A High Efficiency Stepdown 27 Volt to 12 V 10 amp DC – DC Power Supply

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Introduction

This design was inspired by a private communication to G4BAO from G3WDG describing a 12v to 6V stepdown PSU for powering a 24GHz PA module.

This modified version is used to provide 12V at up to at least 10Amps from a 24-28V supply.

Circuit

The circuit is based around the Linear Technology LT1624 High efficiency SO-8 N-channel switching regulator controller IC. The LTC1624 is a current mode switching regulator controller that drives an external N-channel power MOSFET using a fixed frequency architecture. It can be operated in all standard switching configurations including boost and step-down plus others described in the datasheet (1). A maximum high duty cycle limit of 95% provides low dropout operation and the operating frequency is internally set to 200kHz, allowing small inductor values and minimizing PC board space. The operating current level is user-programmable via an external current sense resistor. Wide input supply range allows operation from 3.5V to 36V (absolute maximum.)

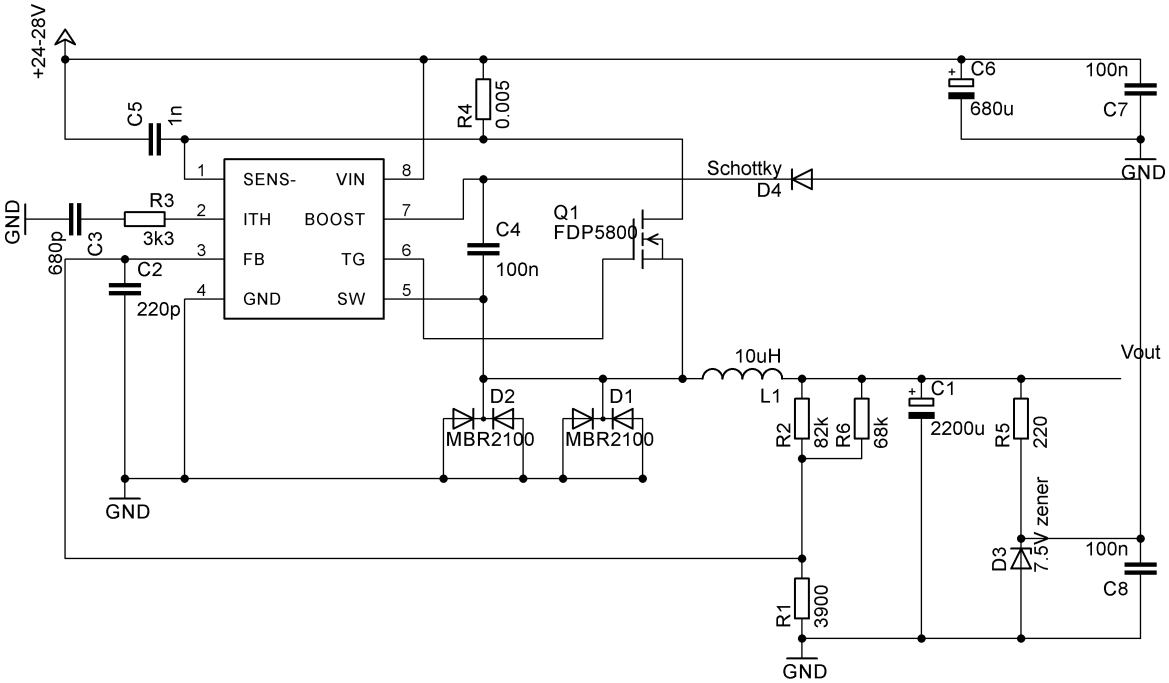

Figure 1 Circuit diagram

The implementation in Figure 1 is based upon the application circuit for a 24V to 12V/10A buck converter with output-derived boost voltage. G3WDG's original 12 to 6V circuit dispensed with the output-derived boost voltage, but modelling using

LTSpice (2) showed that due to the higher input-output differential this was required. This improves efficiency.
The switch circuit uses a single logic level Power FET and a pair of double diodes in a conventional buck circuit. The electrolytic capacitors are low ESR types as the AC ripple current flowing in them is very high. Using other than low-ESR components will cause them to run hot. The FET and diodes dissipate little power so need little heatsinking. I found that when bolted to the side of a diecast box (Fig 1) or if fitted with small heatsinks they run cool.

