Electron Flow Within The Basic SSG Circuit During The Coil Charge And Discharge Cycle

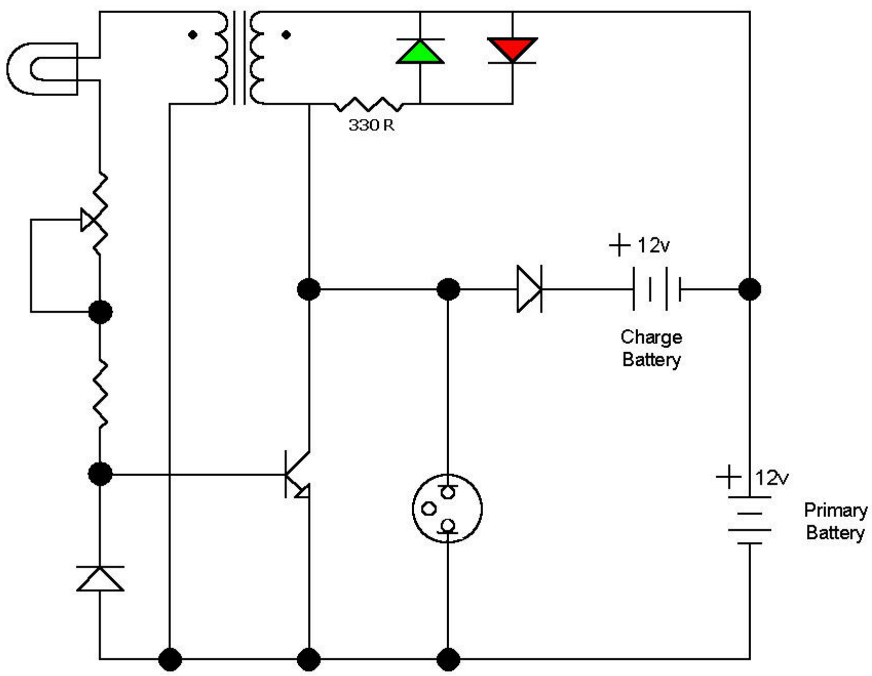
I have been working hard trying to fully understand the SSG circuit. Every time I think I'm close, something unexpected happens, normal for the SSG though. So I went back to basics, hit the books again and set about proving or disproving how I think things are.

There are a few components with specific behaviour when in a circuit like the LED or a rectifying diode, the neon and the coil. Recent discussions with Dave and his view on things, made me question mine. I soon realised that some times I lack the ability to put things across clearly. Especially when things are not quite clear in my own mind.

So, to finally get the SSG's circuit down regarding current and voltage and why it does what it does, I set about mapping the potentials around the circuit. I had a few observable rules to follow.

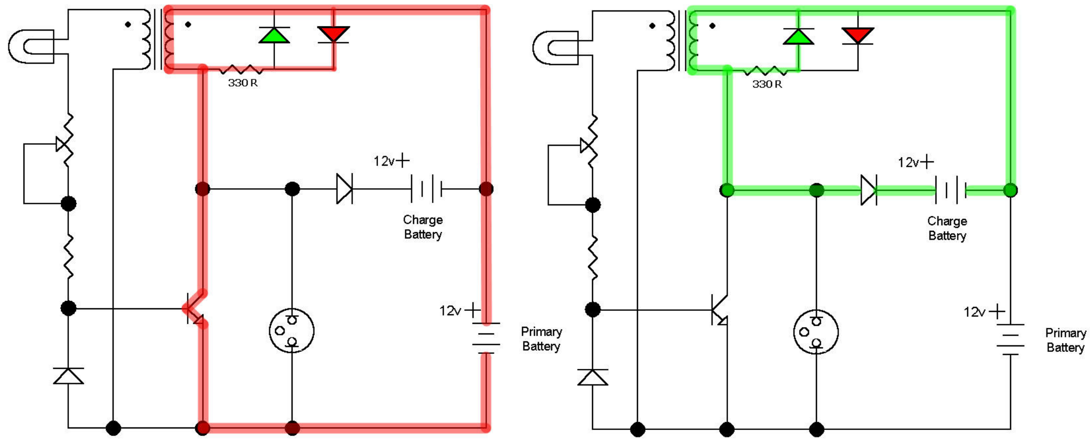
A difference in potential must exist between two points of a circuit for electrons to move.
Electrons move from a negative potential to a more positive potential.
A LED/diode will only allow electrons to pass when the cathode is more negative than the anode.
A neon bulb will light when a potential difference of 90 volts or so exists between it's electrodes. In a DC circuit only the most negative electrode will light.

