The Historical and Contemporary Contributions of Electrical and Computer Engineering to Society

Historical Overview

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Some Electrical Scientists/Engineers

- Ancient Greeks
- William Gilbert
- Pieter van Musschenbroek
- Benjamin Franklin
- Charles Coulomb
- Luigi Galvani
- Alessandro Volta
- Hans Christian Oersted
More Electrical Scientists/Engineers

- Andre-Marie Ampere
- Johann Carl Friederich Gauss
- Georg Ohm
- Michael Faraday
- Joseph Henry
- James Clerk Maxwell
- J. J. Thomson
- Samuel F. B. Morse (Telegraph)
Even More Electrical Engineers/Inventors

- Thomas Edison (Electric lights .....)
- George Westinghouse (A.C. Power Dist.)
- Nikola Tesla (A.C. generators, motors)
- Guglielmo Marconi (Wireless telegraph)
- John Bardeen and Walter Brattain
  - Transistor
- Jack Kilby and Robert Noyce
  - Integrated Circuit
- Marcian (Ted) Hoff (microprocessor)
The Greeks

- Naturally polymerized tree resin (amber)
- Greeks called it **elektron**
The Greeks: Yet Another Mysterious Force

- Heavy black rock
- Lodestone
- Proved to be iron ore
- Greeks found theirs in Magnesia
William Gilbert (1544-1603)

- William Gilbert was born in Colchester, England in 1544.
- William Gilbert’s *De Magnete* (“On the Magnet”) was published in 1600, and quickly became the standard work on electricity and magnetism in Europe.
- *De Magnete* explained many magnetic & electrical phenomena, and disproved common folk tales.
- William Gilbert was the first to make the distinction between magnetic attraction and static electricity.
In 1745 a Dutch Physicist named Pieter Van Musschenbroek invented the first primitive capacitor.

In Pieter’s experiment he filled a glass jar about half-way with water and placed a brass tube through the top of the jar into the water. He then held the jar in one hand, and the wire from an early friction electrical machine in the other. The other end of the wire was placed in the water, and when the friction electrical machine was turned on Pieter experienced a violent shock.

It was this experiment that led to the development of the modern day capacitor.

The charge created by the friction electrical machine had been accumulated by the glass jar, and all discharged at once through Pieter because he completed the circuit because he was grounded.
Ben Franklin (1706-1790)

- Ben Franklin had been formulating ideas about electricity from a young age and described lightening as an electrical current in nature.

- In 1752 to prove that lightening was an electrical current he wanted to see if lightening would pass through metal. Hence the key and kite experiment.

- The key tied to a kite simulated a lightening rod, which is why Ben Franklin got electrocuted.

- The result of this experiment developed into the use of lightening rods to protect people from lightening.
Charles Coulomb (1736 – 1806)

Using a torsion balance Coulomb in 1784 experimentally determined the law according to which charged bodies attract or repel each other.

\[ F = \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r_{12}^2} \mathbf{e}_{12} \]

Coulomb’s Law

- Newton meter\(^2 /\) coulomb\(^2\)
- volt meter / coulomb

\[ \frac{1}{4\pi \varepsilon_0} = 10^{-7} \, c^2 = 8.99 \times 10^9 \]
Luigi Galvani (1737-1798)

In 1792 Galvani used decapitated frogs to generate an electric current.
Alessandro Volta (1745 – 1827)

Interpreted Galvani’s experiment with decapitated frogs as involving the generation of current flowing through the moist flesh of the frog’s leg between two dissimilar metals. Argued with Galvani that the frog was unnecessary.

In 1799 he developed the first battery (voltaic pile) that generated current from the chemical reaction of zinc and copper discs separated from each other with cardboard discs soaked in a salt solution.

The energy in joules required to move a charge of one coulomb through an element is 1 volt.
Hans Christian Oersted (1777 – 1851)

In 1820 he showed that a current produces a magnetic field.
André-Marie Ampère (1775 – 1836)

French mathematics professor who only a week after learning of Oersted’s discoveries in Sept. 1820 demonstrated that parallel wires carrying currents attract and repel each other.

A moving charge of 1 coulomb per second is a current of 1 ampere (amp).
Georg Ohm: Ohm’s Law-1826

• Born in Germany in 1787
• Georg is responsible for the mathematical description of the relationship between voltage and current.
• I = V/R, commonly referred to as Ohm’s Law explains how current through a wire is directly proportional to the Voltage divided by the resistance.
• Ohm’s Law is current flow, which is the basis of the theory of electricity.

Resistance is measured in Ohms (Ω)
Michael Faraday: Electromagnetic Induction - 1831

- Discovered **Electromagnetic induction**, the idea that by passing a magnet through a conductor will produce an electrical current.

- Faraday also invented the first DC electric motors.

- Faraday’s discoveries in magnetism and electricity are the reason why electricity became a viable source of power for modern technology.