The limiting factor for current supplied by the circuit is the temperature rise of the torroidal inductor. I have run the supply up to 10 amperes and the load line is shown in Figure 2. It produces 12.55 volts on no load, dropping to 12.1 Volts at 10A. The toroid runs hot to the touch at 5 Amps without a forced air cooling, but for continuous duty cycle use above 5A you will need to use a fan to keep the Toroid cool. Efficiency is quite good at 80% but not as high as the modelling suggests at around 90% so clearly there are more circuit losses to be investigated

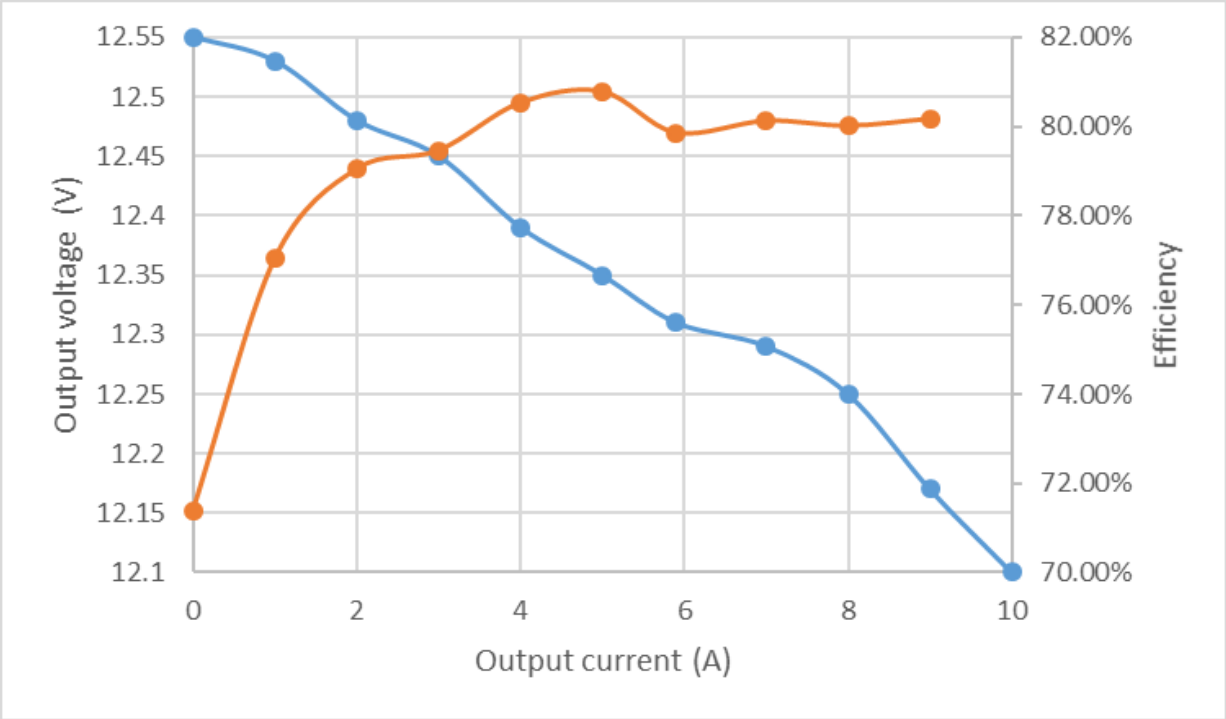

Figure 2 PSU Load Graph

Temperature rise test in a practical usage situation

As my application was for use to power a 12V Microwave SSPA, A test was done running the PSU in a typical JT mode usage of transmitting 1 minute on and 1 minute off at 5 Amps and the temperature of the toroid was monitored with a thermocouple. The PSU PCB was inside an enclosed diecast box with no forced air cooling for this extreme test.
As can be seen from Figure 3 After about 20 minutes of on off cycling the temperature of the toroid settles down t around 72 degrees. As the operating temperature of the Toroid is rated up to 105 degrees C we are well within safety limits and the PSU could likely operate like this without air cooling at a load of more than 5 Amps.