Armed with this information, I began to study RS's Basic SSG circuit schematic with the red and green LED added. This experiment was carried out in March 2006 as part of the Scalar South stuff in the SG group. I was not the first to do this, both Jim Siwek and Marcus Wagner did similar experiments. Jim documented his findings on the Peswiki SSG replication pages. I achieved the same results.



The LED test

When the battery charged the coil the red LED would light. When the base current turned off the transistor and as the magnetic field collapsed the green LED would light. When you rig a small timing light to your SSG so you can adjust the timing of the coil discharge you would use the orientation of the green LED.



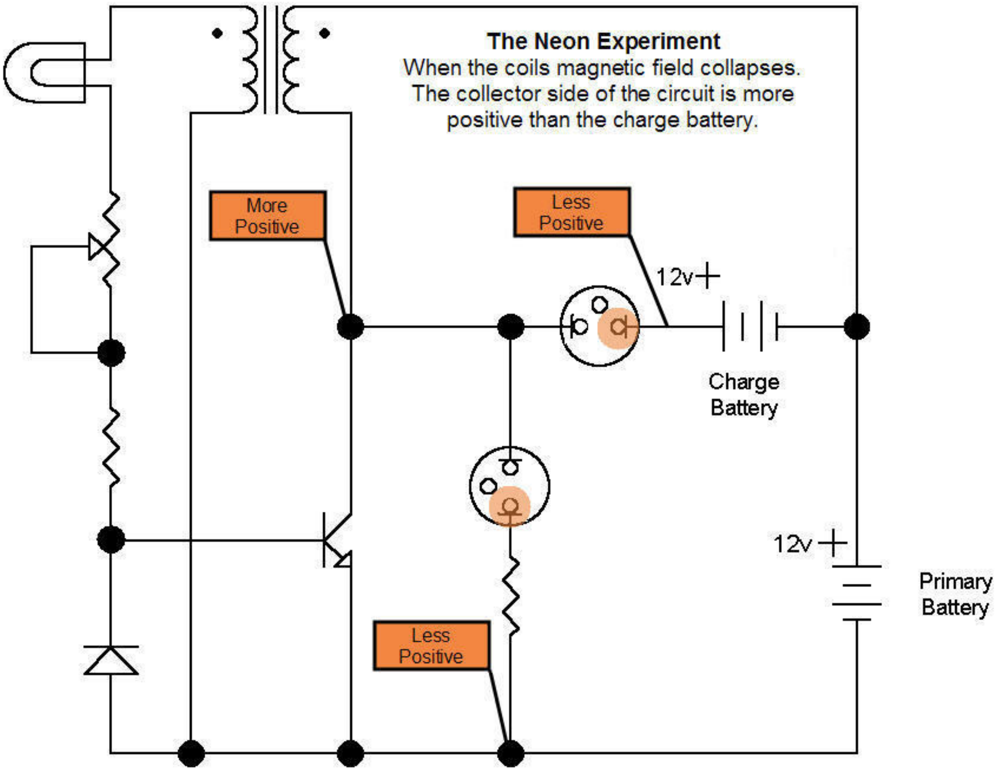
Coil Charge And Discharge Electron Paths

This suggested to me that I was dealing with a true AC wave and that during coil charge the current flowed one way, then flowed the opposite way during discharge, hence the order in which the LED's lit. This theory seemed to be acceptable based on waveform data if it wasn't for the charge battery diode, between the collector and the positive side of the charge battery. I imagined exotic inverse waves, negative energy and all kinds, as to how the "radiant" energy got across this electron dam to the charge battery.

The Neon Experiment

I had noticed in the past that only one leg of the neon bulb would light in the event of myself starting up the SSG without a charge battery connected. I put this down to the neon needing AC to light both electrodes. I later learned that when a neon bulb lights in a DC circuit only the most negative electrode lights. I paid far more attention. I replaced the 1n4007 charge battery diode with a neon bulb and started the rotor. The neon lit with a warm orange glow. To my surprise the neon had the electrode nearest the charge battery lit. I then looked more closely at the neon protecting the transistor. When the charge battery was removed, the electrode nearest the negative bus lit.

