Alun Jones

The worlds simplest switching PSU

This ultra simple switcher converts 12V to 24V for powering 24V appliances of a car battery. The regulation is quite poor but efficiency is typically between 60 and 85%, and generally goes up when V_{IN} is nearer V_{OUT}, i.e. it's more efficient to convert 18V to 24V than 9V to 24V. As the input voltage rises the current consumption goes down, Tr1 is the first major power loss, closely followed by D2, there's nearly no loss in L1, in fact L1 is more efficient than a transformer as there is no secondary winding.

It cannot be run as a step-down regulator as when V_{IN} gets near V_{OUT}, V_{OUT} will start to rise to an unacceptable level, this is because when V_{IN} is > V_{OUT} by more than about 600mV D2 will conduct and V_{IN} will charge C2 via L1. The circuit I built gives 24.5V with the input between 9 and 18V, the output doesn’t vary more than 500mV, I managed to draw more than 500mA before the output fell below 24V.

Circuit Operation

I'm not going to go in to too much detail here. L1, R1, C1 and Tr1 form a blocking oscillator who's frequency will depend on the characteristics of the core and the number of turns.

When Tr1 turns on a current will start to flow in the driver coil this will cause a magnetic field to build up around the coil in the core. Tr1 turns off, the sudden change in magnetic field will induce a voltage spike across the coil (as the inductor resists the change in current by producing a high voltage to try and keep the current flowing). This spike it transferred to C2 via D2, if the circuit is left running C2 would charge to a high voltage (this could be 100s if not 1000s of volts and will again depend on the nature of L1). When the voltage on C2 is high enough to cause D2 to conduct in reverse, Tr2 will turn this will cut of the base of Tr1 and stop the oscillator. The connected load will eventually suck enough volts of C2 to stop D2 conducting, Tr2 turns off and the oscillator continues.

Construction

Not critical, I assembled my first prototype with fly leads and Tr1 mounted on a heat sink.

Use a current limited power supply when you first build this circuit, also mount Tr1 on a good large heat sink, if you find out you don’t need it later you can remove it or use a smaller one.

If is doesn’t oscillate, reverse the connections to the driver or feedback windings on L1, if it still doesn’t work check all the connections.

When I first built this circuit I connected up oscillator first (L1, R1, C1, Tr1) ignoring the rest. I could tell it was working as I could hear a whining sound, if you are unable to hear a noise you could connect the collector of Tr1 to an oscilloscope and view the output. You may have to connect a diode in reverse across the driver winding of L1 (to protect Tr1 from the high voltage pulse), remove it when you decide to build the rest of the circuit.

L1 Details

Non critical, although you may have to do some experimentation, as not all configurations will work.

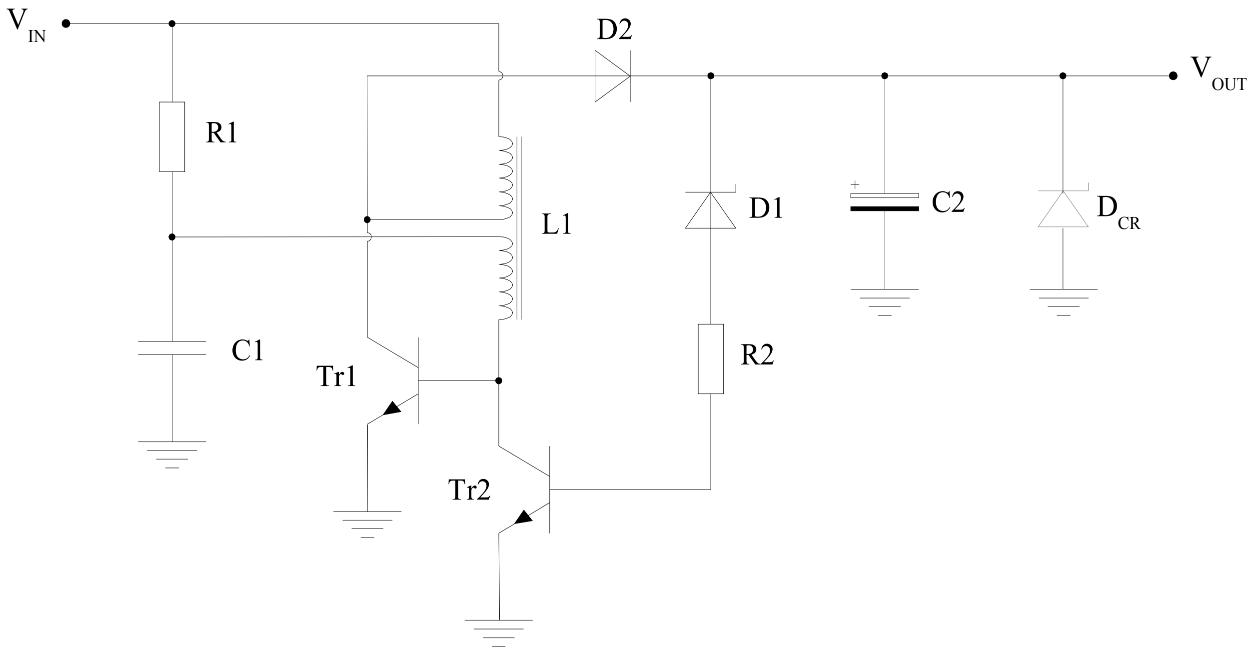
Wind the following coils onto a 20mm ferrite E-core, the order is unimportant although I do recommend winding the driver first, as you want a low resistance, the resistance of the feedback is less important. To achieve maximum efficiency you will have to experiment with different numbers of turns for the driver and feedback.

Driver: 18 turns of 22SWG copper glazed wire.

Feed back: 10 turns of 35SWG copper glazed wire, doesn't need to be thick as it only carries a small signal to the base of Tr2.

CAUTION!

If Tr2 is bad or fails (which is unlikely if the circuit is working properly) a high voltage will build on C2 causing it to explode, this will also happen if it is not connected properly, the same also goes for R2 and D1. To avert disaster connect a 5W zener diode with the same or lower voltage than C2 is rated for in reverse parallel with C2 see diagram (D_{CR} (crowbar) drawn in grey). Turn off the power if it starts to get warm.



Parts List

All resistors are ¼W metal or carbon film

Part	Value	Substation / Comment
R1	10K	Will vary depending on the nature of L1 and Tr1. Try values between 220R and 22K.
R2	33K	10K to 100K will depend on R1, Feedback, Tr2 and, D2.
C1	4.7nF Ceramic	Doesn't seem to affect the frequency of the oscillator much. May not be needed, as the parasitic capacitance of the feedback winding might be sufficient to start oscillation. 220pF to 220nF use the lowest value that works.
C2	220µF 35V Aluminium electrolytic	Try different values, between 10 and 1000µF you may benefit from using a tantalum bead. The lower the frequency output the bigger value you will need.
Tr1	BD135 TIP3055 TIP31 TIP121	Faster transistors maybe of some benefit. Try a high gain Darlington pair power-transistor so a large value for R1 can be used, this will increase the efficiency at lower currents, but the saturation voltage will be higher and it will be less efficient at higher currents.
Tr2	2N2222A	Any general-purpose transistor, try BC547, BC337, 2N3904, ZTX540 etc.
D_{CR}	30V 5W	Only needed once.
D1	BZX79C24 (24V)	Any low power zener will do try different voltages, ok to connect several values in series to increase the voltage rating.
D2	1N4001	General purpose rectifier, try a Schottky barrier e.g. MBRA120.