A High Voltage Generator and Jacob's Ladder

Background

I was bored during Labor Day weekend, and decided to work on a high voltage generator for running spark plugs and other various high voltage experiments.

Luckily I had an old useless monitor sitting around which I knew I could take the flyback transformer out of. A friend came into town for the holiday and we made short work of the monitor.

I found this site describing how to use flybacks out of monitors and it gave a simple circuit to use.

Circuit Operation

This appears to be a Hartley-type oscillator, using the two primary coils. The secondary coil steals energy from the oscillator, probably lowering its frequency of oscillation, but otherwise has little to do with the primary oscillator circuit.

Since the secondary has many more windings than the primary, the voltage across its terminals is much higher than the voltage across the primaries. So much more, in fact, as to producing arcing in air. This is of course the whole point of the device: making pretty looking sparks.

Construction

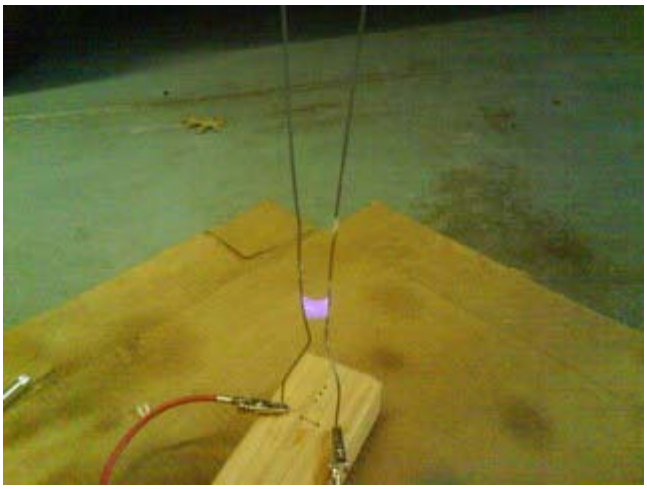
I kept the wiring neat, and used a terminal strip for the low voltage connections. I heat shrinked all the connections on the transformer to reduce the chance of arcing at the base of the transformer instead of where I wanted.

Unfortunately I was still getting some arcing between the high voltage return line and one of the unused pins. I cut the unused pin and then poured 60-second epoxy over it and the base of the high voltage return line. This solved the problem.

Jacob's Ladder

I didn't want to go through the trouble of building a lifter, and I wanted something to demonstrate at my Labor Day grillout party. So I decided a Jacob's ladder was the best "show" for the amount of work.

My roommate took some photos with his phone.



He also took a neat little video available here. In the foreground, you see the Jacob's Ladder running with sparks traveling up between the two polls. In background, you can see the generator.

You might need to download a codec to view it. It opened with no troubles in Quicktime for me.

Measurements

The only way I could think to measure the output voltage of the generator was to measure the length of the sparks it could produce. I found some equations online that related the spark gap to voltage. Unfortunately, these aren't terribly accurate because the gap length depends on the shape of the electrodes, temperature of the air, atmospheric pressure, and humidity. The equation I ended up using was for dry air at STP, and considering it was kind of humid that day, these voltages are probably a bit high.

Supply Voltage versus Gap Distance and Supply Current

Supply Voltage (volts)	Gap Distance (mm)	Supply Current (amperes)
6.03	10	0.13
6.51	12	0.19
7	13.5	0.26
7.49	16	0.325
8	17.5	0.4
8.5	19	0.475
9.02	20.5	0.55

I fit the gap length versus estimated high voltage to a linear equation, and then I was able to predict the gap distance for a given input voltage. This predicted a gap of about 37mm for a 13.5 volt supply. When I connected the generator to a lead acid battery, it produced sparks of about 35mm. That's accurate enough for me.

The equation, for reference, was `D = 3.55 * Vs - 11.12`, where `D` is in millimeters and `Vs` is in volts.

Improvements

A clamping diode for voltage spikes on the primary coils would prolong the life of the tranistor and split the heat dissipation between two devices.

I like this system as it is, since I have pretty good control over the output voltage by varying the input voltage. However, it might be nice to be able to control the timing of the circuit better, say to fire short sparks at specific times for igniting fuel (ie: spark plug timing).

There are also videos floating around of a Telsa coil that "sings" because the primary coils are PWM modulated. I could do something similar in my generator. Since my generator does not shoot four foot bolts of lightening, the only benefit might come from being able to tune the frequency for higher efficiencies.

Safety

A set of longer wires on the output would allow me to operate the generator further from its "business end". I think spark plug lines are probably the best bet here.

Mounting everything in a box would probably make the whole endevour much safer, but I did go to the trouble of heat shrinking

all the wires. The biggest danger is from coming in contact or near the high voltage secondary coil output while the generator is in operation.

Last edited on Sep 7 2007

Contact info and homepage