A capacitance of 1 coulomb per volt is called a **farad** (F)
Johann Carl Friederich Gauss: Gauss’s Law - 1833

Electric Field

$$\iiint \mathbf{E} \cdot \hat{n} \, dS = \frac{q}{\varepsilon_0}$$

Gauss's Law
Joseph Henry: Electromagnets - 1834

American scientist, Princeton University professor, and first Secretary of the Smithsonian Institution.

Discovered self-induction
Stores energy as a magnetic field.

Built the largest electromagnets of his day, in fact Henry is responsible for an electromagnet that lifted over 3500 lbs.

Unit of inductance, L, is the “Henry”
Samuel Morse: Electric Telegraph - 1844

Telegraph - Binary Serial Communications!
James Clerk Maxwell: Speed of Light - 1862

- Discovered what we now call and electromagnetic field

- James Clerk Maxwell predicted that light was a wave, as well as predicting the existence of radio waves.

- Maxwell also added to the theory of electromagnetic induction by proving that current in one wire can induce current in another, even though the two are not connected.

- Also proposed a theory concerning electromagnetism that described how electric and magnetic fields travel through space as waves.
More Maxwell

“From a long view of the history of mankind - seen from, say, ten thousand years from now - there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics.”

-- Richard P. Feynman
The Feynman Lectures on Physics
Vol. II, page 1-11
Thomas Edison (1847-1931)

• Responsible for the first practical and long-lasting light bulb.

• Edison set up the first electrical supply network called “Edison Illuminating Company” in 1878.

• Edison Illuminating Company provided 110 volts of electricity to 59 customers in Manhattan.

• Also established the first research lab responsible for innovation.
Heinrich Hertz (1857 – 1894)

Generates and detects electromagnetic waves in 1887

The frequency of electrical signals is measured in *hertz* (cycles/second)
Nikola Tesla: Tesla Coil - 1891

- Contrary to popular belief Nikola Tesla obtained the first radio patent.

- In 1891 Tesla developed the “Tesla Coil” which is still widely used today in radios and television sets.

- Westinghouse’s success was based largely on the research and breakthroughs made by Tesla

- Tesla’s work laid the foundation for modern AC power systems.

The unit of measurement for magnetic fields is the Tesla
George Westinghouse: AC Power - 1893

• Thomas Edison’s Main Rival in electrical distribution

• Proponent of Alternating Current (AC) as opposed to Direct Current (DC).

• Westinghouse Introduced AC power in 1893 at the World’s Columbian Exposition in Chicago.

• The Westinghouse Company was awarded a contract to set up an AC network to power illuminate the Exposition.

• The AC power display at the Columbian Exposition generated an extensive amount of positive publicity.
Guglielmo Marconi: Radio Telegraph - 1896

- Marconi’s claim to fame is the development of the radio telegraph system.
- Marconi never actually came up with a new principle, he just made vast improvements to the system in place.
- Marconi transmitted the first radio signals via antennas placed in different locations in 1896.
- Similar wireless telegraph systems could only transmit signals via land, Marconi was able to transmit signals over the Atlantic Ocean as well.
But there was a problem…

From *The Wonders of Wireless Telegraphy*
J. A. Fleming, London, 1913
The British Physicist J.J Thomson is probably most famous for his cathode-ray tube experiment in which J.J. Thomson found that the fluorescent light produced by a cathode ray or “electron gun” contained very small negatively charged particles. Particles even smaller than the atom!

This was important development because it eventually led to J.J. Thomson’s model of the atom in 1904 which included positively and negatively charged particles which were positioned by electrostatic forces.

J.J. Thomson’s atomic model was called the plum-pudding model, in which the negatively charged particles were plums and the area surrounding the plums was positively charged.
Vacuum Tube-1904

- Vacuum tubes can create an electrical signal within a space by controlling the movement of electrons, this was the precursor to diodes and solid state electronics.

- Vacuum tubes conduct current in only one direction similar to diodes.

- John Ambrose Fleming Developed the vacuum tube to be used in radio receivers and radars.
Binary Digital Computers - 1939

• George Stibitz foresaw new uses for electromechanical relays utilized in telephone switching systems.

• Employing the use of relays along with flashlight bulbs, and a tobacco tin switch, the first binary adder was created.

• With the use of the binary adder Stibitz built a device called the Complex Number Calculator.

• This was the world’s first digital computer that utilized binary code.
Transistor - 1947

- In 1945 Bell Labs wanted to develop a solid state electrical component to replace the problematic vacuum tube.

- Bell Labs appointed William Shockley, a young theoretician, to head up a team charged with developing an improved version of the vacuum tube.

- After countless experiments the **point-contact** transistor resulted.

- The transistor consisted of strips of gold foil on a plastic triangle pushed into contact with a slab of Germanium.

