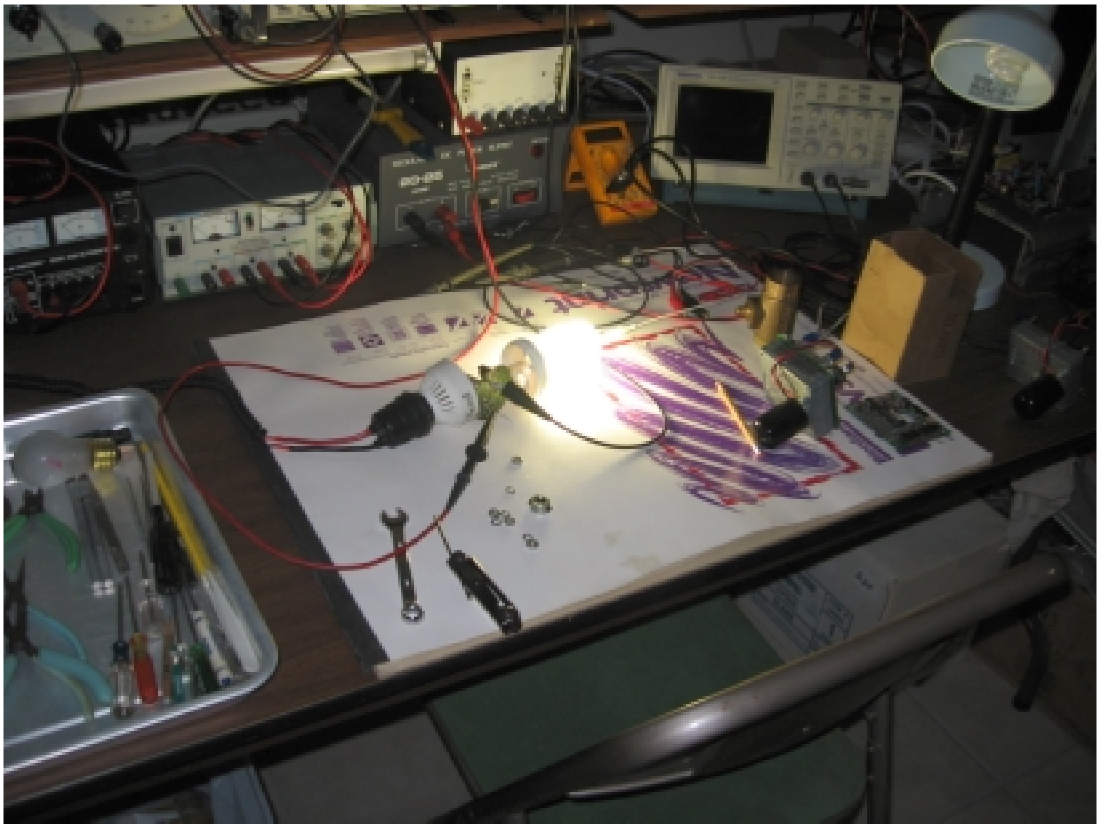
Compact Fluorescent Lamp Repair
by Dennis L Feucht

Now that incandescent lamps are joining CRTs on their way to obsolescence, we are finding compact fluorescent lamps (CFLs) and white LEDs, for spot lighting, growing in familiarity. Like all electronics, CFL eventually fail. Decrying the throw-away mentality and with the requisite skills already in hand (or head), the inquisitive engineer or technician will explore the possibilities of CLF repair. Happily, this is usually not difficult.

Shown below is a CFL that was repaired and still on the electronics bench.



