At the Repair Bench – Plasma Lamp – November 2023

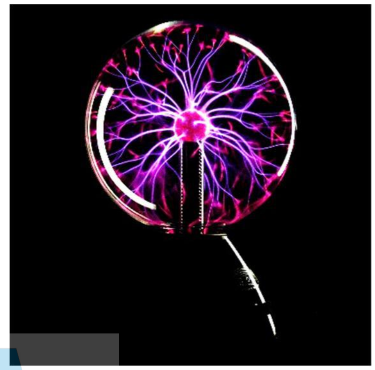

Figure 1 - Operating plasma lamp

A little while ago, one of our fellow club members came to me to ask if I would look at an inoperative novelty item that belongs to his son. I agreed, as I am often likely to do, and so began one of the more unusual repair episodes that I have undertaken.

Don't get me wrong. The repair itself was relatively easy. It is just that this item is so far removed from my usual type of repair that I found it to be intriguing. The item was a plasma lamp (Figure 1), and it had just up and quit working.

Back in March, when the owner first came to me, we took a quick look at it and found a fractured capacitor, a radial film type rated 0.001µF at 1.2kV, with a 5% tolerance. The first step was to source a suitable replacement for this capacitor, though I doubted at the time that the capacitor was the only problem. I had noted a slight indentation in a plastic cover on the circuit board, and that indentation was aligned with and shaped like the body of the diode that was sitting right next to that cover. This was a sure sign of heat, which is why I was not sure that the capacitor was the only problem.

I located a replacement capacitor easily enough, with the exception that the replacement was a 2kV rated device. Time went by, and I had forgotten all about the whole thing until I was asked of the capacitor had come in. I brought the replacement capacitor to the clubhouse on a Saturday morning, but I ended up bringing the unit home with me to make the repairs instead of doing it there at the clubhouse. One of the reasons that I wanted to get it home was that I wanted to explore the circuit so that I could understand the working of the lamp, and I also wanted to draw up a working schematic of the unit.

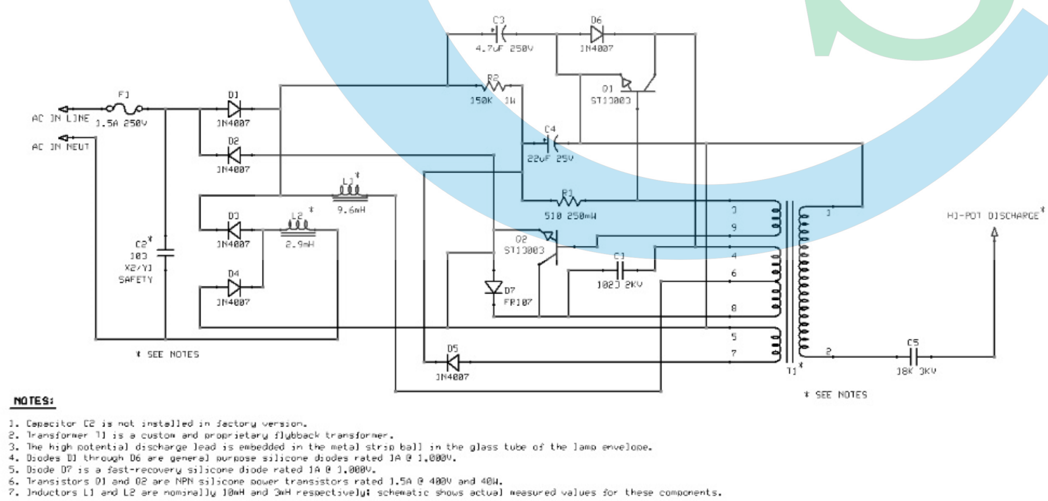

Figure 2- Derived unit schematic

When I started on it at home, I began by disconnecting the circuit board from its incoming power wires coming from the lamp base so that I could have better access to both sides of the circuit board. Then, I began to trace out the circuit and put down into a schematic diagram what I was seeing. I typically use *ExpressSchematic* (part of the *ExpressPCB* package) to draw my schematics, and I did so here. The circuit (see Figure 2) basically consisted of a full wave rectifier for the incoming AC, an oscillator, a chopper or switching transistor, and a multi-section transformer. The transformer has a winding that is part of the oscillator circuit, but largely serves as a flyback transformer to produce the high potential output needed to drive the plasma stream.

The plastic cover that I mentioned earlier is the housing of the transformer, and the diode that had melted a groove into the housing was one of the full wave rectifier set. There are two transistors used, one for the oscillator itself, and the other for the high-frequency switching necessary to create the pulse train input for the transformer. Testing revealed that the oscillator transistor had failed, and the switching transistor was severely past its “best by” date. While this transistor did operate, it was extremely below peak frequency and its *hFE* or *beta* tested out to be a mere 2.5 instead of the normal 200-plus value of a serviceable transistor.

Further testing showed that the diodes used in the unit, seven in all, were all also below spec in performance, although they were still operational. The biggest problem was that one of the diodes, an FR107 fast-recovery type, was not fast at all, having recovery time measured in the 875mS realm instead of the 500nS that it should have been. Voltage drops on the diodes in the full-wave rectifier proved to be quite variable, with one as low as 350mV and another as high as 935mV. The norm is around 535mV for these 1N4007 diodes.

Also indicative of high heat levels in this unit was the condition of the 4.7µF 250V aluminum electrolytic capacitor. This capacitor was quite leaky, acting more like a resistor than a capacitor. The equivalent series resistance (ESR) measured out at just under 5Ω. It should have been down near zero ohms. The transformer, as near as I could tell using an ohmmeter and LRC meter, seemed to be in serviceable condition, as were the resistors, the 18pF 3kV ceramic capacitor and the 1.5A fuse.

Repairs to this unit, then, included replacement of all of the diodes with like types (1N4007 x 6 and FR107 x 1), replacement of both ST13003 transistors, replacement of the 4.7µ 250V and the 22µ 25V electrolytic capacitors, and installation of the new 0.001µF 2kV film capacitor.

It was not a surprise that the unit worked after the repair… after all, that *was* the intent. I was happy, though, that I could make a little boy happy by getting one of his favorite items back to him in working condition. I don’t know how long the unit lasted on its factory parts set, but it is a safe bet that it will most likely fail again at some point in the future, as no substantial design changes or parts improvements were implemented.

The upshot of this repair is that even when something is out of our comfort zone, and even if we have absolutely no documentation, we can still often achieve a successful repair just through common sense and perseverance. It was necessary in this case to almost completely disassemble the unit in order to correctly draw up a schematic and to get to some of the components for testing. In fact, there is a diode and a resistor underneath the transformer housing that cannot be seen or identified until the transformer is removed. Just keep after it and you should make it through.

See you next month…