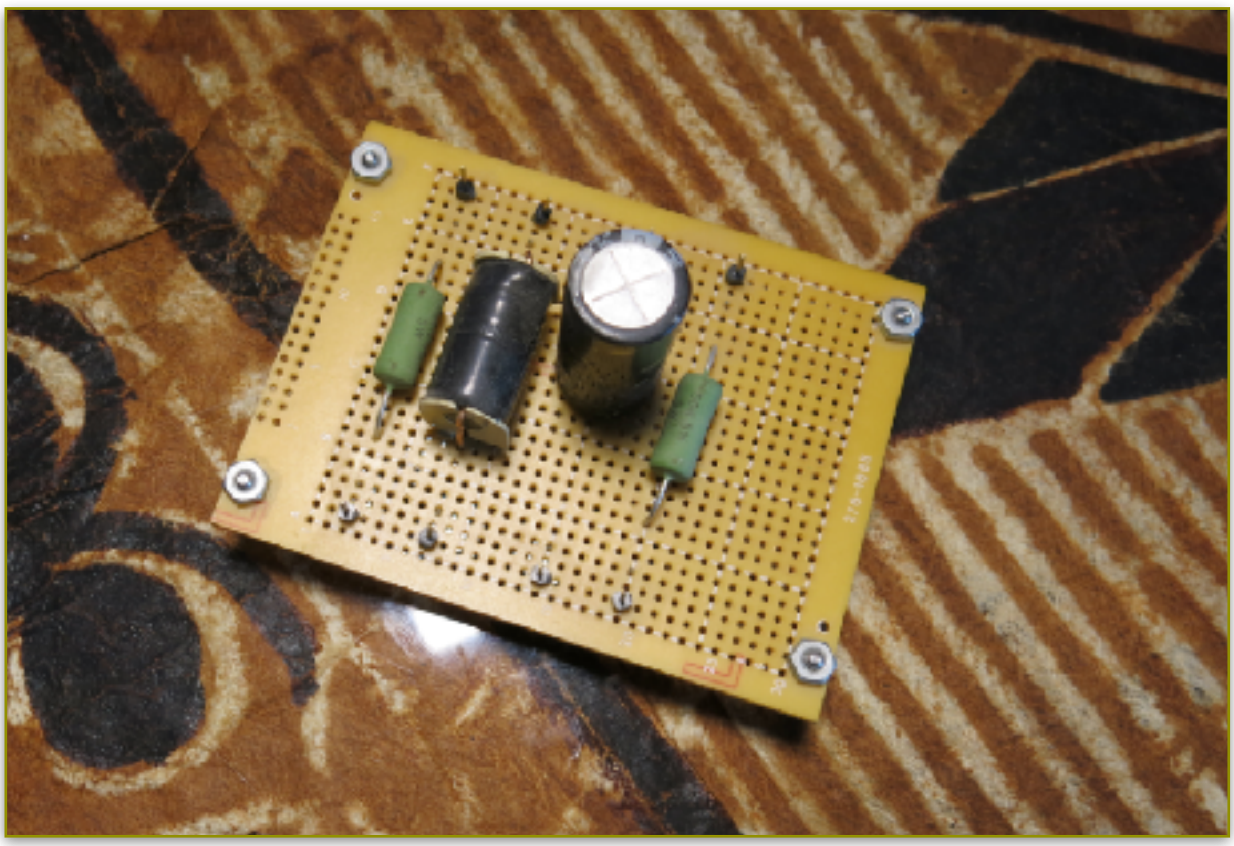
Advanced Learning

Tech Talks

Resistance, capacitance, and inductance are the building-block elements that govern how electronic circuit behave. It is job-one to concern ourselves with these factors, because they are everywhere. The ones in the photo are big chunky values of resistance, inductance, and capacitance but simple wires and within the RLC component are small values of these factors collectively called impedance.