- About a month later Shockley produced his own version of the point-contact transistor called the junction transistor which was able to be mass produced.
John Bardeen and Walter Brattain

- John Bardeen and Walter Brattain were researchers that served as members of Shockley’s team to improve the vacuum tube.

- John Bardeen (the thinker) and Walter Brattain (the tinkerer) performed most of the hands on work as far as building and testing the primitive transistor. Shockley simply seen the potential of a transistor and provided the initial idea.

From left: John Bardeen, William Shockley, Walter Brattain.
Jack Kilby & Robert Noyce: Integrated Circuit - 1959

• Both are responsible for the invention for the Integrated Circuit.

• Jack Kilby worked for Texas Instruments and Robert Noyce worked for Fairchild Semiconductor i.e. a company founded by William Shockley.

• Both men were aware of the potential of digital electronics, but the technology of their time was limited due to something called the “Tyranny of numbers”, which simply means that increasing numbers of components required was larger than the physical capacity of components that could be assembled together.

• The way that Kilby & Noyce solved the problem was by creating entire networks of electronic components and placing them in a crystal(chip) of semiconductor material. Kilby- Germanium, Noyce-Silicon.
First Communications Satellite- 1962

• In 1962 NASA launched *Echo*, the world’s first communications satellite into orbit.

• *Echo* was a large balloon shaped satellite that could be seen with the naked eye from earth.

• The satellite was developed at Langley Research Center.
First Handheld Calculator - 1967

- Texas Instruments developed the first handheld calculator, which utilized the integrated circuit they patented in 1964.

- The TI-35 had a keyboard with 18 keys, and a digital screen which utilize a semi-conductor thermal printer.

- The TI-35 retailed for about $2000 in 1967! Although it cost less than 10% of that to produce it.
First Digital Music- 1970

- Bell Labs developed something called pulse-code modulation back in the 1930s.

- Pulse-code modulation describes a method used to digitally represent analog signals.

- Originally used for telecommunication, the BBC (British Broadcasting Corporation) began experimenting with Pulse-code modulation.

- In 1970 the BBC produced a two-channel recorder, used to record music.
• Following the innovation of integrated circuitry by Kilby & Noyce, Ted Hoff was in turn able to drastically increase the processing power of CPUs (Central Processing Unit).

• Ted thought that it would be a good idea to design a chip programmed with basic logic functions as opposed to multiple chips for each individual function.

• Pair this idea with the integrated circuit Ted was able to create the first microprocessor which contained about 2300 transistors and was about the size of a thumbnail.

Ted’s microprocessor had just as much processing power as a primitive CPU the size of a large desk.
Home Video Game System Developed-1972

• The First ever video game console was the Magnavox Odyssey.
• The Odyssey was an analog gaming system as opposed to digital.
• The Odyssey had no sound and ran on batteries.
• Due to Magnavox’s poor marketing capabilities everyone thought the console would only work on Magnavox televisions, so the console sales suffered.
First Cell Phone Call-1973

- Dr. Martin Cooper, the GM of Motorola at the time, made the first Cell Phone call to his business rival at AT&T’s Bell Labs.

- That Cell phone weighed 30 ounces or about 2lbs

- The first cell-phone released to the public ten years later weighed about half that and cost $3,500.
First GPS-1978

• The Global Positioning System (GPS) is based on a global navigation satellite system used to pinpoint your location at anytime as long as an unimpeded view between four satellites exists.
• *Transit* was the first GPS to be successfully tested, utilizing five satellites and could provide a fix on a location once every hour.
• In 1967 the Navy developed accurate space clocks for satellites.
• In 1978 the first satellite containing an accurate space clock was launched into orbit.
First Laptop Computer- 1979

- The GRiD Compass 1100 developed by GRiD Systems Corporation in 1979 was the first computer one could operate from their lap.
- The design used by the GRiD Compass 1100 set the standard for contemporary laptops by utilizing side mounted drives, a flat screen monitor, and a recessed monitor.
- The GRiD Compass 1100 was also battery powered and had its own operating system.
- Starting out at $8,500 the GRiD Compass 1100 found a market with the U.S. Government and NASA.
IBM releases the first Personal Computer-1981

• The First IBM PC ran on a **4.77 MHz** **intel 8088** microprocessor.
• This primitive PC came equipped with 16 kilobites ok memory(KB) expandable to 256KB.
• Also the IBM PC came with 1-2 160KB floppy disk drives and an option of a color monitor.
• The price tag for this PC was **$1,565**, equivalent to about **$4,000** today.
Introduction of the Internet to the public- 1991

• The World Wide Web or Internet had been theorized and designed as early as 1965.
• In 1969 the first ARPAnet utilizing an information packet switching network was installed at UCLA.
• By 1971 the government had linked computers at several universities and research laboratories to better keep up with information, and by the end of the 1970 there over 100 computers linked together.
• E-mail was also developed along with this.
• In November of 1990 the World Wide Web was invented, and by 1991 there were over 1 million systems connected to the internet.
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