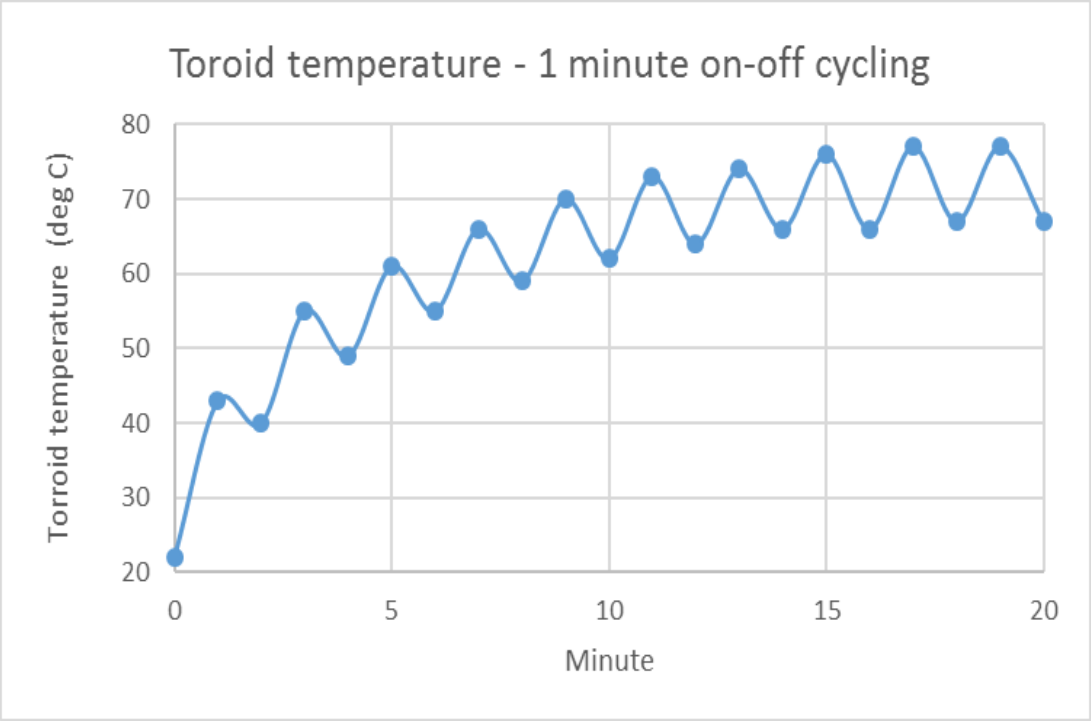

Figure 3 Toroid temperature - 5 Amp load cycling

PCB layout

The PCB layout quite critical so refer to the datasheet and application note if you decide not to use this layout.

