MICROCONTROLLER PROJECT LABORATORY

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BASIC ELECTRONICS CONCEPTS AND COMPONENTS

This handout describes three basic concepts in electronics:

1. Voltage
2. Current
3. Frequency

It also explains the function of six basic components we will use:

4. Resistors
5. Capacitors
6. Diodes
7. Transistors
8. Simple Integrated Circuits
9. Microcontrollers

1 Voltage

Unit of measurement: volt (V)
Symbol in equations: V

Common values:	Batteries:	1.5 V, 9V
	Electrical signals:	3-5 V
	Wall power:	120 V

Voltage is a measurement of potential electrical energy. It is analogous to water pressure in a pipe, or the height of water on a hill. It does not indicate that any action is taking place, just as having a water balloon at the top of a 100-story building doesn't indicate an action. However, dropping the balloon from that building would cause quite an action, just as connecting a 100-volt wire to your hand can cause significant damage.

2 Current

Unit of measurement: ampere (A) (abbreviated "amp")
Symbol in equations: I

Common values:	Light bulbs:	0.5 A
	LEDs:	10 mA
	Electrical circuits:	2 mA

> Note the following metric prefixes:
> M = mega = × 1,000,000
> k = kilo = × 1,000
> m = milli = ÷ 1,000
> μ = micro = ÷ 1,000,000

Current measures the number of electrons flowing from one point to another. It is analogous to the quantity of water flowing through a pipe. Electrical current normally flows from points of high voltage to points of low voltage, just as water will flow down a hill.

Note that power from batteries, at a constant voltage, is called direct current (DC). Wall power reverses direction repeatedly, with the positive and negative directions switching. This is called alternating current (AC).

3 Frequency

Unit of measurement: hertz (Hz) = 1 / second
Symbol in equations: f

Common values:	Wall power:	60 Hz
	Sound:	50 Hz – 5 kHz
	Microcomputers:	10 MHz – 2 GHz

Frequencies means "number of times per second." For example, a 20 Hz wave repeats itself 20 times in one second

4 Resistors

Unit of measurement: ohms (Ω) (resistance)
Symbol in equations: R
Symbol in circuit diagrams:

Common values:	Electronics:	100 Ω - 1 MΩ
	Human body:	100 kΩ (wet) – 10 MΩ (dry)

A resistor lets electricity pass through it, but at a cost:

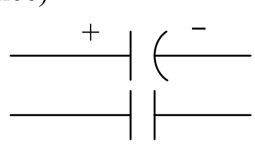
$$\mathbf{V = IR}$$

$$\mathbf{I = V/R}$$

This equation says that when a current *I* passes through a resistor *R*, there is a voltage drop *V* proportional to the current times the resistance. Similarly, if you put a voltage *V* across the two ends of a resistor *R*, a current *I* will flow, equal to the voltage divided by the resistance.

5 Capacitors

Unit of measurement: farads (F) (capacitance)
Symbol in equations: C
Symbol in circuit diagrams:



(positive and negative ends)

(no difference between +/-)

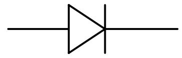
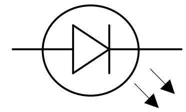
Common values: Electronics: 10 pF - 1000 mF

A capacitor lets high frequency signals pass through, but blocks low frequency signals.

How does this work? A simple capacitor consists of two metal plates very close to each other (hence the diagram). A high frequency signal generates a lot of electromagnetic waves that cross the space between the two plates and let the signal pass through. However, a low frequency signal generates weaker EM waves, or none in the case of a DC, 0-hertz signal. In that case the capacitor acts just like what it is: two wires that are not connected.

In practice, if you connect a capacitor to a voltage source, at first current will pass through due to that initial change, but then the capacitor "charges up" and no current will pass in response to the constant voltage. Note that electrolytic capacitors have a + and – end which much be followed or they blow up.

6 Diodes

Symbol in circuit diagrams:  LED: 

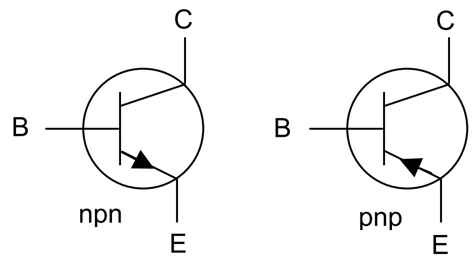
A diode lets current pass through it in only one direction (the direction of the arrow in the diagram). There is a voltage drop of about 0.6 V for a standard silicon diode.

