

Component List

DESIGNATION	QTY	DESCRIPTION
C1	1	4.7µF ±10%, 16V X7R ceramic capacitor (1206) TDK C3216X7R1C475K
C2	1	100pF ±5%, 50V COG ceramic capacitor (0603) TDK C1608COG1H101K
C3, C13	2	1µF ±20%, 16V X7R ceramic capacitors (0603) TDK C1608X7R1C105M
C4, C6	2	220pF ±10%, 50V X7R ceramic capacitors(0603) TDK C1608X7R1H221K
C5, C7, C17	3	0.1 µF ±10%, 50V X7R ceramic capacitors (0603) TDK C1608X7R1H104
C8	1	1.0µF ±10%, 50V X7R ceramic capacitor (1206) TDK C3216X7R1H105K
C9	1	1.0µF ±20%, 100V X7R ceramic capacitor (1210) TDK C3225X7R2A105M
C10, C11	2	0.01 µF ±10%, 100V X7R ceramic capacitors (0805) TDK C2012X7RZA103K or Murata GRM21 BR72A103K
C12	1	0.33µF ±10%, 16V X7R ceramic capacitor (0603) TDK C1608X7R1C334K
C14	1	2.2µF ±20%, 16V X7R ceramic capacitor (0805) TDK C2012JB1C225M
C15, C16	2	150µF, 6.3V ESR < 12mW Panasonic EEFUE0J151R
C18	1	0.0047µF ±10%, 250VAC X7R ceramic capacitor (2220) Murata GA355DR7GC472K
C19	1	100µF, 100V ESR < 0.15W BC Component 2222 13669101
C20 (R8 position)	1	1nF ±10%, 50V X7R ceramic capacitor (0603) TDK C1608X7R1H102K
C21	1	180pF ±5%, 50V COG ceramic capacitor (0603) TDK C1608COG1H181J
D1, D2	2	100V, 1A schottky diodes (SMA) SS1H10 Vishay
D3, D4	2	40V, 2A, schottky diodes (SMB) MBRS240LT3 ON-Semiconductor
L1	1	10.2µH, 4.7A inductor Panasonic ETQP6F102HFA ESR < 14mW
R1	1	30.9kW ±1 % resistor (0603)
R2	1	10.2kW ±1 % resistor (0603)
R3	1	182W ±1 % resistor (0805)
R4a, R4b	2	0.15W ±1 %, 0.25W resistor (0805) CRL1220 Megitt CGS
R5	1	316kW ±1 % resistor (0603)
R6	1	14.7kW ±1 % resistor (0603)
R7	1	1.78kW ±1 % resistor (0603)
R8	1	Fitted with C20
R9	1	Not installed, resistor (0603)
R10	1	1MW ±5 % resistor (0603)
R11	1	200kW ±1 % resistor (0603)
R12	1	100W ±1 % resistor (0603)
R13	1	604W ±1 % resistor (0603)
R14	1	15W ±5 % resistor (0603)
R15	1	7.5kW ±1 % resistor (0603)
T1	1	20W Custom Planar Transformer with ER23 ferrite core
U1	1	MAX5074AUP (20-pin TSSOP-EP)
U2	1	30V, 100% to 200% CTR optically isolated error amplifier (8-pin SO) Fairchild Semiconductor FOD2712
None	1	MAX5074 PC board

Modifications to MAX5074 EV Kit

A 100µF electrolytic capacitor (C19) is added at the input. While its value could be decreased to 33µF, it is important to meet a low ESR to reduce losses due to input ripple current. The tested component (BC Components 2222 13669101) is rated for an ESR < 0.15Ω.

The transformer is based on an ER23 ferrite set, available from several manufacturers. The ferrite material is 3F3, N49, or equivalent, showing low core loss at and above 250KHz.

Windings are realized with five layers of 70µm copper separated by 80µm dielectric layers. Only five layers are used, the auxiliary winding return (pin 6) is connected by an enamel wire strap on the TOP layer (see **Figure 3**).

The primary has 11 turns, with a measured ESR of 225mΩ ; the secondary has 4 turns with an ESR of 25mΩ ; the auxiliary winding has 4 turns and a required ESR < 1Ω.

Primary inductance measures 340µH, while primary leakage inductance is only 430nH, a direct benefit of the planar construction. Parasitic capacitance between primary and secondary measures 110pF.