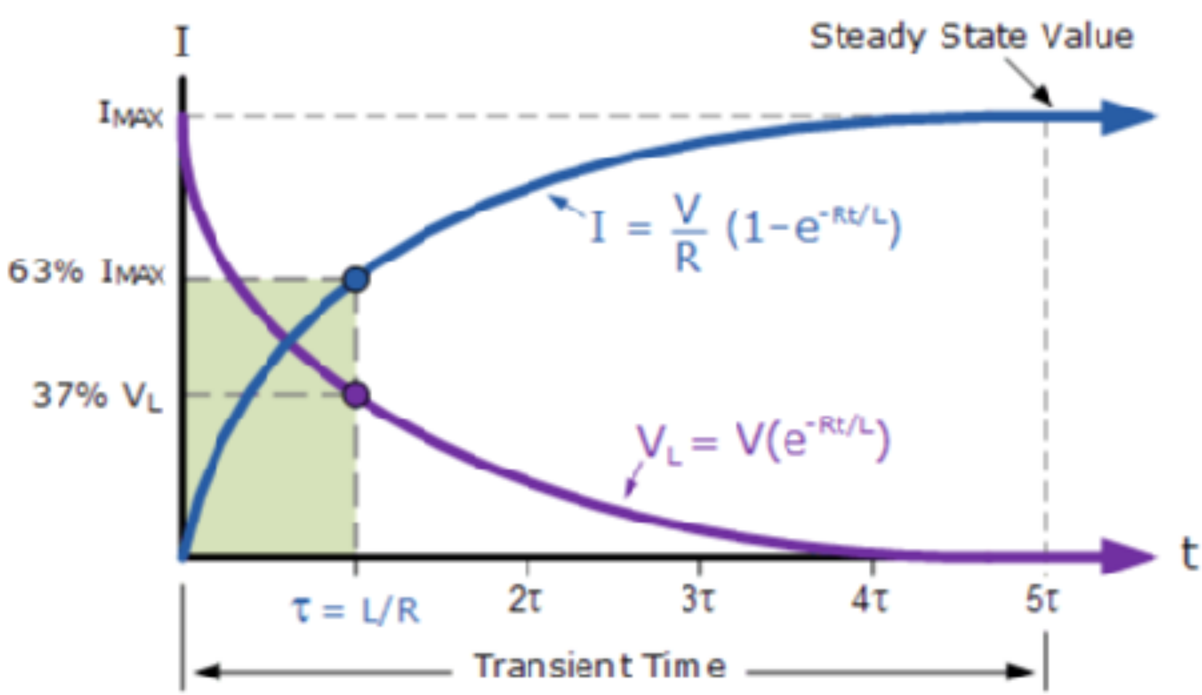


Resistors imped by using energy to generate heat. This causes a voltage drop. Inductors imped by generating a magnetic field that consumes energy lowering current. Capacitors imped by storing electrical static charge reducing voltage. Inductance and capacitance are odd, because their impedance levels are frequency dependent. The good news is all these factors are linear so the math is straight forward.

Curves Ahead

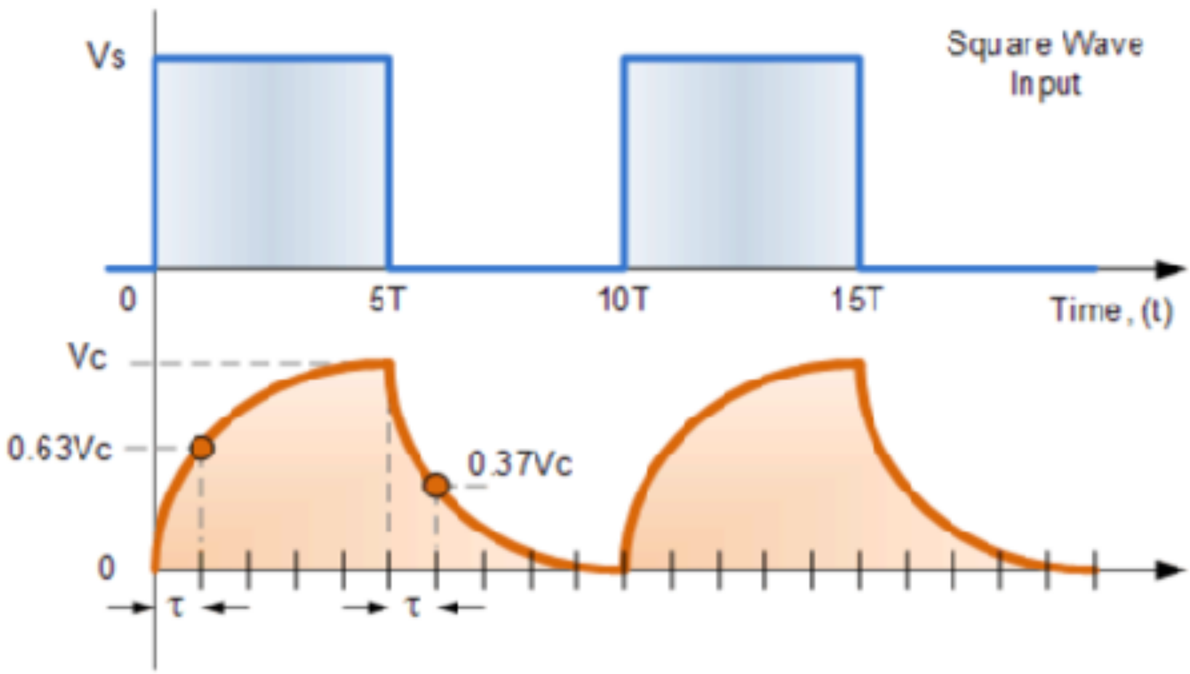
In a series circuit, a resistor causes a current value equal to the supply voltage divided by the resistance value. So the supply voltage is on one end and zero on the other where it returns to the power source. This isn't a practical situation. But if two resistors are in series, the point between them is a practical circuit where the current can be found by V/R, and then V=IR applied to each resistor value and a portion of the supply voltage is shared across the two. In fact, there is always some sort of load resistance when connected to other circuits past your first resistor. Resistors are used to both limit current flow that would otherwise over heat down stream components (heat is generated as the square of the current value, so can be very serious) or as a voltage divider as described earlier. The time variant for a resistor alone is instant. Once the voltage is applied, the values settle immediately.

