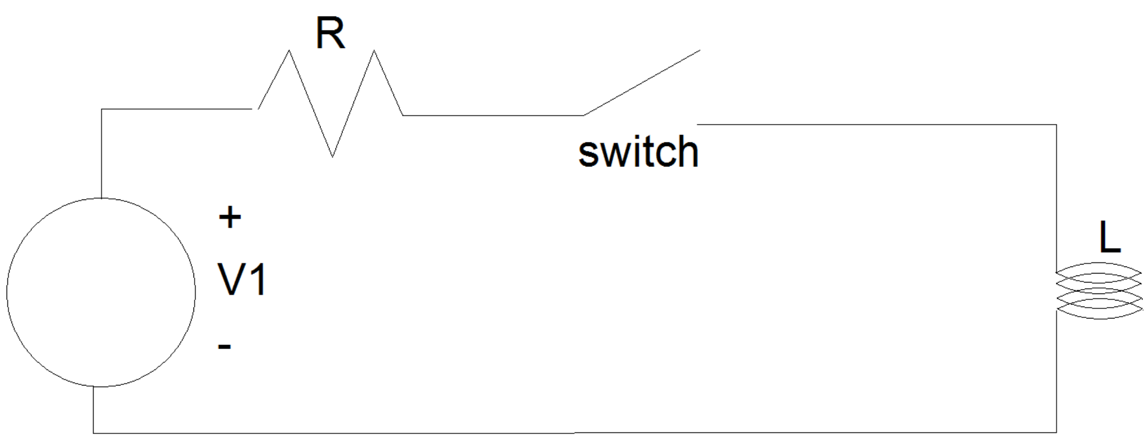
Suppressing Contact Arcing, version 1.0

By R. G. Sparber

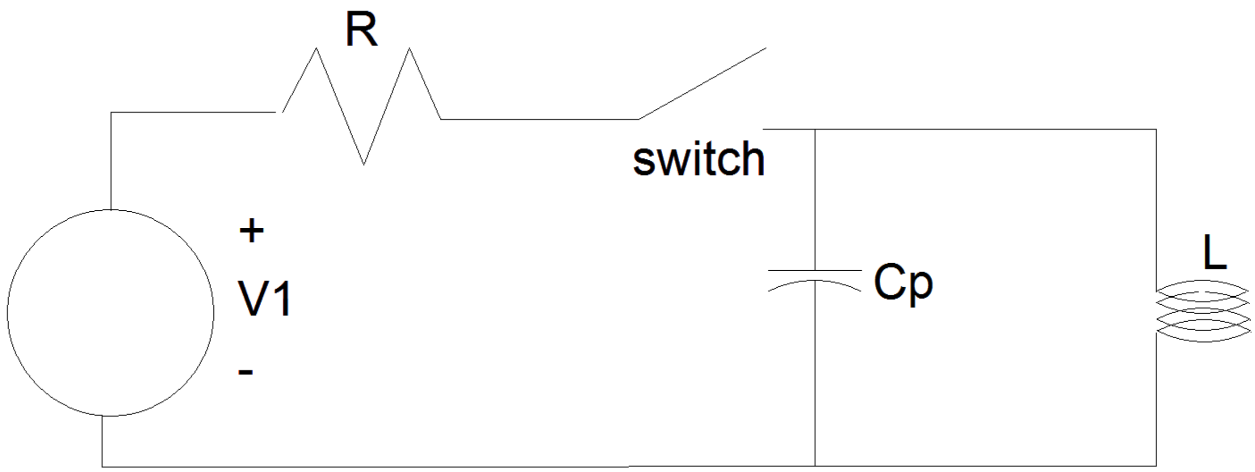


I will start with a simplified circuit.

Say the ideal switch has been open for a long time. The voltage across the ideal coil, L, is zero as is the current through this coil. When the switch is closed, the current will exponentially rise until it reaches a value of $\frac{V_1}{R}$ amps.

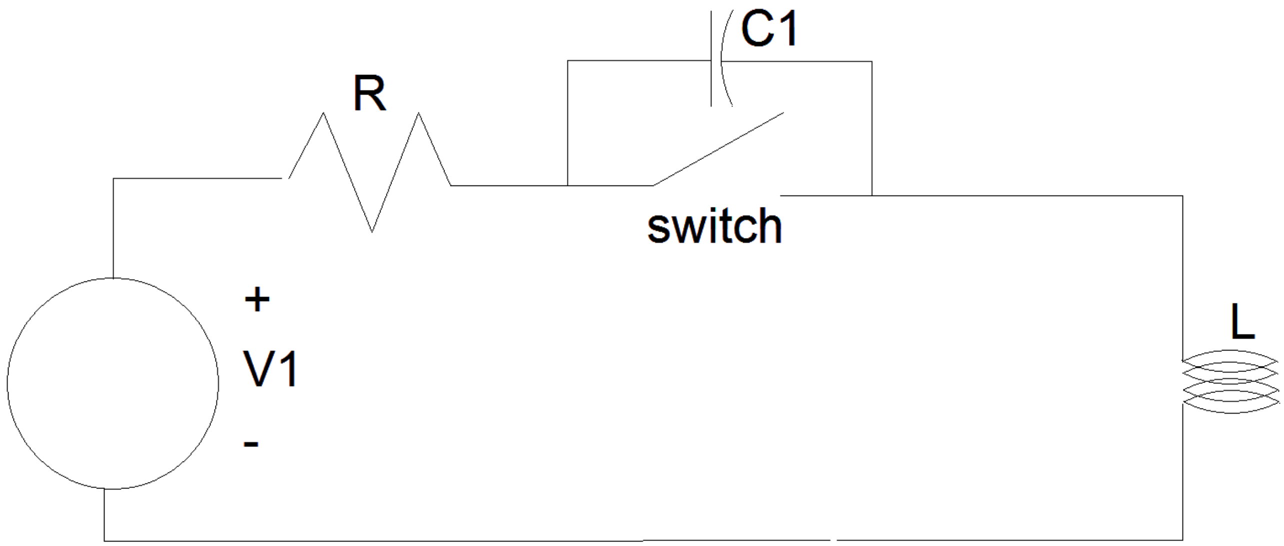
Things start to get interesting when the switch open. The current flowing in the inductor was $\frac{V_1}{R}$ amps before the switch opened and cannot change instantly. The voltage across the inductor rises in order to maintain this current. But in my over simplified model, the voltage rises to infinity and the laws of physics still are not satisfied.

