Electronic Circuits

Electronics – the study of electronic components and their behavior when connected to other parts in a circuit.

When you look at a circuit in which the electrons are flowing, it appears as if nothing is happening. For this reason it may be difficult to ascertain what is happening in an electronic circuit. You see the results when a light illuminates or an image appears on a screen. You can hear the results when the electromagnetic energy is converted to mechanical energy in a speaker. Electronic circuits are in your computers, TV, stereo, radio, and cell phone to name a few.

In this class you will be building two electronic circuits. One will involve the sophisticated integrated circuit (IC) with which you will select parameter for a function to be performed. The other project will be constructing the primitive crystal radio to study the fundamentals of radio communications.

Before any circuit can be built, you must understand the schematic diagram. The schematic diagram uses symbols to represent electronic components, show how they are connected and the current flow in the circuit. Engineers and technicians can read the schematic diagram to build the circuit or to trace the current and repair the circuit. What schematic diagrams don't show is the actual physical parts layout. You must learn to read the schematic diagram and then locate the part in the circuit and vice-versa.

Components that we will be working with; know the circuit designation and the schematic diagram symbol:

Batteries
Capacitors – electrolytic
Capacitors – fixed
Capacitors – variable
Diode – germanium
Diode – silicon
Diode – LED (light emitting)
Earphones
Fuse

Integrated circuits
Inductors
Resistors – fixed
Resistors – variable
Speakers
Switches
Transistors
Transformers
Tubes

Other symbols:

Antenna
Ground – chassis
Ground – Earth

Wires connected
Wires not connected

Make a chart with these symbols and their circuit designation.
Make a color code chart for resistors.
Make a chart to decode the capacitors.

Electronic Components – How it works; how it is constructed; what it is used for

1. Batteries - Batteries are devices that convert chemical energy to electrical energy. As the current returns to the battery at the positive terminal, electrical energy is converted back to chemical energy.
Construction: A typical alkaline battery has a center carbon rod and an outer zinc case filled with an acidic past. When batteries can no longer function. Please dispose of properly as to not contaminate the environment.
Uses: Batteries are used to provide DC to and electronic device such as lap top computers, portable radios, CD players, MP3 players, quartz clocks and watches, and flashlights just to name a few.

2. Capacitors – Capacitors are electronic components that store or hold a charge.
Construction: A simple capacitor consists of two parallel plates. Most are made of multiple parallel plates to increase the capacitance. The dielectric material is air in variable capacitors. Fixed capacitors may have dielectric material of mica, paper, polystyrene, or an insulating paste.

There are many configurations of capacitors. The three most common are:
1. **Fixed** – a preset value of capacitance for a specific function. We have disk capacitors to work with in your time constant project.
2. **Variable** – used in tuning circuits of radios.
3. **Electrolytic** – Used to filter and/or remove the AC from DC. Electrolytic capacitors are easily recognized because one lead is marked positive (+) and the other lead is marked negative (-). They go in a circuit only one way.

Uses:
1. Changing transmit or receive frequencies in radios (your xtal radios)
2. Filtering power supplies for pure DC during AC to DC conversions
3. Used to change tones in audio oscillators
4. Used with resistors in time constant circuits. (your in-class project)
5. Used to bypass RF (radio frequency signals) from AF (audio frequency) circuits.
6. Increasing the power to strobe or camera lights by storing a charge

3. Diodes – Diodes are electronic components that will allow the charge to move in only one direction through it.
Construction: Most diodes will have a wire out of each end of a tubular body. One end of the body will have a band around it to indicate the "cathode" end of the diode.
Germanium diodes are made with crystalline germanium (cathode) with a "cat whisker," tiny thin wire (anode), making contact with the element. This is a "point-contact" type diode.
Silicon diodes are made of type "**N**" material (cathode end) joined to type "**P**" material (anode end). This is a "junction" diode. **Note:** there will be more on the "P" material and "N" material later.
Uses: Diodes are used to separate the AC component of a charge from the DC component of a charge and then only pass the DC charge. The classic example would be the use of very sensitive germanium diodes in the crystal radio. Silicon diodes are used in power supplies to change AC to DC. Other diodes are used as switches in circuits.