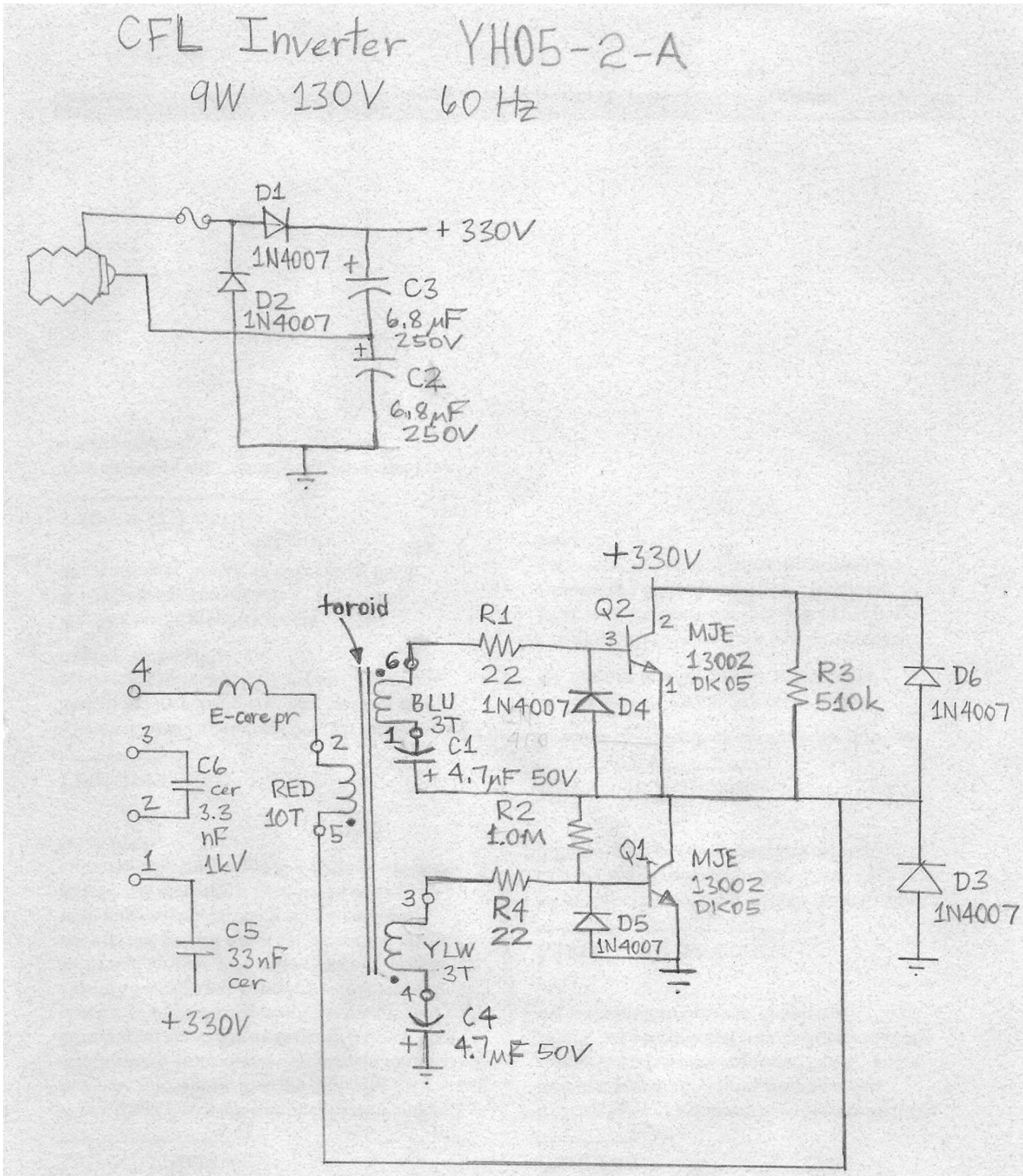
The one specialized item for CFL repair is the power cord with a lamp socket. This is a handy power-line adapter for work on any device that screws into a lamp bulb socket.

One of the most difficult parts of fixing a CFL is to open the enclosure. They snap apart at the seam, as shown in the close-up photo below. The upper section is the lower part of the enclosure, with a top view of the T1 bulb base, cratered a bit from desoldering one of the two wires that connect to it. The lower part consists of the CFL, upper enclosure and inverter electronics board. Note that midway along the rim there is a notch. Sometimes CFL enclosures are hard to open and require wedging a screwdriver into the seam and rotating. Finding where the snaps themselves are and prying at those locations is best. Substantial force in prying apart obstinate enclosures is sometimes needed. Be careful when doing such prying to avoid breaking the fluorescent bulb -- that bulb with some mercury in it. (However, it is better to fix the electronics and continue to use the bulb than relegate both to the dump.)