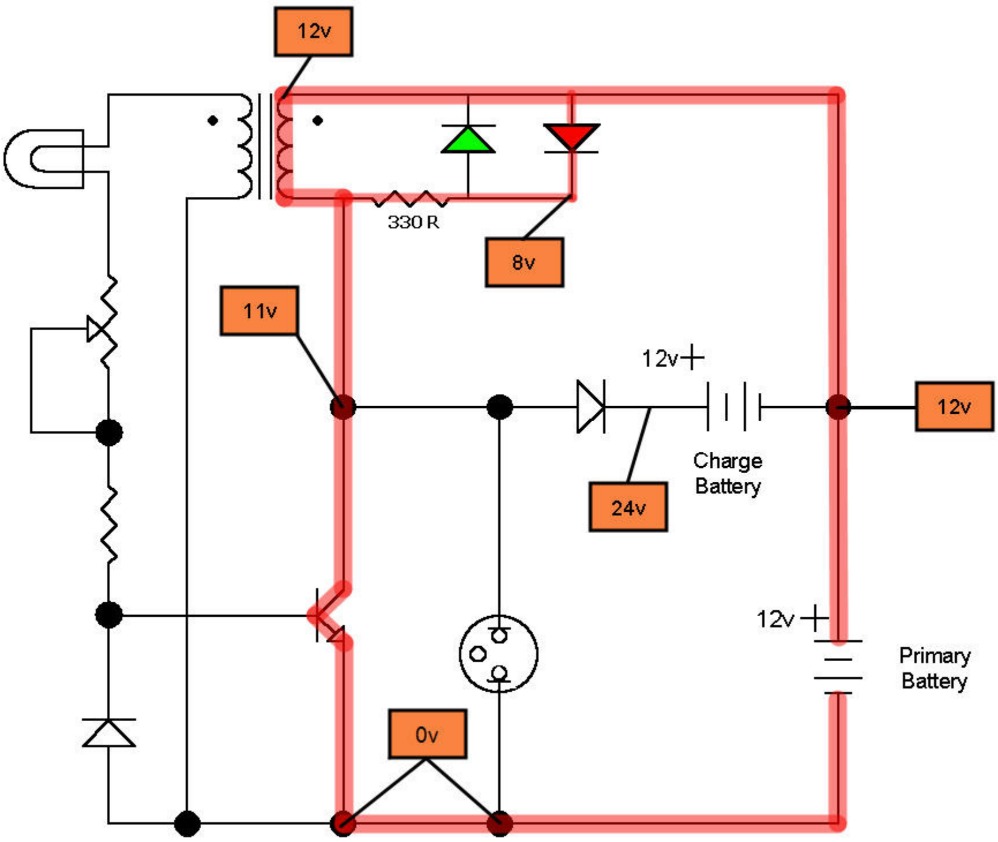
This was a revelation. This clearly proved that during the coil discharge the potential difference was more positive at the collector than the positive side of the charge battery. After studying waveforms and with the data from the LED test, I expected the collector to be negative. Clearly, this wasn't the case. Quite a few days of thought and research went into the results of the experiments with the neons and after some bookwork I realised my theory, based on my initial observations, was wrong.



The Neon Experiment

Mapping The Potentials: Coil Charge

The easiest way to visualise the movement of electrons in the circuit is to map the potentials at various key points.