LEDs or Light Emitting Diodes are diodes that contain a PN junction of crystal material that produces produce photon emissions (light) when a forward current flows through them. The crystalline material is gallium arsenide (GaAs) or gallium phosphide (GaP) or a combination of both and the material determines the wavelength of light emitted. LEDs are noted for their long life of over 50 year. Applications of LEDs include digital display units or other displays in which an array of tiny lamps are used. LEDs have very low current requirements thus LEDs are very cost effective to use.

4. Earphones – Earphones convert electrical energy (electricity) to mechanical energy (sound

Construction: A coil of wire attached to a very thin diaphragm next to a magnet. As the current carrying voice or music information, the magnetic field created in the coil is constantly varying and interacting with the fixed magnetic field of the permanent magnet causing the diaphragm to vibrate at the same rate producing mechanical energy, the sound wave.

Uses: To hear music/voice privately. To hear that which you don't want others to hear. Oh yes, they fit in or around your ear. The old large earphones were nicknamed "cans."

5. Fuse – When excessive current flows into a fuse, the thin wire burns out.

Construction: Most fuses are constructed of thin wire in a small glass tube.

Uses: If an electrical component fail, a fuse protects the circuit from damage due to excessive current flow. When the current becomes excessive, the wire burns and opens the circuit thus stopping the current flow.

6. Integrated Circuits – An IC is a complete circuit on a silicon chip.

Construction: An IC can contain 10s to 100s or 1000s of transistors and diodes over a silicon based platform. An IC may have 6 leads, 8 leads, 12 leads, 14 leads, or 16 leads. The IC that is the CPU in a computer will have 10s to over 100s leads.

Uses: The configuration of an IC can cause it to perform many functions. Basic functions include amplifiers, voltage regulators, pulsing switches, complete radios, memory, and central processing units.

You will need to become very familiar with the function/operation of the **386** and **555** and **741** ICs.

7. Inductors – Inductance is the property that exists when wire is formed into a coil and the tendency of the inductor to resist changes in the flow of current.

Construction: Inductors are made of a coil of wire. The coils may me a single layer or multiple layers. The coil may have an air core or may have a core of ferric material to increase the inductance.

Uses: A few fundamental uses of inductors are in electromagnets (old fashion doorbells), blocking the flow of AC, radio tuning circuits (our crystal radio for example), transformers, motors, and generators.

8. Resistors – Resistors are electronic components that oppose the flow of current in a circuit.
Construction: Most resistors are constructed of a film of carbon. High-powered resistors may be constructed of very fine wire of specific length.

Two fundamental types of resistors are fixed with in circuits and variable such as the volume control on a radio.

Uses: Just about every electronic circuit contains resistors. Three of the most important applications of resistors are:
1. Limiting current flow to LEDs, transistors, speakers and other small and low current electronic components.
2. Voltage dividing, or distributing voltage in various quantities to different parts of a circuit.
3. Resistors can control the rate that a capacitor charges. This is an objective of your in class project.

9. Speakers – Speakers convert electrical energy to mechanical energy.
Construction: ‘bout the same as an earphone but physically much larger.
Use: ‘bout the same as an earphone but you don’t stick it in your ear. Everyone around can hear it.

10. Switch – A switch is an electronic device that makes or breaks the flow of current to a circuit.
Construction: How about examples since there are too many ways to construct a switch. There are knife, slide, rotary, push button, toggle, pull, and rocker switches to name a few.
Uses: This can be summed up in two primary functions, to turn power on or off and to transfer current from one circuit to another. Switches can also transfer current from one circuit or device to another. An example is when you use a switch to select AM or FM reception on a radio or select between two set of speakers.