Once the enclosure is opened, the board and lamp together pull out from the base, as shown for the smaller CFL below. Usually repair can be effected without further disassembly, though you might want to unsolder the two power-line connections to the base to free the board for more careful examination, or reverse-engineering of the circuit diagram. One is at the bottom and is unsoldered from the outside and the other is at the side near the edge of the outer metal screw-connector. These are easy to resolder later and (unlike too much new technology) can be resoldered multiple times without destroying the connector.

The CFL has four wires connected to it which can also be unsoldered. But don't end up with the wires connected to the board, as shown in this photo. They should be unsoldered on the board side to remove the lamp. (This inverter was saved from a unit with a broken CFL lamp.) Reassembly reverses the disassembly procedure. Be sure to form a smooth but sizeable hump of solder on the bottom of the connector base so that it contacts the prong in the socket when screwed into a lighting fixture.

I reverse-engineered the inverters of several CFLs and found that the basic circuit is the same in all of them, regardless of brand or power rating. All use a half-bridge driving a series-resonant circuit. Despite the prevalence of MOSFET power switches in much of today's electronics, high-voltage npn BJTs were used in the examined CFLs. Two magnetics components were used: the base driver and the output inductor that forms a series resonance with the CFL capacitance. The circuit of a 9 W CFL inverter (brand unknown) is shown below.



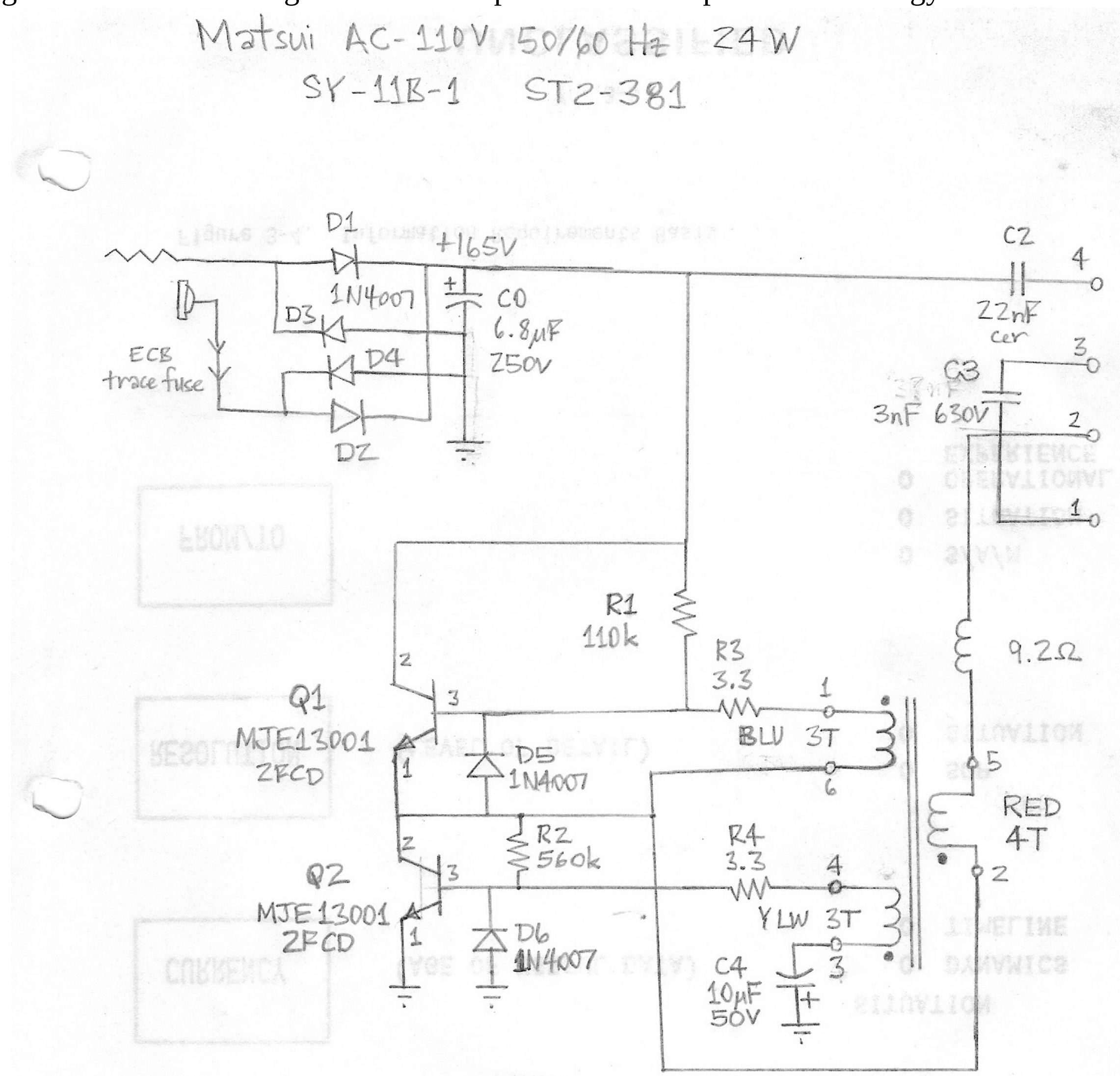
This CFL circuit illustrates some typical features. The MJE13002 BJTs are common in CFLs. They are high-volume, hollow-emitter, high-voltage bipolar junction transistors (BJTs) in TO-92 packages. As such, one would not normally regard them as power devices. In this application, power is delivered at high impedance, and the low currents make it possible to use these BJTs.