The output filter is modified for a lower output voltage: inductor L1 is now 10.2µH and the total output capacitance is 300µF.

The integrating fault protection delay is increased, with C3 now equal to 1µF.

Clamping diodes D1 and D2 are replaced by SSH10 (or equivalent) 100V 1A devices, so forward instantaneous voltage is reduced in case of abnormal loads or transformer defects.

Output voltage is set to 5V by R1 = 30.9K and R2 = 10.2K.

A 180pF capacitor (C21) is added across R1 for a faster reaction of the closed-loop circuits.

A 7.5K resistor (R15) is inserted with C13 to set high-frequency error amplifier gain = 1.

C20, 1nF, replaces R8 to eliminate high-frequency residuals.

R3 is decreased to 180W to set maximum optocoupler LED current to 21mA.

Compensation poles are shifted to accommodate these modifications, so C3, C13, and C14 are now 1µF, 1µF, and 2,2µF, respectively.

Output rectifiers D3 and D4 are replaced by high-current 40V Schottky devices in SMB case.

If a transformer with higher parasitic inductances is used, the output rectifiers must be protected against voltage overshoots.

With a 72V maximum input voltage, only 26V reflected voltage is seen by the rectifiers. This headroom allows rectifier protection by connecting 33V ±5% zeners across them, with appropriate polarities.

As the original Evaluation Kit was not meant to handle high output currents, a heatsink is glued on top of U1 with thermally-conductive glue. This allows a 0.6% gain in efficiency, compared to a no-heatsink situation.

U1 is offered in a 20-lead TSSOP package with exposed pad. Consequently the heatsink could be omitted by a careful PCB layout that allows heat to spread through large power planes and numerous vias.

Efficiency Measurements

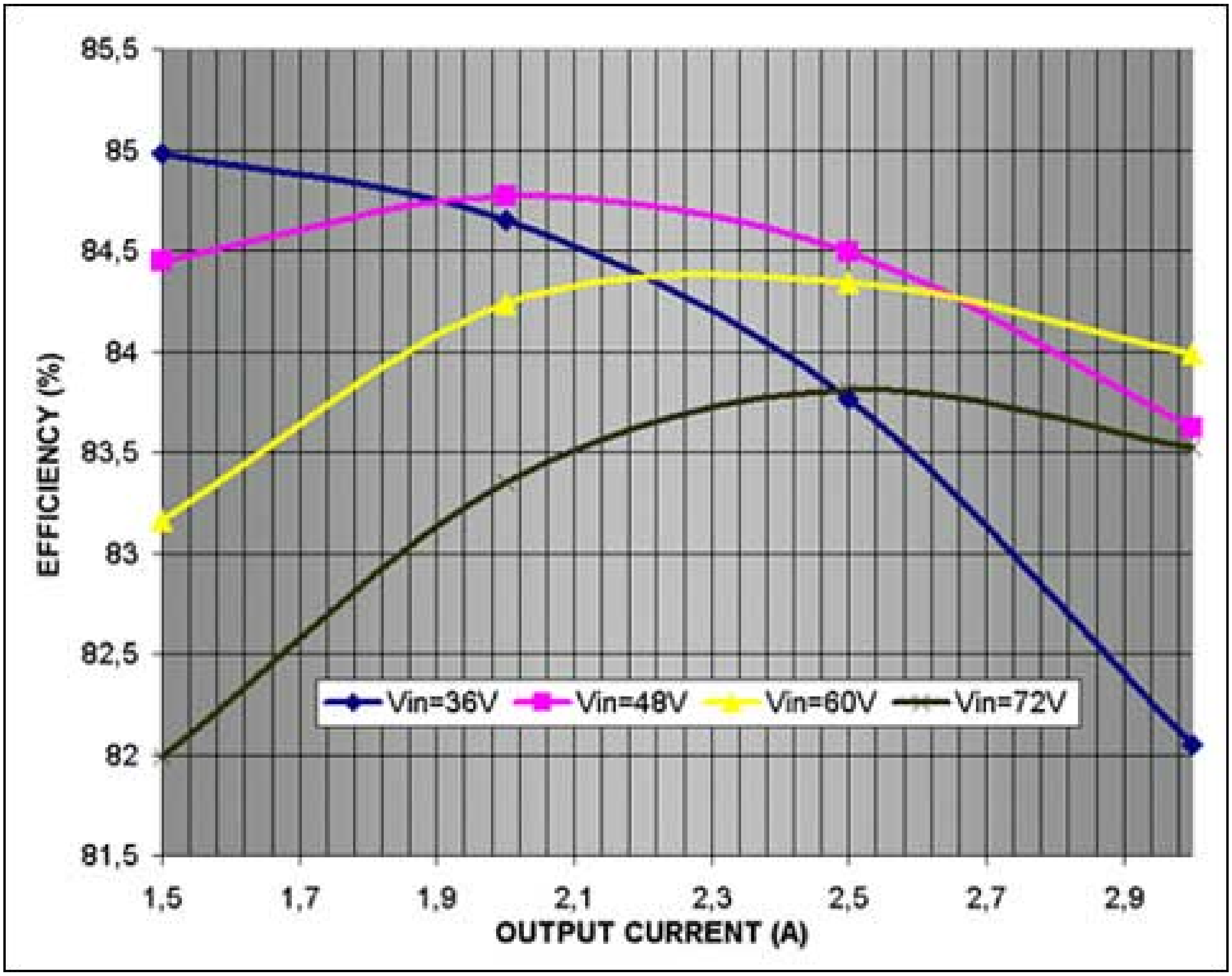
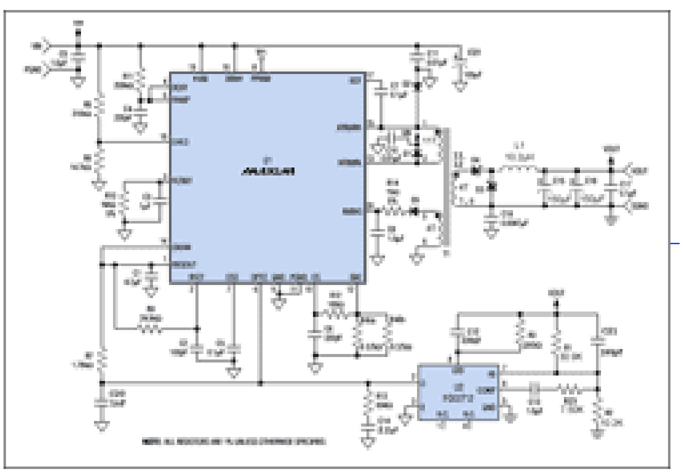