A light-emitting diode (LED) gives off light when current flows through it.

7 Transistors

Symbols in circuit diagrams:

Symbol for gain: h_{FE}, or β



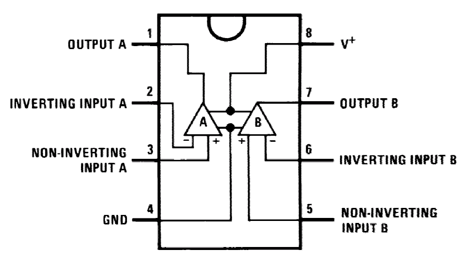
These are standard bipolar transistors. They allow a small current to control a big current. For an npn type transistor, a small current flowing into the base (B) will cause a large current to flow from the collector (C) to the emitter (E), proportional to the gain:

$$\mathbf{I_C = h_{FE} I_B}$$

For a pnp transistor, a small current flows out of the base, and a large current flows from the emitter to the collector

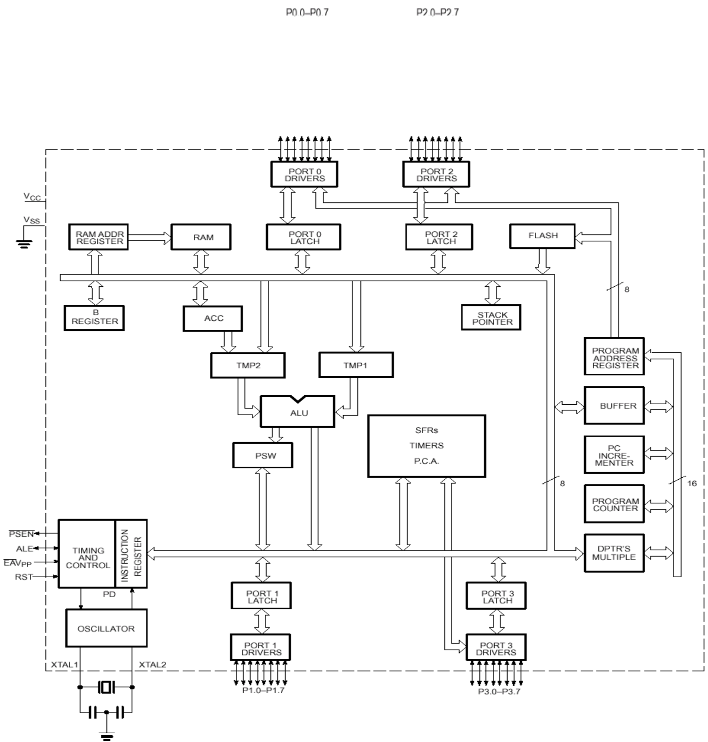
8 Simple Integrated Circuits

Example: LM358 Op-Amp:



Integrated circuits typically contain a large number of circuits embedded on a single chip. They are each designed for a specific function, and are generally mass-produced by the thousands or millions. They come in different packages – this class uses chips in the dual in-line pin (DIP) package that fits into a plastic solderless breadboard.

9 Microcontrollers



What

A microcontroller is a complete computer system on a single chip. Microcontrollers are found in cars, airplanes, microwaves, cellular phones, and any device that needs some intelligent computing behavior without a large personal computer.

Why

They are called microcontrollers because they are *small* (micro) and because they are often used for *control* – they take input from the environment around them, run a program to make decisions, and then output a command to control their environment.

Examples

For example, an automotive microcontroller watches all the systems in your car and coordinates them to give optimal efficiency and prevent failures.

Similarly, your microwave takes some commands from the keyboard and controls the microwave generator and possibly several motors. A digital cellular phone receives and transmits both analog and digital signals, and lets you store data and configure various options.

Summary

The key points of microcontrollers are:

- **Digital and Analog**
  Microcontrollers interface between digital computer programs and the analog physical world.

- **Self-contained (embedded)**
  Microcontrollers are called embedded systems because they are complete systems that are physically a part of the system they control.

- **Control**
  Microcontrollers fundamentally let humans **control** the world around them.