This design uses a peak-charging full-wave voltage doubler for the supply. In the particular unit from which this circuit was traced, one of the output capacitors (C2, C3) failed. The most likely failed parts are the transistors and then the supply electrolytic capacitors. Usually, a failure of either will result in overcurrent from the power-line, causing the on-board fuse to blow. These fuses are probably intended for system-level power-distribution safety because they usually do not protect whatever components in the inverter are vulnerable. The transistors work as well as the fuse in protecting the power line. Consequently, without a replacement fuse, several alternatives come to mind that will probably work just as well: a small-diameter fusible wire, segment of solder, or small snap-in fuse with leads soldered onto the ends.

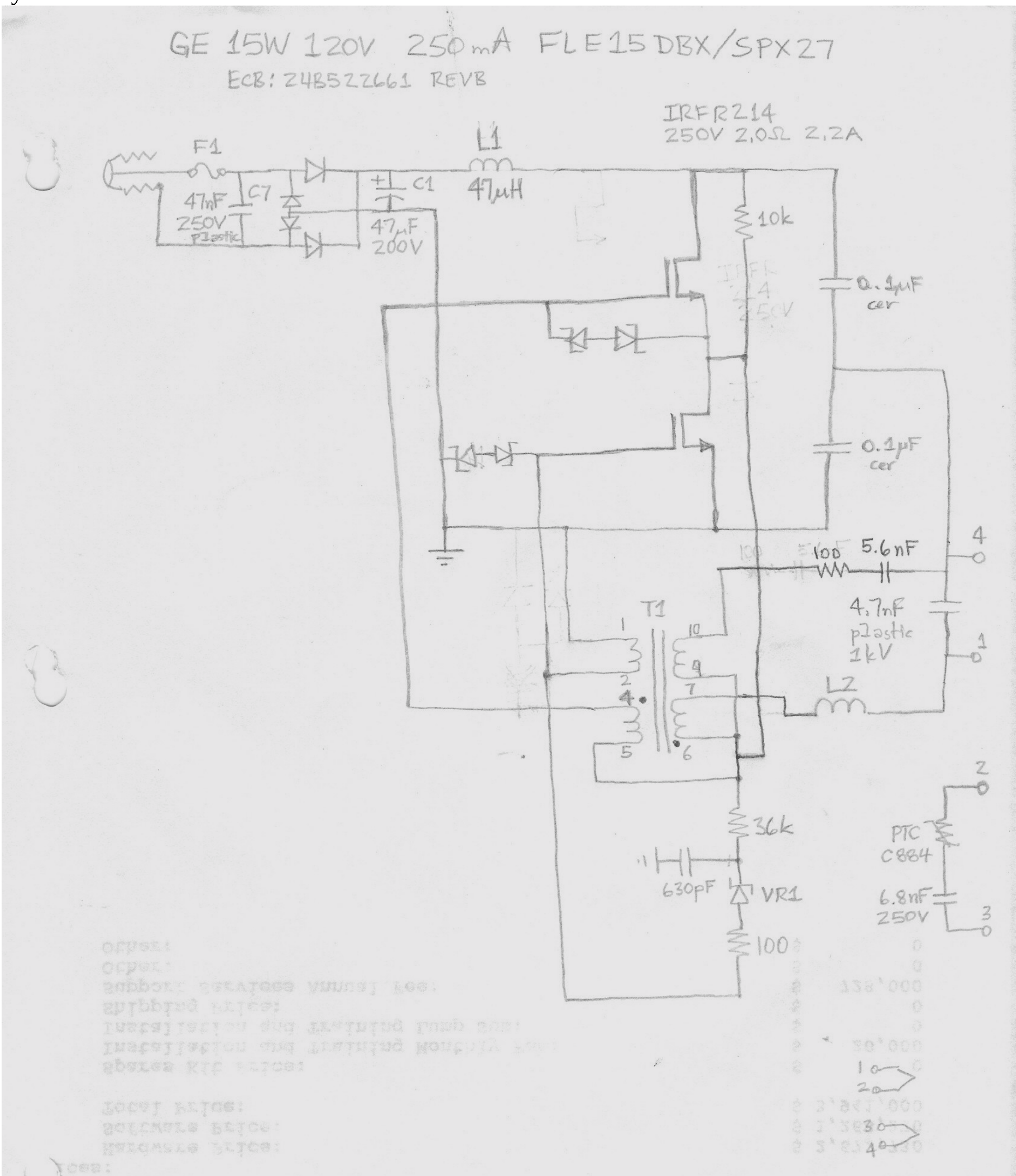
The half-bridge is self-oscillating, with the base-drive transformer. For the required static (dc) turn-on current, R2 through R3 turns Q1 on, current increases in Q1 from out of the +330V supply, into pin 1 of the CFL bulb, back out of pin 4 and through the series inductor, through pins 2 and 5 (the primary winding) of the gate-drive transformer, inducing a voltage across the secondary drive winding of pins 3 and 4. The base drive to Q1 is thus sustained dynamically, and the low-output-level half-cycle of oscillation is underway. As base current sustains Q1 conduction, C4 is charged by that current and eventually its decreasing voltage (on the negative terminal) is sufficient to shut off Q1. The decreasing current of its turn-off causes the secondary base-drive winding with pins 6 and 1 to turn on Q2 and the positive half-cycle begins. Note that the polarities of the base-drive windings for Q1 and Q2 are opposite, as required. C1 (and C4) similarly times out the on-time of Q2.