Figure 1. Efficiency function of output current at various input-voltag values.



[For Larger Images]

Figure 2. Schematic of the MAX5074 5V, 3A power supply.

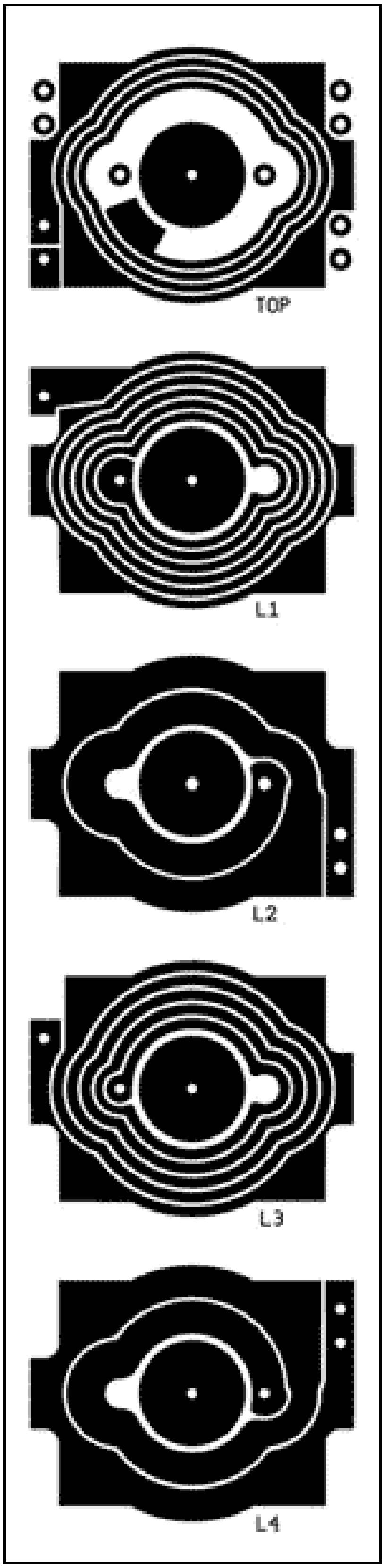


Figure 3. Example of transformer realisation with planar technology.

