EGR 215 Topics in Electrical Engineering Energy

Electric energy can be divided into two areas, **power engineering** and **power electronics**. **Power systems deals with generation, transmission and distribution of large quantities of electric power**. **Power electronics deals with conversion of power in electric form from one waveform to another**, i.e. AC to DC or AC at one frequency to AC at another frequency.

Thomas Alva Edison is the father of power systems, which is why many still have Edison as part of their name, e.g. Southern California Edison. Edison's original power systems were DC, because that's what he used to run his light bulbs, and you could also build DC motors that started when you turned them on, and thus could replace the steam engines found in any industrial plant. (Power to a room full of tools like lathes used to be delivered by having a steam engine in one corner which drove overhead axles via a leather belt. Belts came down to the machines from the axles.)

Edison used a DC generator. **A generator converts mechanical energy into electrical energy, usually by rotating a magnet near a coil of wire. Faraday's Law says that the change in magnetic flux linking the coil induces a voltage on the coil**. The flux change of course is due to the rotation of the magnet.

Edison then moved the electric power from the generator to the customer by stringing wires along on poles, just like telegraph wires. **This is distribution**.

Edison's problem was that the further the load got from the generator, the dimmer the lights got. That's because of voltage divider between the light bulb resistance and resistance in the wires. As the wires got longer, the resistance got longer, and the voltage at the bulb got lower.

There were such things as AC generators, and transformers**. Transformers are electromagnetic devices that convert ac signals from one voltage to another voltage**. Frequency remains the same. The transformer allowed for stepping up ac voltages to very high values (**500 kV on transmission lines, 25 kV on distribution feeders**) so that small currents flowed in the wires, and for stepping down voltages to the same value from different starting points. Thus a house far away from the generator could have the same delivery voltage as a house nearby**. High voltage wires moving large quantities of power are called transmission**.

The problem was motors. You could make a simple AC motor that would run at one speed, if you spun it up to speed by hand, but this was very inconvenient. It took Nicola Tesla to invent the **ac induction motor, which is self-starting**, and George Westinghouse to market it. Together they drove Edison bankrupt, despite an aggressive anti-AC public relations campaign that included electrocuting dogs, elephants and convicts with AC to prove how dangerous the wildly fluctuating deadly AC current was compared to safe, steady DC. (A load of garbage, both are equally dangerous.)

Today, the electric power transmission system is the largest, most complex, and most expensive man made object. The cash flow for electricity is enormous. The big news, however, is **deregulation, the change from a regulated monopoly to competition among generators**. As the situation in California illustrates, deregulation has many unsolved problems, many at the interface between power engineering and economics. It also illustrates the vital, and usually unappreciated role that power systems and power engineering play in modern society.

Power Electronics

Power electronics involves the use of electronic devices (transistors, thyristors) to convert electrical waveforms from one shape to another. Power electronics are ubiquitous, found in almost anything with a power supply, from computers to compact florescent lights to the flash in a disposable camera.

The simplest conversion is AC to DC. For uncontrolled conversion you just use diodes, and get either just the positive part of the sine wave (**half wave rectifier**) or the absolute value (**full wave rectifier**). Then you use a filter to extract the average value.

For controlled rectification, you use a **thyristor, which is a diode that can be turned on by a small current pulse**. The thyristor has four layers, PNPN, and if you inject electrons into the P region it becomes PN. This it stays off for current in both directions until it is triggered, at which point it acts like a diode until it turns off due to reverse bias. With the thyristor, you can let through just a part of the sine wave. The amount let through controls the output voltage, which can be varied by varying when the thyristor is triggered. You can also use a transistor for this type of switching.

For DC to AC, H bridges of transistor switches are used to create square wave AC. This can be filtered to produce a decent sine wave**. Devices that convert DC to AC are called inverters**.

An important use of power electronics is to control motors. **By varying the voltage magnitude and frequency, a power electronics motor drive can operate motors over a large variation of speed and even position** that is not achievable without the electronics. Many modern large and small-scale motor applications in industry, the home, and even hybrid automobiles, rely on power electronics motor drives.