The starting switching frequency is greater than the resonant frequency of the output inductor and lamp. As the lamp conducts, its capacitance shorts leaving the series capacitance between pins 2 and 3 to resonate with the inductor.

Another CFL schematic diagram is shown below. Note the circuit similarity with the previous unit suggesting that CFL circuit design has become optimized for the present technology.



A third and final CFL inverter circuit is shown below. Note the use of MOSFETs in this one (thereby eliminating the shunt diodes across the BJTs of the previous units), the half-bridge Cs instead, and the 165 V supply.



The details of CFL inverter operation are explained at greater length in Abraham Pressman's book, *Switching Power Supply Design*, (2nd edition), published by McGraw-Hill in 1998, ISBN 0-07-052236-7, Chapter 16. Other chapters in the book also apply directly to CFL inverters. Although design details are not necessary for repair, which design engineer would not want to also know how it works in design-level detail? Be warned however that resonant converters are not simple and can absorb much learning time.

Repair is otherwise. After opening the enclosure, visually inspect the filter capacitors. If they are not bulged, they are probably okay. Unsolder the transistors and test them, or check them in-circuit with an ohmmeter. (This will not always work because of the base-drive circuit.) Then make sure the inductor has not opened. After this (and fuse replacement), there isn’t much left to fail. Check the diodes, then the base-drive transformer for open windings. The base-side electrolytic capacitors can also be suspect. Unless a resistor appears charred, it is probably okay. Look also for open, overcurrented circuit-board traces. In semi-tropical or tropical environments, look for bugs that have gotten into the lamp and shorted circuitry. After that, you’re on your own. The lamp itself, of course, can fail, though usually some indication of a failed vacuum seal or dark regions on the bulb face (if not cracked glass) will provide some evidence of that.

CFL lamps are not hard to repair and take little time. They are worth repairing not only for replacement-price savings but also for the familiarity one gains of another household electronics item. You might even adapt a CFL inverter from a unit with a broken lamp for driving a TFL in a customized household (or laboratory) application.

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