Next, consider the case of an almost real switch that can withstand a voltage of V_{br} before breaking down and arcing over. The switch opens, the voltage across the inductor rises but when you get to V_{br} across the switch, current again flows due to the arc so the voltage across the inductor stops rising. The inductor current will then exponentially fall back to zero as the switch continues to arc. Not good.



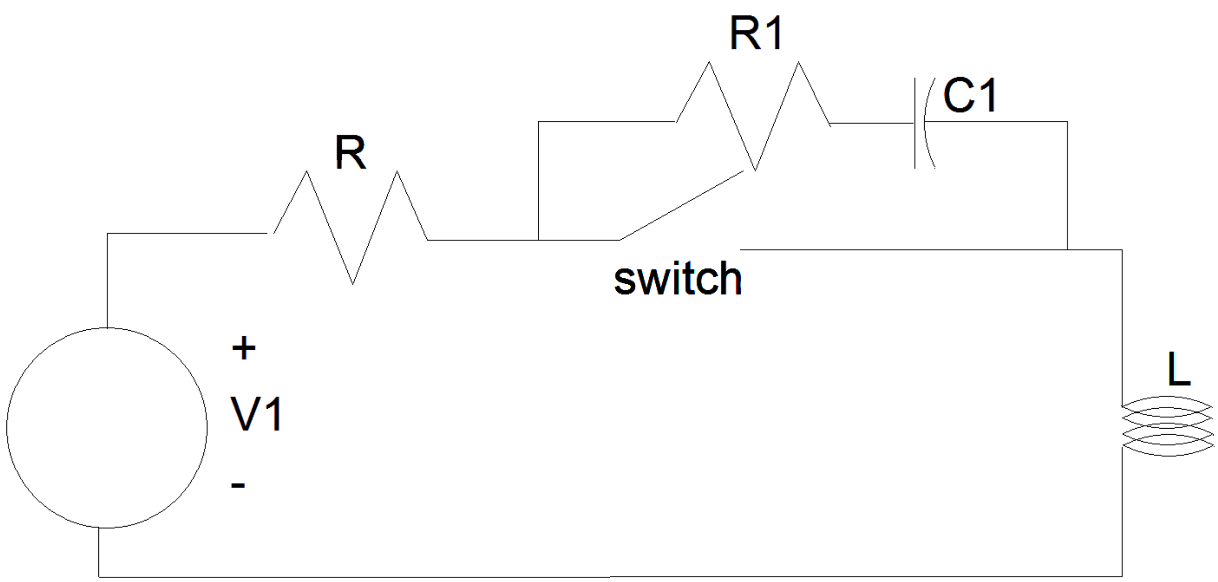
Next I will add a parasitic capacitance, C_p. Some of this capacitance will be from the switch, some will be between the windings of the coil, and some will come from the wires. At the instant the switch opens, current flowing in the inductor will flow in this parasitic capacitance. The effect will be to slow the rise in voltage across the inductor so it is no longer going to infinite volts in zero time. Given an ideal switch, L and C_p would form a tuned circuit and oscillate with a peak voltage of infinity. But with an almost real switch, the voltage would rise across the switch until it arced over.

We can limit the voltage across the switch to less than V_{br} and stop the arcing.



What if we put a capacitor across the switch contacts? When the switch opens, the current flowing in the inductor flows through capacitor C_1. This causes the voltage across the switch to start out at zero and build as the capacitor charges up. You end up with a current that "rings out" from the R C_1 L circuit. That probably is not so bad. But hey, the switch won't arch over.

But consider what happens after the switch has been open for a long time. The current goes to zero so the voltage across R and L is zero. This means that C_1 charges up to the supply voltage, V_1. This is harmless until the switch is closed. Then you short out the capacitor with the switch. The current in our ideal capacitor goes to infinity because the voltage across the capacitor is instantaneously forced to zero. Yet another violation of physics. Damn!



All is not lost. We can make a tradeoff and make this circuit work.

R_1 solves all of our problems. When the switch has been open for a long time, C_1 still charges up to V_1. But when the switch closes, the peak current is limited to $\frac{V_1}{R_1}$ amps. Then the current starts to build in the inductor while the current flowing through R_1 and C_1 falls to zero.

When the switch opens, the current through L, $\frac{V_1}{R}$ amps, immediately starts to flow through R_1 generating an initial voltage across the switch contacts of $\frac{V_1 \times R_1}{R}$ volts. R_1 can be chosen such that this voltage is below the arc over voltage of the switch contacts. So we will let the voltage across the switch rise up a bit, just not enough to cause arcing.

There are other ways to prevent arcing that dissipate less power than a simple RC "snubber". But I'll leave that for another day.

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