11. Transformers – Provides for the transfer of energy from one voltage level to another voltage level by magnetic coupling. Only AC can pass through a transformer. The
Construction: The basic transformer consists of two coils electrically insulated from each other and wound upon a common core made of magnetic material, usually steel. The coil that receives the AC is the primary and the coil from which the AC leaves at some different voltage level is the secondary.
Uses: Transformers can step up voltage. My High power amplifier requires a voltage of 3200 Volts DC. The transformer steps up the AC voltage from 120 VAC to 3200 VAC and a diode will convert the 3200 VAC to 3200 VDC. Your computer p/s has a step down transformer to convert 120 VAC to 19 VAC.

12. Transistors – The term **transistor** is used because the inherent characteristic of this electronic component is "**trans**ferring current across a res**istor**."

Transistors are very compact semiconductor devices that, for many functions, take the place of tubes. For some applications, such as high-powered amplifiers (RF and AF), tubes are still more efficient.

We will study two fundamental types of transistors based on the organization of the materials. The two fundamental types of materials in transistors and diodes are silicon (**Si**) or germanium (**Ge**). Both of these elements have 4 valence electrons and both have cubic or diamond crystal lattice structure.

The materials: Holt p. 874

P-type – In the crystal lattice structure of silicon, some atoms of silicon are replaced with atoms that have 3 valence electrons such as indium (**In**) or aluminum (**Al**). This impurity produces an electron deficiency, or hole, in the fourth bond in the crystal lattice structure. The hole can be filled by a nearby electron which creates another hole in the lattice structure and therefore, the impurities are referred to as *acceptors*. A semiconductor containing acceptors is known as **p-type** material because the majority of **the charge carriers are positively charged holes**.

N-type - In the crystal lattice structure of silicon, some atoms of silicon are replaced with atoms that have 5 valence electrons such as arsenic (**As**). Since only 4 valence electrons are involved in the bonding with neighbor atoms, one electron is left over. The added impurity produces an excess of electrons that is donated to the solid and the impurity is referred to as a donor atom. Semiconductors with donor atoms are called **n-type** semiconductors because **the charge carriers are electrons with negative charges**.

1. **NPN transistors** – p-type material is sandwiched between two n-type materials.

2. **PNP transistors** – n-type material is sandwiched between two p-type materials.

When **p-type** material is joined to **n-type** material a **PN** junction is formed. Holes and electrons on either side of the junction can migrate across the junction and creates a potential barrier that allows the current to flow only in one direction and thus the **PN** junction acts like a diode. Remember that **N** material has an excess of free elections and **P** material has free holes. When a free moving e^- meets a free moving hole, the charges cancel leaving no charge carriers. Since this area has no moving charge carriers it is called an area of **depletion**.

How the transistor works. A property of a transistor is to **amplify a signal**. Refer to the drawing. The outer regions of the transistor and the emitter and collector and the narrow central region is the base and each region will have a wire connected to it. The emitter is usually more heavily doped than the base and thus will have more charge carriers than the base. A small voltage is applied across the emitter and base. A large voltage is applied across the emitter and collector. A small signal entering at the emitter will emerge as a large signal at the collector. Amplification has and you will notice this as a louder signal coming out of the speakers.

I use a small amplifier when I test the crystal radios.

13. Tubes – Electrons are accelerated through a vacuum from one element (cathode) to another element (anode). Internal structures called “grids” will have a voltage applied to assist in accelerating the electrons from the cathode to the anode.

Construction: Most tubes have a glass envelope that contains the elements made of throated tungsten. The glass tube will have pins protruding from the bottom for electrical connections. Some tubes may have a cap on the top for a high current/voltage anode connection.

Uses: Tubes are primarily used to amplify or increase the power of information carried by the electric charge. Tubes are also used to convert AC to DC, and also as voltage regulators.

In most applications tubes are old technology. In some applications though the efficiency and quality of tonal sounds in tubes cannot be reproduced with transistor technology.