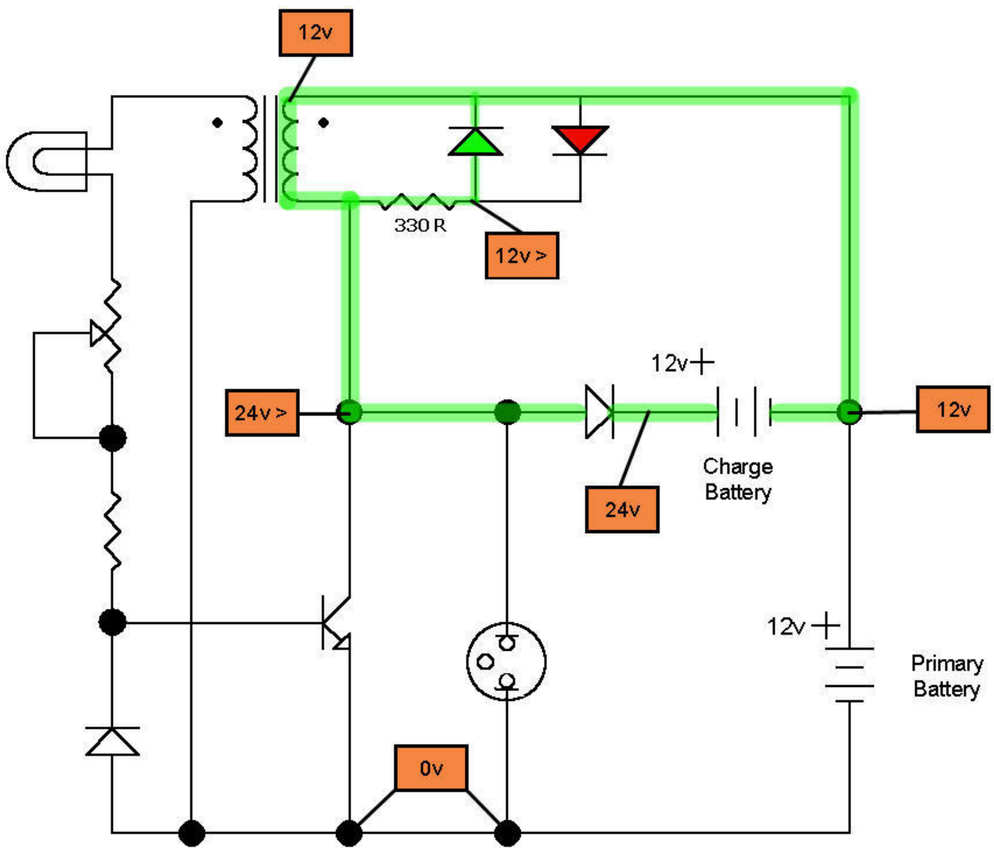


Potentials During Coil Charge

First we have the negative side of the primary battery, which is at zero volts. The next point up is the negative side of the charge battery, which will always equal the voltage of the primary battery. The positive side of the charge battery, at the cathode end of the diode will be the sum of both the primary and charge battery voltages, in this case 24v. During the coil charge, the potential at the top of the coil will equal the primary battery voltage. The voltage drop between the top and bottom of the coil will depend on the resistance of the coil windings and the number of turns. A higher resistance (7 to 10 ohms) will give a voltage drop of 2 to 3 volts when tuned to the sweet spot while a coil of 1 to 2 ohms will have a much smaller voltage drop in the 2oo to 300 mV range. The voltage at the cathode end of the red LED will be less than the voltage at the bottom of the coil due to the resistor.

I could now follow the path of electrons in the circuit from the negative, zero volt side of the primary battery, up through the emitter of the transistor to the top side of the collector. As the potential on the cathode of the charge diode is 24 volts and the potential on the anode is 11volts, no electrons can flow. The same situation arises with the neon, because the strike voltage would need to be greater than 90volts, no electrons can flow. So the electrons flow up toward the coil where the resistor drops more voltage to cathode of the red LED. At the top of the coil the potential is the same as the voltage of the primary battery and the electrons flow back to the positive side of the primary battery completing the circuit.. The red LED lights because the voltage at the cathode is less than the voltage at the anode. The LED is said to be forward biased.

Mapping The Potentials: Coil Discharge.



Potentials During Coil Discharge

During the coil discharge the potential reverses polarity, meaning the top of the coil is now less positive than the bottom. The point of lowest potential is the negative side of the charge battery, which is equal to the primary battery voltage. Since the collapsing field induces a voltage that is proportional to the rate of the collapse. The voltage at the base of the coil can reach very high potentials. Without the charge battery in place the coil discharge can easily light the neon, which has a strike voltage in excess of 90volts. However, with the charge battery and diode in place, an easier path for the electrons presents itself.

The effect of the low but measurable resistance of the charge battery and the forward voltage drop of the diode combine to radically reduce the amplitude of the collapsing field when viewed with an oscilloscope, turning it from a vertical spike into more of a column with greatly reduced height and increased width. While the potential between the bottom of the coil and the transistor collector is greater than the potential of the combined voltage of both batteries electron current can flow as the cathode of the charge diode has less potential than the anode. The electrons flow up through the coil and return to the negative side of the charge battery, completing the circuit.

The green LED will light as long as the voltage drop across the resistor at the anode of the LED is grater than the cathode. When the voltage induced by the collapsing field falls below the combined voltage of both batteries, plus the forward voltage drop of the charge diode, electron flow will cease.