Inductance

Opposition to Change in Current

Ian Woofenden

Derivation: From Latin inducere, *to lead, bring in, induce.*

When you connect the positive and negative leads of a generator, battery, or other energy source to each other with nothing but wire in between, all the charges try to flow at once, with nothing but the size of the wire to stop them. This rush of charge (high current) is called a "dead short" or "short circuit," and it's not pretty. It can lead to melted wires, damaged equipment, and fires.

Electrical loads in a circuit provide a form of regulation. They control the flow of charges. In DC circuits, loads present what's called "resistance" to the flow. In simple terms, this is like squeezing a hose down to a small opening, which restricts the flow. A resistor in a DC electrical circuit slows the flow of charges, only allowing them to travel at a certain speed. At the same time, these resistors and their electronic buddies are doing some form of work, which is the point of the circuit in the first place.

In AC circuits, there are a couple of additional electrical effects besides resistance that regulate the flow of charges in a circuit and assist in doing useful work. These are capacitance—storing energy in an electrostatic field, and inductance—storing energy in a magnetic field. These effects are present in DC when the circuit is being energized and de-energized; but they are present all the time in alternating current (AC) circuits, since the voltage and current are constantly changing.

In my last column, I explained that when charges flow through a coil of wire, it sets up a magnetic field. Conversely, a magnet passing by a wire "induces" a voltage in the wire. This can lead to a flow of charge, which we call "current." In AC circuits, the voltage goes to zero and reverses many times per second, so the charge flow stops and reverses as many times as well. The magnetic field around the wires builds up to its peak when the charge flow is fastest, and drops down to nothing when the current goes to zero (charge flow stops).

When that magnetic field is increasing, there's a reverse effect that the magnetism puts on the movement of charges in the wire itself. This counter-voltage or electromotive force (cemf) tries to slow the charges down. When the charge flow decreases and the magnetic flux collapses, it has the effect of trying to keep the charges flowing. Inductance is like electrical inertia. It opposes change in charge flow speed.

Imagine a flywheel attached to a belt drive. When the belt goes one way, it spins the flywheel up. When the belt direction changes, the flywheel opposes the change, but then slows down and is spun up the other way. The flywheel stores some of the energy and bounces it back in an alternating pattern that echoes the source alternation, but is offset from it.

In the same way, the magnetic field around a coil acts as a sort of shock absorber, in both directions. It removes energy from the circuit when the charge flow rate (amperage) is increasing, and returns it to the circuit when the charge flow rate is decreasing.

"Inductors"—also called coils or chokes—are simply coils of wire wrapped around a solid or air core. Different wire and core materials and different configurations give different levels of "inductance"—the strength of the reverse voltage generated when current through the inductor changes.

Inductance is measured in "henrys"—named after American physicist Joseph Henry, who along with Michael Faraday, discovered induction. The abbreviation for the unit is "h." One henry is the inductance when charge flow that is changing at the rate of 1 amp per second produces a cemf of 1 volt.

Induction is used in various ways in electrical equipment. Motors use induction as a basic part of their design. Transformers rely on induction as they convert from one voltage to another. Induction ovens and cooktops induce electric currents in the cooking vessels, which heat up, cooking the food. Inductors are used in all sorts of electronic devices.

The basic trick to induction is that changing the magnetic field surrounding a wire or through a coil of wire sets up a voltage in any conductors nearby, including in the wire or coil itself. Taking advantage of this natural phenomenon is critical to electrical and electronics design. Next time: Capacitance.

Access

Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

"Basics of Alternating Current Electricity: Part Two—Phase and Power," by Richard Perez in *HP53*.

"Getting the Buzz Out: Electromagnetism for Beginners," by Chris Greacen in *HP35*.