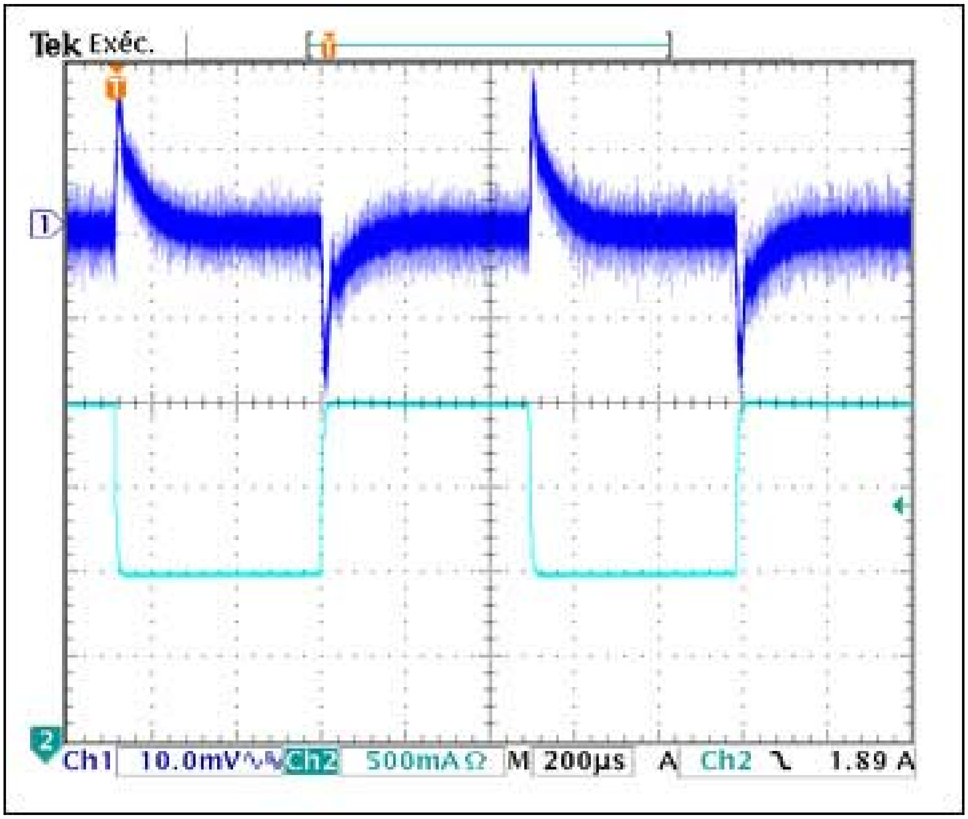


Figure 4. Response to a 1A peak-to-peak transient.