Let's look at the inductor next. Here we just have a coil of wire so the resistance is really quite small and is only a factor when the power is first applied. In a series circuit when the power is switched on, the current spikes only limited by the internal coil resistance. Over time the current creates a magnetic field that tries to collapse, but by doing so, it creates a current that opposes the current from the



supply. It reaches an equilibrium with a reduced current to the rest of the circuit over time that follows by consuming energy to keep the magnetic field energized. So the voltage settles close to the supply value, but the current is reduced by the back EMF induced current.

Capacitors are just the oppose of the inductors. Here the voltage is effected.



The applied voltage tries to fill the capacitor, but the capacitor resists and builds up slowly. The current spikes initially and then reduces to zero. At that point, all the energy from the supply is held in the dielectric material of the capacitor like a battery and no current flows. The voltage is statically held there.

Now all of this changes dramatically with frequency. What's shown above is for DC current case of switched on DC voltage. Inductive and capacitance hinderance to current and voltage is equivalent to a resistance to the total energy transferred and is called reactance, so impedance is the resistance + inductive reactance + capacitive reactance. We need three terms so we can talk about each in turn. The thing to remember is inductors limit current and capacitors limit voltage. When all three (RLC) are in a circuit together we eventually get the voltage to settle at a reduced value and the current dropping. Now the fun part. Inductive and capacitive reactance varies with frequency. So when we apply a alternating voltage source, the inductive reactance is directly proportional to the frequency so as frequency goes up, the current in the circuit reduces. Capacitive reactance is inversely proportional to frequency so the voltage is increases through the capacitor. So what can we learn overall about circuits used to run AC motors or are involved with radio waves?

When we have all three RLC values large enough to affect the circuit, we will see there are resonance frequencies where the reactive element can peak. In fact, this is wonderful, because we can do things like tune a radio to receive just one frequency or in an audio circuit direct the low frequencies to the woofer and the mid-range to its speaker, and the highs to their speaker to provide higher fidelity sound.

Summary

We are not going to be experts with this glance at the physics of basic electronic components, but we can be aware that these elements have a strong influence on how electronics circuits work.

Power supply design depends a lot on understanding just how to arrange the components to go from 120VAC line voltage to say 12V DC voltage to run a computer motherboard. These RLC groups are used to create low-pass and high-pass filters so only the desired frequencies of interest reach our circuits. All of radio/radar to include cellphones and wireless transmissions are dependent on clever use of RLC components.

Of course, there is a lot of depth to learning electrical engineering to understand the details and that's takes about four years at a good school, but you can better understand a YouTube video when they talk about using these components in hobby circuit from this introduction.