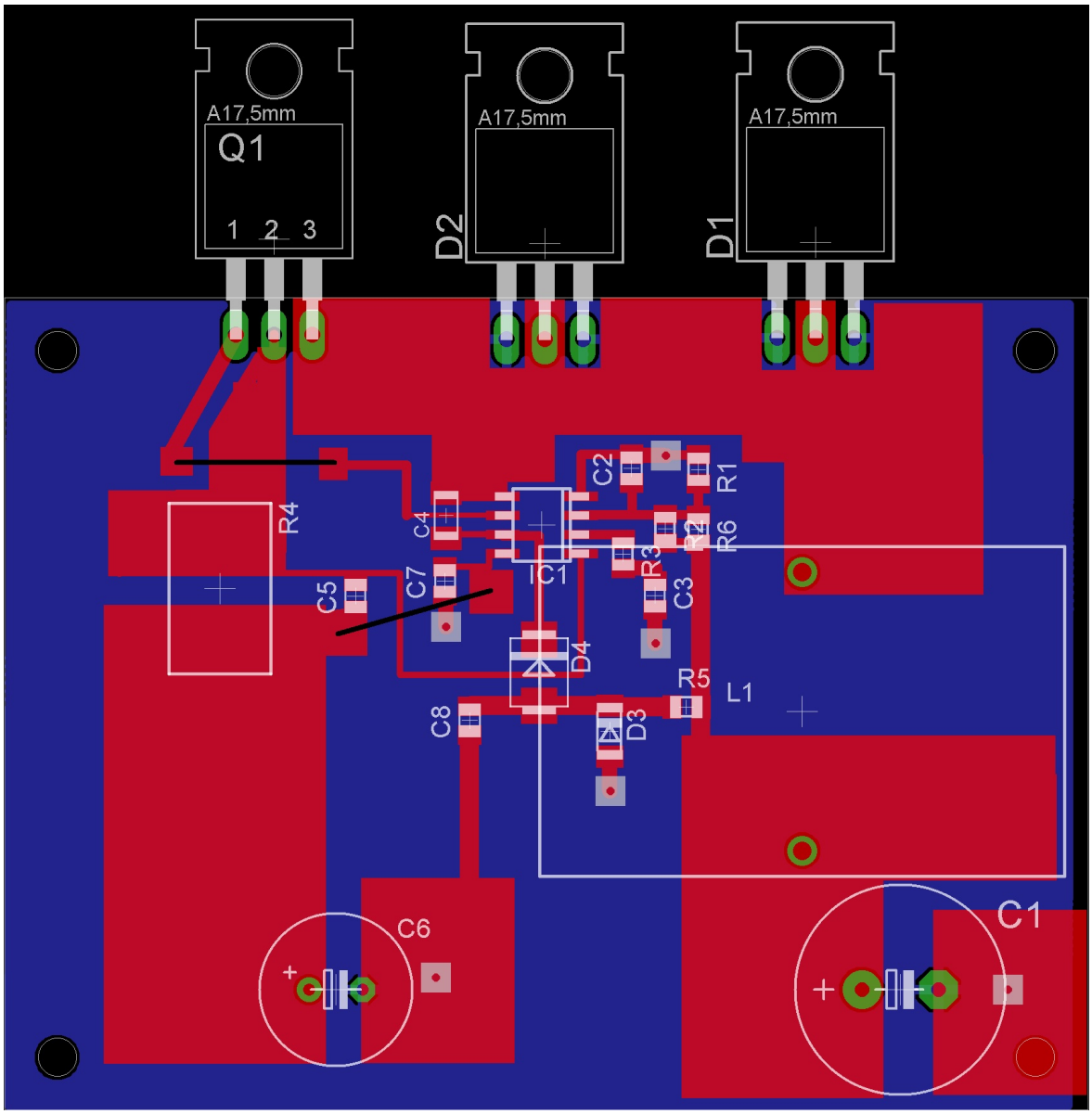

Figure 4 PCB layout

Components list

Circuit Reference	Value	Type
C1	2200u	25V Rubycon ZL Electrolytic Farnell 1144706
C2	220p	0805
C3	680p	0805
C4	100n	1206 (0805 will fit PCB with care)
C5	1n	0805
C6	680u	35V Rubycon ZL Electrolytic Farnell 1144709
C7, C8	100n	0805
D1, D2	MBR2100	TO220 Twin Schottky diode - Farnell 1625129
D3	7.5V Zener	SOD-80 package
D4	1A diode	Schottky SMB package
IC1	LTC1624S8	Switch mode controller – Farnell 1273889
L1	10uH 13.9A Torroid	Farnell 2333662
Q1	FDP5800	TO220 Power MOSFET - Farnell 1495237
R1	3900	0805
R2	82k	0805
R3	3k3	0805
R4	0.005 ohm 5 Watt	Power SMD resistor - Farnell 2420537 or similar
R5	220	R0805
R6	68k	R0805