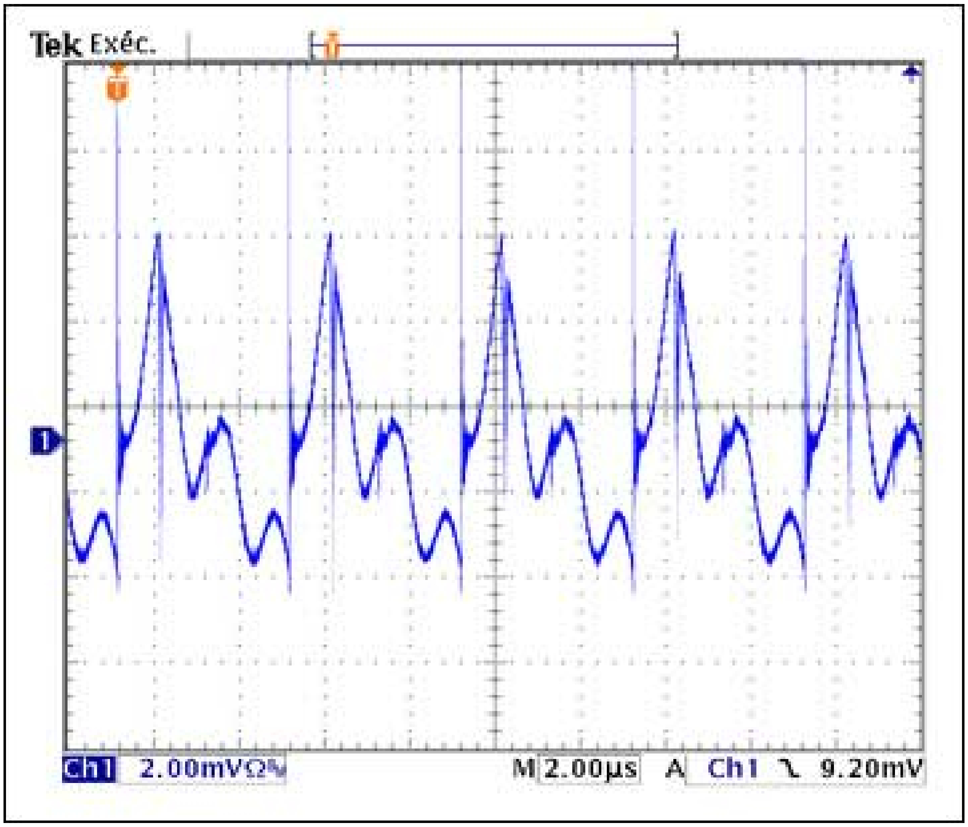


Figure 5. Output-voltage ripple at I = 2.5A, VIN = 60V, BW = 20MHz, 50W adapted.

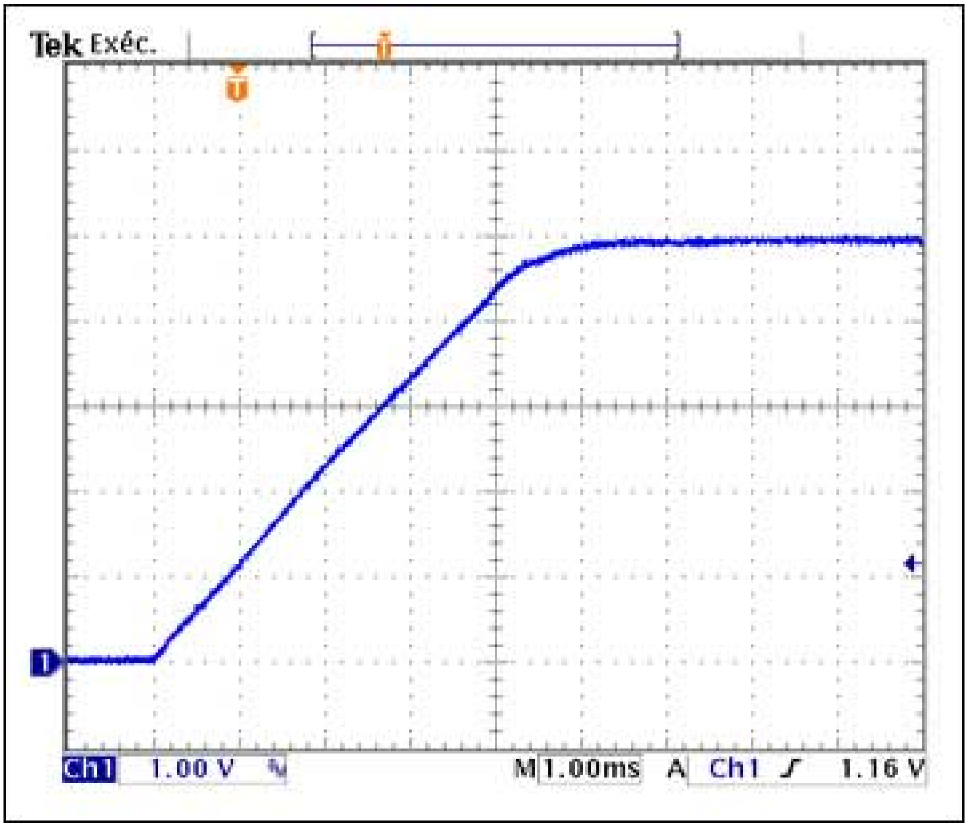


Figure 6. Turn-on waveform at VIN = 48V, 1.8W resistive load.

Application Note 3581: www.maxim-ic.com/an3581

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AN3581, AN 3581, APP3581, Appnote3581, Appnote 3581