DN55
A high efficiency Royer driver for a scanner CCFL
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This design note has been updated to include additional choices of transistors to provide greater efficiency.

This is a practical application using Zetex low V_{CE(sat)} transistors for driving a Harrison 4.5W CCFL lamp (240mm x 3mm) which is used in scanners.

The circuit shown in Figure 1 can be modified for alternative CCFL lamps or fluorescent tubes typically used in LCD displays and emergency lighting.

Using a 12V DC supply, this circuit provides a sinusoidal lamp current of 5mA RMS with a DC supply current of 370mA. The resonant frequency is approximately 65kHz after the lamp has struck. This can vary slightly according to the lamp condition. At resonance, the voltage peak at the collector of each transistor is approximately three times the supply voltage. Therefore the VCEO of Q1 and Q2 should be around 40 volts.

A benefit of this circuit is that when Q1 is conducting, Q2 base is at a negative voltage and therefore the much higher V_{CBO} rating could be used; typically twice V_{CEO}. In practice, because of the dynamic load and possible loss of load altogether, it is prudent to keep the voltage rating higher than the circuit suggests. The efficiency, measured with a 150KΩ load (to give 5mA) in place of the lamp, is greater than 80% when using FM1T619 low saturation (maximum 200mV at 1A @ 25°C) SOT23 device.

Since V_{CE(sat)} x collector current represents the majority of the power loss in this circuit, a more recent Zetex device with lower saturation would be a better choice to improve efficiency. The ZXTN2031FTA has an impressive 40mV saturation at 1A @ 25°C and would increase efficiency towards 90%. If cost is a critical factor, the ZXTN25040DFH (maximum 210mV saturation at 1A @ 25°C) which has a small die size is an alternative to the FM1T619.

Although heat dissipation in these SOT23 devices can be achieved using PCB alone, it is worth noting that a 50mm square pad of 1oz copper is approximately equivalent to a heatsink rated at 110°C per watt. Similarly, the same size pad using 2oz copper is approximately equivalent to a heatsink rated at 70°C per watt. Double sided or multilayer PCBs should utilize thermal vias to aid dissipation where possible. Remember to keep the SOT23 pad geometry correct for soldering with short track leading outward towards the larger copper areas. Ground planes under the SOT23 (tracking permitting) is an additional method of removing heat.

On initial inspection of the Royer circuit it would appear possible that on power-up, if both Q1 and Q2 turn on together they would conduct with only the DC resistance of the coils to limit the current. In practice however, this condition rarely occurs and is virtually eliminated by the connection of R1 direct into the base of Q1. Q1 conducts first because the base drive of Q2 is delayed through the feedback winding T1-B inductance.
For additional circuits (e.g., an op amp) requiring a low current voltage supply higher than 12 volts, the collectors of Q1 and Q2 can be rectified and smoothed providing approximately 36 volts. An additional benefit is that voltage spikes reflected back through the transformer created by lamp loss or failure would be absorbed in the smoothing capacitor and will protect Q1 and Q2 from excessive voltage.

Figure 1  Application circuit
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