Focus Question: How has the Engineering Design Process been used to advance electronics technology?

They store your money. They monitor your heartbeat. They carry the sound of your voice into other people’s homes. They bring airplanes into land and guide cars safely to their destination—they even fire off the airbags if we get into trouble. It's amazing to think just how many things "they" actually do. "They" are electrons: tiny particles within atoms that march around defined paths known as circuits carrying electrical energy. One of the greatest things people learned to do in the 20th century was to use electrons to control machines and process information. The electronics revolution, as this is known, accelerated the computer revolution and both these things have transformed many areas of our lives. But how exactly do nanoscopically small particles, far too small to see, achieve things that are so big and dramatic? Let's take a closer look and find out!

If you've read our article about electricity, you'll know it’s a kind of energy—a very versatile kind of energy that we can make in all sorts of ways and use in many more. Electricity is all about making electromagnetic energy flow around a circuit so that it will drive something like an electric motor or a heating element, powering appliances such as electric cars, kettles, toasters, and lamps. Generally, electrical appliances need a great deal of energy to make them work so they use quite large (and often quite dangerous) electric currents.

What’s the difference between electricity and electronics?

Electronics is a much more subtle kind of electricity in which tiny electric currents (and, in theory, single electrons) are carefully directed around much more complex circuits to process signals (such as those that carry radio and television programs) or store and process information. Think of something like a microwave oven and it’s easy to see the difference between ordinary electricity and electronics. In a microwave, electricity provides the power that generates high-energy waves that cook your food; electronics controls the electrical circuit that does the cooking.

Electronic circuits

The key to an electronic device is not just the components it contains, but the way they are arranged in circuits. The simplest possible circuit is a continuous loop connecting two components. In computers, circuits are dense and complex and include hundreds, thousands, or even millions of separate pathways.
The easiest way to build a circuit is to connect components together with short lengths of copper wire. Electronics designers usually opt for a more systematic way of arranging components on what's called a circuit board. A basic circuit board is a piece of plastic with copper tracks connecting all the attached components.

Electronic equipment that you buy in stores takes this idea a step further using circuit boards that are made automatically in factories. The layout of the circuit is printed chemically onto a plastic board, with all the copper tracks created automatically during the manufacturing process. Components are then simply pushed through pre-drilled holes and fastened into place with a kind of electrically conducting adhesive known as solder. A circuit manufactured in this way is known as a printed circuit board (PCB).

Although PCBs are a great advance on hand-wired circuit boards, they're still quite difficult to use when you need to connect hundreds, thousands, or even millions of components together. The reason early computers were so big, power hungry, slow, expensive, and unreliable is because their components were wired together manually in this old-fashioned way. In the late 1950s, however, engineers Jack Kilby and Robert Noyce independently developed a way of creating electronic components in miniature form on the surface of pieces of silicon. Using these integrated circuits, it rapidly became possible to squeeze hundreds, thousands, millions, and then hundreds of millions of miniaturized components onto chips of silicon about the size of a finger nail. That's how computers became smaller, cheaper, and much more reliable from the 1960s onward.

**Electronics around us**

Electronics is now so pervasive that it's almost easier to think of things that don't use it than of things that do.

Entertainment was one of the first areas to benefit, with radio (and later television) both critically dependent on the arrival of electronic components. Although the telephone was invented before electronics was properly developed, modern telephone systems, cellphone networks, and the computers networks at the heart of the Internet all benefit from sophisticated, digital electronics.

Try to think of something you do that doesn't involve electronics and you may struggle. Your car engine probably has electronic circuits in it—and what about the GPS satellite navigation device that tells you where to go? Even the airbag in your steering wheel is triggered by an electronic circuit that detects when you need some extra protection.
Electronic equipment saves our lives in other ways too. Hospitals are packed with all kinds of electronic gadgets, from heart-rate monitors and ultrasound scanners to complex brain scanners and X-ray machines. Hearing aids were among the first gadgets to benefit from the development of tiny transistors in the mid-20th century, and ever-smaller integrated circuits have allowed hearing aids to become smaller and more powerful in the decades ever since.

Who'd have thought have electrons—just about the smallest things you could ever imagine—would change people’s lives in so many important ways?

**A brief history of electronics**

- **1874:** Irish scientist George Johnstone Stoney (1826–1911) suggests electricity must be "built" out of tiny electrical charges. He coins the name "electron" about 20 years later.
- **1875:** American scientist George R. Carey builds a photoelectric cell that makes electricity when light shines on it.
- **1879:** Englishman Sir William Crookes (1832–1919) develops his cathode-ray tube (similar to an old-style, "tube"-based television) to study electrons (which were then known as "cathode rays").
- **1883:** Prolific American inventor Thomas Edison (1847–1931) discovers thermionic emission (also known as the Edison effect), where electrons are given off by a heated filament.
- **1887:** German physicist Heinrich Hertz (1857–1894) finds out more about the photoelectric effect, the connection between light and electricity that Carey had stumbled on the previous decade.
- **1897:** British physicist J.J. Thomson (1856–1940) shows that cathode rays are negatively charged particles. They are soon renamed electrons.
- **1904:** John Ambrose Fleming (1849–1945), an English scientist, produces the Fleming valve (later renamed the diode). It becomes an indispensable component in radios.
- **1906:** American inventor Lee De Forest (1873–1961), goes one better and develops an improved valve known as the triode (or audion), greatly improving the design of radios. De Forest is often credited as a father of modern radio.
- **1971:** Marcian Edward (Ted) Hoff (1937–) and Federico Faggin (1941–) manage to squeeze all the key components of a computer onto a single chip, producing the world’s first general-purpose microprocessor, the Intel 4004.
- **1987:** American scientists Theodore Fulton and Gerald Dolan of Bell Laboratories develop the first single-electron transistor.
- **2008:** Hewlett-Packard researcher Stanley Williams builds the first working memristor, a new kind of magnetic circuit component that works like a resistor with a memory, first imagined by American physicist Leon Chua almost four decades earlier (in 1971).

**Source:** [http://www.explainthatstuff.com/electronics.html](http://www.explainthatstuff.com/electronics.html)